Programme: M.Sc. Environmental Science

DEPARTMENT OF ENVIRONMENTAL SCIENCE
SCHOOL OF EARTH SCIENCE SYSTEMS
CENTRAL UNIVERSITY OF KERALA

Revised Syllabus effective from December 2021

M.Sc. Environmental Science Programme Structure

Course Code	Title	L	T	P	Credits
First Semester					
EES 5101	Fundamentals of Ecology and Environmental Science	2	1	0	3
EES 5102	Environmental Toxicology and Health	2	1	0	3
EES 5103	Environmental Techniques	2	1	0	3
EES 5104	Climate Change and Current Issues	2	1	0	3
EES5105	Practical I – Ecology			1	1
EES5106	Practical II – Environmental Toxicology			1	1
EES5107	Practical III – Environmental Techniques			1	1
Total Credits					15
Second Semester					
EES 5208	Environmental Microbiology and Biotechnology	2	1	0	3
EES 5209	Environmental Pollution and Control	2	1	0	3
EES 5210	Waste Management	2	1	0	3
EES 5211	EIA and Environmental Auditing	2	1	0	3
EES 5212	Natural Resources Management	2	1	0	3
EES 5213	Practical IV – Environmental Microbiology and Biotechnology			1	1
EES 5214	Practical V – Environmental Pollution			1	1
EES 5215	Practical VI – Waste Management			1	1
Total Credits					18
Third Semester					
EES 5316	Biodiversity and Conservation	2	1	0	3
EES 5317	Environmental Engineering	2	1	0	3
EES 5318	Research Methodology and Statistical Analysis	2	1	0	3
EES 5319	Disaster Management	2	1	0	3
EES 5320	Practical VII – Biodiversity and Conservation			1	1
EES 5321	Practical VIII – Environmental Engineering			1	1
EES 5322	Practical IX – Statistical Analysis			1	1
Total Credits					15

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Fourth Semester			
EES 5423	Internship	3	3
EES 5424	Field / Industrial Visits Report and Viva Voce	3	3
EES 5490	Dissertation/Project Work and Viva Voce	6	6
Total Credits			12
Grand Total Credits			60

ELECTIVES			
EES 5001	Aquatic Ecology	3	3
EES 5002	Current Environmental Issues	3	3
EES 5003	Ecotourism	3	3
EES 5004	Energy and Environment	3	3
EES 5005	Environmental Economics	3	3
EES 5006	Environmental Education	3	3
EES 5007	Environmental Geosciences	3	3
EES 5008	Environmental Genetics and Biotechnology	3	3
EES 5009	Environmental Nanotechnology	3	3
EES 5010	Environmental Stress Biology	3	3
EES 5011	Food Safety and Health	3	3
EES 5012	Forestry	3	3
EES 5013	Industrial Ecology	3	3
EES 5014	Marine Environment	3	3
EES 5015	Occupational Health and Industrial Safety	3	3
EES 5016	Principles of Remote Sensing and GIS	3	3
EES 5017	Water Quality and Human Health	3	3
EES 5018	Cell and the Environment	3	3

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Programme Specific Outcomes

1. To understand the basic concepts of environment and its interactions with the earth and environmental systems and various ecosystems associated with it.

2. Capability to analyse, evaluate and interpret the causes and effects of various environmental problems at local, regional and global scale and to develop management strategies.

3. Capacity to analyse and determine the magnitude of different kinds of environmental pollution, their sources using environmental analytical techniques, quantitative and computational techniques. 4. Acquire interdisciplinary knowledge on the global aspects of climate change, its effects on the environment and its governance

5. Capacity to use biotechnological methods in water and wastewater treatment technology. Ability to apply appropriate techniques for efficient solid waste management practices and to find the solutions to the pollution problems.

6. Ability to use different tools for the management of energy resources, biodiversity conservation, natural disasters and technical knowhow in environment management.

7. Ability to analyse a given research problem, identify research gaps, developing suitable research methodology with suitable research design, data collection, data analysis with suitable statistical tool, interpretation of the findings leading to perfect solution to the problem given.

8. Demonstrate proficiency in quantitative methods, qualitative analysis, critical thinking, and written and oral communication needed to conduct high-level work as interdisciplinary scholars and/or practitioners.

9. Master the core concepts and methods from economic, political, and social analysis as they pertain to the design and evaluation of environmental policies and institutions.

10. Appreciate the ethical, cross-cultural, and historical context of environmental issues and the links between human and natural systems.

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Programme Outcomes

On successful completion of the M. Sc. Environmental Sciences program

PO1 Students would acquire knowledge on the fundamental concepts of chemistry, atoms, molecules, bonding phenomenon, chemical reactivity and product outlet related to environmental chemistry. Students would also have more familiar with the classification of various pollutants such as air/water/soil and physical, chemical and biological control methods of above said pollutants in the environment.

PO2 Students could acquire knowledge with reference to designing of methods, way of data collection, analysis of data, interpretation of results to solve the environmental problems through the assessment of qualitative and quantitative characters, by using artificial intelligence, big data, data analysis and internet things.

PO3 Students will get skill development on qualitative and quantitative analysis of environmental samples using different analytical instruments techniques. Students also understand the work place hazards, mitigation by employing safety devices and also aware of environmental safety standards, certification, safety auditing and management perspectives.

PO4 Students gain knowledge about the importance of natural resources, distribution, utilization, conservation strategies, green energy sources and sustainable management perspectives. Further, students will also be able to understand the importance of environmental impact assessment, public participation in environmental impact assessment and EIA report preparation before implementing potential environmental projects in National, International, Regional and Local levels.

PO5 The students could understand the different type of natural disasters, causes, and impact on natural and man-made environments. Further, students gained knowledge will enable to become volunteers themselves in disaster management program for helping the affected community. Nonetheless, students will also acquire knowledge regarding the importance of preparedness in vulnerable areas.

PO6 Students will be able to acquired technical knowledge about the fundamentals of industrial effluent treatments, water and sewage wastewater treatments, environmental protection with pollutants free, zero waste discharge and operating of pollution control devices technology. Students will be able to understand the key features of environmental laws, acts and legal obligations, applying of green auditing tools and techniques, conducting of onsite assessment and preparation of audit reports before implementing the potential public environmental projects.

PO7 Students will be able to gain technical skills and knowledge of the various environmental toxicants, toxicants in food, drugs, weedicides, heavy metals, pesticides, organic and inorganic chemical molecules, exposure routes of toxicants, toxicological test methods and animal ethics to be followed in toxicological testing studies.

PO8 The students will be able to acquire and understand the management strategies of solid and liquid wastes from municipal and industrial sources, remediation measures of recycling, reuse and recovery from wastes, principles and mechanistic role of machines in the degradation of various pollutants. Students will be able to gain knowledge about

the strategic phenomenon of environmental planning, life cycle assessment, material analysis, environmental impact assessment, risk assessment, environmental auditing, issues in various industrial sectors in cooperation with federal, state and local governing body and official work for mitigation strategies in issues pertaining to the environmental protection.

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EES 5101 Fundamentals of Ecology and Environmental Science

Course Code	EES 5101	Semester	1
Course Title	*Fundamentals of Ecology and Environmental Science*		
Credits	3	Type	Core

Course Description

The course provides an introduction into the basics of Ecology and Environmental Science. The concepts of the different spheres and processes of Environment, ecosystem, population ecology and the interaction of different ecological factors with biotic components are laid out.

Course Outcome

By the end of the course, students are expected to be able to:

- Be well versed with the fundamentals of Ecology and Environmental Science
- Have an in depth understanding into the concepts of ecosystem
- Gain understanding into the population dynamics

Course Structure

The following is a detailed syllabus.

UNIT I: Basics of Environmental Science

Scope and interdisciplinary nature of Environmental Science; Atmosphere- Structure and composition (concepts of homosphere and heterosphere and layers of atmosphere); hydrosphere- marine water, freshwater, concepts of halocline and thermocline in temperate lakes; lithosphere - theory of plate tectonics, constructive, destructive and transform faults, island arcs; biosphere. Environmental factors, concept of limiting factors. Biogeochemical cycles (gaseous and sedimentary). Stoichiometry, Thermodynamics: energy, entropy, enthalpy, Gibb's energy, Acid-Base reactions, redox potential.

UNIT II: Ecosystem

Classification; Biogeographical regions; Biomes; Energy flow; Trophic relations; Ecological pyramids; Productivity and ecological efficiencies: primary and secondary producers. Gaia hypothesis; Niche; Speciation; Ecological Succession and Climax communities, ecotone, edge effect; Biological interactions - Positive and Negative interactions: Mutualism, Proto-cooperation, Commensalism, Competition, Amensalism, Parasitism, Predation, herbivory.

UNIT III: Population Ecology

Characteristics-Population density, natality, mortality, Age Pyramids/Age distribution, Population growth forms/curves (J Shaped and S shaped curves), Population

disturbance, population dispersal (migration, Immigration and emigration), population structure;- Isolation, distribution, population explosion-causes and control measures. r-selection and k-selection. Theory of island biogeography.

UNIT IV: Ecological Factors - Climatic Factors

Light - effect of light on morphology and physiology of plants, distinguishing features of Heliophytes and schiophytes. Temperature – effect of temperature on organisms, classification of vegetation: Megatherms, Microtherms, Mesotherms, Hekisotherms. Wind - Breeze, Storm, Hurricane, westerlies and easterlies, Jetstreams - Morphological and physiological effects of wind on organisms. Humidity and types of humidity – Relative humidity, specific humidity and absolute humidity, mixing ratio, dew point temperature, wet bulb temperature, effect of humidity on organisms. Precipitation- types of precipitation- convectional, orographic and cyclonic. Western disturbance, southwest monsoon and northeast monsoon.

Testing & Evaluation

- Seminar
- Assignment
- Written Exam

References

1. Arora S. (2003). Fundamentals of Environmental Biology, Kalyani Publications, New Delhi.
2. Cotgreave P. and Forseth I. (2002). Introductory Ecology. Blackwell Science, UK
3. Dhaliwal G. S., Sangha G. S. and Raina P. K. (2000) Fundamentals of Environmental Science, Kalyani Publication, India.
4. Freedman B. (1995). Environmental Ecology, Academic Press, USA.
5. Jackson A. R. W. and Jackson J. M. (2000). Environmental Science – The natural environment and human impact, 2nd Edition, Longman Group, UNITed Kingdom.
6. Masters G. M. (2007). Introduction to Environmental Science and Engineering, 3rd Edition, Prentice –Hall of India Pvt Ltd, New Delhi.
7. Odum E.P. (1993). Fundamentals of Ecolgy, W.B.Saunders Co., USA.
8. Rana S.V.S. (2005). Essentials of Ecology and Environmental Science. Prentice –Hall of India Pvt. Ltd. New Delhi
9. Townsend C.R., Begon M. and Harper J.L. (2008). Essentials of Ecology, Blackwell Publications, UK.

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EES 5102 Environmental Toxicology and Health

Course Code	EES 5102	Semester	I
Course Title	*Environmental Toxicology and Health*		
Credits	3	Type	Core

Course Description

The course proposes to give a wide knowledge on environmental toxicants and its impact on health. The course provides a scope for students to understand the toxicants disposition and metabolism, fate of toxicants in the environment, diseases caused by various pollutants, heavy metals and POP's and occupational health and safety.

Course Outcome

Upon completion of this course, students will be able to
- analyse the different types of toxicants, sources and its effects
- distinguish the toxic and non-toxic ingredients in aby products
- explain the fate of pollutants in the environment
- explain the effect of various types toxicants on human and environmental health
- apply the safety and precautionary measures related to environmental toxicants and occupational exposures

Course Structure

The following is a detailed syllabus

UNIT I: Environmental toxicology

Definition and branches of toxicology, scope and importance of toxicology, Principles of toxicology. Toxicants - Classification, routes of entry, transport, storage, metabolism and excretion. Categories of toxic effects - synergistic, antagonistic and additive effects. Acute and chronic toxic effects. Dose-effect and dose response relationships, LOAEL and NOAEL.

UNIT II: Toxicity of environmental pollutants

Toxicity of Persistant Organic Pollutants – pesticides, insecticides, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans. Toxicity of heavy metals – Chromium, cadmium, mercury, arsenic, lead, iron; Biohazards. Radioactive substances, fluorides and carbon monoxide. Mode of action of toxicants, mechanism of toxicants - Biochemical and molecular effects.

UNIT III: Analytical methods for toxicity testing

Principles of toxicity testing, Measurements of LC_{50} and LD_{50} values. Monitoring approaches - indicator populations and indicator species. Model ecosystems - microcosms and mesocosms; Bioassays – in vitro and in vivo; Biosensors – enzyme based and DNA based, immunosensors; whole-cell based biosensors and bio-markers.– Bioindicators - metabolites, , protein induction, cytochrome P450 enzymes, C reactive proteins and metallothioneins.

UNIT IV: Environmental risk and occupational hazards

Environmental and occupational safety - Definitions, concept and scope, occupational exposure, occupational hazards and diseases- Pneumoconiosis's, bagassorsis,

byssicosiss, asbestosis, anthracosis, siderosis, farmer's lungs. Control of toxic materials and protection measures - air, water and soil. Health effects of selfcare and pharmaceuticals products, Toxicity of engineered nanoparticles. Legislative perspective in ecological risk assessment, human health risk assessment. OSHA and its responsibilities

Testing & Evaluation

- Continuous assessment for 40% will be carried out with 2 internal assessment tests, seminars, assignments, group discussions, etc.
- End semester examination for 60% will be conducted at the end of the semester.

References

- B.M. Francis. (1994.), Toxic Substances in the Environment. New York, John Wiley & Sons.
- Bryan Ballantyne, Timothy C. Marrs, Tore Syversen. (2009), General Applied Toxicology. 6 Volume Set, Third Edition. Queensland, John Wiley & Sons.
- Cockerham L.G., Shane B.S. (1993), Basic Environmental Toxicology. USA, CRC Press.
- Edward A. (2013), Laws. Environmental Toxicology: Selected entries from the encyclopedia of sustainability science and technology. New York, Springer-Verlag.
- Hayes, A. W. (2008), Principles and Methods of Toxicology, 5th Edition, Boca Raton, FL, Taylor and Francis.
- I.C. Shaw and J. Chedwick. (2004), Principles of Environmental Toxicology, Boca Raton, FL, Taylor and Francis.
- Levy B.S., Wegman D.H. (1995), Occupational Health recognizing and preventing work related disease. Boston, MA: Little Brown & Co.
- Walker C.H., Sibly R.M., Hopkin S.P., Peakall D.B. (2012), Principles of Ecotoxicology. Fourth Edition. USA, CRC Press.
- Zakrzewski S.F (2002), Environmental Toxicology. 3rd Edition. New York, Oxford Univeristy Press.
- Landis W, Sofield R, Yu M.H., (2017),Introduction to Environmental Toxicology: Molecular Substructures to Ecological Landscapes, Fifth Edition. Canada, CRC Press.

