CURRICULUM OF MASTERS' ACADEMIC PROGRAMMES

School of Environment & Natural Resources
(SENR)

Doon University
Kedarpur, P.O- Ajabpur, Dehradun – 248001

Master of Technology

(*M. Tech. - Environmental Technology*)

A UGC Sponsored Programme

Under

Innovative Programme – Teaching & Research in Interdisciplinary and Emerging Area

(Approved Structure August-2022 onwards)

School of Environment & Natural Resources

DOON UNIVERSITY

Dehradun-248001, Uttarakhand, India

www.doonuniversity.ac.in

M. Tech. Environmental Technology

About the Programme

The Master in Environmental Technology aims to produce environmental engineers/experts/professionals with an ability to apply the scientific knowledge, techniques, skills and modern tools of mathematics, bio/science. Engineering and technology to solve the ever-growing environmental issues and challenges different industries and sectors are facing.

Programme outcome

- Develop capacity to apply the knowledge of environmental science and engineering to provide sustainable solutions to environmental issues and challenges different industries and sectors are facing.
- Sensitize the students on the environmental issues and challenges at regional, national and global scale.
- Impart knowledge, practical training, analytical techniques and skills to solve the environmental problems industries and other sectors are facing.
- Prepare environmental engineers for a successful career in industry, government and private sectors for the development of sustainable technologies in respective sector.

Course duration– 4 Semesters (maximum 6 semesters)

Distribution of credits

Core course (CC)	Elective course (EC)	Thesis Work (TC)	Total credits
37	9	24	**82**

SEMESTER	Total Credits
Semester – I	21
Semester – II	21
Semester – III	20
Semester – IV	20
Total	**82**

Nomenclature: ETE – Elective Course, ETC: Core course, & ETO: Open Course

M Tech Course Nomenclature Series: 500

500: Fundamental Environmental Engineering & Science

510: Water/Water & Wastewater/Sewage Treatment Courses

520: Chemistry & Chemical Technology/Biotechnology/Bioremediation Courses

530: Solid Waste/Industrial waste/Hazardous Waste Courses

540: Air pollution & Modeling courses

550: Instrumentation Technology & Analytical Techniques

560: Green Building and Renewable Energy Technology

570: Environmental Health, Sanitation and Risk Assessment/EIA

580: Industrial Training/Technical writing

590: Software/ Modeling/Project/Thesis/Dissertation

SEMESTER –I **Total Credits: 21**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-PR
1	**ETC – 550**	Basic Instrumentation in Environmental Science & Technology	3-0-0	2	30-50-20-0
2	**ETC – 510**	Principles and Design of Wastewater Treatment and Disposal Systems	3-0-0	3	30-50-20-0
3	**ETC – 590**	Remote Sensing & GIS Application in Environmental Management	1-1-1	3	30-30-20-20
4	**ETC – 530**	Solid and Hazardous Waste Management	3-0-0	2	30-50-20-0
5	**ETC – 500**	Fundamental of Environmental Science and technology	3-0-0	2	30-50-20-0
6	**ETC -591**	Statistical Applications	2-0-1	3	30-30-0-40
7	**ETC - 554**	Lab 1 (Instrumentation)	0-0-3	2	0-0-0-100
8	**ETC – 511**	Lab 2 (Wastewater Treatment)	0-0-3	2	0-0-0-100
9	**ETC-512**	Lab 3 Solid waste management	0-0-3	2	0-0-0-100

SEMESTER –II **Total Credits: 21**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-PR
1	**ETC – 570**	Environmental Impact Assessment and Management	2-1-0	3	30-50-20-0
2	**ETC – 540**	Air Pollution and its Control	2-0-0	2	30-50-20-0
3	**ETC-597**	Environmental System Analysis & Modelling	2-0-1	3	30-30-20-20
4	**Elective I (ETE – 575)***	Industrial Safety & Health Management	3-0-0	3	30-50-20-0
5	**Elective II (ETE-557)***	Environmental Quality and Pollution Monitoring Techniques	3-0-0	3	30-50-20-20
6	**Elective III (ETE-530)**	Research Methodology	3-0-0	3	30-50-20-0
7	**ETC – 541**	Lab 4 (Air pollution)	0-0-2	2	0-0-0-100
8	**ETC-596**	Lab 5 (Computer Application in Environmental Engineering)	0-0-2	2	0-0-0-100

***M**- Midterm exam, **F**- final exam, **A**- assignment and **PR** – practical**Compulsory Elective

SEMESTER –III **Total Credits: 20**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution* M-F-A-PR
1	**ETC – 580**	Industrial/Lab Training/attachment (4 week) & Report Presentation	0-0-2	2	80 – 20 (report + presentation)
2	**Elective IV**	Subject specific Elective (Area of Specialization)	3-0-0	3	30-50-20-0
3	**Elective V**	Online Course[#] (Related to research area of dissertation)	3-0-0	3	30-50-20-0
3	**ETC – 593**	Project - I	0-1-3	12	20-80-0-0 (Report – Presentation)

***M**- Midterm exam, **F**- final exam, **A**- assignment and **PR** – practical*

[#]*Students have to enroll for this online course in second semester itself*

SEMESTER –IV **Total Credits: 20**

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution
1	**ETC – 594**	Project – II	0-0- 20	14	80-20 **(Dissertation – Presentation)**

ELECTIVE COURSES[#] – II Semester

S. No.	Course Code	Course Title	L-T-P	Credits	Marks distribution M-F-A-PR
1	**ETE-525**	Environmental Biotechnology	2-0-1	3	30-30-20-20
2	**ETE-577**	Environmental Audit & Certification	2-0-1	3	30-30-20-20
3	**ETE-535**	Industrial Solid Waste Management	2-0-1	3	30-30-20-20
4	**ETE-594**	Environmental System Analysis	2-0-1	3	30-30-20-20
5	**ETE-514**	Membrane Processes for Water and Waste Treatments	2-0-1	3	30-30-20-20
6	**ETE-515**	Industrial Wastewater Treatment	2-0-1	3	30-30-20-20
7	**ETE-542**	Air Pollution Modeling	2-0-1	3	30-30-20-20
8	**ETE-555**	Environmental Instrumentations	2-0-1	3	30-30-20-20
9	**ETE-596**	Geoinformatics for Resource Management	2-0-1	3	30-30-20-20
10	**ETE-528**	Ecological Engineering	2-0-1	3	30-30-20-20
11	**ETE-518**	Bioremediation Technology	2-0-1	3	30-30-20-20
12	**ETE – 575**	Industrial Safety & Health Management	2-0-1	3	30-50-20-0
13	**ETE-520**	Applied Environmental Chemistry	3-0-0	3	30-50-20-0
14	**ETE – 560**	Sustainable Urban Habitats and Green City	2-0-1	3	30-50-20-0
15	**ETE-557**	Environmental Quality and Pollution Monitoring Techniques	2-0-1	3	30-30-20-20

[#] Course will be offered if the minimum numbers of students in elective course is four

M. Tech. Environmental Technology

FIRST SEMESTER

Course Type	Course code	Course Title	Course Outcome
Core	**ETC – 550**	Basic Instrumentation in Environmental Science & Technology	❖ Recognise the role of various instrumental and analytical techniques in Environmental technology. ❖ Understand the principal and applications of key qualitative and quantitative analytical techniques. ❖ Understand the post experimental treatment of results with various statistical methods
Core	**ETC – 510**	Principles and Design of Wastewater Treatment and Disposal Systems	❖ Learn different characterization techniques for water & wastewater ❖ Understand the principles & design of different physicochemical and biological unit operations/processes involved in water & wastewater treatment ❖ Learn sludge management techniques
Core	**ETC – 590**	Remote Sensing & GIS Application in Environmental Management	❖ Understand the principles of remote sensing (RS) and geographic information systems. ❖ Apply RS & GIS to solve problems of Environmental Science & Engineering, and mapping of natural resources. ❖ Maximize the efficiency of planning and spatial decision making and integrate geographically referenced data and develop queries to generate usable information
Core	**ETC – 530**	Solid and Hazardous Waste Management	❖ Provide comprehensive overviews of solid and hazardous wastes management ❖ Identify current statutory and regulatory framework related to solid and hazardous waste management. ❖ Identify the common techniques for preventing, minimizing, recycling, disposing and treatment of solid and hazardous waste
Core	**ETC – 500**	Fundamental of Environmental Science and technology	❖ Understand the basic concepts of ecosystems, and role of microorganisms in different biogeochemical cycles and nutrient recycling ❖ Learn fundamentals of growth kinetics and control of microbes and their applications in environmental engineering
Core	**ETC -591**	Statistical Applications	❖ Able to design proper sampling methods and its analysis. ❖ To master different statistical techniques to analyze the data. ❖ To create quantitative models to solve real world problems in appropriate contexts. ❖ To skill themselves in using statistical software in visualizing, analyzing statistical models

Core	**ETC - 554**	Lab 1 (Instrumentation)	❖ Summarize and classify capabilities and limitations of analytical instruments used in analysis of environmental pollutants. ❖ Able to perform qualitative and quantitative analysis of air, soil, and water samples
Core	**ETC – 511**	Lab 2 (Wastewater Treatment)	❖ Trained to handle and characterize water & wastewater samples ❖ Learn operation of reactor (SBR) for wastewater treatment
Core	**ETC-512**	Lab 3 Solid waste management	❖ Make physical and chemical analysis of solid wastes and apply them for a management system that will be set up. ❖ Plan a recycling program. ❖ Design a compost facility. ❖ Design and practical demonstration of waste-to-energy program (anaerobic digestion, fuel efficiency analysis, biochar, etc.). ❖ EIA of landfill sites

SECOND SEMESTER

Course Type	Course code	Course Title	Course Outcome
Core	**ETC – 570**	Environmental Impact Assessment and Management	❖ Understand the major principles and different steps within the Environmental Impact Assessment. ❖ prepare EIA reports and evaluation criteria of a EIA reports. ❖ Be able to understand and access the different case studies in Environmental Impact Assessment. ❖ Be able to understand the human development with sustainable approaches
Core	**ETC – 540**	Air Pollution and its Control	❖ Demonstrate a basic understanding of the physical, chemical, and biological characteristics of air pollutants ❖ Acquire a basic understanding of how to design sampling and analysis of air pollutants data ❖ Gain a familiarity with the basic tools of air pollution control methods ❖ Apply knowledge of air pollution legislation on deigning Environmental management system for Industrial and municipal board
Core	**ETC-597**	Environmental System Analysis & Modelling	❖ Be able to conceptually frame the model of environmental system for the modelling study ❖ Be able to explain the physical and chemical laws basis of environmental models ❖ Acquire skills in running air quality models, water quality models. ❖ Acquire skills in applying these models in specific area under specific scenario
Core	**Elective I (ETE – 575)**	Industrial Safety & Health Management	❖ Acquire ability to identify different health hazards at workplace

			❖ Learn methods to control unsafe or unhealthy hazards and propose methods to eliminate the hazard ❖ Learn to use most appropriate PPEs at workplace ❖ Comprehend the legislative measures in industrial safety
Elective	**Elective II (ETE-557)**	Environmental Quality and Pollution Monitoring Techniques	❖ Comprehend the transport of pollutants in the environment and techniques of pre-concentration before analysis. ❖ Understand the sampling protocols and sample preparation aspects for environmental analysis. ❖ Knows about systematic monitoring of water, soil, air, and solid waste samples.
Elective	**Elective III (ETE-530)**	Research Methodology	❖ Improve the professional competency and research aptitude ❖ Learn how to identify a research problem, write literature review, and research paper and dissertation in proper format. ❖ Understand ethical standards of conducting research, and plagiarism issues in dissertation and research publication. ❖ Learn the presentation and discussion skills and develop critical thinking.
Core	**ETC – 541**	Lab 4 (Air pollution)	❖ Acquire a basic understanding of how to design sampling and analysis of air pollutants data ❖ Learn measurement of air pollution sampling and measurement of air pollutants
Core	**ETC-596**	Lab 5 (Computer Application in Environmental Engineering)	❖ Learn the basic techniques required to use and run the air quality models, water quality or environmental models. ❖ Acquire skills with one of the computer programming language such as python. ❖ Acquire skills in using computer programs to customize environmental models for specific purpose

THIRD SEMESTER

Course Type	Course code	Course Title	Course Outcome
Core	**ETC – 580**	Industrial/LabTraining/attachment (4 week) & Report Presentation	❖ Acquainted with practical aspects of the environmental issues and their management in industrial sector. ❖ Apply their knowledge and skills acquired in the classroom to a professional context; ❖ Understand what skills are transferable to new contexts; identify and understand the practices and protocols of the particular Industry/institution. ❖ Refine and reassess career goals as a result of the experience gained during internship. ❖ Learn the presentation and discussion skills and develop critical thinking

