CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA

DEGREE OF M. Sc. Environmental Science

MASTER OF SCIENCE IN ENVIRONMENTAL SCIENCE

(CHOICE BASED CREDIT AND SEMESTER SYSTEM FOR UNDERGRADUATE CURRICULUM)

UNDER THE FACULTY OF SCIENCE

SYLLABUS

(FOR THE STUDENTS ADMITTED FROM THE ACADEMIC YEAR 2019 – '20 ONWARDS)

BOARD OF STUDIES IN ENVIRONMENTAL SCIENCE (PG)

CHRIST COLLEGE (AUTONOMOUS), IRINJALAKUDA - 680125, KERALA, INDIA

JUNE, 2019

Course structure, credits, mark distribution and scheme of evaluation

Semester	Course No.	Name of the Course	Credits	Internal (20%)	External (80%)	Total
I semester	ESW 1C 01	Fundamentals of ecology and environment	3	20	80	100
	ESW 1C 02	Physical processes in the environment	3	20	80	100
	ESW 1C 03	Energy and environment	3	20	80	100
	ESW 1C 04	Environmental pollution and Waste	3	20	80	100
	ESW IC 05	Practical I #	2	10	40	50
	ESW IC 06	Practical II #	2	10	40	50
	ESW IA 01	Special course - Environmental Research Methodology	2			
Total			16	100	400	500
II semester	ESW 2C 07	Fundamentals of Environmental Engineering	3	20	80	100
	ESW 2C 08	Environmental Microbiology and Biotechnology	3	20	80	100
	ESW 2C 09	Hydrology and Water Resource Management	3	20	80	100
	ESW 2C 10	Remote Sensing and GIS	3	20	80	100
	ESW 2C 11	Practical III #	2	10	40	50
	ESW 2C 12	Practical IV #	2	10	40	50
	ESW 2A02	Special course – Environmental Analytical Techniques and Instrumentation	2			
Total			16	100	400	500

III semester	ESW 3C 13	Environmental toolsand monitoring methods.	3	20	80	100
	ESW 3C 14	Environmental Toxicology and Occupational Health and Safety	3	20	80	100
	ESW 3C 15	Biodiversity and Conservation	3	20	80	100
	ESW 3C 16	Environmental Disaster Management	3	20	80	100
	ESW 3C 17	Practical V #	2	10	40	50
	ESW 3C 18	Practical VI #	2	10	40	50
Total			16	100	400	500
IV semester (Four electives)	ESW 4C 19	Elective 1*	4	20	80	100
	ESW 4C 20	Elective 2*	4	20	80	100
	ESW 4C 21	Elective 3*	4	20	80	100
	ESW 4C 22	Elective 4*	4	20	80	100
	ESW 4C 23	Elective 5*	4	20	80	100
	ESW 4C 24	Elective 6*	4	20	80	100
	ESW 4C 25	Elective 7*	4	20	80	100
	ESW 4P 01	Dissertation	8	20	Dissertation 140 Viva 40	200
Total			24	100	500	600
Grand Total	Credits		72			
	Marks					2100

 # Practicals I, II, III and IV will be conducted along with second Semester Examination and Practicals V and VI along with IV semester examination.

*** Four elective papers in IV semester.**

General Instructions

Eligibility for admission

Candidates with a Degree in any Science Subject from the Christ College (Autonomous) or any other University, recognized by the Christ College (Autonomous) can apply for admission to M. Sc. programme in Environmental Science. Admission to the programme will be through an entrance examination conducted by the Department / University. The syllabus and pattern of entrance examination shall be decided by the Department Council or other bodies of the University, from time to time.

Examination / Examiners

There shall be University examinations after successful completion of each semester. For evaluations (including dissertation) in each semester, there shall be one internal and one external examiner. The external examiners for each semester shall be selected from a panel of examiners from outside teaching / R & D institutions, approved by the Departmental Council / University. The internal examiner shall be the faculty member who actually imparted instruction in the particular area in the concerned semester.

Theory / Practical examinations / Dissertation

There shall be theory examinations in all the four semesters. However, Practicals I, II, III and IV will be conducted along with second Semester Examinations and Practicals V and VI along with IV semester examinations. A certified record of practical work done by the student should be submitted at the time of each practical examination.

There shall be four elective papers in IV semester. Also, there shall be provision for addition or deletion of elective papers to be offered, if necessary, in the ensuing years of admission, subject to approval by the Department Council and other bodies of the University.

Students should submit individual dissertation in the fourth semester. They can undertake research work for dissertation, either in the department or in an approved R & D institution outside, subjected to approval by the Department Council. The topic of dissertation may be chosen from an area of one of the elective papers opted in the 4th semester.

Evaluation (Internal & External) and Grading

Calicut University Regulations for Choice-based Credit Semester System for Post Graduate Programmes of Teaching Departments / Schools of the Christ College (Autonomous) (CCSS PG Regulations 2019) will be followed for internal and external evaluation and grading.

Plan of question papers for external / internal examinations

Theory (Core & Elective Papers)

The question papers for theory examinations (core and elective) shall contain the following split up.

Part A: Two essay-type questions of 10 marks each, out of three questions (2x10 =20 marks).

Part B: Eight short answer questions of 5 marks each, out of ten questions (8x5 =40 marks).

Part C: Ten short answer questions of 2 marks each, out of twelve questions (10x2 =20 marks).

Total marks: 80

Practicals

The Board of Examiners for practical examinations shall decide the plan of question papers for practical examinations.The total marks shall be 40, which may also include marks for records / submissions / field reports / viva voce etc.

Duration of examinations

The duration for both theory and practical examinations shall be three hours.

Special course / Ability enhancement course

The Department Council shall decide the evaluation criteria for Special course / Ability Enhancement Course (ES IA Environmental Research Methodology and ES2A02 Environmental Analytical Techniques and Instrumentation). The above courses will be taught through direct lectures / seminars / tutorials and other innovative methods. There shall be an internal evaluation and list of students who have successfully completed such programmes will be forwarded to the University by the Head of the Department, after its approval by the Department Council.

SEMESTER I

ESW1C01 – FUNDAMENTALS OF ECOLOGY END ENVIRONMENT

Number of Credits: 3

Course Outline

Module I: Fundamentals of Environmental Science

Definition, Scope and Importance of Environmental Science; Multidisciplinary nature of environmental Science; Need of Environmental awareness; Ecology, Interrelationship of ecology with other disciplines.