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EES 5103 Environmental Techniques

Course Code	EES 5103	Semester	I
Course Title	*Environmental Techniques*		
Credits	3	Type	Core

Course Description

The course will introduce students to the application of some of the modern laboratory analytical techniques used in Environmental Sciences.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand information regarding environmental sampling, analysis and the various techniques associated.
- Understand the importance of proper sampling in environmental research
- Comprehend the various sampling technique and its applications.
- Select sampling methods for making unbiased research.

Course Structure

The following is a detailed syllabus.

UNIT I: Sampling Techniques and Basics

Sampling of air, water, soil and sediments - Preservation, storage and processing. Titrimetry, Complexometry, Gravimetry, Sedimentation - Centrifuge - types and applications. Density gradient methods, Electroanalytical Methods, Potentiometry.

UNIT II: Separation Techniques

Extraction and separation of inorganic and organic compounds; Chromatography: Paper chromatography, Thin layer chromatography, Column chromatography, High Performance Liquid Chromatography (HPLC), Gas Chromatography and Mass Spectrometry (GC-MS), Gas Chromatography-Tandem Mass Spectrometry (GC-MS-MS), Electrophoresis: Agarose Gel electrophoresis, Poly Acrylamide Gel Electrophoresis, ELISA.

UNIT III: Analytical Techniques - Microscopy

Light microscopy, Bright field microscopy, Dark field microscopy, Phase contrast microscopy, Fluorescence microscopy, Confocal microscopy, Electron microscopy: Transmission Electron Microscopy (TEM) and Scanning Electron Microscopy (SEM).

UNIT IV*: Analytical Techniques* - Spectroscopy

Ultraviolet -Visible spectroscopy; Infrared spectroscopy, Flame emission spectroscopy; Atomic absorption spectroscopy (AAS); Raman Spectroscopy, Nuclear Magnetic Resonance Spectroscopy (NMR). Inductively Coupled Plasma – Mass Spectrometry (ICP-MS).

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Seminar
- Assignment

References

1. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
2. APHA (1998) Standards Methods for the examination of water and Waste water, 20th Edition, Washington DC.
3. B.L. Oser (1965). Hawk's Physiological Chemistry. MacGraw Hill Book Co.
4. Clair N. Sawyer (2003). Chemistry for Environmental Engineering and Science. Tata McGraw Hill.
5. Denise R. Ferrier (2013). Lippincott's Illustrated Reviews Biochemistry; Sixth edition, Iippincott Williams & Wilkins.
6. Douglas A. Skoog, F. James Holler and Timothy A. Niemen. (1998). Principles of Instrumental Analysis. 5th Edition, Saunders College Publishing, Philadelphia.
7. F.W. Fifield (2000). Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
8. Khopkar S M (1985). Basic Concepts of Analytical Chemistry. Wiley Eastern Ltd., New Delhi.

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EES5104 Climate Change and Current Issues

Course Code	EES5104	Semester	I
Course Title	*Climate Change and Current Issues*		
Credits	3	Type	Core

Course Description

The course provides an overarching view of the complex and transdisciplinary subject of climate change in five vastly different but integrated units. The course subtly introduces complex global problems and intertwines the same, but not organically, with climate science, policy, mitigation and adaptation practices, and technologies.

Course Outcome

By the end of the course, students are expected to be able to:

- Illustrate through case study approaches the past global environmental problems
- Demonstrate a deep and scientific understanding of physical basis of climate change
- Differentiate developmental ideologies and policies, and their effect on global climate through IPCC reports, and vulnerability assessments
- Integrate the science, technology, policy, philosophy and ethics of climate change.

Course Structure

The following is a detailed syllabus.

UNIT I: Climate and Meteorology

Weather; Climate; Drivers of Earth's climate system; Energy and material balance; Greenhouse effect and Carbon Cycle; Major Climatic regions of the world based on latitude, with distribution of vegetation; classification of climates; Thornthwaites and koppens classifications; Climatogram studies; El-Nino and La Nino effect. Scale of meteorology; Weather forecasting; Basic numerical modelling approach; Emission inventory.

UNIT II: Energy crisis and impacts

Sources of energy; Conventional energy system – wood, coal, hydro and thermal power energy; Fossil fuels-classification, composition, physico – chemical characteristics and energy content of coal, petroleum and natural gas, nuclear fuel, fission and fusion. Energy use pattern in different parts of the world; Environmental implication; C02 emissions, global warming; Energy conservation and management; Energy audit.

UNIT III: Climate change impacts and measures

Climate change in the past, present and future – trends and causes; Impacts and risks of climate change; Effects on rainfall, forests, glaciers, and oceans; Introduction to climate models; Climate change impact assessment; vulnerability assessments; Scenarios; Climate projections and uncertainty; Role of developed and developing nations;

Multilateral organizations; IPCC; OPEC; Climate change mitigation – global measures, agreements and framework; Kyoto protocol, market based mechanisms and Paris Agreement; The Indian scenario of climate change; NAPCC; Climate change adaptation – sectors and elements; Adaptive capacity and options; Adaptation costs; Climate change and sustainability

UNIT IV: Climate friendly technologies

Non-conventional energy systems – Bioenergy & Anaerobic digestion; Ocean & tidal energy; Nuclear energy; Solar energy – photovoltaics, solar ponds; Hydrogen Energy; Waste to Energy; Wind energy and geothermal energy; Carbon capture and storage (CCS) – ocean and geological injection, scrubbing and mineral carbonation; natural sinks; Environmental impacts of renewable energy and CCS.

Testing & Evaluation

- Case studies, seminars, assignments, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

1. Peake S, 2009. Climate change, Oxford University Press, New York.
2. CABI, 2014. Climate change impact and adaptation in agricultural systems, UK.
3. Armaroli N, Balzani V, 2011. Energy for a Sustainable World – From the Oil Age to a Sun-Powered Future, Wiley-VCH.
4. Armaroli N, Balzani V, Serpone N, 2013. Powering Planet Earth – Energy Solutions for the Future, Wiley-VCH.
5. Chichester, 2010. Renewable Energy and Climate Change. John Wiley & Sons Ltd.
6. Sioshansi FP, 2011. Energy, Sustainability and the Environment, Elsevier.
7. Lee H, 2015. Climate change biology. Elsevier, London.
8. Springer, 2015. Handbook of climate change adaptation, Berlin.
9. Singh D K. (2006). Towards Basics of Natural Disaster Reduction, Research book Centre, New Delhi.
10. Singh T. (2006), Disaster Management approaches and strategies, Akansha Publishing House, New Delhi.

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EES 5105 PRACTICAL I – ECOLOGY

Course Code	EES 5105	Semester	I
Course Title	*PRACTICAL I – ECOLOGY*		
Credits	1	Type	Core

Course Description

The course provides practical exposure to the different biotic and abiotic components of the ecosystem and their analysis.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain practical knowledge into analysing the effects of ecological factors
- Have practical knowledge of the abiotic-biotic and biotic-biotic interactions

Course Structure

The following is a detailed syllabus.

1. Identification of phytoplankton in fresh water samples.
2. Determination of algae in water samples and Nygaard's Algal Indices.
3. Identification of zooplankton in fresh water samples.
4. Primary producers – Light and Dark bottle method
5. Study on the effects of light and temperature on seed germination.
6. Determination of relative humidity in different indoor and outdoor environment.
7. Identification of organism associated with positive and negative ecological interactions in the campus.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Slingsby, D., Cook, C. 1986. Practical Ecology, Palgrave, London
2. Rao, K.S. 1993. Practical Ecology, Anmol Publications

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EES 5106 PRACTICAL II – ENVIRONMENTAL TOXICOLOGY

Course Code	EES 5106	Semester	I
Course Title	*PRACTICAL II – ENVIRONMENTAL TOXICOLOGY*		
Credits	1	Type	Core

Course Description

The course provides a practical knowledge on toxicants and their effect on organisms.

Course Outcome

Upon completion of this course, students will be able to
- analyse the different types of toxicants, sources and its effects
-analyse the effect of different toxicant on plant and animal physiology and behaviour through practical module

Course Structure

The following is a detailed syllabus.

1. Toxic effects of xenobiotics on morphological changes of fishes.
2. Toxic effects of xenobiotics on behavioural changes (Swimming pattern, breathing, condition factor) in fishes.
3. Analysis of the toxicants from environmental samples
4. Calculating the LC_{50}/LD_{50} value of the given sample
5. Toxic effect of chemicals on the seed germination.
6. Toxic effect of chemicals on growth of the plants.
7. Determination of solid food adulteration.
8. To determine total leukocyte count (TLC) of the given blood smear.
9. Toxic effect on chlorophyll and carotenoid content of the plants exposed to toxicants/pollutants.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Cockerham L.G., Shane B.S. (1993), Basic Environmental Toxicology. USA, CRC Press.
2. I.C. Shaw and J. Chedwick. (2004), Principles of Environmental Toxicology, Boca Raton, FL, Taylor and Francis.
3. Zakrzewski S.F (2002), Environmental Toxicology. 3rd Edition. New York, Oxford Univeristy Press.

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EES 5107 PRACTICAL III – ENVIRONMENTAL TECHNIQUES

Course Code	EES 5107	Semester	I
Course Title	*PRACTICAL III – ENVIRONMENTAL TECHNIQUES*		
Credits	1	Type	Core

Course Description

The course provides hands-on training in key analytical methods, data interpretation, researching literature, and scientific reporting of results.

Course Outcome

By the end of the course, students are expected to be able to:

- Practically perform environmental sampling and analyse using appropriate techniques.

Course Structure

The following is a detailed syllabus.

1. Methods of sampling – water, air, soil/sediment
2. Determination of Calcium and Magnesium ions by EDTA Titration
3. Separation of DNA by Gel Electrophoresis.
4. Separation Techniques by Paper chromatography.
5. Elemental Analysis by ICP-MS.
6. Spectrophotometric determination of selective trace elements.
7. Determination of sodium and potassium by flame photometry.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Miroslav Radojevic and Vladimir N. Bashkin (1999), Practical Environmental Analysis, The Royal Society of Chemistry, Cambridge.

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EES 5208 Environmental Microbiology and Biotechnology

Course Code	EES 5208	Semester	II
Course Title	*Environmental Microbiology and Biotechnology*		
Credits	3	Type	Core

Course Description

The course covers the basic concepts of environmental microbiology, microbial ecology, and the applied aspects of environmental biotechnology and industrial microbiology. The course presents an insight into the diverse roles, functions and applications of microbes.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain insight into the basics of microbiology.
- Apply the diverse uses and roles of microbes in their further study.
- Gain experience in environmental biotechnology and industrial applications for future prospects.

Course Structure

The following is a detailed syllabus.

UNIT I: Fundamentals of Environmental Microbiology

Introduction - autotrophy and heterotrophy, Microbial growth and factors affecting microbial growth, cultivation of microorganisms. Aeromicrobiology –sampling techniques, airborne diseases and allergies. Aquatic microbiology –sampling techniques, eutrophication, water borne pathogens and diseases. Soil microbiology – microbes of rhizosphere. Extremophiles.

UNIT II: Microbial Ecology

Microbial diversity – culturable and non-culturable microorganisms; methods for measuring microbial diversity; habitat relations; microbial interactions (i.e., antibiosis, fungi stasis, exploitation and lysis). Value of microbial diversity- microbial role in biogeochemical cycles, Use of microbes in environmental pollution and management, Use of microbes in wastewater treatment, indicator microorganisms.

UNIT III: Environmental Biotechnology

Microbial remediation - composting, biostimulation, bioaugmentation, bioreactor, bioleaching, bioventing. Biodegradation of xenobiotics. Bioremediation of heavy metals and radio-active wastes. Microbe mediated bioconversion. Role of genetically engineered microbes in pollution control, Biofilms and microbial mats, biofouling and corrosion.

UNIT IV: Industrial Biotechnology

Bioenergy - definition, first generation biofuels- bioethanol, biodiesel, second generation biofuels – lingo-cellulosic biofuels; third generation biofuels- algae biofuels, fourth-generation biofuels. Biohydrometallurgy and biomineralization; role of microbes in

fermentation process in environmental cleanup; Biofertilizers and biopesticides, Biosensors and their application in environmental monitoring.

Testing & Evaluation

- Seminar
- Assignment
- Written Exam

References

1. Eweis J. B., Ergas S. J., Chang D. P. Y., Schrodwer E. D. (1998). Bioremediation Principles. New York, Mc Graw Hill.
2. Fulekar M. H. (2010). Environmental Microbiology. New York, Taylor & Francis.
3. Koukkou A. I. (2011). Microbial Bioremediation of Non-metals: Current Research. Haverhill, U K, Caister Academic Press.
4. Lederberg J. (1992). Encyclopedia of Microbiology, New York: Academic Press.
5. Maier R. M., Pepper I. L., Gerba C. P. (2006). Environmental Microbiology. San Diego, Elsevier Academic Press.
6. Passman F. J. (2003). Fuel and Fuel System Microbiology: Fundamentals, Diagnosis and Contamination Control. West Conshohocken, ASTM International.
7. Prescott L. M., Hareley J. P. Klein D. A. (2005). Microbiology (6th Edition). New York, McGraw-Hill Publishing Co. Ltd.
8. Sangeetha J, Thangadurai D, David M, Abdullah M. A. (2016). Environmental Biotechnology: Biodegradation, Bioremediation and Bioconversion of Xenobiotics for Sustainable Development, Boca Raton, Florida, USA, CRC Press.
9. Sen K., Ashbolt N. J. (2011). Environmental Microbiology: Current Technology and Water Applications. Norfolk, UK, Caister Academic Press.

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EES 5209 Environmental Pollution and Control

Course Code	EES 5209	Semester	II
Course Title	*Environmental Pollution and Control*		
Credits	3	Type	Core

Course Description

The modules under this course have been designed to improve the familiarity of the students about different pollution problems and the control strategies in three environmental compartments i.e. air, water and soil. Issues related to noise pollution and their impact on environment and health are dealt with.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the various pollution sources in environment
- Get a clear idea regarding pollution its various effects on humans as well as ecosystem which will make them careful in future.
- Analytical ability to link cause and effect of pollution
- Critical issues of handling pollution vis a vis human beings
- Ability to develop pollution mitigation/abatement strategies

Course Structure

The following is a detailed syllabus.

UNIT I: Air Pollution and Control

Structure and chemistry of atmosphere, Composition of elements in the atmosphere; Temperature inversion, Atmospheric lapse rate, Adiabatic lapse rate. Types and Chemistry of atmospheric pollutants: Photochemical smog-origin and occurrence, Ozone chemistry: Ozone layer, Chemistry of Ozone layer, Ozone depletion, Mitigation of ozone depletion, Montreal protocol; Acid rain- chemical reactions and its ecological effects; Greenhouse effect and global warming, Paris agreement; Effects of air pollutants on plants and animals; Treatment methods, Air quality standards. Air Act, 1981.