Elective	**Elective V**	Online Course related to research area of dissertation	❖ To improve fundamentals of the selected topic of research ❖ To identify the key methods, tools and techniques involved in particular research area
Core	**ETC – 593**	Project - I	❖ Improve the professional competency and research aptitude ❖ Develop the work practice to apply theoretical and practical tools/ techniques to solve real life problems related to industry and environment. ❖ Plan, and engage in, an independent and sustained critical investigation and evaluation of a chosen research topic relevant to environment and society. ❖ Systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions ❖ Appropriately apply qualitative and/or quantitative evaluation processes to original data. ❖ Understand and apply ethical standards of conduct in the collection and evaluation of data and other resources, communicate research concepts and contexts clearly and effectively both in writing and orally.
Elective	**Elective V (ETC-515)**	Industrial Wastewater Treatment	❖ Learn prevention and control of industrial wastewater pollution ❖ Learn various industrial manufacturing process description, wastewater generation, source reduction options and waste treatment flow sheets of different industries. ❖ Acquire ability to use the most suitable methods (physicochemical/biological) to treat industrial effluents
Elective	**Elective V (ETE-535)**	Industrial Solid Waste Management	❖ Evaluate the subject from the technical, legal and economical points by learning of all terms related to general solid waste management program for industries. ❖ Examine the technical points that are required to set up a solid waste management plan for an industry. ❖ Be able to understand waste minimization program for industrial sector and recycling option. ❖ Understand the major options for sustainable solid waste management for industrial sector.
Elective	**Elective V (ETE-525)**	Environmental Biotechnology	❖ Impart the basic knowledge how to prepare and perform sampling and microbial analyses to determine the abundance, growth rate and microbial community composition in different environment. ❖ Understand the role of microbes in n degradation of natural organic compounds and selected pollutants in the environment. ❖ Learn how biotechnological tools can be used to

			study environmental assessment, monitoring and remediation
Elective	**Elective V (ETE-577)**	Environmental Audit & Certification	❖ Comprehending the statutory and regulatory mechanism pertaining to environmental auditing and certification. ❖ Plan for mitigation of the impacts & monitor the mitigation measures and acquire knowledge about Environmental Legislation & Environmental Audit. ❖ Be able to understand and access the different case studies in Environmental Impact Assessment.
Elective	**Elective V (ETE-594)**	Environmental System Analysis	❖ Learn Air Pollution Dispersion Modeling approaches ❖ Understand the role of various natural and man-made systems ❖ Acquire ability to apply environmental databases and environmental software packagesto address specific environmental problems
Elective	**Elective V (ETE-514)**	Membrane Processes for Water and Waste Treatments	❖ Understand the fundamentals of membrane processes ❖ Able to design membrane bioreactors for wastewater treatment
Elective	**Elective V (ETE-542)**	Air Pollution Modeling	❖ Learn various approaches to model formulation, its classification, and criteria for model selection. ❖ Learn indoor air quality models and ❖ Learn modeling approach to air pollution dispersion
Elective	**Elective V (ETE-555)**	Environmental Instrumentations	❖ Recognize the role of various analytical techniques in environmental monitoring. ❖ Understand the basic principles behind common analytical techniques and some important instruments. ❖ Able to perform qualitative and quantitative analysis of air, soil, and water samples
Elective	**Elective V (ETE-520)**	Applied Environmental Chemistry	❖ Understand the role of basic chemistry principles behind different environmental process. ❖ Identify the origin and composition of Air, Soil, and aqueous environment and their physic-chemistry ❖ Understand the chemistry behind cause and transport of various pollutants in air, soil and water
Elective	**Elective V (ETE – 560)**	Sustainable Urban Habitats and Green City	❖ Understand the role of urban ecology, sustainability and cities ❖ Able to suggest mitigation measures to make cities resilient, social sustainability. ❖ Understand the concept of green building ❖ Learn assessments methods for the environmental impact of buildings

FOURTH SEMESTER

Course Type	Course code	Course Title	Course Outcome
Core	**ETC – 594**	Project – II	❖ Improve the professional competency and research aptitude of the student by providing an opportunity to explore the research ideas

			❖ Develop the work practice in students to apply theoretical and practical tools/ techniques to solve real life problems related to industry and environment ❖ Plan, and engage in, an independent and sustained critical investigation and evaluation of a chosen research topic relevant to environment and society. ❖ Systematically identify relevant theory and concepts, relate these to appropriate methodologies and evidence, apply appropriate techniques and draw appropriate conclusions ❖ Appropriately apply qualitative and/or quantitative evaluation processes to original data. ❖ Understand and apply ethical standards of conduct in the collection and evaluation of data and other resources, communicate research concepts and contexts clearly and effectively both in writing and orally

Course Code: ETC - 500
Course Title: Fundamental of Environmental Science and Technology

Number of Credits: 2 **L-T-P 2**-0-0

Unit I: Ecosystems; biotic and abiotic components, production and consumption, trophic levels, productivity and energy flow, food webs, cycling of elements. Description and study of typical natural and artificial ecosystems.

Unit II: Biochemistry, photosynthesis and respiration, important biological compounds, enzymes. An introductory study of environmental resources and their use. Relations and cycles within ecosystems. The causes, monitoring and correction of pollution of environmental systems.

Unit III: Microbiological concepts: cells, Structure and function of cell constituents, classification and characteristics of living organisms, characterization techniques, reproduction, metabolism, microbial growth kinetics. Association of microorganisms with man, animals and plants microorganisms in nature. Extremophilic microorganisms

Unit IV: Microbial Growth and Control: Methods of determining growth, factors affecting growth, types of growth, continuous, discontinuous, synchronous and non-synchronous. Control of micro-organisms-physical control by filtration, irradiation, temperature (high & low), chemical control by antimicrobial agents and chemotherapeutic agents, microbial indicators of water pollution, MPN method for coliform count in drinking water.

Unit V: Applications to environmental engineering: assimilation of wastes, engineered systems, concepts and principles of carbon oxidation, nitrification, denitrification, methanogenesis, etc.

Suggested Readings:

1. Cunningham W.P. and Cunningham M.A. (2007). Principles of Environmental Science: inquiry and Application, Tata McGraw- Hill, New York.
2. Miller G.T. (2001) Environmental Science, (8th Edition), Brooks/ Cole.
3. Sharma, P.D; Ecology and Environment, Rastogi Publications, Meerut.
4. Best, D.I and Stafford D. The Environmental and Biotechnology Blackwell Science and Publication.
5. Harrison R.M. (Edited) (1991) Understanding our Environmental: An Introduction to Environmental Chemistry and pollution, Royal Society of Chemistry.
6. Pelczar, M., Chan, E.C.S, Krieg, N.R. (2001). Microbiology (5th Edition). Tata Mc-Graw Hill Education Private Limited.
7. Roger Y. Stanier (1987). General Microbiology. Macmillan.
8. Lansing M. Prescott (2001). Microbiology (5th Edition). Willey, USA.

Course Code: ETC - 510

Course Title: Principles and Design of Wastewater Treatment and Disposal Systems

Number of Credits: 3 **L-T-P 3**-0-0

Unit-I: Characteristics of water: Physical, chemical and biological standards. Wastewater treatment concepts; pretreatment, primary treatment, secondary treatment, tertiary treatment. Adsorption, Ion-exchange, Membrane processes. O and M of water treatment plants, Industrial water treatment. Water quality standards.

Unit-II: Theory and design of physicochemical unit operations, screening, grit, removal equalization, sedimentation. Filtration: Slow and rapid gravity filter, multi-media filters and pressure filters. Design of slow sand filter and rapid sand filter. Disinfection: theory and application of chlorine. Miscellaneous methods of water treatment- removal of iron and manganese, hardness, fluorides, colour, taste and odour, dissolved metals and gases.

Unit-III: Aerobic unit operations for organic carbon removal such as activated sludge, trickling filter, oxidation ditch, oxidations ponds, aerated lagoons, root zone treatment, vermifilter etc. Anaerobic operations for organic carbon removal such as UASB, filters, fluidized/expanded bed systems etc. Biological unit operations for nitrogen and phosphorus removal.

Unit-IV: Tricking filters classification, Design parameters, NRC formula, Recirculation in tricking filter merits and demerits, Operation problem encountered in tricking filters and Corresponding remedial measures. Design problems, Theory and Design of Rotatory biological contactors**.**

Unit-V: Theory and design of Sludge treatment, sludge thickening, sludge drying, sludge thickening, Sludge conditioning, incineration, aerobic and anaerobic digestion of sludges. Theory and design of wastewater disposal and systems; disposal to inland water bodies, sea/ocean disposal; land/underground disposal.

Suggested readings

1. Metcalf and Eddy (2003) *Wastewater Engineering: Treatment and Reuse*, (4^{th} Edition), Tata McGraw-Hills Comp. Inc., New York.
2. Qasim, S.R., Motley, E.M., Zhu, G. (2000) *Water Works Engineering:Planning Design and Operation*, Prentice Hall, New Jersey.
3. Birde, G.S., Birde, J.S. (2004) *Water Supply and sanitary Engineering*, 7^{th} Ed., Dhanpat Rai Publishing, New Delhi.
4. Viessman, W., Hammer, M.J., Perez, E.M., Chadik, P.A. (2009) *Watersupply and pollution Control*, PHI learning Pvt. Ltd., New Delhi.
5. Hammer, M.J., Hammer, M.J. Jr. (2008) *Water and wastewater Technology*. 6^{th} Ed. PHI learning Pvt. Ltd., New Delhi.

6. Punmia, B.C., Jain, A. (2005) *Environmental Engineering.*Laksmi Pub. Pvt. Ltd, New Delhi.
7. Davis, M. (2010) *Water and Wastewater Engineering*. McGraw Hills, New York.
8. Fair, Geyer,Okun's Water and Wastewater Engineering: Water Supply and Wastewater Removal (2010) (3rd Edition). John Wiley and Sons, New York.

Journals

Water Research - Elsevier

Water Science & Technology - IWA *Water Science & Engineering*

Water Practice & Technology - IWA

Journal of Water, Sanitation and Hygiene for Development - IWA *Applied Water Science* - Springer

Ecological Engineering – Elsevier

Course Code: ETC - 530
Course Title: Solid and Hazardous Waste Management

Number of Credits: 3 **L-T-P 3**-0-0

Unit I: Introduction: Solid waste- Sources and types of solid wastes factors affecting the generation rates. Municipal solid waste (MSW)**:** physical and chemical composition, factors affecting MSW quality and quantity, hierarchy of waste management, RCRA, integrated solid waste management. Overview of solid waste generation and management practices in India. Hazardous wastes, types, sources, composition and classification. Legal framework for handling and storage of municipal, medical and hazards wastes in India.

Unit II: Waste Storage, Collection and transportation, Storage- movable bins, fixed bins. MSW Collection system, Container system, stationary container system, Transfer and transport, processing, waste transportation system, waste, separators, size reduction equipments, screening equipment, Material recovery facility. Hazardous wastes storage- onsite and offsite storage, hazardous waste transportation, international trade/export/ import of hazards waste, Basel Convention, Electronic waste – storage and treatment options. Waste disposal system and health and pollution issues.

Unit III: Waste recycling and waste -to–energy concept: role of formal and informal sector, resource derived fuels (RDF)- concept, processing, application and limitations, waste-to-energy, concept, waste calorific value assessment, sources, Thermal conversion technologies: incineration, gasification, pyrolysis, biogas, fuel from wastes and char; limitation and health issues. Composting and vermicomposting: types, process description, design and operational consideration of aerobic and anaerobic composting, process description.

Unit IV: Hazardous waste treatment methods: criteria for treatment selection, land disposal, combustion, solidification. Sanitary Landfill Technology: Land-filling, site selection criteria, landfill layout, landfill sections, occurrence of gases and, leachate in landfills: composition and characteristics, operation control, waste decomposition phases in sanitary landfill, gas control and utilization, flaring system. Bioreactor landfill- types and operation management, Post closure operations in landfill.

Unit V: Incinerator technology: concept, engineering and applications, types of incinerators, mass incinerator system for MSW, thermal processing system, different units of a typical incinerator, unit operations, fuel gas controlling, air pollution control in incineration, residual management, legal, political and social issues with incineration technology, medical waste treatment, residues management in hazardous waste treatment, Technical issues and solutions in mass incinerators, ecosystem health and occupational issues in incinerator.

Suggested Readings

1. EPA (1995). Decision-Makers' Guide to Solid Waste Management, Vol-I & II. US EPA, Washington, D.C.
2. FAO (2003). On-farm Composting Methods. FAO, Rome.

