MASTER OF SCIENCE (ENVIRONMENTAL SCIENCE) – FIRST SEMESTER

First Semester			
S. No.	Name of Subject	Credits	Total Marks
1	Aquatic Environment	4	100
2	Ecology and Ecosystem Dynamics	5	100
3	Earth Processes and Natural Hazards	5	100
4	Environmental Chemistry and Toxicology	5	100
5	Statistical Methods and Environmental Application	5	100
Total		24	

Subject Name: AQUATIC ENVIRONMENT

Diversity of aquatic habitats; hydrologic cycle Aquatic food webs including microbial loop; trophic cascade Measurement of aquatic primary productivity Lakes - Origin and classification, ecological zonation, thermal stratification, water circulation, physical and chemical characteristics Phytoplankton – diversity and models of nutrient-limited growth, paradox of plankton; a general account of zooplankton A general account of benthic and periphytic communities Characteristics of running water habitats; river continuum concept Oceans: Chemistry of seawater, circulation and ecological zonation in sea, marine biota, coral reefs A general account of estuaries and wetlands Eutrophication: Causes, consequences and control measures

Suggested Readings:

1. Dobson, M. and Frid, C. 1998. Ecology of Aquatic Systems. Longman.
2. Adams, S.M. (Ed). 2002. Biological Indicators of Aquatic Ecosystem Stress. American Fisheries Society, Bethesda.
3. Talling, J.F. and Lemoalle, J. 1998. Ecological Dynamics of Topical Inland Waters. Cambridge University Press.
4. Wetzel, R.G. and Likens, G.E. 2000. Limnological Analysis. Springer-Verlag.
5. Wetzel, R.G. 2000. Limnology: Lake and River Ecosystems. Academic Press.
6. Dodson, S. 2005. Introduction to Limnology. McGraw-Hill, New York.

Subject Name: ECOLOGY AND ECOSYSTEM DYNAMICS

Ecology - introduction to ecology, history and scope of ecology, ecological hierarchy, view point of modern ecology, system ecology, human ecology. Elements of ecology – biotic and abiotic and their interactions.

Ecosystem - concept of ecosystem, structure and functions of ecosystem, ecosystem energetics, ecological dynamics and balance. Food chains and food web, ecological pyramids. Productivity in an ecosystem, primary and secondary productivity, ecological efficiency.

Biogeochemical cycles - evolution of biochemical cycles, biogeochemical cycles at the biosphere levels. Nutrient cycling at ecosystem level.

Ecological models – introduction, analytical and computational models, Predator-prey model of Lotka and Volterra.

Autoecology (Population ecology) - population characteristics, population dynamics, population growth and regulation.

Synecology (Community ecology) - characteristics of community, community structure and composition. Methods of studying communities.

Ecological succession - concepts of ecological succession, general process of succession, types of succession, structural and functional changes in succession.

Ecosystem degradation and restoration - factors/threats of ecosystem, restoration of ecosystem.

Suggested Readings:

1. Odum E.P., Fundamentals of Ecology, Nataraj Publisher, Dehradun 1996
2. Kormondy E. J., Concepts of Ecology, Prentice Hall of India, 1994
3. Rao K. S., Practical Ecology, Anmol Publication Pvt. Ltd., 1998
4. Smith, R.L. and Smith T.M.(2001). Ecology and Field Biology, 6 ed. Benjamin Cummings. San Francisco.
5. Robert, E. Ricklefs and Gracy L. Miller. (2000). Ecology (4th Edition), WH Freeman and Company England.
6. Bingro, H. (2007). Plants- Environment Interaction (3rd Edition), Taylor & Francis Group.
7. Gurevitch, J., S.M. Scheiner, and G.A. Fox. (2002). The Ecology of Plants. Sinauer Associates, Inc. Sunderland, MA, U.S.A.

Subject Name: EARTH PROCESSES AND NATURAL HAZARDS

Origin of earth, evolution earth's mantle and crust, continental drift, plate tectonics, sea floor spreading, seismic waves, plate boundaries;

Exogenetic processes and landforms - denudation, fluvial, aeolian and glacial landforms; Runoff process- generation, component, catchment process;

Rocks – types, formation, minerals, rock cycle. Chemical and mineralogical composition of the earth, abundance of elements, geochemical classification of elements, major and trace elements and their partitioning during mineral formation. Biogeochemical Cycles

Natural hazards- definitions and associated concepts; River flooding- river system, causes and accentuating factors of flooding, effects of flooding, response to flood hazards; Earthquake - worlds earthquake zones, seismic study of Indo-Burma region, hazards associated with earthquakes, response to earthquake hazards; Drought- cause and impact, mitigation and adaptation; Cyclones- cause, frequency and trajectory of tropical cyclone over BB and Arabian Sea, impact of cyclone, mitigation and adaptation. Landslides Common causes of landslides, slope failure, slope stability, prevention and correction methods

