ENVIRONMENTAL SCIENCE CURRICULUM

Serial No.	Sem.	Course Title	Credits	Status
1	Iv	Environmental Chemistry (C)	3:0	New
2	Iv	Introduction to Earth Systems (C)	2:1	New
3	Iv	Environmental Laboratory (C)	0:2	New
4	Iv	Fundamentals of Climate Science (C)	3:0	New
5	v	Environmental Fluid Mechanics (C)	3:0	New
6	v	Introduction to Environmental Science and Engineering	3:0	New
7	v	Design Principles in Environmental Engineering (C)	2:0	New
8	v	Introduction to Geochemistry	2:1	New
9	v	Introduction to Basic Geology	2:1	New
10	vi	Environmental Microbiology	2:0	New
11	vi	Introduction to Aquatic Biology	2:1	New
12	vi	Landfill Engineering	2:0	New
13	vi	Wastewater Treatment (C)	3:0	New
14	vi	Fluid Mechanics Laboratory	1:1	New
15	vi	Surface and Groundwater Quality (C)	3:0	New
16	vii	Introduction to Solid Earth	3:0	New
17	vii	Green Chemistry	3:0	New
18	vii	Natural Hazards and Their Mitigation (C)	3:0	New
19	vii	Experimental Methods in Solid Waste Management (C)	0:2	New
20	vii	Atmospheric Thermodynamics	3:0	**Existing**
21	vii	Principles and Applications of GIS and Remote Sensing	2:1	New
22	viii	Introduction to Climate System	3:0	**Existing**
23	viii	Solid Waste Management	3:0	New
24	viii	Radiative Transfer in the Atmosphere	3:0	**Existing**
25	viii	Modern Bioenergy Technology	2:0	**Existing**

C : core

New Courses

Environmental Chemistry (3:0, Semester IV, Core, Major)

Basic concepts: Chemical equations, chemical reactions, solutions, chemical equilibrium and thermodynamics,
Acid-Base equilibria: Fundamentals, equilibrium diagrams, alkalinity and acidity, the carbonic acid system, buffering in water systems Solubility equilibria: slightly soluble salts, effect of other solutes, removal of heavy metals, Oxidation Reduction equilibria: Oxidation reduction processes, electrochemical potentials, galvanic cells, stability diagrams, measuring redox potential, Basics of water softening, ion exchange and carbon adsorption.
Water and Wastewater analysis: Basic concepts and Instrumental methods of analysis; Determination of major parameters of water such as pH, acidity, alkalinity, hardness, BOD, COD, solids, fluoride, nitrogen, iron, manganese, sulphate, phosphate, volatile acids and trace contaminants.
Atmospheric Composition & Behaviour: Gaseous & particulate constituents of the atmosphere, Temperature and pressure profile of atmosphere, General circulation of atmosphere
Atmospheric Photochemistry: Electromagnetic radiations, Kinetics of thermal and photochemical processes, Reactions in the upper atmosphere, Photoprocesses in the troposphere, Photochemical smog, Photosynthesis, Ozone chemistry.

Reference:

1. C. N. Sawyer, P. L. McCarty, G. F. Parkin, Chemistry for Environmental Engineering, McGraw Hill, 4th edition, 2002.
2. L. D. Bene_eld, J. F. Judkins and B. L. Weand, Process Chemistry for Water and Wastewater Treatment, Prentice Hall, 1982.
3. R. A. Bailey, H. M. Clark, J. P. Ferris, S. Krause, R. L. Strong, Chemistry of the Environment, Academic Press Second Edition, 2002.

Introduction to Earth Systems (2:1, Semester IV, Core, Major)

Earth Surface features, Concept of Geomorphology, Weathering phenomena, Physics and chemistry of Earth's interior, Internal processes, tectonics through time, Geological time scale, Bio-stratigraphy, Early Earth, Rock formation, Rock classification, mineralogy, Basics of crystal symmetry, Composition of Atmosphere and origin of atmosphere, Earth like planetary bodies, Evidence of life in other planet, Basics of hydrosphere and its component, physical property of water, Elementary Oceanography, chemical composition of ocean, Evolution of life and its diversification.