3. Guidelines for Management and Handling of Hazardous wastes MOEF (1991), Govt. of India.
4. Kaily, G. (1997). Environmental Engineering. The McGraw-Hill Companies, New York, NY.
5. Liu, D.H.F., and Liptak, (2000). B.G. Hazardous Waste and Solid Waste, Lewis Publishers, Boca raton, FL.
6. Pichetel, J. (2005). Waste management Practices – Municipal, Hazardous, and Industrial. Taylor and Francis, Boca Raton, USA. 659 pp.
7. Reinhart, D.R., and Townsend, T.G. (1997). Landfill Bioreactor Design and Operations. Lewis Publishers, New York, NY.
8. Tchobanoglous, G., and Kreith, F. (2002). Handbook of Solid Waste Management. McGraw Hill, New York.
9. Tchobanoglous, G., Theisen, H., and Vigil, S.A; Integrated Solid Waste Management: McGraw Hill, New York.
10. UNEP (2009). Developing Integrated Solid Waste Management Plan Training Manual. UNDP, IETC, Okasa, Japan.
11. Wang, L.K., Shammas, N.K. and Hung, Y.T. (2008). Biosolids Engineering and Management. Humana Press, Totowa, NJ, USA.
12. Waste Management (1993). Asian and Pacific Center for Transfer of Technology (N.D.) India. September.

Journals

Waste Management - Elsevier
Waste Management & Research -Sage
Compost Science & Utilizations - Taylor & Francis
International Journal of Environment and Waste Management - Inderscince, UK
Journal of Waste Management - Hindwai
Journal of Material Recycling and Waste Management - Springer
Journal of Hazardous Materials - Elsevier
Bioresource Technology - Elsevier
Waste& Biomass *Valorization* - Springer
Journal of the Air & Waste Management Association - AWMA, USA

Course Code: ETC - 550
Course Title: Basic Instrumentation in Environmental Science & Technology

Number of Credits: 2 **L-T-P 1**-0-1

Unit – I Basic Principles of Instrumentation, solvent extraction and its application, ion exchange and electrophoresis, Paper and Gas Chromatography, Instrumentation and applications of HPLC and TLC.

Unit – II Information on Analytical Methods, Limitations of analytical methods, Accuracy and precision, Classification and minimization of errors. Basic Principals of Spectroscopy, Basic principles, Instrumentation and Applications of UV and VIS spectrophotometers, IR and EMR-Spectrophotometry- interaction of radiation with different types of molecular energy, NMR.

Unit – III Introduction, principle, instrumentation and environmental applications of flame photometer – AAS. Atomization flame atomization graphite furnace atomizers, application of AAS. Atomic Emission Spectroscopy – Instrumentation – quantitative analysis – direct reading spectrometers. Plasma excitation – flame excitation – laser excitation – chemical interferences – concentration range – Mass spectrophotometer.

Unit – IV Introduction, Principle, Instrumentation and Application of Nephelometry, Turbidimetry, Conductometry, Potentiometer, Ion Selective Electrodes.

Unit – V Collection and Presentation of Data, Rules for construction of diagram and graphs – types of diagrams and graphs – measure of centre value, tendency and measure of dispersion – correlation and regression analysis– test of hypothesis, test of significance – t, χ^2 and ANOVA.

Course Code: ETC - 590
Course Title: Remote Sensing & GIS Application in Environmental Management

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Cartography and Photogrammetry – Introduction, map reading, scale, types and sources, map coordinate system and projections (Cylindrical, Conic, Azimuth), map preparation, visualization and guidelines of mapping. Photogrammetry, Geometry of aerial photographs, Concept of Parallax, Terrain Analysis, DEM interpolation techniques, Cartography, Map projections.

Unit-II: Basics of Remote Sensing – Physics of Remote Sensing, Electromagnetic Radiation, Spectral signature for various land cover feature, Visual image Interpretation, RS Data Acquisition Mechanism, Platforms, Sensors, Data Types and Errors, Basics of Thermal, Microwave and LiDAR Remote Sensing.

Unit-III: Digital Image Processing – Concepts of Digital Image Processing, Data and Image storage formats: Image Preprocessing, Radiometric correction, Image Enhancement, Contrast Enhancement, Spatial and frequency domain filtering, Image Classification, and Image Fusion)

Unit-IV: Geographical Information System & GPS – Fundamentals of GIS, Data Input and Output: Spatial and Non spatial Data, Spatial and Network Analysis, Vector & raster based analysis, Global Positioning System, Fundamentals of Mobile Mapping.

Unit-V: Application of Remote Sensing and GIS – Relevance in planning, Land use/Land cover, forestry, agriculture, water resources, urban sprawl, environmental studies, disaster management.

Suggested Readings:

1. Dewitt Bon A. and Paul Wolf (2000). Elements of Photogrammetry, McGraw Hill.
2. George Joseph (2005). Fundamentals of Remote Sensing; Universities Press (India) Pvt. Ltd, Hyderabad, India.
3. Lillesand Thomas M., Kiefer Ralph W. and Chipman Jonathan, (2008). Remote Sensing and Image Interpretation (6th Edition). John Wiley, USA.
4. Jensen, John R. (2000). Remote Sensing of the Environment: An Earth Resource Perspective, New Jersey: Prentice Hall, 544 pages.
5. Longley, Paul A., Goodchild, Michael F., Maguire, David J., and David W. Rhind. (2005). Geographic Information Systems and Science, 2nd ed., John Wiley and Sons, Toronto.
6. Burroughs, P.P. and McDonnel, R.A. (1998). Principles of GIS, Oxford University Press, pp. 162 -166.

Course Code: ETC - 591
Course Title: Statistical Applications

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Introduction: Mathematical models – deterministic and stochastic, generation of environmental data, stochastic processes in environment, the nature of random variables, populations and samples; parameters and statistics.

Unit II: Measurement theory, levels of measurement, statistical descriptors of environmental data-numerical and graphical, Chebyshe's theorem, measurement uncertainty – accuracy, precision and bias.Probability theory: probability concepts; probability distribution functions and their application –discrete and continuous distributions.

Unit III: Data sampling: Methods for selecting sampling locations and times, types of sampling designs- probability and non- probability sampling, sampling theory, sampling distribution, parameter estimation, point and interval estimates; confidence interval estimation of means, differences of means, proportions, difference of proportions, variances ratio of variances sample size determination for different sampling designs

Unit IV: Tests of hypothesis: Hypothesis testing- parametric and non- parametric tests: Concerning means, differences of means, proportions, differences of proportions, variances, ratio of variances.

Unit IV: Correlation analysis: graphical analysis, bivariate correlation, covariance,correlation coefficient, distribution of correlation coefficient and its statisticalsignificance. Simple regression analysis: assumptions and definitions, principleof least squares, regression parameters their distribution and statisticalsignificance, applications in process description and prediction.

Suggested Readings:

1. Cothern C.R. and Ross N.P. (1994). Environmental Statistics, Assessment and Forecasting, Lewis Publishers, Boca Raton, FL.
2. Csuros M. (1997). Environmental Sampling and Analysis, Lab Manual, lewis Publishers, Boca Raton, FL,
3. Everitt B.S. (1999). Chance Rules; An informal Guide to Probability, Risk and statistics, Springer- Verla, New York.

4. Gibbons R.D and Coleman D.E. (2001). Statistical Methods for Detection and Quantification of Environmental Contamination, John Wiley & sons, Inc., New York.
5. Gilbert R. O. (1987). Statistical Methods for Environmental Pollution Monitoring, New York Van Nostrand Reinhold.
6. Ginevan M.E. Splistone D.E (2004). Statistical tools for Environmental Quality Measurement. John Wiley & Sons Hoboken, Nj.
7. Keith L.H. (1991). Environmental Sampling and Analysis: A Practical Guide, Lewis Publishers, Boca Raton, FL.
8. Kottegoda N.T. and Rosso R. (2008). Applied statistics for civil and Environmental Engineers, McGraw- Hill, New York.
9. Ott W.R. (1995). Environmental Statistics and Data Analysis, Lewis Publishers, Boca Raton, F.L.
10. Zhang C. (2007). Fundamentals of Environmental Sampling and Data Analysis, John Wiley & Sons, NJ.USA.

Journals

Applied Statistics
Biometrika
Environmental and Ecological Statistics
Environmentrics
International Statistical Review
Journal of Statistical Computing and Simulation
Journal of the American Statistical Association
Risk Analysis
Statistical Science
Technimetrics

Course Code: ETC - 540
Course Title: Air Pollution and its Control

Number of Credits: 3 **L-T-P 2**-0-0

Unit I: Air pollution: composition and structure of atmosphere, global implications of air pollution. Classification of air pollutants: particulates, hydrocarbon, carbon monoxide, oxides of sulphur, oxides of nitrogen and photochemical oxidants. Indoor air pollution, Effects of air pollutants on humans, animals, property and plants. Mobile air pollution sources, Indoor air quality; Air quality and emission standards (Indian and International)

Unit II: Air pollution chemistry, meteorological aspects of air pollution dispersion; temperature lapse rate and stability, wind velocity and turbulence, plume behaviour, dispersion of air pollutants, the Gaussian Plume Model, stack height and dispersion. Combustion fundamentals (Stoichiometry, thermodynamics, kinetics,); combustion of solid and liquid; Aerosols - Stokes' Law, Brownian Motion of Aerosol Particles, General Dynamic Equation for Aerosols;

Unit III: Air pollution legislation; Ambient air sampling, collection of gaseous air pollutants, collection of particulate air pollutants, stack sampling. Design of gravitational settling chamber, cyclone separator, fabric filter, electrostatic precipitator. Engineering control concepts; process change, fuel change; pollutant removal and disposal of pollutants

Unit IV: Introduction to air pollution control, control devices for particulate contaminants: gravitational settling chambers, cyclone separators, wet collectors, wet and dry scrubbing, fabric filters (Bag-house filter), electrostatic precipitators (ESP), condensation, flare processes, thermal and catalytic oxidation, other emerging air pollution control devices etc.), removal of dry particulate matter, liquid droplets and mist removal, gaseous pollutants and odour removal.

Unit V: Control of gaseous contaminants: Absorption, Adsorption, Condensation and Combustion Control of sulphur oxides, nitrogen oxides, carbon monoxide, and hydrocarbons. Automotive emission control, catalytic convertor, Euro-I, Euro-II and Euro-III specifications, Indian specifications.

Suggested readings

1. Karl B. Schnelle, Charles Arnold Brown (2002). Air Pollution Control Technology Handbook. CRC Press, Boca Raton, USA.
2. Tiwary, A., Colls, J. (2010). Air Pollution: measuring, Modeling and Mitigation. Rutledge, New York, USA.
3. Steyn, D.E., Rao, S.T. (2010). Air Pollution Modeling and Its application. Springer, Netherlands
4. Vallero, D. (2008). Fundamentals of Air Pollution (4^{th} Edition). Academic Press, London, UK.

5. Wang, L.K., Pereira, N.C., Hung, U.T. (2004). Air Pollution Control Engineering. Humana Press Inc., New Jersey, USA.
6. Buonicore, A.J., Davis, W.T. (1994). Air Pollution Engineering Manual. Air and Water Management Association, Van Nostrand Reinhold, New York.
7. Seinfield, J.H., Pandis, S.N. (1998). Atmospheric Chemistry and Physics: from Air Pollution to Climate Change. Wiley, New York.

Journals

Atmospheric Environment - Elsevier
Environmental Science & Technology - ACS
Environmental Pollution - Elsevier
Journal of the Air Pollution Control Association - USA
Water, Air, & Soil Pollution - Springer
Air Quality, Atmosphere & Health - Springer
Journal of Aerosol Science – Elsevier

Course Code: ETC - 570
Course Title: Environmental Impact Assessment and Management

Number of Credits: 3 **L-T-P 2**-1-0

Unit I: Environmental Management System: The evolution of environmental management standard, British Standard 7750, Technical Committee 207, ISO 9000 and ISO 14000 series, origin, objective, scope and applicability of ISO 14000, components parts of ISO 14000 and their relationship, legal considerations and requirements of ISO 14000. ISO 14040: Guidelines standards for a company's management system; general principle of conducting life cycle assessment (LCA), definition, stages and scope of LCA and LCA inventory. ISO guide 64: its purpose. ISO 14000 checklist.

Unit II: EIA: Planning and management of environmental impact studies. Impact indentation methodologies: base line studies, screening, scooping, checklist, networks, overlays. Prediction and assessment of impacts on the socio-economic environment. Environmental cost benefit analysis. Decision methods for evaluation of alternatives, Case studies. Environmental impact assessment at project level, regional level, sectoral level, and policy level. Guidelines of preparation of project report and its evaluation, methods of clearance from the concern authorities at various labels

Unit III: Sustainable development, Environmental policy in planned, mixed and market economies, global environmentalism, Preventive environmentalism and environmental management. Pollution prevention and control laws and acts: Constitution of India & environment, Constitution protection to Environment laws, Administrative & legislative arrangement for Environmental production, Indian Standards, Pollution control acts in India, critical appraisal, fiscal incentives for environmental protection.

Unit IV: Environmental Audit: Introduction, Environmental information Purpose & advantage of studies, General approach of environmental Auditing Environmental Audit, Audit programs in India, Auditing program in major polluting Industries, Reports of the Environmental audit studies. Ethics in society, Environmental consequences, Responsibility for environmental degradation, Ethical theories and codes of Ethics, Changing attitudes.

Unit V: Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation; Waste audits, emission inventories and waste management hierarchy for process industries; Thermodynamic constraints to waste minimization; Holistic and critical technology assessment; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks.

