# Department of Environmental Science & Engineering

# Course Structure of 2-Year M. Tech Programme in Environmental Science & Engineering

**INDIAN INSTITUTE OF TECHNOLOGY (INDIAN SCHOOL OF MINES) DHANBAD, JHARKHAND 826004**

***Effective from 2020***

## Course Structure

**ENVIRONMENTAL SCIENCE & ENGINEERING**
**(Semester-wise List of All Courses)**

**SEMESTER: 1**

| Course Type | Course Code | Name of the Courses | L | T | P | Credit |
|---|---|---|---|---|---|---|
| DC1 | ESC501 | Ecology and Environmental Microbiology | 3 | 0 | 0 | 9 |
| DC2 | ESC502 | Water Supply and Treatment | 3 | 0 | 0 | 9 |
| DC3 | ESC503 | MATLAB Programming for Numerical Computation | 3 | 0 | 0 | 9 |
| DC4 | ESC504 | Air and Noise Pollution | 3 | 0 | 0 | 9 |
| DC5 | ESC505 | Wastewater Engineering | 3 | 0 | 0 | 9 |
| DP1 | ESC521 | Water Chemistry Practical | 0 | 0 | 3 | 3 |
| DP2 | ESC522 | Air and Noise Pollution Practical | 0 | 0 | 3 | 3 |
| | | **Total** | **15** | **0** | **6** | **51** |

**SEMESTER: 2**

| Course Type | Course Code | Name of the Courses | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **DC/DE** | ESC506 | Environmental Laws and Impact Assessment | 3 | 0 | 0 | 9 |
| **DC/DE** | ESC507 | Municipal Solid Waste Management | 3 | 0 | 0 | 9 |
| | | Departmental Elective-1 | 3 | 0 | 0 | 9 |
| | | Open Elective-1 | 3 | 0 | 0 | 9 |
| | | Open Elective-2 | | | | |
| DP3 | ESC523 | Wastewater Engineering Practical | 0 | 0 | 3 | 3 |
| DP4 | ESC524 | Soil and Microbiology Practical | 0 | 0 | 3 | 3 |
| | | **Total** | **15** | **0** | **6** | **51** |

**SEMESTER: 3**

| Course Type | Course Code | Name of the Courses | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **Research Work** | ESC597 | Thesis | **0** | **0** | **0** | **36** |
| **Contact Hrs.** | | **Total** | **0** | **0** | **0** | **36** |

**SEMESTER: 4**

| Course Type | Course Code | Name of the Courses | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **DE/OE** | | Departmental Elective-2/Open Elective-3 | 3 | 0 | 0 | 9 |
| **DE/OE** | | Departmental Elective-3/Open Elective-4 | 3 | 0 | 0 | 9 |
| **Research Work** | ESC597 | Thesis | **0** | **0** | **0** | **18** |
| | | **Total** | **6** | **0** | **0** | **36** |

**LIST OF DEPARTMENTAL ELECTIVE COURSES**

| Course Type | Course Code | Name of the Courses | L | T | P | Credit |
|---|---|---|---|---|---|---|
| **Departmental Elective-1 (2nd Semester)** | | | | | | |
| **DE** | ESD501 | Environmental Geology and Resource Management | 3 | 0 | 0 | 9 |
| **DE** | ESD502 | Environmental Biotechnology | 3 | 0 | 0 | 9 |
| **DE** | ESD503 | Environmental Modelling | 3 | 0 | 0 | 9 |
| **DE** | ESD504 | Green Engineering Concepts and Life Cycle Analysis | 3 | 0 | 0 | 9 |
| **Departmental Elective-2 (4th Semester)** | | | | | | |
| **DE** | ESD505 | Advanced Water and Wastewater Treatment | 3 | 0 | 0 | 9 |

| | | | | | | |
|---|---|---|---|---|---|---|
| **DE** | ESD506 | Environmental Biogeochemistry | 3 | 0 | 0 | 9 |
| **Departmental Elective-3 (4th Semester)** | | | | | | |
| **DE** | ESD507 | Biomedical and Hazardous Waste Management | 3 | 0 | 0 | 9 |
| **DE** | ESD508 | Social Impact Assessment and R&R | 3 | 0 | 0 | 9 |
| **OPEN ELECTIVE** | | | | | | |
| **Open Elective- 1 (2nd semester)** | | | | | | |
| **OE** | ESO501 | Environmental Management System and Auditing | 3 | 0 | 0 | 9 |
| **OE** | ESO502 | Environmental Aspects of Industries | 3 | 0 | 0 | 9 |
| **Open Elective- 2 (2nd semester)** | | | | | | |
| **OE** | ESO503 | Instrumental Techniques in Environmental Analysis | 3 | 0 | 0 | 9 |
| **OE** | ESO504 | Environmental Remote Sensing & GIS | 3 | 0 | 0 | 9 |
| **Open Elective- 3 (4th semester)** | | | | | | |
| **OE** | ESO505 | Climate Change and Modelling | 3 | 0 | 0 | 9 |
| **OE** | ESO506 | Environmental Geotechnology | 3 | 0 | 0 | 9 |
| **Open Elective- 4 (4th semester)** | | | | | | |
| **OE** | ESO507 | Air and Noise Pollution Control | 3 | 0 | 0 | 9 |
| **OE** | ESO508 | Soil Pollution and Restoration | 3 | 0 | 0 | 9 |

# Department of Environmental Science and Engineering
# Indian Institute of Technology (Indian School of Mines), Dhanbad

***Syllabus for 2-Year M. Tech Programme in Environmental Science and Engineering***

<table>
<tr><th colspan="6">Semester-I</th></tr>
<tr><td>ESC 501</td><td colspan="2">Ecology and Environmental Microbiology</td><td>L<br>3</td><td>T<br>0</td><td>P<br>0</td><td>C<br>9</td></tr>
<tr><td colspan="6">Course Objectives:<br>➢ Understanding the concept and importance of Ecology & Microbiology<br>Learning Outcomes:<br>➢ Application of Ecology & biodiversity for sustainable development.<br>➢ Use of microbiology for design of biological treatment processes</td></tr>
<tr><td>Unit I</td><td colspan="4">Fundamentals of Ecology and Ecosystem – Structural and Functional Components. Food chain & Food webs. Ecological pyramids; Energy flow. Ecosystem Stability- Inertia & Resilience, fragile ecosystem, Hot Spots; Aichi Target 15 & REDD+, Ecosystem services; NPV Ecosystems, and the Millennium Development Goals, Landscape ecology. Population and Community Ecology- Characteristics and Structure, Population interaction; Population growth; Habitat; ecological niches and Ecotone.</td><td>8L</td></tr>
<tr><td>Unit II</td><td colspan="4">Biogeochemical cycling; C, N, P and S cycle, Nutrient cycling in tropics. Limiting factors, Shelford’s laws, indicator species; Habitat, ecological niches and Ecotone. Aquatic ecology –stratification, productivity, life form; impacts of thermal discharge, Marine, Estuarine and Wetland ecosystem; Population and community; Ecological successions; trends of ecosystem development. succession in land & water.<br>Ecotoxicology: Background, importance & measurement; LC50, EC50, NOEC, LOEC, toxic units, ecosystem response to de-oxygenation, eutrophication - kinetics, lake phosphorous model, Pesticides & Bio-accumulation.</td><td>10L</td></tr>
<tr><td>Unit III</td><td colspan="4">Environmental importance of microbiology- Classification, distribution of microbes, Nutrition, Enumeration of microbes, Bacterial growth curve, Batch culture, continuous culture, Effects of environmental factors on growth, Control of Microbes. Microbial Metabolism- Glycolysis, TCA, and ETC, Fermentation, Energy balance -Growth, Enzymes, metabolic pathways and intermediate products, Different kinetics model. Water microbiology-Analysis, Water-borne diseases and pathogens,<br>MPN and MFT test; faecal coliform and faecal streptococci; IMVIC test</td><td>9L</td></tr>
<tr><td>Unit IV</td><td colspan="4">Air microbiology- Microorganisms of air, Air-borne diseases and pathogens.<br>Soil Microbiology-Microbial flora, soil borne pathogens, Bio-fertilizers, N-fixation, root nodule formation, VAM fungi, Bio-pesticides. Concept of microbial remediation- Degradation of natural substances, Mechanism and Application; Microbial composting; Vermicomposting; Microbial applications for Bioenergy from waste.</td><td>12L</td></tr>
<tr><td colspan="6">Books and References:<br>Text Books<br>1. Fundamentals of Ecology (3rd Ed.) 2001- MC Dash, Tata - McGraw Hill, New Delhi.<br>2. Introduction to Environmental Engg. (1991). - GM Masters, Prentice Hall of India.<br>3. Microbiology– MJ Pelzer et. al - Tata McGraw Hill, New Delhi(1998).<br>4. Microbiology for Environmental Scientists & Engineers (1980) – AF Gaudy, and ET Gaudy, MGH, NY.<br>Reference Books<br>1. Environmental Microbiology: editors; Ian Pepper, Charles Gerba, Terry Gentry, Academic Press, 2014.<br>2. Environment & Ecology - A Complete Guide. R Rajgopalan, Lexis Nexis, 2017.</td></tr>
</table>

| ESC 502 | Water Supply and Treatment | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- Understanding the water chemistry and principles of water treatment processes and its design and development.