UNIT II: Water Pollution and Control

Composition of pure water; Physical and Chemical properties of water. Chemical reactions and equilibria in water; Natural, organic and inorganic components in water - Concepts of DO, BOD and COD; Sources of water pollution; Types of water pollutants and standard limits; Effects of water pollution on plants and animals; Treatment Methods, Water quality standards. Water Act, 1974.

UNIT III: Soil Pollution and Control

Weathering and paedogenesis; Factors affecting soil formation, Development of soil profile; Structure of Soil; Physico-chemical characteristics of soil; Ion-exchange and adsorption processes in the soil; Classification of soil, Fate of chemicals in the soil; sources of soil pollution; Effects of soil pollution on microbes, plants and animals. Control methods.

UNIT IV: Noise, Thermal, Radioactive Pollution and emerging micro and nano pollution and Control

Sources of noise pollution: indoor and outdoor noise pollution; Effects of noise pollution; Thermal and nuclear power plants as sources of thermal pollution. Effects of thermal pollution on aquatic flora and fauna; Control measures of thermal pollution; Sources of marine pollution; Pollution status of coastal and ocean waters; Radioactive pollution: types and sources, half-life period, natural radiation. Control strategies for Noise, Thermal and radioactive Pollution. Source, effect, control strategies of plastic, oil and emerging micro and nano pollutants

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. A. K. De (2001). Environmental Chemistry, New Age International Publishers, New Delhi.
2. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
3. Dara S. S, (1998). A Text Book of Environmental Chemistry and Pollution Control, S. Chand & Company Ltd, New Delhi
4. F. W. Fifield (2000). Environmental Analytical Chemistry. 2nd edition, Blackwell Publishers.
5. Howard S Peavy (2003). Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
6. Julian E Andrews et al., (2004). An Introduction to Environmental Chemistry, Blackwell Publishing.
7. Sawyer C.N., Mc Carty P. L., and Parkin, G. F (2003). Chemistry for Environmental Engineering and Science, Tata McGraw-Hill Publishing Company Ltd., New Delhi.
8. S. E. Manahan (2009). Fundamentals of Environmental Chemistry, CRC Press, USA.
9. Stanley E. Manahan (2010). Environmental Chemistry, 9th Edition, CRC Press, London.

Programme: M.Sc. Environmental Science

EES 5210 Waste Management

Course Code	EES 5210	Semester	II
Course Title	*Waste Management*		
Credits	3	Type	Core

Course Description

The course highlights the various waste management strategies and technologies in all waste categories. The course deals with waste generation, collection, transportation, processing, and disposal. The course explores existing and sustainable processes, and provides basic knowledge on waste audit and relevant laws.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate a thorough understanding of the waste management sector, issues at global, regional and local scales.
- Illustrate all the steps involved in waste management, and technologies and strategies involved thereof.
- Discriminate the various waste categories and their respective potential for treatment.
- Analyze and integrate various technological options, and conceptualize a management solution for particular waste characteristics.

Course Structure

The following is a detailed syllabus.

UNIT I: Sources, Classification and Regulatory Framework

Types and Sources of solid and hazardous wastes - Need for solid and hazardous waste management – Elements of integrated waste management and roles of stakeholders - Salient features of Indian legislations on management and handling of municipal solid wastes, hazardous wastes, biomedical wastes, lead acid batteries, electronic wastes, plastics and fly ash – Financing waste management.

UNIT II: Municipal Solid Waste Management

Waste generation rates and variation - Composition, physical, chemical and biological properties of solid wastes – Hazardous Characteristics – TCLP tests – waste sampling and characterization plan - Source reduction of wastes –Waste exchange - Extended producer responsibility - Recycling and reuse Practical: Composition of MSW, Determination of Physical and Chemical Properties of MSW

UNIT III: Storage, Collection and Transport of Wastes

Handling and segregation of wastes at source – storage and collection of municipal solid wastes – Analysis of Collection systems - Need for transfer and transport – Transfer stations Optimizing waste allocation– compatibility, storage, labeling and handling of hazardous wastes –hazardous waste manifests and transport

UNIT IV: Waste Processing Technologies and Their Disposal

Objectives of waste processing – material separation and processing technologies – biological &chemical conversion technologies – methods and controls of Composting - thermal conversion technologies, energy recovery – incineration – solidification & stabilization of hazardous wastes- treatment of biomedical wastes, Waste disposal options – Disposal in landfills - Landfill Classification, types and methods – site selection - design and operation of sanitary landfills, secure landfills and landfill bioreactors – leachate and landfill gas management – landfill closure and environmental monitoring – Rehabilitation of open dumps – landfill remediation

Testing & Evaluation

- Mini projects, group discussions, seminars, assignments, characterization of unknown wastes, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

1. David H.F. Liu, Bela G. Liptak (1999). Hazardous Waste and Solid, CRC Press
2. Kanti L. Shah(1999). Basics of Solid and Hazardous Waste Management Technology, Prentice hall
3. Lawrence K. Wang, Yung-Tse Hung, Howard H. Lo and Constantine Yapijakis (1992). Handbook of Industrial and hazardous waste treatment, Marcel Dekker, Inc, Basel, New York
4. Michael D. LaGrega, Philip L.Buckingham, Jeffrey C.Evans (2001). Hazardous waste management, Waveland Press, Inc, Long Grove, USA
5. Riser-Roberts, E., (1998). Remediation of Petroleum Contaminated Soils - Biological, Physical and Chemical processes, Lewis Publisher, New York.
6. RusselBoulding, J (1995). Vadose-Zone and Ground Water Contamination - Assessment, Prevention and Remediation, Lewis Publishers, Tokyo.
7. Solid Waste Technology & Management, Thomas H. Christensen (2011). A John Wiley and Sons, Ltd. Publication, UK.
8. Tandon (1995). Recycling of Crop, Animal and Human Waste in Agriculture, Mc Graw Hill Publishing Co.

Programme: M.Sc. Environmental Science

EES 5211 EIA and Environmental Auditing

Course Code	EES 5211	Semester	II
Course Title	*EIA and Environmental Auditing*		
Credits	3	Type	Core

Course Description

This course examines principles, procedures, methods, and applications of environmental impact assessment. The goal of the course is to promote an understanding of how environmental impact assessment is conducted and used as a valuable tool in the engineering project management decision-making process. Also to understand the importance of auditing for the effective resource management.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the concept, historical context and wider importance of
- Be familiar with EIA legislation.
- Know the key steps in the EIA process.
- Understand the importance of Social Impact Assessments and public participation in the EIA process.
- Gain an overview of methods and instruments that are commonly used to develop an EIA.
- Understand the auditing process for the conservation of natural resources.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT I: Importance of EIA

History and objectives – Basis for Environment Impact Assessment, Environmental Protection Act, 1986. EIA Notification 1994 and 2006, Approach to EIA studies – mandatory requirements, project screening, scoping, environmental baselines, Public Participation best practices; terms of reference (ToR); Phases of EIA – Identification, Prediction, Evaluation, Decision making and Post Impact Monitoring, Major limitations of Environmental Impact Assessment.

UNIT II: Methodologies

Impact identification methods – Adhoc Methods – Checklist Methods – Matrix Methods – Network Methods, Overlays, Leopold matrix, Batelle's Environmental Evaluation System (BEES), Cost-Benefit Analysis.

UNIT III: Assessment Procedure

Prediction and Assessment of Impacts on natural Resources – Biota, Surface Water, Ground Water, Air, Noise, Hazards, Historic and Cultural Resources, Transportation, Socio-economic relationships.

Case Studies: Land Clearing Projects – Dam sites – EIA for Aquaculture, Steel, Mines, Hydel, Thermal, Nuclear, Oil and Gas based Power Plants – Highways projects – Industrial Projects.

UNITI IV: Environmental Auditing

Definition of Environment Audit and its importance for industries, Factories Act. Types of Audit and Definitions. Life Cycle Assessment, Environmental audit: Pre-Post audit process; International organization for standardization (ISO), ISO 14000 standards and certification, Environmental Management System (EMS), Eco labelling.

Testing & Evaluation (if any)

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Bregman, J. I., (1999). Environmental Impact Statements, Lewis Publishers, London.
2. Canter, L.W., (1996). Environmental Impact Assessment, Mc Graw Hill, New York.
3. Eccleston, C. H., (2000). Effective Environmental Assessment, Lewis Publishers, London.
4. Eccleston, C.H., (2000). Environmental Impact Assessment- A Comprehensive Guide to Project and Strategic Planning, John Wiley and Sons.
5. M. E. Jensen and P. S. Bourgeron (2001). A guide book for Integrated Ecological Assessments Springer-Verlag, New York, Inc.

Programme: M.Sc. Environmental Science

EES 5212 Natural Resources Management

Course Code	EES 5212	Semester	II
Course Title	Natural Resources Management		
Credits	3	Type	Core

Course Description

This course focuses on the need of sustainable management of the Earth's depleting natural resources such as clean water, energy, minerals and biological resources, in relation to the growth of the human population.

During the programme, students develop a good scientific understanding of how the earth's natural systems work and new approaches to balancing the needs of society.

Course Outcome

By the end of the course, students are expected to be able to:

- Appreciate the role of natural resources in the sustenance of life on earth.
- Explain and discuss the distribution of different natural resources and their sustainable management.
- Develop Skills in recognising and solving environmental and social impacts of resource depletion.
- Enhance the knowledge base and skill sets.
- Be an active and lifelong learner and develop strategies to do so.
- Be innovative by generating new ideas, artefacts, products, interpretations or ways of viewing professional projects and tasks.

Course Structure

The following is a detailed syllabus.

UNIT-I Introduction

Concept of resource, classification of natural resources-renewable and non-renewable resources. Factors influencing resource availability, distribution and uses. Interrelationships among different types of natural resources. ecological economics of provisioning, regulating and cultural ecosystem services as well as theories and concepts in political ecology and critical human approaches. Sustainable use and management of natural resources in a professional role, such as that of policymakers, trainers or practioners in government agencies, private firms or NGOs.

UNIT-II Forest Resources

Forest vegetation, status and distribution, contribution as resource. Use and over-exploitation, deforestation. Timber extraction, mining, dams and their effects on forest and tribal people, Forest products.

UNIT-III Soil and Water Resources

Soil resource, Soil fertility management, Waste Land-National scenario, waste land management through social forestry programme.

Water resources: Sources and utilization, water demand, conflicts over water, conservation of water, dams-benefits and problems, interlinking of river.

UNIT-IV Mineral Resources

Mineral wealth of our planet, non-renewable nature of mineral deposits, the inexhaustible nature of mineral elements, Classification of Minerals, Minerals of India. Economic importance of minerals. Management of Mineral resource, use and exploitation of mineral resources, environmental effects of extracting and using mineral resources. Remedial measures.

Sources of energy and their classification; Energy forms and transformation. Fossil fuel, Solar Energy, Bio energy, Nuclear Energy, Hydro Energy, Wind and Thermal Energy.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Francois Ramade (1984). Ecology of Natural Resources. John Wiley & Sons Ltd.
2. Odum, E.P. (1971). Fundamentals of Ecology. W.B. Saunders Co. USA, 574p
3. Cunningham, W.P. Cooper, T.H. Gorhani, E & Hepworth, M.T. (2001). Environmental Encyclopedia, Jaico Publishing House.
4. Cunningham, W.P., Cunningham, M.A. & Saigo, B. (2004). Environmental Science, a Global Concern. (8th edition). McGraw-Hill (Boston)
5. Heywood, V.H. and Watson, R.T. (1995). Global Biodiversity Assessment. Cambridge Univ. Press.
6. Miller T.G. Jr. Environmental Science, Wadsworth Publishing Co. (TB)
7. Townsend C., Harper J, and Michael Begon. Essentials of Ecology, Blackwell Science.
8. Wright, R.T. (2005). Environmental Science - toward a Sustainable Future. (9th International Edition), Pearson Education International, Prentice Hall Publishers.

Programme: M.Sc. Environmental Science

EES 5213 PRACTICAL IV - ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

Course Code	EES 5213	Semester	II
Course Title	*PRACTICAL IV - ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY*		
Credits	1	Type	Core

Course Description

The practicals in this course fall into an array of techniques used in a basic microbiology laboratory.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain insight into the basics of microbiology from practical aspects.

Course Structure

The following is a detailed syllabus.

1. Inoculation techniques and culture techniques: Pour plate by dilution, streak plate, broth cultures.
2. Gram staining techniques.
3. Sampling, isolation and enumeration of airborne microorganisms.
4. Sampling, isolation and enumeration of microorganisms in soil samples.
5. Assessment of Water Quality by Membrane Filter, Total Coliform, E. coli, Feacal Coliform.
6. MPN technique for coliform analysis.
7. Isolation of DNA from Bacteria.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Green, L.H., Goldman, E. 2021. Practical Handbook of Microbiology, CRC Press, 4th edition.

Programme: M.Sc. Environmental Science

EES 5214 PRACTICAL V - ENVIRONMENTAL POLLUTION

Course Code	EES 5214	Semester	II
Course Title	*PRACTICAL V - ENVIRONMENTAL POLLUTION*		
Credits	1	Type	Core

Course Description

The practical course will train the students to analyse and quantify the pollution parameters from water, air and soil. Help to identify and interpret the results on quality of the water and air environment.

Course Outcome

By the end of the course, students are expected to be able to:

- Analyse the water quality parameters.
- Analyse the air quality parameters.

Course Structure

The following is a detailed syllabus.

1. Determination of pH and Conductivity of different water and soil samples.
2. Determination of total dissolved solids in water samples.
3. Determination of Carbonates and Bicarbonates in water samples.
4. Determination of Chloride in water sample by $AgNO_3$ method.
5. Determination of Total alkalinity of different water samples.
6. Determination of DO in water sample modified Winkler's method.
7. Determination of BOD/COD in water samples.
8. Determination of SO_2 by PRA method.
9. Determination NO_x by spectrophotometric method.
10. Measurement of noise level in different environments by sound level meter (SLM).
11. Determination of particulate matters PM_{10} and $PM_{2.5}$

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Andrew D. Eaton, Lenore S. Glesceri, Eugene W. Rice and Arnold E. Greenberg (Eds) (2005). Standards Methods for the Examination of Water and Wastewater Analysis. 21st Edition, APHA, Washington DC.
2. Dara S. S, (1998). A Text Book of Environmental Chemistry and Pollution Control, S. Chand & Company Ltd, New Delhi

Programme: M.Sc. Environmental Science

EES 5215 PRACTICAL VI - WASTE MANAGEMENT

Course Code	EES 5215	Semester	II
Course Title	*PRACTICAL VI - WASTE MANAGEMENT*		
Credits	1	Type	Core

Course Description

The practical course highlights the various waste management strategies and technologies in all waste categories.

