Department of Earth and Environmental Studies

M. Tech. Curriculum

FIRST SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	ES1001	Fundamentals of Environment and Sustainability	3-1-0	4
2	ES1002	Environmental Chemistry	3-1-0	4
3	ES1003	Treatment and Management of water and waste water	3-1-0	4
4		Elective I	3-1-0	4
5		Elective II	3-1-0	4
6	ES1051	Environmental Analysis (Sessional)	0-0-4	2
7	ES1052	Microbiology and Waste water Engineering Practical	0-0-4	2
TOTAL				**24**

SECOND SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	ES2001	Air and Noise pollution Quality and Control	3-1-0	4
2	ES2002	Solid, Nuclear and Hazardous waste Management	3-1-0	4
3		Elective – I	3-1-0	4
4		Elective –II	3-1-0	4
5		Elective –III	3-1-0	4
6	ES2051	Air and Noise monitoring and analysis, VISIT to Industries	0-0-2	1
7	ES2052	Environmental Lithology, RS & GIS Practical	0-0-4	2
8	ES2053	Project I	0-0-2	1
TOTAL				**24**

THIRD SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	ES3051	Project II	0-0-0	11
2	ES3052	Seminar-I	0-0-0	2
TOTAL				**13**

FOURTH SEMESTER

Sl. No	Sub. Code	Subject	L-T-P	Credits
1	ES4051	Project III	0-0-0	11
2	ES4052	Seminar-II& Viva-voce	0-0-0	3
TOTAL				**14**

TOTAL CREDIT POINT: 75

Sub Discipline: DEPARTMENTAL ELECTIVES

ELECTIVES FOR SEMESTER – I

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
ES9011	Mining and the Environment	3-1-0	4
ES9012	Environmental Geology and soil conservation	3-1-0	4
ES9013	Remote sensing and GIS	3-1-0	4
ES9014	Green Chemistry / Technology	3-1-0	4

ELECTIVES FOR SEMESTER – II

SUBJECT CODE	SUBJECT	L-T-P	CREDIT
ES9015	Hydrogeology and Watershed Management	3-1-0	4
ES9016	Natural Hazards and Disaster Management	3-1-0	4
ES9017	Environmental Management	3-1-0	4
ES9018	Noise control Engineering	3-1-0	4
ES9019	Numerical methods and Modelling of Environmental Systems	3-1-0	4
ES9020	Environmental Radio-chemistry	3-1-0	4
ES9021	Environmental Biotechnology	3-1-0	4

Sub Discipline: LABORATORY& SESSIONAL COURSES

ES1051	Environmental Analysis (Sessional)	0-0-4	2
ES1052	Microbiology and Waste water Engineering Practical	0-0-4	2
ES2051	Air and Noise monitoring and analysis, VISIT to Industries	0-0-2	1
ES2052	Environmental Lithology, RS & GIS Practical	0-0-4	2

Sub Discipline: PROJECT, SEMINAR etc.

ES2053	PROJECT-I	0-0-2	1
ES3051	PROJECT-II		11
ES3052	Seminar-I		02
EST 4051	Project III		11
EST 4052	Seminar-II& Viva-voce		03

DETAILED SYLLABI OF COURSES

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES1001	**Fundamentals of Environment & Sustainability**	**3-1-0**	**4**	Dr. K. Adhikari, Prof. A.De

Environment as an idea, Environmental interrelationship, Environmental ethics.; Earth as a system – systems & feedbacks, Environmental unity, Uniformitarianism, Changes and equilibrium in systems, Ecology &Ecosystem, Biodiversity, The biogeochemical cycles; Segments of environment of earth – Atmosphere, Lithosphere, Hydrosphere and Biosphere. **[10]**

Materials balance; Mathematics of Growth; Energy and Environment; Current environmental issues. **[7]**

Sustainability, Sustainable development – Sustaining Living Resources, Sustainable Energy, Sustainable Future. **[8]**

Fundamentals of microbiology; Degradation or Monitoring of pollutants from a Biological origin ; Microbes and Metabolism, Microbial diversity, Metabolic pathways of particular relevance to Environmental Biotechnology; Viruses, Bacteria, and Fungi, Protozoan and Helminthes, Ectoparasites and Rodents; Freshwater environments: the influence of physico-chemical conditions on microbial communities. **[10]**

Biological systems in Environment : Extremophiles, Thermophiles, Xenobiotics; Microbiology of wastewater treatment, Biotechnology in wastewater treatment, Microbiology of drinking water treatment, Microbiology and public health aspects of wastewater effluents and bio-solids. **[10]**

Text books :

1. *Microbiology, Michael J Pelczar Jr, ECS Chan, Noel R Kraig, 5th edition, 2001, Publisher : McGraw Hill Education, ISBN-10: 0074623206, ISBN-13: 97800746232206*