**Learning Outcomes:**

- An insight into the structure of drinking water supply systems, water collection, water purification and water supply scheme for drinking water.
- An understanding of water quality criteria and standards, and their relation to public health.

Student can apply knowledge of basic water chemistry to solve problems associated with drinking water treatment.

| | | |
|---|---|---|
| **Unit I** | Water chemistry: Chemical equilibrium and fundamentals of kinetics; Acids and bases; Titrations; Buffers and buffer intensity; Precipitation and dissolution; Oxidation & reduction reactions stoichiometry and pE& pH relation. | **7L** |
| **Unit II** | Water quality parameters, Water quality standards; conventional contaminants and emerging contaminants; Water treatment: Source selection process, selection of treatment chain, plant siting, Treatability studies.<br>General considerations for source of drinking water; Water demand forecasting; Determination of reservoir capacity; Economic sizing of pumping mains/pumping station | **8L** |
| **Unit III** | Principles of Water Treatment process: Historical overview of water treatment, Considerations for layout of treatment plant, Sedimentation, Coagulation & Flocculation processes, Disinfection/ Chlorination, Water Softening, Filtration, removal of Dissolved Solids, Fluoride, Iron and Manganese etc.<br>Water treatment plant design: Aeration tank; Sedimentation tank; Filters & Chlorination facility. Introduction to various types of software such as EPANET, LOOP and WaterCAD | **14L** |
| **Unit IV** | Environmental Engineering Hydraulics Design: Methods of distributing water, distribution reservoirs, distribution systems, distribution system components, capacity and pressure requirements, design of distribution systems, hydraulic analysis of distribution systems, cross – connections in distribution systems, construction of water distribution systems, pumping required for water supply systems. | **10L** |

***Books and References:***

**Text Books**


1. Peavy, H. S., Rowe, D. R., and Tchobanoglous, G. (2013). Environmental Engineering, McGraw Hill Book Company, Singapore.
2. Garg, S. K. (2017). Water Supply Engineering, Khanna Publishers, New Delhi.


**Reference Books**


1. Masters, G.M. (2007) Introduction to Environmental Engineering and Science, Prentice Hall, New Delhi.
2. Nathanson, J.A. (2014). Basic Environmental Technology: Water supply, waste management and pollution control, Prentice-Hall of India, New Delhi.
3. Manual on Water Supply and Treatment. Ministry of Urban Development, New Delhi. (2009).

| ESC 503 | MATLAB Programming for Numerical Computation | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To provide the basic idea of numerical problem solving using modern day computer programme such as MATLAB**.**

**Learning Outcomes:**

The students will be able to

- Quickly formulate mathematical models using MATLAB.
- Implement the theoretical idea of the subject in various environmental problem-solving projects.

| | | |
|---|---|---|
| **Unit I** | Introduction to MATLAB Programming: Basics of MATLAB programming, Matrices in MATLAB, Basic Matrix Operations, Array operations, Loops and execution control, working with files: Scripts and Functions and Plotting and program output. | **8L** |
| **Unit II** | Approximations and Errors: Defining errors and precision in numerical methods, Truncation and round-off errors, Error propagation. | **6 L** |
| **Unit III** | Linear and Nonlinear Equations: Gauss Elimination, Iterative methods: Gauss Siedel, Special Matrices: Tri-diagonal matrix algorithm, Nonlinear equations in single variable, MATLAB function fzero in single variable, Newton-Raphson in single variable, MATLAB function fsolve in single and multiple variables, Newton-Raphson in multiple variables. | **10L** |
| **Unit IV** | Regression and Interpolation: Introduction, Linear least squares regression including lsqcurvefit function, Functional and nonlinear regression including lsqnonlin function. Application of MATLAB for Environmental Engineers. | **15L** |

***Books and References:***

**Text Books**

1. Fausett L.V. (2007) Applied Numerical Analysis Using MATLAB, 2nd Ed., Pearson Education

**Reference Books**

1. Chapra S.C. and Canale R.P. (2006) Numerical Methods for Engineers, 5th Ed., McGraw Hill

| ESC 504 | Air and Noise Pollution | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To comprehend the essential concepts of Air and Noise pollution

**Learning Outcomes:**

The students should be able to:

- Explain basic principles on various aspects of atmospheric chemistry
- Identify the major sources, effects and monitoring of air and noise pollutants.
- Understand the key transformations and meteorological influence on air and noise
- Relate and analyse the pollution regulation on its scientific basis.

| | | |
|---|---|---|
| **Unit I** | Atmospheric chemistry:<br>Evolution of Atmosphere- scales of atmospheric motion - global circulation- radiative energy balance-greenhouse gas chemistry-radiative forcing–global warming potential-climate feedback mechanism-chapman mechanism on ozone depletion-estimation of rain pH due to atmospheric gases and pollutants, particle/aerosol chemistry and photochemistry for smog formation. | **14L** |
| **Unit II** | Air Pollution: Types and Sources of air pollution-ambient and indoor air pollution- Health and environmental effects of air pollution- air pollution episodes- Emission factors, inventory and predictions.<br>Air quality monitoring - Objectives, time and space variability in air quality; air sampling design, analysis and interpretation of air pollution data, guidelines of network design in urban and rural areas. Stack monitoring. Air pollution standards and indices. | **8L** |
| **Unit III** | Meteorology: Forces affecting vertical and horizontal movement of air, global and local circulation of air, types of cloud, micro climate, wind profiles, topographic effects, stability of atmosphere using temperature profile, inversions, plume behaviour and calculation of plume rise, turbulent diffusion, concept of mixing height and determination of stability class. | **9L** |
| **Unit IV** | Noise Pollution Basics of acoustics- propagation of indoor and outdoor sound- noise profiling effects of noise – measurement, index and mitigation methods- health effects of noise- Vibration and its Effects, Whole body vibration problems in opencast mines-ground vibration and Air blast. | **8L** |

***Books and References:***

**Text Books**

1. Boubel, R. W., Vallero, D., Fox, D. L., Turner, B., & Stern, A. C. Fundamentals of air pollution 4th edition Elsevier, 2008
2. Arthur C. Stern Fundamentals of air pollution 2nd edition, Elsevier, 1984
3. Murphy, E., King,E., Environmental Noise Pollution, Elsevier, 2014

**Reference Books**

1. De Nevers, N., Air Pollution Control Engineering, 3rd edition Waveland Press Inc 2016.
2. Peterson, A.P.G., Handbook of Noise Measurement General Radio Inc 1980.

| ESC 505 | Wastewater Engineering | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To describe methods of advanced effluent treatment for higher discharge standards and effluent re-use.

**Learning Outcomes:**

- Understand the role of each unit process within typical treatment process trains, their interaction and the context of when they are applied.
- Appreciate the advantages, disadvantages and limitations of the technologies and new developments.

| | | |
|---|---|---|
| **Unit I** | Sources and characterization of wastewater, variation in quantity & quality, flow rate, treatment flow-sheets. Sewage treatment process- an overview. Reactor design: reactor type, hydraulic characteristics, C-diagram. | **5L** |
| **Unit II** | Hydraulic Design of Sewer: Types & Design of sewerage, construction laying and testing of sewer lines Design of Sewage Pumping Station, Maintenance of sewerage system, introduction of software for sewer design. | **8L** |
| **Unit III** | Preliminary treatment- design and operation of approach channel, screen and grit chamber. design and operation of type –II settling, Design of clari-flocculator, equalization tank. | **10L** |
| **Unit IV** | Principle of biological treatment; derivation of bacterial growth kinetics. Process design and operation of attached growth, suspended growth and hybrid process: activated sludge process - its modifications, trickling filter, RBC, oxidation ditch, aerated lagoon, Biofilter, anaerobic baffled reactor, UASB reactor. Waste stabilization pond, Design and operation of biological nitrification, de-nitrification system; Floating aquatic plant system. | **8L** |
| **Unit V** | Sewage disposal in isolated un-sewered areas, septic tank, cesspools, Sludge characteristics and disposal methods: design and operation of sludge drying bed. Design and operation of treatment plant | **8L** |

***Books and References:***

**Text Books**

1. Wastewater Engineering: Treatment, disposal, Reuse (4th ed.) - Metcalf & Eddy Inc. Tata McGraw-Hill, New Delhi, 2003.
2. Environmental Engineering- HS Peavy, RR Donald, and G Tchobanoglous, McGraw-Hill Int. Singapore, 1985.

