

Department of
Environmental Science & Engineering

Approved Syllabus and Course Content of
M. Tech (Environmental Science & Engineering)
by BOCS held on 27.03.2015

Effective from 2015-16



INDIAN SCHOOL OF MINES
DHANBAD- 826 004, JHARKHAND

FIRST SEMESTER

SI No.	Subject Code	Name of the Course	L T P	Total Credit Hours
1.	AMC 511 51	Advanced Numerical Methods and Applied Statistics	3-1-0	7
2.	ESC 511 01	Ecology, Biodiversity and Environmental Microbiology	3-1-0	7
3.	ESC 511 02	Water Supply and Treatment	3-1-0	7
4.	ESC 511 03	Environmental Chemistry	3-1-0	7
5.	ESC 511 04	Principles of Air and Noise Pollution	3-1-0	7
6.		Electives – (Any one)	3-0-0	6
	ES E 511 01	Environmental Aspects of Industries		
	ES E 511 02	Environmental Systems Optimisation and Modelling		
	ES E 511 03	Instrumental Techniques in Environmental Analysis		
	ES E 511 04	Environmental Geology and Resource Management		
	ES E 511 05	Environmental Geotechnology		
	ES E 51106	R & R, CSR and Social Impact Assessment		
	ES E 51107	Water Management and Conservation		
7.	ESC 512 01	Ecology and Environmental Microbiology Practical	0-0-2	2
8.	ESC 512 02	Environmental Chemistry Practical	0-0-2	2
9.	ESC 512 03	Air and Noise Pollution Practical	0-0-2	2
10.	ESC 516 01	Field and Industrial Visits and Seminar (s)		(02)
		Total Credits	18-5-6	47 + (2)

SECOND SEMESTER

SI No.	Subject Code	Name of the Course	L T P	Total Credit Hours
1.	ESC 521 01	Environmental Laws, Impact Assessment and Auditing	3-1-0	7
2.	ESC 521 02	Wastewater Engineering	3-1-0	7
3.	ESC 521 03	Solid and Hazardous Waste Management and Land Reclamation	3-1-0	7
4.	ESC 521 04	Design of Air Pollution Control Systems	3-1-0	7
5.		Electives – (Any two)	3-0-0	6x2= 12
	ES E 521 01	Remote Sensing and GIS		
	ES E 521 02	Noise Control Engineering		
	ES E 521 03	Environmental Economics and Socio-Economic Planning		
	ES E 521 04	Advanced Wastewater Engineering		
	ES E 521 05	Climate Change and Modeling		
	ES E 521 06	Life Cycle Assessment		
	ES E 521 07	Environmental Biotechnology		
	ES E 521 08	Renewable Energy		
	ES E 521 09	Environmental Management System		
6.	ESC 522 01	Wastewater Engineering Practical	0-0-2	2
7.	ESC 522 02	Solid and Hazardous Waste Management and Land Reclamation Practical	0-0-2	2
8.	ESC 526 01	Field Visits, Excursions and Seminar(s)		(02)
		Total credits	18-4-4	44+ (2)

THIRD SEMESTER

SI No.	Subject Code	Name of the Course	L T P	Total Credit Hours
1.	ESC 536 01	Industrial Training/ Minor Project	0-0-0	4
2.	ESC 534 02	Seminar and Viva voce on Industrial Training/ Minor Project	0-0-0	2
3.	ESC 535 03	Comprehensive Viva-voce (to be conducted at the end of II Semester, marks to be added while computing III Semester GPA)	0-0-0	4
4.	ESC 538 04	Dissertation (Interim)	0-0-0	15
5.	ESC 534 05	Seminar and Viva-voce on Dissertation	0-0-0	10
6.	ESC 530 06	Evaluation of Teaching Assignment/ Laboratory Development Work etc.	0-0-0	5
		Total credits	0-0-0	40

FOURTH SEMESTER

SI No.	Subject Code	Name of the Course	L T P	Total Credit Hours
1.	ESC 548 01	Dissertation	0-0-0	20
2.	ESC 544 02	Seminar on Dissertation	0-0-0	5
3.	ESC 545 03	Viva-voce on Dissertation	0-0-0	10
4.	ESC 540 04	Evaluation of Teaching Assignment/ Laboratory Development Work etc.	0-0-0	5
		Total credits	0-0-0	40

Part I: Advanced Numerical Methods:

Solution of tridiagonal system, Evaluation of double and triple integrals by numerical method and its application, solution of non-linear simultaneous equations numerical solution of integral equations, Advanced methods of interpolation, Numerical solution of simultaneous first order ordinary differential equations and higher order O.D.E. Initial and Boundary value problems, Numerical solution of partial differential equation: Laplace and Poisson equation, Heat conduction and waved equations.

Reference Books:

1. Numerical methods by M.K. Jain, S.R.K. Iyengar and R.K. Jain
2. Numerical methods- E. Balagurusamy
3. Numerical methods-S. Dey & S. Gupta, Mc-Graw Hill Education Ltd.
4. Numerical Algorithms- E.V. Krishnamurthy and S.K. Sen

Part II: Applied Statistics:

Review of binomial, Poisson, normal and lognormal probability distributions. Interval estimates, tests of significance for mean, variance (one & two population case-Z, t, χ^2 and F test), tests for correlation and regression coefficients. Non-parametric tests: Sign test, Mann-Whitney Wilcoxon, U-test, run test and test of randomness. One way and two-way analysis of variance. Time series analysis, reliability and life testing experiments in engineering problems.

Reference Books:

1. Miller & Freund's:Probability and Statistics for Engineers (5th ed.)-Richard A. Johnson, PHI.
2. Probability and Statistics in Engineering (4th ed.) -W.W. Hines, D.C. Montgomery, D.M. Goldsman & C.M. Borror,Wiley.
3. Fundamentals of Mathematical Statistics- S.C. Gupta & V.K. Kapoor
4. Fundamentals of Applied Statistics- S.C. Gupta & V.K. Kapoor

Ecology: Components of ecosystem: biotic and abiotic factors, Food chain & web, ecological pyramids, ecosystem stability -inertia and resilience, fragile ecosystem, hot spots. System ecology, Energy flow.

Biodiversity: Importance, distribution, measurement, and conservation. Impacts of climate change on Biodiversity.

Biogeochemical cycling: C, N, P and S cycle; biological N fixation, nutrient cycling in tropics, limiting factors, Bio-monitoring, biotic indices, indicator species.