Reference books :

1. *Introduction to Environmental Engineering and Science, Gilbert M Masters & Wendell P Ela, 3rd Edition, June 2015, Publisher : PHI Learning, ISBN-10: 9332549761, ISBN-13: 9789332549760*
2. *Fundamentals of Ecology, Eugene P Odum, 5th Edition, July 2004, Publisher: Cengage Learning, ISBN-10: 0534420664, ISBN-13: 978-0534420664*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES1002	**Environmental Chemistry**	**3-1-0**	**4**	Dr. R.N. Saha

Natural and anthropogenic sources, inorganic pollutants (SO, NOx, CO, CO2, hydrocarbon, SPM).Classification of elements, particles, ions, radicals in the atmosphere. **[10]**
Chemical processes for formation of inorganic and organic particulate matter.; Toxic chemicals in the environment (pesticides, insecticides, carbon monoxide, ozone, PAN, MIC, PAH, carcinogens) **[12]**

Principles and application of analytical techniques – titrimetry, grarvimetry, Solvent extraction, colorimetry, spectrophotometry, chromatography, gas chromatography, HPLC, GC-MS, atomic absorption spectroscopy, ICP-AES, flame photometry, electrophoresis, X-ray fluoresence, X-ray diffraction; Stoichiometry, **[8]**

Gibbs energy, chemical potential, chemical equilibria, acid base reactions, buffers and buffer index, pE-pH diagrams, redox potential, solubility product, solubility of gases in water, the carbonate system **[8]**

Biochemical and speciation aspects of Arsenic, cadmium, lead and mercury. **[7]**

Text books :

1. *Solutions Manual for Environmental Chemistry, Colin Baird and Michael Cann, Publisher: W. H. Freeman; 5th edition (May 7, 2012),ISBN-10: 1464106460 ISBN-13: 978-1464106460*
2. *Chemistry Fundamentals: An Environmental Perspective. Phyllis Buell and James Girard Publisher: Jones & Bartlett Publishers; 2nd edition (April 2002),ISBN-10: 0763710741,ISBN-13: 978-0763710743*

Reference books :

1. *Elements of Environmental Chemistry,Ronald A. Hites&Jonathan D. Raff,Publisher: Wiley; 2nd edition (April 24, 2012),ISBN-10: 1118041550, ISBN-13: 978-1118041550*
2. *Chemistry for Environmental Engineering and Science,Clair Sawyer , Perry McCarty& Gene Parkin,Publisher: McGraw-Hill Education; 5th edition (August 27, 2002),ISBN-10: 0072480661, ISBN-13: 978-0072480665*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES1003	**Treatment and Management of Water and Wastewater**	**3-1-0**	**4**	Dr. Susmita Datta, Dr. Sandip Mondal

Root causes of degradation of water resources, Water resource management issues; Compliance of environmental regulations and ethics in water resource management; Drinking water standards and wastewater characteristics, Sources of water pollution: groundwater and surface water. **[8]**

Treatment options and selection of appropriate methods; Physico-Chemical treatment: Filtration, Coagulation, Flocculation and settling, Chemical precipitation, Design of Flocculator, settler **[12]**

Biological treatment: Activated sludge process – basics of operation and trouble shooting, Design of activated sludge treatment system. **[9]**

Trickling filter: Basic operation and trouble shooting, Designing Trickling filter system, Lagoons and Reed bed treatment basics, Lagoon design, submerged aerated filters-upward flow, **[8]**

Anaerobic sludge blanket system: Operation and Principle; Sludge disposal and treatment; Ion-exchange; Disinfection of water; Membrane separation. **[8]**

Text books :

1. *Wastewater Engineering-Treatment and Reuse.Metcalf& Eddy, 4th edition, McGraw-Hill, 2003; Publisher: McGraw-Hill Science/Engineering/MathISBN-13: 978-0070418783, ISBN-10: 0070418780.*

Reference books :

1. *Fundamentals of Water Treatment Unit Processes: Physical, Chemical, and Biological. David Hendricks.Publisher: CRC Press/ IWA Publishing, 2011; ISBN-10: 1420061917, ISBN-13: 978-1420061918.*
2. *Environmental Engineering.HowardPeavy, Donald Rowe, George TchobanoglousPublisher: McGraw Hill Education (India) Private Limited; First edition (1 August 2013);ISBN-10: 9351340260, ISBN-13: 978-9351340263*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES1051	**Environmental Analysis**	**0-0-4**	**2**	Dr. R.N. Saha

Analysis of water and water quality parameters- Concept of pH, Measurement of acidity, alkalinity **[6]**