**Reference Books**

1. Wastewater Treatment for Pollution Control (3rd ed.) - SJ Arceivala, Tata McGraw Hill,1998
2. Wastewater Treatment Plants: Planning, Design and Operation Holt - SR Qasim, Rinehart & Winston, NY, 1985
3. Industrial Water Pollution Control (2nd ed.) - WW Eckenfelder, Jr., McGraw Hill Edition, NY 1989.

| ESC 521 | Water Chemistry Practical | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 3 |

**Course Objectives:**

- The subject offers the readers a fundamental understanding of the water quality parameters and its role in environmental engineering.

**Learning Outcomes:**

- Understand the water quality parameters and the significance.
- Understanding the operational condition during research work.

| | | |
|---|---|---|
| **Exp. 1.** | Calibration of pH meter, TDS and conductivity meter and determination of pH, TDS and conductivity of a given water sample. | **2 Hr.** |
| **Exp. 2.** | Calibration and standardization of Nephelometer and determination of turbidity of a water sample. | **2 Hr.** |
| **Exp. 3.** | Determination of acidity and alkalinity of given water sample. | **2 Hr.** |
| **Exp. 4.** | Determination of hardness of given water sample. | **2 Hr.** |
| **Exp. 5.** | Determination of nitrate of given water sample. | **2 Hr.** |
| **Exp. 6.** | Determination of sulphate of given water sample. | **2 Hr.** |
| **Exp. 7** | Determination of chloride of given water sample. | **2 Hr.** |
| **Exp. 8.** | Determination of chlorine demand, residual chlorine and breakpoint. | **2 Hr.** |
| **Exp. 9.** | Determination of optimum coagulant dose using jar test. | **2 Hr.** |
| **Exp. 10.** | Determination of optimum lime soda dose for hardness removal | **2 Hr.** |
| **Exp. 11.** | Determination of sodium and potassium by flame photometer. | **2 Hr.** |

***Books and References***

1. APHA (2012) Standard methods for the examination of water and waste water, edn. American Public Health Association, Washington, DC.

| ESC 522 | Air and Noise Pollution Practical | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 3 |

**Course Objectives:**

- To apply the theory of air and noise pollution in relevance to practical situations.

**Learning Outcomes:**

The students should be able to:

- Use engineering equipment through laboratory investigations for air and noise pollution as a representative of industrial practices.

| | | |
|---|---|---|
| **Exp. 1.** | Calibration of orifice of the RDS & Determination of SPM/PM10/PM 2.5 in ambient air | **2 Hr.** |
| **Exp. 2.** | Determination of $SO_2$ in ambient air | **2 Hr.** |
| **Exp. 3.** | Determination of NOx in ambient air | **2 Hr.** |
| **Exp. 4.** | Wind rose diagram and use of portable weather tracker | **2 Hr.** |
| **Exp. 5.** | Demonstration of Stack Monitoring Kits, IAQ meter (CO and GRIMM), flue gas analyzer and analyzers (CO and ozone) | **2 Hr.** |
| **Exp. 6.** | Use of excel/spread sheet for calculation and design<br>Preparation of input files required EPA air quality models | **2 Hr.** |
| **Exp. 7** | Noise survey and development of noise profile in a multiple noise sources situation | **2 Hr.** |
| **Exp. 8.** | Ambient noise monitoring | **2 Hr.** |
| **Exp. 9.** | Traffic noise monitoring | **2 Hr.** |
| **Exp. 10.** | Frequency spectrum analysis of machine noise | **2 Hr.** |
| **Exp. 11.** | Audiometry survey for assessing hearing accuracy | **2 Hr.** |

| Semester II | | | | | |
|---|---|---|---|---|---|
| **ESC 506** | **Environmental Laws and Impact Assessment** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **9** |

**Course Objectives:**

- Understating the environmental laws, acts, standard for environmental compliance.
- Understating the EIA and its methodologies for Industries and Regulators.

**Learning Outcomes:**

- Concepts and applications of Environmental Laws and EIA in real world situations.

| | | |
|---|---|---|
| **Unit I** | National and Global Environmental Policies, Forest Policy, Water Policy, Mineral Development policy. | **7L** |
| **Unit II** | Environmental Legislation-Acts, Rules, Regulations and Notifications. Environmental Standards, Criteria for Standard Setting | **12L** |
| **Unit III** | Environmental Clearance; Forest clearance; Consent to Establish & Consent to Operate; Environmental conservation plan for endangered flora and fauna. Framework for EIA, Screening, Scoping, Baseline studies, EIA Methodologies (Adhoc, Checklist, Matrix, Network, and Overlay Methods). | **12L** |
| **Unit IV** | Strategic Environmental Assessment, Cumulative Impact Assessment, Risk and Uncertainty in EIA. | **8L** |

***Books and References:***

**Text Books**


1. Impact Assessment and Sustainable Resource Management-Theory and Practice 2014. P. Wathern and U. Hynman Routledge Taylor and Francis.
2. Environmental Impact Assessment (Latest Edition 2nd Ed., 1996) -LW Canter, McGraw Hill Inc. Singapore.


**Reference Books**


1. Environmental Assessment, 2001. Ravi Jain, LV Urban, GS Stacey, H Balbach, McGraw-Hill.
2. Introduction to Environmental Impact Assessment 2005. J Glasson, R Therivel, A Chadwick, Routledge Taylor and Francis.

| ESC 507 | Municipal Solid Waste Management | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To impart knowledge and skills in various components of Municipal Solid Waste Management.

**Learning Outcomes:**

- Understand the fundamental principles of existing and emerging technologies for the treatment of waste and recovery of materials and energy from waste.
- Have an overview of the Indian and international waste management regulations and guidelines for the design, construction, operation and management of waste treatment facilities.
- Explain the ways of operation of collection, transfer, treatment, management and disposal of wastes as per Solid Waste Management Rules, 2016. .

| | | |
|---|---|---|
| **Unit I** | **Introduction to Solid Waste Management:**Definitions, sources and types of solid waste; Problems due to improper solid waste management (SWM); Objectives and principles of SWM. Functional elements of SWM: Waste generation, On-site handling and processing, Collection, Transfer and transport, Disposal | **6L** |
| **Unit II** | **Quantity and Composition of Wastes and Management of Some Special Wastes:** Estimation of solid waste generation and composition: Sampling methodology; Characterization and composition of solid wastes; Life cycle and Fundamentals of modelling techniques for effective waste management. Special waste fractions management: E-waste, plastic waste, Construction & Demolition waste. | **8L** |
| **Unit III** | **Solid waste disposal (Sanitary landfilling):** Classification, types and methods of landfilling; Design and operation of landfills; Generation and control of landfill gas and leachate; Landfill liner; Dump site rehabilitation. | **6L** |
| **Unit IV** | **Waste Processing Technologies and Energy Recovery:** Thermal conversion technologies: Incineration, Gasification, Pyrolysis, Refuse-derived fuel (RDF). Mechanical biological treatment: Anaerobic Digestion and Composting. | **6L** |
| **Unit V** | **Integrated Solid Waste Management and Case Studies:** Components of Integrated SWM. Sustainable SWM techniques at source: Segregation and sorting, reduce, reuse, and recycle. Present scenario of SWM in Urban Local Bodies: Current practices and deficiencies; Case studies of some of the successfully operating Waste to Energy plants; Role of informal sectors in SWM | **8L** |
| **Unit VI** | **Laws and Regulations:** Salient Features of Solid Waste Management Rules, 2016: Duties and responsibilities of waste generators and other stakeholders (Ministries, Pollution control boards, Local authorities, Manufacturers, Industries, etc.); Criteria for setting up solid waste management facilities; Time frame for implementation and monitoring etc. | **5L** |

***Books and References:***

**Text Books:**


1. Tchobanoglous, G., Theisen, H., & Vigil, S. A. (2014). Integrated Solid Waste Management: Engineering Principles and Management Issues. New Delhi: McGraw-Hill Education (India) Private Limited.
2. Peavy, H. S., Rowe, D. R., &Tchobanoglous, G. (2010). Environmental Engineering. New York: McGraw-Hill.
3. Khan, I. H., & Ahsan, N. (2012). Textbook of solid waste management. New Delhi: Satish Kumar Jain for CBS Publisher and Distributors.


**Reference Books:**

1. Tchobanoglous, G., &Kreith, F. (2002). Handbook of Solid Waste Management-Second Edition. New York: McGraw-Hill.
2. CPHEEO (2000). Manual on Municipal Solid Waste Management, Central Public Health and Environmental Engineering Organisation, Ministry of Urban Development, Govt. of India, New Delhi.
3. Williams, P. T. (2005). Waste treatment and disposal-Second Edition. London: John Wiley & Sons.

| Syllabus of Departmental Elective Courses "Group A" for 2nd Semester | | | | | |
|---|---|---|---|---|---|
| **ESD 501** | **Environmental Geology and Resource Management** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **9** |

**Course Objectives:**

- To acquire basic knowledge of earth's resources and its optimum utilization for sustainable development.
- To explain the most common methods used to mitigate each type of hazardous natural process.