Reference:

1.The Dynamic Earth System by Patwardhan PHI Learning Private Limited , New Delhi . ISBN -978-81-203-1496-2

2.The Earth System .by Kump, Kasting and Crane, Prentice Hall, ISBM 0-13-142059-3
3.Modern physical Geology..by G.R. Thompson and J. Turk, Saunder College Publishing

Environmental Laboratory (0:2, Semester IV, Core, Major)

Characterization of Water Quality - Electrical conductivity, pH, Chlorides, Sulphates, Alkalinity, Hardness,
Characterization of pollutants in water - Estimation using spectroscopic and chromatographic techniques
Determination of dissolved and suspended solids in water samples, Determination of turbidity of water samples
Determination of chlorine in bleaching powder, Determine the optimum dosage of coagulant for coagulation of suspended solids in water sample
Soil surface sorption properties - Cation exchange capacity, Organic content, Grain size distribution , Pore water salinity
Sampling and measurement techniques in air quality, -gaseous pollutants and particulates, air quality standards, Instrumental techniques for gas analysis.
Estimation of total coliforms by MPN and Membrane Filtration Method

Reference:

1. APHA, Standard methods for the examination of water and wastewater. American Public Health Association, 20th edition, Washington DC, (1999).
2. SP 36 : Part 1 : 1987 Compendium of Indian standards on soil engineering: Part 1 Laboratory testing of soils for civil engineering purposes

Fundamentals of Climate Science (3: 0, Semester IV, Core, Major)

Atmospheric structure and composition, Observations and theory of the general circulation of the atmosphere, Global energy balance, Radiative processes in the atmosphere,the greenhouse effect, natural and anthropogenic climate change, waves in the atmosphere, clouds, weather systems, tropical dynamics and monsoons,ocean circulation

Reference:

1. Dennis L. Hartmann, Global Physical Climatology, Academic Press, 1994

1. Wallace J.M. and Hobbs, P.V., Aytmospheric Sciences: An Introductory survey, Academic Press

2. Peixoto J.P and Oort, A.H., Physcs of Climate. American Institute of Physics, New York.

Environmental Fluid Mechanics (3:0, Semester V, Core, Major)

Fundamentals of environmental fluid mechanics; Equations governing fluid motion in the environment; Environmental transport processes: advection, convection, diffusion and dispersion; Processes evident in natural fluid flows: boundary layers, turbulence, stratification, waves, mixing, jets and plumes; Environmental fluid systems: rivers and streams, aquifers and wetlands, lakes and reservoirs, and the atmospheric boundary layer

Reference:

Cushman-Roisin, B., Environmental Fluid Mechanics, John Wiley & Sons, Inc., 2010.

Mihailovic, D. T., Gualtieri, C., 2010. Advances in Environmental Fluid Mechanics, World Scientific Pub Co Inc, 2010.

Rubin, H. and Atkinson, J.F., Environmental Fluid Mechanics, Marcel Dekker, Inc., 2001.

Shen, H. H., Cheng, A. H. D., Wang, K-H, Teng, M. H., Liu, C. C. K., Environmental Fluid Mechanics: Theories and Applications, ASCE, 2002.

Wang, K-H., Teng, M. H., Chen, H-C., Advanced Experimental Techniques in Environmental Fluid Mechanics, ASCE, 2003.

Introduction to Environmental Science and Engineering (3:0, Semester V, Elective)

Basics of hydrology: Rainfall and runoff analysis, Reservoirs, Groundwater and wells, water conservation.
Water treatment: coagulation, softening, reactors, mixing and flocculation, sedimentation, filtration, disinfection, adsorption.
Wastewater treatment: wastewater microbiology, domestic wastewater, municipal wastewater treatment systems, unit operations of pretreatment, primary and secondary treatment, sludge treatment and disposal,
Water quality management in rivers and lakes, sources of pollution,
Air pollution: Standards, effect of air pollutants, origin and fate of air pollutants, atmospheric dispersion, air pollution control at stationary and mobile sources, Noise pollution: Effects of noise on people, rating systems, community noise, sources, transmission of sound outdoors, traffic noise prediction, nose control,
Introduction to Hazardous waste management, Environmental impact statements and global pollution issues.
Introduction to Environmental legislation, regulation, ethics and systems overview

Reference:

1. Gilbert M. Masters, Introduction to Environmental Engineering and Science, Prentice Hall, 3rd edition, 2007.
2. M. L. Davis and D. A. Cornwell, Introduction to Environmental Engineering, McGraw Hill, 4th edition, 2006.