Module II: Components of the Environment

a) The atmosphere or the air: Layers of Atmosphere, Composition of air; importance of atmosphere,

meteorological conditions and air circulation.

b) The hydrosphere or water: Importance of water, distribution of water at global, national and state level. Hydrological cycle.

c) Lithosphere or the rock and the soil: Elementary composition of rocks in the earth crust. Types of rocks; Process of soil formation: Physical weathering, Chemical and biological weathering of rocks; Role of soil in shaping the biosphere.

Module III: Environmental Factors

(a) Climatic Factors - Light, Temperature of Air (atmospheric temperature), Rainfall (precipitation), Humidity of air, atmosphere (gases and wind), fire. (b) Topographic Factors: height of mountains, direction of mountains and valleys, steepness of slope and exposure of slope (c) Edaphic factors: Soil - soil formation, soil profile, soil erosion, soil conservation (d) Biotic factors: Intraspecific interactions; Interspecific interactions: Neutralism, Commensalism, Mutualism, Proto co-operation, Parasitism, Predation.

Module IV: Ecosystem Definition

Components of ecosystem; Abiotic components: Light, Temperature, Pressure, Water, Wind, Soil; Biotic components; Energy flow in an ecosystem: Primary production, Secondary production; Food chain: Grazing food chain, Detritus food chain; Ecological pyramids: Pyramid of number, Pyramid of biomass, Pyramid of energy; Food web; Ecological indicators. Biogeochemical cycles: a) Gaseous cycles: Oxygen cycle, Carbon cycle and Nitrogen cycle. b) Sedimentary cycles: Phosphorus cycle, Sulphur cycle.

Module V: Population Ecology and Community Ecology

Population characteristics- Population growth and its dynamics; natality, mortality, growth patterns; Age distribution, Malthus theory; Community structure, Species diversity, Ecological dominance, Ecotone, Edge effect, Ecological equivalence, Succession and Climax; Ecological adaptations.

References

1. Odum, E. P. (1971), Fundamentals of Ecology, W B Saunders Company, Philadelphia.
2. Odum, E. P. and Barrett, G. W. (2005), Fundamentals of Ecology, Belmont, CA: Thomson Brooks/Cole, USA.
3. Krebs, C. J. (1989), Ecological Methodology, Harper Collins Pub. New York.
4. Robert, L. S. (1990), Ecology and Field Biology, Harper Collins Pub, New York.
5. Michael, P. (1990). Ecological Methods for Laboratory and Field Investigations, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Chapman, J. L. and Reiss, M. J. (1992), Ecology-Principles and Applications, Cambridge University Press, New York.
7. Brewer, R. (1994). The Science of Ecology, Saunders College Publishing, New York.
8. Mukherjee, B. (1996), Environmental Biology, Tata McGraw- Hill Pub. Co. Ltd, New Delhi.

9. Colin, R., Townsend, Michael, B. and John, L. H. (2012), Essentials of Ecology, third Edn, Blackwell Science Publishers, New Jersey, USA.
10. Singh, J.S., Singh, S.P. and Gupta, S.R. (2008), Ecology, Environment & Resource Conservation, Anamaya Publications, New Delhi.

ESW1C02 – PHYSICAL PROCESS IN THE ENVIRONMENT

Number of Credits: 3

Course Outline

Module I: Sun-Earth System

Planetary motion and seasons; Solar radiation - global distribution, effect of atmosphere - scattering, absorption and reflection, greenhouse effect; Structure of atmosphere and atmospheric circulation; General circulation of the atmosphere and Indian monsoons; General circulation of Oceans; Winds and surface circulation, causes of ocean currents, characteristics of convergence, divergence, upwelling and sinking of ocean waters; Deep-sea circulation, Thermohaline conveyor belt.

Module II: Thermodynamics, Atmospheric stability

Composition of dry air and atmospheric water vapor content; Potential temperature, virtual temperature, isothermal and adiabatic processes; Stable, unstable and neutral equilibriums, Inversions; Atmospheric boundary layer depth, structure, diurnal variations and their significance in pollutant dispersion.

Module III: Clouds and precipitation

Cloud formation and classification, aerosols, condensation and ice nuclei, droplet growth - curvature and solute effects, precipitation mechanisms; Weather and climate - Climatic zones, continental & maritime climates; Climate change and variability, Natural and anthropogenic causes of climate change, El Nino and ENSO events.

Module IV: Earth Systems

Earth's geological history and development and evolution of the earth systems; Gaia Hypothesis; Introductions to various systems - Atmosphere, Hydrosphere, Lithosphere, Biosphere and their linkages, types of ecosystems. Properties and Structure of the Earth: crust, mantle, core, earth's magnetic field; Recycling of the lithosphere the rock cycle, weathering (physical, chemical and biological) and erosion, sedimentation, metamorphism; Rock types - igneous, metamorphic and sedimentary rocks; Concept of plate tectonics and continental drift; Geological time-scales.

Module V: Global water balance

Hydrological cycle, relationship of surface, groundwater and stream-flow, Stream hydrograph; Groundwater - aquifers; Groundwater exploitation and management.

References

1. Barry, R. G. and Chorley, R. J. (1997), Atmosphere, Weather and Climate (6th Edition), Methuen, London.
2. Fred, G. B. (1998), Environmental Geology - Principles and Practice, Blackwell Science Publishers, New Jersey, USA.
3. Subramaniam, V. (2002), Text Book of Environmental Science, Narosa Publishing House, New Delhi.
4. Andrew, D. W and Stanley, T. (2004), Environmental Hydrology (2nd Edition), Lewis Publishers, Boca Raton, FL.
5. John, M. and Mike, U. (2006). The Atmosphere and Ocean - A Physical Introduction (3rd Edition), Neil Wells, John Wiley & Sons, NY.
6. Mike, R. L. and Marta, P. (2006), Physical Processes in Earth and Environmental Sciences, Blackwell publishers, New Jersey.
7. Saxena, H. M. (2006) Environmental Studies, Rawat Publications, Bengaluru, India.
8. Roger, D. M. and Lawrence, R. W. (2007), Environmental Disasters, Natural Recovery and Human Responses, Cambridge.
9. David H. and Tim S. (2010), Earth Environments - Past, Present and Future, Wiley -Blackwell, New Jersey.
10. Peter, S., Kenneth, A. and Kenneth A. (2012), Fundamentals of the Physical Environment, Rutledge, USA.

ESW1C03 – ENERGY AND ENVIRONMENT

Number of Credits: 3

Course Outline

Module I: Energy basics

Laws of thermodynamics; Forms and types of energy; Energy resources classification - perpetual, renewable and non - renewable; conventional and non- conventional; secondary energy sources; sun as source of energy, nature of its radiation, thermal dynamics of earth system, solar constant, distribution of solar radiation across various atmospheric levels, ecologically important radiations, energy flow in Ecosystems.