Suggested Readings:

1. Bell F.G., Geological Hazards: Their Assessment, Avoidance & Mitigation, Taylor and Francis, 2003.
2. Bell F.G., Environmental Geology - Principles and Practice, Blackwell Science, 1998.
3. Don L. Anderson, *Theory of the Earth.* Blackwell Scientific Publications, 1989.
4. Krauskopf K.B. and Bird D.K., Introduction to Geochemistry. McGraw-Hill, 1994.
5. Smith K.and Ward R., Floods: Physical Process and Human Impacts, John Wiley and Sons, 1998
6. Kale V.S., Flood studies in India, Geological Society of India, 1998

Subject Name: ENVIRONMENTAL CHEMISTRY AND TOXICOLOGY

Introduction concept and scope of environmental chemistry and green chemistry; Stoichiometry; Chemical Thermodynamics - Gibb's energy ,chemical potential, Gibb's phase equilibria, equilibrium of chemical reactions; Chemical Kinetics: Simple reaction mechanisms, order and molecularity of chemical reactions, First, second and zero order reactions, Catalysis, Adsorption; Chemistry of the atmosphere – gases and particles, atmospheric reactions, Chemistry of Photooxidants, Chemistry of atmospheric precipitation.

Chemical species in water; The carbonate system, organic matter and humic matter in water , acid base reactions, pH and pOH, ionic product of water, common ion effect, buffer solutions solubility of gases in water, solubility and solubility product, hydrolysis, chemical equilibrium, oxidation and reduction, radionuclides, Environmental Toxicology: Introduction to Environmental Toxicology, Concepts of Toxicology, Dose-Response Relationships, Absorption of Toxicants, , Toxic substances in the environment, Biochemical impacts of toxic substances, their sources and entry roots, Pesticide Residues, Eco-system influence on the fate and transport of toxicants; Transport of toxicants by air and water; Transport through food chain - bio-transformation and bio- magnification.

Suggested Readings:

1. De A.K., Environmental Chemistry, Wiley Eastern Limited, 1990
2. Manahan S.E., Fundamental of Environmental Chemistry, Lewis, 2001
3. Shaw I.C. and Chadwick J., Principles of Environmental Toxicology, Taylor& Francis ltd, 2008
4. Gupta P.K., Methods in Environmental Analysis- Water, Soil and Air, Agrobios, 2000
5. Connell D.W., Basic Concept of Environmental Chemistry, Lewis, 1997
6. Ibanez, J.B., Hernandez-esparza, M.H., Doris Serrano ArthuroFregoso-Infante ,C., Singh, M.M. (2007). Environmental Chemistry Fundamentals, Springer.
7. Fifield, F.W. and P.J.Haines (Eds), P.J. (1998). Environmental Analytical Chemistry, Blackwell.
8. Keith, L.H.(edtr).(1988). Principles of Environmental Sampling, American Chemical Society.
9. Clesceri, L.S.(1998). Standard Methods for Examination of Water and Waste Water, American Public Health Association, 28th Edition.
10. Lodge, J.P. Jr. (edtr). (1988). Methods of Air Sampling and Analysis, Lewis. Neil, P.O. (1994). Environmental Chemistry, Champman & Hall.

Subject Name: STATISTICAL METHODS AND ENVIRONMENTAL APPLICATION

Introduction to statistics, Sampling, Data collection and recording

Linear Programming, Graphical and Simplex methods, Measures of central tendency, dispersion, Moments, Skewness and Kurtosis, Probability, Conditional probability, Bayes' theorem

Random variable – two dimensional random variables – standard probability distributions Binomial Poisson and normal distributions - moment generating function

Sampling distributions – confidence interval estimation of population parameters – testing of Hypotheses – Large sample tests for mean and proportion – t-test, F-test and Chi-square test – Curve fitting-method of least squares

Regression and correlation – rank correlation – multiple and partial correlation – analysis of variance-one way and two way classifications – experimental design – Latin square design

Time series analysis

Difference among means: F-test: 1 way ANOVA; F-test: 2 ways ANOVA. Computer applications in environmental modeling. Computer-based modeling: Linear, regression, validation and forecasting. Computer-based modeling for population and population studies.