Design Principles in Environmental Engineering (2:0, Semester V, Core, Major)

Laws of conservation: mass, energy and momentum balances

Fundamentals of chemical reaction engineering: thermodynamics, stoichiometry and kinetics of chemical reactions, chemical reactors – stirred tank and plug flow reactors,
Design for waste water treatment processes: physical unit operations such as sedimentation and filteration, chemical and biological treatment processes
Design for air pollution control: gas-liquid interactions, absorption and adsorption processes, particulate emission control

Reference:

1. Mackenzie Davis and Susan Masten, Principles of Environmental Engineering, McGraw Hill, 2004.
2. Mackenzie Davis and David Cornwell, Introduction to Environmental Engineering, McGraw Hill, 2006.
3. James Mihelcic and Julie Beth Zimmerman, Environmental Engineering: Fundamentals, sustainability and Design, John Wiley, 2010
4. Frank R. Spellman and Nancy E. Whiting, Environmental Engineer's Mathematics Handbook, CRC Press, 2005

Introduction to Geochemistry: (2:1, Semester V, Elective)

Geochemical Fundamentals/Chemistry Review , The Elements; basic principles of inorganic chemistry, periodic properties, Thermodynamics and chemical reactions, solubility , Aquatic Chemistry, pH-pE, Biology and redox , Organic Chemistry
High temperature geochemistry - Planetary geochemistry , Age and Origin of the Solar System., Planet formation, differentiation of the Earth, igneous processes, Radiogenic isotope geology/Geochronology
Low temperature geochemistry - The hydrologic cycle and Sedimentary geochemistry, Chemical Processes, Photosynthesis/respiration, Aquatic Microbial Biochemistry in rain, rivers, lakes, estuaries, Chemical weathering, soil formation, geochemistry of clays, The oceans, marine chemistry, primary productivity, Gaia, Marine Sediments: a record of environmental global history, light isotope geochemistry, Global Climate: Present and Future, atmospheric CO
Lab component: will involve exposure to instrumental methods which include a) titration b) chromatography using liquid and gas columns c) analyses of cation and anion using Ion Chromatography, towards chemical analysis of rock samples, measurement of soil moisture contents, geo-chemical characterization of rock samples and determination of CO2 concentrations in air

Reference:

1. John Victor Walther, Essentials of Geochemistry, Jones and Bartlett Publishers 2nd Edition, 2009.
2. R. Gill, Chemical Fundamentals of Geology, Springer; 2nd edition, 1995.

Introduction to Basic Geology (2:1, Semester V, Elective)

Classification of rocks; Geology of southern India: tectonic concepts; The earth structures and its significance; Shear/suture zones-identification, interpretation and

implications, Fluid influence in shear zones; Petrological, geochemical and geochronological: methods, approaches and inferences, origin-exhumation-weathering: the rock cycle, landforms, element mobility and interactions; Linking rocks/mineral chemistry to tectonics with Indian examples.
Laboratory component: Sample preparation of rock specimens, Petrological observation of rock and mineral thin sections

Reference:
1. Ron H. Vernon & Geoffrey Clarke, Principles of Metamorphic Petrology
Cambridge University Press 2008
2. Ron H. Vernon, A Practical Guide to Rock Microstructure
Cambridge University Press 2004
3. Using Geochemical Data: Evaluation, Presentation, Interpretation
by Hugh R. Rollinson, Longman Publishing Group (1993)
4. Kent C. Condie, Earth as an Evolving Planetary System
Academic Press; 1st edition 2004
5. Earth Structure: An Introduction to Structural Geology and Tectonics
by Ben A. Van Der Pluijm & Stephen Marshak, W W Norton & Co Inc (Np); 2 edition (2003)
6. Anthony R. Philpotts, Petrography of Igneous and Metamorphic Rocks
, Waveland Pr Inc 2003

Environmental microbiology (2:0, Semester VI, Elective)