Module II: Non-renewable energy resources:

Coal, oil, natural gas, heavy radioactive elements; formation of fossil fuels in the geological time scale, India's non- renewable energy reserves and usage pattern; world's energy reserves and consumption; Non-renewable energy usage and limitations, role of fossil fuels in modern economy, Environmental impacts of fossil fuels exploitation and utilization.

Module III: Renewable energy resources

Biomass, wind, hydroelectric, ocean, geothermal; Secondary energy resources - electricity, hydrogen;

Alternate energy resources; Renewable energy usage, limitations and scope; modern techniques for energy resource recovery using microbes, solar collectors, photovoltaics, solar ponds, nuclear-fission and fusion, Magneto- Hydrodynamic Power (MHD) and biomass gasification.

Module IV: Nuclear energy generation and environmental safety

Radioactivity from nuclear reactors, fuel processing and radioactive waste, hazards related to power plants, dose from environment and nuclear radiations, pathways analysis and dose assessment, radioactivity risk assessment, criterion for safe exposure.

Module V: Energy production and impacts on environment

Degradation of air, water and land; Important multipurpose power projects and environmental issues in India; Energy use pattern in different parts of the world and its impact on the environment; energy utilization in urban and rural contexts; Sustainable energy management, problems and solutions; Energy crisis and challenges of energy transformation; Energy conservation measures for sustainable development.

Reference

1. Walters, C. (1986), Adaptive Management of Renewable Resources, Macmillan Publishing Company, New York.
2. John, C., Sawhill, H. and Richard, C. (1986), Energy Conservation: Successes and Failures, Brookings Institution Press, Washington DC.
3. Widell J. W., Weir, A. D. (1986), Renewable Energy Resources, E & F N Spon Limited, London.
4. Goldemberg J., Johansson, T. B., Reddy, A. K. N. and Williams, R. H. (1988), Energy for Sustainable World, Wiley Eastern Ltd, New Delhi.
5. Joan, S. (1992), Getting to Know About Energy: In School and Society, Falmer Press, London.
6. IDRC (1993), AGENDA 21: Green Paths to the Future, International Development Research Centre, Ottawa.
7. Gilbert, M. M. (1997), Introduction to Environmental Engineering and Science (2nd Edition), Prentice Hall, New Jersey, USA.
8. Mittal, K. M. (1997). Non - conventional Energy Systems: Principles, progress and prospects. Wheeler Publications, Chennai.
9. Falmer, P., Elliot, D. (2003), Energy, Society and Environment, Technology for a Sustainable Future, Rutledge, USA.
10. Robert A. R. and Jack P. K. (2005), Energy and the Environment, Wiley Eastern Ltd, New Delhi.

ESW1C04 – ENVIRONMENTAL POLLUTION AND WASTE MANAGEMENT

Number of Credits: 3

Course Outline

Module 1: **Fundamental Concepts**

(A basic understanding only expected), Chemical equations and Stoichiometry, Chemical Kinetics - Control of reaction - First, second and zero order reactions, Thermodynamics - Energy, enthalpy, entropy - Gibbs energy and chemical potential, Chemical equilibria, Acid-base equilibria, Redox reactions and redox potential, Radio-nucleides, unsaturated and saturated hydrocarbons.

Module II: Environmental pollution

Pollution - physical, chemical and biological; radio nuclides, Electromagnetic radiations, Electro-smog, noise and light pollution; sources - industrial, commercial, domestic etc.; Industrial process and their pollution potentials - mining, smelting, cement production, petroleum refining, thermal power plants, pulp and paper, tannery, dairy, textile dyeing and bleaching.

Module III: **Chemistry of Air**

History of evolution of the earth's atmosphere, Role of chemical constituents in atmospheric processes (Water, COx, NOx, SOx, O2 & Ozone). Air pollution: Particulate matter - Respirable and irrespirable, inorganic and organic species in PM; gaseous pollutants (CO, SOx & NOx), secondary air pollutants, organic air pollutants, volatile organic pollutants; Green-house gases, greenhouse effect and climate change, Ozone layer - Chemistry of the ozone layer - ozone depletion and the chemicals that cause ozone depletion, Photochemical smog - origin and occurrence, Oxidizing and reducing smog - ecological effects, Acid rain and its ecological effects, trans-boundary air pollution; Meteorological factors affecting air pollutants, diffusion, turbulence and transportation, plume rise and stability conditions, Wind roses; Effects of pollutants on human beings, plants, animals, materials and climate; Ambient air quality standards. Pollution monitoring methods and pollution abatement: Air quality monitoring techniques - high volume air samplers, stack samplers, measurement of PM, gaseous pollutants.

Module IV: **Chemistry of Water**

Composition and structure of pure water, Physical properties of water and aqueous solutions, Solubility of solids, liquids and gases in water , Chemical reactions and equilibria in water–carbonate equilibria, metal ion equilibria, redox equilibria, Water pollution: Physical and chemical properties of water; pollution of water resources, types and sources, solids and turbidity, alkalinity, acidity, salinity, hardness, nutrients, fluoride, heavy metals, organic pollutants, oxygen demanding wastes, (COD, BOD,DO), persistent organic pollutants (DDT, PCBs, PAHs, Dioxin) etc. Pollution monitoring methods and pollution abatement: Water, soil and

biological sample analysis for parameters such as dissolved and suspended solids, BOD, COD, turbidity, hardness, chloride, phosphate, sulphate, nitrogen compounds, heavy metals, pesticides, oil and grease etc. Wastewater and its treatment: water as a scarce natural resource, sources of water pollution; Introduction to wastewater treatment and waste management.

Module V: **Chemistry of soil**

Introduction, weathering and pedogenesis, factors of soil formation, development of soil profile, structure of soil, gross composition- texture and structure, organic and inorganic components of soil, physico-chemical characteristics of soil, ion-exchange and adsorption processes in the soil, classification of types of soil (Reference to India and Kerala),soil quality parameters and assessment, method of analysis of texture (International pipette method).Soil pollution: macro and micro pollutants in soil, heavy metals, radionuclides, agrochemical pollutants (fertilizers, pesticides, animal wastes),industrial wastes (oil drilling, coal fired power plants, mining), municipal solid wastes, biomedical wastes.