Aquatic ecology: Lentic and lotic habitat, stratification, productivity, community & life form, Wetland, marine and estuarine ecosystem.

Population and community ecology, habitat, ecological niche and ecotone, ecological successions.

Ecotoxicology: Background, importance & measurement, ecosystem response to de-oxygenation, eutrophication, Pesticides & Bio-accumulation.

Ecosystems and the millennium development goals, landscape ecology

Microbiology: General properties of microorganisms: Environmental importance of microorganisms, classification, distribution, enumeration of microbes, Prokaryotic and Eukaryotic cells.

Bacteria: Cell structure, spore, morphology and reproductions, bacterial nutrition, culture media and culture characteristics, growth of bacteria, batch culture, specific growth rate and doubling time, continuous culture, synchronous growth, effects of environmental factors on growth.

Control of microbes: Physical and chemical methods, destruction and suppression.

Microbial metabolisms: Anabolism and catabolism, glycolysis, TCA cycle and ETC, fermentation and anaerobic respiration, energy balances (ΔG) growth, substrate partitioning and theoretical yield, electron acceptors, enzymes, Monod and Halden kinetics.

Drinking water microbiology: Stream pollution, water borne diseases and pathogens, MPN test, faecal coliform and faecal streptococci, MF techniques, IMViC test.

Air microbiology: Air borne diseases and pathogens.

Soil microbiology: Bio-fertilizer, VAM fungi, N-fixations, Bio-pesticides, degradation of natural substances, composting, Bio-energy from waste.

Books and References:

1. Fundamentals of Ecology (3rd ed.) - Eugene P. Odum. WB Saunders Company, Philadelphia, 1971.
2. Fundamentals of Ecology- MC Dash, Tata - McGraw Hill, New Delhi, 1996.
3. Introduction to Environmental Engg. - GM Masters, Prentice Hall of India, 1991.
4. Microbiology (5th Ed.) – MJ Pelzer et. al - Tata McGraw Hill, New Delhi, 1993.
5. Microbiology for Environmental Scientists and Engineers – AF Gaudy, and ET Gaudy, McGraw-Hill, New York, 1980.

ES C 511 02 Water Supply and Treatment

[3-1-0]

Water Resources: Aquifers and its properties.

Water Quality: Definitions, Characteristics, and Perspectives: The hydraulic cycle and water quality, physical water-quality Parameters, chemical water-quality parameters, biological water-quality parameters, water quality requirements.

Engineered Systems for Water Purification: Historical overview of water treatment; Water treatment processes: Aeration, solids separation, settling operations, coagulation, softening, filtration, disinfection, dissolved solids removal.

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.

Books & References:

1. Water Resources Engineering - LW Mays, Wiley Text Books, 2000.
2. Environmental Engineering- HS Peavy, RR Donald and G Tchobanoglous, MGH Int. Ed. NY, 1985.
3. Water Quality and Treatment Handbook - AWWA, McGraw-Hill Pub. 1999.
4. Water Treatment plant Design - ASCE, McGraw-Hill Publisher, 1997.
5. Water Supply and Sewerage – EW Steel and TJ McGhee, McGraw Hill NY, latest Ed.
6. Manual of Water Supply and Treatment (3rd ed.) – Ministry of Urban Development, New Delhi, 1991.

ES C 511 03 Environmental Chemistry

[3-1-0]

Atmospheric chemistry: Chemical components in the atmosphere, tropospheric chemistry, oxidizing capacity of atmosphere, hydroxyl radical, global budgets of CO₂ and methane, tropospheric ozone and NO_x. Stratospheric chemistry: Chapman mechanism, catalytic losses, aqueous phase chemistry (acid rain formation), greenhouse gas and aerosol chemistry, radiation, effective temperature of earth, radiative forcing, feedback systems.

Aquatic Chemistry: Acids and Bases, titrations, buffers and buffer intensity, chemical equilibrium calculations, pC-pH diagram. Precipitation and dissolution, water softening and water conditioning, Langelier index, solubility diagram, co-existence of phases in equilibrium, Complexation of metal ions and organic complexes in natural water.

Oxidation and reduction reaction stoichiometry, Redox couples, pE-pH diagrams, redox control in natural systems.

Basic concepts of organic chemistry- Aliphatic organic compounds, aromatic compounds, detergents, pesticides, behaviour and fate of organics in the environment. Basic concepts of colloid chemistry.

Soil chemistry: Weathering reactions, structure and surface reactions of clays and oxides, forces at soil-water interfaces.

Books & References:

1. Aquatic Chemistry: An introduction emphasizing chemical equilibria in natural waters (2nd ed.) - W Stumm and JJ Morgan, Wiley-Interscience, New York, 1981.
2. Environmental Chemistry (9th ed.) - SE Manahan, CRC Press, 2009.
3. Chemistry for Environmental Engineering and Science (5th Ed.) – CN Sawyer, PL McCarty, and GF Parkin, McGraw Hill, 2002.
4. Introduction to atmospheric chemistry - DJ Jacob, Princeton University Press Princeton, New Jersey, 1999.
5. Principles and Application of Aquatic Chemistry - FMM Morel, and JG Hering, John Wiley & Sons, Inc., NY, 1993.
6. First Principles of Meteorology and Air Pollution - M Lazaridis, Springer publication, 2010.

Sources of air pollution- Stationary and mobile, fugitive emissions, secondary pollutants; Effects of air pollution in regional and global scale, air pollution episodes; Emission factors, inventory and predictions.

Atmospheric meteorology, structure of atmosphere and layer classification, energy transfer in atmosphere, geostrophic flow, buoyancy and frictional force, local and general circulation, global climate and micro climate, wind profiles, topographic effects, temperature profiles in atmosphere, stability, inversions, plume behavior, turbulent diffusion, concept of mixing height and determination of stability class application of acoustic sounding (SODAR) technique.

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.

Dispersion of air pollutants and modeling – Types and classification of models, purpose of air quality modeling, Box models, Gaussian dispersion model – Assumptions, modifications for ground reflection, line sources and complex terrain. Physics of plume rise, Holland's equation, Briggs equation, etc. Indoor air quality modeling, Features and application of regulatory models.

Noise Pollution: Basics of acoustics and specification of sound; sound power, sound intensity and sound pressure levels; plane, point and line sources, multiple sources; outdoor and indoor noise propagation; psycho-acoustics and noise criteria, effects of noise on health, annoyance rating schemes; special noise environments: Infra-sound, ultrasound, impulsive sound and sonic boom; noise standards and limit values; noise instrumentation and monitoring procedure. Noise indices.