Basics of microbiology, Microorganisms found in surface water and waste water, Pathogenic Organisms, Classification of pathogens; bacterial pathogens, viruses, protozoa, Monitoring bacterial pathogens; Enumeration techniques, emerging technologies, standards, Enumeration and identification of viruses, Polymerase chain reactions, Development of microorganism typing techniques, New and re-emerging microorganisms, Toxicity tests, Analysis and application of toxicity test results, Removal of pathogenic organisms, Environmental factors of survival, Bacterial physiology, phylogeny, and the ecology of microbes in soil and marine sediments, bacterial adhesion, and biofilm formation. Microbes in the degradation of pollutants.

Reference:
1. Gerard Tortora, Berdell Funke, Christine Case, Microbiology: An Introduction: International Edition, 2009
2. Raina M. Maier, Ian L. Pepper, and Charles P Gerba, Environmental Microbiology, Academic Press, 2008.

Introduction to aquatic biology (2:1, Semester VI, Elective)

Ecological significance and water problems in aquatic habitat, Biological effects of temperature, Community ecology, Characteristics of communities, Ecological niche, Ecological succession, Sere climax and types of succession, Types of ecosystem, Dynamics of ecosystem, Energy primary production, Secondary production, Food chain, Food web, Trophic levels, Ecological pyramid of numbers, Pyramid of

biomass, Pyramid of energy, Importance of fishery and cultivable species, Freshwater habitat characteristics, Fresh water biodiversity and freshwater adaptations.

Marine habitat characteristics, zonation, Stratification, Pelagic, communities, Plankton, benthic region, Intertidal seashores, Intertidal sandy shore, Intertidal muddy shore, Coastal biota: plankton, phytoplankton, zooplankton, benthos, fish, bivalves and other animals, Eutrophication and coastal pollution: monitoring and control conservation and management of coastal ecosystem and intertidal sea shore, Water pollution: causes of water pollution, ecological effects of water pollution, domestic sewage and industrial pollution and environmental toxicology (ecotoxicology), Biological water quality monitoring

Laboratory component:
Identification of microbes and zooplanktons, Identification of Benthic organisms, Determination of BOD & COD of water sample, Water parameter analysis in field and Geographical identification of field location

Reference:

1. E. P Odum Basic Ecology, Harcourt Brace College Publisher, 1983.
2. APHA, Standard methods for the examination of water and wastewater. American Public Health Association, 20th edition, Washington DC, 1999
3. N J Hoboken, Aquatic biology: Ecology of freshwaters: a view for the twenty-first century, J. Wiley & Sons. 2010

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Landfill Engineering (2:0, Semester VI, Elective)

Physico-chemical and engineering properties of soil, Ground water flow and contaminant transport, Criteria for landfill site location, Design of landfill components such as liners, covers, leachate collection and removal, Gas generation and management, Principles and methods of monitoring ground water quality and quantity, End uses of landfill sites, Risk assessment approaches, Contaminated site characterization and remediation technologies, Environmental laws and regulations

Reference:

1. Rowe, R. Kerry, Quigley, Robert M., Brachman, Richard W. I., and Booker, John R. Barrier Systems for Waste Disposal Facilities , 2nd ed., Spon Press, Taylor & Francis Group, London, 2004.
2. Sharma, H.D., and Reddy, K.R., Geoenvironmental Engineering: Site Remediation, Waste Containment and Emerging Waste Management Technologies, John Wiley & Sons, Inc., Hoboken, New Jersey, 2004.
3. Tchobanoglous, Theisen and Vigil, Integrated Solid Waste Management - Engineering Principles and Management Issues, McGraw Hill 1993.

