Central University of Rajasthan

DEPARTMENT OF ENVIRONMENTAL SCIENCE
SCHOOL OF EARTH SCIENCES

Integrated M.Sc. Environmental Science (5 Years)

(Course Syllabus)

February 2019

Program Objectives

1. To create trained manpower with sound knowledge in the field of environment.
2. To integrate environment science with other science and social science subjects for better solutions and sustainable development

Program Outcomes

On completing the program, student s will able to:

1. Provide basic concepts, principles, and methods related to environment with knowledge support from other disciplines
2. Use various state-of-the-art tools and techniques in the field of environment monitoring and assessment
3. Develop socio-economic context of environmental issues
4. Work independently in various sectors like academic, research and consultancy

Central University of Rajasthan
School of Earth Sciences
Integrated M.Sc. Environmental Science

Course Structure and Syllabus

Semester I

S. No.	Course Code	Subject	Credit
1		Mathematics	4
		English	2
		Biology	4
		2 courses (Physics, Chemistry, Computer Science, Statistics, Economics)	4+4
			18

Semester II

S. No.	Course Code	Subject	Credit
1		Mathematics	4
		English/ICT	2
		Biology	4
		2 courses (Physics, Chemistry, Computer Science, Statistics, Economics)	4+4
			18

Semester III

S. No.	Course Code	Subject	Credit
1	EVS 201	Environmental Studies	3
		Biology	4
		2 courses (Maths, Physics, Chemistry, Computer Science, Statistics, Economics)	4+4
		Social Science	3
			18

Semester IV

S. No.	Course Code	Subject	Credit
1	EVS 202	Science of Environment and Climate	4
		2 courses (Maths, Physics, Chemistry, Computer Science, Statistics, Economics, Biology)	4+4
		Open elective (Science)	3
		Open elective (Social Science)	3
			18

Semester V

S. No.	Course Code	Subject	Credit

1	EVS 301	Global Environmental Issues	3
	EVS 302	Environmental Field Methods	3
		2 Courses from Biology	3+3
		Open elective (Science)	3
		Open elective (Other than Science)	3
			18

Semester VI

S. No.	Course Code	Subject	Credit
1	EVS 303	Current Trends in Environment Science	3
	EVS 304	Project	3
		2 Courses from Biology	3+3
		Open elective (Science)	3
		Open elective (Other than Science)	3
			18

Semester VII

S. No.	Course Code	Title of the Course	Credit
1	EVS 401	Ecology and Environment	3
2	EVS 402	Natural Resources, Biodiversity and Wildlife Conservation	3
3	EVS 403	Environmental Chemistry	3
4	EVS 404	Environmental Geoscience	3
5	EVS 405	Environmental Policies, Legislation and Sustainable Development	3
6	EVS 406	Environmental Pollution	3
7	EVS 407	Environmental Laboratory-I	3
8	ATM XXX	Fundamentals of Atmosphere, Land and Ocean	3
		Total Credits	**24**

Semester VIII

S. No.	Subject Code	Title of the Course	Credit
1	EVS 408	Instrumentation for Environmental Monitoring and Analysis	3
2	EVS 409	Air and Water Quality Management	3
3	EVS 410	Environmental Toxicology	3
4	EVS 411	Remote Sensing and GIS	4(3T+2P)
5	EVS 412	Field Trip	1
6	EVS 413	Environmental Laboratory-II	3
7	ATM XXX	Statistical Analysis and Computer Programming	3(2T+2P)
8	EVS 4XX	Elective 1*	3
		Total Credits	**23**

Semester IX

S. No.	Subject Code	Title of the Course	Credit
1	EVS 501	Coastal and Marine Environment	3
2	EVS 502	Environmental Impact Assessment and Management	3
3	EVS 503	Environmental Biotechnology	3 (2T+2P)
4	EVS 504	Science of Climate and Climate Change	3
5	EVS 505	Minor Project	2
6	ATM XXX	Arid Environment and Desert Meteorology	3
7	EVS 5XX	Elective 2*	3
8		Open Elective**	3
		Total Credits	**23**

Semester X

S. No.	Subject Code	Title of the Course	Credit
1	EVS 521	Project	20
		Total Credits	**20**

* 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	EVS 414	Solid Waste Management	3
2	EVS 415	Environmental Disasters and Management	3
3	EVS 416	Hydrogeology	3
4	EVS 417	Wastewater Treatment and Management	3(2T+2P)
5	EVS 418	Energy and Environment	3
6	ATM XXX	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.	EVS 506	Environmental Modelling	3
2	EVS 507	Geoinformatics for Natural Resources Management	3
3	EVS 508	Environmental and Occupational Health	3
4	EVS 509	Nanotechnology for Pollution Mitigation	3
5	EVS 510	Water Resource Management	3
6	ATM XXX	Aerosol and Atmospheric Chemistry	3
7		Massive Open Online Courses (MOOCs)	3

SEMESTER III

EVS 201: Environmental Studies (3 Credits)

Objectives

1. Creating awareness about environmental problems among students.
2. Disseminate basic knowledge about the environment and its allied problems.
3. To encourage participation of students in environment protection and environment improvement.
4. To develop an attitude of concern for the environment.

Intended Learning Outcomes

1. The students would be able to take up the cause of environmental protection.
2. The students would encourage their peers and disseminate knowledge to the stakeholders in the public.
3. The students would understand the transnational character of environmental problems and ways of addressing them, including interactions across local to global scales.
4. The students would reflect critically about their roles and identities as citizens, consumers and environmental actors in a complex, interconnected world.

Syllabus as per UGC (Compulsory Course)

SEMESTER IV

EVS 202: Science of Environment and Climate (4 Credits)

Objectives

1. To give understanding of basic processes and principles for environmental change and global climate change
2. To create sound background to improve linkage between science, society and governance

Intended Learning Outcomes

After course completion, the student will able to:

1. describe the linkage between different components of earth system and climatic development of the Earth
2. explain the basic principles and laws of the climate system
3. account for the impact of climate change on society and role of various mitigation and adaptation measures

Course Content

Earth System and components, Introduction to Atmosphere, Structure of Atmosphere, Atmospheric Thermodynamics, biogeochemical cycles, Hydrological cycle, GHGs, Atmospheric Radiation, atmospheric circulation, energy system, greenhouse effect, Aerosol effect, Basics of oceanography, human interaction with the earth system, land use dynamics, Climate change causes and impacts, climate variability, adaptation and mitigation, integrated approach of climate change, sustainability and environmental issue management, International initiatives to control global warming, convention and treaties related to environmental issues.

Suggested Readings

1. Lewis A. Owen. Introduction to Global Environmental Issues, Routledge. 1997.
2. David D. Kemp. Global Environmental Issues: A Climatological perspective, Routledge. 1994.
3. A. Chandrasekar . Basics of Atmospheric Science, PHI Learning Pvt. Ltd., New Delhi, 2010
4. Mark Maslin. Climate Change Very Short Introduction, Oxford, 2014

SEMESTER V

EVS 301: Global Environmental Issues (3 Credits)

Objectives

1. To impart knowledge to students on environmental issues associated with the impacts of human use of natural resources.
2. To study the role of key stakeholders in local, regional and global environmental issues.
3. To articulate interdisciplinary, historical, ethical, global and cross-cultural link of environmental issues between human and natural systems.

Intended Learning Outcomes

1. The student should be able to learn about various local, regional and global environmental issues.
2. The student will learn on effect of spatial (local, regional and global), temporal (days, years, centuries) and magnitude (relative to other issues) scale of environmental problems.

Course Content

Global warming, Climate change causes and impacts, climate variability, international initiatives to control global warming, IPCC, deforestation, Water security, Food security, Biodiversity loss, invasive species, Convention and treaties to related to environmental issues, Biomedical wastes, Antibiotic resistance, infectious diseases, concept of sustainability, Ocean acidification.

Suggested reading

1. Lewis A. Owen. Introduction to Global Environmental Issues, Routledge. 1997.
2. Frances Harris. Global Environmental Issues, John Wiley and Sons. 2004
3. David D. Kemp. Global Environmental Issues: A Climatological perspective, Routledge. 1994.
4. R E Hester, R M Harrison, John T Houghton CBE FRS IPCC WGI, Manuel Barange, Frans Berkhout. Global Environmental Change, Royal Society of Chemistry. 2002.
5. Ho-Won Jeong. Global Environmental Policies: Institutions and Procedures, Macmillan. 2001.
6. Michael L. McKinney and Robert M. Schoch. Environmental Science: systems and solutions, Third Edition (Jones and Barlett Publishers, 2003)

EVS 302: Environmental Field Methods (3 Credits)

Objectives

1. To introduce basic tools and techniques required for collection and sampling of water and soil samples.
2. To make student understand how the basic experiments related to water and soil parameters are performed.
3. To expose students to standard methods used in air monitoring, noise measurement and biodiversity studies.

Intended Learning Outcomes

1. The students should be able to develop basic analytical skills for analysis of environmental samples and interpret experimental findings.

Course Content

1. Determination of pH of water samples.
2. Determination of Electrical Conductivity of water samples.
3. Determination of Total Dissolved Solids of water samples.
4. Determination of acidity of water samples.
5. Determination of alkalinity of water samples.
6. Determination of pH of Soil samples.
7. Determination of Electrical conductivity of soil samples.
8. Determination of acidity of soil samples.
9. Determination of alkalinity of soil samples.
10. Determination of exchangeable bases in soil samples.
11. Visit to Ambient Air Quality Monitoring station (SOx , NOx, O_3, HC, SPM, RSPM).
12. Measurement of noise pollution.
13. The Secchi Disk Experiment.
14. Measure Biodiversity using various indices.
15. Study plant population frequency by quadrat method.

Suggested reading

1. Handbook of methods in Environmental Studies Vol—I & II; S.K. Maiti; ABD Publishers, Jaipur, India
2. G. Swarajya Lakshmi, Prabhu Prasadini P, Ramesh Thatikunta, Tayaru V.N.L.V. Environmental Science : A Practical Manual;, BS Publications/BSP Books, 2010.
3. Radojevic M. and Valdimir N.B. Practical Environmental Analysis, RSC publishing, 2006.