Books & References:

1. Environmental Engineering - AP Sincero and GA Sincero, Prentice Hall of India, 1999.
2. Environmental Pollution Control Engineering- CS Rao, Wiley Eastern Ltd., New Delhi, 1996.
3. Environmental Noise Pollution - PE Cunniff, McGraw Hill, New York, 1987.
4. Handbook of Noise Measurement - APG Peterson & EE Gross, General Radio Co., West Concord, Mass, 1967.
5. Englewood cliffs New Jersey, latest edition.
6. Air Pollution Control Equipment – H Brauer and YBG Verma, Berlin Heidelberg, New York, latest edition, 1981.

ELECTIVES

ES E 511 01 Environmental Aspects Industries

[3-0-0]

Environmental laws related to Various Industries. Mineral production, history of environmental problems. Mining Methods- Opencast and underground mining. Unit operations: Site clearance, drilling, blasting, transportation, reclamation, mine closure, etc. Mineral beneficiation and their environmental impacts.

Metallurgical Industries and their Environmental Aspects: Unit operations, sources and management of pollution in integrated steel plants, ferrous and non-ferrous metals.

Thermal Power Plants: Introduction: site selection, layout and unit operations; Fuel and fuel handling -types of fuels, solid, liquid and gaseous. Fuel burning equipments; Pollution control devices- ash handling, management and its utilisation. Environmental management for captive power plants. Environmental problems in cement industries.

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-land and off-shore exploration; petrochemical plants.

R&R, industrial disasters, industrial safety. Environmental laws related to industrial production. Safety audit; Occupational Health & Safety Management System; Risk Assessment, Hazard and Operability Studies (HAZOP) and analysis; Disaster Management.

Books & References:

1. Environmental Impact of Mining - CG Down & J Stocks, Applied Sc. Pub, London, 1978.
2. Environmental Impacts of Mining: Monitoring, Restoration and Control – M Sengupta, Lewis Publishers, Boca Raton, 1993.
3. Best Practices Environmental Management in Mining - EPA (Australia): 1997-2004.
4. Tailings Management - GM Ritcey, Elsevier, 1997.
5. Environmental Management in Mining Areas - NC Saxena, Gurdeep Singh and R Ghosh (Ed.), Scientific Publishers (India), Jodhpur 2003.

ES E 511 02 Environmental System Optimisation and Modelling

[3-0-0]

Systems approach - Concept and analysis. Problems formulation, model construction and deriving solution from models using LPP. Limitation and Application of LPP to wastewater management systems, to air quality management of non-point source pollution, sensitivity analysis;

Lagrange multipliers- unconstrained and constrained optimisation, limitations of Lagrange's multipliers. Sequential search algorithms- box algorithm,

Separable and integer programming- application to multi-objective planning. Application of integer programming to municipal solid waste management.

Transportation models. Dynamic programming models- application to land use planning and air pollutant emission control. Present value concepts- optimization over time.

Fate and Transport of contaminants in surface and sub-surface environment, Streeter - Phelps model and introduction of various available software's.

Books & References:

1. Operation Research: An Introduction (8th ed.) - HA Taha, Prentice Hall Pub, 2007.
2. Operation Research: Theory & Applications (4th ed.) - JK Sharma, Macmillan India Limited, 2009.
3. Environmental Systems Optimization- DA Haith, Wiely Sons, NY, 1982.
4. Handbook of Environmental and Ecological Modelling - SE Jorgensen, B Halling-Sorensen, and SN Nielsen, CRC Press, 1995.
5. Fundamentals of Atmospheric Modelling - MZ Jacobson., Kluwer Academic Press, 2002.
6. An Introduction to Water Quality Modelling (2nd ed.) – A James, Wiley, 1993.
7. Techniques for Environmental System Analysis - RH Pantell, Wiley, NY, 2001.
8. System Analysis and Design - RJ Aguilar, Prentice Hall, Englewood Cliffs, NJ, 1993.

ES E 511 03 Instrumental Techniques in Environmental Analysis [3-0-0]

Basic Concepts for Environmental Analysis: Precision and accuracy, types of errors, titrations, extractions and quality control.

Spectrometry and Photometry: UV-Vis Spectrophotometer, Flame Photometer, Infrared Spectrophotometer, Atomic Absorption Spectrophotometer (AAS), Mass Spectrometry (MS), Fourier transform infrared spectroscopy (FTIR), Nuclear Magnetic Resonance (NMR), Inductively coupled plasma spectrometry (ICPMS).

Chromatography: Basic theory and types of chromatography, Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Ion Chromatography (IC).

Ion Selective Electrodes: Operating principle, Primary components, Applications in environmental analysis. Polarography and cyclic voltametry.

Total Organic Carbon Analysis: Operating principle and primary components

Books & References:

1. Settle. Instrumental Methods of Analysis (6th ed.) - HH Willard, LL Merritt, and JA Dean, CBS Publishers, New Delhi, 1986.
2. Fundamentals of Analytical Chemistry (6th ed.) - DA Skoog, DM West, T Holler, Saunder's Publication, 1992.
3. Modern Methods of Chemical Analysis - RL Recsok, LD Shields, John Wiley & sons, Inc, 1990.
4. Instrumental Methods of Chemical Analysis – GW Ewing, McGraw Hill Book Company, Inc. 1975
5. Fundamentals of Molecular Spectroscopy – CN Banwell, McGraw Hill, NY, 1990.

ES E 511 04**Environmental Geology & Resource Management****[3-0-0]**

Introduction to Environmental Geology: Scope and applications of Environmental Geology, the environmental crisis, Overview of limited resources, population growth.

Earth materials: The rock cycle, physical properties of rocks, soils, Impact of various activities on soil and their management.

Geological work: Weathering and erosion, transportation, deposition. Geological work of wind and river.

Flooding: Magnitude and frequency, recurrence interval, impact on urbanization.

Energy and mineral resources: Fossil fuels, energy supply and energy demand, alternative sources of energy, mineral resources of India.

Geologic Hazards: Landslides - The human impacts of landslides, subsidence, Earthquake process- Detecting, locating and measuring earthquakes, volcanoes - Major types of Volcanoes and their environmental impacts.

Water Resources: Watershed characteristics - Drainage Pattern, precipitation, evapotranspiration, surface runoff, groundwater runoff, and hydrological cycle. Groundwater movement & contamination: Types of aquifer, water table, Darcy's Law, conserving and managing water resources, rainwater harvesting, impact of climate change on water resources.

