Central University of Rajasthan

DEPARTMENT OF ENVIRONMENTAL SCIENCE
SCHOOL OF EARTH SCIENCES

Integrated M.Sc. (5 year) / M.Sc. (2 year)
Environmental Science

(Course Syllabus)

February, 2018

Central University of Rajasthan
School of Earth Sciences
Integrated M.Sc. (5 year) / M.Sc. (2 year) Environmental Science

Course Structure and Syllabus

First Semester:

S.No.	Subject Code	Name of the Subject	Credit
1	MSE 101	Ecology and Environment	3
2	MSE 102	Natural Resources, Biodiversity and Wildlife Conservation	3
3	MSE 103	Environmental Chemistry	3
4	MSE 104	Environmental Geoscience	3
5	MSE 105	Environmental Policies, Legislation and Sustainable Development	3
6	MSA 101	Fundamentals of Atmosphere, Land and Ocean	3
7	MSE 106	Environmental Pollution	3
8	MSE 107	Environmental Laboratory-I	3
		Total Credits	**24**

Second Semester:

S.No.	Subject Code	Name of the Subject	Credit
1	MSE 201	Instrumentation for Environmental Monitoring and Analysis	3
2	MSE 202	Air and Water Quality Management	3
3	MSE 203	Environmental Toxicology	3
4	MSA 203	Statistical Analysis and Computer Programming	3(2T+2P)
5	MSE 204	Remote Sensing and GIS	4(3T+2P)
6	MSE 205	Field Trip	1
7	MSE 206	Environmental Laboratory-II	3
8	MSE XXX	Elective 1*	3
		Total Credits	**23**

Third Semester:

S.No.	Subject Code	Name of the Subject	Credit
1	MSE 301	Coastal and Marine Environment	3
2	MSE 302	Environmental Impact Assessment and Management	3
3	MSA 302	Arid Environment and Desert Meteorology	3
4	MSE 303	Environmental Biotechnology	3 (2T+2P)
5	MSE 304	Science of Climate and Climate Change	3
6	MSE 305	Minor Project	2
7	MSEYYY	Elective 2*	3
8		Open Elective**	3
		Total Credits	**23**

Fourth Semester:

S.No.	Subject Code	Name of the Subject	Credit
1	MSE 401	Project	20
		Total Credits	**20**

Total: 90 Credits

* Minimum 6 students are required to run elective courses (List enclosed)

**Open elective can be selected from any department of the university.

MOOCs can be selected based on the availability

Elective Courses I

S.No.	Subject Code	Name of the Subject	Credit
1	MSE 207	Solid Waste Management	3
2	MSE 208	Environmental Disasters and Management	3
3	MSE 209	Hydrogeology	3
4	MSE 210	Wastewater Treatment and Management	3(2T+2P)
5	MSE 211	Energy and Environment	3
6	MSA 205	Simulation and Visualization in Earth Sciences	3(2T+2P)
7		Massive Open Online Courses (MOOCs)	3

Elective Courses II

S.No.	Subject Code	Name of the Subject	Credit
1.	MSA 306	Aerosol and Atmospheric Chemistry	3
2	MSE 306	Environmental Modelling	3
3	MSE 307	Geoinformatics for Natural Resources Management	3
4	MSE 308	Environmental and Occupational Health	3
5	MSE 309	Nanotechnology for Pollution Mitigation	3
6	MSE 310	Water Resource Management	3
7		Massive Open Online Courses (MOOCs)	3

Semester I

MSE 101: Ecology and Environment (3 Credits)

Definition, principles and scope of ecology, abiotic and biotic factors, autecology, synecology, limiting factors, adaptation, negative and positive interaction between species, population and community interactions, key stone species, dominant species, invasive species, ecotone, edge effect, ecological succession, concept of climax, structure and function of ecosystems, productivity, energy flow, ecological efficiencies, nutrient cycling, major biomes.

Suggested Readings

1. Odum, E.P.and Barerett G.W. Fundamentals of Ecology, 5th edition, Brooks Cole, Cengage Learning, 2005.
2. Botkin, D.B., and Keller,E.A.Environmental Science. Earth as a Living Planet, 7thedition, John Wiley & Sons, INC, 2009.
3. Smith R.L., Smith T.M., Hickman G.C. and Hickman S.M. Elements of Ecology, 6th editionBenjamin-Cumming, 2006.
4. Begon, M., Townsend, C. R., and Harper, J. L. Ecology from Individuals to Ecosystems. Wiley-Blackwell, USA.
5. Chapman, J. L. and Reiss, M. J. Ecology: Principles and Applications. Cambridge University Press, UK.

MSE 102: Natural Resources, Biodiversity and Wildlife Conservation (3 Credits)

Natural resources, classifications, factors, resources availability and inter-relationships, concept of biodiversity, alpha, beta and gamma diversity, economic value of biodiversity, biodiversity losses, red data book, threatened plants and animals of India, endemic species, hotspots of biodiversity, wildlife distribution in India, wildlife protection acts in India, in-situ & ex-situ conservation, united nation role on biodiversity conservation, national biodiversity action plan in India (NBAP).