Wastewater treatment (3:0, Semester VI, Core, Major)

Wastewater generation patterns /sources - quantification and quality issues, Pathogens and microbiological risks from wastewater,

Pollution Indicators - physical, chemical, biological and microbiological,
Water Testing - Physico-chemical properties, Biological and microbiological characteristics,
Microbial Metabolism with respect to waste water remediation and water treatment,
Organic Matter Removal-Anaerobic and Aerobic methods, Modelling Activated Sludge Processes,
Nitrogen, Phosphorus and Pathogen removal from wastewater, Aquatic and water Toxicity and toxicology, Physico-chemical basis and processes for aeration, mixing, settling, microbial killing processes,
Sludge physical properties, settling properties, characterization, remediation, treatment and disposal.
Membrane Bio-reactors, Anaerobic Wastewater Treatment reactor designs, Hybrid reactors, Biofilm Reactors, Anaerobic biofilm reactors.
Micro-biological and Phyto-remediation techniques,
Grey and Black water recycling, needs, Ground water pollution, sources and mechanisms, sustainability issues, in-situ and ex-situ bioremediation

Reference:

1. APHA, Standard methods for the examination of water and wastewater. American Public Health Association, 20th edition, Washington DC, (1999).
2. Metcalf & Eddy Incorporation, Wastewater engineering, treatment and re-use. Revised by George Tchobanoglous, Franklin, L. Burton and H. David Stensel, Tata McGraw-Hill Publishing Company limited, New Delhi., 2003.

Fluid Mechanics Laboratory (1:1 Semester VI, Elective)

Measurement of fluid properties; Flow visualization: Reynolds experiment, Flow separation in flow around bodies; Measurement of flow discharge: Venturimeter, Orifice meter, Weirs and Notches; Bernoulli's experiment; Drag forces and drag coefficient: Terminal velocities of spheres; Vorticity experiment; Momentum conservation: forces on a vane; Hydraulic Jump.

Surface and Groundwater Quality (3:0, Semester VI, Core, Major)

Hydrologic Cycle, Water and chemical budgets; Sources and types of water pollution, Water quality standards, Fate and transport in aquatic systems, Rivers and streams, Lakes & Reservoirs, Wetlands, Estuaries. Groundwater flow and geologic controls on flow, Vadose zone hydrology, Contaminant transport in groundwater, Modeling environment.

Reference:

1. Chin, D. A., Water quality engineering in natural systems. Willey InterScience, 2006.

2. Bedient, P.B., Rifai, H.S.,Newell, C.J., Ground Water Contamination: Transport and Remediation. Prentice Hall, Englewood Cliffs, NJ, USA. 1994.

Introduction to Solid Earth (**3:0 Semester VII, Elective)**

History of the Earth: Introduction to Earth history, origin of the Earth and solar system; origin and evolution of life, mass extinctions, interpretation of the geological record of Earth history; measurement of geological time, historical development of concepts.
The dynamic Earth: Introduction to the dynamic Earth, Gravity and Magnetic fields, thermal structure and heat flow, Radioactivity, internal structure of the earth. Continental drift and plate tectonics, earthquakes, volcanoes, mountain-building processes; igneous and metamorphic processes; surface processes, erosion, soil, and sediment formation, important morphological features on the earth, interactions among the lithospheric, hydrospheric, atmospheric, and biospheric systems.

Reference:

1. C.M.R. Fowler, The solid earth: An introduction to Global Geophysics, Cambridge University Press, 2005.
2. Philip Keary and Frederick Vine, Global Tectonics, Blackwell Science, 1996.
3. Raymond Siever, John Grotzinger, and Tom Jordan, W. H. Freeman; Understanding Earth, Frank Press, Fourth Edition (July 17, 2003)

Green Chemistry (3:0 Semester VII, Elective)

Introduction and principles of green chemistry, Tools of green chemistry-alternative starting material, alternative target/product, Process analytical chemistry, Evaluation of methods to design safer chemicals, Reaction types, yield and atom economy, Examples of green chemistry, Solid acids and bases as catalysts, Organocatalysis, Catalysis and Green chemistry, Catalysis in novel reaction media, Enatoselective catalysis, Future trends in green chemistry.