**Learning Outcomes:**

- Development of an understanding of the resource management with the geological inputs.
- Techniques to utilize earth's resources and ways of mitigating its hazards.

| | | |
|---|---|---|
| **Unit I** | Introduction to Environmental Geology: Overview of limited resources, Earth's Geosphere, Atmosphere and Hydrosphere, Population growth and Environmental Crisis.<br>Earth materials: The Geological Cycle- Rock Cycle, Properties of Rocks, Soils, Impact of various activities on soil and their management. | **10L** |
| **Unit II** | Geological Work: Weathering, erosion, transportation, deposition, Geological work of wind and river, Flooding - Recurrence interval and its control measures, Impact on Urbanization,<br>Energy resources: Fossil Fuels, Energy supply and energy demand, Alternative energy sources, Mineral resources: Its Environmental concerns, Mineral resources of India | **10L** |
| **Unit III** | Geologic Hazards: Landslides -The human impact of Landslides, Subsidence and its causes, Earthquake hazards and its mitigation measures, Volcanoes - Major types of Volcanoes and their environmental impact. Hydrosphere: Hydrological cycle, Occurrence of groundwater, Watershed characteristics- drainage pattern, Precipitation, Evapotranspiration, Surface Runoff, Groundwater runoff, Types of Aquifers, Water table, Darcy's law, Groundwater Movement & Contamination | **10L** |
| **Unit IV** | Conservation and Management of Water resources: Groundwater Pollution and its control measures, Rainwater Harvesting and Artificial recharge, Impact of climate change on water resources | **9L** |

***Books and References:***

**Text Books**


1. Environmental Geology by Carla W. Montgomory, Mc Graw Hill Education, (10th Edition)- 2013.
2. Environmental Geology: Ecology, Resource and Hazard Management - by K.S.Valdiya, 2nd Edition, :, Mc Graw Hill Education , 2013.


**Reference Books**


1. Environmental Geology-D. R. Coates, John Wiley & Sons, NY.1980.
2. The State of India's Environment: A Citizen Report -Anil Agarwal, Vol 1&2, 1991.
3. Textbook of Soil Science - Biswas and Mukherjee, TMH, New Delhi, 2017.

| ESD 502 | Environmental Biotechnology | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- Provides comprehensive knowledge of state-of-the-art biotechnological processes for wastewater treatment, landfilling, sludge treatment, bioremediation, bioenergy production and metal recovery.

**Learning Outcomes:**

- Able to describe biotechnological solutions to address environmental issues including pollution, recovery of mineral resource, renewable energy and water recycling.

| | | |
|---|---|---|
| **Unit I** | Genetic Engineering: Cell genetic material; Nucleic acid-based methods of analysis: Extraction of nucleic acids from environmental samples, Polymerase chain reaction (PCR), Real-time PCR, PCR detection of specific and universal genes. | **5 L** |
| **Unit II** | Introduction to Recombinant DNA technology, Safety, social, moral and ethical considerations; Applications of recombinant technology for enhanced biodegradation, organisms with novel catabolic capabilities; Detection of pathogens and parasites in environmental samples using nucleic acid probes and PCR. | **8 L** |
| **Unit III** | Ex-Situ and in-situ bioremediation of soil; Phytoremediation; Ex-situ and in-situ biological decontamination of groundwater; Landfill leachate; bio-treatment of Industrial Wastewater and Surface Waters; Microbial degradation of contaminants in gas phase. | **11L** |
| **Unit IV** | Environmental applications of biological processes: Bio-bleaching in pulp and paper industries, bioleaching of ores for recovery of precious metals, Biological desulphurization of coal, Biological fuel generation (bio-hydrogen, bio-methanation and alcohol production), bio-insecticides, cleaner biotechnologies in oil and agro-industries, Use of immobilized cells and enzymes as biosensors. | **15 L** |

***Books and References:***

**Text Book:**

1. Environmental Biotechnology: Principles and Applications, B. E. Rittmann and P. L. McCarty, 2001.

**Reference Books:**

1. B. Bhattacharya and R. Banerjee, Environmental Biotechnology, 2008.
2. Smith, J.E. (2004) Biotechnology, 3rd Edition, Cambridge University Press, UK.

| ESD 503 | Environmental Modelling | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To provide basic knowledge on mathematical model construction and analyse environmental problems mathematically

**Learning Outcomes:**

The students should be able to:

- Describe the transport of various kinds of contaminants.
- Formulate mass balances and develop mathematical models.
- Critically evaluate and solve and models for varied physico-chemical conditions.

| | | |
|---|---|---|
| **Unit I** | Introduction, Water Quality, Development of Mathematical Models, Reaction Kinetics, Mass Balance, Steady state solutions, Types of loadings, Types of Reactors, Incompletely mixed systems, Advection, Diffusion, Dispersion, Distributed systems (steady state and Time variable), Control Volume approach (Steady state solutions). | **8L** |
| **Unit II** | River Quality modelling, Streeter Phelps model, Fate and transport of pollutants in rivers and streams, Pulse and step inputs, transport in estuaries, Fate and transport of pollutants in lakes, step and pulse input models, Fate and transport of pollutants in subsurface systems, Step and pulse input models | **10L** |
| **Unit III** | Meteorological modelling: Comparison of boundary layer (BL) and free atmosphere characteristics, diurnal cycle of the ABL, convective BL, potential temperature, degree of turbulence, variance of the vertical and horizontal velocity, comparison between day time and night time BL, prediction of CBL height and Monin-Obukhov length (L). | **10L** |
| **Unit IV** | Air quality modelling (AQM): Major AQM types & scales, steps in model formulation, types of input required for dispersion modelling, Preparation of meteorological data for air quality models (surface and upper air data). Emission quantification for point, area and line sources. The box model, Gaussian plume and puff model, Receptor Models such as Chemical Mass Balance (CMB) and Positive Matrix Factorization (PMF).<br>Performance evaluation of models: Model parameterization, calibration and validation, sensitivity analysis and its role, errors and uncertainty analysis.Application of commonly used regulatory models (AERMOD, CALPUFF and CALRoads) and their applications to industrial problems. | **10L** |

***Books and References:***

**Text Books**

1. Lazaridis, M., First principles of meteorology and air pollution, Environmental pollution series volume 19, Springer 2011.

2. Paolo, Z., Air pollution modelling, Springer, 1990.

**3.** Dunnivant, F.M., Anders, E., A Basic Introduction to Pollutant Fate and Transport: An Integrated Approach with Chemistry, Modeling, Risk Assessment, and Environmental Legislation. John Wiley & Sons 2006.

**Reference Books**

1. Howard S. Peavy, Donald R. Rowe, George Tchobanoglous Environmental Engineering (Indian Edition) McGraw-Hill, 2017

2. Steven C. Chapra, Surface Water-Quality Modelling, Waveland Press, 2008

3. Stull, R. "Practical Meteorology: An algebra-based survey of atmospheric science" – version 1.02b. Univ. of British Columbia. 2017

| ESD 504 | Green Engineering Concepts and Life Cycle Analysis | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- Enable the students to acquire the knowledge and skills needed to address concepts of sustainability and cleaner production
- To understand the concept of life cycle analysis (LCA) and the basic principles of the methods.

**Learning Outcomes:**

- Thorough understanding of the concepts of sustainability and cleaner production, and the challenges that engineers face in applying these concepts in an industrial and societal context.
- Detail training on how to use LCA.
- Critically analyse environmental emissions and develop simple methodologies to reduce these emissions.

| | | |
|---|---|---|
| **Unit I** | **Green Engineering:** Principles; System Approach; An Introduction to Sustainability Concepts and Life Cycle Analysis (Introduction, Material flow and waste management).<br>**Risk and Life Cycle Framework for Sustainability:** Introduction, Environmental Risk Assessment, Example Chemicals and Health Effects, Environmental Problems etc. | **10L** |
| **Unit II** | **Overview of LCA Methodology:** Historical Development of LCA; Goal Definition, Life Cycle Inventory, Life Cycle Impact Assessment, Life Cycle Interpretation, LCA Software tools.<br>ISO Framework for LCA.<br>Life Cycle Inventory and Impact Assessments; Unit Processes and System Boundary; Data Quality; Procedure for Life Cycle Impact Assessment; Impact Category definition; Impact category classification, characterization, and weighting. Interpretation of LCIA Results; Sensitivity Analysis; LCIA Practices.Factors for Good LCA Study. Benefits and Drawbacks LCA. | **20L** |
| **Unit III** | **Design for Sustainability and Case Studies:** Environmental Design for Sustainability: Economic, Environmental, and Social Performance Indicators, Sustainable Engineering Design Principles and Environmental Cost Analysis. Case Studies of LCA applications. | **9L** |

***Books and References:***

**Text Books**


1. Life Cycle Assessment Handbook-A Guide for Environmentally Sustainable Products- Mary Ann Curran, John Wiley & Sons, Inc. Hoboken, New Jersey, 2012.
2. Life cycle Assessment Inventory Guidelines and Principles-B.W. Vigon, C.L. Harrison and U.S.E.P.A. Risk Reduction Engineering Laboratory, Lewis Publishers 1994.