SEMESTER VI

EVS 303: Current Trend in Environmental Science (3 Credits)

Objectives

1. To explain the current challenges and trends in the field of environment
2. To develop scientific knowledge on various processes to manage and control pollution

Intended Learning Outcomes

1. Students will be able to describe the key environmental challenges and their analysis
2. Increase awareness and other management skills to protect environment

Course Content

Current trends in the field of environmental pollution, environmental quality, climate change, biological diversity and conservation, recent advances in solid and wastewater treatment and management, pollution control techniques, environmental protection laws and regulations, natural resource management, clean energy, environmental health and safety.

Suggested Readings

Journals: Environment International, Environmental Research, Global Environment Changes, Energy and Environment, Science of the Total Environment, Climate change, Environmental Pollution, Journal of Environment Pollution and Human Health, Journal of Environmental Management

EVS 304: Project **(3 Credits)**

Objectives

1. To provide individual platform to conduct study on environmental problems and apply their knowledge to identify the possible solutions
2. To perform review or scientific experiment to use knowledge and further preparation of scientific report.

Intended Learning Outcomes

1. Able to identified environmental problem and use of instruments and tool to work on environmental problem
2. Learn to identify problem, develop methods, result interpretation and report preparation.

Each student will work for Int. M. Sc. Project under the supervision of formally assigned supervisor in the department. Dissertation will be evaluated by committee of expert members based on their report presentation.

SEMESTER VII

EVS 401: Ecology and Environment (3 Credits)

Objectives

1. To impart knowledge on different environmental and ecological setup of various ecosystems.
2. To understand the community dynamics in terms of energy and food relationship.
3. To understand the interactions of organisms and their environments and the consequences of these interactions for population, community, and ecosystem dynamics.

Intended Learning Outcomes

1. The student should be able to learn central ideas behind the ecology of individuals, populations, communities and/or ecosystems;
2. This will lead to development of critical thinking about scientific evidence to understand ecological patterns and processes and different ecological phenomenon

Course Content

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.

EVS 402: Natural Resources, Biodiversity and Wildlife Conservation (3 Credits)

Objectives

1. To generate qualified postgraduates who can be part of professional organizations working in the field of conservation and environmental protection.
2. To generate a skilled post graduates who can undertake research in the field of Biodiversity, Wildlife biology and Nature conservation.
3. To provide an alternate avenue for students to specialize as "environmental entrepreneurs" in areas such as Environmental audits, Environmental education, Ecotourism etc.
4. To create awareness about Biodiversity and Nature Conservation.

Intended Learning Outcomes

1. Students will be competent in basic natural resources management principles and evaluation of biodiversity and wildlife management.
2. Students will be able to apply knowledge to solve problems related to wildlife conservation and management.
3. Students will have a greater knowledge of how wildlife conservation and management relates to the economy and environment, both currently and in the future.
4. Students will be able to critically evaluate current events and public information related to wildlife conservation and natural resources management as being scientifically-based or opinion-based and contribute to the knowledge base of information.
5. Students will be able to write in a style appropriate for technical or informative publications for various audiences related to wildlife & natural resources conservation and management.

Course Content

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.

EVS 403: Environmental Chemistry (3 Credits)

Objectives

1. To understand the role of chemistry in environmental science.
2. To gain a clear concept of different chemical phenomena occurring in various environmental matrices i.e. air, water and soil.
3. To develop an understanding of chemical methods and instrumentals procedures used for physic-chemical analysis of environmental matrices.

Intended Learning Outcomes

1. The student should be able to apply fundamental concepts of chemistry to analyze chemical processes involved in different environmental problems (air, water & soil)
2. The student should be able to understand the interconnections between different environment matrices and the effect of human activities on the natural chemical processes.

Course Content

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

EVS 404: Environmental Geoscience (3 Credits)

Objectives

1. To introduce students to the basic concepts and principles of physical and environmental geology, focusing on Earth materials and processes.
2. To expose students to questions like how geologic processes and hazards influence human activities (and sometimes the reverse), the geologic aspects of pollution and waste-disposal problems, and several other environmental processes.

Intended Learning Outcomes

1. The students would be able to understand the spectrum of interactions between people and the physical environment.
2. The students would develop an understanding of how geology interacts with major environmental problems facing people and society.
3. The knowledge shared with the students will provide a useful foundation for discussing and evaluating specific environmental issues, as well as for developing ideas about how the problems should be solved.

Course Content

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.

EVS 405: Environmental Policies, Legislation and Sustainable Development (3 Credits)

Objectives

1. To develop an understanding of the prevailing national and international provisions of environmental policies and legislations.
2. To introduce students with the concept of sustainability and sustainable development.

Intended Learning Outcomes

1. The students will be able to understand the relevance of environmental policies and legislation in place and suggest solutions of the gaps in the existing policies and legislation.
2. The students will be able to understand the role of sustainable development and its urgent need in the light of current short sighted development practices.

Course Content

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.

EVS 406: Environmental Pollution (3 Credits)

Objectives

1. To make the students aware of history of environmental pollution, definition and classification of environmental pollution and pollutants along with their causes and effects.
2. To gain a clear concept over water and air quality parameters and standards.
3. To develop an understanding of control and management techniques utilized in controlling environmental pollution.

Intended Learning Outcomes

1. The student should be able to know important aspects of environmental pollution and explain the behaviour of the various forms of pollution in environmental systems.
2. The student should be able to acquire knowledge of remediation techniques/methods along with proper understanding of various processes involved based on physico-chemical or biological principles.

Course Content

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.

EVS 407: Environmental Laboratory-I (3 Credits)

Objectives

1. To understand the interactions of organisms and their environments and the consequences of these interactions for population, community, and ecosystem dynamics.
2. To develop an understanding of geological samples through field visit and analyzing samples.
3. To introduce how the basic environmental experiments relating to air, water and soil analysis are performed and understand which experiment is appropriate for given environmental problem.

Intended Learning Outcomes

1. The student should be able to develop basic analytical skills which are required in environmental monitoring.
2. The students would be able to identify the geological samples in field during routine field visits.
3. The students would exhibit an understanding of physical factors shaping the geomorphic features.

Course Content

(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.

Suggested Readings

1. Eaton, A. D., Clesceri, L. S., Greenberg, A. E., & Franson, M. A. H. (2017). Standard methods for the examination of water and wastewater. American public health association, 23, 1504.
2. Handbook of methods in Environmental Studies Vol—I & II; S.K. Maiti; ABD Publishers, Jaipur, India
3. Estefan, G., Ryan, J., Sommer, R.[2013].Methods of soil, plant, and water analysis. International centre for agriculture research in the dry area (ICARDA),3, 244.

ATM XXX: Fundamentals of Atmosphere, Land and Ocean (3 Credits)

Course from Department of Atmospheric Science

Semester VIII

EVS 408: Instrumentation for Environmental Monitoring and Analysis (3 credits)

Objectives

1. To develop an understanding of the principles of sampling, chemical analysis, and instrumentation which is more important than knowing ‘‘specific how.’’
2. To introduce the students with the basic aspects of environmental chemical data collection process, such as the systematic planning, sensible field procedures, solid analytical chemistry, and the evaluation of data quality in context of their intended use.
3. To expose students to the data collection fundamentals that are applicable to every environmental project.

Intended Learning Outcomes

1. The students will develop a comprehensive view of project work, step-by-step detailed procedures for common field sampling tasks, and a wealth of practical tips for all project tasks.
2. The students will understand the effective role of obtaining data of scientifically reliable and legally defensible nature by exercising good laboratory practices.
3. The students will understand the basics of various instrumentation techniques that may be employed in the environmental data acquisition and would be able to obtain data of intended quality.

Course Content

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.

EVS 409: Air and Water Quality Management (3credits)

Objectives

1. To train the students about determination of the air and water quality parameters.
2. To understand the environmental objectives for maintaining air and water quality standards.
3. To understand the complete procedure for getting ISO Certification for achieving environment and quality standards.

Intended Learning Outcomes

1. The student will be able to evaluate various physicochemical and biological parameters of water and Air quality.
2. The Students will be able to evaluate the validity and limitations of these quality parameters
3. The student will be able to learn about various quality control standardizing bodies

Course Content

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.

EVS 410: Environmental Toxicology (3 Credits)

Objectives

1. To introduce the basic concepts and principles of toxicology
2. To understand the concept of toxicity test and dose- response relationship.
3. To develop an understanding about the dispersion and circulating mechanisms of different xenobiotic compounds in environment
4. To gain insight over ecosystem influence on the fate and transport of toxicants

Intended Learning Outcomes

1. The students should acquire knowledge relating to the fundamentals in the basic areas of toxicology and understand the discipline's relevancy to real-world issues.
2. The students should be able to identify relationships between chemical exposure and effects on physiological systems and design strategies for study of dose-response relationships

Course Content

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

EVS 411: Remote Sensing and GIS **4credits (3T+2P)**

Objectives

1. To process remotely sensed data to make it useful in geographic information systems.
2. To critically assess the strengths and weaknesses of remote sensing instruments and platforms for a variety of application scenarios
3. To develop multi-step remote sensing workflows to solve problems in a variety of application areas.
4. To apply acquired knowledge and critical thinking skills to solve a real-world problem with appropriate remote sensing data and processing methods.
5. To clearly and concisely communicate findings from the analysis of remotely sensed data through the written word and graphical products.

Intended Learning Outcomes

Learning outcomes having successfully completed the course, students should have acquired the following:

Knowledge and understanding: The student is expected to have:

1. Basic knowledge in electromagnetic radiation theories and how the atmosphere affects the radiation and multi-spectral reflection properties for different objects.
2. Knowledge to extract information from multiple satellite images to understand and study seasonal effects and how to calculate trends from multiple satellite data for long time series and creating maps showing change over time.

Proficiency and skills: The student is expected to be able to:

1. Extract statistics and other information from a digital satellite image.
2. Perform automated and supervised classification of digital satellite data.
3. Perform a map accuracy assessment on a classification and analyses on digital satellite data integrated with other geographical information in a geographical information system.