Application in environmental research

Practical on every topic using Excel, SPSS and STATISTICA

Text Books:

1. Bowker and Liberman, Engineering Statistics, Prentice-Hall, 1972.
2. Venkatraman, M.K., Numerical Methods in Science and Engineering, National Publisher Company.
3. Berthouex, P.U., Statistics for Environmental Engineers , Lewis Publ., 1994
4. Wayne R., Ott Environmental Statistics and Data Analysis, CRC Press. (1995)
5. Spiegel M. R., and Stephens L.J. Schaum's outline of theory and problems ofStatistics. McGraw Hill, Singapore, 1999.

MASTER OF SCIENCE (ENVIRONMENTAL SCIENCE) – SECOND SEMESTER

Second Semester			
S. No.	**Name of Subject**	**Credits**	**Total Marks**
1	Environmental Biology	5	100
2	Environmental Physics	5	100
3	Climatology and Meteorology	5	100
4	GIS-Remote Sensing and Application	5	100
5	Environmental Impact Assessment	4	100
Total		24	

Subject Name: ENVIRONMENTAL BIOLOGY

Major environmental pollutants and their impact on plant and animal systems Damage of cell ultrastructure due to atmospheric pollutant, mode of action visible symptoms of air pollution damage in plants, chlorosis and necrosis Transmission of pollutants in plants. Response of animals to environmental pollutant. Potential hazards of nitrates, chlorine, arsenic and polycyclic organic hydrocarbons in human health.

Biological monitoring, bio indicators and control of environmental pollution Xenobiotics and microbial transformation of pollutants in the soil. Biodiversity and its conservation:- Definition, hotspots of biodiversity, strategies for biodiversity conservation, protected areas, gene pool. Impact of radiation on biological system Fermentation technology and biofertilizer technology Soil microorganisms and their functions. Physical techniques used in biology.

Practical: Experimental observation on effect of acid rain on plants; effect of water pollution in flora and fauna, effect of air pollution in flora and fauna, study on bioremediation. Study of some soil microorganisms through collection of sample.

Suggested Readings:

1. Bell J.N.B., Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons, 2002
2. Ming-Ho Yo., Environmental Toxology-Biological and Health Effects of Pollutant, Third Edition, CRC Press, 2011.
3. Saradhi P.P., Biophysical processes in living systems, Oxford & IBH Publishing, 2008.

4. Prosser C. Ladd., (editor). Comparative Animal Physiology, fourth edition, Wiley- Liss, New York, 1991.
5. Krishnamurthy, K.V. (2004). An Advanced Text Bookon Biodiversity- Principle and Practices, Oxford & IBH Publishing.
6. Bertold, Hock and Erich, F. F. Elstner. (editors)(2004). Plant Toxicology, Fourth Editon, CRC Press.
7. Mari S. Golub (Editor),(2005). Metals, Fertility and Reproductive Toxicity, CRC Press
8. Stanley, E.Manahan, (2004). Environmental Chemistry,Eightedition,CRC Press.
9. Toxicological and environmental chemistry (Journal) published by Taylor and Francis

Subject Name: ENVIRONMENTAL PHYSICS

Basic Mathematics: Elementary Vector Operations; Taylor Series; Exact Differential; Partial Differential Equations; Gauss's theorem; Stoke's theorem; Potential Function; Solid angle.

Properties of Gases and Liquids: Physical properties of gases such as density, heat capacity, and molecular diffusivity, exchanges between organisms or land surfaces and their environment; Evaporation of water from soils, plants, and animals, surface water bodies; Cloud Physics.

Transport of Heat, Mass and Momentum: Transport of heat, mass, and momentum in the atmosphere across different interface such as soil, vegetation, water. Mass transfer by Gases, water vapour and particles. Mass diffusion, Mass exchange between air, plants and animals. Properties of turbulance, Roughness parameters, Aerodynamic resistance, Bowen ratio, flux gradients, wind speed gradients. Turbulent transfer, profiles and fluxes across vegetation canopies. General equation for transport within a gas. Verticle fluxes, Eddy Covariance. Conduction, Convection and Advection in gases, liquids and solids. Diffusion coefficients for momentum, heat, water vapor, and other gases and dependence on temperature. Transient heat balance. Sensible heat flux, latent heat flux.

Radiation Environment: Properties of Electromagnetic radiation, Principles of radiation absorption and emission, Concepts of BlackBody, Wein's law, Kirchoff's law, Planck's law, Stefan-Boltzman's law; Radiative exchange between layers and surfaces, radiative resistance; Cosine law, Spectral reflectivity and absorptivity, Beer's law, Kubelka-Munk Equations. Irradiance and radiance. Principle of scattering and absorption of shortwave and long wave radiation, Aerosol Optical depth, Single scattering Albedo, Radiation balance, concept of radiative forcing.