Module VI: **Solid wastes**

Definition, types, source, categories, generation rates; Indian and International scenario; Waste management approaches (collection, segregation and transport of solid wastes); handling wastes at source, domestic, municipal solid wastes; Hazardous wastes; Biomedical wastes; Nuclear wastes; Environmental impacts of wastes; recycling of wastes and waste minimization techniques; solid waste processing technologies, mechanical and thermal volume reduction; biological and chemical techniques for energy and other resource recovery; Introduction to the concepts of waste biomass resources, utilization of organic manure; waste and earthworms, vermicomposting - the concept, advantages and phases; case studies / success stories in India for management of different types of solid wastes.

Reference

1. Abbasi, S. A. (1998), Environmental Pollution and its Control, Coent International, Pondicherry, India.
2. Shaw, I. C. and Chadwick, J. (1997), Principles of Environmental Toxicology, Taylor & Francis Ltd., Bengaluru, India.
3. Gilbert M. M. (1997), Introduction to Environmental Engineering and Science (2nd Edition), Prentice Hall, New Jersey, USA.
4. Connell, D. W. (1997), Basic Concepts of Environmental Chemistry, Lewis Publishers, New York.
5. Freeman, H. M. (1998), Standard Book of Hazardous Waste Treatment and Disposal, McGraw Hill, New York.
6. David, H. F. and Bela, G. L. (2000), Air Pollution, Lewis Publishers, Boca Raton, FL.
7. Robert, U., Ayres, Leslie, A. (2002), A Handbook of Industrial Ecology, Edward Elgar Publishing Limited, Cheltenham, UK.
8. Mirsal, I. A. (2004), Soil Pollution, Springer Publications, New York.

9. Marquita, K. H. (2004), Understanding Environmental Pollution (Second edition), Cambridge University Press, New York.
10. Manahan, S. E. (2004), Environmental Chemistry, Lewis Publishers, New York.
11. Lawrence, K. W., Yung-Tse, H., Howard, H. L., Constantine, Y., Kathleen, H. L. (2005), Handbook of Industrial and Hazardous Wastes Treatment (Second Edition), Marcal Dekker Inc., New York.
12. Crittenden, J. C. et al (2005), Water Treatment - Principles and Design (Second Edition), John Wiley & Sons, New York.
13. Bailey, R. A. et al (2005), Chemistry of the Environment, Academic Press, Cambridge, UK.
14. Shilpa, S., Verma, H. N., Bhargava, S. K. (2006), Air Pollution and Its Impact on Plant Growth, New India Publishing Agency, New Delhi.
15. Ira, S. R. (2008), Principles and Practices of Toxicology in Public Health, Jones and Barlett Publications, Massachusetts, USA.

ESW1C05 – PRACTICAL - I

Number of Credits: 2

Course Outline

1. Methods of sampling and preservation of water.
2. Physico-chemical analysis of water - colour, temperature, turbidity, conductivity, salinity, pH, free carbon dioxide, alkalinity, acidity, Dissolved Oxygen (DO), BOD, COD, TS, TDS, TSS, total hardness, calcium, magnesium, chloride, iron and manganese(colorimetric method), nitrate, nitrite and total nitrogen, phosphate, sulphate, oil and grease, detergents and other parameters determining water quality.
3. Estimation of Na and K in water using Flame Photometry.
4. Estimation of Fluoride and Arsenic content in water using analytical / instrumental methods.
5. Analysis of heavy metals (As, Hg, Pb, Cd etc.) in water using instrumental methods.
6. Estimation of microbiology of water (Coliforms and other Pathogenic groups) using standard methods.
7. Assessment of micro algal / phytoplankton / zooplankton diversity associated with water and estimation of their numerical strength using standard methods.
8. Drainage Basin Analysis - Generation of drainage density and drainage frequency maps.
9. Collection and testing of ground water quality.
10. Inclusion of other innovative methods other than those listed above in the area of water quality assessment.

ESW1C06 – PRACTICAL - II

Number of Credits: 2

Course Outline

1. Collection and morphological analysis of rock types.

2. Methods of sampling and storage of soil/sediment.
3. Determination of physical and chemical properties of Soil; Analysis of pH, N, P, K, TOC, CEC, Fertility value, Soil moisture, Soil texture, Porosity, Bulk Density, Elasticity and Permeability – Infiltration rate.
4. Sieve analysis of sediments, pipette analysis, pebble classification.
5. Analysis of pesticide content in soil / sediment samples (instrumental methods)
6. Estimation of soil biota using standard methods.
7. Air quality – Analysis of Suspended Particulate Matter, Analysis of gaseous components like oxides of carbon, nitrogen, sulphur etc. in ambient air.
8. Assessment of wind velocity; Wind rose analysis
9. Collection of meteorological data and its analysis; Climatograph
10. Assessment of population / community structure using various sampling methods. Estimation of frequency, Density, Abundance, IVI etc. using standard methods.
11. Assessment of biotic interactions like Neutralism, Commensalism, Mutualism, Proto co-operation, Parasitism, Predation etc.
12. Assessment of primary and secondary production in aquatic and terrestrial ecosystems.
13. Evaluation of communities and assessment of diversity indices.
14. Segregation and analysis of solid waste.

ESW1A01 – ENVIRONMENTAL RESEARCH METHODOLOGY – SPECIAL COURSE

Number of Credits: 2

Course Outline

Module I: Concepts of Research

Basic concepts of research - Meaning, Objectives, Motivation and Approaches. Types of Research (Descriptive/Analytical, Applied/ Fundamental, qualitative/Quantitative, Conceptual/Empirical, Serendipity, Research methods versus Methodology, Research and scientific method. Research Process.

Module II: Research Formulation

Research formulation - Observation and Facts, Prediction and explanation, Induction, Deduction. Defining and formulating the research problem, Selecting the problem and necessity of defining the problem. Literature review - Importance of literature reviewing in defining a problem, Critical literature review, Identifying gap areas from literature review. Hypothesis - Null and alternate hypothesis and testing of hypothesis.

Module III: Research Design

Research Design - Basic principles, Meaning, Need and features of good design, important concepts. Types of research designs. Development of a research plan - Exploration, Description, Diagnosis, Experimentation, determining experimental and sample designs. Important experimental designs.

Module IV: Sampling

Sampling: Definition, purpose, principles and advantages of sampling. Unit of sampling, population: techniques, characteristics of good samples, Sampling errors and ways to reduce them.

Module V: Data Collection

Data Collection Experiments and surveys, Data collection techniques, collection of primary data, data through questionnaires, data through schedules, secondary data, selection of appropriate method for data collection, case study method.

Module VI: Scientific Documentation and Communication

Research report writing (Thesis and dissertations, Research articles, Oral communications). Project proposal writing Presentation techniques - Assignment, Seminar, Debate, Workshop, Colloquium, Conference Abstract, synopsis, summary. Referencing methods. Ethics in reporting research: data errors and plagiarism. Checking documents for plagiarism.