Suggested Readings:

1. Canter, L.W. (1996). Environmental Impact Assessment, McGraw Hill, New York
2. Christopher S. and Mark Y. (2007) Environmental Management Systems, (third edition), Earthscan Publications, First South Asian Edition.
3. Cunningham W.P. and Cunningham M.A. (2007) Principles of Environmental Science:

inquiry and Application, Tata McGraw- Hill.

4. David L. G. and Stanley B.D. (2001) ISO 14000 Environmental Management, Prentice Hall.
5. Earth scan J.B. (Ed) (2005) Environmental Management in Organizations, the IEMA Handbook (Sections 1.1,1.2,1.3,3.2,3.4,4.3,4.4,5.3,).
6. Gilbert M.M. (2004) Introduction to Environmental Engineering and Science (2nd Ediction). Pearson Education.
7. Harrison R. M. (Ed), (2001) Polluting: Sources, Effects and Control, (selected chapters), Royal Society of Chemistry.
8. LaGrega M.D. Buckingham P.L. and Evans J. C. (1994) Hazardous Waste Management McGraw-Hill International Edition, New York.
9. Lawrence, D.P. (2003). Environmental Impact Assessment – Practical solutions to recurrent problems, Wiley-Interscience, New Jersey.
10. Petts, J. (1999). Handbook of Environmental Impact Assessment, Vol., I and II, Blackwell Science, London.
11. World Bank –Source book on EIA.

Journals

Environmental Impact Assessment Review- Elsevier
Journal of Environmental Management
Environmental Modeling-Elsevier
Science of the Total Environment-Elsevier
Journal of Cleaner Production-Elsevier

Course Code: ETC - 597
Course Title: Environmental System Analysis & Modelling

Number of Credits: 3 **L-T-P 2**-1-0

Unit I: System and System Analysis, Static and Dynamic System, models and modeling, Types of Models, Stochastic and Deterministic Models, Dynamic Simulation Modeling, Necessity of models in management of Environmental System, Steps followed in Modeling, Model Conceptualization, Model Development, Solution Methodologies- Numerical, analytical and Monte Carlo methods of simulation, Numerical solutions to ordinary & partial differential equations

Unit II: Atmospheric structure, composition and thermodynamics, the continuity and thermodynamic energy equations, the momentum equation in Cartesian and spherical coordinates, Vertical-coordinate conversions, Hydrostatic and nonhydrostatic models, sigma-pressure coordinate, sigma-altitude coordinate, Finite-differencing the equations of atmospheric dynamics, Boundary-layer and surface processes

Unit III: Air Pollution Dispersion Modeling:Meteorological factors affecting air quality, Lapse rates, Dry adiabatic, Moist Adiabatic and ambient Lapse rates , Stable, Unstable and Neutral Atmospheric Condition, Maximum Mixing height, Temperature Inversions, Effect of Lapse Rate on Plume behavior- Conning, Looping, Lofting, fanning, fumigation, Point Source Gaussian Plume Model- Effective Stack Height, Pasquil-Gifforth Stability criteria, Horizontal and Vertical Dispersion, Wind Speed Correction, Numerical Examples and Some case studies on Air Pollution Dispersion Modeling

Unit IV: Surface Water Quality Modeling: Control mass and volume, Material balance equation, Dissolved Oxygen Depletion, Biochemical Oxygen Demand Measurement, Modeling BOD as a First-order Reaction, Ultimate Biochemical Oxygen Demand, Biological Oxygen Demand: Temperature Dependence, Nitrogenous Oxygen Demand, Theoretical Oxygen Demand, Chemical Oxygen Demand, Dissolved Oxygen Sag Curve, Steps in Developing the DO Sag Curve, Numerical Examples and some case studies on surface water quality modeling.

Unit V:

Application of Statistical modeling in environmental system, time series modeling and forecasting, Time Series Regression and ExploratoryData Analysis, Autocorrelation and Partial Autocorrelation, ARIMA Models, Multiplicative Seasonal ARIMA Models, Spectral Analysis and Filtering, The Spectral Density, Periodogram and Discrete Fourier Transform, Linear Filters, Signal Extraction and Optimum Filtering,

Suggested Readings:

1. Jacobson, Mark Z. (2005). Fundamentals of Atmospheric Modelling, Cambridge University Press
2. Shumway, Robert H., Stoffer, D. H. (2014). Time Series Analysis and Its Applications: With R examples, Springer
3. Brockwell, P. J., Davis, R. A. (2000). Introduction to time series and Forecasting. Springer
4. Arya, S. Pal (1998). Air Pollution Meteorology and Dispersion, 1st Edition, Oxford University Press.
5. ÅsaMoberg (1999). Environmental Systems Analysis Tools -differences and similarities. Master Thesis. Stockholm University, Sweden.
6. Barrat, Rod (2001). Atmospheric Dispersion Modelling (1st Edition), Earthscan Publications.
7. Jo Smith and Pete Smith (2007). Introduction to Environmental Modelling. Oxford University Press, UK.
8. Mboden, Dieter M., Pfenninger, Stefan (2013). Introduction to Systems Analysis-Mathematically Modeling Natural Systems. Springer, USA.
9. Pantell, R.H. (1976). Techniques of Environmental Systems Analysis. John Wiley & Sons Inc, USA.
10. Thérivel R. and Partdário M.R. (1996). The practice of strategic environmental assessment. Earthscan Publications Ltd., London.
11. Therivel R., Wilson E., Thompson S., Heaney D. and Pritchard D. (1992). StrategicEnvironmental Assessment. Earthscan Publications Limited, London, UK.
12. V.K. Jain (2008). System Analysis and Design. Dreamtech Press, New Delhi.

Journals

Geoscientific Model development - Copernicus
Atmospheric Chemistry & Physics- Copernicus
Atmospheric Environment- Elsevier
Journal of Atmospheric Science – American Meteorological Society

Journal of Applied Meteorology and Climatology - American Meteorological Society

Environmental System Research-Springer
Environmental Modelling & Software –Elsevier
Environmental Modeling & Assessment-Springer
The International Journal of Life Cycle Assessment - Springer
Journal Australian Life-Cycle Assessment Society

Course Code: ETE - 575
Course Title: Industrial Safety & Health Management

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Introduction: Occupational Health Hazards, Promoting Safety, Safety and Health training, Stress and Safety, Ergonomics - Introduction, Definition, Objectives, Advantages, Importance of Industrial safety, role of safety department, Safety committee and Function. Design and location, distance between hazardous units, colour coding, Lighting, ventilation, Flow charts, pilot plant applications and machine guarding and its types, Housekeeping. Accidents related with maintenance of machines, maintenance of machines- advantages. Works permit systems - Significance of documentation.

Unit II: General causes and classification of fire, Detection of fire, extinguishing methods, firefighting installations with and without water, Machine guards and its types, automation. High pressure hazards, safety, emptying, inspecting, repairing, hydraulic and nondestructive testing, hazards and control in mines. Definition: Incident, accident, injury, dangerous occurrences, unsafe acts, unsafe conditions, hazards, error, oversight, mistakes, etc. Accident Prevention: Theories / Models of accident occurrences, Principles of accident prevention, Accident and Financial implications, Hazard identification and analysis, fault tree analysis, Event tree analysis, failure modes and effects analysis, Hazop studies, Job safety analysis - examples, Plant safety inspection - objectives and types check procedure inspection report.

Unit III: Types and effects of radiation on human body, Measurement and detection of radiation intensity, disposal of radioactive waste, control of radiation, Industrial noise: sources, measurement, effects on health and its control. Air pollutants: Effect of different gases and particulate matter, acid fumes, smoke, fog on human health. Vibration - effects, measurement and control measures, Industrial Hygiene. Safe limits of amperages, voltages, distance from lines, etc., Overload and Short circuit protection, Earthing standards and earth fault protection, Electrical equipment in hazardous atmosphere, Criteria in their selection, installation, maintenance and use. Introduction of Construction industry, Scaffolding and Working platform. Welding and Cutting, Excavation Work, Concreting and Cementing work, Transportation of men and material, Handling and Storage of compressed gas.

Unit IV: First aid: Body structure and Functions, Position of causality, the unconscious casualty, fracture and dislocation, Injuries in muscles and joints, Bleeding, Burns, Scalds and accidents caused by electricity, Respiratory problems, Rescue and Transport of Casualty, Cardiac massage, poisoning, wounds, Personal Protective Equipments: Need, selection, supply, use, care and maintenance, Personal protective devices for head, ear, face, eye, foot, knee and body protection, Respiratory personal protective devices.

Unit V: Legislative measures in industrial safety: Factories Act. (1948). Workman's Compensation Act, 1943, Employees State Insurance Act, 1948, Mines Act, Air (Prevention and control) Pollution Act, 1981, Water (Prevention and Control) Pollution Act, 1974, Boiler Vessels Act, Child labour and Women Employee Act, The factories rules, history, Provisions under the factories Act and rules made there under with amendments, Functions of safety management. ILO

Convention and recommendations in the furtherance of safety, health and welfare. Bureau of Indian standards on safety and health 14489 - 1998 and 15001 – 2000, OSHA, Process Safety Management (PSM) as per OSHA, PSM principles, OHSAS – 18001, EPA Standards, Performance measurements to determine effectiveness of PSM.

Suggested Readings:

1. Air (Prevention and control of pollution) act (1981). Commercial Law Publishers (India) Pvt. Ltd., New Delhi.
2. Brown, D.B. (1976). System analysis and Design for safety, Prentice Hall.
3. Gupta, R.S. (1977). Hand Book of Fire Technology. Orient Longman, Bombay.
4. Hazop and Hazom, by Trevor AKlett, Institute of Chemical Engineering
5. Heinrich H.W. (1980). Industrial Accident Prevention. McGraw-Hill Company, New York.
6. ILO 1988. Major Hazard control- A Practical Manual, ILO, Geneva (1988).
7. John Ridley (1983). Safety at Work. Butterworth & Co., London. Krishnan N.V. (1997). Safety Management in Industry. Jaico Publishing House, Bombay.
8. The Environment Act (Protection) (1986). Commercial Law Publishers (India) Pvt. Ltd., New Delhi.
9. The Factories Act (1948). Madras Book Agency, Chennai, 2000
10. The Mines Act (1952). Commercial Law Publishers (India) Pvt. Ltd., Allahabad.
11. V.J. Davies and K. Thomasin (1990). Construction Safety Hand Book. Thomas Telford Ltd., London.
12. Water (Prevention and control of pollution) act (1974). Commercial Law publishers (India) Pvt. Ltd., New Delhi.

Course Code: ETE - 557
Course Title: Environmental Quality and Pollution Monitoring Techniques

Number of Credits: 3 **L-T-P 2**-0-1

Unit 1 Transport of Pollutants in the Environment and Approaches to their Analysis
Sources, Dispersal, Re-concentration and Degradation, Transport and Re-concentration of Neutral Organic Compounds, Bioconcentration, accumulation in Sediments, Biomagnification, Degradation, Transport and Re-concentration of Metal Ions, Solubilization, Deposition in Sediments, Uptake by Organisms, Safe Level, Sampling and Sample Variability, Representative Samples, Sample Storage, Critical Paths and Critical Groups, General Approach to Analysis, The Choice of Laboratory or Field Analysis, Quality Assurance, Finding a Suitable Method , Laboratory Standards.

Unit 2- Water Analysis – Major Constituents
Sampling, Measurement of Water Quality, Suspended Solids, Dissolved Oxygen and Oxygen Demand, Total Organic Carbon, pH, Acidity and Alkalinity, Water Hardness, Electrical Conductivity, Techniques for the Analysis of Common Ions, Ultraviolet and Visible Spectrometry, Emission Spectrometry (Flame Photometry), Ion Chromatography, Examples of the Use of Other Techniques.

Unit 3- Water Analysis – Trace Pollutants
Organic Trace Pollutants, Guidelines for Storage of Samples and their Subsequent Analysis, Extraction Techniques for Chromatographic Analysis, Gas Chromatography, Liquid Chromatography, Immunoassay, Spectrometric Methods, Metal Ions, Storage of Samples for Metal Ion Analysis, Pretreatment, Atomic Spectrometry, Visible Spectrometry, Anodic Stripping Voltammetry, Liquid Chromatography, Metal Speciation: A Comparison of Techniques

Unit 4- Analysis of Land, Solids and Waste
Common Problem Areas in the Analysis of Solids, Sampling, Pretreatment, Extraction of the Analyte, Sample Clean-up, Analytical Determination, Quality Assurance and Quality Control, Specific Considerations for the Analysis of Biological Samples, Sampling and Storage of Plant Material, Pretreatment, Extraction Techniques for Organic Contaminants, ashing and Dissolution Techniques for Trace Metals, Analysis of Animal Tissues, Specific Considerations for the Analysis of Soils, Sampling and Storage, Pretreatment, Extraction of Organic Contaminants, Extraction of Available Ions, Dissolution Techniques for the Determination of Total Metal Concentrations in Soil, Determination of pH. Specific Considerations for the Analysis of Contaminated Land, Waste and its Disposal by Landfill, Sediments and Sewage Sludge.