Suggested Readings:

1. Monteith J. and Unsworth, M., Principles of Environmental Physics: Plants, Animals, and the Atmosphere, 4e, Academic Press, 2013.
2. Campbell G.S., Norman, J.M., An Introduction to Environmental Biophysics, 2e, Springer-Verlag, New York, 1997.
3. Iqbal M., Introduction to solar Radiation, Academic press, 1983.
4. Petty, G.W. (2006). A First Course in Atmospheric Radiation, second ed. Sundog Publishing.
5. Foken, T. (2008). Micrometeorology. Springer-Verlag, Berlin, Heidelberg.
6. Jacobson, Mark Z.(2005). Fundamentals of Atmospheric Modelling, Cambridge University Press.

Subject Name: CLIMATOLOGY AND METEOROLOGY

The earth and the atmosphere system, Overview of the structure and composition of the atmosphere; Energy for the earth-atmosphere- sun relation, rotation revolution and variation of energy received, radiation and atmospheric interaction.

Meteorology fundamentals- , temperature; pressure, pressure belts, wind and atmospheric circulation; atmospheric moisture- , condensation, formation of precipitation, dew, fog and clouds; atmospheric stability (-lapse rate, adiabatic process, mixing height.)

Micrometeorology- introduction to ABL, microclimate of vegetated surface, urban microclimate- factors that modifies meteorological process in urban area, modified process and observed results, UHI, thermal comfort.

Weather system- Tropical system- equatorial trough, ITCZ, jet streams, vortices; monsoon, El-Nino Climate- elements of climate, climate control; classification of climate, degree days, thermal comfort.

Climate of India; spatial and temporal patterns of climatic parameters- temperature, rainfall and its variability in India with special reference to N.E.

Suggested Readings:

1. Ahrensand R C. D., Hensen. Meteorology Today: An Introduction to weather climate and the Environment. 10th Edition. Brookes/ Cole Cengage Learning Learning, 2013
2. Oliver J.E. and. Hidore J.J., Climatology: An atmospheric science, Second Edition, Pearson Education, 2003
3. Das P.K., Monsoon.12th Edition, National Book Trust of India, 2013
4. Wang B., The Asian Monsoon. Springer Praxis Publishing, 2006
5. Thornthwaite C. W., An Approach toward a Rational Classification of climate. Geographical Review, 38(1), 59-94(1948)

Subject Name: GIS-REMOTE SENSING AND APPLICATION

Introduction to Remote sensing – principles, spectral reflectance of earth's surface features; Data products and data sources. Applications of Remote Sensing in environmental monitoring and assessment.

Introduction to GIS – principles, digital image processing- image rectification, enhancement and mosaicking elements of map- projection, scale, coordinate systems Image interpretation classification, ground truth data and training set manipulation, accuracy assessment; introduction GPS; NDVI, overlay analysis, model running.

Suggested Readings:

1. Jense J. R., Remote Sensing of the Environment – An earth resource perspective. Pearson Education, 2009
2. Lillesand T. M., Remote Sensing and Image Interpretation. John Wiley, 2004
3. Burrough P.A. and McDonnell R.A., Principles of Geographical Information Systems. 2nd Edition, Oxford University Press, 2006

Subject Name: ENVIRONMENTAL IMPACT ASSESSMENT

Definition of nature of environment, project, stages of project and impact Introduction and Principle – purpose of EIA, Sustainable development and EIA Origin and development of EIA

The EIA Process – methodologies and practice

Early stages - Screening, Scoping and consideration of alternatives Baseline studies

Impact identification and prediction, evaluation, and mitigation – Environmental Management plan, Public consultation and participation, EIA presentation, The EIS, review and decision making Post decision making EIA – monitoring and Audit

The Indian EIA regime – guidelines and notifications Environmental priorities in India and sustainable development.

EIA case studies – River Valley Project, Township, Oil Refinery, Highway Development issues in the Northeast India

Suggested Readings:

1. Glasson, The rival and Chadwick, Introduction to Environmental Impact Assessment, Routledge, 2005
2. Morgan R. K., Environmental Impact Assessment - A Methodological Approach, Springer 1998
3. Carter E.L., Environmental Impact Assessment, McGraw-Hill Education, 1996
4. All guidelines and notifications of Government of India

MASTER OF SCIENCE (ENVIRONMENTAL SCIENCE) – THIRD SEMESTER

Third Semester			
S. No.	**Name of Subject**	**Credits**	**Total Marks**
1	Agriculture and Environmental Sustainability	5	100
2	Environmental System Analysis	5	100
3	Environmental Pollution and Management	5	100
4	Soil Science	5	100
5	Energy and Environment	4	100
Total		**24**	

Subject Name: AGRICULTURE AND ENVIRONMENTAL SUSTAINABILITY

Agroclimatic zones of India & N E India; heat unit concept; thermal time and thermal use efficiency; cardinal temperature; photoperiodism; thermoperiodism; phenology of crops; meteorological factors associated with pest and disease incidence (potato blight; apple scan; groundnut red hairy caterpillar; locust etc); growing seasons and botanical features of major crops (rice; wheat; maize; sugarcane; rapeseed & mustard and pulses).