Books & References:

1. Environmental Geology - DR Coates, John Wiley & Sons, NY 1981.
2. The State of India's Environment: A Citizen Report -Anil Agarwal, Vol. 1&2, 1985.
3. Textbook of Soil Science - TD Biswas and SK Mukherjee, Tata McGraw-Hill, New Delhi, 1994.
4. Reclaimed Land, Erosion Control, Soils and Ecology - MJ Haigh (ed.), Rotterdam: A A Balkema / New Delhi: Oxford and IBH, 2000.
5. Environmental Geology - Indian Context –KS Valdiya, TMH Delhi, 1987

ES E 511 05**Environmental Geotechnology****[3-0-0]**

Geotechnology and environment, basics of soil materials, ground Investigation, compaction, shear Strength, groundwater and permeability, permeability and settlements, instruments, waste disposal by landfill, contaminated land, derelict land, tailing dam, waste materials in geotechnical construction, application of geotextiles.

Books & References:

1. Environmental Geotechniques - R Sarsby, Thomas Telford Publishing, London, 2000.
2. The Nature and Properties of Soil - NC Brady, and R Ray, Pearson Prentice Hall, 2008
3. Basic and Applied Soil Mechanics (2nd ed.) – G Ranjan & ASR Rao, New Age Publ. 2008.
4. Geotechnical Engineering – SK Gulhati and M Datta, Tata McGraw Hill, New Delhi, 2005
5. Hydrology – HM Raganath, Wiley Eastern Limited, 1990
6. Introduction to Hydrology – W Viessman (Jr), JW Knapp, GL Lewis and TE Harbaugh, Harper and Row, London, 1977.

ES E 511 06 R & R, CSR and Social Impact Assessment [3-0-0]

Social impact assessment of industrial and developmental activities. Quality of life concept- and its use in development planning. Social surveys and socio-economic data generation. Social cost of environmental pollution. Rehabilitation and resettlement of project affected people. Laws related to social development. Policies and guidelines of rehabilitation planning, corporate social accountability/responsibility. Specific case studies from various sectors including mining.

Boos & References:

1. Environmental Management in Mining Areas– Saxena NC, Singh Gurdeep and Ghosh R, (Ed.), Scientific Publishers (India), Jodhpur 2003.
2. Development-induced Displacement, Rehabilitation and Resettlement in India: Current Issues and Challenges- Sakarama Somayaji, Smrithi Talwar Routledge Contemporary South Asia Series.
3. Rehabilitation of Displaced Villagers, B.C. Muthayya, R.N.Tripathy, M.L. Santhanan, O.N. Srivastava, National Institute of Rural Development.

ES E 511 07 Water Management and Conservation [3-0-0]

Ground water resources and its management: Groundwater management strategies. Rainwater Harvesting: Introduction, basic components of rainwater harvesting, Catchment Areas (Rooftop, Land surface catchment etc.), design of Collection Devices & Conveyance Systems; advantages & disadvantages; design of rainwater harvesting structure, safety consideration, development cost; material requirements, effectiveness of technology, future development. Direct (surface, sub-surface) and indirect (induced) techniques of artificial recharge, planning of artificial recharge projects, artificial recharge techniques and design, monitoring, mechanism for artificial recharge projects, case histories of artificial recharge in India. Artificial recharging of groundwater and use of domestic and industrial waste waters. General Guidelines for the evaluation of groundwater recharge projects with case studies. Diagnosis and control of rivers and streams stresses, siltation and pollution problems from watershed. Problems, Restoration, Conservation of rivers and lakes, National lake conservation plan. River linking and hydro power projects.

Books & References:

1. Water Resources Engineering- Larry W. Mays, John Wiley and Sons
2. Water Resources Engineering - Ray K Linsley, Joseph B Franzini, David L Freyberg, George Tchobanoglous, Mc Graw Hill, 4th Ed.
3. Hydrology and Water Resources Engineering- S.K. Garg, Khanna Publishers
4. Hydrology- M.M. Das, M.D. Saikia, PHI Learning Pvt Ltd., New Delhi, 3rd Ed.
5. Rainwater Harvesting for Drylands and Beyond (Vol. 1) – B Lancaster, Rainsource, Tucson, U. S. A., 2009.

ES C 512 01 Ecology and Environmental Microbiology (Practical) (0-0-2)

Environmental Ecology: Measurement of leaf area and calculation of Leaf Area Index (LAI) and Leaf Area Ratio (LAR); estimation of chlorophyll and moisture contents of leaves (from grass and tree leaves); measurement of productivity by harvest method; estimation of root-biomass quantitative and qualitative characters of plant communities ecological sampling of an area (line transect and quadrat method) “species-area” curve method Study of vegetation by physiognomic method biological spectrum method study of pond ecosystem.

Environmental Microbiology: Apparatus used for a microbiological laboratory. Methods of sterilisation and disinfections. Culture media: Media preparation semi-synthetic and synthetic media. Liquid, Solid and semisolid media, nutrient agar, PDA media. Gram staining techniques for detection of gram positive and gram negative bacteria. 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. Microbiology of Air: Enumeration of microbes by exposure plate method. Microbiology of soil: Isolation of microbes by serial dilution methods and colony count by colony counter. Study of fungi (medium Rose Bengal agar). Study of fresh water and polluted water algae (blue green algae, Green algae and Diatoms).

ES C 512 02 Environmental Chemistry (Practical) (0-0-2)

Calibration of pH meter by two points method. Determination of chloride, nitrate, sulphate, alkalinity, acidity, total hardness, colour, turbidity, metals and metalloids, and sodium concentration.

Soil sampling, determination of soil pH, conductivity, salinity, organic carbon, nitrogen, phosphorus, sodium, potassium, and cation exchange capacity of soil.

Demonstration of UV-VIS spectrophotometer, Flame photometer, AAS, GC, TOC and HPLC.

ES C 512 03 Air and Noise Pollution (Practical) (0-0-2)

Demonstration of air pollution monitoring instruments; Calibration of HVS by orifice method; Determination of SPM; PM₁₀; SO₂; ammonia and NO_x in ambient air; Respirable dust monitoring by RDS and FPM; Demonstration of stack monitoring kits; Demonstration of Indoor air quality CO, VOC and aerosol monitors; Determination of atmospheric stability class using portable anemometers; Development of wind rose diagram.