Suggested Readings

1. Daniel, D., Chiras and Reganold, John P. Natural Resource Conservation: Management for a Sustainable Future (X Ed.), Addison Wesley, Boston. 2009.
2. Singh, N. Irabanta. Endemic Bioresources of India, Bishan Singh Mahendra Pal Singh, Dehradun. 2008.
3. Enger, E.D. and Smith, B.F. Environmental Science: A Study of Interrelationships. 11th ed. McGraw Hill Inc., USA. 2006.
4. Heywood, V.H. and Watson, R. T. Global biodiversity Assessment. UNEP-Cambridge, 1995. Hunter, Malcolm L., Jr., and Gibbs, James P. Fundamentals of Conservation Biology. 3rd ed. Wiley-Blackwell. 2006.

MSE 103: Environmental Chemistry (3 Credits)

Stochiometry, acid base reactions, Henry's law, carbonate system. Air chemistry: Chemical speciation, particles, ions and radicals in the atmosphere, chemical processes for formation of inorganic and organic particulate matter, photochemical reactions in the atmosphere, oxygen and ozone chemistry, photochemical smog. Water chemistry- physico-chemical and biological parameters, concept of DO, BOD, COD. Soil chemistry: physico-chemical characteristics, organic matter and organic carbon, nitrogen pathways, C/N ratio, NPK in soils.

Suggested Readings

1. Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company. 2008.
2. De, A. K. Environnemental Chemistry. 4th ed. New Age International (P) Ltd., New Delhi, India.2001.

3. Harrison, R. M. and de Mora, S. J. Introductory Chemistry for the Environment Science. 2nd ed. Cambridge University Press, New Delhi. 1996.
4. Manahan, S. E. Fundamentals of Environmental Chemistry. 2nd ed. CRC Press, Inc., US. 2001.
5. Sawyer, C.N. and McCarty, P.L. G.F. Parkin (eds). Chemistry for Environmental Science and Engineering,Tata-McGraw-Hill Edition. 2003.

MSE 104: Environmental Geoscience (3 Credits)

The earth system, plate tectonics, basic geologic processes, minerals and rocks, igneous rocks and processes, sedimentary rocks and processes, metamorphism, deformation, geological time scale, evolution of the continents, internal geosystems: volcanoes, earthquakes, exploring earth's interior, surficial geosystems: weathering, erosion, and mass wasting; interface between climate and tectonics, stream transport, winds and deserts, glaciers, concept of major, minor and trace elements; mobility of elements, geochemical cycles; geoindicators, mineral resources. geobiology: life interacts with the earth.

Suggested Readings

1. Keller, E.A. Introduction to Environmental Geology. 4th ed. Prentice Hall of India. 2007.
2. Eby, N. Principles of Environmental Geochemistry. Brooks Cole, USA. 2003.
3. Bennett, M.R. and Doyle, P. Environmental geology: - Geology and the Human Environment. John Wiley and Sons.1997.
4. Botkin, Daniel B. and Keller, Edward A.Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA. 2007.
5. Grotzinger J., Jordan Thomas H., Press Frank, Siever Raymond: Understanding Earth; Freeman and Company. 2014.

MSE 105: Environmental Policies, Legislation and Sustainable Development (3 Credits)

National Environmental Policy, constitutional provisions (Article 48A, 51A). Acts, rules regulations and amendments thereof –Air (Prevention and Control of Pollution) Amendment Act, 1987, Water (Prevention and Control of Pollution) Amendment Act, 2012, Wild Life (Protection) Amendment Act, 2013, Forest (Conservation) Second Amendment Rules, 2014, Environment Laws (Amendment) Act, 2015,Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2015, Bio-Medical Waste Management Rules, 2016, National Green Tribunal Act 2010. Sustainable Development: definition and concepts, evolution and development of international environmental laws with reference to Stockholm Conference on Human Environment, Montreal Protocol, Kyoto Protocol, Earth Summits, UN Summit on Millennium Development Goals. Environmental Movements.

Suggested Readings

1. Shelton D. and Kiss A. C. Judicial Handbook on Environmental Law, United Nations Environment Programme, 2005.
2. Jaswal, P.S. and Jaswal, N. Environmental Law. Pioneer Publications, Delhi. 2003.
3. Tiwari, R. K. Global Environmental Policies. ABD Publishers, 2007.
4. Trivedy R. K. Handbook of Environmental Laws, Guidelines, Compliance & Standards, Vol. 1 & 2 Environ – Media Karad, India, 2004.
5. Kuttingayloan G. M. Conventions, Treaties and other Responses to Global Issues, Vol. 1 & 2 EOLSS Publishers Co Ltd, 2009.