Course Content

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.

EVS 412: Field Trip **(1 Credit)**

Objectives

1. To get exposure of various tools, techniques, instruments available in other reputed institutes.
2. To provide opportunity to interact with experts, resource person outside classroom
3. To have a wider exposure of the field and developing their understanding about different environmental aspects

Intended Learning Outcomes

1. Students will learn new things and may able to interlinked classroom learning with real time application
2. Students will able to work on different instruments for environmental monitoring and assessment
3. Students will learn to write report of their exposure and learning

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.

EVS 413: Environmental Laboratory-II (3 Credits)

Objectives

1. To understand the concept of Data Quality and ways to obtain scientifically reliable data.
2. To get a hands on experience with the instruments which are used for environmental sampling and analysis
3. To perform qualitative and quantitative analysis of water and air quality parameters and learn interpretation of results for problem identification.

Intended Learning Outcomes

1. The students should be able to critically evaluate and interpret experimental data and findings and apply them for problem identification and quantification.

Course Content

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.)

Suggested Readings

1. Eaton, A. D., Clesceri, L. S., Greenberg, A. E., & Franson, M. A. H. (2017). Standard methods for the examination of water and wastewater. American public health association, 23, 1504.
2. Chaurasia, S., Gupta, A.D.[2014]. Handbook of water, air and soil analysis. International E-publication,123.

ATM XXX- Statistical Analysis and Computer Programming 3credits (2T+2P)

Course from Department of Atmospheric Science

EVS 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.

LIST OF COURSES (ELECTIVE-I)

EVS 414: Solid Waste Management (3 credits)

Objectives

1. To understand the sources of solid and hazardous wastes.
2. To understand the methods available for solid waste disposal.
3. To evaluate the health risks posed by abandoned waste sites and waste disposal operations.
4. To understand the Life cycle inventory of Solid Waste Management.
5. To evaluate the legislation designed to control the production, cleanup and disposal of solid and hazardous waste disposal operations.

Intended Learning Outcomes

1. The students would be able to understand the hierarchical structure in solid waste management and the need for a sustainable solution.
2. The student would be able to characterize the solid waste qualitatively as well as quantitatively for better management approaches.
3. The student would be able to integrate GIS techniques for the identification of better site and development of better management plans.
4. The students would be able to understand the main aspects of waste policy and regulations and would be able to come up with significant policy interventions needed.

Course Content

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.

EVS 415: Environmental Disasters and Management (3 credits)

Objectives

1. To study types of environment disasters.
2. To study various causes and effects of environmental disasters.
3. To suggest remedies to overcome environmental disasters.
4. To bring public awareness and create sense of social responsibilities among the members of the society.

Intended Learning Outcomes

1. Capacity to integrate knowledge and to analyse, evaluate and manage the different public aspects of disaster events at a local and global levels, even when limited information is available.
2. Capacity to describe, analyze and evaluate the environmental, social, cultural, economic, legal and organisational aspects influencing vulnerabilities and capacities to face disasters.
3. Capacity to work theoretically and practically in the processes of disaster management (disaster risk reduction, response, and recovery) and relate their interconnections
4. Capacity to design and perform research on the different aspects of the emergencies and disaster events while demonstrating insight into the potential and limitations of science, its role in society and people's responsibility for how it is used.

Course Content

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.

EVS 416: Hydrogeology (3 credits)

Objectives

1. Expose students to estimate various parameters and characteristics related to hydrology and hydrogeology.
2. Provide background on various test and techniques in steady and unsteady flow conditions

Intended Learning Outcomes

1. To use quantitative methods to calculate the groundwater movement and flow in different types of aquifers
2. To interpret field measurement and experimental data related to groundwater flow and well hydraulics

Course Content

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

EVS 417: Wastewater Treatment and Management 3credits (2T+2P)

Objectives

1. To learn about various methods used for the characterization of wastewater.
2. To provide basic description of the main technologies and processes used for treatment of wastewater.
3. To understand the basic design criteria and the operation of wastewater treatment facilities/plants.

Intended Learning Outcomes

1. The students would be able to explain the main physical, chemical and biological processes used for wastewater treatment.
2. The students would be able to understand different sources of water pollution and their corresponding qualities, linking these to the basic objectives of wastewater treatment and the need for water quality standards for wastewater effluent disposal.

Course Content

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.

EVS 418: Energy and Environment (3 credits)

Objectives

1. To understand the physical principles underlying energy and their interaction in the environment.
2. To understand the impacts of the implementation of energy and environmental technologies and policies on sustainability.
3. To understand the broader view of energy, environment and climate change problems and issues.

Intended Learning Outcomes

1. The students would be able to identify and exhibit an ability to integrate major factors affecting the atmosphere and climate.
2. The students would be able to demonstrate expertise on energy supply, demand and security issues and their associated environmental impacts in a global and societal context.
3. The students would exhibit innovative and creative solutions to energy and environmental problems through projects.

Course Content

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.

ATM XXX: Simulation and Visualization in Earth Sciences 3credits (2T+2P)

Course from Department of Atmospheric Science

Semester IX

EVS 501: Coastal and Marine Environment (3 Credits)

Objectives

1. To develop an understanding of the dynamic processes that affect oceans i.e. water, sea floor, and abundant life forms.
2. To understand the role being played by ocean- atmosphere interaction in the climate processes.
3. To understand the role of ocean processes in the coastal and marine landform creation

Intended Learning Outcomes

1. The students will understand the role of physical processes in the dynamic processes of ocean circulation.
2. The students will be able to formulate solutions ailing the current state of the coastal and marine environment in terms of chemical and biological interactions.
3. The students will be able to use the knowledge base to promote ocean awareness in the light of human exploitation of its resources.

Course Content

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.

EVS 502: Environmental Impact Assessment and Management (3 credits)

Objectives

1. To explain the major principles of environmental impact assessment in India
2. To understand the different steps within environmental impact assessment.
3. To discuss the implications of current jurisdictional and institutional arrangements in relation to environmental impact assessment
4. To understand how to liaise with and the importance of stakeholders in the EIA process
5. To be able to access different case studies/examples of EIA in practice

Intended Learning Outcomes

1. Student will be able to understand the strategic and organisational context of environmental management in different settings and design and deliver practical outcomes that contribute positively to environmental performance.
2. Student will be able to Synthesise and prioritise information from desktop and field environmental assessments, rank the relative values identified, assess the risks imposed by the development, and determine appropriate environmental management strategies.
3. Student will be able to articulate and justify specific policies or courses of action on complex environmental issues using discipline based knowledge and established management principles.

Course Content

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.

EVS 503: Environmental Biotechnology **3 credits (2T+2P)**

Objectives

1. To train the students about conservation of resources via recycling of waste materials and recovery of valuable products such as metals and oils.
2. To impart a working knowledge of the principles, techniques and current applications of biotechnology to environmental quality evaluation, monitoring, remediation of contaminated environments and energy production.
3. Understand the principles of bioremediation and phytoremediation of synthetic organic pollutants and basic physiology of a microorganism during bioremediation studies.
4. Know various techniques to modify and augment microorganisms in the laboratory and environment
5. To understand the genetic structure of microorganisms and their amplification methods.

Intended Learning Outcomes

1. The student should be able to understand basic principles of microbiology of environmental engineering systems, different microbial metabolism, natural/advanced environmental biotechnologies.
2. The student should be able to recognize and apply environmental biotechnology approaches in treatment and disposal of organic wastes, production of biomaterials /biofuels and pollution control.

Course Content

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.

EVS 504: Science of Climate and Climate Change (3 Credits)

Objectives

1. To educate students about science of climate science
2. To provide information about what national and international organizations are working for mitigation and adaptation to address climate change

Intended Learning Outcomes

After completing the course, participants will be able to:

1. Explain the fundamentals of climate change science
2. Describe the expected consequences of climate change and the role of mitigation and adaptation.

Course Content

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

EVS 505: 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.

ATM XXX: Arid Environment and Desert Meteorology (3Credits)

Course from Department of Atmospheric Science

MSE YYY: Elective-II (3 Credits)

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

LIST OF COURSES (Elective-II)

EVS 506: Environmental Modelling (3 Credits)

Objectives

1. To provide idea, methodology and basic tools available in environmental modelling
2. To expose student with different modelling approaches in environmental management & decision making

Intended Learning Outcomes

1. Understand various approaches for development and application of environmental models
2. To use available models for finding various solutions and scenarios related to environmental issues

Course Content

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.

EVS 507: Geoinformatics for Forest Management (3 credits)

Objectives

1. To generate qualified postgraduates who can be part of professional organizations working in the field of Forest Management.
2. To generate a skilled post graduates who can undertake research in the field of forest Biodiversity & Wildlife conservation thrugh geospatial technology.
3. To create awareness about the role of Remote Sensing and GIS for forest management. Intended Learning Outcomes

Intended Learning Outcomes

1. Students will be able to recognize locally-important woody species and understand their ecology, use, and potential markets, measure forest trees and products.
2. Students will be able to extract qualitative and quantitative forest resource data from maps, aerial photographs, and digital data sources and perform boundary surveying, forest inventory, and mapping.
3. Students will recognize and describe the methods of forest regeneration and protection, including the basic principles of wild land fire, wild land firefighting, forest health and the ability to identify major health threats and forest pests.
4. Students will be proficient in Geographic Information Systems (GIS) and Global Positioning Systems (GPS) and apply those and other technologies to the protection or management of natural resources and develop a professional forest management plan

Course Content

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.

EVS 508: Environmental and Occupational Health (3 Credits)

Objectives

1. To understand the principles and application of environmental and occupational health science in relation to the identification, evaluation and control of contaminants and related human exposures
2. To introduce diseases associated with exposure to common environmental and occupational factors, and approaches for investigating the work-relatedness of disease
3. To develop an understanding towards industrial hygiene principles of recognition, identification, evaluation and control of contaminants at workplace.