Course Outcome

By the end of the course, students are expected to be able to:

- Quantify and perform qualitative analysis of different categories of waste.
- Analyze and integrate various technological options, and conceptualize a management solution for particular waste characteristics.

Course Structure

The following is a detailed syllabus.

1. Characterization of solid waste from different sources.
2. Vermi-Composting technology - Analysis
3. Designing of secured/sanitary landfills.
4. To study of methods of management of biomedical waste.
5. Determination of organic carbon in compost.
6. Determination of inorganic phosphate in leachate samples.
7. Determination of total nitrogen in leachate samples.
8. Determination of TSS/TDS in leachate samples

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Kanti L. Shah(1999). Basics of Solid and Hazardous Waste Management Technology, Prentice hall

Programme: M.Sc. Environmental Science

EES 5316 Biodiversity and Conservation

Course Code	EES 5316	Semester	3
Course Title	*Biodiversity and Conservation*		
Credits	3	Type	Core

Course Description

This course focuses the biodiversity concepts, values, threats to biodiversity, issues involved, and the concepts of conservation. It gives an insight into important organizations and programmes involved like IUCN, MAB programme, CBD. The different laws connected with both biodiversity and conservation are given emphasis.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain understanding into the concepts of measuring biodiversity.
- Understand the importance of biodiversity in their life.
- Follow the activities of CBD and MAB in a more scientific manner.
- Understand the various conservation strategies being undertaken
- Follow the laws connected with biodiversity and conservation.

Course Structure

The following is a detailed syllabus.

UNIT-I: Introduction

Biodiversity – Definition; Genetic diversity, Species diversity and ecosystem diversity; alpha, beta, and Gamma diversity; Latitudinal and altitudinal gradients of biodiversity; Methods of measuring biodiversity; values of Biodiversity – Direct and indirect use values, consumptive use value, productive use value, optional value, social value. Endemism, significance of the endemism; Hotspots of Biodiversity.

UNIT-II: Threats to Biodiversity

Global estimates of species loss. Threats to biodiversity: habitat loss, habitat fragmentation, deforestation, invasive species, over exploitation, pollution and climate change, Man- Wildlife conflicts. Ecological consequences of reduction in biodiversity. Red data book and IUCN categories- criteria for categorization. Threatened species. Keystone species. Brief account of endangered flora and fauna of India.

UNIT III: Conservation of Biodiversity: Approaches and Strategies

Historical perspective of conservation, Importance of conservation, Conservation and sustainable development, Role of CBD and MAB, Ecosystem people and traditional conservation mechanisms, In situ conservation: Biosphere reserves, National parks, Wild life sanctuaries, Protected area management. Ex situ conservation: Botanical gardens, Zoological parks, Herbaria, cryopreservation, seed banks, gene banks.

UNIT IV: Conservation Policies and Law

The Biological Diversity Act, 2002. Biological Diversity Rules, 2003. Intellectual Property Rights (IPR), TRIPS, Indigenous Knowledge Systems, The protection of plant varieties and farmer's rights (PVPFR) Act, 2001, 2007. Forest (conservation) Act, 1980 and its amendments. Wildlife Protection Act. National Green Tribunal Act 2010. National and International conservation policies and conservation challenges.

Testing & Evaluation

- Seminar
- Assignment
- Written Exam

References

1. Dadhich L. K. and A. P. Sharma (2002). Biodiversity-Strategies for Conservation, APH publishing corp. New Delhi,
2. Khan. T. I and Dhari, N (1999). Global Biodiversity Conservation measures –Al-Ajmi Pointer Publishers, Jaipur.
3. Krishnamurthy K. V (2003). An Advanced Text book on Biodiversity – Principles and Practice – Oxford and IBH publishing, New Delhi.
4. Chiras D. D and Reganold J. P. (2011). Natural Resource Conservation: Management for a sustainable future, 10/E Prentice Hall.
5. Gaston K. J. and Spicer J. (2004). Biodiversity an introduction. Blackwell Publications, UK
6. Krishnamurthy K. V. (2003). Advanced text book on Biodiversity. Oxford & IBH, New Delhi
7. Maiti P. K. and Maiti P. (2011). Biodiversity- Perception, Peril and Preservation. PHI Learning. New Delhi.

Programme: M.Sc. Environmental Science

EES 5317 Environmental Engineering

Course Code	EES 5317	Semester	III
Course Title	*Environmental Engineering*		
Credits	3	Type	Core

Course Description

The goal of environmental engineering is to ensure that societal development and the use of water, land and air resources are sustainable. This goal is achieved by managing these resources so that environmental pollution and degradation is minimized.

Course Outcome

By the end of the course, students are expected to be able to:

- Plan and of water distribution systems.
- Plan, design, and operation of water and wastewater treatment facilities in municipalities and industries.
- plan to dispose and reuse of wastewaters and sludges,
- Plan and design the air pollution control systems.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT – I: Hydraulics

Hydraulics – Pressure- Hydrostatic Pressure, Pressure Head, Measurement of Pressure, Static Head, Flow, Friction Head, Velocity Head, Design of Pressure Pipes – Darcy Weisbach Formula, Manning's Formula, Hazen William's Formula – limiting velocities, Minimum and Maximum Test Pressure and Working Pressure in pipes – selection of pipe material – Pump types, Horse power, Characteristic Curves – selection and determination of capacity.

UNIT – II: Designing of Water and Wastewater Treatment Plant

Water Quality, water demand, Stages of water treatment, Screening, Flash Mixer – Design – Clariflocculator – parameters for design – Filtration - Rapid sand filter and Pressure filter; Disinfection – chlorination process, chlorine demand, and residual chlorine, Ozonation, UV process. Physical and Chemical Unit Operations and Applications, Design Parameters and Design of Primary and Secondary Settling Tanks – Activated Sludge – Design of Aeration Tanks– Diffusers and Mechanical Aerators. Design criteria for Trickling Filters.

UNIT – III: Sludge Processing and Disposal Methods

Sludge Processing and Disposal Methods- Sludge thickening, Sludge stabilization, Sludge dewatering, Design of Anaerobic Digester and Sludge Drying Bed – Reverse Osmosis – Ion Exchange; Incinerators and Multiple Evaporators.

UNIT – IV: Air Pollution Control Design

Minimum Stack Height – Plume Rise, Ground Level Concentration of Pollutants. Design of Settling Chamber, Cyclones, Fabric filters and Electrostatic Precipitators. Wet Scrubber. Case studies: Distillery, Dyeing, Electroplating, Paper and Pulp, Steel, Tannery - Industrial Effluent Treatments.

Testing & Evaluation

- Class room assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Environmental Engineering: A Design Approach, Sincero A. P and Sincero G. A. (1999). Prentice-Hall of India Pvt. Ltd., New Delhi.
2. Gilbert M. Masters (2004). Introduction to Environmental Engineering and Science, Prentice-Hall of lndia Pvt. Ltd., New Delhi.
3. Howard S Peavy (2003). Environmental Engineering, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
4. Frank R. Spellman, (2003). Handbook of Water and Wastewater Treatment Plant Operations, Lewis Publishers, London.
5. Metcalf and Eddy (2003). Wastewater Engineering: Treatment and Reuse, Tata Mc Graw Hill Publishing Company Ltd., New Delhi.
6. Hammer M.J. and Hammer Jr M. J. (2001). Water and Wastewater Technology, Prentice Hall of lndia Pvt. Ltd., New Delhi.

Programme: M.Sc. Environmental Science

EES 5318 Research Methodology and Statistical Analysis

Course Code	EES 5318	Semester	III
Course Title	*Research Methodology and Statistical Analysis*		
Credits	3	Type	Core

Course Description

The course deals with the theory of statistical analysis, and study of various scientific methods and processes involved for performing sound research. The course offers students basic and advanced understanding of scientific research through real-time research problems, statistical data, and so forth. The course imparts students with scientific inquiry, temper, vigour and research ethics.

Course Outcome

By the end of the course, students are expected to be able to:

- Develop strong scientific temperament, vigour and research ethics
- Illustrate the basic steps in research by analyzing research publications
- Execute specific hypotheses by developing sampling, experimental and research plan on their own
- Profound understanding of advanced statistical concepts, calculations, and relevant, available softwares

Course Structure

The following is a detailed syllabus.

UNIT – I: Research Documentation and Ethics

Scientific documentation, literature collection, hypothesis, design, planning and execution of investigation, Preparation of scientific documents, general articles, research papers, review articles, editing of research papers, methods of citation and thesis writing. Stakeholders in research, Publication and research industry, Publication process; Ethics in Environmental Research; Plagiarism and its consequences; Good laboratory practice and Laboratory safety.

UNIT II: Descriptive statistics

Fundamentals of Statistics– Collection of Data – Classification and Tabulation- Diagrammatic Representation – Measures of Central Tendencies and Dispersion – Moments, Skewness and Kurtosis – Normal, Poisson and Binomial Distributions.

UNIT III: Standard distributions

Tests of Significance – Mass and alternative hypothesis – error level of significance – Equal and Unequal Sampling – f, t, z, Chi-square test, Analysis of variance – One-way ANOVA – Two-way ANOVA – Regression and correlation - simple and multiple. Cluster analysis – PCA, Graph Plotting.

UNIT – IV: Environmental Models

Lotka – Volterra Model, Leslie's Matrix Model – Point Source Stream Pollution Model – Air Quality Model. Thermal Plume and Dispersion models. Decision Support Systems – Data Analysis using packages (SPSS, Systat, Matlab Simulink).

Testing & Evaluation

- Data analysis, research designs for real-time research questions, seminars, written examinations (Continuous Assessment)
- Written examination for theory and practical component (End Semester Assessment)

References

1. Bliss, G.I. (1970). Statistics in Biology. Mc Graw Hill Book Company, Vol. I and II. New Delhi.
2. Vittal, R.R. (1986). Business Mathematics and Statistics, Murgham Publications.
3. Haynes, R (1982). Environmental Science Methods, Chapman & Hall, London.
4. Khan, I.A and Kanum, A., (1994). Fundamentals of Bio-Statistics, Ukaaz Publication, Hyderabad.
5. Gupta, S. P. (1996). Statistical Methods, Sultan Chand & Sons Publications, New Delhi.
6. Byron S Gottfried (1996). Programming with C, Hill Publishing Co, New Delhi.
7. Wardlaw, A.C. (1985). Practical Statistics for Experimental Biologists. Wiley Chichester.
8. Kothari, C.R (1996). Quantitative Techniques, Vikas Publishing Housing Pvt Ltd, Hyderabad
9. Miller, J, (1989). Statistics for Advanced Level, Cambridge University Press

Programme: M.Sc. Environmental Science

EES 5319 Disaster Management

Course Code	EES 5319	Semester	III
Course Title	*Disaster Management*		
Credits	3	Type	Core

Course Description

Disaster Management modules described offer theoretical and practical management skills in preparation, response and recovery from natural and man-made disasters

Course Outcome

By the end of the course, students are expected to be able to:

- Get a basic understanding about disasters and how to deal with disasters.
- Gain basic conceptual understanding of disasters and its relationships with development.
- Understand the approaches of Disaster Risk Reduction (DRR) and the relationship between vulnerability, disasters, disaster prevention and risk reduction.
- Understand Medical and Psycho-Social Response to Disasters.
- Prevent and control Public Health consequences of Disasters
- Enhance awareness of Disaster Risk Management institutional processes in India
- Build skills to respond to disasters.

This course is modelled towards employability, entrepreneurship and skill development.

This is a value added course.

Course Structure

The following is a detailed syllabus.

UNIT I: Introduction on Disaster

Natural Disaster: such as Flood, Cyclone, Earthquakes, Landslides etc., Man-made Disaster: such as Fire, Industrial Pollution, Nuclear Disaster, Biological Disasters, Accidents (Air, Sea, Rail & Road), Structural failures(Building and Bridge), War & Terrorism etc. Causes, effects and practical examples for all disasters.

UNIT II: Risk and Vulnerability Analysis

Risk: Its concept and analysis, Risk Reduction, Vulnerability - concept and analysis, Strategic Development for Vulnerability Reduction.

UNIT III: Disaster Preparedness and Response Preparedness

Disaster Preparedness: Concept and Nature, Disaster Preparedness Plan, Prediction, Early Warnings and Safety Measures of Disaster. Role of Information, Education, Communication, and Training, Role of Government, International and NGO Bodies. Role of IT in Disaster Preparedness, Role of Engineers on Disaster Management.

Disaster Response: Introduction Disaster Response Plan, Communication, Participation, and Activation of Emergency Preparedness Plan, Search, Rescue, Evacuation and Logistic Management, Role of Government, International and NGO Bodies Psychological Response

and Management (Trauma, Stress, Rumor and Panic), Relief and Recovery, Medical Health Response to Different Disasters.

UNIT IV: Rehabilitation, Reconstruction and Recovery

Reconstruction and Rehabilitation as a Means of Development. Damage Assessment, Post Disaster effects and Remedial Measures. Creation of Long-term Job Opportunities and Livelihood Options, Disaster Resistant House Construction, Sanitation and Hygiene, Education and Awareness, Dealing with Victims' Psychology, Long-term Counter Disaster Planning, Role of Educational Institute.

Preamble – Expected outcome and goal - Guiding principles, Priorities for action.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

1. Bryant Edwards (2005). Natural Hazards, Cambridge University Press, U.K.
2. Carter, N W. ((1992). Disaster Management: A disaster Manager's Handbook, Asian Development Bank, Manila.
3. Disaster Planning: The Preservation of Life and Property, Harold D. Foster (1980). Springer Verlay, New York.
4. Disaster Management, Shailendra K Singh, Subash C. Kundu and Shobu Singh (1998). Mittal Publications, New Delhi.
5. Gautam Ashutosh. (1994). Earthquake: A Natural Disaster. Ashok Publishing House. New Delhi.
6. Natural Disasters – A Guide for Relief Workers, (1980). JAC Adhyatma Sadhna Kendra-Mehrauli, New Delhi.
7. Roy, P.S. (2000). Space Technology for Disaster management: A Remote Sensing & GIS Perspective, Indian Institute of Remote Sensing (NRSA), Dehradun.
8. Sharma, R.K. & Sharma, G. (2005). (ed) Natural Disaster, APH Publishing Corporation, New Delhi.
9. Singh D K. (2006). Towards Basics of Natural Disaster Reduction, Research book Centre, New Delhi,
10. Singh T. (2006), Disaster Management approaches and strategies, Akansha Publishing House, New Delhi.

Programme: M.Sc. Environmental Science

EES 5320 PRACTICAL VII - BIODIVERSITY AND CONSERVATION

Course Code	EES 5320	Semester	III
Course Title	PRACTICAL VII - BIODIVERSITY AND CONSERVATION		
Credits	1	Type	Core

Course Description

The course provides practical knowledge of measuring biodiversity. An account of the endangered species of India is also provided.