Demonstration of noise pollution monitoring equipment; namely modular precision sound level meter, noise dose meter, human vibration monitoring instrument, audiometer, etc. Noise survey in a multiple noise sources situation in order to develop noise contour diagram for the entire locality. Noise monitoring at residential localities. Frequency spectrum analysis of machine noise. Audiometry survey in order to assess present status of hearing acuity of the subject. Traffic noise situation monitoring; human vibration monitoring (whole body as well as hand-arm vibration).

SECOND SEMESTER

ES C 521 01 Environmental Laws, Impact Assessment and Auditing

[3-1-0]

Environmental Policies-National and international; international treaties. Carbon management-Kyoto Protocol and Clean Development Mechanism (CDM), carbon neutrality.

Environmental Legislations-acts, rules, regulations and notifications. Environmental standards, criteria for standard setting.

Environmental Clearance; Forest clearance; Consent to Establish & Consent to Operate; Environmental conservation plan for endangered flora and fauna; The Mines and Minerals (Development and Regulations) Act.

Framework for EIA; screening, scoping and baseline studies; techniques for assessment of impacts on physical resources, ecological resources, human use values and quality of life values.

Impact assessment methodologies-various methods, their applicability. Strategic environmental assessment. Cumulative impact assessment. Risk and uncertainty in EIA; environmental management planning; disaster management planning.

Environmental audit, objectives, types, features, planning of audits; organisation of auditing programme, 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.

Introduction to ISO 14001 series, OHSAS 18001; case studies.

Books & References:

1. Environmental Impact Assessment (2nd Ed.) -LW Canter, McGraw Hill Inc. Singapore, 1996.
2. Strategic Environmental Assessment - Therivel et al., Earthscan, London, 1992.
3. Environmental Impact Assessment-Cutting edge for the 21st century - A Gilpin, CUP, London, 1994.
4. Environmental Impact Assessment-Theory & Practice - P Wathern, and U Hynman, Sydeny, 1988.
5. Renewable Energy Environment and Development- M Dayal, Konark Pub. Pvt. Ltd., 1998
6. Planning and Implementation of ISO14001, Environmental Management System- G Gyani and A Lunia, Raj Publishiong House, Jaipur, 2000.
7. ISO 14001 Auditing Manual - G Woodside, and P Aurrichio, McGraw- Hill, 1999.
8. An Introduction to Environmental Audit - RD Tripathi, Alpha Publications, 2009.
9. "The ISO: 14000 Handbook" – J Caseio (Ed), Published - CEEM Information Services. 2000
10. A Guide to the Implementation of the ISO: 14000 Series on Environmental Management - I Ritchie, and W Hayes, Prentice Hall, New Jersey, 1998.
11. OHSAS & SA Guidelines.

Sewage characteristics, quantity & quality, flow rate, treatment flow-sheets. Sewage treatment process, reactor type, hydraulic characteristics, C-diagram. Preliminary treatment-design and operation of screening and grit chamber. Sedimentation, design and operation PST; chemical precipitation.

Principle of biological treatment; derivation of bacterial growth kinetics used in designing of wastewater treatment plant. Process design and operation of activated sludge process and its modification. Bulking and rising sludge. Design of secondary settling tank.

Wastewater treatment for small communities, oxidation ditch, extended aeration system, SBR; process design and operation of mechanically aerated lagoon and waste stabilization pond system.

Sanitation: Rural sanitation, short term and long term control of insects, rodents, vectors and nuisance; municipal sanitary standards and regulation. Sewage disposal in isolated unsewered areas, septic tank, cesspools and their effluent disposal methods.

Design and operation of biological nitrification, de-nitrification system; luxurious phosphorus uptake.

Aerobic attached growth process: Process design and operation of trickling filter, RBC, Bio-filter.

Anaerobic treatment: Process microbiology and biochemistry; application for treatment of sewage, advantage and disadvantages. Concept of Common Effluent Treatment Plant (CETP). Floating aquatic plant system and its design and operation.

Sludge characteristics and disposal methods: design and operation of sludge drying bed. Design and operation of treatment plant. Trouble shooting and trouble free operation. Sources and characteristics of industrial wastewater, effects on environment. Standards related to industrial wastewater. Waste volume reduction, waste strength reduction, neutralization, equalization and proportioning. Advanced wastewater treatment. Industry specific wastewater treatment for chloro-alkali, electroplating, distillery, tannery, pulp and paper, fertilizer, etc. Treatment technology of coal washery and coke oven effluents. Acid mine drainage: Occurrence, effects and treatment technologies.

Books & References:

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

ES C52103 Solid & Hazardous Waste Management & Land Reclamation [3-1-0]

Solid and Hazardous Waste Management: Municipal solid waste management: Engineering principles; sources, nature and characteristics; quantitative and qualitative; Solid waste problems: Industrial (Ash dyke, Sedimentation), mining (OB dump, Tailing Dam), refineries and petrochemical plants, agricultural and domestic (urban) wastes. Hydrologic aspects of solid waste. Regulatory aspects of solid waste management.

Solid waste disposal: Sanitary landfill planning, site selection, design and operation, equipment, costs, aerobic landfill stabilization. Biological oxidation. Composting, optimum conditions for composting. Pyrolysis; Incineration - waste characterization, combustion calculation, unit operations, supply of air, products of combustion, furnace temperature, furnace calculation, storage of refuse, waste reduction and environmental control.

Biomedical waste categorization, generation, collection, transport, treatment and disposal.

Hazardous waste landmark episodes, classification, generation. Guidelines for HWM. Regulatory framework in the USA, EU and India, Basal convention and other international statistics. Treatment and disposal; remediation of contaminated sites.

Reclamation and ecological restoration of degraded land: Physical/technical reclamation: Top soil management- inventory, removal, transportation, preservation and redistribution; monitoring of top soil quality, shelf life of topsoil; slope stability and drainage, estimation of soil erosion, sediment load and design of sedimentation pond. Soil amendment, mulches and coir mats; principles of ecological restoration, SERI guidelines; factors affecting plant establishment and growth. Mine soil characteristics: physical, chemical and biological; programmes and planning of vegetation cover development; establishment of grass-legume cover; application of Bio-fertilizer. Monitoring and aftercare of restored site; evaluation of restoration success and indicator parameters. Reclamation equipments and cost.

Mine closure: planning – environmental impacts of mine closure, development of closure plan, closure guidelines, mine closure activity, closure cost.

Mine Tailings Management: Reclamation of tailings impoundments etc.

Current bioremediation practice and application; factors influencing bioremediation, bioremediation system and process, In situ bioremediation.