Intended Learning Outcomes

1. Acquire knowledge on health effects caused by exposure to environmental and occupational hazards at workplace recognizing the roles of various occupational health professionals.
2. Understand conceptual frameworks for analysing and managing occupational and environmental health hazards along with importance industrial safety, hygeine and exposure guidelines.

Course Content

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.

EVS 509: Nanotechnology for Pollution Mitigation (3 credits)

Objectives

1. To provide basic overview of nanoscience and nanotechnology along with introduction to different classes of nano based materials
2. To provide knowledge over different methods of nanomaterial synthesis and characterization techniques involved
3. To familiarize with the applications and role of nanotechnology in treatment of environmental contaminants present in various environmental matrices.

Intended Learning Outcomes

1. Able to acquire knowledge over fundamental principles of nanotechnology along with current and potential future nanotechnology applications
2. Understand relevancy of this field in the area of environmental clean up/remediation along with potential benefits and risks

Course Content

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.

EVS 510: Water Resource Management (3 Credits)

Objectives

1. To provide exposure of different methods of water conservation and harvesting
2. To give understanding of nexus of water with other sectors and their importance in future sustainable development
3. To learn the principles of integrated water resources management

Intended Learning Outcomes

1. The students should be able to start developing strategic water resources planning at various geographical scales.
2. The students should be able to deal with new challenges of water resources management and their linkage with other sectors like agriculture, energy.

Course Content

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.

ATM XXX: Aerosol and Atmospheric Chemistry (3 Credits)

Course from Department of Atmospheric Science

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.

Semester X

EVS 521: Project (20 Credits)

Objectives

1. To Identify/define environmental problems existing in the area of interest
2. Generate research questions and/or relevant hypotheses
3. Identify and apply appropriate research methods to deal with the research questions and hypothesis
4. Conduct research responsibly and ethically using good laboratory practices
5. Evaluate, interpret, and analyze a body of empirical data and evidence to generate an empirical model for better understanding
6. Discuss findings and prepare report in the broader context of the field

Intended Learning Outcomes

1. Able to identified real existing problem and exposure to problem based learning
2. Able to prepare scientific report with clear findings
3. Produce publishable results or generate a decision support system

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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Mapping Table for Integrated M.Sc. in Environmental Science

	Course Code	Name of the Course	Course Type	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Semester III							
	EVS 201	Environmental Studies	C	X		X	
Semester IV							
	EVS 202	Science of Environment and Climate	C	X		X	
Semester V							
	EVS 301	Global Environmental Issues	C				
	EVS 302	Environmental Field Methods	C		X		X
Semester VI							
	EVS 303	Current Trends in Environment Science	C	X		X	
	EVS 304	Project	C		X	X	X
Semester VII							
	EVS 401	Ecology and Environment	C		X	X	X
	EVS 402	Natural Resources, Biodiversity and Wildlife Conservation	C		X	X	
	EVS 403	Environmental Chemistry	C	X	X		X
	EVS 404	Environmental Geoscience	C	X	X	X	
	EVS 405	Environmental Policies, Legislation and Sustainable Development	C	X		X	X
	EVS 406	Environmental Pollution	C	X	X		X
	EVS 407	Environmental Laboratory-I	C	X	X		X
	ATM XXX	Fundamentals of Atmosphere, Land and Ocean	C	X	X	X	
Semester VIII							
	EVS 408	Instrumentation for Environmental Monitoring and Analysis	C	X	X	X	X
	EVS 409	Air and Water Quality Management	C	X	X	X	
	EVS 410	Environmental Toxicology	C	X	X	X	
	EVS 411	Remote Sensing and GIS	C	X	X		X
	EVS 412	Field Trip	C	X		X	X
	EVS 413	Environmental Laboratory-II	C	X	X	X	
	ATM XXX	Statistical Analysis and Computer Programming	C	S	X		X
	EVS 414	Solid Waste Management	E	X		X	
	EVS 415	Environmental Disasters and Management	E	X	X	X	X
	EVS 416	Hydrogeology	E	X	X	X	
	EVS 417	Wastewater Treatment and Management	E	X	X	X	
	EVS 418	Energy and Environment	E	X		X	X
	ATM XXX	Simulation and Visualization in Earth Sciences	E	S	X		
		Massive Open Online Courses (MOOCs)	E				
Semester IX							

	EVS 501	Coastal and Marine Environment	C	X	X		
	EVS 502	Environmental Impact Assessment and Management	C	X	X	X	X
	EVS 503	Environmental Biotechnology	C	X	X	X	
	EVS 504	Science of Climate and Climate Change	C	X	X	X	
	EVS 505	Minor Project	C		X	X	
	ATM XXX	Arid Environment and Desert Meteorology	C	X	X	X	
	EVS 506	Environmental Modelling	E	X	X	X	
	EVS 507	Geoinformatics for Forest Management	E	X	X		X
	EVS 508	Environmental and Occupational Health	E		X	X	X
	EVS 509	Nanotechnology for Pollution Mitigation	E	X	X	X	
	EVS 510	Water Resource Management	E	X		X	X
	ATM XXX	Aerosol and Atmospheric Chemistry	E	X		X	
		Massive Open Online Courses (MOOCs)	E				
Semester X							
	EVS 521	Project	C	X	X	X	

Central University of Rajasthan

DEPARTMENT OF ENVIRONMENTAL SCIENCE
SCHOOL OF EARTH SCIENCES

Master of Science in Environmental Science

(Course Structure and Syllabus)

February, 2019

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

Course Structure and Syllabus

Semester I

S. No.	Subject Code	Name of the Subject	Credit
1	EVS 401	Ecology and Environment	3
2	EVS 402	Natural Resources, Biodiversity and Wildlife Conservation	3
3	EVS 403	Environmental Chemistry	3
4	EVS 404	Environmental Geoscience	3
5	EVS 405	Environmental Policies, Legislation and Sustainable Development	3
6	EVS 406	Environmental Pollution	3
7	EVS 407	Environmental Laboratory-I	3
8	ATM XXX	Fundamentals of Atmosphere, Land and Ocean	3
		Total Credits	**24**

Semester II

S. No.	Subject Code	Name of the Subject	Credit
1	EVS 408	Instrumentation for Environmental Monitoring and Analysis	3
2	EVS 409	Air and Water Quality Management	3
3	EVS 410	Environmental Toxicology	3
4	EVS 411	Remote Sensing and GIS	4(3T+2P)
5	EVS 412	Field Trip	1
6	EVS 413	Environmental Laboratory-II	3
7	ATM XXX	Statistical Analysis and Computer Programming	3(2T+2P)
8	EVS 4XX	Elective 1*	3
		Total Credits	**23**

Semester III

S. No.	Subject Code	Name of the Subject	Credit
1	EVS 501	Coastal and Marine Environment	3
2	EVS 502	Environmental Impact Assessment and Management	3
3	EVS 503	Environmental Biotechnology	3 (2T+2P)
4	EVS 504	Science of Climate and Climate Change	3
5	EVS 505	Minor Project	2
6	ATM XXX	Arid Environment and Desert Meteorology	3
7	EVS 5XX	Elective 2*	3
8		Open Elective**	3
		Total Credits	**23**

Semester IV

S. No.	Subject Code	Name of the Subject	Credit
1	EVS 521	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	EVS 414	Solid Waste Management	3
2	EVS 415	Environmental Disasters and Management	3
3	EVS 416	Hydrogeology	3
4	EVS 417	Wastewater Treatment and Management	3(2T+2P)
5	EVS 418	Energy and Environment	3
6	ATM XXX	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.	EVS 506	Environmental Modelling	3
2	EVS 507	Geoinformatics for Forest Management	3
3	EVS 508	Environmental and Occupational Health	3
4	EVS 509	Nanotechnology for Pollution Mitigation	3
5	EVS 510	Water Resource Management	3
6	ATM XXX	Aerosol and Atmospheric Chemistry	3
7		Massive Open Online Courses (MOOCs)	3

Program Objectives

1. To impart knowledge of environmental problems of regional and global scale;
2. To train the students for scientific analyses of environmental components for critical understanding, efficient environmental decision-making and management.
3. To prepare them for global competence for career options in education, research, industries, consultancy, environmental journalism etc.
4. To train the students for Environmental Impact Assessment and for management systems
5. To understand the impacts of climate change to develop mitigation strategies
6. To prepare students for designing, conducting independent research in the area of their interest.
7. To sensitize students towards developing the earth as a green planet for a clean habitat for all living forms.

Program Outcomes

After completion of Programme, student will able to

1. Use concepts and methods from ecological, biological chemical, geological and physical sciences and their application in environmental problem-solving.
2. Apply systems concepts and methodologies to analyze and understand the interactions between social and environmental processes.
3. Demonstrate proficiency in quantitative methods, qualitative analysis, critical thinking, and written and oral communication needed to conduct ethical research as interdisciplinary scholars.
4. Demonstrate an understanding of legal, regulatory, and ethical considerations relating to environment within the broader societal context

SEMESTER I

EVS 401: Ecology and Environment (3 Credits)

Objectives

1. To impart knowledge on different environmental and ecological setup of various ecosystems.
2. To understand the community dynamics in terms of energy and food relationship.
3. To understand the interactions of organisms and their environments and the consequences of these interactions for population, community, and ecosystem dynamics.

Intended Learning Outcomes

1. The student should be able to learn central ideas behind the ecology of individuals, populations, communities and/or ecosystems;
2. This will lead to development of critical thinking about scientific evidence to understand ecological patterns and processes and different ecological phenomenon

Course Content

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.

EVS 402: Natural Resources, Biodiversity and Wildlife Conservation (3 Credits)

Objectives

1. To generate qualified postgraduates who can be part of professional organizations working in the field of conservation and environmental protection.
2. To generate a skilled post graduates who can undertake research in the field of Biodiversity, Wildlife biology and Nature conservation.
3. To provide an alternate avenue for students to specialize as "environmental entrepreneurs" in areas such as Environmental audits, Environmental education, Ecotourism etc.
4. To create awareness about Biodiversity and Nature Conservation.