Measurement of hardness, residual chlorine, chlorides, DO, BOD, **[6]**

Measurement of DO, BOD, COD, Fluoride **[6]**

Phosphate-P, Sulphate, turbidity, phenol, cyanide, Different form of nitrogen. **[6]**

Analysis of Soil: soil pH, N:P:K ratio, Organic carbon **[6]**

Text books :

1. *Wastewater Engineering-Treatment and Reuse. Metcalf& Eddy, 4th edition, McGraw-Hill, 2003; Publisher: McGraw-Hill Science/Engineering/MathISBN-13: 978-0070418783, ISBN-10: 0070418780.*

Reference books :

1. *Practical Environmental Analysis. MiroslavRadojevic& Vladimir N. Bashkin, Publisher: Royal Society of Chemistry; 2nd edition (April 26, 2006),ISBN-10: 0854046798, ISBN-13: 978-0854046799*
2. *Practical Manual of waste water chemistry. Barbara A. Hauser,Publisher: CRC Press, 1st edition (June 1, 1996).ISBN-10: 1575040123 ISBN-13: 978-1575040127*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES1052	**Microbiology and Waste Water Engineering Practical**	**0-0-4**	**2**	Dr. Susmita Datta, Dr. Sandip Mondal

Lab safety and General introduction, Briefing of Lab Equipments, Analysis of micro-organism present in drinking water, Method of Culturing of Microorganisms. **[6]**

Analysis of micro-organism present in sediment / soil of waste water treatment (biological) area, Gram Staining, **[6]**

Evaluation of Activated Sludge process through useful parameters like MLSS, MLVSS, SVI, HRT, N/P RATIO, DO, BOD, COD, Specific pollutants, calculation of treatment efficiency. **[9]**

Studies on metal inhibition on immobilized enzyme; Demonstration and experiment of Nano filtration / Membrane filter. **[6]**

Demonstration and application of HPLC, GC, AAS, Ion Meter for waste water analysis. **[3]**

Text books :

1. *Practical Microbiology by R.C. Dubey&D.K. Maheshwari, S Chand & Co Ltd; 5 edition. ISBN-10: 8121921538, ISBN-13: 978-8121921534.*

Reference books :

1. *Experiments in Microbiology, Plant Pathology and Biotechnology by K.R. Aneja. NEW AGE Publisher. ISBN-10: 812241494X, ISBN-13: 978-8122414943.*
2. *Textbook of Practical Microbiology by Subhash Chandra Parija, Ahuja Publishing House. ISBN-10: 8189443062, ISBN-13: 978-8189443061.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES2001	**Air and Noise Pollution Quality and Control**	**3-1-0**	**4**	Dr. K. Adhikari, Dr. S. Datta, Prof S. Bhattacharya

Air qualities and their pollution parameters; Sampling and measurement of air pollution parameters: Ambient air sampling, Stack sampling, Monitoring equipment, Analysis of air pollutants. **[8]**

Meteorology of Air pollution control Engineers: Solar radiation, Heat balance, Wind velocity, Wind rose, Turbulence, Wind profile, Humidity, Temperature; Atmospheric stability: Lapse rate, Inversion, Plume shape, Maximum mixing depth, Air pollution concentration model, General ideas in Air Pollution Control. **[12]**

Air pollution control methods, equipment, design and engineering: Particulate emission control – Gravity settling chamber, Cyclone separator, ESP, Bag filter, Venturi scrubber. **[8]**

Control of gaseous emission; Control of specific gaseous pollutants – Control of VOC, Control of NO_X, Control of SO_X, Control of CO &CO_2; Pollution from mobile sources, problems, effects, testing and control, preventive measures. **[9]**

Noise – sources, measurements, effects and occupational hazards, Standards, Noise mapping, Noise attenuation, Prediction equations, Control measures, Legal aspects of noise. **[8]**

Text books :

1. *Environmental Engineering. Arcadio P. Sincero and Gregoria A. Sincero; 1st edition (August 18, 1995), Publisher: Prentice Hall; ISBN-13: 978-0024105646, ISBN 10: 0024105643.*

Reference books :

1. *Environmental Pollution Control Engineering. C.S. Rao; 2nd Edition, Publisher: New Age International, 2006; ISBN-13:9788122418354, ISBN-10:812241835X.*
2. *Air Pollution Control Equipment. H. Brauer and Y. B. G. Verma; latest edition; Publisher: Springer, 1981; ISBN-13:9783540104636, ISBN-10:3540104631.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES2002	**Solid, Nuclear and Hazardous waste Management**	**3-1-0**	**4**	Dr. K. Adhikari, Dr. R.N. Saha

Solid waste sources: Industrial, Mining, Agricultural and Domestic (Urban) wastes. Municipal solid waste management: Waste generation, collection, storage, transfer, processing (including composting of organic waste), treatment and disposal. **[10]**