Books & References:

1. Ecorestoration of the coalmine degraded lands – Subodh Kumar Maiti, Springer, 2013.
2. Quarry Reclamation - NJ Coppin and AD Bradshaw, Mining Journal Books, London, 1982.
3. Hazardous Waste Management (2nd ed) - Lagrega, MD, PL Buchingham and JC Evans, McGraw Hill, NY, 2001.
4. Bioremediation Principles - JB Eweis, SJ Ergas, DYP Chang and ED Schroeder, McGraw-Hill, Singapore, 1998.

Introduction: General principles of air pollution control, aerosols – Size distribution of aerosols, physical and chemical properties, and particle dynamics – Terminal settling velocity, slip correction factor, stopping distance and removal mechanism.

Control device for Particulates: Types and classification of control device for particulates, design aspects of control device, selection criteria, concepts of removal efficiency and calculation basics of flue gas and control device. Design and operation of gravity settling chambers, efficiency of settling chambers using plug flow and mixed flow models. Cyclone separators: Concept, types and cut diameter, design equations, and pressure drop. Design and operation of fabric filters, ESP, wet dust scrubber.

Control device for gaseous pollutants: Absorption – Types, two-film theory, mechanism, concept of equilibrium curve, application of mass balance, design of L/G, diameter and height of tower. Application of adsorption and condensation for control of pollutants and their design. Thermal incinerators – principles, types, design equations using energy balance approach, SCR and SNCR.

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 NO_x, concept of IGCC and CCS. Control of motor vehicle emissions; Indoor air pollution control.

Books & References:

1. Air pollution control equipment calculations - L Theodore, John Wiley & Sons, Inc., Hoboken , New Jersey, 2008
2. Air Pollution Control Equipment – H Brauer and YBG Verma, Springer-Verlag, Berlin Heidelberg, NY, latest Ed.
3. Environmental Pollution Control Engineering - CS Rao, Wiley Eastern Ltd., New Delhi, 1996.
4. Air Pollution- Its Origin and Control - K Work and CF Warner, IEP, New York, latest Ed.
5. Air Pollution Control Engineering - Noel de Nevers, McGraw Hill, Singapore, 1995.

ELECTIVES

ES E521 01 Remote Sensing and GIS

[3-0-0]

Definition and overview of Remote Sensing history and evolution of Remote Sensing and Remote Sensing systems.

Electromagnetic Radiation, terms and definitions, laws of radiation, EM spectrum, interaction between EM radiation and matter, reflection, absorption and transmission, interaction between EM radiation and atmosphere, atmospheric windows.

Remote Sensing systems – Active and passive systems, imaging and non-imaging systems, concept of resolutions in RS – Spatial, spectral, radiometric and temporal; Orbits and remote sensing platforms for earth observation, earth observation satellites (LANDSAT, SPOT, IRS, IKONOS, world view and sensors for stereo data {MOMS, CARTOSAT}) and their characteristics. Satellite imaging modes and geometric errors; image quality & structures.

Aerial photography/aerial photo interpretation; Digital Image Processing, Digital Image Structure; Image processing functions: Image Restoration, Image Enhancement, Image Transformation; Image Classification and Accuracy Assessment: Supervised Classification, Unsupervised Classification. Spatial Information System: An Overview, Projections in GIS. GIS data types: Raster Geographic data representation, Vector Data Representation, Object-Oriented Geographic Data.

Introduction to Spatial Analysis: Preparation of Thematic Maps from Remote Sensing Data. Spatial Interpolation, Terrain Mapping and Analysis: DEM, TIN, slope and aspect, Viewsheds and Watersheds.

Integration of Remote Sensing and GIS: Environmental Applications, Suitability Analysis, Risk Analysis, Hazard Analysis etc.

Fundamental Concepts of GPS: Types of GPS, GPS Satellite, Applications of GPS in resource surveys, mapping and navigations.

Books & References:

1. Hydrologic and Hydraulic Modeling support with Geographic Information Systems - D Maidment and D Djokic (ed), ESRI Press, 2002.
2. Arc Hydro: GIS for Water Resources - D Maidment, ESRI Press, 2002
3. Rainfall runoff Modeling - KJ Beven, Wiley & Sons, 2001
4. Essential Image Processing and GIS for Remote Sensing - JG Liu, and PJ Mason, Wiley – Blackwell, 2009.
5. Concepts and Techniques of Geographic Information Systems (2nd ed.) - CP Lo, and AKW Yeung, Prentice Hall, 2006.
6. Principles of Geographical Information Systems - PA Burrough and RA. McDonnell, OUP, Oxford, 1998.
7. Geographic Information System - KT Chang, Tata McGraw-Hill, Publication Edition, 2002.

ES E 521 02 Noise Control Engineering

[3-0-0]

Noise measurement techniques and analysis: Worksite, ambient and road transport. Noise prediction, modelling and mapping. Noise impact assessment: Schultz fractional, Impact method; Value function curves. Noise abatement measures - Sound absorption, acoustic barrier, vibration isolation, vibration damping, muffling, personal protector and green belt- Principles and design considerations. Noise pollution and management in mines, washeries, power plants, fertilizer plants, cement plants, etc. Human vibration- whole body vibration problems in opencast mines, health effects and control measures.

Ground vibration and air blast, environmental and health effects; strategic control, abatement measures and noise exposure.

Books & References:

1. Industrial Noise Control and Acoustics - RF Barron, Marcel Dekker, Inc., New York, 2003.
2. Engineering Noise Control: Theory and Practice - D Bies et al., Routledge Publishers, 2003.
3. Vibrations - B Balachandran, and EB Magrab, Thomson Asia Pte. Ltd., Singapore, 2003.
4. Vibrations from Blasting – D Siskind, International Society of Explosives, 2000.
5. Noise control: Principles and Practice (2nd ed.) – Bruel, and Kjaer, B & K Publisher, Denmark, 1986.

ES E 521 03 Environmental Economics and Socio-Economic Planning

[3-0-0]

Environmental Economics: Economy and environment - The historical development of environmental economics; circular economy and sustainable economy. Economics of pollution;- The optimal level of pollution, the market achievement of optimal pollution, Taxation and optimal pollution, Environmental standards, Taxes and subsidies, Marketable pollution permits, Measuring environmental damage -Total economic volume and valuation methodology, pollution control policy in mixed economies. Environmental Values Ethics; discounting the future, alternative to adjusting discounting rates.