Course Outcome

By the end of the course, students are expected to be able to:

- Gain practical skills to measure biodiversity
- Understand the status of endangered species in India

Course Structure

The following is a detailed syllabus.

1. Determination of species density using quadrat method.
2. Determination of abundance of species in a given area.
3. Determination of frequency and relative frequency of species in a given area.
4. Determination of diversity indices – Shanaon wiener, Simpson Index, IVI.
5. Identification of endangered flora and fauna of India.
6. Flora and fauna of biodiversity hotspots of India.

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Henderson, P.A. 2003. Practical methods in Ecology, Blackwell Publishing, USA

Programme: M.Sc. Environmental Science

EES 5321 PRACTICAL VIII - ENVIRONMENTAL ENGINEERING

Course Code	EES 5321	Semester	III
Course Title	*PRACTICAL VIII - ENVIRONMENTAL ENGINEERING*		
Credits	1	Type	Core

Course Description

This course provides the practical on hand experiences on calculation, design and identification of treatment processes.

Course Outcome

By the end of the course, students are expected to be able to:

- Design the treatment processes
- Solve the problems related to treatment processes

Course Structure

The following is a detailed syllabus.

1. Calculation of Hydrostatic Pressure, flow rate
2. Calculation of Horse power and Pumping
3. Calculation and optimization of coagulant using Jar test apparatus
4. Calculation and designing of Sedimentation Tank
5. Calculation and designing of Activated Sludge Processes
6. Calculation and designing of Trickling Filter
7. Calculation and designing of Disinfection Process
8. Calculation and designing of sludge drying beds, windrow
9. Calculation and designing of minimum stack height
10. Calculation and designing of Cyclone, Electrostatic Precipitator

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Jerry A. Nathanson, 2002. Basic Environmental technology, Prentice Hall of India Publications, India
2. Krikpatrick, 1977. Advanced Mathematics for water and wastewater treatment plant operators, Ann Arbor Science Publishers, Inc, USA

Programme: M.Sc. Environmental Science

EES 5322 PRACTICAL IX - STATISTICAL ANALYSIS

Course Code	EES 5322	Semester	III
Course Title	*PRACTICAL IX - STATISTICAL ANALYSIS*		
Credits	1	Type	Core

Course Description

Course Outcome

By the end of the course, students are expected to be able to:

- Collect, analyze, visualize and interpret data for environmental research

Course Structure

The following is a detailed syllabus.

1. Collection of Data: Primary data – Secondary data – Classification and Tabulation – Diagrammatic Representation
2. Mean, median, mode, Standard Deviations, Errors.
3. Data Analysis using software: SPSS, Systat and Excel stat: Editing,
4. Data Tabulation Analysis: Descriptive statistics – Correlation – Regression
5. Factor analysis and Cluster analysis
6. Principal Component Analysis (PCA)
7. One-way ANOVA and Two-way ANOVA
8. Graph Plotting with different software's

Testing & Evaluation

- Practical internal and End semester assessment

References

1. Kothari, C.R (1996). Quantitative Techniques, Vikas Publishing Housing Pvt Ltd, Hyderabad.
2. Khan, I.A and Kanum, A., (1994). Fundamentals of Bio-Statistics, Ukaaz Publication, Hyderabad

Programme: M.Sc. Environmental Science

EES 5423 Internship

Course Code	EES 5423	Semester	IV
Course Title	*Internship*		
Credits	3	Type	Core

Course Description

The course provides an opportunity to do the internship at industries, factories, research institutes, NGO's and related field work.

Course Outcome

By the end of the course, students are expected to be able to:

- Get experienced in an industry or factory processes.
- Demonstrate the ability to solve the pollution problem on the environment
- Students will get the feel for the work environment which boost their confidence.

Course Structure

- Students must undergo a minimum 3 weeks either at Industries/factories/Research institutes/ NGOs or the field work.

Testing & Evaluation

- Continuous assessment
- Visit report evaluation
- Viva voce

Programme: M.Sc. Environmental Science

EES 5424 Field / Industrial Visits Report and Viva Voce

Course Code	EES 5424	Semester	IV
Course Title	*Field / Industrial Visits Report and Viva Voce*		
Credits	3	Type	Core

Course Description

The course provides an opportunity to visit different industries, factories, research institutes and nature laden areas.

Course Outcome

By the end of the course, students are expected to be able to:

- Illustrate how a process takes place in an industry or factory.
- Demonstrate the impact of the industrial processes on environment
- Understand the concepts with clarity

Course Structure

The following is a detailed syllabus.

- Field visits to different nature laden areas.
- Visits to research institutes.
- Industrial visits to several factories and industries.

Testing & Evaluation

- Continuous assessment during the visit
- Visit report evaluation
- Viva voce

Programme: M.Sc. Environmental Science

EES 5490 Dissertation/Project Work and Viva Voce

Course Code	EES 5490	Semester	IV
Course Title	*Dissertation/Project Work and Viva Voce*		
Credits	6	Type	Core

Course Description

The course provides an insight into the good research practices and hand-on experience of a specific topic of research.

Course Outcome

By the end of the course, students are expected to be able to:

- demonstrate skills required for carrying out research
- Analyse the data obtained
- Write dissertation
- Present the research findings

Course Structure

The following is a detailed syllabus.

- Carrying out research project work on a specific topic
- Writing a dissertation on the topic of research

Testing & Evaluation

- Continuous assessment of research progress
- Seminars
- Dissertation evaluation
- Viva voce

Programme: M.Sc. Environmental Science

EES 5001 Aquatic Ecology

Course Code	EES 5001	Semester	I & III
Course Title	*Aquatic Ecology*		
Credits	3	Type	Elective

Course Description

The course offers tremendous scope for all biologists for learning the multidisciplinary concepts of these fascinating and important ecosystems. The course delves into the physical, chemical, biological, and environmental aspects of the aquatic ecosystems. It emphasizes through its content the need for conservation of aquatic bodies.

Course Outcome

By the end of the course, students are expected to be able to:

- Advocate strongly the need for aquatic ecosystems, and the services they offer to mankind
- Discriminate between lentic, lotic, wetlands, transitionary zones, and marine ecosystems
- Classify, characterize, analyze and research on various aspects of aquatic ecosystems
- Develop strategies and action plans for conservation of aquatic ecosystems

Course Structure

The following is a detailed syllabus.

Unit I: Water

Nature of Water, Chemical and physical properties, Movement of water, Basic principles of fluid dynamics. Movement of light and heat in water, Diffusion of chemicals. Hydrological cycle, interaction of water with other ecosystems.

Unit II: Aquatic Physiography and Chemistry

Basics of oceanography, Geography and types of aquatic habitats, intermediate habitats – significance. Physiography of marine, lentic and lotic ecosystems, formation, characterization, and flow types. Unique and extreme aquatic habitats. Types of elements and chemicals in water, physical chemistry of chemical transformations, oxygen – photosynthesis and respiration, carbon – forms and transformations. Nutrient cycling – carbon, nitrogen, sulphur, phosphorus, silicon, iron and trace nutrient cycles, and interactions.

Unit III: Aquatic Biology

Types of organisms, major taxonomic groups, classification of organisms by habitat, function and level of interaction. Unicellular and Multicellular organisms in aquatic habitats and their role. Trophic states. Food web, prey and predator interactions.

Complex interactions. Species diversity, measures of diversity, and threat perception. Ecosystem services of key aquatic organisms.

Unit IV: Aquatic Pollution

Global change and its effect on aquatic habitats and vice-versa. Types of pollutants – sources and effect, eutrophication, toxins – natural and artificial, anthropogenic chemicals and metals pollution. Toxicology in aquatic habitats, bioassessment and mitigation measures. Chemical and Biomarkers of pollution. Water and wastewater treatment. Wetland conservation.

Testing & Evaluation

- Classroom discussions, seminars, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

- American Public Health Association, et al. 1996. Standard Methods for Examination of Water and Wastewater (19th Edition). American Public Health Assoc., New York.
- Barnes, R.S.K. and K. H. Mann. (1980). Fundamentals of Aquatic Ecosystems. Blackwell Scientific Publications, Oxford.
- Brönmark, C. and L.-A. Hansson. (1998). The Biology of Lakes and Ponds. Oxford UniversityPress, Oxford.
- Cole, G. A. (1983). A Textbook of Limnology.3rd edition.C.V. Mosby, Co., St Louis.
- Dodds, W. K. and M. R. Whiles (2010). Freshwater Ecology (Second Edition). Academic Press, London.
- Gopal, B. and R. G. Wetzel. 1995. Limnology of Developing Countries. Vol. 1-4. Int. Assoc.Theor. Appl. Limnology.
- Lerman, A., D. M. Imboden, and J. R. Gat, Editors. (1995). Physics and Chemistry of Lakes (2nd.Edition). Springer-Verlag, New York.
- National Research Council. (1992). Restoration of Aquatic Ecosystems. The National Academies Press, Washington, DC.
- Wetzel, R. G. (2001). Limnology: Lake and River Ecosystems. 3rd Edition Academic Press, New York.

Programme: M.Sc. Environmental Science

EES 5002 Current Environmental Issues

Course Code	EES 5002	Semester	
Course Title	*Current Environmental Issues*		
Credits	3	Type	Elective

Course Description

The course provides an investigation of the scientific principles behind global environmental issues. The course focuses on key ecological concepts and the changing relationship of humans with the natural world including the different approaches to understanding and solving environmental problems, from local to global scales. It investigates such issues as human populations and environmental impact; loss of species biodiversity; air, water, and soil pollution; energy use; climate change; and waste management.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the global environment from a geographer's "perspective".
- Examine environmental issues from multiple, and often competing, perspectives.
- Examine environmental issues as "conflicts" between natural and human systems.
- Examine specific issues that include atmospheric issues, aquatic issues, terrestrial issues, biodiversity issues, waste issues, and energy issues.

Course Structure

The following is a detailed syllabus.

UNIT I: Population

Population explosion, Malthusian theory, Population distribution, population unsustainability, population growth, population pyramids, pattern of India population, scale of urbanization, migration trends- rural and urban, Population displacement due to developmental projects. International initiatives on population related issues.

UNIT II: Environmental and human health

Hazardous chemicals, pesticides and their impact, polychlorinated biphenyls (PCBs), Lead, mercury, arsenic, cadmium, asbestos, dioxins. Environment and development, poverty and environmental degradation, water requirement, CommUNITy participation in water conservation, Water harvesting, role of NGOs in environmental protection. Social consequences of development and environmental changes

UNIT III: Global Issues

Acid rain and its effects on ecosystems (flora, fauna and human beings). Ozone layer depletion, causes and consequences of Ozone depletion, CFCs, Montreal Protocol. Climate change, global warming- causes and impact of global warming, International initiatives to control global warming, Kyoto Protocol.

UNIT IV: Natural Resources

Depletion and regeneration of natural resources, Renewable and non-renewable resources, Biotic Resources- Forests, agriculture, fisheries, livestock, biodiversity and its conservation, Abiotic Resources- Surface and ground water, Energy, non-energy mineral resources, land resources, soil erosion, ecosystem services. Sustainable development

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Botkin, Daniel B. and Keller, Edward A. (2007), Environmental Science: Earth as a Living Planet. 6th ed. John Wiley & Sons, USA.
- Cunningham, W. P. and Cunningham, M. A. Principles of Environment Science.
- Enquiry and Applications. 2nd ed. Tata McGraw Hill, New Delhi. 2004.
- Rajagopalan, R. (2008), Environmental Studies: From crisis to cure, Oxford University Press, New Delhi.
- Richards, I. S. (2008), Principles and Practice of Toxicology in Public Health. Jones and Bartlett Publishers, London.
- Singh, J.S., Singh, S.P. and Gupta, S.R. (2006), Ecology, Environment and Resource Conservation. Anamaya Publishers, New Delhi, India.
- UNEP. Global Environment Outlook 3. Geneva: UNEP, Global Resource Information Division. 2003.
- World Commission on Environment and Development (WCED): Our Common Future, Oxford University Press, London. 1987

Programme: M.Sc. Environmental Science

EES 5003 Ecotourism

Course Code	EES 5003	Semester	
Course Title	*Ecotourism*		
Credits	3	Type	Elective

Course Description

The course introduces the importance of incorporating environment friendly practices into the tourism industry. It gives an insight into the sustainable and responsible tourism and also the various alternative tourisms that are developed recently. The course also focuses on the sustainable management of ecotourism projects.

Course Outcome

By the end of the course, students are expected to be able to:

- Develop ecotourism projects
- Have a thorough understanding of the certifications required for the purpose
- Follow sustainable and responsible tourism practices
- Conduct awareness programmes on ecotourism

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT I: Introduction

Ecosystem processes, goods and services with special reference to tourism activities; an overview of Tourism-Environment linkages – 'Intangibility', 'Heterogeneity', 'Perishability' and 'Inseparability' of Tourism and their Ecological, Environmental, social, economic, cultural, ethical implications; impacts of mass tourism, environmental concerns, need for environmental conservation, alternative tourism strategies.

UNIT II: Alternative tourism: typology & strategies

Alternative tourism typology- Ecotourism, Ecocultural Tourism, Heritage Tourism, Adventure Tourism, Health Tourism, Farm Tourism, Urban Eco-tourism, Fishing Tourism- definitions, strategies, potentials and constraints; Responsible tourism, incorporation of pro-poor, community run/based, gender balanced tourism strategies.

UNIT III: Ecotourism and Sustainable development

Evolution and characteristics of ecotourism; Eco-development, Sustainable development, carrying capacity and development, Adaptive and sustainable management of ecosystem and its resources with reference to Ecotourism; Eco-tourism industry in India; Potentials and constraints for promoting Eco-tourism in India; Eco-labels, Ecotels and Ecotourism certification programmes.

UNIT IV: Ecotourism Policy & Planning- a futuristic perspective

Eco-tourism components and impact monitoring – Ecotourism opportunity spectrum (ECOS), Ecological foot print analysis, Limits of acceptable change (LAC), Visitor activity management (VAM), Visitor impact management (VIM), World Ecotourism Summit; suggestions for long term sustainable Eco-tourism initiatives.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Buckley, R.C. (2009). Ecotourism: Principles and Practices. CAB International, Oxford, 368pp
- Fennell, D. A. (2008). Ecotourism: An introduction. New York, NY: Routledge.
- Weaver, David, (2008). Ecotourism, John Wiley & Sons; 2nd Edition Paper back, pp.360.
- Brent Ritchie J R & G I Crouch, (2005). The Competitive destination: A sustainable tourism perspective, CABI, UK.
- Eagles, P.F.J, S.F. McCool, & Haynes, Christopher,D.A. Christopher. (2002). Sustainable tourism, in protected areas: guidelines for planning and management, IUCN, Gland, Switzerland.
- Honey, M, (2008). Ecotourism and Sustainable Development Who Owns Paradise? Second Edition, Island Press, USA, Paperback pp.558.
- Wood, M, E, (2003). Eco-tourism: principles, practices and policies for sustainability, UNEP, DTIE/ TIES, 61 pp. accessed at uneptie.org/ tourism/home.html

Programme: M.Sc. Environmental Science

EES 5004 Energy and Environment

Course Code	EES 5004	Semester	
Course Title	*Energy and Environment*		
Credits	3	Type	Elective

Course Description

The course covers environmental impact of energy production and consumption. Further aspects studied are energy, energy efficiency, consumption patterns and sustainability.