Module VII: Information Science, Extension and Ethics

Sources of Information - Primary and secondary sources. Library - books, journals, periodicals, reference sources, abstracting and indexing sources, Reviews, Monographs, Patents. Internet -Search engines and software, online libraries, e-Books, Encyclopedia, Institutional Websites. Intellectual Property Rights - Copy right, Designs, Patents, Trademarks, Geographical indications. Safety and precaution - ISO standards for safety, Lab protocols, Lab animal use, care and welfare, animal houses, radiation hazards. Extension: Lab to Field, Extension communication, Extension tools. Bioethics: Laws in India, Working with man and animals, Consent, Animal Ethical Committees and Constitution.

Reference

1. Ahuja, R. (2001), Research Methods, Rawat Publication, Jaipur.
2. Earl, R. B. (2010), The Basics of Social Research, Wadsworth Publishing, California, USA.
3. Denscobe, M. (2017). The Good Research Guide for Small Scale Social Research Projects, Viva Books, New Delhi.
4. Devendra, T. (2009), Research Methodology in Social Science, Deep & Deep Publications, New Delhi.
5. Gurumani, N. (2006), Research Methodology for Biological Sciences, MJP Publishers, Chennai.
6. Holmes, D. (2010), Research Methods for the Biosciences, Oxford, New York.
7. Kothari, C. R. (2014), Research Methodology-Methods and Techniques, New Age, Kerala.
8. Levin, R., Rubin, D. S, (2008), Statistics for Management, Dorling Kindersley Pvt. Ltd., Noida, India.
9. Mohankuma, P. S. (2001). Handbook on Research Methodology, Right Publishers, Kudanechoor, Kerala.
10. Narwal S. S. D. and Singh, J. P. (2004), Research Methods in Plant Science, Allelopathy Vol. 1. (Soil Analysis) Scientific Publishers, Jodhpur, India.

SEMESTER II

ESW2C07 – FUNDAMENTALS OF ENVIRONMENTAL ENGINEERING

Number of Credits: 3

Course Outline

Module I: Introduction to Environmental Engineering

Concepts, characteristics of environmental engineering, civil engineering and environmental engineering, ecological principles and environmental engineering, public and environmental health; ethics in environmental engineering; concepts of industrial ecology and its applicability in environmental engineering.

Module II: Environmental engineering and water pollution

Sources of water pollution, pollutant dynamics in environment, aquatic ecology, self-purification; measurement of water pollution, water quality parameters, water pollution treatment (primary, secondary and tertiary, constructed wetlands), reduction, reuse and recycling techniques. Anaerobic, aerobic process, methanogenesis, bioreactors, cell and protein (enzyme) immobilization techniques; Treatment schemes for waste water, dairy, distillery, tannery, sugar, antibiotic industries;

Module III: Environmental engineering and Solid waste

Solid waste characterization, dynamics of wastes in environment, management of solid waste (end of the pipeline techniques, management at the origin) and disposal of wastes; reduction, reuse and recycling techniques. Treatment methods (composting, incineration, pyrolysis, sanitary landfills); Waste disposal in landfills (site selection, design, and operation of sanitary landfills, secure landfills and landfill bioreactors); leachate and landfill gas management; landfill closure and post-closure environmental monitoring; landfill remediation).Legislation on management and handling of municipal solid wastes, bio-medical wastes and hazardous wastes, Vermi composting and vermi-technology.

Module IV: Environmental engineering and Air pollution

Air pollution characterization, pollutant dynamics in environment, management of air pollution (end of the pipeline techniques, management at the origin) and disposal of wastes; reduction, reuse and recycling techniques.

Module V: Environmental engineering and physical pollution

Physical pollution (noise, radiation, light), pollutant dynamics in environment, management of physical pollution (end of the pipeline techniques, management at the origin) and control techniques.

Reference

1. Gilbert, M. M. (1997), Introduction to Environmental Engineering and Science (2nd Edition), Prentice Hall, New Jersey, USA.

2. Brimicombe A. (2003), GIS, Environmental Modeling and Engineering, Taylor & Francis, London.
3. Ruth F. W. and Matthews, R. (2007), Environmental Engineering (4th Edition). Butterworth-Heinemann, Oxford, UK.
4. Butterworth H., Glenn, O. S., Delmar D. F., William, J. E. and Richard K. F. (1992), Soil and Water Conservation Engineering, John Wiley & Sons, New York.
5. Vesilind P. A. (1997), Introduction to Environmental Engineering, PWS Publishing Company, Boston.
6. Stanley E. M. (1999), Industrial Ecology: Environmental Chemistry and Hazardous Waste (1st edition), CRC Press, Boca Raton, Florida.
7. Robert U. A., Leslie, A. (2002). A Handbook of Industrial Ecology, Edward Elgar Publishing Limited, Massachusetts, USA.
8. George T., Franklin, L., Burton and Stensel H. D. (2003), Waste Water Engineering - treatment and re-use (4th Edition), Metcalf & Eddy Inc., Tata McGraw Hill, New Delhi.

ESW2C08 – ENVIRONMENTAL MICROBIOLOGY AND BIOTECHNOLOGY

Number of Credits: 3

Course Outline

Module I: Scope and history of Environmental Microbiology

Characteristics, classification, identification and morphology of microorganisms. Microbial world: Bacteria, Archaea, Fungi, Algae, Virus, Protozoa. Identification of microorganisms – Direct microscopic examination, culture characteristics, biochemical and physiological properties, Antibiotic sensitivity testing, serological methods, Phage typing, protein analysis, comparison of nucleotide sequences.

Module II: Environmental Microbiology

Physiological status of microorganisms in the environment. Organic substrate use by microorganisms, Microbes in air, water and soil. Microorganisms in extreme environments, Foreign derived microorganisms- Survival and fate, genetically engineered microorganisms- fate and effects.

The aquatic microorganisms. Nature of marine and fresh water environments, Biofilms and Microbial mats, Water and disease transmission, Microbial analysis of water quality.

The environment of soil microorganisms, Microbial diversity in soil, biogeochemical role of soil microorganisms. Biodegradation of herbicides and pesticides. Soil microorganisms associated with plants. Soil microorganism's interactions with the atmosphere, the role and importance of microbial ecosystems, biogeochemical transformation.

Module III: Environment Biotechnology

Principles and scope, Role of biotechnology in Environmental Protection, biotechnology in industrial pollution control–Paper industries, Textile Industries, Petrochemical Industries, Leather Industries and Mining Industries.