**Reference Books**


1. Environmental Life- Cycle Assessment- Marry an Curran, McGraw Hill. 1996.
2. The Computational Structure of Life Cycle Assessment- ReinoutHeijungs and Sangwon Suh, Springer-Science+Business Media, B.V, 2002.
3. Background and Future Prospects in Life cycle Assessment-Walter Klopffer, Springer,2014.

| Open Elective Group - A for 2nd Semester | | | | | |
|---|---|---|---|---|---|
| **ESO 501** | **Environmental Management System and Auditing** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **9** |

**Course Objectives:**

- To learn methodologies of Environmental Management System through ISO Guidelines, Life Cycle Assessment and Social Accountability.
- To learn the implementation of Environmental Management System through Environmental Audits.

**Learning Outcomes:**

- The students will learn environmental management system and various auditing processes.
- The students will be able to prepare the statutory Environmental Statement for various industries.
- The students will be able to serve and guide the industrial sector as good corporate citizens.

| | | |
|---|---|---|
| **Unit I** | Environmental Audit: Objectives, Types of Audits, Features, Audit Criteria, Planning and Organising Audits; Pre-visit data collection, Audit Protocol; Onsite Audit; Data Sampling - Inspections - Evaluation and Presentation; Exit Interview; Audit Report - Action Plan - Management of Audits; Waste Management Contractor Audits; Environmental Statement. | **12L** |
| **Unit II** | Overview of Life Cycle Assessment (LCA) approach. Inventory and Impact Assessment. | **05L** |
| **Unit III** | Introduction and Formulation of ISO Guidelines in Environmental Management Systems; ISO 14000 Series, Principles; Accreditation Process, Environmental Auditor Criteria, Benefits of EMS; Aspect-Impact Analysis, Continual Improvement, Environmental Performance, Environmental Policy, Vision and Mission, Objective and Target, Environmental Management Planning, Implementing EMS, Plan-Do-Check-Act (PDCA), Preventive and Corrective Action, Internal and External Audits, Documentation, Roles and Responsibilities, Management Reviews & Improvements; Legal and Regulatory Concerns; Integrating ISO 9000 & ISO 14000, BS 7750, EMAS. Preparation of ISO Manuals. | **12L** |
| **Unit IV** | Social Accountability: Requirements, Social Accountability (SA) 8000, Certification, Elements of Social Management System, Social policy, Planning, Implementation, Business Benefits, Corporate Social Responsibility (CSR), different Models. | **10L** |

***Books and References:***

**Text Books**


1. ISO 14001 Auditing Manual – Gayle Woodside and Patrick Aurrichio, McGraw-Hill,1999.
2. Planning and Implementation of ISO14001, Environmental Management System- GirdharGyani& Amit Lunia, Raj Publishing House, Jaipur, 2000.
3. Introduction to Environmental Audit- R. D. Tripathi, Alfa Publication.


**Reference Books**


1. The ISO: 14000 Handbook - Joseph Caseio (Ed), Published - CEEM Information Services. 2000.
2. INSIDE ISO: 14000 – The Competitive Advantage of Environmental Management - Don Sayre, VinityBooks International, New Delhi, 2001.
3. A Guide to the Implementation of the ISO: 14000 Series on Environmental Management – Ritchie, I and Hayes W, Prentice Hall, New Jersey, 1998.

| ESO 502 | Environmental Aspects of Industries | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To learn various process engineering, unit operations of Mining, Metallurgical, Thermal Power, Cement and Petroleum Industries.
- Application of Air-Water-Soil Pollution Control Mechanism in these Industries

**Learning Outcomes:**

- Understanding the environmental aspects and impacts of each unit operations of the polluting industries.
- The students will be able to understand and orient themselves with the industry before they undergo summer training, internship, interview or job.
- The students will be able to conceive and prepare Environmental Management Plan of these industries.

| | | |
|---|---|---|
| **Unit I** | Environmental laws related to Various Industries.<br>**Mining Industry**:Mineral production, history of environmental problems. Mining Methods- Opencast and underground mining. Unit operations: Site clearance, drilling, blasting, transportation, reclamation, R&R, mine closure, etc. Mineral beneficiation and their environmental impacts.<br>**Metallurgical Industry**: Unit operations, sources and management of pollution in integrated steel plants, DRI plants, Aluminium Plants, Copper, Lead, etc. Metallurgical Plant Location and Layout. | **20 L** |
| **Unit II** | **Thermal Power Plants & Cement Industries**: Introduction: site selection, layout and unit operations; Fuel and fuel handling -types of fuels, solid, liquid and gaseous. Fuel burning equipment; Pollution control devices- ash handling, management and its utilisation. Environmental management for captive power plants.<br>Environmental problems in cement industries. Co-Processing | **6 L** |
| **Unit III** | **Petroleum Industry:** Production and consumption of the oil and gas, unit operations involved in exploration and production of petroleum and natural gas; Major environmental problems in On-Shore and off-shore exploration | **6 L** |
| **Unit IV** | **Chemical Industry:** Petrochemical, Paint, Chemical Fertilizer, Pesticides, Distilleries, Pharmaceuticals, Pulp & Paper, Sugar Industries, etc. | **7L** |

***Books and References:***

**Text Books**


1. Sustainable Mining Practices: A global Perspective (2005) V.Rajaram, S.Dutta, K Parameswaran. A.A. Balkema Publishers.
2. Environmental Management in Mining Areas - NC Saxena, Gurdeep Singh and R Ghosh (Ed.), Scientific Publishers (India), Jodhpur 2003.
3. Environmental Control in Petroleum Engineering, John C Reis, Elsevier Science & Technology Books, 1996.


**Reference Books**


1. R.C Gupta (2012), Energy and Environmental Management in Metallurgical Industries, PHI Learning Pvt. Ltd.
2. Environmental Impact of Mining - CG Down & J Stocks, Applied Sc. Pub, London, 1978.
3. Environmental Impacts of Mining: Monitoring, Restoration and Control – M Sengupta, Lewis Publishers, Boca Raton, 1993.
4. S.C.Bhatia (2001), Environmental Pollution and Control in Chemical Process Industries, Khanna Publishers, New Delhi.

| ESO 503 | Instrumental Techniques in Environmental Analysis | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- Provides a fundamental understanding of the design, operational principles and practical applications of modern instrumental methods employed in chemical analysis of environmental samples.

**Learning Outcomes:**

- Develop critical thinking skills in the areas of instrument selection, method development and data interpretation.

| | | |
|---|---|---|
| **Unit I** | Basic Concepts for Environmental Analysis: Precision and Accuracy, Types of Errors, Quality Control and Quality Assurance | **6 L** |
| **Unit II** | Spectroscopic techniques: Principle of operation, primary components and applications in Environmental analysis of UV-Vis Spectrophotometer, Flame Photometer, Fourier transform infrared spectroscopy (FTIR), Atomic Absorption Spectrophotometer (AAS), Inductively coupled plasma atomic emission analysis, ICPMS, Nuclear Magnetic Resonance (NMR), Mass spectrometry, XRF spectrometers | **17 L** |
| **Unit III** | Chromatographic analysis:Basic theory, principle, primary components, environmental applications and data analysis of Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Ion Chromatography (IC), GC-MS. | **11 L** |
| **Unit IV** | Potentiometry, Voltametry, Polarography;Operating principle and primary components of Total Organic Carbon Analyzer (TOC) | **5L** |

***Books and References:***

**Text Book:**

1. Fundamentals of Analytical Chemistry (6th ed.) - DA Skoog, DM West, T Holler, Cengage; 9th edition (2014).

**Reference books:**

1. Instrumental Methods of Analysis (6th ed.) - HH Willard, LL Merritt, and JA Dean, CBS Publishers & Distributors; 7 edition edition (2004).
2. Modern Methods of Chemical Analysis - RL Recsok, LD Shields, 1990.
3. Instrumental Methods of Chemical Analysis – GW Ewing, 1975.

| ESO 504 | Environmental Remote Sensing and GIS | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- Understanding of the fundamental concepts of Remote Sensing and Geographic Information System.
- Understanding the wide application of Remote Sensing and GIS in Environmental System.