Course Outcome

By the end of the course, students are expected to be able to:

- Summarize the basic concepts of energy, its distribution and general Scenario.
- Explain different energy storage systems, energy management, audit and economic analysis.
- Summarize the environment eco system and its need for awareness.
- Identify the various types of environment pollution and their effects.
- Discuss the social issues of the environment with associated acts.

Course Structure

The following is a detailed syllabus.

UNIT I: Non-renewable Energy resources

Fossil fuels-classification, composition, physico – chemical characteristics and energy content of coal, petroleum and natural gas, nuclear fuel, fission and fusion.

UNIT II: Renewable Energy Resources

Biomass, bio-fuel, hydroelectric power; Non-conventional energy resources: tidal energy, wind energy, geothermal energy, solar energy, solar radiation and its spectrum, solar collectors, photovoltaics, solar ponds, hydrogen energy.

UNIT III: Energy Resource Management

Energy crisis; Energy Conservation and Management; Energy audit; Recycling of wastes**:** Types - sources - composition of waste - recycling of waste for Industrial, Agricultural and Domestic Purposes.

UNIT IV: Energy Use and its Environmental Impact

Energy use pattern in different parts of the world; Environmental implication; CO_2 emissions, global warming; thermal pollution, air pollution; radioactive waste, radioactivity from nuclear reactors, radioactivity risk assessment and criteria for safe exposure; impacts of large-scale exploitation of Solar, Hydro and Wind energy.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Armaroli N, Balzani V, 2011. Energy for a Sustainable World – From the Oil Age to a Sun-Powered Future, Wiley-VCH.
- Armaroli N, Balzani V, Serpone N, 2013. Powering Planet Earth – Energy Solutions for the Future, Wiley-VCH
- Chichester, 2010. Renewable Energy and Climate Change. John Wiley & Sons Ltd.
- Sioshansi FP, 2011. Energy, Sustainability and the Environment, Elsevier

EES 5005 Environmental Economics

Course Code	EES 5005	Semester	
Course Title	*Environmental Economics*		
Credits	3	Type	Elective

Course Description

This course focuses on economic causes of environmental problems. In particular, economic principles are applied to environmental questions and their management through various economic institutions, economic incentives and other instruments and policies. Economic implications of environmental policy are also addressed as well as valuation of environmental quality, quantification of environmental damages, tools for evaluation of environmental projects such as cost-benefit analysis and environmental impact assessments. Selected topics on international environmental problems are also discussed.

Course Outcome

By the end of the course, students are expected to be able to:

- Enhance their ability to conduct professional economic research
- Develop and present professional proposals, papers, and presentations;
- Increase their ability to analyze environmental policies through a deeper understanding of economic behaviour and incentives; economic institutions, property rights and contracts.

Course Structure

The following is a detailed syllabus.

UNIT I: Economy and the Environment

World environmental history and economic development, valuation of natural resources, Inter-linkages between the economy and the environment. Economics of Natural Resource Exploitation

– Renewable and Non-Renewable Resources – Methods of valuation of Environmental Costs and Benefits. Entropy- Principle and law of entropy. Material flow in economy.

UNIT II: Environmental Policy

Design of Environmental Policy. Economic Instruments for Environmental Protection: Command & Control versus Incentives and Subsidies. Effectiveness of these instruments. Indian scenario and comparisons with China and developed countries.

UNIT III: Sustainable Development

Concept and objectives. Strategic Planning for Sustainable Development, Natural resource based economic and social development. Climate Change, India:Vulnerability of regions and populations – Adaptation options.

UNIT IV: Green Economy

New model for development, Green economy and green economy initiatives, Role of UNEP. Brundtland Commission. ecological economics Economic Growth and the Environment: Environmental Kuznets' curve, Foreign Direct Investment and the Environmental quality.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Allen V. Kneese and James L. Sweeney, eds. (1985), Handbook of Natural Resource and Energy Economics, Chapters 2,12,14,17, North Holland.
- Bohm, P. and Russell, C., `Comparative Analysis of Alternative Policy Instruments',Chap. 10 in Handbook of Natural Resource and Energy Economics, Vol.I Ed. A.V.
- Field, B.C., (1994), Environmental Economics: An Introduction, McGraw Hill.
- Fisher, A.C., (1995), Environment and Resource Economics, Selected readings, New Horizon in Environmental Economics, Ed. W.E. Oates,.
- Hanley, Nick, Jason F. Shogren & Ben White (1997), : Environmental Economics in Theory and Practice, New Delhi: Macmillan –India.
- James, D.E., (1978), Economic Approaches to Environmental Problems: Techniques and Results of Empirical Analysis, Elsevier Scientific Publishing Co..
- Kolstad Charles., (2010), Environmental Economics, New Delhi: Oxford University Press.

Programme: M.Sc. Environmental Science

EES 5006 Environmental Education

Course Code	EES 5006	Semester	I
Course Title	*Environmental Education*		
Credits	3	Type	Elective

Course Description

This course is designed to prepare students to implement environmental education opportunities in formal and non-formal education settings.

Course Outcome

By the end of the course, students are expected to be able to:

- Develop a foundational knowledge of environmental education.
- Understand the importance of developing an environmentally literate populace.
- Critically examine environmental issues in the Indian context.
- Understand how local, regional, state, national, and international laws and regulations influence environmental decisions.
- Locate and use environmental education teaching and learning materials.
- Integrate instructional technology into environmental education settings.

Course Structure

The following is a detailed syllabus.

UNIT –I Introduction

Objectives, Scope and Nature of Environmental Education a) Meaning, definition and characteristics of environmental education – content. b) Importance, objectives, scope and guiding principles of environmental education. c) Factors of degradation of environment – adverse socio – economic impacts of degradation of environment.

UNIT – II Environmental Policies

India and Environmental Issues and Policies Major environmental problems in India – Environmental protection and polices in India – Need and objectives of conservation – Environmental conservation measures taken in India – Constitutional amendments made and Environmental laws

UNIT -III Environmental Movements

Environmental Movements and Developments Environmental movements in India: Silent Valley movement, Chipko movement, Narmada Bachao, Andolon, National Test Range at Baliupal, Orissa – conditions for achieving the goals of sustainable development – Strategies for sustainable development in India.

International Efforts for Environmental Protection The Stockholm conference 1972 – Brundtland commission 1983 – Nairobi conference 1982 – The Rio Summit 1992 – the Rio Declaration at the earth charter – Major achievements of the Rio Summit – Main features of the Rio Declaration – Kyoto conference and part on Global Warming.

UNIT - IV Role of Education

Environmental Education in the School Curriculum, major constraints for its implementation, Teacher's role – national resource centre for environmental education, role of individual in conservation of natural resources - Role of information technology.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

- KK Shrivastava (2016) Environmental Education: Principles, Concepts and Management,Kanishka Publishing House.
- KC Jain (2016) Environment Education, Tandon Publications.
- Sharma, R. A. (2008). Environmental Education. R. Lall Books Depot. Meerut.
- Singh,Y. K. (2009). A text book of environmental science. APH Publishing Corporation , New Delhi.
- Depot. Kumar, A. (2009), Education for Environmental and Human value, R. Lall Books Publications, Meerut, India
- Reddy, P. K., & Reddy, N. D. (2001). Environmental education. Anmol publications, New Delhi.
- Kelu, P. (2000). Environmental Education. Neelkamal Publications, Hyerabad.
- Sharma, R. G. (1986). The handbook of environmental education., Metropolitan Book, New Delhi.

Programme: M.Sc. Environmental Science

EES 5007 Environmental Geosciences

Course Code	EES 5007	Semester	
Course Title	*Environmental Geosciences*		
Credits	3	Type	Elective

Course Description

The course covers a broad range of topics, ranging from Earth materials and their use to Earth processes, including natural hazards and their impact on human lives. It also deals with using geological knowledge to address interactions between humans and the physical environment: the biosphere, the lithosphere, the hydrosphere, and, to some degree, the atmosphere.

Course Outcome

By the end of the course, students are expected to be able to:

- Outline how geoscience relates to the environment.
- Explain the mechanisms behind plate tectonics and plate motion; describe the basic internal structure of the Earth as well as the Earth's composition.
- Outline the major groups of the main rock-forming minerals; describe igneous, metamorphic and sedimentary rocks; and explain the roles rocks and minerals play in the environment.
- Describe the conditions that make some natural Earth processes hazardous to people and discuss the role of science in evaluating natural hazards.
- Outline the mechanisms behind geological processes that include earthquakes, volcanoes, and landslides and identify associated hazards and ways of minimizing their effects.
- Discuss the factors that control the distribution of mineral resources, including fossil fuels, and explain the environmental impact of mineral development. Describe the basics of Earth system science and how it can be used to study global climate change.

Course Structure

The following is a detailed syllabus.

UNIT I: Basic concepts

Evolution of earth and it's environment; components of the physical environment, atmosphere, hydrosphere and lithosphere. Internal structure of earth; Geological maps, Geological time scale, Hydrological cycle, the concept of rock cycle; Agents, types and products of weathering; Rocks and mineral, classification, soil formation, soil profile, soil classification, soils of India.

UNIT II: Environmental geology

Environmental factors of deep seated processes of lithosphere volcanic, seismic and diastrophic tectonic processes with special reference to Indian sub-continent, reservoir induced seismicity, environmental geologic mapping, geological aspects of environmental impact of dredging, mining, river-sand mining, quarrying , deforestation, resettlement, farming, and other types of land use, environmental factors of ground water depletion, bore wells, siltation of reservoirs, Geo environmental changes associated with highway construction, bridges, tunnels, high rise buildings.

UNIT III: Plate tectonics and geological hazards

Concept of plate tectonics; Major and minor lithospheric plates, plate margins and types, causes of plate movement, sea floor spreading and continental drift; geodynamic elements of earth: Mid-ocean ridges, trenches, transform faults and Island arcs. Interrelation of topo sheet – contour, gradient, dip, strike; Geological structures: Joints, fold, fault and unconformities.

UNIT IV: Application of geology in engineering

Geological time scale of rocks; properties of rocks, Geological and environmental investigations for the construction of dams, bridges, highways and tunnels; Impact of major geotechnical projects on the environment.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Bell, F.G., (1999). Geological Hazards, Routledge, London.
- Brownlow, A.N., (1979). Geochemistry, Prentice Hall.
- Bryant, E., (1985). Natural Hazards, Cambridge University Press.
- Keller, E.A., Environmental Geology & Turk and Turk.
- Krynine, D.S. and Judd, W.R., (1998) Principles of Engineering Geology, CBS, New Delhi.
- Lahee, (1987) Field Geology. Sixth Edition. Mc Graw Hall Co..
- Sawkins,J.S.,Chase,C.G., Darby,D.G. and Rapp,G., (1978).The evolving earth, Mac Millan Publishing Co., New York.
- Smith, K., (1992). Environmental Hazards, Routledge, London.
- Spencer, Structure of the Earth. Wiley. Brian Mason, 1966, Principles of Geochemistry, Wiley.

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EES 5008 Environmental Genetics and Biotechnology

Course Code	EES 5008	Semester	
Course Title	*Environmental Genetics and Biotechnology*		
Credits	3	Type	Elective

Course Description

The course proposes to cover the modern biotechnological tools for environmental applications and sustainable development.

Course Outcome

At the end of the course, students should be able to

- associate the biotechnology tools in environmental applications
- articulate the available modern tools of biotechnology for environmental remediation
- apply the biotechnological tools for sustainable environment

Course Structure

The following is a detailed syllabus.

UNIT I: Genetic Engineering

Introduction to genetic engineering, Restriction endonucleases, properties of restriction enzymes, introduction of cloned genes into new hosts using plasmid and phage vector systems, isolation of plasmids, DNA – cloning of DNA fragments, Cloning of single stranded DNA, Shuttle vectors and their environmental applications.

UNIT II: Biotechnology for environment

Recombinant DNA Technology, development of genetically engineered microorganisms (GEMs), Polymerase Chain Reaction (PCR) and development of gene probes for environmental remediation, Uses of GEMs in bioremediation, Genosensor technology.

UNIT III: Genetically modified microorganisms

Genetically modified microbes & their uses in Environmental, Microbial reactors, management of recycling & up gradation technologies, Bioenergy from waste, Biogas technology – process and biogas from organic waste.

UNIT IV: Biotechnology for Management of Resources

Bio-transformation of heavy metals, improved oil recovery, role of environmental biotechnology in management of resources, reclamation of wasteland, biomass production, microorganisms in mineral and energy recovery, nanotechnology for control of pollution.

Testing & Evaluation

- Continuous assessment for 40% will be carried out with 2 internal assessment tests, seminars, assignments, group discussions, etc.
- End semester examination for 60% will be conducted at the end of the semester.

References

- Environmental Biotechnology and Cleaner Bioprocesses. Boca Raton, Taylor & Francis.
- Evano, G.H. and Furlong, J.C. (2004), Environmental Biotechnology - Theory and Application. USA, John Wiley and Sons.
- Jjemba, P.K. (2004), Environmental Microbiology - Theory and Application. USA, Science Pub. Inc..
- Kuhad R.C., Singh A. (2013), Biotechnology for Environmental Management and Resource Recovery. New York, Springer-Verlag.
- Martin C.C. (2008), Environmental Genomics. Totowa, NJ, USA, Humana Press.
- Pepper, I.L. and Gerba, C.P. (2005), Environmental Microbiology - Laboratory Manual. USA, Elsevier.
- Ratledge, C. and Kristiansen, B. (2002), Basic Biotechnology. 2nd ed. Cambridge, Cambridge University Press.
- Rittman, B. and McCarty, P. L. (2000), Environmental Biotechnology: Principles and Applications. 2nd edition. USA, Tata McGraw-Hill.
- Rittmann, B.E. and McCarty, P.L. (2001), Environmental Biotechnology – Theory and Application. USA, McGraw Hill.

Programme: M.Sc. Environmental Science

EES 5009 Environmental Nanotechnology

Course Code	EES 5009	Semester	I
Course Title	*Environmental Nanotechnology*		
Credits	3	Type	Elective

Course Description

The primary goal of the course is to increase student awareness of how nanomaterials interact in natural and engineered environments. We will examine both the potential benefits of nanomaterials/nanotechnology for environmental applications (groundwater remediation, drinking water production) and the potential environmental and toxicological hazards associated with nanomaterials/nanotechnology.