Solid waste characterization and reduction, reuse and recycling, resource recovery and utilization; Life cycle assessment of waste. **[08]**

Landfill design and operation: site selection, design and operations, equipments, costs, liner and covers, leachate control and treatment, gas recovery and control, landfill monitoring and reclamation; Incinerator. **[12]**

Biomedical waste categorization, generation, collection, transport, treatment and disposal. **[08]**

Hazardous waste: Characteristics including classification and generation, Collection, Treatment, Monitoring, Disposal; Remediation of contaminated sites; Radioactive waste management. **[07]**

Text books :

1. *Solid and Hazardous Waste Management. S.C. Bhatia, Publisher: Atlantic Publishers & Distributors (P) Ltd., 2007. ISBN-13: 9788126908141, ISBN-10: 8126908149.*

Reference books :

1. *Integrated Solid Waste Management: Engineering Principles And Management Issues. Tata McGraw-Hill publisher, ISBN-10:9339205243, 13:9789339205249.*
2. *Solid and Hazardous Waste Management, M.N. Rao, Razia Sultana, Publisher: BS Publication, ISBN 10:9381075778, ISBN 13:9789381075777.*
3. *Integrated Solid waste management, George Tchobangolous, Hilary Theisen, Samuel Vigil. Mcgraw-Hill Inc. ISBN 0-07-112865-4*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES2051	**Air and Noise Monitoring and Analysis, VISIT to Industries**	**0-0-2**	**1**	Dr. K. Adhikari, Dr. R.N. Saha

Demonstration of air pollution monitoring instruments; Determination of SPM **[6]**

Determination of SOx, NOx and CO in ambient air **[6]**

Wind rose diagram; Stack monitoring. **[6]**

Demonstration of noise pollution monitoring equipment; Development of noise contour diagram in a locality through noise survey **[6]**

Traffic noise situation monitoring **[6]**

Text books :

1. *Handbook of methods in environmental studies (Volume No. 2).Author: S. K. Maiti. Publisher: Oxford Book Company, 2011; ISBN-13: 9789350300053, ISBN-10: 9350300052.*

Reference books :

1. *Air analysis- a practical treatise on the examination of air. Author: James Alfred Wanklyn. Publisher: Nabu Press (September 6, 2011); ISBN-13: 978-1179653167, ISBN-10: 1179653165.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES2052	**Environmental lithology, RS & GIS Practical**	**0-0-4**	**2**	Dr. K. Adhikari, Prof S. Bhattacharya

Analysis of satellite imagery with reference to landuse and landcover analysis **[12]**

Elements of digital image processing **[9]**

Preparation of thematic maps including overlaying using GIS **[9]**

Text books :

1. *Remote Sensing and GIS - Anji Reddy M., The Book Syndicate, Hyderabad, 2000.ISBN: 978-81-7800-135-7, 81-7800-135-7*

Reference books :

1. *Principles of Geographical Information Systems - P A Burrough and R. A. McDonnell, OUP, Oxford, 1998.ISBN-10: 0198233655,ISBN-13: 978-0198233657*
2. *Geographic Information System- Kang Tsung Chang, Tata Mc Graw Hill, Publication Edition, 2002. ISBN- 0071267581 9780071267588*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9011	**Mining and Environment**	**3-1-0**	**4**	Dr. K. Adhikari

Overview**:** History of environmental problems in mines and present environmental scenario; Environmental Parameters and Standards**:** Baseline data, Impact of mining activities on environmental parameters, Mitigating measures, monitoring and control. National and international standards and regulations. **[9]**

Environmental Parameters**:** Water quality – physical, chemical, biological, criteria and standards, Classification and chemistry of major air pollutants. Soil chemistry – nature and importance of soil, soil properties, soil amendments. **[8]**

Waste Management **:** Chemical aspects of environmental pollution by mine wastes and their impact, Production and characterization of solid wastes in different types of mines, Generation and characterization of mine effluents and leachate, Management of different types of mine wastes, **[8]**

Ventilation Planning **:** Central and boundary ventilation, Ventilation schemes for various methods of working, Estimation of the operating pressure and air quantity requirements of mine, Preparation of ventilation plans for underground mines, Control of heat and humidity through air quantity regulation and refrigeration, Control of dust, fumes and other pollutants. **[8]**

Environmental Hazards In Mines**:** Mine Fires, Explosions, Inundation, Mine Occupational Diseases – Causes, Detection, monitoring and control. Disaster Management **-** Emergency organization, Developments in rescue, reviving and resuscitating apparatus, Cooling and fire resistant clothings, Location and rescue of trapped miners, Investigation of disaster. Mine rescue rules; Mine Closure**:** Principles, planning, financial provisions, implementation, standards for closure criteria, systems approach for mine closure and development of closure plan. **[12]**