MSA 101: Fundamentals of Atmosphere, Land and Ocean (3 Credits)

Structure of the atmosphere and its composition, thermodynamics of dry and moist air, formation of cloud droplets and precipitation, radiation basics and budget, aerosol-cloud interaction and ozone depletion, components of the earth system, hydrologic and biogeochemical cycles, soil composition, carbon flux and photosynthesis, vegetation dynamics, landscape heterogeneity, land-use/land-cover changes, characteristics of ocean basins, properties of sea water, mixed layer, heat budgets of the ocean, ekman dynamics, upwelling and down welling processes, currents.

Suggested Readings

1. Neil C., The Atmosphere and Ocean: A Physical Introduction (Advancing Weather and Climate Science), Wiley.
2. Maarten H. P. Ambaum, Thermal Physics of the Atmosphere (Advancing Weather and Climate Science) Wiley.
3. Gary E. Thomas, Knut Stamnes, Radiative Transfer in the Atmosphere and Ocean: Cambridge Atmospheric and Space Science Series.
4. Bonan, G., Ecological Climatology: Concepts and Applications, 2nd Edition, Cambridge, 2008.
5. Shuttleworh, W. J., Terrestrial Hydrometeorology, 1st Edition, John Wiley & Sons.,2012.

MSE 106: Environmental Pollution (3 credits)

Environmental pollution-local, regional and global aspects, major sources of environmental pollutants and their effects on environment. Water pollution- sources and effects, water quality parameters and standards, drinking water treatment, water disinfection; wastewater treatment. Air pollution- sources and effects, air quality parameters, mitigation of air pollution, mechanical and engineering methods. Soil pollution, soil reclamation methods. Noise pollution, Radioactive pollution and Thermal pollution-sources, effects and abatement methods.

Suggested Readings:

1. Pepper I.L., Gerba C.P. and Brusseau M.L. Environmental and Pollution Science; Academic Press. 2011.
2. Hill M.K. Understanding Environmental Pollution: A Primer, Cambridge University Press, 2010.
3. Peirce J.J., Vesilind P.A. and Weiner R.Environmental Pollution and Control, 4th Edition, Kindle Edition.
4. Rao C.C. Environmental Pollution Control Engineering, New Age International, New Delhi, India, 2007.
5. Harrison R.M. Pollution: Causes, Effects and Control, 4th edition, Royal Society of Chemistry, 2001.

MSE 107: Environmental Laboratory (3 credits)

(A)Ecology: Determination of minimum size of quadrat for community study, determination of density, frequency, abundance and dominance of plant species using quadrat method, preparation of raunkiers frequency classes of a community/vegetation, calculation of index of diversity,

(B)Geoscience: Introductory practical exercises in Environmental geology, Particle size analysis, Bulk density, Specific gravity, Water content, Loss-on ignition, Mineral identification, Analysis of geomorphological features;

(C)Environmental Chemistry: GLP, Preparation of standard solution in lab –from analytical grade chemicals and solutions available, air analysis: oxides of nitrogen and sulphur, water analysis: pH, electrical conductivity, turbidity, total suspended solids, total dissolved solids, dissolved oxygen, soil analysis: moisture content, organic carbon, organic matter, water holding capacity.

Semester II

MSE 201: Instrumentation for Environmental Monitoring and Analysis (3 credits)

Sampling methodologies for environmental matrices, sampling protocols- selection of sites, time and frequency for sampling, preservation, Storage and handling of samples; Good Laboratory Practices. Principles, working and applications of high volume sampler, respirable sampler, particle size analyser, spectrophotometer (UV-Visible), Flame Photometer, Atomic absorption spectrophotometer (AAS). Phase contrast, fluorescent, polarization microscopes, SEM; Gas Chromatograph (GC), GC-MS, HPLC, Ion chromatograph, X-ray diffraction, X-Ray fluorescence, Inductively coupled plasma – mass spectrometry, Inductively coupled plasma-Atomic emission spectrometry.

Suggested Readings:

1. Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company 2008.
2. Reeve, R. Introduction to Environmental Analysis. John Willey & Sns.2002.
3. Skoog, D. A., Holler, F.J., &Crouch, S.R. (2006) Principles of Instrumental Analysis, Brooks Cole.
4. Chatwal, G. R., and Anand, S. K. Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi. 2007.
5. De, A.K. Environmental Chemistry, New Age International, New Delhi. 2000.

MSE 202: Air and Water Quality Management (3credits)

Air quality standards and monitoring NAAQS, Dispersion and modelling (Box and Plume model), air quality survellience network, control approaches (stationary and mobile), indoor air quality management, Water quality standards (physical, chemical, microbiological, radiological), CPCB, BIS, ISO, USEPA, WHO, water quality assurance, Water Quality Modeling, ISO 9000, 14000,

Suggested Readings:

1. Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company 2008.
2. Reeve, R. Introduction to Environmental Analysis. John Willey & Sns.2002.
3. Skoog, D. A., Holler, F.J., &Crouch, S.R. (2006) Principles of Instrumental Analysis, Brooks Cole.
4. Chatwal, G. R., and Anand, S. K. Instrumental Methods of Chemical Analysis, Himalaya Publishing House, Delhi. 2007.
5. De, A.K. Environmental Chemistry, New Age International, New Delhi. 2000.