Course Outcome

By the end of the course, students are expected to be able to:

- Describe the basic concepts of nanoscience and nanoengineering and have the ability to convey those concepts to the general public.
- Evaluate mechanisms that define nanomaterial fate and transport, nanomaterial toxicity, and ecological effects in natural and engineered environments.
- Understand the near term and future applications of nanomaterials and nanoscience, as well as the benefits and pitfalls of widespread use of these materials in society.
- Actively and collaboratively engage in the discussion of environmental nanotechnology.

Course Structure

The following is a detailed syllabus.

UNIT-I Introduction

Environmental Nanotechnology- An introduction, Concept of Nano pollution, Nanotechnology for Reduced waste and improved energy efficiency, Nanotechnology based water treatment strategies.

UNIT-II Synthesis of Nano materials

Microorganisms for synthesis of Nano materials and for toxicity detection: Natural and artificial synthesis of Nano particles in microorganisms; Use of microorganisms for nanostructure formation, Testing of environmental toxic effect of Nano particles using microorganisms.

UNIT-III Applications in Waste Management

Waste remediation: Nanoporous polymers and their applications in water purification, Photo-catalytic fluid purification. Energy conversion; Hierarchical self-assembled nanostructures for adsorption of heavy metals, Nano-pesticide formulations, Nanoparticles for dye removal and water filtration.

UNIT-IV Safety of Nanomaterials

Pollution by Nano-particles- Health impact, Safety and Toxicological effects. Societal impact & Ethical issues in Nanoscience and Nanotechnology, Problems and possible solutions, Regulation, Green Nanotechnology.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Seminar
- Assignment

References

- Hambleton, P.; Salusbury, T. (Eds.) (1994), Biosafety in Industrial Biotechnology. Springer.
- Mark Wiesner, Jean-Yves Bottero (2007), Environmental Nanotechnology: Applications and Impacts of Nanomaterials: Applications and Impacts of Nanomaterials, McGraw Hill Professional.
- Jo Anne Shatkin (2013), Nanotechnology: Health and Environmental Risks, Second Edition, CRC Press, Taylor and Francis.
- Vicki H. Grassian (Ed) (2008), Nanoscience and Nanotechnology: Environmental and Health Impacts, John Wiley & Sons, Inc.
- Berube, D. M. (2006), Nano-hype: The Truth Behind the Nanotechnology Buzz. New York: Prometheus Books.
- Jean-Yves Bottero (2007), Environmental Nanotechnology: Applications and Impacts of Nanomaterials, McGraw-Hill Education.
- Mukesh K Burman (2012), Nanotechnology: Emerging Issues and Application,Sarup Book Publishers.
- Geoffrey B. Smith, Claes-Goran S. Granqvist (2010), Green Nanotechnology: Solutions for Sustainability and Energy in the Built Environment, CRC press.

Programme: M.Sc. Environmental Science

EES 5010 Environmental Stress Biology

Course Code	EES 5010	Semester	
Course Title	*Environmental Stress Biology*		
Credits	3	Type	Elective

Course Description

The course provides an insight into the different types of environmental stresses and the response of different groups of organisms to the stresses. Also, the role of chemical molecules in the biotic-biotic interactions is covered in this course.

Course Outcome

By the end of the course, students are expected to be able to:

- Demonstrate a linkage between a stress factor and an effect on the organism
- Understand and appreciate the role of chemical molecules in signalling in several organisms.

Course Structure

The following is a detailed syllabus.

Unit I: Introduction to Environmental Stresses

Introduction to environmental stresses, Types of stresses, Abiotic factors: temperature, water, salinity, UV radiation, Biotic factors: competitors, pathogens, pests.

Unit II: Plant Responses to Environmental Stress

Adaptations of plants to environmental stress, Eco-physiological responses of extremophiles, tolerance of plants to pollutants, tolerance index of plants, Use of stress indicators for biomonitoring.

Unit III: Animal Responses to Environmental Stress

Biological responses to high altitude and deep sea environment; Osmoregulation in fish, water conservation and adaptive mechanisms in desert habitats; hibernation and aestivation, Circadian rhythms and biological clock; Bioindicators and biomonitors of pollution.

Unit IV: Chemical Ecology

Chemical interactions between biota of an ecosystem, Allelopathy, Chemotaxis, Chemical messages during insect herbivory, Volatiles for chemical communication, Chemistry behind Plant pathogen interactions.

Testing & Evaluation

- Seminars
- Written tests
- Group discussions

- Assignments

References

- Plant Physiological Ecology 2008.Lambers, Hans,Chapin III, F. Stuart,Pons, ThijsL., Springer
- Plant Ecophysiology. 1996. (Ed) M.N.V Prasad. John Wiley & Sons
- Physiological Animal Ecology 1996.Gideon N Louw. Prentice Hall
- Physiology and Molecular Biology of Stress Tolerance in Plants. 2006.(Eds) K.V. MadhavaRao, A.S. Raghavendra, K. Janardhan Reddy. Springer.
- Physiological Plant Ecology(Eds)Lange, O.A., Nobel,P.S., Osmond, C.B. and Ziegel, H. Encyclopedia(Vol. I-IV) Springer Verlag
- Environmental Physiology of Plants.2002. By Alastair H. Fitter, Robert K.M. Hay Academic Press
- Animal Physiology: Adaptation and Environment 5thedition, 2002. By Knut Schmidt-Nielsen

Programme: M.Sc. Environmental Science

EES 5011 Food Safety and Health

Course Code	EES 5011	Semester	I
Course Title	*Food Safety and Health*		
Credits	3	Type	Elective

Course Description

This course aims to equip the learners with the basic food safety knowledge to enable them to work with food in a safe and hygienic manner. The course is a comprehensive coverage of Food borne diseases, including surveillance and investigation; Foodborne hazards, including microbiological and chemical agents; Substances added to food, both directly and indirectly; Food technologies, including the latest developments; Food commodities, including their potential hazards and controls; Food safety management systems, including their elements and the roles of stakeholders

Course Outcome

By the end of the course, students are expected to be able to:

- Define food hygiene.
- List the responsibilities of a food worker.
- Identify various foodborne pathogens.
- Understand the importance of food safety preparedness.
- Understand the requirements of HACCP.
- Identify food regulations and procedural analysis in food industry.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT –I Introduction

Concepts of food safety, establishing the problems, susceptibilities within the food chain, Food borne pathogens and outbreaks, seafood and shell fish, mercury and toxins

UNIT –II Regulations

Food safety regulations: the roles of federal, state, and international agencies, Hormones and antibiotics: antibiotic resistance, contamination of foods. Organic food, chemical contamination of food, Genetically modified foods. Food safety preparedness: Perspective from the food industry

UNIT –III Procedural Analysis

Risk perception and analysis; Globalization, sustainable agriculture, local food networks, slow foods; Restaurant and food service inspections, food safety in the home

UNIT –IV Food safety

Bioterrorism and food safety, Over-nutrition: food marketing, supersizing, obesity. Legal consequences of food outbreaks, Dietary Supplements.

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar

Assignment References

- Food Safety Management, A Practical guide for the food industry, 2013 Elsevier Publishers (1st Edition, 2013).
- Food Safety and Standards Act, Rules & Regulations, 2015, Akalank Publications (13th Edition edition), India.
- P K Das (2006). Handbook on the Food Safety & Standards Act, 2006 Universal-Law-Publishing-Co-Ltd, India
- SN Mahindru (2007) Food and Nutrition Education KSK Publishers & Distributors.
- Punam Chopra (2005) Food and Nutrition Education APH Publishing Corporation, India
- Steier, Gabriela, Patel, Kiran (Eds.) (2016) International Food Law and Policy, Springer, Germany
- Alok Bhargava (2008) Food Economics and Health, Oxford University Press, New Delhi.
- PS George (2002) Some Reflections on Food Security in India, Academic Foundation, New Delhi.

Programme: M.Sc. Environmental Science

EES 5012 Forestry

Course Code	EES 5012	Semester	
Course Title	*Forestry*		
Credits	3	Type	Elective

Course Description

The course provides an introduction into the forest ecosystem and the different ways and techniques that can applied in silviculture. The vast resources available in the forests and their uses are discussed in detail. And, the laws and acts pertaining to forests and forestry are discussed in detail.

Course Outcome

By the end of the course, students are expected to be able to:

- Appreciate the significance of forests in well-being of the human beings
- Follow the acts and legislations in connection with the proper upkeep of the forests and forested land
- Understand the various steps in silviculture practices in different ecosystems.

Course Structure

The following is a detailed syllabus.

Unit I: Introduction

Definition of forestry, Concepts, terminologies, need and scope. Forest as an ecosystem: Biotic and abiotic components, ecological and physiological factors influencing vegetation, productivity, nutrient cycling, stresses, Forest types in India and conservation initiatives: forest genetic resources and gene conservation in situ and ex-situ, REDD+, Research and Extension needs, Tribal community participation in forestry programme, Joint Forest Management.

Unit II: Silviculture

General principles, nursery system, Silvicultural systems - wood selection, felling, establishment and management of stands, technical methods and constraints, Silviculture practices in specialized ecosystems like Mangroves and Cold deserts.

Unit III: Forest resources and utilization

Sustainable harvest of forest resources, Timber- logging and extraction techniques and principles, transportation system, storage and sale, Need and importance of wood seasoning and preservation; Non-Timber Forest Products (NTFPs) definition and scope - collection; processing and disposal/sale.

Unit IV: Forest legislation

Pre- and post-independence forest policies in India: 1894 & 1952. National Forest Policy: 1988. Forestry Policies and issues related to land use, timber and non-timber products. Indian Forest Act 1927; Forest Conservation Act, 1980; Application of Indian Penal Code to Forestry.

Testing & Evaluation

- Seminars
- Written tests
- Group discussions
- Assignments

References

- The Silviculture of Indian trees by R.S. Troup (2011) Volume 1, 2 & 3. Nataraj Publishers, Delhi.
- Forest Ecology by J.P. Kimmins (2003) 3rd Edition. Benjamin Cummings Publisher, USA.
- Perspectives on social forestry by B.L. Sharma and R. Vishnoi (2000). Daya Publishing house, Delhi.
- Ensuring sustainability in Forestry: Certification of Forests by H.S. Gupta, M. Yadav, D. K. Sharma and A.M. Singh (2013). TERI Press, Delhi.
- The practice of silviculture: Applied forest ecology by M.S. Ashton and M.J. Kelty (2018) 10th Edition. Wiley, USA.
- Forest Ecosystems by D.A. Perry (1994). The Johns Hopkins University Press, USA.
- Forest Ecology in India by N.A. Rao (2007). Cambridge University Press, UK.
- Forest wildlife ecology and habitat management by D.R. Patton (2010). CRC Press, Boca Raton.
- Silviculture in the tropics by S. Guenter, M. Weber, B. Stimm and R. Mosandl (2011). Springer-Verlag, Berlin.

Programme: M.Sc. Environmental Science

EES 5013 Industrial Ecology

Course Code	EES 5013	Semester	
Course Title	*Industrial Ecology*		
Credits	3	Type	Elective

Course Description

This course aims to introduce the concepts underlying industrial ecology and some tools used in it. It will also discuss eco-industrial development, the key issues involved and some cases from India. It will, therefore, expose students to the multidisciplinary nature of environmental issues and integrate pollution prevention with sustainable development.

Course Outcome

By the end of the course, students are expected to be able to:

- Evaluate environmental impact from materialand energy flows in a life cycle perspective based on thermodynamics and suggest improvements with the
- Awareness of the risk for problem shifting
- Apply material strategies such as dematerialisation, substitution and waste hierarchies regarding different products
- Describe the usability of different tools and strategies for optimising materialand energy flows in a life cycle perspective
- Describe and use life cycle assessment to quantify environmental impacts from a system,
- Search and analyse information regarding a societal environmental problem, propose realistic system approches for increased resource efficiency and present the results both orally and in written form

Course Structure

UNIT I: The Environment and the Anthrosphere

Definition – Environment and Anthrosphere, Components of the anthrosphere, effects of the anthrosphere on earth, integration of the anthrosphere into the total environment, the anthrosphere and industrial ecology.

UNIT II: Industrial ecology and industrial systems

Levels of material utilization, links to other environmental spheres, consideration of environmental impacts in industrial ecology, Key attributes – energy, materials and diversity. Life cycle, consumable, recyclable and service products. Societal factors and environmental ethics.

UNIT III: Industrial Metabolism and waste disposal

Networks of Nutrient and Energy transfer. Industrial metabolism, ion exchange, photolytic reactions, thermal treatment methods, biodegradation of wastes, treatment methods for solid and liquid wastes.

UNIT IV: Industrial ecosystems

Components of the industrial ecosystem, overview of an integrated industrial ecosystem, examples of symbiotic industrial ecosystems, designing and developing of symbiotic industrial ecosystem. Industrial Ecology and the Legal System.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Bourg D., Erkman S. (2003), Perspectives of Industrial Ecology. Texas, Greenleaf.
- Graedel T.E., Allenby B.R. (2010), Industrial Ecology and Sustainable Engineering. New Jersey, USA, Prentice Hall.
- Graedel T.E., Allenby B.R. (2003), Industrial Ecology. New Jersey, USA, Printice Hall.
- Manahan S.E. (1999), Industrial Ecology: Environmental Chemistry and Hazardous Wastes, Boca Raton, CRC Press,.
- Socolow R., Andrews C., Berkhout F, Thomas V. (2010), Industrial Ecology and Global Change. Cambridge, Cambridge University Press,.
- Suh S. (2009), Handbook of Input-Output Economics in Industrial Ecology. New York, Springer-Verlag.

Programme: M.Sc. Environmental Science

EES 5014 Marine Environment

Course Code	EES 5014	Semester	
Course Title	*Marine Environment*		
Credits	3	Type	Elective

Course Description

The course proposes to provide a deeper knowledge on marine ecosystems, marine biodiversity and effect of environmental changes on marine biodiversity.

Course Outcome

At the end of the course, students should be able to

- recall the roles and importance of different ecosystems in the marine environment
- discuss the marine biodiversity and necessity of marine biodiversity conservation
- appraise the different available renewable marine resources for sustainable environment
- correlate the pollution and environmental factors on marine environment and its biodiversity.

Course Structure

The following is a detailed syllabus.

UNIT I: Introduction to Marine ecosystem

Marine ecosystem – estuaries, rocky and sandy shores, pelagic ecosystems, continental shelf seabed, deep sea, mangroves forests, seagrass meadows, coral reefs, Polar Regions.

UNIT II: Marine Biodiversity

Distribution of marine biodiversity, relationship between global climate and marine biodiversity, hypoxia and dead zone, significance of marine biodiversity, marine ecosystem functioning. Extinct and endangered marine species, fisheries management and conservation.