Unit 5- Atmospheric Analysis
Gases: Determination of Time-Weighted Average Concentrations, Absorption Trains, Solid Adsorbents, Diffusion (or Palmes) Tubes, Determination of Instantaneous Concentrations, Direct-Reading Instruments, Gas Detector Tubes, gas Chromatography and Mass Spectrometry, Monitoring Networks and Real-Time Monitoring, Remote Sensing and other Advanced Techniques.
Particulates: Sampling Methods, high-Volume Samplers, Personal Samplers, Cascade Impactors,

Further Considerations for Organic Compounds, Sampling Particulates in Flowing Gas Streams, PM10 Sampling, Sampling of Acid Deposition, Analytical Methods Involving Sample Dissolution, Metals, Organic compounds, Direct Analysis of Solids, X-Ray Fluorescence, X-Ray Emission, Neutron Activation Analysis, Infrared Spectrometry, Methods for Asbestos Analysis.

Suggested Readings:

1. Andrew D. Eaton, Lenore S. Clesceri, Arnold E. Greenberg. (1995). Standard Methods for the Examination of Water and Wastewater (19th Edition). APHA, AWWA, WEF of U. S. A.
2. Clair N. Sawyer, Perry L. McCarty, Gene F. Parkin (2004). Chemistry for Environmental Engineering and Science (5th Edition). McGraw-Hill. New York.
3. Danli Xi, Yusheng Sun, Xiuying Zhao (2007). Environmental Monitoring. China High Education Press.
4. Danli Xi. (1998). Environmental Engineering Handbook—Environmental Monitoring Volume. China High Education Press.
5. Edit Commission of China EPA. (2002). Monitoring and Analyses Methods for Water and Wastewater (4th Edition). China Environmental Science Press.
6. Frank R. Burden, Ian McKelvie, (2002). Ulrich Forstner, Alex Guenther. Environmental Monitoring Handbook. McGraw-Hill.
7. G. Bruce Wiersma (2004). Environmental Monitoring. CRC Press.
8. Ling Chen, Jianfu Zhao, YanlingQiu, Siqing Xia (2008). Environmental Monitoring. Chemical Industry Press.
9. YanlingQiu, Ling Chen, Jianfu Zhao (2006). Monitoring and Analysis of Drinking Water Quality. Chemical Industry Press.
10. Zhanpeng Jiang (1990). Environmental Engineering Monitoring. Tsinghua University Press.

Journals

Journal of Hazardous Materials-Elsevier

Environmental Pollution - Elsevier

Ecotoxicology and Environmental Safety- Elsevier

Water Research-Elsevier

Environmental Chemistry Letters – Springer

Environmental Toxicology & Chemistry – Wiley

Journal of Analytical Chemistry-Springer

International Journal *of Environmental* Analytical Chemistry-Taylor & Francis

Journal *of* Chromatography-Elsevier

Chromatography *Research International*

The *Journal* of *Chromatographic* Science-Oxford

Journal *of Separation Science*-Wiley

Course Code: ETC - 596
Course Title: Lab 5 - Computer Application in Environmental Engineering

Number of Credits: 2 **L-T-P 0**-0-2

Types of Models, Stochastic and Deterministic Models, Dynamic Simulation Modeling, Necessity of models in management of Environmental System, Steps followed in Modeling, Model Conceptualization, Model Development,

Introduction to programming, –Design Principles-control flow-execution steps-desirable & undesirable characteristics, Conditional statements, Functions — calling Functions – Passing arguments- Arrays – Defining and processing an array – Array Functions-Passing arrays to Functions – Multidimensional Arrays – Strings-arrays of Strings- String Manipulation functions, General Characteristics of Object Oriented programming,

Solution Methodologies- Numerical methods : Solution of Algebraic and transcendental equation, The Bisection Method, iteration method, Newton-Raphson method, Interpolation, Finite differences, Forward differences, backward differences, Numerical differentiation and integration, Simpson's 1/3-rule, Simpson's 3/8 rule, Romberg integration, Matrices and linear system of equations, Rank, inverse of a Matrix, Gauss elimination method, LU decomposition Eigenvalue problem, SVD, Numerical solution of ordinary differential equations, Runge-Kutta Method

Suggested Readings:

1. Introduction to Numerical Analysis: S. S. Shastry, Prentice Hall of India
2. Numerical Analysis Using MATLAB and spreadsheets: Steven T. Karris, Oxford publications
3. A Primer on Scientific Programming with Python: Hans PetterLangtangen, Springer
4. Computational Physics with Pyhton: Eric Ayars, e-book, California state University
5. Learning Python: Mark Lutz, O'Reilly

Journals:
Environmental Modelling & Software –Elsevier
Environmental Modeling & Assessment-Springer
Envirometrics– Elsevier
Geoscientific Model development– Copernicus

Course Code: ETE - 525
Course Title: Environmental Biotechnology

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Concept of environmental biotechnology and environmental engineering, scope and importance, genetic engineering structure of DNA, RNA, Replication of DNA, genetic code, Genomic and cDNA libraries-PCR (polymerase chain reaction) and gene closing- use of genetically altered microorganisms for field biodegradation of hazardous materials. Molecular biology tools for Environmental management, rDNA technology in waste treatment, Genetic Sensors, Metagenomics, Bioprospecting, Nanoscience in Environmental management, Biosensors development to monitor pollution.

Unit II: Bioremediation, Types of bioremediations, Bio augmentation for bioremediation, Bioreactors, Bioremediation of herbicides, pesticides, hydrocarbons, oil spills. Bioaugmentation, Biosorption, Boleaching, bioremediation: Bioreactors for Bioremediation, Metabolic pathways for Biodegradation for specific organic pollutants. Microbiology of degradation of xenobiotic in environment– ecological considerations, decay behavior and degradative plasmids, hydrocarbons, substituted hydro carbons, oil pollution, surfactants, pesticides. Biological detoxification of cyanide, oxalate, urea, petrochemical industry effluents, toxic organics, phenols.

Unit III: Microbiology of wastewater treatment: Aerobic processes - Activated sludge, oxidation ditches, trickling filters, towers, rotating discs, rotating drums, oxidation ponds. Anaerobic processes: Anaerobic digestion, anaerobic filters, up-flow anaerobic sludge blanket reactor. Treatment schemes for waste waters of dairy, distillery, tannery, sugar and antibiotic industry. Activated Sludge Process (ASP) – Trickling Filters – oxidation ponds. Bioreactors – RBC, Biological filters-fluidized bed reactors, inverse fluidized bed biofilm reactor, membrane bioreactor Neutralization, equalization and pretreatment. ETP Sludge management

Unit IV: Novel methods of pollution control: Vermitechnology, vermistabilization, Methane production, Root zone treatment, Membrane technology, Biodegradable plastics. Air pollution and its control through biotechnology, Biotechnology in reduction of CO_2 emission, Bioscrubbers, Biobeds, Biotrickling filters and their applications. Bioremediation of Petroleum Sludge using Bacterial Consortium and Biosurfactant- Biofilms in Porous Media. Environmental Nanotechnology Research - Nanotechnology for Bioremediation of Heavy metals and organic pollutants.

Unit V: Environmental Biotechnology in Bio-energy production- Chemistry and Biochemistry of Biomass, energy crops, chemical and enzymatic parameters, degradation of cellulose. Biodiesel: source of raw material and processing of biodiesel, production of bio-ethanol, process and production, quality. Bio-hydrogen production, production of hydrogen from waste water. Genetic engineering to enhance hydrogen production rates. Algal Technology in renewable energy production.

Suggested Readings:

1. Alan Scragg (1999). Environmental Biotechnology. Longman.
2. Bailey, J. E. and Ollis, D. F. (1986). Biochemical Engineering Fundamentals (2nd Edition). Mac-Graw Hill, New York.
3. Bruce E. Rittmann, Eric Seagren, Brian A. Wrenn and Albert J. Valocchi, Chittaranjan Ray, LutgardeRaskin (1991). *In situ* Bioremediation (2nd Edition). Nayes Publication, U.S.A.
4. Chakrabarty K.D., Omen G.S. (1989)., Biotechnology and Biodegradation, Advances in Applied Biotechnology Series, Vol.1, Gulf Publications Co., London.
5. Forster, C. F and Waste, D.A. J. (1987). Environmental Biotechnology, Ellis Horwood Halsted Press.
6. G. Mattock E.D. (1978). New Processes of Wastewater Treatment and Recovery. Ellis Horwood.
7. Hendricks, D. (2006). Water Treatment Unit Processes – Physical and Chemical' CRC Press, New York.
8. Lee, C.C. and Shun dar Lin (1999). Handbook of Environmental Engineering Calculations, Mc-Graw Hill, New York.
9. Metcalf and Eddy (1991). Waste water Engineering Treatment, Disposal and Reuse. Mc-Graw Hill. New York.
10. Old R.W. and Primrose, S.B. (1985). Principles of Gene Manipulation (3rd Edition) Blackwell Science Publication, Cambridge.
11. Sayler, Gray S. Robert Fox and James W. (1991). Blackburn Environmental Biotechnology for Waste Treatment, Plenum Press, New York.
12. Sayler, Gray S. Robert Fox and James W. (1991). Environmental Biotechnology for Waste Treatment, Plenum Press, New York.

Journals

Journal of Biotechnology-Elsevier
Bioresource Technology-Elsevier
Biotechnology Journal-Wiley *Nature Biotechnology*
Indian Journal of Biotechnology
Reviews in Environmental Science and Biotechnology-Springer
Environmental Technology-Taylor & Francis
Biomass and Bioenergy-Elsevier
International Journal of Environment and Bioenergy
Biotechnology for Biofuels-Springer
Renewable Energy-Elsevier
Renewable and sustainable Energy Reviews-Elsevier

Course Code: ETE - 577
Course Title: Environmental Audit & Certification

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Environmental management System: environmental policy, implementation and requirements of Environmental Management System (EMS) standards, inter-relationships and differences between the ISO 14000 series, EMAS, the ISO 9000 series and Total Quality Management.

Unit II: Environmental audit: principles of auditing, types of environmental audit, compliance audits, environmental risk assessments, pre-acquisition/ divestment audits, EMS audits, environmental statement audits, internal audit, single issue audits (e.g. waste or energy). Planning and preparation, audit team, examination of documented systems and internal control, site setting, site inspections and interviews, audit reporting and follow-up.

Unit III: Environmental legislations: roles and responsibilities of all national environmental regulatory agencies; local government and regional planning authorities; waste, environmental health and water regulatory authorities, other agencies responsible for enforcement of environmental law. Knowledge of major national environmental legislation (planning law, air, water, land, waste, hazardous substances, Eco – labeling, IPCC), National Environmental Protection Acts, Environmental Policy Plans.

Unit IV: Environmental Aspects/Impacts and Performance: environmental aspects/ impacts of an operation, identification of fugitive emissions and waste streams, interpretation of process flow diagrams. Assessment of environmental effects of products using LCA, environmental performance of industry, amelioration techniques to mitigate environmental effects.

Unit V: Certification system: international standard for environmental management systems ("EMS"). ISO 14001 2004, international and national EMS certification system, environmental audit system in India. Environmental management and certification Institutes.

Suggested Readings:

1. Canadian Standards Association (1992). Environmental Life Cycle Assessment. Draft Report. Ontario (Toronto), Canada: Canadian Standards Associations
2. Ciambrone , D.F. (1997). Environmental Life Cycle Analysis, CRC Press.
3. Environ (1988). Elements of Toxicology and Chemical Risk Assessment. Washington, D.C. Environ Corporation.
4. Freeman, A.M., (1982). Air and water Pollution Control: A Benefit-Cost Assessment. Wiley, New York.
5. Guinee, Jeroen B. (1992). Classification. Draft Report. Leiden Sweden: Center of Environmental Science, Lieden University.
6. Handbook on Life Cycle Assessment (2004). Operational Guide to the ISO Standards,

Kluwer Academic Publishers.

7. Jain, R.K., Urban, L.V., Stacey, G.S., Balbach, H.E. (1993). Environmental Assessment, Mc-Graw-Hills, New York.

Journals

Journal of Cleaner Production- Elsevier
The International Journal *of* Life Cycle Assessment - Springer
Journal Australian Life-Cycle Assessment Society
Environmental System Research-Springer

Course Code: ETE - 535
Course Title: Industrial Solid Waste Management

Number of Credits: 3 **L-T-P 2**-0-1

Unit 1: Hazardous waste: Sources and characteristics, handling, collection, storage and transport. Storage facility development: on-site and off-site waste storage, storage design criteria, marking and labeling. Sampling and analysis of hazardous wastes – analytical approach for hazardous waste characterization – proximate analysis – survey analysis – directed analysis – analytical methods.