Micrometerology- microclimate and micrometereology of crops; day and night radiation, humidity, temperature, wind and CO_2 profiles in crop canopies; different methods and modification of field microclimate; light interception of crop canopies as influenced by leaf area index; leaf arrangements and leaf transmissibility; extinction coefficient and radiation use efficiency.

Evapotranspiration- concepts of water balance; evapotransipiration (ET): potential and actual ET, consumptive use and different approaches of ET determination; water use and water use-efficiency; dry matter production and crop yield functions; irrigation scheduling based on ET.

Agricultural pollution and sustainability - Agricultural pollutants and their remediation with special reference to agrochemical (pesticides and fertilizers) and heavy metals; Sustainable agriculture; soil erosion; desertification, watershed management and dryland agriculture.

Special features of North East agriculture - Hill ecosystem; shifting cultivation in hill states and impact on environment; biomass burning and its impact. Interaction between agriculture and landscape degradation; Flood damage on ecosystem due to Brahmaputra flood and related environmental problems; vegetation recovery in degraded land and sandy areas caused by flood.

Suggesting Readings:

1. Reddy T.Y. and Reddi; G.H.S.; Principles of Agronomy; Kalyani Publishers; 2010.
2. Panda S.C.; Agrometeorology and Contingent Crop Planning; Agrobios (India); 2010.
3. Arakeri H.R. and Roy D.; Principles of Soil Conservation and Water Management; Oxford IBH Pub. Co. Pvt. Ltd.; 2000.

Subject Name: ENVIRONMENTAL SYSTEM ANALYSIS

Introduction to Environmental Systems Analysis (ESA), identification and description of ESA, concepts and methods, particularly in the ecosystem services framework

Environmental system boundaries and scale: environmental system boundaries – physical boundaries relating to interface between hydrosphere, lithosphere, biosphere and the atmosphere, closed system and open system, environmental system existence in spatial scales (microscopic and macroscopic), hierarchical organization – system, sub-system and system components (or system element)

ESA tools: Life Cycle Assessment (LCA), Life Cycle Costing (LCC), Cost-Effectiveness Analysis (CEA), Material Input Per unit Service (MIPS), Material Flow Analysis (MFA), Risk Assessment (RA), Strategic Environmental Assessment (SEA), Environmental Impact Assessment (EIA), Environmental Management Systems (EMS), Energy Analysis (EA), Economic Valuation (EV), Carbon Footprint (CF), and Ecological Footprint (EF)

ESA in decision-making: Analyzing decision problem (goals, decision or control variables), basic information on roles of environmental system models (structure, parameter, interconnections, computer simulation, testing, validity and sensitivity, solving the decision problems by scenario analysis, optimization and control, decision strategies, planning, etc.)

ESA Methodologies: Data collection, data source and data management, data validation, data interpretation, statistical analysis (application software – R, SPSS, etc.)

Application of ESA tools: Climate change, waste management, natural hazards, biodiversity conservation, agriculture, sustainable management of natural resources, best practice management, case-studies

Suggested Readings:

1. Walter J. Weber, Jr., Francis A. DiGiano, Process Dynamics in Environmental Systems, Wiley, 1996.
2. Mike J. Barnsley, Environmental Modeling: A Practical Introduction, CRC Press, 2007.
3. Miguel F. Acevedo, Simulation of Ecological and Environmental Models, CRC Press, 2012.
4. Charles Eccleston, J. Peyton Doub Y., Effective Environmental Assessments: How to Manage and Prepare NEPA EAs. CRC Press, 2001.
5. Anjaneyulu, Valli Manickam, Environmental Impact Assessment Methodologies, CRC Press, 2011.

Subject Name: ENVIRONMENTAL POLLUTION AND MANAGEMENT

Introduction- Definition, Great pollution disasters, Modern pollution issues, Role of individual in pollution prevention, Risk and benefits associated with pollution.

Air pollution-Source and emission of air pollutant, Pollutant transport and properties of air pollutants, Health effects and source control, Trans boundary pollution, acid rain, Air Pollution Monitoring, air quality standards, Regulations and abatement of air pollutants.

Water pollution-Introduction of water quality, Characteristics of water, Classification of pollutants, Concept of concentration, Water monitoring and water quality guidelines, Organic and Inorganic Pollutants, Cause and effect of water pollution, Counter measures of water pollution, Case study.