Reference:

1. Paul T. Anastas and John C. Warner, Green Chemistry: Theory and Practice. Oxford University Press, 2000.
2. William McDonough and Michael Braungart, Cradle to Cradle: Remaking the Way We Make Things. New York: North Point Press, 2002.
3. Paul T. Anastas and John C. Warner, Green Chemistry: Theory and Practice. Oxford University Press, 2000.
4. Roger A. Sheldon, Isabel Arends, and Ulf Hansfeld, Green Chemistry and Catalysis.Wiley-VCJ Verlag GmbH & Co. KGaA. Weinreim, Germany, 2007

Natural Hazards and Their Mitigation (3:0, Semester VII, Core, Major)

Definitions and basic concepts, different kinds of hazards and their causes, Geologic Hazards: Earthquakes, causes of earthquakes and their effects, plate tectonics, seismic waves, measures of size of earthquakes, earthquake resistant design concepts; Slope instability and landslides, causes of landslides, principles of stability analysis,

remedial and corrective measures for slope stabilisation, Climatic Hazards: Floods, causes of flooding, regional flood frequency analysis, flood control measures, flood routing, flood forecasting and warning systems; Droughts, causes and types of droughts, effects of drought, hazard assessment and decision making; Use of GIS in natural hazard assessment, mitigation and management.

Reference:

1. Donald Hyndman and David Hyndman, Natural Hazards and Disasters, Brooks/Cole Cengage Learning, 2008
2. Edward Bryant, Natural Hazards, Cambridge University Press, 2005
3. J Michael Duncan and Stephan G Wright, Soil Strength and Slope Stability, John Wiley & Sons, Inc, 2005.
4. Amr S Elnashai and Luigi Di Sarno, Fundamentals of Earthquake Engineering, John Wiley & Sons, Inc, 2008

Experimental methods in Solid Waste Management (0:2 Semester VII, Core, Major)

Solid waste characterization - Water leach test, Toxicity Characteristic Leach Procedure
Pollutant sorption capacity characterization – Kinetics & adsorption isotherms, Distribution coefficients
Pollutant transport – Column experiments to evaluate transport and partitioning in vadose and saturated zones, Diffusion coefficients
Laboratory determination of soil permeability for contaminant flow
Chemical solidification of contaminated wastes-Lime and cement stabilization, Leaching and compressive strength measurements

Reference:

1. US EPA publication SW-846: Test Methods for Evaluating Solid Waste, Physical/Chemical Methods, 1996.
2. BIS Compendium on Engineering Properties of Soils

Principles and Applications of GIS and Remote Sensing (2:1 Semester VII, Elective)

Principles of Remote Sensing: Physical aspects of remote sensing, spectral characteristics of earth's surface and of atmosphere.
Sensors and their characteristics: multi-spectral scanners Aerial and satellite platforms. Visual and machine interpretation of imagery. Ground truth data. Digital image processing and image classification.
Geographical information systems: Introduction, historical development, from the real world to GIS, basic data models, Geo-references and co-ordinate systems, basic spatial analysis and modeling, GIS implementation and project management, GIS issues and prospects, open source GIS – concepts, Integrating GIS for environmental modeling.
Application of GIS and Remote Sensing: Remote sensing and GIS integration, Applications to resources inventorying, monitoring and management; Surface and

groundwater resources, Soils, Ecology, Landuse/landcover dynamics, Urban sprawl analysis, Hazards and disasters, Coastal zone management.

Laboratory component: Installing open source GIS software, GIS- digitization of vector layers, creation of thematic layers, collection of field data using GPS, remote sensing data analysis – case study.

Reference:

1. T.M. Lillesand and R.W. Kiefer, Remote Sensing and Image Interpretation John Wiley & Sons, Inc., New York, 2000.

2. Sabins, F. F., Jr. / Remote sensing Principles and Interpretation, 2nd Edition, New York: W.H.Freeman, 1986.

3. P.A. Burrough, Principles of Geographical Information System for Land Resource Assessment, Oxford University Press, New York, 1986.

4. P.A. Longley, M.F. Goodchild, D.J. Manguire, D.W. Rhino, Geographical Information System, Volume I: Principal and Technical Issues, Volume II: Management Issues and Applications, John Wiley & Sons.