Text books :

1. *Environmental Impact of Mining Down CG and Stocks J. Applied Science Publishers, London, 1978. Publisher: Elsevier Science & Technology, ISBN-10: 0853347166, ISBN-13: 978-0853347163*

Reference books :

1. *Environmental Impacts of Mining Monitoring, Restoration, and Control, MritunjoySengupta, Publisher: CRC Press (26 March 1993), ISBN-10: 0873714415, ISBN-13: 978-0873714419*
2. *Best Practice Environmental Management in Mining: Training Kit, Author: Environment Australia Staff, Edition: illustrated, Publisher: Australian Government - Department of the Environment and Heritage, 2002, ISBN: 0642996318, 9780642996312*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9012	**Environmental Geology and Soil Conservation**	**3-1-0**	**4**	Prof A. Gangopadhyay, Dr. K. Adhikari

Relevance of Environmental geology; Earth materials and processes – Geologic cycles, Earth Resources: types of rocks, origin and properties, role of natural agencies in earth processes, groundwater resources. **[10]**

Geological Hazards – Earthquakes, Volcanism, Landslide, Flood, Coastal Hazards. **[9]**

Exploitation of Resources and its impact; Energy and Environment – Coal, Oil and Gas. **[8]**

Soil profile development, Soil classification; Physical, chemical and biological properties of soil; Soil erosion and desertification. **[10]**

Land use and soil; Soil conservation and management. **[8]**

Text books :

1. *A Textbook of Geology. P. K. Mukerjee. Publisher: World Press; (2006); ISBN-10: 8187567546, ISBN-13:9788187567547.*
2. *Hydrology: Principles, Analysis and Design. H. M. Raghunath; Publisher: New Age International; 2nd Edition (2006); ISBN-10: 8122418252, ISBN-13: 9788122418255*

Reference books :

1. *Groundwater Hydrology. David Keith Todd, Larry W. Mays; Publisher: Wiley India; 3rd edition (August 6, 2004); ISBN-10: 8126530030, ISBN-13: 9788126530038.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9013	**Remote Sensing and GIS**	**3-1-0**	**4**	Dr. K. Adhikari, Prof. S. Bhattacharya

Maps – their types, map reading, map scale, map projections basics; Fundamental concepts of Remote Sensing, Physics of Remote Sensing, Effects of atmosphere, Spectral Reflectance of Earth surface features in different wave regions of electromagnetic spectrum; Characteristics of Space platforms, sensors, scanning and orbiting mechanisms, resolutions – spatial, spectral, radiometric and temporal, IRS and other remote sensing satellites. **[9]**

Fundamentals of satellite image interpretation; Principles : data encoding and decoding, digital image formats – band sequential and band interleaved, software – raster and vector files ; Image rectification and restoration ; Techniques of image interpretation, Multi-spectral data analysis. **[9]**

Digital Terrain modelling, database management system, overviews of image processing methods for feature extraction, spatial feature manipulation, spatial filtering, supervised classification and unsupervised classification. **[9]**

GIS – definition, components of GIS, maps and spatial data, sources of spatial data : census and survey data, air-photos, satellite images, field data ; Spatial entities – Raster and Vector spatial data structures, comparison of vector and raster methods, DTM, Database management system. **[9]**

GIS database application and development ; Data input and editing ; Data analyzing operation in GIS ; GIS Modeling and Decision Support System **[9]**

Text books :

1. *Remote Sensing & GIS, Basudeb Bhatta, 2nd Edition, August 2011, Publisher: Oxford Publications, ISBN-10: 0198072392, ISBN-13: 978-0198072392*

Reference books :

1. *Principles of Geographical information Systems, Peter A Burrough and Rachael A Mcdonnel, December 2006, Publisher: Oxford University Press, ISBN-10: 0199228620, ISBN-13: 978-0199228620.*
2. *Essential Image Processing and GIS for Remote Sensing, Jian Guo Liu and Philippa Mason, July 2009, Publisher: Wiley-Blackwell, ISBN-10: 0470510322, ISBN-13: 978-0470510322*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9014	**Green Chemistry and Clean Technologies**	**3-1-0**	**4**	Dr. R.N. Saha

Definition and strategy of green chemistry, Why Green Chemistry?Prevention, Atom Economy, Less Hazardous Chemical Syntheses, Designing Safer Chemicals, Safer Solvents and Auxiliaries, Design for Energy Efficiency. **[9]**

Use of Renewable, Feed stocks, Reduce Derivatives, Catalysis, Design for Degradation, Real-time analysis for Pollution Prevention, Inherently Safer Chemistry for Accident Prevention, Laboratory pollution prevention. **[9]**