Module IV: Emerging trends in Environment Biotechnology

Agro – biotechnology – Bio- pesticides and Bio-fertilizers; Ecological Engineering-Aquatic macrophyte based wastewater treatment systems (AMATS)-constructed/artificial wetlands, Nutrient film techniques (NFT), Municipal solid waste management, Role of composting and vermicomposting; Biodegradable plastics – Biopolymers-PHBs and PHAs, Phyto – reactors-Plants used to produce genetically engineered products

Module V: Biotechnological Methods in Pollution Control

Air pollution control: Bio scrubbers, biofilters and membrane bioreactors. Bio-desulphurization of coal. Green belts. Bioremediation: Soil/ land contaminated with oil spills, and synthetic organic compounds (xenobiotics) such as PCBs, PAHs. Bioremediation technology, bioremediation of marine oil spills. Phytoremediation. Biosensors. -Concept, principle, and development of biosensors. Biosensor's for environmental monitoring-BOD, ammonia, and nitrite.

Reference

1. Freeman, W. H. and Lynch, M. and Hobbie, J. E. (1988), Microorganisms in Action- Concepts and Applications of Microbial Ecology, Blackwell Scientific Publications, New Jersey, USA.
2. Claus, W. G. (1989), Understanding Microbes A Laboratory Text Book for Microbiology, W. H. Freeman, New York.
3. Prescott, L. M., Harley, J. P. and Klien, D. A. (1993), Microbiology, WCB Publishers, Dubuque, Iowa, USA.
4. Pelczar, M. J., Reid, R. and Chan, E. C. S. (1996), Microbiology, Tata Mc-Graw Hill Publishing Co Ltd, New Delhi.
5. Abbasi, S. A. (1998), Environmental Pollution and its Control, Coent International, Pondicherry, India.
6. Abbasi, S. A. and Ramaswamy, E. V. (1999), Biotechnological Methods of Pollution Control, Universities Press India Ltd, Hyderabad.
7. Ogilvie, L. A., Hirsch, P. R. (2012), Microbial Ecological Theory: Current Perspectives, Caister Academic Press, Poole, UK.

ESW2C09 – HYDROLOGY AND WATER RESOURCE MANAGEMENT

Number of Credits: 3

Course Outline

Module I: Introduction to hydrology

Definition, History of hydrology, Branches of hydrology - Chemical hydrology, Eco-hydrology,

Hydrogeology, hydro-informatics, hydrometeorology, isotope hydrology, surface hydrology.

Module II: The hydrologic cycle

Structure and properties of water, Inventory of Earth's water; different process of hydrologic cycle - precipitation, Canopy interception, snow melt, run off, sub surface flow, infiltration, evaporation, transpiration, sublimation, advection, condensation.

Module III: Surface water resources

Precipitation, infiltration, water balance, Evapo- transpiration and runoff; Drainage basin, Surface water hydrology - rainfall and surface runoff relationship, runoff, runoff characteristics, open channel flow; Statistical analysis in hydrology, Probable maximum precipitation, hydrograph, flow duration curve, Flood frequency analysis and estimation, Water balance.

Module IV: Groundwater resources

Rock properties affecting ground water, vertical distribution of ground water, zone of saturation; Darcy's law -permeability, transmissivity and storage coefficient; Viscous character of groundwater flow; Geologic formations as aquifers, type of aquifers; Distribution of water - local, regional and global; Ground water exploration.

Module V: Water resource management

Flood and flood plain management; Water-shed management, water harvesting and artificial recharge to ground water; water pollution and water treatment; Wetland and riparian management; forest management and water resources; Issues concerned with river linking in India.

Reference

1. Aggarwal, A. (1991), Floods, Floodplains and Environmental Myths, Centre for Science and Environment, New Delhi.
2. Andrew, D. W. and Stanley, T. (2004), Environmental Hydrology (2nd Edition), Lewis Publishers, Boca Raton, Florida.
3. Karanth, K. R. C. (1988), Ground Water: Exploration, Assessment and Development, Tata-McGraw Hill, New Delhi.
4. Mahajan, G. (1989), Evaluation and Development of Groundwater, Ashish Publishing House, New Delhi.
5. Rao, K. L. (1982), India's Water Wealth, Orient Longman, Delhi.
6. Subramaniam, V. (2002), Text Book of Environmental Science, Narosa Publishing House, Delhi.
7. Timothy, D. (2003), Fundamentals of Hydrology, Rutledge, Taylor and Francis Group, U.K.
8. Todd, D. K. (2004), Groundwater Hydrology, John Wiley & Sons Inc., New York.
9. Vijay, P. S. (1995), Environmental Hydrology, Kluwer Academic Publications, The Netherlands.
10. Wright, R. T. and Nebel, B. J. (2002), Environmental Science: Toward a Sustainable Future, Prentice Hall India Ltd, Delhi.

ESW2C10 – REMOTE SENSING AND GIS

Number of Credits: 3

Course Outline

Module I: Fundamentals of Environmental Appraisal Tools

Scales-Definition, types of scales, representation and conversion (introduction only),Maps-Definition and classification, Map conversions (Grids, Contours, Isobars, etc.),Measurements of area and distance (Square and Plannimeter Methods),Topographical Maps, Cadastral maps, Toposheets (Interpretation and studies),Surveying-Definition and classification, Survey instruments (Introduction to Compass, Theodolite, Clinometer, Abeny Level, Cartographic equipments), Preparation of maps (Basics of cartography), Photogrammetry- Definition and types (Aerial and terrestrial photographs), Method and equipments used in Aerial Photo Interpretation (Introduction only).

Module II: Remote Sensing

Introduction- Definition, History and Scope of Remote Sensing, Meaning and Scope of remote Sensing, Indian Remote sensing Programs.

Module III: Remote Sensing

Electromagnetic Spectrum, Sensors and Platforms, Types of platforms, scanners and data products, Image processing, Photo-interpretation and Photogrammetry, Applications of remote Sensing

Module IV: Geographical Information System (GIS) I

History and Development, Concepts, Components and organization of GIS, Introduction to mapping and GIS, Remote Sensing, GPS and GIS.

Module V: Geographical Information System (GIS)II

Fundamentals of computing GIS, Theory of GIS, Spatial Data concepts, Processing and visualization, Information analysis and digital data processing, Introduction to GIS packages, Geographical analysis, Applications of GIS.

Reference

1. Begni, G. and Richard, E. (2005), Remote Sensing: a Tool to Monitor and Assess Desertification, Les dossiers thématiques du CSFD, France.
2. Daplyn, P., Cropley, J., Treagust and Gordon, A. (1994). The Use of Geographical Information Systems in Socio-economic Studies, The Natural Resources Institute, Central Avenue, Chatham, UK.
3. Donnay, J. P., Barnsley, M. J. and Longley, P. A. (2001), Remote Sensing and Urban Analysis, Taylor & Francis, London.
4. Franklin, S. E. (2001), Remote Sensing for Sustainable Forest Management, Lewis Pub, London.