Noise pollution-Sources and measurement indices of noise pollution, Effect of meteorological parameters on noise propagation, Noise exposure level and standards, Noise control and abatement measures, Impact of noise on human health, Mitigation of noise pollution, Case study.

Managing the Oceans-Implications of uncontrolled exploitation of marine resources, Cause and impact of marine pollution, Strategies for sustainable harvesting of oceanic resources, Marine pollution control and remedial action.

Managing air, water and land- Action on the atmosphere, Strategies to reduce pollution, climate change and its impact, Need for international action and changing attitudes to deal with cause and consequences of the damage to the atmosphere, Clean, safe water strategies; Managing the land-Wetland, Agriculture/industry/urbanization induced land pollution and its mitigation, Land reclamation measures, Land management through phytoremediation and bio-remediation; Biological mediated pollution control

Suggested Readings:

1. Manahan S.E., Environmental Chemistry, Lewis, 1994
2. De A.K., Environmental Chemistry, Wiley Eastern Limited , 2000
3. James W. Moore., Inorganic Contaminants of Surface Water, Springer- Verlag
4. Bell, J.N.B. (2002). Air Pollution and Plant Life, 2nd Edition, John Wiley and Sons.
5. Cheremisinoff, N.P. (1996). Bio-Technology for Waste and Wastewater Treatment William Andrew Publishing.
6. Fellenberg, G. (1999). Chemistry of Pollution, John Wiley and Sons.
7. El-Halwagi M.M., (1997). Pollution Prevention through Process Integration, AP.
8. Kush S., (2001). Automobile Pollution, Sarup

Subject Name: SOIL SCIENCE

Soil Formation: Weathering-. And Soil formation - Profile development - Soil composition. Soil forming rocks and minerals - Classification

Soil physics: Soil separates and particle size distribution - Soil texture and structure - Bulk density, particle density, pore space, soil air, soil temperature, soil water, and soil consistence - Significance of physical properties to plant growth.

Soil chemistry: Soil colloids - Inorganic colloids - Clay minerals - amorphous - Ion exchange reactions - Organic colloids -, Soil reaction- ph, Eh, CEC, base saturation –problem soils (acid, alkaline and sodic soils); Transportation of pollutants in soil system.

Soil biology: Soil organic matter - Decomposition - Humus formation - Significance on soil fertility, nutrient availability. Soil microorganisms and their roles in soil quality.-C: N ratio.

Soil and climate change: effects of global warming on soils and its management- - Relative importance of soil and vegetation management in global warming.

Practical: Study of physico-chemical properties of soil collected from different areas: Soil organic carbon, Water holding capacity, pH, Bulk density, and soil respiration. Soil microbial biomass carbon estimation, soil nutrient analysis (N, P, K, Ca, Mg, etc); studies on various soil working and analytical equipment and tools.

Suggested Readings:

1. Brady N.C., and R.R. Weil. 2010. Elements of the Nature and Properties of Soils, 3rd Ed. Prentice Hall.
2. Stewart B.A., Advances in soil sciences, Lewis Publisher, 2000.
3. Biswas T.D. and Mukherjee S.K., Textbook of Soil Sciences, Publisher: McGraw- Hill Inc.,US, 2nd edition, 1995.

Subject Name: ENERGY AND ENVIRONMENT

Energy sources, forms, significance and its ultimate fate, Energy flow patterns, effects of energy use on the environment and analyses of current energy related problems, Energy production and consumption pattern –World and India.

Principles of generation of thermal, hydroelectric, Wave, Tidal, OTEC, wind, geothermal, and solar power, bio-energy and biofuels, promise and problems of Nuclear energy, Magneto Hydro Dynamics (MHD).

Fossil fuels-classification, composition, physicochemical characteristics and energy content of coal, petroleum and natural gases, air pollution and thermal pollution from fossil fuels, Laws of thermodynamics and its application.

Thermochemical conversion technology, Biomass Power Generation Technologies, Wind Energy Conversion Technology and Energy Storage, Solar Energy Engineering, Power Plant Engineering.

Energy conservation, substitution and management, Laws of limiting energy utilization, Emerging Alternate Energy Conversion System, Energy Efficiency and Performance Assessment, Energy and Power Auditing and Management.

Radioactive wastes from nuclear power plants, hazards related of hydropower.