**Learning Outcomes:**

- To develop applications of environmental remote sensing and GIS which can directly enhance service delivery on land use management, ground water management/prospects, agriculture, forestry, food and water security, disaster management, etc.
- Knowledge on concepts and applications leading to modeling of earth resources management using Remote Sensing.

| | | |
|---|---|---|
| **Unit I** | Introduction, Types, Application and importance of Remote Sensing; Physics of Remote Sensing; The Electromagnetic spectrum; Spectral Reflectance Curves; Spectral Signatures; Resolution. Remote Sensing Platforms: Ground, airborne and satellite-based platforms; Some important Remote Sensing Satellites. | **10L** |
| **Unit II** | Sensors: Passive and Active Sensors; Major Remote Sensing Sensors; Satellite band designations and principal applications; Colour / False Colour; Aerial Photography/ Aerial Photo Interpretation, LiDAR**.** | **10L** |
| **Unit III** | Digital Image Processing: Pixels and Digital Number; Digital Image Structure; Format of Remote Sensing Data; Image Processing functions: Image Restoration, Image Enhancement, Image Transformation, Image Fusion, Image Classification and Analysis; Image interpretation strategies. | **9 L** |
| **Unit IV** | Geographic Information System: Introduction; Preparation of thematic map from remote sensing data; Co-ordinate systems; GIS components: Hardware, software and infrastructures; GIS data types: Data Input and Data Processing; DEM/ DTM generation. Integration of GIS and Remote Sensing.<br>Application of Remote Sensing and GIS in Environmental Management (Water resources – Urban Analysis –Watershed Management – Resources Information Systems, Suitability Analysis). An introduction Global Positioning System. | **10 L** |

***Books and References:***

**Text Books**


1. Remote Sensing & GIS - by Basudeb Bhatta, Oxford University Press (OUP) Higher Education Division, (Second Edition), 2011.
2. Introduction to Remote Sensing - by James B. Campbell and Randolph H.Wynne, (Fifth Edition), The Guiford Press, 2011
3. Concepts and Techniques of Geographic Information Systems by Chor Pang Lo, Albert K. W. Yeung, Prentice Hall, 2002.


**Reference Books**


1. Principles of Geographical Information Systems - P A Burrough and R. A. McDonnell, OUP,Oxford 1998.
2. Geographic Information System- Kang Tsung Chang, Tata Mc Graw Hill, Publication Edition, 2007.

| Syllabus of Compulsory Departmental Practical Courses for the 2nd Semester | | | | | |
|---|---|---|---|---|---|
| **ESC 523** | **Wastewater Engineering Practical** | **L** | **T** | **P** | **C** |
| | | **0** | **0** | **3** | **3** |

**Course Objectives:**

- To develop the skill for conducting Treatability studies of wastewater by various Unit Operations and Processes using laboratory scale models.
- To introduce the students how the common environmental experiments relating to wastewater quality are performed.

**Learning Outcomes:**

- Perform common environmental experiments relating to wastewater, and know which tests are appropriate for given environmental problems.
- The candidate at the end of the experimental exercise would be able to perform field-oriented testing of wastewater.

| | | |
|---|---|---|
| **Exp. 1.** | Determine DO, BOD, COD and biodegradability index of a given wastewater Sample | **2 Hr.** |
| **Exp. 2.** | Determine the ammonical nitrogen and TKN concentration in the given wastewater samples. | **2 Hr.** |
| **Exp. 3.** | Determine TS, TSS, VSS and FS in the given sludge samples | **2 Hr.** |
| **Exp. 4.** | Determine the MLVSS, MLSS, SVI and VSS/SS ratio of a given sludge sample | **2 Hr.** |
| **Exp. 5.** | Determine the settling velocity of the suspended solids in wastewater samples. | **2 Hr.** |
| **Exp. 6.** | Determine the oil and grease content in given wastewater samples. | **2 Hr.** |
| **Exp. 7.** | Determine the phenol and cyanide concentration of a given wastewater sample. | **2 Hr.** |
| **Exp. 8.** | Performance evaluation of UASB reactors for the given wastewater samples. | **2 Hr.** |
| **Exp. 9.** | Determination of heavy metals through AAS analysis. | **2 Hr.** |
| **Exp. 10.** | Determination of priority pollutants using GC analysis. | **2 Hr.** |

| ESC 524 | Soil and Microbiology Practical | L | T | P | C |
|---|---|---|---|---|---|
| | | 0 | 0 | 3 | 3 |

**Course Objectives:**

- Develop idea about culture media and staining techniques.
- Develop understanding about the microbiology of air, water and soil environment.

**Learning Outcomes:**

- Plan and conduct an experiment for physico-chemical properties of soil
- Understand the preparation of culture media and staining techniques.
- Learn methods for enumeration of microbes from air, water and soil.

| | | |
|---|---|---|
| **Exp. 1.** | Determination of Specific Gravity, Bulk Density and Moisture Content of a given soil sample. | **2 Hr.** |
| **Exp. 2.** | Determination of Organic Carbon, NPK and CEC of a given soil sample | **2 Hr.** |
| **Exp. 3.** | Determination of Bioavailable and Total Heavy Metals in soil. | **2 Hr.** |
| **Exp. 4.** | Quantitative and qualitative characters of plant communitiesEcological sampling of an area (line transect and quadrate method) "species-area" curve method. | **2 Hr.** |
| **Exp. 5.** | Study of vegetation of pond ecosystem. Study of fresh water and polluted water algae – (Blue green algae, Green algae and Diatoms). | **2 Hr.** |
| **Exp. 6.** | Culture media preparation– Semi-synthetic and Synthetic media. Liquid, Solid and semisolid media, Nutrient agar, PDA media. | **2 Hr.** |
| **Exp. 7** | Gram staining techniques for detection of gram positive and gram-negative bacteria. Study of fungi (medium – Rose Bengal agar). | **2 Hr.** |
| **Exp. 8.** | Bacteriology of drinking water and domestic sewage -MPN techniques for total coliform, Faecal coliform and Faecal Streptococci (FS), Membrane filtration techniques for faecal coliform and total coliform. IMViC test. | **2 Hr.** |
| **Exp. 9.** | Microbiology of Air: Enumeration of microbes by exposure plate method. | **2 Hr.** |
| **Exp. 10.** | Microbiology of soil: Isolation of microbes by serial dilution methods and colony count by colony counter. | **2 Hr.** |

***Books and References:***

**Text Book**

1. K. R. Aneja (2007), Experiments in Microbiology, Plant Pathology and Biotechnology; New Age International, New Delhi.

**Reference Book**

1. APHA 2012 Laboratory Manual.
2. J. G. Cappuccino, N. Sherman (2014) Microbiology, a laboratory Manual. Benjamin-Cummings Publishing Company, SF, USA.

## Semester-III

| Course No. | Course Name | L | T | P | C |
|---|---|---|---|---|---|
| **Semester - 3** | | | | | |
| ESC 508 | Thesis Unit 1 | 0 | 0 | 0 | 9 |
| ESC 509 | Thesis Unit 2 | 0 | 0 | 0 | 9 |
| ESC 510 | Thesis Unit 3 | 0 | 0 | 0 | 9 |
| ESC 511 | Thesis Unit 4 | 0 | 0 | 0 | 9 |
| | **Total** | **0** | **0** | **0** | **36** |

## Semester-IV

**Syllabus of Departmental Elective Courses of "Group – B" for the 4th Semester**

| ESD 505 | Advanced Water and Wastewater Treatment | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To describe methods of advanced effluent treatment for higher discharge standards and effluent re-use.

**Learning Outcomes:**

- Understand the role of each unit process within typical treatment process trains, their interaction and the context of when they are applied.
- Appreciate the advantages, disadvantages and limitations of the technologies and new developments.

| | | |
|---|---|---|
| **Unit I** | Biological nutrient removal: Nitrogen removal- nitrification, denitrification, processes for biological nitrogen removal, Anammox process; Phosphorous removal- Enhanced Biological Phosphorus Removal, application of phostrip, Bardenpho and phoredox process; Combined N and P removal by A2/O, bardenpho, UCT and VIP process; Gas stripping: Design of stripping towers. | **10L** |
| **Unit II** | Membrane Filtration: Membrane process terminology & classification, Materials, membrane configurations, membrane operation, Reverse osmosis, ultrafiltration, microfiltration, nanofiltration, Electrodialysis. | **8 L** |
| **Unit III** | Adsorption: Types of adsorbents, fundamentals of adsorption, sorption isotherm models and rate considerations, Design of granular and powdered activated carbon contactor; Ion Exchange: Fundamentals of ion exchange, types of ion exchange resins, application of ion exchange, operational considerations; Advanced Oxidation Process: Theory of advanced oxidation, technologies used to produce hydroxyl radicals, applications. | **13 L** |
| **Unit IV** | Sludge handling and disposal: Thickening, stabilization, conditioning, dewatering, heat drying and thermal reduction, Design of aerobic and anaerobic sludge digesters, land application of sludge and design consideration. | **8 L** |

***Books and References:***

**Text Book:**

1. Wastewater Engineering: Treatment and Reuse - Metcalf & Eddy, McGraw Hill Education; 4th edition (2017).

**Reference Book:**

1. Wastewater Treatment for Pollution Control and reuse- SJ Arceivala, McGraw Hill Education; 3rd edition (2017)

| ESD 506 | Biomedical and Hazardous Waste Management | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- Understanding the concept of biomedical and hazardous wastes.
- Basics of the treatment of hazardous wastes.
- Insight of regulatory framework related to hazardous waste management.