5. Haynes, R. (1982), Environmental Science Methods, Chapman and Hall, London.
6. Heywood, I., Cornelius, S. and Carver, S. (1998). An Introduction to Geographical Information Systems. Pearson education Ltd., New Delhi.
7. Janwar, M. L. and Chouhan, T. S. (1998). Remote Sensing and Photogrammetry, Vijayan Prakashan, Jodhpur.
8. Jha, V. C. (2000), Geomorphology and Remote Sensing, ACB Publications, Calcutta.
9. Khan M. Z. A. (1998), Test Book on Practical Geography. Concept Pub. Co. New Delhi.
10. Khna, N. (1998), Quantitative methods in Geographical Research, Concept Pub Co. New Delhi.

ESW2C11 – PRACTICAL - III

Number of Credits: 2

Course Outline

1. Analysis of waste water for major physico-chemical parameters.
2. Analysis of the impact of air pollutants on biological systems.
3. Analysis of the microbiology of ambient air.
4. Analysis of the physical properties of solid waste which include specific weight, moisture content, field capacity etc.
5. Analysis of chemical properties of solid waste (proximate analysis) like loss of moisture, volatile combustible matter, fixed carbon, ash, elemental analysis, energy content etc.
6. Basic techniques in microbiology, Sterilization techniques.
7. Culture media preparations.
8. Isolation techniques: serial dilution, plating.
9. Identification of bacteria and fungi from environmental samples: physiological and biochemical methods.
10. Staining – Simple and Gram's, spore staining, Negative staining
11. Microscopic counting of microbes using haemocytometer.
12. Measurement of microbes using ocular and stage micrometer.
13. Estimation of coliform bacteria in water by MPN method.
14. Estimation of microbial count in soil and water.
15. Enumeration and identification of microbes and determination of their motility
16. THB load of microorganisms in different environmental samples.
17. Determination of potability of water using coagulant demand, chlorine demand and residual chlorine.
18. Estimation of synthetic organic compounds (xenobiotics) in water and soil /sediment samples
19. Visit to an industry / plant having pollution control (air, water, soil) facilities and submission of a report.

ESW2C12 – PRACTICAL - IV

Number of Credits: 2

Course Outline

1. Identification of rocks and minerals
2. Study of topographic maps – identification of scale, latitude and longitude,
3. Study of various geomorphic and environmental features in the maps
4. Interpretation of aerial photos using stereoscopes
5. Identification of various geomorphic and environmental features and the preparation of various thematic maps
6. Interpretation of satellite imageries
7. Brief description of the important geomorphic and environmental features
8. Preparation of photogeologic maps
9. Map digitization and analysis.
10. Working with GPS devise
11. Creating Geodatabase
12. Editing spatial data
13. Editing attribute data
14. Image enhancement and filtering techniques
15. Image subset and image mosaic
16. Image classification
17. Map creation.
18. Drainage Basin Analysis - Generation of drainage density and drainage frequency maps.
19. Application of RS/GIS techniques in water resource management

ESW2A02 – ENVIRONMENTAL ALAYTICAL TECHNIQUES AND INSTRUMENTATION – SPECIAL COURSE

Number of Credits: 2

Course Outline

Module I: Analytical Techniques and Instrumentation - I

Gravimetric Methods - Principle and application of gravimetric methods in determination of total, dissolved, suspended, volatile and fixed solids present in water and waste water. Estimation of moisture content of soil, phytomass, compost and vermi-compost using moisture balance

Volumetric Methods - Importance of volumetric analysis. - Standardization of reagents using volumetric titrations

Electrochemical Methods - pH meters, Glass and reference electrodes - Ion selective electrodes- Electrical

conductivity measurements: Conductivity Meters

Photometric methods- Principle and applications of colorimetry, Nephelometry and Turbidometry – Spectrophotometry - Optical design of filter photometer, single beam spectrophotometer, double beam – UV – Visible – Spectrophotometer - Flame photometry (FP) - Atomic Absorption Spectrophotometry (AAS), Magnetic Resonance spectroscopy (NMR) - X-ray Fluorescence - X-ray Diffraction

Dosimetry - Geiger Muller Counter - Scintillation counter.

Module II: Analytical Techniques and Instrumentation - II

Chromatography - Paper chromatography- Thin layer chromatography - Column chromatography - Gas liquid chromatography- GC-MS- High Performance Liquid Chromatography (HPLC)

Electrophoresis - Gel electrophoresis - Immuno electrophoresis (ELISA, Blotting Techniques, RFLP, etc.)

Microscopy - Light microscope, Bright field, Dark field, Phase contrast and Fluorescent microscope - Electron Microscopy - Transmission Electron Microscope (TEM) and Scanning Electron Microscopy (SEM)

Module III

Flow Cytometry, Micrometry Microtechniques - Fixation, Sectioning, Histological and histochemical staining

Module IV

Centrifugation - Basic principles of sedimentation, Types of centrifuges, Analytical and Preparative centrifugation, Differential and density gradient centrifugation.

Reference

1. Rump, H. H. and Krist, H. (1998), Laboratory Manual for the Water, Wastewater and Soil, VCH Publishers, New York.
2. Skoog, D. A. and Leary, J. J. (1992). Principles of Instrumental Analysis, 4thedn., Saunder's College Publishing, Fortworth, USA.
3. Stanley, E. M. (2004), Environmental Chemistry, CRC Press, Boca Raton, Florida.
4. Bour, E. J. (1982), Introduction to Chemical Instrumentation, 4th edition, Wiley and Sons, NY.
5. Christian, G. D. (2001), Analytical Chemistry, 5th edition, John Wiley and Sons Inc., India
6. Khopkar, S. M. (1993), Environmental Pollution analysis, Wiley Eastern Ltd., New Delhi.
7. Manahan, S. E. (2007), Environmental Chemistry, 7th edition, Lewis Publications, Florida, USA.
8. Manly, (2001) Statistics for Environmental Science and Management, Chapman and Hall / CRC Press, Boca Raton, FL, USA.
9. Vogel, A. I. (1998), Quantitative Analysis, 6th edition, Prentice Hall Inc., New Jersey, USA.
10. Willard, H. H., Merritt L. L. and Dean, J. A. (1976), Instrumental Methods of Analysis, 5th edition, Van Nostrand Reinhold.