Applications and benefits of green chemistry: Production of new chemicals, materials, and products. Examples of successful green technologies; Alternative synthetic routes, new separation processes, new methods for delivery or product application (Alternative solvents, Energy vs. material activity). Importance of pollution and wastefulness in modern cultures by reflecting on the green chemistry. **[9]**

Process optimization for cleaner industrial processes; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation, concept of industrial ecology and symbiosis of eco-industrial parks. **[9]**

Case studies on industrial applications of cleaner technologies in chemical, metallurgical, pulp & paper, textile and other industries. **[9]**

Text books :

1. *Green Chemistry: Theory and Practice. Paul Anastas, John Warner. Publisher: OUP USA; Reprint edition (23 March 2000); ISBN-10: 0198506988, ISBN-13: 978-0198506980*
2. *Green Chemistry and Engineering. MukeshDoble, Ken Rollins, Anil Kumar. Publisher: Academic Press (27 July 2010); ISBN-10: 008052477X,ISBN-13: 9780080524771*

Reference books :

1. *Real-world Cases in Green Chemistry. Michael C. Cann, Marc E. Connelly. Publisher: American Chemical Society (2000); ISBN-10: 0841237336, ISBN-13: 9780841237339.*
2. *Green Chemistry: An Introductory Text. Mike Lancaster, Janet Scott, Karen Wilson. Publisher: Royal Society of Chemistry; New edition (1 May 2010); ISBN-10: 1847558739, ISBN-13: 978-1847558732.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9015	**Hydrogeology and Watershed Management**	**3-1-0**	**4**	Dr. K. Adhikari

Groundwater and the hydrologic cycle ; Water bearing properties of rocks ; Zone of aeration and saturation ; Hydrogeologic formations. **[9]**

Groundwater flow – Properties of water in relation to flow, Darcy's law, Flow through aquifers, Storage equations. **[8]**

Quality of groundwater; Groundwater provinces in India; Saline water intrusion; Subsurface contaminant transport; Groundwater recharge (including Rainwater Harvesting technique), discharge and balance. **[10]**

Meteorology ; Watershed characteristics – Drainage area, Linear measurements, Basin shape, Watershed relief, Drainage pattern, Landcover and landuse ; Stormwater management ; Channel and Reservoir Routing. **[9]**

Dams and Barrage ; Various methods of catchment routing ; Assessment of routing techniques ; Soil surveys and land capability classifications ; Erosion and Sedimentation ; Measures for erosion control ; Watershed catchment modeling ; Hydrologic design criteria. **[9]**

Text books :

1. *Hydrology and the Management of Watersheds, Kenneth N. Brooks, Peter F. Ffolliott, Joseph A. Magner. 4th Edition, Publisher: Wiley, 2003, ISBN: 978-0-470-96305-0; ISBN: 9780470963050; DOI: 10.1002/9781118459751.*

Reference books :

1. *Hydrological Modelling and the Water Cycle: Coupling the Atmospheric and Hydrological Models (Water Science and Technology Library) by SoroushSorooshian, Kuo-lin Hsu, Erika Coppola, Barbara Tomassetti, Marco Verdecchia, Guido Visconti, Publisher: Springer Science & Business Media, 2008, ISBN: 978-3-540-77842-4; e-ISBN: 978-3-540-77843-1.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9016	**Natural Hazards and Disaster Management**	**3-1-0**	**4**	Dr. K. Adhikari

Concepts of disaster; Introduction to Natural & Anthropogenic Disasters: Cyclone, flood, drought, land slide, land subsidence, fire, earthquake and others ; Issues and concern for various causes of disasters, Psychological and Social Dimensions in Disasters, Trauma and Stress. **[9]**

Natural Disasters and Mitigation Efforts, Flood Control, Drought Management, Cyclones, Avalanches, Forest Fires, Oil Fires, Accidents in Coal Mines, Emergency Management, Land Use Planning, Inter-Linking of Rivers ; **[9]**

Techniques of monitoring and design against the disasters: Disaster mapping, assessment, pre-disaster risk & vulnerability reduction; **[9]**

Recent Trends in Disaster Information Provider, Electronic Warning Systems, Geo Informatics in Disaster Studies, Remote Sensing & GIS Technology; **[9]**

Post disaster recovery & rehabilitation, Disaster related infrastructure development; Applications in Disaster Management: Statistical Seismology, Quick Reconstruction Technologies, Role of Media in Disasters, Management of Epidemics, Forecasting Management of Casualties. **[9]**

Text books :

1. *Standard Handbook of Hazardous Waste Treatment and Disposal Harry Freeman, Publisher: McGraw-Hill, 1998, Edition: 2, illustrated, ISBN: 0070220441, 9780070220447.*

Reference books :