**Learning Outcomes:**

- Understanding the concept of biomedical and hazardous wastes and their treatment strategies.
- Understanding the principles of regulatory framework for the treatment and disposal of hazardous wastes.

| | | |
|---|---|---|
| **Unit I** | Biomedical Waste: categorization, generation, collection, transport, treatment and disposal, Infectious Waste, segregation processes, color coding and types of container for segregation processes of biomedical waste, Biomedical waste management. | **8L** |
| **Unit II** | Hazardous Waste Treatment: waste reduction, neutralization, Incineration, combustion and Pyrolysis, unit operations, supply air, products of combustion, furnace temperature, furnace calculation, and environmental control, disposal. Precautions in collection, reception, treatment, transport, storage, and disposal, and import procedure for environmental surveillance. | **8L** |
| **Unit III** | Hazardous Chemicals: Toxic chemicals, flammable chemicals, pesticides, explosives, reactive substances, Cyanide wastes, water-soluble chemical compounds of heavy metals, & toxic metals. Hydrocarbons, point pigment dyes, oil emulsion tars, phenols, asbestos, acid/alkaline slurry, Physical properties, and chemical composition and lethal dose and concentration on human life flora and fauna. Storage, collection, transport. | **8L** |
| **Unit IV** | HWM, Regulatory framework, Basal Convention and other international statistics, monitoring of critical parameters/provide risk-analysis. HAZON, HAZOP, Consequence Analysis.Emergency Management: Indian and foreign legislation in respect of the above. Case studies, leakage, explosion, oil-spills and fire of hazardous chemical storage. Leakage in atomic reactor plants. | **8L** |
| **Unit V** | Radioactive wastes generated during mining, processing of atomic minerals, and in atomic reactors, and disposal of spent fuel rods. Treatment and disposal; remediation of contaminated sites. E-Waste: recovery of useful materials from e-waste, treatment of e-waste. | **7L** |

***Books and References:***

**Text Books**

1. Brunner, C. R. (1989). Hazardous waste incineration. John Wiley & Sons.
2. Dawson, G. W., & Mercer, B. W. (1989) Hazardous waste management. John Wiley & Sons.

**Reference Books**

1. Ludwig, C., Hellweg, S., & Stucki, S. (2012). Municipal solid waste management: strategies and technologies for sustainable solutions. Springer Science & Business Media.
2. Green, A. E. S. Medical waste incineration and pollution prevention. A. E. S. Green (1992.). New York: Van Nostrand Reinhold.

| ESD 507 | Environmental Biogeochemistry | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- Biogeochemistry is the exciting interface between the biological, geological, and chemical sciences. Many Earth System questions require an understanding of all three elements and many new advances and breakthroughs are emerging as experimental and analytical approaches are applied across traditional disciplinary boundaries.

**Learning Outcomes:**

- Students will develop understanding about biogeochemical consequences due to changes in anthropogenic activities as well as climate change and precipitation patterns.

| | | |
|---|---|---|
| **Unit I** | Biogeochemical provinces-Atmosphere-Lithosphere; Concept of forests, lakes, ponds, rivers, mangroves, salt marsh, estuaries, oceans, Rock weathering processes; Tectonic setting. | **8L** |
| **Unit II** | Freshwater and Marine biogeochemistry, Global biogeochemical cycles - carbon cycle, nitrogen cycle, phosphorus cycle, sulphur cycle. | **8L** |
| **Unit III** | Ecosystem productivity and limiting nutrient role; Fluxes and transfer of nutrients. | **6L** |
| **Unit IV** | Sediment biogeochemistry; Soil biogeochemistry. Stable and unstable isotopes, and their application to various biogeochemical problems. Biogeochemical cycling of toxic metals. | **17L** |

***Books and References:***

**Text Books**


1. Biogeochemistry: An Analysis of Global Change, W.H. Schlesinger, Emily S. Bernhardt, Academic Press, Elsevier, 2013.
2. Environmental Geochemistry: A Holistic Approach, JAC Fortescue, 2012, Springer-Verlag, New York.


**Reference Books**


1. Ecosystem Biogeochemistry, CS Cronan, Springer International Publishing, 2018.
2. Stable Isotopes in Ecology and Environmental Science, R Michener, Kate Lajtha, Blackwell Publishing Ltd, 2008.
3. Perspectives on Biogeochemistry, ET Degens, 2000, Springer-Verlag, New York.
4. Biogeochemistry of Trace Elements in Coal and Coal Combustion Byproducts (KS Sajwan, AK Alva, RF Keefer), Kluwer Academic/Plenum Publisher, New York, 1999.

| ESD 508 | Social Impact Assessment and R&R | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To develop an understanding of the role and scope of Social Impact Assessment (SIA) in relation to the land acquisition process.

**Learning Outcomes:**

- Procedure and method of R&R.
- After the completion of course, the student will be able to understand the different dimensions of the Social Impacts.
- Necessity to study the impacts and the R&R issues that may cause by projects or industries and the methods to overcome these.

| | | |
|---|---|---|
| **Unit I** | **Social Impact Assessment**<br>Introduction: Evolution of Social Impact Assessment (SIA), SIA Policy in Indian Context, Provision of SIA in Fair Compensation Transparency in Land Acquisition and R&R, 2013 SIA Policy. Need and Advantages of Legal Mandates and Administrative Procedures for Social Impact Assessment, Basic Model for Social Impact Assessment: SIA Framework, Project Policy Development, Type and Setting, Identification of Assessment Variables | **10L** |
| **Unit II** | **Quality of Life**<br>**Basis of Evaluation of Social Costs:**<br>Quality of Life (QoL) (Value Function Curve and Pearson Correlation using SPSS).<br>Steps in the Social Impact Assessment Process: Public Involvement, Identification of alternatives, Baseline Conditions, Scoping, Projection of Estimated Effects - Investigate the probable impacts, Predicting Responses to Impacts, Indirect and Cumulative Impacts, Mitigation Plan, Monitoring. Social impacts of industrial and developmental activities.<br>Social surveys and socio-economic data generation. Social cost of environmental pollution. | **10L** |
| **Unit III** | **Rehabilitation & Resettlement**<br>Rehabilitation and resettlement of project affected people.Policies and guidelines of rehabilitation planning, corporate social accountability/responsibility. National Policy of Resettlement and Rehabilitation, R&R policy, its critical evaluation, objectives and general principles, PAPs, Types of compensations. | **09L** |
| **Unit IV** | **Case Studies:**<br>(1) R&R Policy of Coal India Limited<br>(2) Jharia Fire and Jharia Action Plan<br>(3) Unstable areas in Raniganj Coalfields and R&R Plan Narmada Action Plan of R&R | **10L** |

***Books and References:***

**Text Books**


1. General Sociology, K E Verghese, Macmillan India Limited, 2012.
2. Environmental Management in Mining Areas– Saxena NC, Singh Gurdeep and Ghosh R, (Ed.), Scientific Publishers (India), Jodhpur 2003.


**Reference Books**


1. Community Development in Coal Mining Complexes, ENVIS Monograph No.7 (March 2001), N. Panda, A.K. Pal, G. Singh, N. C. Saxena.
2. National R&R Policy (2007), Ministry of Rural Development, Govt. of India.
3. Social Impact Assessment, Council for Social Development, New Delhi (2010).

| ESD 509 | Air and Noise Pollution Control | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To understand and evaluate the behaviour of air and noise pollutants and the strategies to control their presence in the ambient atmosphere.

**Learning Outcomes:**

The students should be able to:

- Brief on the behaviour of air pollutants in atmosphere
- Design different types of control equipment's for the abatement of air and noise.
- Evaluate the engineering solutions for industrial and vehicular air pollution problems.

| | | |
|---|---|---|
| **Unit I** | General properties of particle and flue gas and particle dynamics | **3L** |
| **Unit II** | Design of control device for gaseous pollutant-absorption-adsorption-incineration-condensation | **9L** |
| **Unit III** | Design of control device for particulate pollutant-Gravity settler-Cyclone separators- fabric filters-Electrostatic Precipitator -wet scrubber | **9L** |
| **Unit IV** | Industrial Air Pollution Control: Dust control and abatement measures in mines; role of green belts. Thermal power plants: Control principle to improve overall thermal efficiency, Fuel and flue gas desulphurization, FBC, control of NOx, control of mercury, concept of Integrated Gasification Combined Cycle (IGCC) and Carbon Capture and Storage (CCS). Control of motor vehicle emissions. | **5L** |
| **Unit V** | Indoor air pollution control, auxiliary equipments design for air pollution control such as hoods, fans and ducts, calculation to estimate pressure drop due to air pollution control device and total cost estimation procedure including operating cost. | **5L** |
| **Unit VI** | Noise Control Measures - Sound Absorption, Acoustic Barrier, Vibration Isolation, Vibration Damping, Muffling, Personal Protector Green Belt Development--Principles and design considerations, Industrial Noise Pollution Control methods | **8L** |

***Books and References:***

**Text Books:**


1. Theodore, L. Air pollution control equipment calculations, John Wiley & Sons, Inc 2008
2. De Nevers, N., Air Pollution Control Engineering, 3rd edition Waveland Press Inc 2016.
3. Noise Pollution and Control Strategy- by Sagar Pal Singal , Alpha Science International Ltd; 2005 2nd Edition.
4. Noise Control: Principles and Practice - Bruel&Kjaer, 2nd ed. B & K Pub., Denmark 1982


**Reference Books:**


1. W. T. Davis, Air Pollution Engineering Manual, 2nd edition., Wiley-Inter-Science Publication, John Wiley and Sons Inc 2000.
2. Cooper, C.D., Alley, F.C. Air pollution control: A design approach, 4th edition Waveland Press, Inc 2010.
3. Industrial Noise Control and Acoustics – Randall F Barron, Marcel Dekker, Inc., New York 2002.
4. Engineering Noise Control: Theory and Practice – David Bies et. al., Routledge Publishers 1988.

| ESD 510 | Soil Pollution and Restoration | L | T | P | C |
|---|---|---|---|---|---|
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**Course Objectives:**

- Understanding land degradation and soil pollution due to mining and their restoration.
- Integration of engineering techniques with ecological process for restoration of productivity.