MSE 203: Environmental Toxicology (3 credits)

Principles of toxicology, ecotoxicology, global dispersion of toxic substance; dispersion and circulating mechanisms of pollutants, ecosystem influence on the fate and transport of toxicants; toxicity tests; animal management in toxicological evaluation, statistical concepts of LD50; dose-effect and dose response relationship; frequency response and cumulative response; bio-transformation and bio-accumulation, influence of ecological factors on the effects of toxicity.

Suggested Readings

1. Haye's A.W. and Kruger C.L., Hayes' Principles and Methods of Toxicology, 6th edition, CRC Press. 2014.
2. Walker C.H., Sibly R.M., HopkinS.P., PeakallD.B. Principles of Ecotoxicology, 4th ed, CRC Press. 2008.
3. Shaw I.C. and Chadwick J. Principles of Environmental Toxicology; Taylor& Francis. 1998.
4. Frank C. Lu. Basic Toxicology: Fundamentals, Target Organs, and Risk Assessment, Taylor and Francis. 2003

MSA 203- Statistical Analysis and Computer Programming **3credits (2T+2P)**

Notion of probability, probability laws, discrete and continuous distributions, normal distribution, poisson's distribution, random variables, moments, expectance operator, gaussian statistics, significance tests: Student's T, Fischer's Z, and F-test, correlation, goodness-of-fit tests (ks, chi squared), program statements, variables, operators, functions, and input/output, program structure, computer program debugging, vector variables, creating plots and graphs, relational operators, if…end structures, and for loops, switch structures and while loops, elementary statistical analysis and histograms, error propagation and statistical correlation, data import and export, curve fitting

Lab

Computation of correlation coefficient, chi-squares test, T-test, estimating trends linear and man kendall, binomial and normal distributions, data types and data structures, flow control and looping, writing and calling functions, debugging and functions as objects, markov chains, monte carlo, basics of MATLAB, R.

Suggested Readings

1. Boas, M, Mathematical Methods in the Physical Sciences, 2nd Edition, Wiley&Sons. 1983.
2. Talyor, J.R., An Introduction to Error Analysis, University Science Books. 1997.
3. Norman Matloff, The Art of R Programming: A Tour of Statistical Software Design.
4. Phil Spector, Data Manipulation with R Paul Teetor, The R Cookbook.
5. Wilks, D., Statistical methods in the atmospheric sciences, Academic Press. 2006.

MSE 204- Remote Sensing and GIS **4credits (3T+2P)**

Fundamentals of remote sensing, atmospheric window, aerial photography, imaging systems, satellites, sensors, platforms, data generation. image interpretations, image enhancement, image classification techniques and accuracy assessment. GIS concepts. vector and raster data structures. hardware and software requirement in GIS. GIS as decision support system, GPS: concepts, available constellations, accuracy and types of errors, types of gps machines, interface of GPS data with GIS. advance tools in remote sensing (microwave, hyperspectral, LiDAR), applications of RS, GIS & GPS in natural resources management.

Lab

Study of SOI topographical maps, satellite images interpretation, digitization- point, line, polygon data, data conversion-vector to raster, raster to vector, preparation of land use/land cover maps using visual and digital interpretation, techniques GPS surveying and hands on GPS operation, remote sensing and GIS applications for resource monitoring- case study

Suggested Readings

1. George Joseph, Fundamentals of remote sensing, Universities press (India) Pvt Ltd., Hyderabad, 2003
2. Jenson, J.R. Introductory Digital Image Processing: Prentice Hall Series, 1996.
3. Jensen, J.R., Remote Sensing of the Environment – An Earth Resources Perspective, Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi, 2000.
4. Lillesand, Thomas M. and Kiefer, Ralph, W., Remote Sensing and Image Interpretation, John Wiley and Sons, New York, 2000.
5. Michael N. Demers. Fundamentals of Geographical Information Systems. John Wiley & Sons, Inc., 2008.
6. Rampal, K.K., Handbook of Aerial Photography and Interpretation, Concept Publishing Company, New Delhi, 1999.

MSE 205: Field Trip **(1 Credits)**

To have a wider exposure of the field and developing their understanding about different environmental aspects, students will undergo extensive one week field work in third semester.

Each student will submit his/her field work report along with departmental presentation for evaluation.

MSE 206: Environmental Laboratory (3 credits)

Lab

Evaluation of LoB, LoD and PQL, Working and trouble shooting on Ion chromatograph, UV-Visible spectrophotometer, flame photometer, electrodes, volume samplers, etc. distillation unit; sampling strategies. Analysis of Water Quality parameters (BOD, COD, MPN, F, N, Heavy metals,etc.), Monitoring of air quality parameters (SO_2, NO_2, NH_3, SPM, RSPM, etc.)

MSE XXX: Elective-I (3 Credits)

This is an elective course and student can opt any one course from the courses given below as per his/her own interest and requirement. Minimum 6 students should be enrolled to run an elective course.