1. *Hazardous Waste Management, 2nd Edition, Michael D. LaGrega, Phillip L. Buckingham, Jeffrey C. Evans, Publisher: Waveland Press, 2010, ISBN: 1478609346, 9781478609346.*
2. *Hazardous Waste Management Engineering Martin EJ & Johnson JH, Van Nostrand-Reinhold, NY, 1987, DOI: 10.1002/ep.670060318, Volume 6, Issue 3 August 1987.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9017	**Environmental Management**	**3-1-0**	**4**	Dr K. Adhikari, Prof S. Bhattacharya

Environment and Sustainable Development - carrying capacity, relation among quality of life, carrying capacity and resource utilization. **[9]**

Environmental Protection - consideration in socio economic developmental policies and planning. Total cost of development and environmental protection cost, Cleaner development mechanisms and their applications. **[12]**

Environmental Impact Assessment – Definition, Objectives, Types - Rapid and Comprehensive EIA, EIS, Detailed procedure for conducting EIA, Limitations of EIA. **[8]**

Prevention of Significant Deterioration (PSD) Programme, Frame work of Impact assessment, Scope and contents of EIA, Methodologies and techniques of EIA, Attributes and Standards, Public participation in EIA ; Environmental Management Plan (EMP) and Disaster Management Plan (DMP). **[8]**

Environmental Audit – methods, procedure, reporting ; Law: International pollution control law, Legal pollution control in India- special acts- 1) The water (prevention and control of pollution) Act, 1974; 2) The air (prevention and control of pollution) Act, 1981; 3) The environment protection Act, 1986. **[8]**

Text books :

1. *Environmental Impact Assessment. Author: Larry Canter; Publisher: McGraw-Hill Science/Engineering/Math; 2nd edition (September 1, 1995); ISBN-13: 978-0070097674, ISBN-10: 0070097674.*
2. *Environmental Impact Assessment: Theory and Practice. Author: Peter Wathern; Publisher: Rout ledge (14 June 1990); ISBN-13: 978-0415078849, ISBN-10: 0415078849*

Reference books :

1. *An Introduction to Environmental Audit. Author: R.D. Tripathi; Publisher: Alfa Publications (January 1, 2009); ISBN-13: 978-9380096612, ISBN-10: 9380096615.*
2. *Renewable Energy: Environment and Development. Author: MaheshwarDayal; Publisher: Konark Publication, 1991; ISBN-13: 9788122001501, ISBN-10: 8122001505.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9018	**Noise Control Engineering**	**3-1-0**	**4**	Prof S. Bhattacharya

Fundamentals of sound and hearing; Nature of noise, effects, sources; Noise rating and noise measurement. **[9]**

Noise control in buildings (airborne and structure born sound insulation, reduction of noise from building services). **[9]**

Noise control in the urban environment (outdoor sound propagation, noise reduction measures). **[9]**

Noise control in industry (indoor sound propagation, noise control of indoor noise sources). **[9]**

Legal aspects of noise pollution; Assessment of impacts of noise environment. **[9]**

Text books :

1. *Engineering Noise Control: Theory & Practice, David A Bies and Colin A Hansen, 4th Edition, June 2009, Publisher: CRC Press, ISBN-10: 0415487072, ISBN-13: 978-0415487072.*

Reference books :

1. *Environmental Engineering, A P Sincero& G A Sincero, 2008, Publisher: PHI Learning, ISBN-10: 8120314740, ISBN-13: 978-8120314740.*
2. *Mechanical Vibrations and Industrial Noise Control, L G Lasithan, February 2014, Publisher: PHI Learning India, ISBN-10: 8120347993, ISBN-13: 978-8120347993.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9019	**Numerical methods and Modeling of Environmental Systems**	**3-1-0**	**4**	Dr. Supriya Pal, Prof S. Bhattacharya

Approximations and errors: accuracy and precision, round-off errors, truncation errors, Taylor's series, total numerical error. **[9]**

Roots of equations: graphical method, bisection method, false position method, fixed point iteration method, Newton – Raphson method, Secant method, multiple roots, system of nonlinear equations, roots of polynomials, Muller's method, Bairstow's method. **[9]**

Solution of linear algebraic equations: Gauss elimination, pivoting, scaling, Gauss – Jordan, Gauss – Siedel, LU decomposition, Tridiagonal systems, Cholesky decomposition. Curve fitting: Least squares regression, linear regression, polynomial regression, multiple linear regression, nonlinear regression. **[9]**

Ordinary diffrential equation: Euler's method, Heun's method, midpoint method, Runge – Kutta methods, stiffness and multi-step methods. Partial differential equations, Finite difference, Finite element, other methods. **[9]**

Environmental modeling: Introduction to mathematical modeling, problems and prospects of such modeling in different fields of environment. Case Study [**9]**

Text books :

1. *Numerical methods for engineers, 5th edition, Tata Mcgraw hill edition 2006. ISBN-13:9780070634169, 10:0070634165*