Economics of natural resources -Renewable resources, extinction of species, optimal use of exhaustible resources measuring and mitigating natural resource scarcity. Development and environment- development, preservation and conservation, irreversibility and sustainability, environment and the developing countries. Carrying capacity based development planning. Cost benefit analysis of environmental change; appraisal of sustainable development projects; principles of cost allocation, preventive, punitive and social costs.

Socio-economic Planning: Importance of socio-economic development planning. Social indicators and their importance; social impacts of industrial and developmental activities. Quality of life concept- and its use in development planning. Social surveys and socio-economic data generation. Social cost of environmental pollution. Rehabilitation and resettlement of project affected people. Laws related to social development. Corporate Social Responsibility (CSR), different models; Social Accountability (SA) 8000; certification.

Books & References:

1. Values for the Environment: A Guide to Economic Approach – JT Winpeny, Overseas Development Institute, London, HMOS, 1991.
2. Economic Analysis of Environmental Impacts - D John, LF Scura, RA Carpenter, and PB Sherman, Earthscan Publications Ltd., London 1995.
3. Environmental Assessment Source Book (Vol. 1) World Bank, Environment Department, Washington DC, The World bank, 1991.
4. Valuing the Environment – J Barde and DW Pearce (Ed.), Earthscan Publication, London, 1991.

ES E521 04 **Advanced Wastewater Engineering**

[3-0-0]

Biological nutrient removal: Nitrogen removal: nitrification, denitrification, processes for biological nitrogen removal, phosphorous removal mechanism; application of phostrip, bardenpho and phoredox process. Combined N and P removal by A2/O, bardenpho, UCT and VIP process. N&P removal in SBR.

Membrane Separation: Membrane process terminology & classification, Materials, membrane configuration, membrane operation, ultrafiltration, reverse osmosis, microfiltration, Nanofiltration: Applicability, limitations, advantages and disadvantages, membrane fouling, electro dialysis, membrane bioreactors.

Adsorption: Types of adsorbents, fundamentals of adsorption, adsorption isotherm, activated carbon adsorption kinetics, activated carbon treatment.

Ion Exchange: Fundamentals of ion exchange, types of ion exchange resins, general characterization of ion exchange resins, theory and application of ion exchange.

Advanced Oxidation Process: Theory of advanced oxidation, technologies used to produce hydroxyl radicals, applications.

Sludge handling and disposal: Sludge processing steps- Preliminary operations, thickening, stabilization, conditioning, dewatering, heat drying and thermal reduction. Aerobic and anaerobic sludge digestion microbiology and design, land application of sludge and design consideration. Sludge storage, land application of domestic sewage and ground water recharge.

Books & References:

1. Wastewater Engineering: Treatment, disposal, Reuse (4th ed.) - Metcalf & Eddy Inc. Tata McGraw-Hill, New Delhi, 2003.
2. Wastewater Treatment for Pollution Control (2nd ed.) - SJ Arceivala, Tata McGraw-Hill, 1998.
3. Wastewater Treatment Plants: Planning, Design and Operation Holt - SR Qasim, Rinehart & Winston, NY, 1985.
4. Wastewater Treatment - DW Sunderstorm and HE Klei, Prentice-Hall, Englewood Cliffs, NJ, 1979.
5. Biological Wastewater Treatment: Theory and Application - CLP Grady, and HC Lim, Marcel Dikker, NY, 1980.

ES E 521 05 Climate Change and Modeling

(3-0-0)

Introduction to Climate system; Global energy balance, assessment, MAGICC energy balance model.

Causes of climate change, climate feedback mechanisms, Climate modeling: importance and significance, types of models, history of climate models, sensitivity, parameterization.

Energy balance models: Energy balance models and glacial cycles, box models, convective adjustment, radiative-convective models, two dimensional models, models of intermediate complexity, general circulation modeling of the atmosphere, ocean, and cryosphere, land surface modeling.

Modeling of atmospheric chemistry, coupled modeling, working with climate models, climate model evaluation, climate model predictions and policy, volcanic eruptions; detection and attribution of anthropogenic forcing.

Books & References:

1. *Climate Change and Climate Modeling* - JD Neelin, Cambridge University Press, 2010.
2. *Climate Change and the Kyoto Protocol: The Role of Institutions and Instruments to Control Global Change* - MG Faure, J Gupta, and A Nentjes, Edward Elgar Publishing, 2003.
3. *Physics of Climate* - JP Peixoto, and AH Oort, American Institute of Physics, NY, 520 pp, 1992.
4. *Global Physical Climatology* - DL Hartmann, Academic Press, San Diego, 411 pp, 1994.
5. *An Introduction to Three-Dimensional Climate Modeling* (2nd ed.) - WM Washington, and CL Parkinson, Univ. Science Books, Mill Valley, CA, 353 pp.
6. IPCC Fourth Assessment Report (AR4), 2007.

ES E 521 06 Life Cycle Assessment

[3-0-0]

Introduction of LCA, benefits of conducting LCA, limitation of conducting LCA.

Components of LCA: Goal and scope, functional unit, system boundaries, data quality, critical review process.

Inventory analysis: Data collection, defining system boundaries, calculation procedures, validation of data, relating data, allocation and recycling.

Impact assessment: Category definition, classification, characterisation, valuation/weighting.

Interpretation: Identification of significant environmental issues, evaluation, conclusions and recommendations.

Applications of LCA: Solid waste management, cement industry, water management, mining sector etc.

Books and Reference:

1. *Life Cycle Assessment -A guide to approaches, experiences and information sources* - AA Jensen, L Hoffman, BT Møller, A Schmidt, European Environmental Agency, 1997.
2. *Life Cycle Assessment: Principles and Practice - Scientific Applications International Corporation and MA Curran, National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, 2006.*
3. *Integrated Solid Waste Management: A Life Cycle Inventory* (2nd ed.) - FR McDougall, PR White, M Franke, and P Hindle, Wiley, 2001.

ES E 521 07 Environmental Biotechnology**[3-0-0]**

Introduction to environmental biotechnology, cell genetic material, Nucleic acid-based methods of analysis- Extraction of nucleic acids from environmental samples, Polymerase chain reaction- Steps of PCR, design of primers, PCR detection of specific and universal genes, RT-PCR, real-time PCR, Recombinant DNA techniques- Cloning, metagenomics, sequence analysis, comparative genomics.

Bacterial genetic recombination, recombinant DNA technology, applications in environmental engineering.

Bioremediation for soil environment- Biotechnologies for *ex-situ* and *in-situ*, remediation of soil, phytoremediation technology for soil decontamination.