Suggested Readings:

1. Devins D.W., Energy: Its Physical Impact on the Environment, John Wiley and Sons, 1982.
2. Fowler J.M., Energy and Environment, McGraw Hill, 1984.
3. Ristinen R.A. and Kraushaar J.J., Energy and the Environment, John Wiley and Sons, 1998.
4. Energy and the Challenge of Sustainability, World Energy Assessment, UNDP, 2000.
5. Rai G.D., Non –Conventional Sources of Enegry, Khanna Publishers 1997.
6. Ravingranath N.H., Usha Rao K., B.Nataranjan and P. Monga Renewable Energy and Environment-A Policy Analysis for India, Tata- McGraw Hill,2000
7. Nakicenovic N., (edtr) Global Energy Perspectives, Cambridge University Press, 1998
8. Dandekar and Sharma., "Hydro Power Engineering"
9. Varshney., "Hydro Power Structures" NCB Roorkee, India.

MASTER OF SCIENCE (ENVIRONMENTAL SCIENCE) – FOURTH SEMESTER

Fourth Semester			
S. No.	Name of Subject	Credits	Total Marks
1	Natural Resource and Biodiversity Conservation	5	100
2	Hydrogeochemical Processes	5	100
3	Environmental Plant Physiology and Biochemistry	5	100
4	Solid Waste Management and Technology	5	100
5	Project	4	100
Total		24	

Subject Name: NATURAL RESOURCE AND BIODIVERSITY CONSERVATION

Natural resource - introduction to earth's natural resources, types of natural resources and their classification, value of natural resources, extraction and uses of natural resources- linkages and benefits. Potentiality of natural resources for economic and livelihood development.

Conservation and management of natural resources- humans and conservation vice-versa, conservation and protection, sustainable use of natural resources. Natural resource management approaches: Community based natural resource management (CBNRM) and Integrated natural resource management (INRM).

Biodiversity - understanding biodiversity, dimensions of biodiversity, taxonomic diversity, speciation and extinction of species, mass extinction events, measurement of biodiversity: diversity indices. Megadiverse countries, Ecoregions, Biodiversity hotspots. Importance of biodiversity, threats to biodiversity, causes and consequences of biodiversity loss, biodiversity and vulnerability to climate change, biodiversity and human health.

Natural resources and biodiversity in India and Northeast India- biogeographic region of India, significance of NE India biodiversity, important forest resources and their diversity in NE India -medicinal plants, bamboo, orchids, palms, rattans, timbers, gymnosperm etc. Endemic and rare species biodiversity conservation with reference to NE India. Case studies.

Conservation of biodiversity: in situ and ex situ, selection criteria for protection of species, IUCN conservation status, Red Data book, ethics in conservation of biodiversity. Biodiversity related national and international conventions and organizations.

Management of biodiversity - Sacred groves, Community reserve forest, Reserve forests, National Parks, Wildlife Sanctuary, Biosphere Reserve, Private/corporate forest. Traditional ecological knowledge, CBD, Participatory Rural Appraisal (PRA), Constrains of conservation.

Suggested Readings:

1. Krishnamurthy K. V., Textbook of Biodiversity, CRC Press, 2003.pp. 276.
2. Krishnamurthy K. V., An Advanced Textbook on Biodiversity: principles and Practice, Oxford & IBH Pub. Co. Pvt. Ltd., 2008.
3. Maiti Prabodh K. and Maiti Paulami., Biodiversity: Perception, Peril and Preservation, PHI, New Delhi, 2001. pp.560.
4. Anne, E. Magurran. (2003). Measuring Biological Diversity. Wiley-Blackwell, pp-264.
5. Anne, E. Magurran and Brian, J.(2010). Biological Diversity Frontiers in Measurement and Assessment. McGill (Eds.), Oxford University Press. pp-368.
6. Joshi, P. C. and Joshi, N. (2004). Biodiversity and conservation. A.P.H. Pub., pp- 384.
7. Gabriel, Melchias. (2001). Biodiversity and conservation. Science, University of Michigan, pp-.236
8. Pandey, B.N. (2012). Biodiversity Issues Threats and Conservation. Narendra Publishing, pp.-202.
9. Navjot, S. Sodhi and Paul R. (2010). Conservation Biology for All. Ehrlich (Eds.), Oxford University Press. pp-360.
10. Gary A. Klee. (1991). Conservation of Natural Resources. Prentice Hall College Div., pp. 1180.
11. Rai, G. D. (1997). Non-conventional energy sources. Khanna Publishers, New Delhi. pp. 912.

Subject Name: HYDROGEOCHEMICAL PROCESSES

Catchment hydrology-The global system, fluxes, reservoirs, and residence times; Evaporation, condensation, precipitation; Regional water balances and resources; Structure and properties of water; Precipitation and Interception; Water and energy balance, Subsurface flow; Infiltration and soil moisture; Hydrographs.

Groundwater transport - Water in natural formations (aquifer, aquitard, aquiclude etc); Hydraulic head; conductivity, permeability, storativity, and porosity; Darcy's law, advection, dispersion, adsorption and decay; Steady state groundwater flow & Flow nets; Forces on water in the unsaturated zone; Tracer techniques.