Reference books :

1. *Environmental Hydraulics:Numerical Methods Volume 3 Edition, Jean-michel (editor) Tanguy, Publisher Wiley-iste, ISBN-10:1848211554, ISBN-13:9781848211551*
2. *Introductory Methods of Numerical Analysis 5th Edition, S.S Sastry, Publisher: PHI Learning, ISBN-108120345924, ISBN-139788120345928*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9020	**Environmental Radiochemistry**	**3-1-0**	**4**	Dr. R.N. Saha

Basic of nuclear chemistry; Mass-energy relation of atomic nuclei, Concept of nuclear angular momentum, magnetic dipole moment, nuclear binding energy and stability of atomic nucleus. **[9]**

Liquid drop model, binding energy equation and its application.Radioactive decay and equilibrium, types of reactions, nuclear reactor and its design, chemical effects of nuclear transformations, fission and fusion, fission products and fission yields.Calculation. **[9]**

Radioactive techniques: tracer technique, neutron activation analysis, counting techniques such as G.M. ionization and proportional counter. **[9]**

Biological effects of radiations, manmade and natural radiation, application of nuclear radiation for medicine, agriculture and environmental sample analysis. **[9]**

Applications of radioisotopes in Physico-Chemical Investigations, Radiation hazard and its management **[9]**

Text books :

1. *Essentials of Nuclear Chemistry by HariJeevanArnikar, Issue 1653 of Journal of chemical education collection, Publisher: New Age International, 1995, ISBN: 8122407129, 9788122407129.*
2. *Nuclear and Radiochemistry: Fundamentals and Applications, Karl Heinrich Lieser, Publisher: John Wiley & Sons, 2008, ISBN: 3527612572, 9783527612574.*

Reference books :

1. *Radiochemistry and Nuclear Chemistry 1by Gregory Choppin (Author), Jan-OlovLiljenzin (Author), Jan Rydberg (Author), Christian Ekberg Laboratory of Nuclear Chemistry, Institute of Chemistry, EötvösLoránd University, Budapest, HungaryISBN-13: 978-0124058972, ISBN-10: 0124058973, Publisher: Academic Press; 4 edition (October 8, 2013).*
2. *Handbook of Environmental Isotope Geochemistry, Mark Baskaran, Publisher: Springer Science & Business Media, 2011, ISBN: 3642106374, 9783642106378.*

SUBJECT CODE	SUBJECT	L-T-P	CREDIT	DEVELOPER
ES9021	**Environmental Biotechnology**	**3-1-0**	**4**	Dr. Surabhi Chaudhury, Dr. S. Kazi

Bioremediation: What is Bioremediation, Case histories, Constraints and Priorities pf processes, Types of bioremediation, Applications with examples. **[9]**

Biotechnology and Oil spill, Biostimulation of naturally occurring microbial activities, Bioaugmentation – insitu, exsitu, Intrinsic and Engineered bioremediation, Solid phase bioremediation- land farming, prepared beds, soil piles, phytoremediation, Composting, Bioventing and Biosparging, Liquid phase bioremediation-suspended bioreactors, fixed biofilm reactors **[9]**

Biotechnology for Hazardous waste management: Xenobiotic compounds, Recalcitrance, Hazardous wastes, Biodegradation of xenobiotics, Biological detoxification, Biotechnology Applications to Hazardous waste management, Examples of Biotechnological Applications to Hazardous waste management. **[9]**

Industrial Waste : Different waste pollution from different industries – milk products, fermentation, slaughter house, tannin, fat processing laundry soap, textile dyeing and , pulp-paper, steel pickling etc, **[9]**

Treatment of biological industry wastes like vaccine, antibiotic, enzyme etc plant waste treatment, Treatment and disposal of radioactive waste. **[9]**

Text books :

1. *Text Book of Environmental Biotechnology by Pradipta Kumar Mohapatra. I.K. International Publishing House Pvt. Ltd. Publisher: I.K. International Publishing House; 1st Ed. edition (February 5, 2007), ISBN-10: 818823754X, ISBN-13: 978-8188237548.*
2. *Environmental Biotechnology: Concepts and Applications by Hans Joachim, Jordening and Josef Winter. Wiley- VCH Verlag GmbH & Co. KGaA, Weinheim, Publisher: John Wiley & Sons, 2005, ISBN: 3527305858, 9783527305858.*

Reference books :

1. *Environmental Biotechnology - Theory and Application by Gareth M. Evans, Judith C. Furlong Publisher- Wiley, ISBN: 0470856769, 9780470856765.*
2. *Environmental Biotechnology by R.A. Sharma Publisher- Pointer publisher, ISBN 10: 8171325246 / ISBN 13: 9788171325245.*

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