Intended Learning Outcomes

1. Students will be competent in basic natural resources management principles and evaluation of biodiversity and wildlife management.
2. Students will be able to apply knowledge to solve problems related to wildlife conservation and management.
3. Students will have a greater knowledge of how wildlife conservation and management relates to the economy and environment, both currently and in the future.
4. Students will be able to critically evaluate current events and public information related to wildlife conservation and natural resources management as being scientifically-based or opinion-based and contribute to the knowledge base of information.
5. Students will be able to write in a style appropriate for technical or informative publications for various audiences related to wildlife & natural resources conservation and management.

Course Content

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.

EVS 403: Environmental Chemistry (3 Credits)

Objectives

1. To understand the role of chemistry in environmental science.
2. To gain a clear concept of different chemical phenomena occurring in various environmental matrices i.e. air, water and soil.
3. To develop an understanding of chemical methods and instrumentals procedures used for physic-chemical analysis of environmental matrices.

Intended Learning Outcomes

1. The student should be able to apply fundamental concepts of chemistry to analyze chemical processes involved in different environmental problems (air, water & soil)
2. The student should be able to understand the interconnections between different environment matrices and the effect of human activities on the natural chemical processes.

Course Content

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

EVS 404: Environmental Geoscience (3 Credits)

Objectives

1. To introduce students to the basic concepts and principles of physical and environmental geology, focusing on Earth materials and processes.
2. To expose students to questions like how geologic processes and hazards influence human activities (and sometimes the reverse), the geologic aspects of pollution and waste-disposal problems, and several other environmental processes.

Intended Learning Outcomes

1. The students would be able to understand the spectrum of interactions between people and the physical environment.
2. The students would develop an understanding of how geology interacts with major environmental problems facing people and society.
3. The knowledge shared with the students will provide a useful foundation for discussing and evaluating specific environmental issues, as well as for developing ideas about how the problems should be solved.

Course Content

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.

EVS 405: Environmental Policies, Legislation and Sustainable Development (3 Credits)

Objectives

1. To develop an understanding of the prevailing national and international provisions of environmental policies and legislations.
2. To introduce students with the concept of sustainability and sustainable development.

Intended Learning Outcomes

1. The students will be able to understand the relevance of environmental policies and legislation in place and suggest solutions of the gaps in the existing policies and legislation.
2. The students will be able to understand the role of sustainable development and its urgent need in the light of current short sighted development practices.

Course Content

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.

EVS 406: Environmental Pollution (3 Credits)

Objectives

1. To make the students aware of history of environmental pollution, definition and classification of environmental pollution and pollutants along with their causes and effects.
2. To gain a clear concept over water and air quality parameters and standards.
3. To develop an understanding of control and management techniques utilized in controlling environmental pollution.

Intended Learning Outcomes

1. The student should be able to know important aspects of environmental pollution and explain the behaviour of the various forms of pollution in environmental systems.
2. The student should be able to acquire knowledge of remediation techniques/methods along with proper understanding of various processes involved based on physico-chemical or biological principles.

Course Content

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.

EVS 407: Environmental Laboratory-I (3 Credits)

Objectives

1. To understand the interactions of organisms and their environments and the consequences of these interactions for population, community, and ecosystem dynamics.
2. To develop an understanding of geological samples through field visit and analyzing samples.
3. To introduce how the basic environmental experiments relating to air, water and soil analysis are performed and understand which experiment is appropriate for given environmental problem.

Intended Learning Outcomes

1. The student should be able to develop basic analytical skills which are required in environmental monitoring.
2. The students would be able to identify the geological samples in field during routine field visits.
3. The students would exhibit an understanding of physical factors shaping the geomorphic features.

Course Content

(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.

Suggested Readings

1. Eaton, A. D., Clesceri, L. S., Greenberg, A. E., & Franson, M. A. H. (2017). Standard methods for the examination of water and wastewater. American public health association, 23, 1504.
2. Handbook of methods in Environmental Studies Vol—I & II; S.K. Maiti; ABD Publishers, Jaipur, India
3. Estefan, G., Ryan, J., Sommer, R.[2013].Methods of soil, plant, and water analysis. International centre for agriculture research in the dry area (ICARDA),3, 244.

ATM XXX: Fundamentals of Atmosphere, Land and Ocean (3 Credits)

Course from Department of Atmospheric Science

Semester II

EVS 408: Instrumentation for Environmental Monitoring and Analysis (3 credits)

Objectives

1. To develop an understanding of the principles of sampling, chemical analysis, and instrumentation which is more important than knowing ‘‘specific how.’’
2. To introduce the students with the basic aspects of environmental chemical data collection process, such as the systematic planning, sensible field procedures, solid analytical chemistry, and the evaluation of data quality in context of their intended use.
3. To expose students to the data collection fundamentals that are applicable to every environmental project.

Intended Learning Outcomes

1. The students will develop a comprehensive view of project work, step-by-step detailed procedures for common field sampling tasks, and a wealth of practical tips for all project tasks.
2. The students will understand the effective role of obtaining data of scientifically reliable and legally defensible nature by exercising good laboratory practices.
3. The students will understand the basics of various instrumentation techniques that may be employed in the environmental data acquisition and would be able to obtain data of intended quality.

Course Content

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.

EVS 409: Air and Water Quality Management (3credits)

Objectives

1. To train the students about determination of the air and water quality parameters.
2. To understand the environmental objectives for maintaining air and water quality standards.
3. To understand the complete procedure for getting ISO Certification for achieving environment and quality standards.

Intended Learning Outcomes

1. The student will be able to evaluate various physicochemical and biological parameters of water and Air quality.
2. The Students will be able to evaluate the validity and limitations of these quality parameters
3. The student will be able to learn about various quality control standardizing bodies

Course Content

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.

EVS 410: Environmental Toxicology (3 Credits)

Objectives

1. To introduce the basic concepts and principles of toxicology
2. To understand the concept of toxicity test and dose- response relationship.
3. To develop an understanding about the dispersion and circulating mechanisms of different xenobiotic compounds in environment
4. To gain insight over ecosystem influence on the fate and transport of toxicants

Intended Learning Outcomes

1. The students should acquire knowledge relating to the fundamentals in the basic areas of toxicology and understand the discipline's relevancy to real-world issues.
2. The students should be able to identify relationships between chemical exposure and effects on physiological systems and design strategies for study of dose-response relationships

Course Content

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

EVS 411: Remote Sensing and GIS **4credits (3T+2P)**

Objectives

1. To process remotely sensed data to make it useful in geographic information systems.
2. To critically assess the strengths and weaknesses of remote sensing instruments and platforms for a variety of application scenarios
3. To develop multi-step remote sensing workflows to solve problems in a variety of application areas.
4. To apply acquired knowledge and critical thinking skills to solve a real-world problem with appropriate remote sensing data and processing methods.
5. To clearly and concisely communicate findings from the analysis of remotely sensed data through the written word and graphical products.

Intended Learning Outcomes

Learning outcomes having successfully completed the course, students should have acquired the following:

Knowledge and understanding: The student is expected to have:

1. Basic knowledge in electromagnetic radiation theories and how the atmosphere affects the radiation and multi-spectral reflection properties for different objects.
2. Knowledge to extract information from multiple satellite images to understand and study seasonal effects and how to calculate trends from multiple satellite data for long time series and creating maps showing change over time.

Proficiency and skills: The student is expected to be able to:

1. Extract statistics and other information from a digital satellite image.
2. Perform automated and supervised classification of digital satellite data.
3. Perform a map accuracy assessment on a classification and analyses on digital satellite data integrated with other geographical information in a geographical information system.

Course Content

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.

EVS 412: Field Trip **(1 Credit)**

Objectives

1. To get exposure of various tools, techniques, instruments available in other reputed institutes.
2. To provide opportunity to interact with experts, resource person outside classroom
3. To have a wider exposure of the field and developing their understanding about different environmental aspects

Intended Learning Outcomes

1. Students will learn new things and may able to interlinked classroom learning with real time application
2. Students will able to work on different instruments for environmental monitoring and assessment
3. Students will learn to write report of their exposure and learning

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.

EVS 413: Environmental Laboratory-II (3 Credits)

Objectives

1. To understand the concept of Data Quality and ways to obtain scientifically reliable data.
2. To get a hands on experience with the instruments which are used for environmental sampling and analysis
3. To perform qualitative and quantitative analysis of water and air quality parameters and learn interpretation of results for problem identification.

Intended Learning Outcomes

1. The students should be able to critically evaluate and interpret experimental data and findings and apply them for problem identification and quantification.

Course Content

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.)

Suggested Readings

1. Eaton, A. D., Clesceri, L. S., Greenberg, A. E., & Franson, M. A. H. (2017). Standard methods for the examination of water and wastewater. American public health association, 23, 1504.
2. Chaurasia, S., Gupta, A.D.[2014]. Handbook of water, air and soil analysis. International E-publication,123.

ATM XXX- Statistical Analysis and Computer Programming 3credits (2T+2P)

Course from Department of Atmospheric Science

EVS 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.

LIST OF COURSES (ELECTIVE-I)

EVS 414: Solid Waste Management **(3 credits)**

Objectives

1. To understand the sources of solid and hazardous wastes.
2. To understand the methods available for solid waste disposal.
3. To evaluate the health risks posed by abandoned waste sites and waste disposal operations.
4. To understand the Life cycle inventory of Solid Waste Management.
5. To evaluate the legislation designed to control the production, cleanup and disposal of solid and hazardous waste disposal operations.

Intended Learning Outcomes

1. The students would be able to understand the hierarchical structure in solid waste management and the need for a sustainable solution.
2. The student would be able to characterize the solid waste qualitatively as well as quantitatively for better management approaches.
3. The student would be able to integrate GIS techniques for the identification of better site and development of better management plans.
4. The students would be able to understand the main aspects of waste policy and regulations and would be able to come up with significant policy interventions needed.

Course Content

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.

EVS 415: Environmental Disasters and Management (3 credits)

Objectives

1. To study types of environment disasters.
2. To study various causes and effects of environmental disasters.
3. To suggest remedies to overcome environmental disasters.
4. To bring public awareness and create sense of social responsibilities among the members of the society.