**Learning Outcomes:**

- Understanding causes of soil pollution due to anthropogenic activities (mining) and their restoration processes.
- Innovative methods of fertility restoration in derelict lands.
- Quantification of loss of ecosystem goods and services due soil pollution and after restoration.

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| **Unit I** | Soil pollution: anthropogenic sources; pollutants (metals & organic); pedogenesis, impacts on physical, chemical, nutritional and biological characteristics; effects on ecosystem services, Remediation of soil pollution using Electrokinentic method | **9 L** |
| **Unit II** | Importance of land reclamation, rehabilitation, ecological Restoration (ER); National & International practices (SERI guidelines), principles of ER, theoretical foundation of ER. Regulatory framework of ER. Evaluation of restoration success and indicator parameters. Mine pit limnology - formation, hydrology, chemistry, optimum depth; ecology. Engineering reclamation: Issues, site preparation; drainage and erosion control; estimation of soil erosion – USLE & RUSLE, diversion ditch; Design of sedimentation ponds. Reclamation equipments and cost. | **10 L** |
| **Unit III** | Topsoil management: Importance, properties; process-inventory, removal, storage, reuse. shelf life of topsoil. Process of increasing soil fertility by innovative approaches - mulches, coir matting, soil amendments, superabsorbent, biofertilizer – VAM fungi. Grass-legume mixture: importance, planting procedure; Hydroseeding. Seeds – treatment & testing. Vegetation establishment & selection of plant species*: C*over development technique; Miwayanki methods. Management & aftercare of restored site. | **10 L** |
| **Unit IV** | Carbon sequestration (CS): Types of carbon in RMS; Biomass carbon, estimation of CS rate; soil respiration, Ecosystem C pool. Biodiversity management during mine closure. Ecosystem services, valuation of ecosystem goods & services, calculation of NPV and IRR. Mine Tailings Management: Reclamation of tailings impoundments etc. Current bioremediation practice and application. | **10 L** |

***Books and References:***

**Text Book**

1. Quarry Reclamation - NJ Coppin&AD.Bradshaw, Mining Journal Books, London (1982).

**Reference Book**

1. Ecorestoration of the Coalmine degraded lands - Subodh Kumar Maiti, SPRINGER (2013).
2. Lyle ES (Jr) Surface mining reclamation manual, Elsevier, NY (1987).
3. Soil pollution a reality – FAO, United Nation, Rome (2018).

| Open Electives of Group-B for 4th Semester | | | | | |
|---|---|---|---|---|---|
| **ESO 505** | **Climate Change and Modelling** | **L** | **T** | **P** | **C** |
| | | **3** | **0** | **0** | **9** |

**Course Objectives:**

- To explore the climate change on local, national and international prospect through specified models.

**Learning Outcomes:**

The student should be able to

- Explain and critically evaluate the current state of climate change science and relationship between Earth's climate system.
- Recognize the key factors influencing global and regional climate in the past, present, and future.
- Interpret, and critically evaluate different approaches to incorporate uncertainty into climate modelling.

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|---|---|---|
| **Unit I** | Description of the climate system and its components: Atmosphere, Ocean Composition and properties, The cryosphere and the land surface and the terrestrial biosphere. The Energy balance, hydrological and carbon cycles: The Earth's energy budget, The heat balance at the top of the atmosphere: a global view, Heat storage and transport, Heat balance at the surface, The hydrological cycle and the carbon cycle. | **8L** |
| **Unit II** | Modelling of the climate system: Introduction to a climate model, Types of models, A hierarchy of model, Energy balance models, Intermediate complexity models, General circulation models, Components of a climate model (Atmosphere, Ocean, Sea ice, Land surface, Marine biogeochemistry and Ice sheets), Testing the validity of models. | **10L** |
| **Unit III** | The response of the climate system to a perturbation: Climate forcing and climate response, Notion of radiative forcing, Major radiative forcings, Equilibrium response of the climate system - a definition of feedback, Transient response of the climate system, Direct physical feedbacks, Water vapour feedback and lapse rate feedback, Cloud feedback, Cryospheric feedbacks, Geochemical, biogeochemical and biogeophysical feedbacks. | **6L** |
| **Unit IV** | Brief history of climate: causes and mechanisms, Internal climate variability, The climate since the Earth's formation, The last million years: glacial interglacial cycles. | **5L** |
| **Unit V** | Future climate changes: Emission scenarios, the purpose of the scenarios and scenario development, Special Report on Emission Scenarios (SRES), Representative concentration pathways (RCPs), Climate projections for the 21st century, Changes in global mean surface temperature, The spatial distribution of surface temperature and precipitation changes, Changes in the ocean and sea ice, Changes in the carbon cycle and climate-carbon feedbacks, Long-term climate changes, The carbon cycle and Sea level and ice sheets. | **10L** |

***Books and References:***

**Text Books**


1. Goosse H., P.Y. Barriat, W. Lefebvre, M.F. Loutre, and V. Zunz. Introduction to climate dynamics and climate modelling. Universitécatholique de Louvain, Online textbook available at http://www.climate.be/textbook. 2010.
2. C. Donald Ahrens, Essentials of Meteorology: An Invitation to the Atmosphere, Cengage Learning, 2015
3. K. McGuffie and A. Henderson-Sellers. The Climate Modelling Primer, Wiley Blackwell, 2014.


**Reference Books**


1. Stull, R.. "Practical Meteorology: An algebra-based survey of atmospheric science" – version 1.02b. Univ. of British Columbia. 2017.
2. Lazaridis, M., First principles of meteorology and air pollution, Environmental pollution series volume 19, Springer 2011.

| ESO 506 | Environmental Geotechnology | L | T | P | C |
|---|---|---|---|---|---|
| | | 3 | 0 | 0 | 9 |

**Course Objectives:**

- To learn various soil engineering for land reclamation purposes, conversion of degraded waste land in new land use.
- To learn the application of soil mechanics in soil improvement, subgrade-drainage system, enhancing slope stability in mining areas, hilly regions, etc.

**Learning Outcomes:**

- The students will learn environmental geo-techniques to reclaim degraded land for conversion in to various land uses like construction, infrastructure, agriculture, or development of aesthetics.
- The students will be able to stabilize erosion prone land, unstable hill and mine slopes.

| | | |
|---|---|---|
| **Unit I** | Basics of soil materials, Physical Characterisation of soil, Three Phase (Solids-water-air) relationships, Consistency, Index properties, Ground Investigation, Classification of soils, Structure and Clay Minerals | **11 L** |
| **Unit II** | Soil Compaction: Factors affecting compaction, Consolidation of disturbed soil, Primary and Secondary Consolidation, Ground improvement techniques. | **8 L** |
| **Unit III** | Shear strength of soil and its application in waste dumps, reclaimed sites, hill slopes, etc. Stability analysis. | **4L** |
| **Unit IV** | Capillarity and Permeability of soil, Hydrodynamic Case-Flow Condition, Seepage, Flow nets through a pervious medium, Two-Dimensional Flow-Laplace's Equation, Steady State Flow, Flow-lines, Equipotential Lines. Prevention of erosion, protective filters. | **6 L** |
| **Unit V** | Design of tailing dams, precautionary measures. Geotechnical construction, application of geotextiles. | **6L** |
| **Unit VI** | Geotechnology and environment; Case studies, Issues in soil degradation and remediation. | **4 L** |

***Books and References:***

**Text Books**

1. The Nature and Properties of Soil - NC Brady, and R Ray, Pearson Prentice Hall, 2008.
2. Basic and Applied Soil Mechanics (2nd ed.) – G Ranjan & ASR Rao, New Age Publ. 2008.
3. Geotechnical Engineering – SK Gulhati and M Datta, Tata McGraw Hill, New Delhi, 2005.

**Reference Books**

1. Environmental Geotechniques - R Sarsby, Thomas Telford Publishing, London, 2000.
2. Hydrology – HM Ragunath, Wiley Eastern Limited,1990.
3. Introduction to Hydrology – W Viessman (Jr), JW Knapp, GL Lewis and TE Harbaugh, Harper and Row, London, 1977.