Unit II: Landfill technology: key principle of a landfill site, co-disposal landfill, purpose-designed landfill, planning, siting, and permitting of landfills, Planning, Siting, Landfill processes, lechate collection and treatment, Risks of landfill and their control, liner system, liner selection procedure, waste compatibility, co-disposal criteria, multi-disposal system, stabilized waste landfilling, Landfill operations, Landfill equipment, Filling sequences, Daily cover, Monitoring, Post-closure care and use of old landfills, Landfill mining

Unit III: Waste-to-Energy: Heat value of refuse, Ultimate analysis, Compositional analysis, Proximate analysis, Calorimetry, Materials and thermal balances, Combustion air, Waste-to-energy combustors, Modular starved air combustors, Pyrolysis, Mass burn versus RDF, Waste Incinerator- principle, types, operation and technical controls, Rotary Kilns, Fluidized-bed Incinerators, Reciprocating Grate Incinerators, undesirable effects of combustion, Waste heat, Ash management, Air pollutants and control, Dioxin problem.

Unit IV: Material separation and recycling: General expressions for materials separation, separation techniques, Binary separators, Polynary separators, Reciprocating and disc screens, Float/sink separators, Theory of operation, Air classifiers, Other float/sink devices, Magnets and electromechanical separators, Magnets, Eddy current separators, Electrostatic separation processes, Other devices for materials separation, Materials separation systems, Performance of materials recovery facilities. Material recycling in industries: case studies, environmental management, and resource recovery, waste audit and benefits. Case studies of material recovery from mining waste solids, Metal Processing industry, food and beverage industry, paper and pulp industry.

Unit V: Industrial waste immobilization, stabilization, solidification, additives, key issues in waste stabilizations, waste assessment, performance tests, case studies, transitional techniques in waste treatment and management, criteria for selection of technology, Thermal desorption technique, Industrial sludge treatment. Legal frameworks for hazardous waste handling and storage waste trading, international laws, Basel Convention, Procedure for hazardous waste storage and transport clearance.

Suggested Readings:

1. EPA (1995). Decision-Makers' Guide to Solid Waste Management, Vol-I & II. US EPA, Washington, D.C.
2. FAO (2003). On-farm Composting Methods. FAO, Rome.
3. Guidelines for Management and Handling of Hazardous wastes MOEF (1991), Govt. of India.
4. Kaily, G. 19997. Environmental Engineering. The McGraw-Hill Companies, New York, NY.
5. Liu, D.H.F., and Liptak (2000). B.G. Hazardous Waste and Solid Waste, Lewis Publishers, Boca raton, FL.
6. Pichetel, J. (2005). Waste management Practices – Municipal, Hazardous, and Industrial. Taylor and Francis, Boca Raton, USA. 659 pp.
7. Reinhart, D.R., and Townsend, T.G. 19997. Landfill Bioreactor Design and Operations. Lewis Publishers, New York, NY.
8. Tchobanoglous, G., and Kreith, F. (2002). Handbook of Solid Waste Management. McGraw Hill, New York.
9. Tchobanoglous, G., Theisen, H., and Vigil, S.A (1993). Integrated Solid Waste Management: McGraw Hill, New York.
10. UNEP, 2009. Developing Integrated Solid Waste Management Plan Training Manual. UNDP, IETC, Okasa, Japan.
11. Wang, L.K., Shammas, N.K. and Hung, Y.T. (2008). Biosolids Engineering and Management. Humana Press, Totowa, NJ, USA.
12. Waste Management (1993). Asian and Pacific Center for Transfer of Technology (N.D.) India, September.

Journals

Waste Management - Elsevier
Waste Management & Research -Sage
Compost Science & Utilizations - Taylor & Francis
International Journal of Environment and Waste Management - Inderscince, UK
Journal of Waste Management - Hindwai
Journal of Material Recycling and Waste Management - Springer
Journal of Hazardous Materials - Elsevier
Bioresource Technology - Elsevier
Waste& Biomass *Valorization* - Springer
Journal of the Air & Waste Management Association - AWMA, USA

Course Code: ETE - 594
Course Title: Environmental System Analysis

Number of Credits: 3 **L-T-P 2**-0-1

Unit 1: Introduction to natural and man-made systems, Systems modeling as applied to environmental systems. Nature of environmental systems, the model building process, addressing to specific environmental problems. Application of optimization methods such as search techniques, linear programming, dynamic programming and integer programming to analyze various environmental management alternatives, Integrated management strategies addressing multi-objective planning and optimization over time. Strategies for analyzing and using environmental systems models, Laboratory - Simulation of Environmental Processes, Application of Environmental Databases and Environmental Software Packages, including systems optimization.

Unit II: System and System Analysis, Static and Dynamic System, models and modeling, Types of Models, Stochastic and Deterministic Models, Dynamic Simulation Modeling, Necessity of models in management of Environmental System, Steps followed in Modeling, Model Conceptualization, Model Development, Solution Methodologies- Numerical, analytical and Monte Carlo methods of simulation, Computer Coding, Data Acquisition and Processing, Model Calibration, Model Validation and Verification, Sensitivity Analysis

Unit III: Air Pollution Dispersion Modeling: Meteorological factors affecting air quality, Lapse rates, Dry adiabatic, Moist Adiabatic and ambient Lapse rates, Stable, Unstable and Neutral Atmospheric Condition, Maximum Mixing height, Temperature Inversions, Effect of Lapse Rate on Plume behavior- Conning, Looping, Lofting, fanning, fumigation, Point Source Gaussian Plume Model-Effective Stack Height, Pasquil-Gifforth Stability criteria, Horizontal and Vertical Dispersion, Wind Speed Correction, Numerical Examples and Some case studies on Air Pollution Dispersion Modeling

Unit IV: Application of Operation Research in Environmental Engineering: Introduction, The Linear Programming Model, Examples of Linear Programming Problems, Developing Linear Programming Models, Graphical Solution to LP Problems, The Simplex Method, Simplex Tableau for Maximization Problem, Marginal Values of Additional Resources, Sensitivity Analysis, Complications in Applying the Simplex Method, Application in resource allocation and, Water Quality and West water Treatment, Application of Transportation Problems and Dynamic Programming in Water Supply Engineering.

Unit V: Case studies of dynamical systems/Case study on environmental modeling using empirical data.

Suggested Readings:

1. Arya, S. Pal (1998). Air Pollution Meteorology and Dispersion, 1st Edition, Oxford University Press.

2. ÅsaMoberg (1999). Environmental Systems Analysis Tools -differences and similarities. Master Thesis. Stockholm University, Sweden.
3. Barrat, Rod (2001). Atmospheric Dispersion Modelling (1st Edition), Earthscan Publications.
4. Jo Smith and Pete Smith (2007). Introduction to Environmental Modelling. Oxford University Press, UK.
5. Lindfors L.G. et al., 1995. Nordic Guidelines on Life Cycle Assessment. Nord 1995:20. Nordic Council of Ministers, Köpenhamn.
6. Mboden, Dieter M., Pfenninger, Stefan (2013). Introduction to Systems Analysis-Mathematically Modeling Natural Systems. Springer, USA.
7. Pantell, R.H. (1976). Techniques of Environmental Systems Analysis. John Wiley & Sons Inc, USA.
8. Thérivel R. and Partdário M.R. (1996). The practice of strategic environmental assessment. Earthscan Publications Ltd., London.
9. Therivel R., Wilson E., Thompson S., Heaney D. and Pritchard D. (1992). Strategic Environmental Assessment. Earthscan Publications Limited, London, UK.
10. V.K. Jain (2008). System Analysis and Design. Dreamtech Press, New Delhi

Journals

Environmental System Research- Springer
Environmental Modelling & Software–Elsevier
Environmental Modeling & Assessment-Springer
The International Journal *of* Life Cycle Assessment - Springer
Journal Australian Life-Cycle Assessment Society

Course Code: ETE - 514
Course Title: Membrane Processes for Water and Waste Treatments

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Introduction to membrane separation processes, Membrane filtration, dead and filtration, Cake filtration, Equation of Ruth, Kozney-Carman law, Cross flow filtration, general principles. Membrane Manufacturing, Biological Membranes, Membrane Polymer Manufacturing: Chemistry, Industrial Processes and Membrane Performance Implications.

Unit II: Membrane characterization, Membrane module types, Transport Mechanisms and Membrane Fouling, Membrane principles and transport mechanisms, Membrane fouling, Pressure Driven Membrane Processes.

Unit III: Membrane Process: Functioning in closed loop, open loop and with re-circulation, Module arrangement; series or parallel and optimization. Economic study, Applications: drinking water, municipal wastewater, Case studies. Coupling Renewable Energy & Membrane Technology, Applications and Processes, Other membrane applications, Current research in membrane science & technology

Unit IV: Electrodialysis: Electrodialysis Development, Principles, Electrochemistry, Industrial Applications and Membrane Performance Implications. Reverse osmosis, Nanofiltration, Membranes and modules, MF/UF experimental set up, Laws of MF/UF, Limiting Phenomena: Concentration polarization and membrane fouling, Mass transport, and Energy balance.

Unit V: Microfiltration- principles and applications, Ultrafiltration- principles and applications, Membrane Bioreactors, Membrane bioreactor (MBR) principles and applications, Industry performance of drinking water ultrafiltration and wastewater MBR Technology.

Suggested Readings:

1. Judd, S. and Jefferson, B. (2003). Membranes for Industrial Wastewater Recovery.
2. Mallevialle, J., Odendaal, P.E. and Wiesner, M.R. (1996). Water Treatment Membrane Processes, McGraw-Hill. New York.
3. Mulder, Marcel (1991). Basic Principles of Membrane Technology, Kluwer Academic Publishers, Dordrecht, Netherlands.
4. Baker, R.W. (2004). Membrane technology and applications (2^{nd} Edition), John Wiley.
5. Schäfer, A., Fane, A.G. and Waite, T.D. (2005) Nanofiltration - Principles & Applications, Elsevier.
6. Ho, W.S. Winston, Sirkar and Kamalesh K. (Eds). (1992). Membrane Handbook, Chapman & Hall, New York, USA.
7. Hillis, Peter (Ed.) 2000. Membrane Technology in Water and Wastewater Treatment, Royal Society of Chemistry, Cambridge, UK.
8. Schäfer, A.I. (2001). Natural Organics Removal using Membranes, Principles, Performance

and Cost, CRC Press, USA.

9. Noble, Richard D., Stern, S. Alexander (Eds) (1995). Membrane Separations Technology - Principles and Applications, Elsevier.

Journals

Water Research-Elsevier
Desalination-Elsevier
International Journal of Water
Applied Water Science
Journal of Water & Health-IWA
Ultrapure Water & Industrial Water Treatment Magazine
Water Resource & Industry-Elsevier
Water Science & Technology-IWA
Journal of Water Reuse-IWA
Desalination & Water Treatment –Taylor & Francis
Journal of Water Chemistry & Technology-Allerton Press

Course Code: ETE - 515
Course Title: Industrial Wastewater Treatment

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Introduction: Industrial scenario in India, Industrial activity and Environment - Uses of Water by industry, Sources and types of industrial wastewater, Nature and Origin of Pollutants, Industrial wastewater and environmental impacts, Regulatory requirements for treatment of industrial wastewater – Industrial waste survey, Industrial wastewater monitoring and sampling - generation rates, characterization and variables, Toxicity of industrial effluents and Bioassay tests – Major issues on water quality management.

Unit II: Prevention and Control of Industrial Pollution, Benefits and Barriers, Waste management Hierarchy, Source reduction techniques, Pollution Prevention of Assessment, Material balance, Evaluation of Pollution prevention options, Cost benefit analysis, payback period - Waste Minimization Circles.

Unit III: Treatment Technology: Equalisation, Neutralisation, Oil separation, Flotation, Precipitation, Heavy metal Removal, Aerobic and anaerobic biological treatment, Sequencing batch reactors, High Rate reactors, Chemical oxidation, Ozonation, carbon adsorption, Photocatalysis, Wet Air Oxidation, Evaporation, Ion Exchange, Membrane Technologies, Nutrient removal, Treatability studies.

Unit IV: Wastewater Reuse Residual Management: Individual and Common Effluent Treatment Plants, Joint treatment of industrial and domestic wastewater - Zero effluent discharge systems, Quality requirements for Wastewater reuse, Industrial reuse, Present status and issues, Disposal on water and land, Residuals of industrial wastewater treatment – Quantification and characteristics of Sludge, Thickening, digestion, conditioning, dewatering and disposal of sludge, Management of RO rejects.

Unit V: Industrial manufacturing process description, wastewater characteristics, source reduction options and waste treatment flow sheet for Textiles, Tanneries, Pulp and paper, metal finishing, Oil Refining, Pharmaceuticals, Sugar and Distilleries.