Solid Waste Management (3:0, Semester VIII, Elective)

Classification and characterization of solid wastes, The RCR (recover, recycle and reuse) principle, Handling and treatment of MSW (municipal solid waste), Biological treatment, Thermal treatment, Landfill, Integrated waste management, Sludge generation from treatment of industrial waste waters, Physico-chemical characterization of sludge, Sludge handling, treatment and disposal options, Siting, operation and maintenance of Toxic Substances Disposal Facilities (TSDFs), Surface and ground water control, Closure and post closure care of land fills, Treatment of hazardous wastes: Air stripping, Soil vapour extraction, Carbon absorption, Steam stripping, Stabilization and solidification, Thermal methods – combustion, liquid injection incinerators, Biological methods – conventional treatment, In-situ bio-remediation

Toxicology and risk assessment: Toxic effects, dose-response relationships, carcinogens, ecotoxicology, risk, exposure and toxicity assessment, risk characterization, ecological risk assessment.

Environmental, legal and public health aspects of solid waste management

Reference:

1. F.McDougall, P.White, M.Franke and P.Hindle, Integrated Solid Waste Management- Life Cycle inventory, Blackwell Publishing, 2001.
2. Charles A.Wentz, Hazardous Waste Management, McGraw-Hill International Editions, Singapur, 1989
3. G.Kiely, Environmental Engineering, Mc-Graw Hill International Edition, 1998.
4. Dawson and Mercer,Hazardous Waste Management –John Wiley, 1981
5. Lagrega M.D., Buckingham P.L., and Evans J.C., Hazardous Waste Management , McGraw Hill International Edition. (1994)

Existing Courses

Atmospheric Thermodynamics (3:0, Semester VII, Elective)

Vertical structure and composition of the atmosphere, Kinetic theory of gases, First and second principles of thermodynamics, Thermodynamics of dry air, Concept of saturation vapor pressure, Water vapor in the atmosphere, Properties of moist air, Isobaric and isothermal processes, Atmospheric stability, Parcel and area methods, Nucleation, Effect of aerosols, Clouds and precipitation, Forms of atmospheric convention

Reference:

1. Iribane, I. V. and Godson, W. I., Atmospheric Thermodynamics, Second Edition, D. Reidel Publishing Company, 1971
2. Rogers, R. R. 1979, A short course in cloud physics, Second Edition, Pergamon Press
Bohren, C. F. and Albhecht, B. A., Atmospheric Thermodynamics, Oxford University Press, 1998.
3. Tsonis, A. A., An Introduction to Atmospheric Thermodynamics, Cambridge University Press , 2002.
4. Wallace, J. M. and Hobbs, P. V., Atmospheric Science, an Introductory Survey, Second Edition, Academic Press, 2006.

Introduction to Climate System (3:0, Semester VIII, Elective)

Equations of motion for the atmosphere and oceans, Observed mean state of the atmosphere and oceans, Exchange of momentum, Energy and water between the atmosphere and surface, Angular momentum cycle, Global water cycle, Radiation energetics, Entropy in climate system, Climate variability

Reference:

1. Peixoto J., and Oort, A. H., Physics of the Climate, American Institute of Physics, 1997.

Radiative Transfer in the Atmosphere (3:0, Semester VIII, Elective)

Electromagnetic spectrum, Fundamentals of atmosphere and radiation, Laws of thermal radiation, Emissivity, Absorptivity and albedo of surfaces, Beer's law, Theory of scattering, Principles of radiative transfer, Radiative transfer in a plane parallel atmosphere, Approximation of radiative transfer, The role of radiation in climate

Reference:

1. Liou, K. N. An Introduction to Atmospheric Radiation, Academic Press, 1980
2. Thomas, G. E. and Stammes, K. Radiative transfer in the atmosphere and oceans, Cambridge University Press, 1999.

Modern Bioenergy Technology (2:0, Semester VIII, Elective)

Biomass and its properties relevant for conversion technology, bio-energy conversion technologies – thermochemical and biological energy conversion devices – stoves, combustors and gasifiers for heat, power and co-generation applications. Boliogical conversion techniques and devices. Efficiency, emissions and performance of end use devices.

Reference:

1. Gary L. Borman and Kenneth W. Ragland, Combustion Engineering, McGraw-Hill International Editions, Mechanical engineering series, 1998.
2. Johansson T.B., H.Kelly, A.K.N. Reddy and R.H. Williams, (Eds), Renewable Energy – Sources for Fuels and Electricity, Island Press, 1993.
3. Ravindranath N.H. and D.O.Hall, Biomass, Energy and Environment, Oxford Press, 1995.
Relevant paper from current literature.