Elective I courses

MSE 207: Solid Waste Management (3 credits)

Introduction, concerns over waste, current approaches – legislation, solid waste generation and composition, waste collection, central sorting, biological treatment, thermal treatment, landfilling; integrated waste management, development of integrated waste management systems: case studies and their analysis; life cycle assessment; life cycle inventory of solid waste, LCI case studies, life cycle inventory model for integrated waste management.

Suggested Readings

1. George Tchobanoglous G. and Kreith F. Handbook of Solid Waste Management, Butterworth-Heinemann, 2003.
2. Zhu D., AsnaniP.U., Zurbrügg C. and Anapolsky S.Improving Municipal Solid Waste Management in India, World Bank, 2007.
3. White P., Franke M. and Hindle P. Integrated Solid Waste Management: A Life Cycle Inventory; Springer, 2011.
4. Reddy P.J. Municipal Solid Waste Management, CRC Press, 2011.
5. Chandrappa R. and Das D.B. Solid Waste Management, Springer, 2012.

MSE 208: Environmental Disasters and Management (3 credits)

Causes and phases of disasters, rapid and slow onset disasters. nature and responses to geo-hazards, floods and cyclones, structure and nature of tropical cyclone, tsunamis, earthquakes, scales, magnitude and intensity, hazards and risks, volcanic eruptions, landslides, mine related hazards, early warning from satellites, risk mitigation and training, un draft resolution on disasters, international decade for natural disaster reduction (IDNDR), regulation/guidelines for disaster management.

Suggested Readings

1. Carter, N.W. Disaster Management: A Disaster Manager's Hand Book, Asian Development Bank, Manila. 1992.
2. Sahni, P.and Malagola M. (Eds.).Disaster Risk Reduction in South Asia, Prentice-Hall of India, New Delhi. 2003.
3. Singh T. Disaster management Approaches and Strategies, Akansha Publishing House, New Delhi. 2006
4. Sinha, D. K. Towards Basics of Natural Disaster Reduction, Research Book Centre, New Delhi. 2006

5. Smith, K. Environmental Health, Assessing Risk and Reduction Disaster, 3rd ed, Routledge, London. 2001.

MSE 209: Hydrogeology (3 credits)

Hydrologic cycle, precipitation measurement, frequency analysis of rainfall, intensity-duration-frequency relationship, probable maximum precipitation, evapotranspiration, infiltration process – infiltration capacity, measurement of infiltration, infiltration indices, effective rainfall, hydrograph-factors affecting hydrograph, baseflow, unit hydrograph, S curve hydrograph, characteristic of ground water, types of water in rocks, typification of groundwater, types of aquifers, darcy's law and its validity, groundwater level and fluctuation, dupuit's assumptions, recuperation test, transmissibility, specific capacity, pumping test, steady and unsteady flow analysis, storage coefficient - specific yield heterogeneity and anisotropy, well hydraulics, soil.

Suggested Readings

1. Chow, V.T. and Maidment, "Hydrology for Engineers", McGraw-Hill Inc., Ltd., 2000
2. Raghunath H.M., Ground Water Hydrology, Wiley Eastern Ltd., Second reprint, 2000.
3. Raghunath, H.M., "Hydrology", Wiley Eastern Ltd., 2000
4. Singh, V.P., "Hydrology", McGraw-Hill Inc., Ltd., 2000.
5. Subramanya, K., "Engineering Hydrology", Tata McGraw-Hill Publishing Co., Ltd., 2000.
6. Todd, D.K.: Groundwater Hydrology, John Wiley and Sons, New York

MSE 210: Wastewater Treatment and Management 3credits (2T+2P)

Major sources of water pollution, physico-chemical and biological properties of sewage, quality of industrial effluents produced from textile, dairy, leather, thermal power and chemical industries. Sewage treatment: pre-treatment, primary, secondary and tertiary treatment methods. Activated sludge, oxidation ponds, trickling filter, UASB reactors, water disinfection methods. Treatment plants- STP and ETP, recycling of waste water, recycling of industrial effluent after treatment.

Lab

Collection, storage and preservation of wastewater samples, microbiological examination of wastewater, determination of oil and grease, biochemical oxygen demand, chemical oxygen demandestimation of major cations, anions, heavy metals and organic contaminants present in wastewater using spectrophotometric/chromatographic methods.

Suggested Readings

1. Tchobanoglous G., Burton F.L. and StenselH. D. Wastewater Engineering: treatment and Reuse. 4th ed. Metcalf and Eddy Inc., New York, NY: McGraw-Hill, 2003.
2. Qasim S.R., Motley, E.M. and Zhu.G. Water works Engineering – Planning, Design and Operation, Prentice Hall, New Delhi, 2002.
3. Lee C.C. and Shun dar Lin, Handbook of Environmental Engineering Calculations, Mc Graw Hill, New York, 1999.
4. Hendricks D. Water Treatment Unit Processes – Physical and Chemical, CRC Press, New York, 2006.
5. Staff M.W.H. Water Treatment: Principles and Design. 2nd ed. New York, NY: Wiley, 2005.