Intended Learning Outcomes

1. Capacity to integrate knowledge and to analyse, evaluate and manage the different public aspects of disaster events at a local and global levels, even when limited information is available.
2. Capacity to describe, analyze and evaluate the environmental, social, cultural, economic, legal and organisational aspects influencing vulnerabilities and capacities to face disasters.
3. Capacity to work theoretically and practically in the processes of disaster management (disaster risk reduction, response, and recovery) and relate their interconnections
4. Capacity to design and perform research on the different aspects of the emergencies and disaster events while demonstrating insight into the potential and limitations of science, its role in society and people's responsibility for how it is used.

Course Content

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.

EVS 416: Hydrogeology (3 credits)

Objectives

1. Expose students to estimate various parameters and characteristics related to hydrology and hydrogeology.
2. Provide background on various test and techniques in steady and unsteady flow conditions

Intended Learning Outcomes

1. To use quantitative methods to calculate the groundwater movement and flow in different types of aquifers
2. To interpret field measurement and experimental data related to groundwater flow and well hydraulics

Course Content

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

EVS 417: Wastewater Treatment and Management 3credits (2T+2P)

Objectives

1. To learn about various methods used for the characterization of wastewater.
2. To provide basic description of the main technologies and processes used for treatment of wastewater.
3. To understand the basic design criteria and the operation of wastewater treatment facilities/plants.

Intended Learning Outcomes

1. The students would be able to explain the main physical, chemical and biological processes used for wastewater treatment.
2. The students would be able to understand different sources of water pollution and their corresponding qualities, linking these to the basic objectives of wastewater treatment and the need for water quality standards for wastewater effluent disposal.

Course Content

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.

EVS 418: Energy and Environment (3 credits)

Objectives

1. To understand the physical principles underlying energy and their interaction in the environment.
2. To understand the impacts of the implementation of energy and environmental technologies and policies on sustainability.
3. To understand the broader view of energy, environment and climate change problems and issues.

Intended Learning Outcomes

1. The students would be able to identify and exhibit an ability to integrate major factors affecting the atmosphere and climate.
2. The students would be able to demonstrate expertise on energy supply, demand and security issues and their associated environmental impacts in a global and societal context.
3. The students would exhibit innovative and creative solutions to energy and environmental problems through projects.

Course Content

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.

ATM XXX: Simulation and Visualization in Earth Sciences 3credits (2T+2P)

Course from Department of Atmospheric Science

Semester III

EVS 501: Coastal and Marine Environment (3 Credits)

Objectives

1. To develop an understanding of the dynamic processes that affect oceans i.e. water, sea floor, and abundant life forms.
2. To understand the role being played by ocean- atmosphere interaction in the climate processes.
3. To understand the role of ocean processes in the coastal and marine landform creation

Intended Learning Outcomes

1. The students will understand the role of physical processes in the dynamic processes of ocean circulation.
2. The students will be able to formulate solutions ailing the current state of the coastal and marine environment in terms of chemical and biological interactions.
3. The students will be able to use the knowledge base to promote ocean awareness in the light of human exploitation of its resources.

Course Content

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.

EVS 502: Environmental Impact Assessment and Management (3 credits)

Objectives

1. To explain the major principles of environmental impact assessment in India
2. To understand the different steps within environmental impact assessment.
3. To discuss the implications of current jurisdictional and institutional arrangements in relation to environmental impact assessment
4. To understand how to liaise with and the importance of stakeholders in the EIA process
5. To be able to access different case studies/examples of EIA in practice

Intended Learning Outcomes

1. Student will be able to understand the strategic and organisational context of environmental management in different settings and design and deliver practical outcomes that contribute positively to environmental performance.
2. Student will be able to Synthesise and prioritise information from desktop and field environmental assessments, rank the relative values identified, assess the risks imposed by the development, and determine appropriate environmental management strategies.
3. Student will be able to articulate and justify specific policies or courses of action on complex environmental issues using discipline based knowledge and established management principles.

Course Content

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.

EVS 503: Environmental Biotechnology **3 credits (2T+2P)**

Objectives

1. To train the students about conservation of resources via recycling of waste materials and recovery of valuable products such as metals and oils.
2. To impart a working knowledge of the principles, techniques and current applications of biotechnology to environmental quality evaluation, monitoring, remediation of contaminated environments and energy production.
3. Understand the principles of bioremediation and phytoremediation of synthetic organic pollutants and basic physiology of a microorganism during bioremediation studies.
4. Know various techniques to modify and augment microorganisms in the laboratory and environment
5. To understand the genetic structure of microorganisms and their amplification methods.

Intended Learning Outcomes

1. The student should be able to understand basic principles of microbiology of environmental engineering systems, different microbial metabolism, natural/advanced environmental biotechnologies.
2. The student should be able to recognize and apply environmental biotechnology approaches in treatment and disposal of organic wastes, production of biomaterials /biofuels and pollution control.

Course Content

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.

EVS 504: Science of Climate and Climate Change (3 Credits)

Objectives

1. To educate students about science of climate science
2. To provide information about what national and international organizations are working for mitigation and adaptation to address climate change

Intended Learning Outcomes

After completing the course, participants will be able to:

1. Explain the fundamentals of climate change science
2. Describe the expected consequences of climate change and the role of mitigation and adaptation.

Course Content

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

EVS 505: 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.

ATM XXX: Arid Environment and Desert Meteorology (3Credits)

Course from Department of Atmospheric Science

MSE YYY: Elective-II (3 Credits)

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

LIST OF COURSES (Elective-II)

EVS 506: Environmental Modelling (3 Credits)

Objectives

1. To provide idea, methodology and basic tools available in environmental modelling
2. To expose student with different modelling approaches in environmental management & decision making

Intended Learning Outcomes

1. Understand various approaches for development and application of environmental models
2. To use available models for finding various solutions and scenarios related to environmental issues

Course Content

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.

EVS 507: Geoinformatics for Forest Management (3 credits)

Objectives

1. To generate qualified postgraduates who can be part of professional organizations working in the field of Forest Management.
2. To generate a skilled post graduates who can undertake research in the field of forest Biodiversity & Wildlife conservation thrugh geospatial technology.
3. To create awareness about the role of Remote Sensing and GIS for forest management. Intended Learning Outcomes

Intended Learning Outcomes

1. Students will be able to recognize locally-important woody species and understand their ecology, use, and potential markets, measure forest trees and products.
2. Students will be able to extract qualitative and quantitative forest resource data from maps, aerial photographs, and digital data sources and perform boundary surveying, forest inventory, and mapping.
3. Students will recognize and describe the methods of forest regeneration and protection, including the basic principles of wild land fire, wild land firefighting, forest health and the ability to identify major health threats and forest pests.
4. Students will be proficient in Geographic Information Systems (GIS) and Global Positioning Systems (GPS) and apply those and other technologies to the protection or management of natural resources and develop a professional forest management plan

Course Content

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.

EVS 508: Environmental and Occupational Health (3 Credits)

Objectives

1. To understand the principles and application of environmental and occupational health science in relation to the identification, evaluation and control of contaminants and related human exposures
2. To introduce diseases associated with exposure to common environmental and occupational factors, and approaches for investigating the work-relatedness of disease
3. To develop an understanding towards industrial hygiene principles of recognition, identification, evaluation and control of contaminants at workplace.

Intended Learning Outcomes

1. Acquire knowledge on health effects caused by exposure to environmental and occupational hazards at workplace recognizing the roles of various occupational health professionals.
2. Understand conceptual frameworks for analysing and managing occupational and environmental health hazards along with importance industrial safety, hygeine and exposure guidelines.

Course Content

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.

EVS 509: Nanotechnology for Pollution Mitigation (3 credits)

Objectives

1. To provide basic overview of nanoscience and nanotechnology along with introduction to different classes of nano based materials
2. To provide knowledge over different methods of nanomaterial synthesis and characterization techniques involved
3. To familiarize with the applications and role of nanotechnology in treatment of environmental contaminants present in various environmental matrices.

Intended Learning Outcomes

4. Able to acquire knowledge over fundamental principles of nanotechnology along with current and potential future nanotechnology applications
5. Understand relevancy of this field in the area of environmental clean up/remediation along with potential benefits and risks

Course Content

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.

EVS 510: Water Resource Management (3 Credits)

Objectives

1. To provide exposure of different methods of water conservation and harvesting
2. To give understanding of nexus of water with other sectors and their importance in future sustainable development
3. To learn the principles of integrated water resources management

Intended Learning Outcomes

1. The students should be able to start developing strategic water resources planning at various geographical scales.
2. The students should be able to deal with new challenges of water resources management and their linkage with other sectors like agriculture, energy.

Course Content

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.

ATM XXX: Aerosol and Atmospheric Chemistry (3 Credits)

Course from Department of Atmospheric Science

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.