Bioremediation for water environment- *ex-situ* decontamination of groundwater, *in-situ* Bioremediation of groundwater, landfill leachate, Industrial wastewater Biotreatment technologies, Biotreatment of surface waters. Biotreatment of metals- microbial transformation of metals, Biological treatment technologies for metals remediation, Bioleaching and Biobeneficiation, Bioaccumulation, oxidation/reduction processes, biological methylation.

Bioremediation for air environment- atmospheric environment for microorganisms, microbial degradation of contaminants in gas phase, Biological filtration processes for decontamination of air stream, Bioscrubbers.

Books & References:

1. Environmental Biotechnology: Principles and Applications (1st ed.), BE Rittmann and PL McCarty, McGraw-Hill Publishing Co., 2001.
2. Environmental Biotechnology, B Bhattacharya and R Banerjee, OUP, 2008.
3. Microbiology (2nd ed) - LM Prescott, JP Harley, and DA Klein, Wm. C. Brown Publishers, Dubuque, Iowa, 1993.

ES E 521 08**Renewable Energy****[3-0-0]**

Renewable Energy Sources: Introduction, Solar Energy, Principle of Wind Energy Conversion. Tidal and geothermal Energy and Bio-Energy.

Wind Energy and its Utilization: Wind energy scenario in India, properties of wind, wind velocity and wind rose diagram, estimation of power in wind; Types of wind turbines, characteristics, construction of wind mills; Aerodynamic considerations of wind mill design, wind stream profile, rotor blade profile and cross section; Drive system-gears, wind electric generators, regulating and control systems for wind mills; Performance evaluation and recent technologies of wind energy conversion system; Wind energy potential estimation and site selection; wind farms, cost estimation of the energy from wind energy conversion system.

Solar Energy and Its Utilization: Solar radiation spectrum; The Photo Voltaic effect; Spectral response; p-n junction; different types; characteristics; temperature effect; Photovoltaic modules; Battery storage; Charge regulators, Solar thermal collectors applications: solar ponds; dryers; distillation; solar cooker. Passive Solar design.

References

1. Pillai, G.M., "Wind Power Development in India", Part-II, Shailesh Art Print.
2. Sorensen, B., "Renewable Energy", Academic Press.

3. Burton, T. et al, "Wind Energy Handbook", John Wiley and Sons Ltd.
4. Lysen, E.H.A., "Introduction to Wind Energy", Franklin Institute Press.
5. Boyle, G., "Renewable Energy Power for a Sustainable Future", Oxford University Press.
6. Bansal, N.K., Kleemann, M. and Heliss, M., "Renewable Energy Sources and Conversion Technology", Tata McGraw-Hill Publishing Company.

ES E 521 09 Environmental Management System

[3-0-0]

Introduction and formulation of ISO Guidelines in environmental management systems; ISO 14001 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. Preparation of ISO manuals for industry; integrating ISO 9000, ISO 14001 and OHSAS 18001; case studies

Quality Assurance (QA) and Quality Control (QC). OHSAS 18001.

Books and References:

1. Planning and Implementation of ISO14001, Environmental Management System- G Gyani and A Lunia, Raj Publishing House, Jaipur, 2000.
2. ISO 14001 Auditing Manual - G Woodside, and P Aurrichio, McGraw- Hill, 1999.
3. An Introduction to Environmental Audit - RD Tripathi, Alpha Publications, 2009.
4. "The ISO: 14000 Handbook" – J Caseio (Ed), Published - CEEM Information Services. 2000
5. A Guide to the Implementation of the ISO: 14000 Series on Environmental Management - I Ritchie, and W Hayes, Prentice Hall, New Jersey, 1998.
6. OHSAS & SA Guidelines.

PRACTICALS

ES C5 22 01 Wastewater Engineering (Practical)

(0-0-2)

Determination of TS, TSS, TDS, volatile solids, MLSS and MLVSS. Determination of TKN, Nitrite & Nitrate. Determination of the phosphorus and sulphate. Determination of BOD, COD, TOC, DO and their relationships. Determination of optimum dose of coagulant by Jar-Test. Determination of Sludge Volume Index (SVI) and development of sludge settling characteristics curve.

ES C 522 02 Solid and Hazardous Waste Management & Land Reclamation (Practical)

(0-0-2)

Sample preparation; sampling techniques; coning and quartering method; overburden and other wastes sampling. Profile sampling. Characterisation of Solid Waste, Proximate and Ultimate Analysis, Calorific Value. Determination of coarse fraction, pH & buffered pH, KCl & CaCl₂ solution; EC & CEC; exchangeable Na & K; non-exchangeable K & HNO₃-soluble-K. ESP and SAR. Mineralisable -N and total nitrogen in profile samples. Determination of organic matter and organic carbon C: N ratio; Determination of plant available P and total P; Analysis of toxic elements. DTPA-extractable micronutrients and trace elements in OB samples; Leachate Analysis.

THIRD SEMESTER PROJECT WORK [40 CR]

A candidate after passing the qualifying examination shall undertake an Industrial training / Minor project work under the supervision of a faculty member of the ESE. An interim report on dissertation topic has also to be submitted and will be evaluated by an Examination Board constituted for this purpose.

SI No.	Subject Code	Name of the Course	Total Credit Hours
1.	ESC 536 01	Industrial Training/ Minor Project	4
2.	ESC 534 02	Seminar and Viva-voce on Industrial Training/ Minor Project	2
3.	ESC 535 03	Comprehensive Viva-voce (to be conducted at the end of II Semester, marks to be added while computing III Semester GPA)	4
4.	ESC 538 04	Dissertation (Interim)	15
5.	ESC 534 05	Seminar and Viva-voce on Dissertation	10
6.	ESC 530 06	Evaluation of Teaching Assignment/ Laboratory Development Work etc.	05
		Total	40

FOURTH SEMESTER PROJECT WORK [40 CR.]

On the completion of dissertation work each student has to submit for examination, a dissertation embodying the result of the research work carried out by him/her. The viva-voce examination will be conducted by a Board of Examiners to be constituted by ISM.

SI No.	Subject Code	Name of the Course	Total Credit Hours
1.	ESC 548 01	Dissertation	20
2.	ESC 544 02	Seminar on Dissertation	5
3.	ESC 545 03	Viva-voce on Dissertation	10
4.	ESC 540 04	Evaluation of Teaching Assignment/ Laboratory Development Work etc.	5
		Total	40