MSE 211: Energy and Environment (3 credits)

Energy basics, heat budget of the earth, energy resources, conventional and non-conventional energy sources: fossil fuels-coal, oil and nature gas: hydroelectric power: tidal, wind, geothermal energy: biomass: solar collectors, photovoltaics, solar ponds: nuclear-fission and fusion. Environmental implications of energy use; energy use pattern in India and the world, renewable energy potential in

India, emissions of CO_2 in developed and developing countries including India, impact of large scale exploitation of solar, wind, hydro and other renewable energy sources.

Suggested Readings

1. Andrew R.W., Jackson & Julie M. Jackson, Environmental Science – The Natural Environment and Human Impact, Addison Wesley Longman Limited, 1996.
2. Carless, Jennifer, Renewable Energy: A Concise Guide to Green Alternative, Walker, New York, 1993.
3. Ebbing, D.D.General Chemistry, (International 4th Edition) MA : Houghton Mifflin, Boston, 1993.
4. Santra, S.C. Environmental Science, 2nd Edition, New Central Book Agency (P) Ltd, Kolkata, India, 2005.
5. United Nations Scientific Committee on Effects of Atomic Radiation Report 2000, New York, USA, 2000.

MSA 205: Simulation and Visualization in Earth Sciences 3credits (2T+2P)

Global, regional, mesoscale, and coupled models, weather forecast evaluation: jet stream analysis, standard diagnostics and skill scores, predictability and ensemble forecasting, visualization of experimental and simulated data, fractals for visualization of complex and large data sets, visualization of meteorological for scientific decision making, analysis of time series, analyzing trends in climate data.

Lab

Unix/Linux operating system, introduction to UNIX/LINUX, basic commands, file management; shell scripting, visualization of atmospheric datasets. familiarization with post-processing and visualization software (GrADs, Ferret, NCAR Graphics, etc.), familiarization with multiple data formats, implementation of simple climate models and atmospheric processes.

Suggested Readings:

1. Kantha and Carol Anne Clayson, Numerical Models of Oceans and Oceanic Processes, Acdemic press.
2. James C. McWilliams. Fundamentals of Geophysical Fluid Dynamics, Cambridge University Press.
3. Mark Z Jacobson. Fundamentals of Atmospheric Modeling, Cambridge University Press.

Semester III

MSE 301: Coastal and Marine Environment (3 Credits)

The origin of the ocean, history of marine science, morphologic and tectonic domains of the ocean floor; ocean basins, ocean sediments, composition of seawater, carbon dioxide-carbonate system; biological pump, atmospheric circulation, ocean circulation, waves, tides, estuaries: classification, nomenclature, circulation and mixing;ekman spiral, upwelling, formation of bottom waters, el nino; la-nina; enso, coasts, life in the ocean, primary and secondary production, pelagic communities, benthic communities, uses and abuses of the ocean, marine pollution and climate change.

Suggested Readings

1. Garrison Tom S. Essentials of Oceanography 5th ed. Belmont, Brooks/Cole, Cengage Learning. 2009.
2. Paul R. Pinet.Introduction to Oceanography: Jones & Bartlett Learning. 2011.
3. Alan P. Trujillo and Harold V Thurman. Essentials of Oceanography, Prentice Hall. 2013.
4. Lalli M.C. and Parsons T.R.Biological Oceanography: An Introduction, Elsevier. 2012.
5. Frank J. Millero. Chemical Oceanography, CRC Press. 2014.

MSE 302: Environmental Impact Assessment and Management (3 credits)

Objectives and development of EIA. EIA notifications, benefits of EIA, Prior Environmental Clearance, application for EC. EIA methodology, advance tools and GIS in EIA process, Environmental Impact Statement (EIS), project types, important considerations in EIA, Environmental Management Plan (EMP), Environmental appraisal, accounting and environmental audit, Green Balance Sheet (GBS), Life Cycle Analysis –LCA, Social impact assessment (SIA), Strategic Environmental Assessment (SEA), post project analysis.

Suggested Readings:

1. Anjaneyulu, Y. and Manickam, V. Environmental Impact Assessment Methodologies. B.S. Publications. 2002.
2. Cutter, S. L. Environmental Risks and Hazards. Prentice Hall of India, New Delhi. 1999.
3. Glasson, J. Therivel, R. and Chadwick, A. Introduction to Environmental Impact EIA. Routledge, London. 2006.
4. Morris, P. and Therivel R. (Eds) Methods of Environmental Impact Assessment. 2nd ed, Spon Press London. 2001.
5. Rao, P. S. and Rao, P.M. Environmental Management and Audit. Deep and Deep Publications. 2000.

MSA 302: Arid Environment and Desert Meteorology (3Credits)

General characteristics of deserts and desert biomes, causes of aridity, geomorphology, desertification causes, processes, indicators, mapping and vulnerability, forecasting, dust storms and sand storms, dynamic effects of deserts on meteorological processes, monsoon pattern in deserts, desert microclimates, human impacts and desertification, inter-annual variability in aridity (drought), global climate and deserts, advance tools for desert management.