Semester IV

EVS 521: Project **(20 Credits)**

Objectives

1. To Identify/define environmental problems existing in the area of interest
2. Generate research questions and/or relevant hypotheses
3. Identify and apply appropriate research methods to deal with the research questions and hypothesis
4. Conduct research responsibly and ethically using good laboratory practices
5. Evaluate, interpret, and analyze a body of empirical data and evidence to generate an empirical model for better understanding
6. Discuss findings and prepare report in the broader context of the field

Intended Learning Outcomes

1. Able to identified real existing problem and exposure to problem based learning
2. Able to prepare scientific report with clear findings
3. Produce publishable results or generate a decision support system

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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Mapping Table for M.Sc. in Environmental Science

	Course Code	Name of the Course	Course Type	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Semester I							
	EVS 401	Ecology and Environment	C	X		X	
	EVS 402	Natural Resources, Biodiversity and Wildlife Conservation	C	X		X	X
	EVS 403	Environmental Chemistry	C	X	X	X	
	EVS 404	Environmental Geoscience	C	X		X	
	EVS 405	Environmental Policies, Legislation and Sustainable Development	C		X		X
	EVS 406	Environmental Pollution	C	X		X	
	EVS 407	Environmental Laboratory-I	C	X	X	X	
	ATM XXX	Fundamentals of Atmosphere, Land and Ocean	C	X	X	X	
Semester II							
	EVS 408	Instrumentation for Environmental Monitoring and Analysis	C	X		X	
	EVS 409	Air and Water Quality Management	C	X	X	X	
	EVS 410	Environmental Toxicology	C	X		X	
	EVS 411	Remote Sensing and GIS	C	X	X	X	
	EVS 412	Field Trip	C	X		X	X
	EVS 413	Environmental Laboratory-II	C	X		X	
	ATM XXX	Statistical Analysis and Computer Programming	C		X	X	
	EVS 414	Solid Waste Management	E	X		X	
	EVS 415	Environmental Disasters and Management	E		X		X
	EVS 416	Hydrogeology	E	X		X	
	EVS 417	Wastewater Treatment and Management	E	X	X	X	
	EVS 418	Energy and Environment	E		X	X	
	ATM XXX	Simulation and Visualization in Earth Sciences	E		X	X	
		Massive Open Online Courses (MOOCs)	E				
Semester III							
	EVS 501	Coastal and Marine Environment	C	X	X	X	
	EVS 502	Environmental Impact Assessment and Management	C	X	X	X	X
	EVS 503	Environmental Biotechnology	C	X		X	
	EVS 504	Science of Climate and Climate Change	C	X	X	X	
	EVS 505	Minor Project	C		X	X	
	ATM XXX	Arid Environment and Desert Meteorology	C	X	X	X	
	EVS 506	Environmental Modelling	E	X	X	X	
	EVS 507	Geoinformatics for Forest Management	E	X	X		
	EVS 508	Environmental and Occupational Health	E	X	X	X	
	EVS 509	Nanotechnology for Pollution Mitigation	E	X	X		
	EVS 510	Water Resource Management	E	X	X		X
	ATM XXX	Aerosol and Atmospheric Chemistry	E	X		X	
		Massive Open Online Courses (MOOCs)	E				
Semester IV							
	EVS 521	Project	C	X	X	X	

Central University of Rajasthan

DEPARTMENT OF ENVIRONMENTAL SCIENCE
SCHOOL OF EARTH SCIENCES

Ph.D. Environmental Science

(Course Syllabus)

February 2019

Program Objectives

1. To create a researcher focused on interdisciplinary socio-ecological issues and application of sustainable approaches for addressing environmental concerns and challenges
2. To train and provide hand-on training to students in modern tools and techniques to address environmental issues
3. To prepare future manpower for designing, conducting independent research in the area of their interest.

Program Outcomes

After successful completion of the program, student will

1. Able to work on various interdisciplinary aspects of environment for sustainable development of society
2. Able to handle recent tools and techniques to find the solution for various environmental challenges
3. Able to work as independent researcher to work for society and contribute to solutions to the environmental challenges

Central University of Rajasthan

School of Earth Sciences

Ph.D. Environmental Science

Course Structure and Syllabus

No	Course Code	Title of the course	Type of Course	Credits
1	EVS 701	Research Methodology	Core	4
2	EVS 702	Advance Analytical Techniques	Core	4
3	EVS 703	Water Resources and Climate Change	Elective	4
4	EVS 704	Air Pollution and Control	Elective	4
5	EVS 705	Environmental Biotechnology	Elective	4
6	EVS 706	Nanotechnology: Environmental Applications	Elective	4
7	EVS 707	Geospatial Technology for Environmental Management	Elective	4
8	EVS 708	Biogeochemistry	Elective	4

Total Credit Requirement: 12 (8 credits core courses + 4 credits elective course)

Compulsory Course (8 credits): EVS 701 (4 credits), EVS 702 (4 credits)

Elective Course (4 credits): student has to select any one course from list of elective course as per his/her requirement

EVS 701: Research Methodology (4 Credits)

Objectives

1. To develop understanding of the basic framework of research process
2. The course aims to augment the aptitude of research among students
3. To facilitate the students in understanding the tools and techniques of conducting thesis
4. To develop an understanding of the ethical dimensions of conducting applied research

Intended Learning Outcomes

Student should be able to:

1. work on identification of research questions, review the research literature
2. identify different ways to collect and analyse qualitative and quantitative data
3. develop good research proposal and further completion of thesis and research publications

Course Content

Unit – 1: Research Basics

S. No.	Topic	No. of Lecture (Hrs)
1	Research Basics: definition, purpose and types (qualitative, quantitative, cross-sectional, longitudinal, pure, applied, action, evaluation, historical, survey, exploratory and case study); Significance of research in applied sciences/ arts/ social sciences; Process of Research; Objectives and Dimensions of Research	4
2	Research problem, Research questions, Research design	2
3	Tools of Research: Library, Field, Laboratory; Methods of research: Qualitative and Quantitative	3
4	Systematic review of literature in applied sciences/arts/social sciences	2
5	Features of research study Preparation of Research proposal/ synopsis	3
6	Research Ethics (Issues relating to referencing and documentation, copyrights, plagiarism etc.), Impact Factor, H-Index, Citation Index, references/ bibliography	3
7	Structuring the Ph.D. Thesis: chapter format, pagination, identification, using quotations, footnotes, abbreviations, presentation of tables and figures, referencing, documentation, use and format of appendices, indexing	3
	Total Lectures (Hrs)	**20**

Unit – 2: Statistical Techniques

S. No.	Topic	No. of Lecture (Hrs)
1	Data: Types (primary and secondary data), collection methods; presentation (Graphical and diagrammatical); relevance, limitations and cautions.	2
2	Data Processing: checking, editing, coding, transcriptions, classification and tabulation. Data analysis: meaning and methods; quantitative and qualitative analysis	2
3	Bivariate Data Analysis using Correlation and Regression analysis	2
4	Analysis of time series, Interpolation and Extrapolation	2

5	Statistical fallacies: Bias, Faulty generalization, inappropriate comparison, misuse of various tools like mean, median, mode, dispersion, correlation etc., technical errors.	2
6	Theoretical distribution: Normal, Poisson, Binomial with application in various area/ disciplines	3
7	Sampling: types, steps; sampling errors Sampling of attributes (including chi square test), Sampling of small and large sample variables (including ANOVA)	2
8	Hypothesis Testing: fundamentals of hypothesis testing in applied sciences/arts/social sciences	2
9	Parametric vs. non-parametric tests	3
	Total Lectures (Hrs)	**20**

Unit 3: Data Analysis in Environmental Studies

S. No.	Topic	No. of Lecture (Hrs)
1	Environmental sampling: Finite-population sampling, stratified random sampling, composite sampling, ranked set sampling, capture-recapture methods	4
2	Time series analysis: Trend estimation, autocorrelation function, autoregressive models, forecasting methods	4
3	Spatial statistics: Interpolation techniques, autocorrelation, Variogram estimation	4
4	Introduction of statistical packages (SPSS, R): Calculation of various statistical parameters, tests, temporal and spatial data analysis, preparation of charts	4
5	Interpretation of statistical outputs in reports and papers	4
	Total Lectures (Hrs)	**20**

Suggested Readings

1. Jay L Devore: Probability and Statistics for Engineering and the Sciences: CENAGAGE, Learning. Print in India.
2. Rice, J.A. (2007): Mathematical Statistics and Data Analysis: CENAGAGE Learning Pvt. Ltd.
3. Spiegel M.R. and Stephens J.L. (2010) Statistics, Tata McGraw Hill.
4. Das N.G. (2011): Statistical Methods, Tata McGraw Hill.
5. Bernard A. Rosner (2011), Fundamentals of Biostatistics, 7th Ed., Cenagage Learning Pvt. Ltd.
6. L.W.Neuman.1997. Social Research Methods: Quantitative and Qualitative approaches. Allyn& Bacon. 560 pp6.
7. Vinay Kumar Srivastava. 2004. (ed) Methodology and Fieldwork, Oxford University Press, New Delhi
8. Dawson, Catherine, 2002, Practical Research Methods, New Delhi, UBS
9. Publishers'Distributors
10. Kothari, C.R.,1985, Research Methodology- Methods and Techniques, New Delhi,
11. Wiley Eastern Limited.
12. Kumar, Ranjit, 2005, Research Methodology-A Step-by-Step Guide for Beginners (2nd Edition), Pearson Education.

EVS 702: Advance Analytical Techniques (4 Credits)

Objectives

1. To make student aware of advance/emerging technologies used for environmental pollution monitoring and their control.
2. To introduce students to the current trends of sampling and modern analysis relevant to environmental sciences.

Intended Learning Outcomes

1. The students would be should be able to critically evaluate and interpret experimental data and findings.
2. The students will be able to explain the theoretical aspects of key analytical techniques and instruments used in geochemistry as well as nanotechnology, including but not limited to advance spectroscopy, chromatography and hyphenated techniques.
3. The student will be able to undertake the correct sample preparation and characterization prior to analysis by the chosen techniques or instruments.
4. Students will be able to design an analytical work-flow to acquire data and achieve the research objectives of their project.
5. Students will be able to process data from the complex instruments and demonstrate an understanding of the limitations and quality of the data. Justify the approach taken to data processing.
6. Students will be able to write a clear and concise justification and description of the analytical techniques employed, suitable for publication in a scientific journal.

Course Content

Analytical tools in environmental science- sampling techniques, extraction processes, principles and applications of Electro-analytical techniques, Separation Methods, Qualitative Optical Spectroscopic methods, Quantitative Optical Spectroscopic methods, Mass Spectrometry (MS), Hyphenated techniques, Microscopic and surface analysis, Emerging technologies for environmental monitoring and pollution control, Current trends of Remote Sensing and GIS applications in Environmental Science.

Suggested Readings

1. Skoog, D.A., Holler, F., Crouch, S.R., Instrumental Analysis, Cenage Learning India Pvt. Ltd, New Delhi, 2007
2. Settle, F. Instrumental Techniques for Analytical Chemistry, Prentice-Hall, Inc., Englewood Cliffs, NJ, (1997).
3. Popek, E. P. Sampling and analysis of environmental pollutants: a complete guide, USA: Academic (2003).
4. Lillesand, T., Kiefer, R. W., & Chipman, J. Remote sensing and image interpretation. John Wiley & Sons, (2014).