Suggested Readings:

1. Metcalf and Eddy (2003) Wastewater Engineering: Treatment and Reuse, 4th ed., Tata McGraw-Hills Comp. Inc., New York.
2. Qasim, S.R., Motley, E.M. and Zhu, G. (2000) Water Works Engineering: Planning Design and Operation, Prentice Hall, New Jersey.
3. Birde, G.S. and Birde, J.S. (2004) Water Supply and sanitary Engineering, 7th Ed., Dhanpat Rai Publishing, New Delhi.
4. Viessman, W., Hammer, M.J., Perez, E.M. and Chadik, P.A. (2009) Water supply and pollution Control, PHI learning Pvt. Ltd., New Delhi.

5. Hammer, M.J. and Hammer, M.J. Jr. (2008) Water and wastewater Technology. (6th Edition). PHI learning Pvt. Ltd., New Delhi.
6. Punmia, B.C., Jain, A. (2005). Environmental Engineering. Laksmi Pub. Pvt. Ltd, New Delhi
7. Davis, M. (2010). Water and Wastewater Engineering. McGraw Hills.
8. Fair, Geyer,Okun's Water and Wastewater Engineering: Water Supply and Wastewater Removal (2010) (3rd Edition). John Wiley and Sons, New York.

Course Code: ETE - 542
Course Title: Air Pollution Modeling

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Introduction to Air Quality Modelling. Approaches to model formulation. Model classification, criteria for model selection.

Unit II: Air pollution meteorology - meteorological parameters, stability classification; plume rise; plume behaviour, dispersion parameters.

Unit III: Basic diffusion equation, deterministic, numerical and statistical modeling approach. Introduction to boundary layer, turbulence - physical modeling approach. Stochastic modeling approach to air pollution dispersion.

Unit IV: Theory of Gaussian plume model and its application. Introduction to Indoor air quality models. ISCST3, CALINE4, ROADAIR.

Unit V: Case studies of air pollution modeling systems and their application in pollution load and dispersal predictions.

Suggested Readings:

1. Tiwary, A., Colls, J. (2010). Air Pollution: measuring, Modeling and Mitigation. Rutledge, New York, USA.
2. Steyn, D.E., Rao, S.T. (2010). Air Pollution Modeling and Its application. Springer, Netherlands.
3. Vallero, D. (2008). Fundamentals of Air Pollution (4th Edition). Academic Press, London, UK.
4. Wang, L.K., Pereira, N.C., Hung, U.T. (2004). Air Pollution Control Engineering. Humana Press Inc., New Jersey, USA.
5. Seinfield, J.H., Pandis, S.N. (1998). Atmospheric Chemistry and Physics: from Air Pollution to Climate Change. Wiley, New York.
6. Nicolas Mazzeo (Ed) (2011). Air Quality-Models and Applications. InTech Publications, USA.
7. Pasquill, F. (1962). Atmospheric diffusion Van Nostrand, New York.
8. Seinfeld, J.H. (1986). Atmospheric chemistry and physics of air pollution, John Wiley & Sons.

Journals

Atmospheric Environment - Elsevier
Environmental Science & Technology - ACS
Environmental Pollution - Elsevier
Journal of the Air Pollution Control Association - USA
Water, Air, & Soil Pollution - Springer
Air Quality, Atmosphere & Health - Springer
Journal of Aerosol Science – Elsevier

Course Code: ETE - 555
Course Title: Environmental Instrumentations

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Spectroanalytical Methods: Electromagnetic radiation, properties, emission and absorption of radiation. Fluorescence and Phosphorescence. Atomic absorption and emission spectrometry- principle and instrumentation. ICP source. Fluorimetry, nephelometry and turbidimety, principle and instrumentation. Ultraviolet-visible spectrophotometry principle and instrumentation. Beer's law.

Unit II: Spectroanalytical Methods: Electromagnetic radiation, properties, emission and absorption of radiation. Fluorescence and Phosphorescence. Atomic absorption and emission spectrometry- principle and instrumentation. ICP source. Fluorimetry, nephelometry and turbidimety, principle and instrumentation. Ultraviolet-visible spectrophotometry principle and instrumentation. Beer's law.

Unit III: Spectroanalytical Method: Chromatographic Methods, Classification, general theory-column efficiency and resolution, band broadening. Evaluation methods, quantitative determination. Principle and instrumentation of gas chromatography and HPLC. Ion exchange chromatography and size exclusion chromatography. Mass spectrometry

Unit IV: Electro analytical Methods: Potentiomety- electrochemical cell, reference electrodes, Glass electrode. Measurement of pH. Potentiometric titrations. Ion – selective electrodes. Conductomety, electrolytic conductivity, specific, equivalent and molar conductance. Conductance cells, conductivity meters. Conductometric titrations. Coulometry and polarography.

Unit V: Radio analytical and Other methods: Particles emitted in radioactive decay. Measurement of radioactivity, Ionization chamber, proportional counter, scintillation counter and Geiger counter. Isotopic dilution analysis and activation analysis. NDIR for CO analysis, chemiluminescent analyzer for NOx, fluorescent analyzer for SO_2 , flow injection analysis and CHNS analyzer. Gel documanetaion, PCR technology.

Suggested Readings:

1. Ardrey, R.E. (2003). Liquid Chromatography - Mass Spectrometry: An Introduction. John Wiley & Sons Ltd., USA.
2. Daniel C. Harris (2010). Quantitative Chemical Analysis (6^{th} Edition). W. H. Freeman.
3. Douglas A. Skoog, F. James Holler, Timothy A. Nieman (1998). Principles of instrumental analysis. Saunders College Pub. USA.
4. Galen Wood Ewing (1985). Instrumental methods of chemical analysis. McGraw-Hill, New York.
5. H.H, Willard, L.L Merit, J.A. Dean and F.A. Settle (1986). Instrumental Methods of Analysis

(7th Edition). CBP Publishers and Distributors, New Delhi.

6. Mendham, J., Denney, R.C., Barnes, J.D. and Thomas, M. (2002). Vogel's Textbook of Quantitative Chemical analysis (6th Edition). Pearson Education Ltd New Delhi.
7. R S Khandpur (2006). Handbook of Analytical Instruments. McGraw Hill Professional, New York.
8. Raghbir Singh Khandpur (1991). Handbook of modern analytical instruments. TAB Books Division of the McGraw-Hill Cos.
9. Skoog, D.A., West D.M. and Nieman, T.A. (2004). Principles of Instrumental Analysis (5th Edition). Thomson Asion (P) Ltd. Singapore.
10. Techniques and Instrumentation in Analytical Chemistry- Book Series. Elsevier.

Journals

American Journal of Analytical Chemistry
Journal of Analytical Chemistry-Springer
International Journal *of Environmental* Analytical Chemistry-Taylor & Francis
Journal of *Chromatography*-Elsevier
Chromatography *Research International*
The *Journal* of *Chromatographic* Science-Oxford
Journal *of Separation Science*-Wiley

Course Code: ETE - 596
Course Title: Geoinformatics for Resource Management

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Components of Remote Sensing - Energy, Sensor, Interacting Body - Active and Passive Remote Sensing – Platforms – Aerial and Space Platforms - Balloons, Helicopters, Aircraft and Satellites- Synoptivity and Repetivity - Electro Magnetic Radiation (EMR) – EMR Spectrum – Visible, Infra-Red (IR), Near IR, Middle IR, Thermal IR and Microwave – Black Body Radiation – Planck's Law - Stefan-Boltzman law. Advances in Remote Sensing: Advance Classification, Hyperspectral Remote Sensing, Microwave Remote Sensing, Thermal Remote Sensing, LiDAR: introduction and applications.

Unit II: Atmosphere characteristics - Scattering of EMR - Raleigh, Mie, Non –Selective and Raman Scattering – EMR Interaction with water vapour and ozone – Atmosphere Windows – Significance of Atmospheric Windows - EMR interaction with earth surface Materials – Radiance, Irradiance , Incident , Reflected , Absorbed and Transmitted Energy – Reflectance – Specular and Diffuse Reflection Surfaces – Spectral Signature – Spectral Signature curves – EMR interaction with water, soil, and Earth surface.

Unit III: GIS - Components of GIS – Hardware, Software and Organization Context – Data– Spatial and Non Spatial – Maps – Types of Maps – Projection – Types of Projection – Data Input – Digitizer, Scanner - Editing - Raster and Vector data structures - Comparison of Raster and Vector Date structure – Analysis using raster and Vector Data - Retrieval, Reclassification, Overlaying, Buffering – Data Output – Printers and Plotters. Advances in GIS and Current Trends: Current Trends and advancement in GIS, Participatory GIS and Mobile GIS, WebGIS, Open source GIS softwares, Distributed GIS systems.

Unit IV: Satellites – Classification – Based on Orbits – Sun Synchronous and Geo Synchronous – Based on Purpose – Earth Resources Satellites, Communication Satellites, Weather Satellites, Spy Satellites, Satellite Sensors, Resolution – Spectral , Spatial Radiometric and Temporal Resolution – Description of Multi Spectral Scanning – Along and Across Track scanners – Description of Sensors in Landsat, SPOT, IRS series – Current Satellites – Radar – Speckle – Back Scattering – Side Looking Airborne Radar - Synthetic Aperture Radar – Radiometer – Geometrical characteristics.

Unit V: Digital Satellite Image - Image enhancement - Filtering - Classification – Integration of GIS and Remote Sensing – Application Remote Sensing and GIS in Environmental Engineering –management and monitoring of land, air, water pollution, conservation of resources and coastal zone management. Case-studies on National Initiatives-NNRMS, Forest Cover/Type Mapping, Bio Mass Estimation, Habitat Analysis, Bio-Diversity Characterization, Environmental Monitoring, Hazard Monitoring, Urban Sprawl, Solid Waste Management, Watershed and Sea Surface Temperature.

References

1. Dewitt Bon A. and Paul Wolf (2000). Elements of Photogrammetry, McGraw Hill.
2. George Joseph (2005). Fundamentals of Remote Sensing; Universities Press (India) Pvt. Ltd, Hyderabad, India.
3. Lillesand Thomas M., Kiefer Ralph W. and ChipmanJonathan,(2008). Remote Sensing and Image Interpretation (6^{th} Edition), John Wiley.
4. Jensen, John R. (2000). Remote Sensing of the Environment: An Earth Resource Perspective, New Jersey: Prentice Hall, 544 pages.
5. Longley, Paul A., Goodchild, Michael F., Maguire, David J., and David W. Rhind. (2005). Geographic Information Systems and Science, 2nd ed., John Wiley and Sons, Toronto.
6. Burroughs, P.P. & McDonnel, R.A. (1998). Principles of GIS, Oxford University Press.

Journals

Asian Journal of Geoinformatics
International Journal of Geoinformatics
Journal of Indian Society of Remote Sensing
Remote Sensing of Environment
ISPRS Journal of Photogrammetry and Remote Sensing
International Journal of Remote Sensing and GIS
American Journal of Geographic Information System
International Journal of Geographical Information Science

Course Code: ETE - 528
Course Title: Ecological Engineering

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Ecological Engineering: Aim, scope and applications of Ecology and Ecological Engineering. Principles of ecological engineering, nature of an ecosystem, communities in ecosystem, Energy flow and material cycling in ecosystems – Productivity in ecosystems. Rationale of ecological engineering and eco-technology, classification of eco-technology

Unit II: Principles, characteristics and components of Systems and Modeling – Structural and functional interactions in environmental systems, environmental systems as energy systems. Mechanisms of steady – State maintenance in open and closed systems - Modelling and eco-technology: Elements of Modelling: Modelling procedure, Classification of ecological models, Applications of models in eco-technology, Ecological economics, and Human modifications of environmental systems.

Unit III: Ecological Engineering Processes: Self-organizing processes, multiple seeded microcosms – Interface coupling in ecological systems. Concepts of energy – Determination of sustainable loading of ecosystems, Adapting ecological engineering systems to potentially catastrophic events – Agro ecosystems – Determination of sustainable loading of ecosystems

Unit IV: Eco-sanitation: concept and applications. Principles and operation of soil infiltration systems, Wetlands and ponds Source separation systems – Aquaculture systems, vermifiltration system, duckweed pond system development, detritus based, treatment for solid wastes, vermitechnology in waste stabilizations and energy recovery, applications of ecological engineering for marine systems.

Unit V: Case studies of integrated ecological engineering systems and their commercial prospects.

Suggested Readings:

1. Etnier, C. and Guterstam, B. (1997). Ecological Engineering for Wastewater Treatment. Lewis Publishers.
2. Kangas, P.C. and Kangas, P. (2003). Ecological Engineering: Principles and Practice. Lewis Publishers.
3. Mitsch, J.W and Jorgensen, S.E. (1989). Ecological Engineering – An Introduction to Ecotechnology, John Wiley & Sons, New York.
4. White, I.D, Mottershed, D.N and Harrison, S.L. (1994). Environmental Systems – An Introductory Text, Chapman Hall, London.