Lab

Desert severe weather pattern, understanding of desert microclimates using GrADs, inter-annual variability in aridity (drought) using observed/reanalysis datasets, development of different aridity indices using global and regional model outputs.

Suggested Readings

1. Bothma, J. duP. Carnivore Ecology in Arid Lands. Springer-Verlag Berlin Heidelberg 1998.
2. Kalwar, S. C. Arid Ecology. Pointer Publishers.1999.
3. Prakash, I. 2001. Ecology of Desert Environments. Scientific Publishers, Jodhpur.
4. Walter, W. Herbivore Plant Interactions and Desertification in Arid Land. Springer verlag. Publication.2010.
5. Principles of Meteorological Analysis, W.J. Saucier, Dover Publications 1989.

MSE 303: Environmental Biotechnology 3credits (2T+2P)

Genetic material, structure and function, recombinant DNA technology, genetically engineered microorganisms (GEMs), PCR, gene banks, bioremediation and phytoremediation, bioreactors, xenobiotics, integrated treatment system for biodegradation of polychlorinated biphenyls (PCBs), polycyclic aromatic hydrocarbons, pesticides and detergents, fermentation technology, production, recovery, stability and formulation of bacterial and fungal enzymes, enzyme kinetics, purification, enzyme applications, bio-transformation of heavy metals, oil field biotechnology, biomass production, biogas and biofuel production, microorganisms in mineral and energy recovery, biotechnology for environmental management.

Lab

Various tools and techniques of environmental microbiology lab, survey of microorganisms of water and soil and their morphological identification, isolation of DNA from bacterial cells, multiplication of DNA by PCR technique.

Suggested Readings

1. Evano, G.H. and Furlong, J.C. Environmental Biotechnology – Theory and Application. John Wiley and Sons, USA. 2004.
2. Jjemba, P.K. Environmental Microbiology – Theory and Application. Science Pub. Inc., USA. 2004.
3. Pepper, I.L. and Gerba, C.P. Environmental Microbiology - Laboratory Manual. Elsevier, USA. 2005.
4. Ratledge, C. and Kristiansen, B. Basic Biotechnology. 2nd ed. Cambridge University Press, Cambridge, UK. 2002.
5. Rittman, B. and McCarty, P. L. Environmental Biotechnology: Principles and Applications. 2nd edition. Tata McGraw-Hill, USA. 2000.

MSE 304- Science of Climate and Climate Change (3 Credits)

Description of the climate system, natural greenhouse effect, the effect of trace gases and aerosols, feedbacks in the climate system, climate change in the past, ice ages, proxy records, abrupt climate change, Instrumental record of climate, climate variability on various time-scales, simple models of climate, General Circulation Models, Projections and scenarios, impacts and mitigation of climate change.

Suggested Readings

1. Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller: IPCC, 2007.
2. Changes in Atmospheric Constituents and in Radiative Forcing. In: Climate Change 2007: Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.
3. J. David Neelin. Climate Change and Climate Modeling, Cambridge University Press
4. Kevin E. Trenberth. Climate System Modeling, Cambridge University Press
5. Boris A. Kagan. Ocean Atmosphere Interaction and Climate Modeling, Cambridge University Press

MSE 305: Minor Project **(2 Credits)**

Visit to research laboratories/minor project during summer vacations (3-4 weeks). Evaluation will be based on report submission and presentation based on their visit to respective laboratories/institutions/industry.

MSE YYY: Elective-II **(3 Credits)**

Student can select any one elective course from the courses given under Elective IIas per his/her own interest and requirement.

Elective II courses

MSE 306: Environmental Modelling (3 Credits)

Introduction to the various types of models, role of modelling in the environmental sciences, model parameterization, approaches to development of models. application of excel for model development - linear simple and multiple regression models; models of population growth and interactions: Lotka-Volterra model, Leslie's matrix model, point source stream pollution model, Box model, Gaussian plume model; hydrological modelling, water quality modelling.

Suggested Readings

1. Goodchild, M. F., Parks, B. O., Steyaert, L. T. Environmental Modeling with GIS. Oxford University Press. 1993.
2. Jakeman, A. J., Beck, M. B. and McAleer, M. J. Modeling Change in Environmental System. John Wiley and Sons.1993.
3. Schmoor, J. L. Environmental Modelling. A Wiley-Interscience Publication. John Wiley and Sons. Inc. 1996.
4. Sokal, R.R. and Rohlf, F.J. Biometry: The Principles and Practice of Statistics in Biological Research. 3rd ed. W.H. Freeman and Co., USA. 1995.
5. Wainwright, J. and Mulligan, M. Environmental Modelling, John Wiley and Sons. 2004.

MSE 307: Geoinformatics for Forest Management (3 credits)

Forest eco-systems concepts, primary productivity, nutrient cycling, conservation of forest ecosystems, forest types in India, conventional survey, remote sensing based classification of forests, spectral properties of vegetation, sampling methods, forest monitoring through remote sensing, GIS for management and modelling of forests, forest fire, fire management by RS & GIS, role of afforestation and forest regeneration. human impacts; encroachment, poaching, grazing, shifting cultivation and control, disease and stress detection, principles of conservation, needs for forest conservation, advances in RS & GIS techniques for forest conservation & management.