EVS 703: Water Resources and Climate Change (4 Credits)

Objectives

1. The aim of the course is to develop linkage between climate change and water resources, including understanding, modelling and projection of hydrological processes at river basin scale.
2. To develop capability of various tools and techniques to use climate data and various processing methods

Intended Learning Outcomes

3. Students will be able to demonstrate an understanding of linkages between climate and water resources
4. Able to set hydrological model for studying the impacts of climate change on water resources and hydrological processes

Course Content

Elements of a watershed, hydrological cycle, hydro-meteorological variables and measurement, rainfall-runoff modelling, land capability classification, use of remote sensing and GIS tools in database preparation, hydrological models- calibration and validation, application of rainfall-runoff model, interlinking surface-groundwater, impact of landuse/landcover change on surface and groundwater resources, impact of climate change and water resources, regional and global climate models and scenarios, bias-correction techniques, spatial and temporal downscaling, uncertainity in hydrologic projections, hydro-climatic extremes

Suggested Readings

1. Burrough, P.A. and McDonnell, R.A. (1998) Principles of geographical information systems. Oxford University Press, Oxford, 327 pp.
2. Chow, V.T 1988, Applied Hydrology, Tata McGraw Hill Publishing Co.
3. Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W. (2005) Geographic Information Systems and Science. Chichester: Wiley. 2nd edition.
4. Subramanya, K 2004, Engineering Hydrology, Tata McGraw-Hill, New Delhi.
5. Saeid Eslamian, Handbook of Engineering Hydrology: Modeling, Climate Change, and Variability

EVS 704: Air Pollution and Control (4 Credits)

Objectives

1. To introduce major pollutants present in air
2. To provide knowledge of various sampling methods and pollution control technologies

Intended Learning Outcomes

Students should able to learn about

1. Effect of atmosphere and anthropogenic sources in air pollution
2. Understand the basic theory and application of pollution control devices

Course Content

Inorganic and organic pollutants, aerosols, particulate matters, future trends for urban pollution in developed and developing countries, atmospheric dispersion and modelling, plume behaviour, recent technologies for air sampling and analysis of persistent organic pollutants, Organic Carbon and Black carbon analysis, dose response analysis, Health risk assessment, carcinogenic potencies, toxic equivalent factors (TEFs). Air pollution control technologies-Settling chamber, cyclone separator, fabric filter, electrostatic precipitators; wet collector (scrubber); Methods of control of gaseous pollutants-condensation, absorption, adsorption, combustion and biological control systems, green belt, green bench and carbon credits.

Suggested Readings

1. Baird, C. and Cann, M. Environmental Chemistry. W.H. Freeman and Company 2008.
2. Davis, M.L. and Cornwell, D.A. Introduction to Environmental Engineering. WCB/McGraw-Hill Publications.
3. Nevers, Noel De, Air Pollution Control Engineering, McGraw-Hill International Editions, 2000.
4. Ray, T.K. Air Pollution Control in Industries. Tech Books International, New Delhi.
5. Vallero, Daniel A. Fundamental of Air Pollution, Fourth Edition, Academic Press.

EVS 705: Environmental Biotechnology (4 Credits)

Objectives

1. To impart knowledge about applications of biotechnology to environmental quality evaluation, monitoring, remediation of contaminated environments/ industrial effluents.
2. To understand various optimization techniques for biochemical engineering of culture experiments.
3. Understand the principles of bioremediation of synthetic organic pollutants and basic physiology of a microorganism during bioremediation studies.
4. To understand the microbial physiology and enzyme kinetics for biodegradation studies.

Intended Learning Outcomes

1. The student should be able to understand basic principles of microbiology of environmental engineering systems, for treatment of various organic wastes.
2. The student should be able to recognize and apply environmental biotechnology approaches in treatment and disposal of organic wastes, production of biomaterials /biofuels and pollution control through optimization techniques.

Course Content

Introduction, role of biotechnology in environment management, industrial waste management, advanced waste water treatment, hazardous waste management, biomedical waste management, oil spill, PCBs, PAH, dioxins; Bioprocess engineering, optimization softwares, enzyme kinetics, purification, kinetics, applications, metagenomics, degradation of xenobiotics, environmental toxicity, assays.

Suggested Readings

1. Biochemical Engineering fundamentals, 2nd ed. By J E Bailey and D F Ollis, McGraw Hill, 1986.
2. Bioprocess Engineering Principles by Pauline M. Doran, Academic Press
3. Environmental Biotechnology by Indu Shekhar Thakur., IK International Pvt. Ltd.
4. Fundamentals of Enzymology by Nicholas C. Price & Lewis Stevens, 3rd edition, Oxford University press, New York.
5. Industrial Microbiology by CASIDA
6. Introduction to Biodeterioration by D. Allsopp and K.J. Seal. ELBS/Edward Arnold

EVS 706: Nanotechnology: Environmental Applications (4 Credits)

Objectives

1. To provide a broad view of the nascent field of nanoscience and nanotechnology, different methods of their synthesis and characterization techniques.
2. To develop an understanding towards varied applications of nanotechnology in the area of environmental remediation.

Intended Learning Outcomes

1. The student will have working knowledge of nanoscience and nanotechnology, including theory and experiments
2. The students should be able to critically evaluate and interpret scientific information.
3. The student should be able to propose potential projects related to the subject.

Course Content

History of nanotechnology, nanoscale material classification; properties of nanoparticles; synthesis method-top-down and bottom-up approach; physical, chemical and biological methods of preparation; characterization techniques; role of nanoparticles in environmental clean-up; application of nanoparticles in wastewater treatment, water disinfection, contaminated groundwater/ surface water and soil/sludge/sediment treatment; remediation mechanisms; potential risks, public health & environmental concerns; case studies.

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. and Kalariakkal N. Nanomaterials: Synthesis, Characterization and Applications. Apple Academic Press. 2013.

EVS 707: Geospatial Technology for Environmental Management (4 Credits)

Objectives

1. To introduce GIS and Remote Sensing in environmental management
2. To expose students to applications of GIS and remote sensing in environmental management
3. To develop a sound basis for understanding the operation of GIS and Remote Sensing in environmental management.
4. To understanding the role played by technical experts, stakeholders and decision-makers
5. To demonstrate case studies of a selected areas using GIS software.

Intended Learning Outcomes

1. Students will be able understand GIS concepts in an interdisciplinary setting and to identify and source data for use in evidence-based decision making in environmental management.
2. Students will be able to use airborne and space-borne imagery to characterize the biophysical environment at landscape and regional scales and apply GIS software's for spatial data preparation, analysis and visualization with in-depth skills of vector and raster processing.
3. Students will be able to demonstrate ability to conduct a GIS research project in the area of environmental management and proficiency in integrating GIS data analysis with simple statistical analysis.

Course Content

Environment & ecosystems, functions and types of ecosystem, ecosystem model concept, types of models & applications, forest biomass, forest inventory methods, types of sample plots, volume estimation, uncertainty of forest biomass estimates, fundamentals of geospatial technology: definition, advantages and limitations, concept & principles, earth resource satellite sensors, image classification, advances in geospatial technology, geospatial applications in environmental management, multilevel remote sensing and ground data to estimate forest biomass, advance tools in RS & GIS for assessment of biomass, carbon pool and flux assessment, carbon sequestration and impacts on climate change.

Suggested Readings

1. Baretl, E.C. and Culis I.F. Introduction to Environmental Remote Sensing, second edition, Chapman and Hall, New York, 1993.
2. Lintz, J. and Simonent, D.S. Remote Sensing of environment Addision Wesley, Rading mars, 1976.
3. Jorgensen, Sven Erik. Handbook of environmental and ecological modeling. CRC Press. pp. 403–404. 1996.
4. Grant, William Edward & Swannack, Todd M. Ecological modeling: a common-sense approach to theory and practice. John Wiley & Sons. p. 74. 2008.
5. Hall, Charles A.S. & Day, John W. Ecosystem Modeling in Theory and Practice: An Introduction with Case Histories. University Press of Colorado. p. 9. 1990.

EVS 708: Biogeochemistry (4 Credits)

Objectives

1. To introduce and investigate processes and factors controlling the biogeochemical cycles of elements within and between the hydrosphere, lithosphere, atmosphere and biosphere.

Intended Learning Outcomes

1. Students will be able to explain and use examples of how organisms and biodiversity affect biogeochemical processes.
2. The students will be able to explain an array of modern and paleoecological questions using biogeochemical approach.

Course Content

Introduction, biogeochemical characteristics, evolution of biogeochemical cycles, biogeochemical cycling of macro elements, biogeochemical cycling of trace elements, interactions of biogeochemical cycles, regional biogeochemistry, advances in biogeochemistry, stable isotopes in biogeochemistry and their application to various environmental problems.

Suggested Readings

1. William H. Schlesinger, Biogeochemistry, Elsevier. 2005.
2. Thomas S. Bianchi, Biogeochemistry of Estuaries; Oxford University Press. 2009.
3. Kenneth D. Black and Graham Shimmield, Biogeochemistry of Marine Systems; CRC Press. 2003.
4. Fengxiang X. Han, Arieh Singer, Biogeochemistry of Trace elements in the Arid environments; Springer. 2007.
5. K. Ramesh Reddy, Ronald D. DeLaune. Biogeochemistry of Wetlands; CRC Press. 2008.
6. William H. Schlesinger and Emily S. Bernhardt, Biogeochemistry- An analysis of global change; Academic Press. 2013.

Mapping Table for Ph.D. in Environmental Science

Course Code	Name of the Course	Course Type	Outcome 1	Outcome 2	Outcome 3
EVS 701	Research Methodology	C	X	X	X
EVS 702	Advance Analytical Techniques	C	X	X	X
EVS 703	Water Resources and Climate Change	E	X	X	
EVS 704	Air Pollution and Control	E	X	X	
EVS 705	Environmental Biotechnology	E	X	X	
EVS 706	Nanotechnology: Environmental Applications	E	X	X	
EVS 707	Geospatial Technology for Environmental Management	E	X	X	
EVS 708	Biogeochemistry	E	X	X	