Journals

Ecological Engineering-Elsevier
Water Research-Elsevier
Water Science & Technology-IWA
Journal of Water Reuse-IWA
Desalination & Water Treatment –Taylor & Francis
Journal of Water Chemistry & Technology-Allerton Press
International Journal of Water
Applied Water Science
Journal of Water & Health-IWA
Ultrapure Water & Industrial Water Treatment Magazine
Water Resource & Industry-Elsevier

Course Code: ETE - 518
Course Title: Bioremediation Technology

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Bioremediation - Processes and principles of bioremediation technology: biodegradation, Acclimation, detoxification activation, bio-availability. Types of bioremediation: *Ex situ* and *in-situ*, Bioaugmentation and biostimulation, solid phase and slurry phase bioremediation. Factor affecting bioremediation process: impact of chemical structure, recalcitrance, predicting products of biodegradation, cometabolism and biotransformation.

Unit II: Microbial Degradation of Biopolymers: Cellulose, xylan, starch and other glucans, pectin, lignin and chitin, lipids and fats and bioplastics. Biodegradation of Hydrocarbons: Methane, ethane, propane, butane and other long chain alkanes, alkenes, alkynes, Aerobic and anaerobic biodegradation of aromatic compounds, Microbial degradation of halogenated and sulfonated compounds, Biodegradation of pesticides, PCB, PAH and other industrial chemicals.

Unit III: Bio stimulation of naturally occurring microbial activities: - environmental modification – use of cosubstrates, oxygen supplementation, (Composting and aerobic bioreactors, in situ aeration)– Nutrients and fertilizers, Criteria to be met for considering bioremediation- factors affecting bioremediation, treatability studies for bioremediation-purpose, experimental design and example protocol. Advantages and disadvantages of specific bioremediation technologies- land farming, prepared beds, biopiles, composting, bioventing, biosparging, pump and treat method, constructed wet lands, use of bioreactors for bioremediation. Phytoremediation.

Unit IV: Hazardous wastes, biotechnology for hazardous waste management, cyanide detoxification, detoxification of oxalate, urea. Biotechnological application for pollution reduction in Paper and pulp industry, tannery industry, oil refining industry, textile mill industry, Air pollution control through bioremediation: Deodorization process bioscrubbers, biobed, biotrickling filters.

Unit V: Reforestation through micropropagation casurina for tropical reforestation on adverse sites, development of stress tolerant plants; use of mycorrhizae in reforestation, reforestation of contaminated soils. Vermitechnology in waste bioremediation and contamination removal. Constructed wetland and energy-biomass system for waste remediation and energy harvesting. Case studies of bioremediation of polluted sites.

Suggested Readings:

1. Baker, K.H and Herson, D.S. (1994). Bioremediation. Mc Graw Hill, Inc. New York.
2. Barry King, R., Long, G.M. and Sheldon, J.K. (1992). Practical Environmental Bioremediation. Lewis Publishers, New York.

3. Cookson, J. (1994). Bioremediation Engineering: Design and Applications. Mc-Graw Hill Inc., New York.
4. Edward D. Schroeder and Juana B. Eweis (1998). Bioremediation Principles. Mc-Graw Hills, New York.
5. Gadd G.M. (2001). Fungi in Bioremediation. Cambridge University Press, UK.
6. James G. Speight and Karuna K. Arjoon (2012). Bioremediation of Petroleum and Petroleum Products (Energy and Environment). Wiley.
7. Levin M.V. and Gealt, M.A. (1993). Biotreatment of Industrial & Hazardous Waste. Mc-Graw Hill. Inc. New York.
8. Martin Alexander (1999). Biodegradation and Bioremediation (2nd Editon)., Elsevier Science & Technology.
9. Raina M. Maier, Ian L. Pepper (2001). Environmental Microbiology. Academic Press. UK.
10. Ronald L. Crawford, Don L. Crawford (2005). Bioremediation: Principles and Applications. Cambridge University Press, UK.
11. Singh, Ajay, Kuhad, Ramesh C., Ward, Owen P. (Eds.) (2009). Advances in Applied Bioremediation. Springer.

Journals

*B*ioremediation *and Biodegradation*-Springer
International Journal *of Environmental* Bioremediation*& Biodegradation*
Bioremediation Journal-Taylor & Francis
International Biodeterioration and Biodegradation-Elsevier
Biodegradation and Bioremediation - Springer
Environmental Technology-Taylor & Francis
Environmental Science & Technology
International Journal *of* Phytoremediation- Taylor & Francis
Ecological Engineering-Elsevier

Course Code: ETE - 520
Course Title: Applied Environmental Chemistry

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Oxidation - reduction reactions and equations; gas laws, equilibrium and Lechatelier's principle, activity and coefficients, variations in equilibrium relationships, shifting chemical equilibrium, amphoteric hydroxides, buffers and buffer index; solubility of salts, complex formation. Chemical reactions: chemical equilibrium and chemical thermodynamics, acid-base equilibria, solubility equilibria, oxidation-reduction equilibria. Process kinetics, reaction rates and catalysis, surface and colloidal chemistry, adsorption.

Unit II: Concept and scope of environmental chemistry, components of environment. Atmospheres: Chemical composition of atmosphere- particles, ions and radicals, formation of particulate matter, photochemical and chemical reactions in the atmosphere, chemistry of greenhouse gases and ozone layer depletion, gaseous transformations in the atmosphere and removal mechanisms; photochemical smog; nuclear winter. Global environmental problems: chemistry of CFC, ozone depletion, greenhouse effect, acid rain, La Nino etc.

Unit III: Lithosphere: Chemical composition of lithosphere, water and air in soil, inorganic and organic components in soil; acid, base and ion- exchange reaction in the soil, soil acidity, salinity and sod city, effects of ecological factors on the toxicity of soil, Bio- geochemical cycles. Chemistry of pollution due to detergents, pesticides, polymers, trace-organics, metals, petroleum and radioactive compounds.

Unit IV: Chemistry of water and waste water: Hydrological cycle, structure of water molecule, basic concept of colloidal and quantitative chemistry. Applications of principles of chemistry for solving environmental engineering problems.

Suggested Readings:

1. Bailey R.A. (2002). Chemistry of the Environment, Academic Press, San Diego.
2. Masters G.M. (2004). Introduction of Environmental Engineering and Science (2nd Edition) Pearson Education.
3. Baird C. (1999). Environmental Chemistry (2nd Edition), WH Freeman and Co.
4. Buell P. and Girard J. (2002). Chemistry fundamentals: An Environmental Perspective (2nd Edition), Jones & Bartlett Publishers.
5. Bunce N. (1991). Environmental Chemistry, Wuerz publishing Ltd. Winnipeg, Canada.
6. Harrison R.M. (1991). Introductory Chemistry for the Environmental Sciences, Cambridge University Press.
7. Sawyer, McCarty, and Parkin (2002). Chemistry for Environmental Engineering. Mc-Graw and Hills, New York.

Course Code: ETE - 560
Course Title: Sustainable Urban Habitats and Green City

Number of Credits: 3 **L-T-P 2**-0-1

Unit I: Introduction: Urban ecology, sustainability and role of cities: Theories of urban ecology and linkages with sustainable development, Concepts of Eco-cities, smart cities, compact cities etc. Management of Urban Environment: air quality, noise, drainage system, urban water management, urban waste management, challenges and opportunities of urban, rural and peri-urban growth.

Unit II: Urban Ecosystem: Urban institutes, networks and stakeholders– roles and responsibilities. Urban climate and resource quality, urban habitats – natural and man-made, urban wildlife, urban forest system and management, urban flood issues and managements, integrated urban environmental planning and framework, Urban gardens and landscapes – concept and applications. Urban transport, eco-system health, urban planning and sustainability.

Unit III: Climate Change, Energy and Building: Environment and energy in a global context, world resources, economics and law, sustainability in architecture, issues related to and responses to climate change, renewable energy. Climate, comfort and building performance climate, topography, condensation, thermal comfort, climate influences on design, solar electric systems, heat transfer, thermal performance, thermal mass, building regulations, Renewable energy systems design - Photovoltaics, solar hot water, small scale biomass and wind power systems design. Adaptation and mitigation measures to make cities resilient, social sustainability.

Unit IV: Concept of green building – concept and environmental issues, energy and resource supply. Principles of ventilation, cooling techniques, energy building services: an environmental perspective, dampness and condensation, breathing walls; solar resource, solar water heating, water and waste, waste solutions. Environmentally responsive materials, contained composite structures, Timber use, Rammed Earth, Timber construction.

Unit V: Environmental Impact of Buildings: environmental ethics. Assessments methods, embodied energy and life cycle analysis; energy distribution, energy and nuclear power, the intelligent building, low or zero carbon housing. Environmental sustainability assessment, management and post occupancy evaluation. Energy performance ratings. Computer simulation of buildings, data for simulation, modelling strategies, lighting, computational fluid dynamics and practical examples.

Suggested Readings:

1. Augenbroe, G. (2002). Trends in building simulation. Building and Environment 37, 891-902.
2. Bolin, B. et al. (1991). World Commission on Environment and Development, Our Common Future. Oxford University Press.
3. Bolin, B. et al. (1986). The Greenhouse Effect, Climate Change and Ecosystems. John Wiley,

USA.

4. Boyle, G et al. (2003) Energy Systems and Sustainability, Oxford University Press / The Open University
5. Boyle, G. (2004). Energy Systems and Sustainability. Oxford University Press.
6. Boyle, G. (ed) (2004). Renewable Energy: Power for a Sustainable Future (2nd Edition), Oxford University Press/The Open University
7. Brown, R., and Gillespie, T. 1995. Microclimatic Landscape Design, Wiley.
8. Evans, M. (1980). Housing, Climate and Comfort. Architectural Press.
9. Evans, M. (2004). Renewable Energy. Oxford University Press.
10. Girardet, H. (2004). Cities People Planet. Wiley Academy.
11. This Common Inheritance: Britain's Environmental Strategy, 1990 Houghton,
12. Thomas, R. (2001). Photovoltaics and Architecture. Spon Press.

Journals

International Journal of Sustainable Built Environment –Elsevier *Sustainable Cities and Society* – Elsevier

Journal of Green Building

Canadian Journal of Green Building & Design

International Journal of Sustainable Building Technology and Urban Development Energy and Buildings - Elsevier

Building and environment – Elsevier *Renewable Energy* – Elsevier

Course Code: ETC - 580
Course Title: Industrial Training/attachment (8 week) & Report Presentation

Number of Credits: 4 **L-T-P 0-4**-1

The aim of this course is to enable the student with practical aspects of the environmental issues and their management in industrial sector. The students have to arrange and undergo an industrial training for minimum eight weeks in an industry giving emphasis to energy conservation/management/renewable energy/energy audit/wastewater treatment, solid waste management, pollution abetment technologies and equipments during the semester break between semester 2 and semester 3 and complete within 60 calendar days. The students are requested to submit a report of the training undergone and present the contents of the report before the evaluation committee. Evaluation committee will award the marks of end semester based on training quality, contents of the report and presentation.

Course Code: ETE - 582
Course Title: Project Proposal Writing and seminar

Number of Credits: 2 **L-T-P 0-0**-2

This course aims to improve the professional competency and research aptitude of the student by providing an opportunity to explore the research areas, problem identification and formulating it a dissertation project work. The students learn the Writing Process, Prewriting procedures, Writing the first draft, Revision, text and time management, text organizations, expert opinion, brainstorming session, final draft check lists, Citation methods, Reference checking. The students also learn about research ethics, manuscript preparation for publication, components of thesis, and plagiarism. Students have to submit a literature review on the relevant topic of their dissertation work, which will be evaluated by the supervisor of the student.

Course Code: ETC - 593
Course Title: Project - I

Number of Credits: 8 **L-T-P 0**-1-3

This course aims to improve the professional competency and research aptitude of the student by providing an opportunity to explore the research ideas. This will consist of a mini research project to be completed during 3rd Semester. The project work aims to develop the work practice in students to apply theoretical and practical tools/ techniques to solve real life problems related to industry and environment. The project work can be a design project/ experimental project and / or computer simulation project on any of the topics in the area of GIS, Environmental Modelling, and Energy/Renewable energy technology, Material Development and Testing, Liquid and Solid Waste Management and Treatment. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute, subject to the approval of the Departmental Committee. The evaluation of the project will be done by Schools committee consist of Supervisor (Chairman) and two members – (one external, and one from the same School of other School of the parent Institute).

Course Code: ETC - 594
Course Title: Project - II

Number of Credits: 14 **L-T-P 0**-1-20

The Project – II further aims to improve the professional competency and research aptitude by providing an opportunity to explore the research ideas through research and development. The student is required to undertake the master research project– II during the fourth semester. The problem of third semester (Project – I) can be continued in the 4th semester to explore the idea in detail. The Project – II will consist of original and new research contribution by the student, complied in a Thesis Form for final evaluation. The project work can be a design project/ experimental project and / or computer simulation project on any of the topics in the area of: RS & GIS, Environmental Modelling, Energy/Renewable Energy Technology, Material Development and Testing, Liquid and Solid Waste Management and Treatment or any other Applied Research Topic which covers the mandate of this M. Tech. Programme. The project work is allotted individually on different topics. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide (Chairperson) and another expert in the specified area of the project shall be two essential members (one from same School and other from other Institutions/Organizations).