Understanding of hydrogeochemical processes-Measurements and interpretation of water quality data; Identification of hydrogeochemical processes through Major ion chemistry, Graphical presentation and Statistical analyses; Groundwater flow and transport models; Modeling runoff and PhreeqC, MINTEQ-A.

Chemical Weathering- Clay mineralogy, Cation exchange and Carbonate mineral equilibrium; Silicate weathering, Carbonate weathering, Contaminant transport Adsorption processes; Hydrogeochemical processes and its role in contemporary environmental scenario.

Arsenic and fluoride hydrogeochemistry; Remote sensing and hydrological networks; Desalination, Controlling demand and waste; Integrated water resources management; Case studies.

Suggested Readings:

1. Hornberger, G.M., Raffensberger, J.P., Wiberg, P.L., and Eshleman, K.N. (1998) Elements of physical hydrology. Johns Hopkins University Press, Baltimore, 302p.
2. Fetter, C.W., Applied Hydrogeology 4rd ed. (2001). This text will be supplemented by material from Freeze, A. and Cherry, J., Groundwater (1979),
3. Chow, V.T., Maidment, D.R. and Mays, L.W., Applied Hydrology (1988), Dingman, S.L., Physical Hydrology (1998).
4. Todd, D.K. Ground water Hydrology, John Wilay and Sons, N.Y.,USA.

Subject Name: ENVIRONMENTAL PLANT PHYSIOLOGY AND BIOCHEMISTRY

Plant growth and development in relation to environmental stress -water and temperature stress, drought stress and resistance

Anaerobiosis in soils, the effect of anoxia on plant metabolism, plant adaptation, survival and growth in waterlogged soils.

UV radiation and its effect on cellular processes and metabolism.

Effect of air pollutants in light reactions in chloroplasts, photosynthesis, photorespiration and dark respiration, membrane transport

Physiological and molecular aspects of plant tolerance to atmospheric pollutants

Oxyradicals and scavenging systems, enzyme system associated with plant defense mechanisms, superoxidedismutase, role of stomata in plant defense system

Bioconversion of pollutants- active vs. inactive process Enzymatic degradation by monooxygenase

Role of cytochrome P 450 and its multiple forms. Metal toxicity: metal biomacromolecule interaction.

Suggested Readings:

1. Fitter A.H. and Hay R.K.M., Environmental Physiology of Plants, Third edition, Academic Press, 2001.
2. Park S. Nobel., Physicochemical & Environmental Plant Physiology (3rd Edition) Academic Press, 2005
3. Levitt J., Responses of Plants to Environmental Stress, Volume-I, Second edition, Academic Press, New York,1972.
4. Lehninger, A.(1993). Biochemistry, Kalyani Publishers.
5. Taiz, L.and Zeiger, E.(1998). Plant Physiology, Sinauer Associates.
6. Pintan, Roberto., Varanini, Zeno. and Nannipieri, Paolo. (editors).(2007).The Rhizosphere-Biochemistry and Organic Substances at the Soil Plant interface 2nd Edition, CRC Press.
7. Voet, D. and Voet, J. (2004). Biochemistry, John Wiley and Sons.
8. Roger, R. (2001). Hand Book of Plant Ecophysiology Techniques, Kluwer.

Subject Name: SOLID WASTE MANAGEMENT AND TECHNOLOGY

Municipal Solid waste –Definitions, sources, generation, segregation, classification and physico-chemical characterization; principles of solid waste management; Hazardous wastes: definition, source, effects and management; Biomedical wastes: definition, source, effects and management; E-waste generation & management; Eco friendly disposal methods of solid wastes.

Flyash: definition, source, effects and management

Waste treatment technologies for resource and energy recovery - basic principles; techniques of resource & energy recovery; composting, vermicomposting, microbial decay, anaerobic digestion, incineration, pyrolysis.; landfill engineering and leachate management; mining of old landfills; advances in waste recycling and recovery technologies to deliver added-value products.

Interface of waste and resource management and engineering in the context of sustainable waste management in global cities and developing countries; life cycle analysis.

Suggested Readings:

1. White P.R. et al, Integrated Solid Waste Management, Lewis Publisher, 1989.
2. Manual on Municipal Solid Waste Management, CPHEEO, Ministry of Urban Development, Govt. of India, New Delhi, 2000
3. David L.H.F. and Liptak D. G., Hazardous waste and solid waste, Lewis Publisher, 2000
4. Oberoi N.K, Environmental Management, (2nd Edition) Excel Books, New Delhi, 2003.

Subject Name: PROJECT