UNIT III: Marine Resources and Energy

Fossil records, fishing, mining – minerals and crude oil, tourism, Energy from Marine Environment – Renewable – marine wind power, osmotic power, tidal power, wave power, ocean thermal energy; Non renewable energy.

UNIT IV: Marine Pollution

Sources and types of marine pollution, effects of marine pollution – physicochemical and biological effects, impact of climate and environmental factors on marine environment and biodiversity. Mitigation measures for marine pollution.

Testing & Evaluation

- Continuous assessment for 40% will be carried out with 2 internal assessment tests, seminars, assignments, group discussions, etc.
- End semester examination for 60% will be conducted at the end of the semester.

References

- Farmer A. (1997), Managing Environmental Pollution. New York, Routledge.
- Hofer T.N. (2008.), Marine Pollution: New Research, New York, Nova Science Publishers,
- Iversen E.S. (1996), Living Marine Resources: Their Utilization and Management. New York, Chapman Hall,
- Kaiser M.J., Attrill M.J. (2011), Marine Ecology: Process, Systems and Impacts. Oxford, Oxford University Press.
- Multon B. (2012), Marine Renewable Energy Handbook. Philippines,Wiley-ISTE.
- Polunin V.C. (2008), Aquatic ecosystems: Trends and Global Prospects. Cambridge, Cambridge University Press.

Programme: M.Sc. Environmental Science

EES 5015 Occupational Health and Industrial Safety

Course Code	EES 5015	Semester	I
Course Title	*Occupational Health and Industrial Safety*		
Credits	3	Type	Elective

Course Description

This course examines occupational safety and health practices needed to address occupational safety and health issues in the workplace. Students will utilize regulatory standards as a guide to apply policies, procedures, standards and occupational safety and health principles. Industry recognized best practices, origin of the standards, the process and rules of inspections, citations and penalties and polices will be covered.

Course Outcome

By the end of the course, students are expected to be able to:

- Evaluate workplace to determine the existence of occupational safety and health hazards
- Identify relevant regulatory and national consensus standards along with best practices that are applicable.
- Select appropriate control methodologies based on the hierarchy of controls
- Analyse injury and illness data for trends.
- Provide industry with inputs on health and safety.
- Learn and disseminate issues related to occupational health and hazards.
- Develop protocol for an industry on disaster prevention, health issues, safety measures and environment management.

This course is modelled towards employability, entrepreneurship and skill development

Course Structure

The following is a detailed syllabus.

UNIT I: Occupational Health

Hazards and Safety–Physical, Chemical and Biological hazards. Occupational Diseases and Occupationally induced illness - Prevention and Control. Health problems in different types of industries. Measures for Workers. Health Education Medical First Aid and Management of Medical Emergencies. Epidemiological approaches. Ergonomics.

UNIT II: Industrial Safety Management Techniques

Industrial Safety Standards. Dispersion of Radioactive material and release of Toxic and inflammable materials. Work Study - Method of Study and Measurement. Measurement of Skills. Safety - Cost of Expenses. Principles and Functions in Safety Management.

UNIT III: Hazards Exposure evaluation

Sampling techniques, Personal monitoring, Biological monitoring; Threshold Limit Values (TLV), STEL; List of Industries involving Hazardous process Occupational Hazards under the First Schedule of the Factories Act,1948; Permissible Limits of certain Chemical substances in work environment under the Second Schedule of the Factories Act,1948.

UNIT IV: Hazards Control

Causes of Accident – Theory of accidents, Accident Reporting system, Safety Audit, Accident prevention, Safety Committee, Case studies on Bhopal, Chernobyl and similar disasters - Control of Hazards Substitutions, Isolation, Personal Protective Equipment (PPE).

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

- A B C of Industrial Safety, Walsh, W and Russell, L, (1984), Pitma Publishing United Kingdom.
- Della D.E., and Giustina, (1996), "Safety and Environmental Management", Van Nostrand Reinhold International Thomson Publishing Inc.
- Environmental and Industrial Safety, Hommadi, A. H. (1989), I.B.B Publication, New Delhi.
- Environmental Strategies–Hand Book, Kolluru R. V, (1994) Mc Graw Hill Inc., New York.
- Goetsch D.L., (1999), "Occupational Safety and Health for Technologists", Engineers and Managers", Prentice Hall.

Programme: M.Sc. Environmental Science

EES 5016 Principles of Remote Sensing and GIS

Course Code	EES 5016	Semester	
Course Title	*Principles of Remote Sensing and GIS*		
Credits	3	Type	Elective

Course Description

The purpose of this course is to introduce the students the basic concepts and principles of various components of remote sensing and also provide an exposure to GIS and its practical applications

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the concepts of Photogrametry and compute the heights of objects
- Understand the principles of aerial and satellite remote sensing, able to comprehend the energy interactions with earth surface features, spectral properties of water bodies .
- Understand the basic concept of GIS and its applications, know different types of data representation in GIS
- Understand and Develop models for GIS spatial Analysis and will be able to know what the questions that GIS can answer are
- Apply knowledge of GIS software and able to work with GIS software in various application fields
- Illustrate spatial and non spatial data features in GIS and understand the map projections and coordinates systems
- Apply knowledge of GIS and understand the integration of Remote Sensing and GIS

Course Structure

The following is a detailed syllabus.

UNIT-I: Introduction

Principles of Remote sensing: Electromagnetic Radiation (EMR),interaction of EMR-earth's surface-reflection-transmission, Spectral signatures and characteristics, spectral reflectance curves. Process of data acquisition, storage, analysis and visualization.

UNIT II: Remote Sensing System

Remote Sensing observations and platforms: Air borne and space borne platforms. Active, Passive and Optical remote sensing, Concept of Microwave remote sensing and microwave remote sensors. Multi-Spectral Imagery (MSI) - Hyperspectral Imagery (HSI)-Thermal Scanner Imagery. Scattrometer and Altimeter.

Remote sensing satellites; Land observation satellites, IRS series, LANDSAT series, SPOT series; High resolution satellites, Weather/Meteorological satellites, NIMBUS Applications, Marine observation satellites OCEANSAT.

UNIT III: Aerial Photography

Elements of photographic system, Geometric characteristics of aerial photographs, Photogrammetry, Visual and digital image processing, Digital image interpretation: Pattern recognition, shape analysis, texture analysis. Integration with GIS.

UNIT IV: Principles and application of GIS

Introduction to GIS, Components of GIS, Geospatial data architecture, operations, Layers and features, Raster and Vector. Types of data –Spatial, Attribute data-types of attributes-scales/ levels of measurements. Data File Formats, Datum Projection and re projection, Topology. Global positioning System (GPS). Spatial database Management Product Generation: Types of output products. Application of Remote sensing: Land Use / Land Cover Mapping, Geologic and Soil Mapping, Agricultural applications, Forestry applications, Water Resource applications, Urban and Regional Planning application, Wetland Mapping, Wildlife Ecology applications, Archaeological applications, Environmental and Disaster Assessment. Applications of GIS: Resources mapping, Inventory and monitoring of natural resources, Land cover mapping, Wetland mapping, Applications to Agriculture, Water Management, Ground Water Modelling, Coastal and Marine applications.

Testing & Evaluation

- Group Discussion
- Seminar
- Assignment
- Written Exam

References

- Anji Reddy, M. 2004: Geoinformatics for Environmental Management. B.S. Publications.
- Chang. T.K. 2002: Geographic Information Systems. Tata McGraw Hill.
- Clarke, Keith C., Bradley O. Parks, and Michael P. Crane, 2002. Geographic Information Systems and Environmental Modeling, Upper Saddle River, NJ: Prentice Hall.
- Heywood. I, Cornelius S, CrverSteve. 2003: An Introduction to Geographical Information Systems, Pearson Education.
- Jensen, J.R., 2000. Remote Sensing of the Environment - An Earth Resources Perspective, Pearson Education, Inc. (Singapore) Pvt. Ltd., Indian edition, Delhi.
- Lillesand, Thomas M. and Kiefer, Ralph, W. 2000. Remote Sensing and Image Interpretation, John Wiley and Sons, New York.
- Muralikrishna, I.V. 1995. Remote Sensing and GIS for Environmental Planning. Tata- McGraw Hill.
- Ram Mohan Rao. 2002: Geographical Information Systems. Rawat Publication.

- Skidmore A. 2002: Environmental modeling with GIS and Remote Sensing. Taylor and Francis Tar Bernhardsen. Geographical Information Systems. John Wiley.
- Thomas M. Lilesand, Ralph W.Kiefer, Jonathan W. Chapman, 2007. Remote sensing and Image interpretation, Wiley India publication, New Delhi.

Programme: M.Sc. Environmental Science

EES 5017 Water Quality and Human Health

Course Code	EES 5017	Semester	I
Course Title	*Water Quality and Human Health*		
Credits	3	Type	Elective

Course Description

Provide a broad, in-depth overview of important relationship between water quality and human health (e.g., point and non-point source pollution, infectious diseases, human impact on water quality, preventative measures) and how the quality of water determines the health of people both in the developed and developing world.

Course Outcome

By the end of the course, students are expected to be able to:

- Understand the relationship between human behaviour and water quality
- Develop remediation strategies for several types of microbial water quality contamination.
- Understand epidemiological studies related to water quality and public health
- Understand various water sources and transmission mechanisms of infectious agents from those sources to humans
- Organize and present well-synthesized scientific discussions on topics relevant to waterborne disease and public health
- Critically evaluate the scientific literature on waterborne diseases

Course Structure

The following is a detailed syllabus.

UNIT –I Introduction

Understanding the significance of the environment for human health,-Human population pressures and pollution dynamics, Common terms and definitions in water quality, Aquatic resources of the world, Sources of drinking water, Common contaminants of drinking water and linkages to disease. Non-point source pollution, Agricultural runoff, TMDLs, Best management practices (BMPs) and Numeric vs narrative standards.

UNIT –II Water Pollution and the Evolution of Microbial Pathogens and Waterborne diseases

Virulence evolution, Subpopulation selection of Bacterial Pathogens

(Protozoa- Cryptosporidiosis, Giardiasis, *Toxoplasma gondii,* Bacteriology- *Shigella, Vibrio cholearae, Pseudomonas)* Virology - survival and persistence of viruses, (Adenovirus, Norovirus and Rota virus)

UNIT–III Sewage Treatment

Sewage treatment in developed countries, Primary, secondary, and tertiary treatments, Land application of sewage, Sewage treatment in developing Countries

UNIT – IV Influence of Climate Change on Water Quality

Climate Change, Change the Dynamics of Human Pathogens in Water, Water sanitation practices - Biofilms, Antibiotic resistance, Case studies, Vaccines, Water sanitation practices- preventive measures, Education and proper hygiene, Proper waste disposal, Water chlorination, improving surveillance, Changes in human behavior, Human population growth, Modern lifestyle effects on the water quality and human health, Predicative models- Modelling infectious diseases

Testing & Evaluation

- Class room MCQ assessment
- Take Home Test
- Group Discussion
- Field visits
- Seminar
- Assignment

References

- Edward A. Laws (1993). Aquatic Pollution: An Introductory Text. 3rd Edition, Wiley Publishers.
- Steven Percival, Rachel Chalmers, Martha Embrey, Paul Hunter, Jane Sellwood and Peter Wyn-Jones (2003). Microbiology of Waterborne Diseases, Academic Press.
- Guidelines for drinking water quality (1993), 4th Edition by WHO Geneva.
- Howard G, Bartram J (2003), Domestic water quantity, service level and health. World Health Organization, Geneva.
- Ainsworth R, ed. (2004) Safe piped water: Managing microbial water quality in piped distribution systems. IWA Publishing, London, for the World Health Organization, Geneva.
- MN Maulik (2011), Water Supply, Waste Water Treatment & Sewage Disposal, Standard Book House, New Delhi, India.
- Satinder Ahuja (ED) (2013), Pollution Assessment, Analysis, and Remediation, Elsevier.

Programme: M.Sc. Environmental Science

EES 5018 Cell and the Environment

Course Code	EES 5018	Semester	II & IV
Course Title	*Cell and the Environment*		
Credits	3	Type	Elective

Course Description

The course articulates the interaction of prokaryotic and eukaryotic cells with the environmental factors at cellular and molecular scale for all students of biology. The course deals with basics of cell biology, and cellular communication and its ecological importance and environmental applications. The course also integrates significant cellular pathways with environmental signals, and presents an overview of environmental stress at sub-cellular, organismal and ecosystem scales.

Course Outcome

By the end of the course, students are expected to be able to:

- Articulate the basics of cellular biology, and environmental stress biology
- Discriminate between prokaryotic and eukaryotic stress response mechanisms
- Corroborate cellular communications and their environmental applications
- Acquire a thorough understanding of environmental stressors, mechanisms thereof, and its implications at sub-cellular, organismal and ecosystem scales

Course Structure

The following is a detailed syllabus.

Unit I: Cell Biology – Basics

Overview of the cell and its origin, composition of prokaryotic and eukaryotic cells, cell organelles – structure and function – nucleus, chloroplast, mitochondria, lysosome and vacuoles, endoplasmic reticulum, golgi apparatus, cell wall. Cell metabolism – photosynthesis, lipid metabolism, carbohydrate metabolism and protein synthesis

Unit II: Cellular Communication

Membrane vesicle trafficking, extracellular matrix, apoptosis, autophagy, quorum sensing, cell adhesion – importance in biofilms and wastewater treatment, role of cell to cell communication at an ecosystem scale

Unit III: Environmental Stressors

Environmental stress at cellular levels – sensing, processing and response – mechanism. Abiotic stressors – nutrients, light, temperature, oxidative stress, osmotic pressure. Biotic stressors – predator, pathogens & toxins. Environmental stressors at ecosystem scale and environmental issues.

Unit IV: Environmental Interactions & Cell Signalling

Concept of signal transduction, Protein kinases and phosphatases, Signal transduction pathways – mTOR signalling, MAP kinase signalling, PI3K signalling. Reactive oxygen,

nitrogen species and redox signalling. Environmental signals and disease, Overview of environmental signals and response – at cellular, organismal and ecosystem scale.

Testing & Evaluation

- Classroom discussions, seminars, written examinations (Continuous Assessment)
- Written examination (End Semester Assessment)

References

- Lodish, H. and Baltimore, D. 2000. Molecular Cell Biology, 3rd Edition. Scientific American Books, W H Freeman, New York.
- Hancock, J.T. 2017. Cell signalling. Oxford University Press.
- Singh, D.P. 2003, Stress physiology. New Age International.
- O'Toole, G.A. and Ghannoum, M.A. 2004. Microbial Biofilms. American Society of Microbiology.
- Winans, S.C. and Bassler, B.L. 2008. Chemical Communication among Bacteria. American Society of Microbiology.