Suggested Readings

1. Kimmins J.P. Forest Ecology. MacMillan. 2003.
2. Adrian N. Forest Ecology and Conservation: A Handbook of Techniques (Techniques in Ecology & Conservation). 2001.
3. Steven E. Franklin. Remote Sensing for Sustainable Forest Management.CRC Press. 2001.
4. Köhl, Michael, Magnussen, Steen S., Marchetti, Marco.Sampling Methods, Remote Sensing and GIS Multiresource Forest Inventory, XIX, 373 p. 2006.

MSE 308: Environmental and Occupational Health (3 Credits)

Basic principle of environmental health, physiological responses of man to relevant stresses in the environment, principles and methods of occupational health, relationship of occupational hygiene, safety and disease, occupational hazards in industries and other sectors, safety requirements and measures, major occupational diseases- Pneumoconiosis, Silicosis, Anthracosis, Asbestosis, Byssinosis, Bagasosis, Farmer's lung, Metal poisoning. Global Occupational Health Network (GOHNET).

Suggested Readings

1. Guidotti, T.L. Global Occupational Health, Oxford publication. 2011.
2. Steven S. Sadhra and Rampal K.G. Occupational Health, Risk assessment and Management. 1999.
3. Benjamin O. Alli, Fundamental Principles of Occupational Health and Safety, Second edition, International Labour Organization. 2008.

4. Sue Reed, Dino Pisaniello, Geza Benke and Kerrie Burton, Principles of Occupational Health and Hygiene, Publisher-Allen & Unwin. 2013.
5. OSHA Field Safety and Health Manual. 2011.

MSE 309: Nanotechnology for Pollution Mitigation (3 credits)

Introduction to nanoscience and nanotechnology, history, synthesis of nanomaterials- bulk synthesis, physical and chemical approaches, characterization techniques, classification of nanomaterials, nanoremediation, organic and inorganic contaminants. Application of nanoparticles for ground water, surface water and soil remediation; water purification and disinfection; in situ and ex situ applications, benefits and potential risk.

Suggested Readings

1. Sellers K., Mackay C., Bergeson L.L., Clough S.R., Hoyt M., Chen J., Henry K., Hamblen J., Nano-technology and the environment, CRC Press, Taylor and Francis Group.
2. Shong C.W., Haur S.C., Wee A.T.S., Science at the Nanoscale - An Introductory Text Book, PAN Stanford Publishing.
3. Kane D.M., Micolich A., Roger P., Nanomaterials: Science and Applications. Pan Stanford, 2016.
4. Krishnamoorthy S. Nanomaterials: A Guide to Fabrication and Applications. CRC Press, 2015.
5. Haghi A.K., Zachariah A.K., Kalariakkal N., Nanomaterials: Synthesis, Characterization and Applications. Apple Academic Press. 2013.

MSE 310: Water Resource Management (3 Credits)

Water challenges and issues; soil and water conservation- techniques of water saving, in situ, ex situ rainwater conservation, pressurized irrigation, aquaculture, protected (poly/green house) cultivation, use of saline-sodic water, domestic and industrial water management; rainwater harvesting; groundwater recharge. Principles and key elements of IWRM; Water security indicators; Water-Energy-Food nexus; Economic of water issues: Private sector involvement in water resources management: community participation; principles of international and national laws in the area of water management; government policies at national and state level.

Suggested Readings

1. Technical Advisory Committee, Dublin principles for water as reflected in comparative assessment of institutional and legal arrangements for Integrated Water Resources Management, Technical Advisory Committee Background paper No: 3. Global water partnership, Stockholm, Sweden. 1999.
2. Technical Advisory Committee, Effective Water Governance". Technical Advisory Committee Background paper No: 7. Global water partnership, Stockholm, Sweden, 2003.
3. Technical Advisory Committee, Integrated Water Resources management, Technical Advisory Committee Background Paper No: 4. Global water partnership, Stockholm, Sweden. 2002.
4. Technical Advisory Committee, Water as social and economic good: How to put the principles to practice". Technical Advisory Committee Background paper No: 2. Global water partnership, Stockholm, Sweden, 1998.

Open Elective **(3 Credits)**

This is an open elective course and student can choose one course either from courses given under open elective of department or from any other schools in the university as per his/her own interest and requirement.

Open Elective Courses

Any course can be selected from any department of the university

Semester IV

MSE 401: Project **(20 Credits)**

Each student will work for M. Sc. Project under the supervision of formally assigned supervisor in the department. Student shall complete the process of academic interaction to obtain teachers consent to supervise his/her project work by the end of third semester. The work on research project will start in 4th semester under the supervision of assigned faculty member and will be completed by end of 4th semester with submission of dissertation. Dissertation will be evaluated by committee of expert members based on their presentation and viva- voce.

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