SEMESTER III

ESW3C13 – ENVIRONMENTAL ASSESMENT TOOLS AND MONITORING METHODS

Number of Credits: 3

Course Outline

Module I

Quantitative and qualitative depletion of environmental resources, Methods of resource analysis. Monitoring of environmental resources.

Module II: Basics of Environment Impact Assessment (EIA) and Risk Assessment (RA)

Concept of EIA, Evolution of EIA, EIA practice in India, EIA Notifications 1994, 1997 2009; Other related notifications; Project Screening in EIA, defining and examining scope, objectives and alternatives in EIA Projects, project planning and processes, baseline information, Impact prediction, decision making; cumulative impact assessments, strategic impact assessments.

Module III: Types of EIA

Rapid EIA, comprehensive EIA, strategic EIA, data collection, ecological impacts, environmental impacts (Air, water, land and noise), socioeconomic and cultural impacts, health impacts, prediction of impacts; methodologies, cost benefit analysis, Environmental Management Plan (EMP).

Module IV: Environmental Impact Statements

Preparation and contents of Environmental Impact Statements (EIS); Reviewing EIA/EIS; Use of EIA in public participation and decision making; EIA in sustainable development. EIA - case studies: mining projects, hydroelectric projects, nuclear power projects, thermal power projects, refineries etc.

Module V: Fundamental Statistics

Introduction-Importance and limitation; Classification and tabulation of data; Graphical representation; Measures of central tendencies- mean median and mode; Measures of dispersion- range, standard deviation and co-efficient of variation; Moments, Skewness and Kurtosis; Limit theorems: Central limit theorem, Strong Law of large number, Weak Law of large number. Correlation and regression- Scatter diagrams-Karl Pearsons coefficient of correlation-Rank correlation-Linear and Curvilinear regressions; Probability- Basic probability and statistics, probability fundamentals, computation and laws of probability, fundamentals of inference; probability theory, sample space and events, axioms of probability, conditional probability, independent events, Bayes' formula; addition and multiplication theorems-Binomial, Poisson and normal distribution, Probit analysis (Graphic Method only); Testing of Hypothesis: Null and alternative hypothesis- Two types of error- Level of significance test based on t, z, Chi-square and analysis of Variance – one-way, two- way, three-way analysis(Computational only using softwares for data analysis like Excel, SPSS, Minitab and R

Module)

Module VI: Application of computers in statistics

Data analysis using packages-SPSS, Introduction to Database Management System (DBMS), Data structures in eco-informatics, Databases for eco-informatics, Web applications development in eco-informatics: Introduction to Internet, protocols, WWW, URL, Web Site, Web Browser, Web Server. Eco-informatics applications in Natural Resources Management, wildlife conservation and management, habitat suitability studies, habitat modeling in study of anthropogenic pressures on environment such as industrialization, urbanization and other threats.

Reference

1. Ludwig, J. A. and James F. R. (1988), Statistical Ecology, John Wiley & Sons, New York.
2. Gupta, S.P. (2004), Statistical Methods, Sultan Chand & Sons New Delhi.
3. Robert, R. S. and James, F. R. (1994), Biometry: The Principles and Practices of Statistics in Biological Research (3rd edition), W. H. Freeman, New York.
4. Zar, J. H. (1999), Biostatistical Analysis, Person Education, New Delhi.
5. Bowerman, B. L., Richard, T. O. and Michael, L. H. (2001), Business Statistics in Practice, McGraw-Hill Irwin, New York.
6. Harry, F and Steven, C. A. (1994), Statistics - Concepts and Applications, Cambridge, UK.
7. Frederick, E. C., Dudley, J. C. and Sidney, K. (1979), Applied General Statistics, Prentice Hall India, Delhi.
8. Richard, I. L. and David, S. R. (1997), Statistics for Management (7th Edition), Prentice Hall, New Jersey, USA.
9. Digby, P. G. N. and Kempton, R. A. (1991), Multivariate Analysis of Ecological Communities, Chapman and Hall, London
10. Friedrich, R. (2005), Ecological Informatics - Scope, Techniques and Applications, Springer, New York.

ESW3C14 – ENVIRONMENTAL TOXICOLOGY AND OCCUPATIONAL HEALTH AND SAFETY

Number of Credits: 3

Course Outline

Module I: Ecotoxicology as a synthetic science

major classes of environmental pollutants - inorganic, heavy metals, organics, organometallics, radioactive isotopes, gases; routes of entry into ecosystems - surface waters, land, atmosphere; long-range movement and global transport of pollutants; Fate of pollutants in ecosystems - biotransformation, bioaccumulation and biomagnification.

Module II: Toxicity testing:

Test organisms used in bioassays; Definition of toxicity, case studies (As, Hg problems); Concept of dosimetry - lethal, sub-lethal and chronic tests, dose response curves, LC50, MATC-NOEC, brief statistical methodology; toxicant effects - cellular, organismic, population and ecosystem-Level effects, global effects.

Module III: Biochemical effects of environmental contaminants

Environmental carcinogens, mutagens, asbestos, hormone mimics; Biomarkers and bio-indicators; metabolic impacts; biochemical parameters - enzymes, metabolites, structural changes, biosynthesis and catabolism of proteins, lipids, carbohydrates and nucleic acids, toxic response of different tissues and organelles, tissue specificity.

Module IV: Environmental health and safety

Concept of environment, health and safety; Diseases through pollution(Environmental contamination related diseases- Gastroenteritis, Hepatitis, allergies, respiratory diseases, food-borne diseases, vector borne diseases); Management to control diseases; Occupational health, health and safety considerations; Environmental health and human society, Health problems in different types of industries: Construction, textile, steel, food processing, tanneries, cement, thermal and nuclear power plants, pharmaceuticals; Occupational health and safety considerations in waste treatment plants.

Module V

Environmental health and occupational hygiene: Basis of environment and occupational health, biological monitoring (e.g. BEI), Occupational hygiene, preventive measures; Occupational health & safety management system, OHSAS – 18000.

Module VI: Safety and health management

Occupational health hazards, Promoting safety, Safety and health training, Stress and safety; Ergonomics- Introduction, Definition, Objectives, Advantages; Ergonomics hazards, Musculoskeletal disorders and cumulative trauma disorders; Importance of industrial safety, role of safety department, Safety committee and function.

Module VII: Environmental risk assessment and management

Perceived risks, real risks, hazard identification, hazard characterization, health risk assessment, risk management.

Reference

1. Rowland, A. J. and Cooper, C. (1983), Environment and Health, Edward Arnold Publishers Ltd, London.
2. Encyclopedia of Occupational Health & Safety (Vol. 1 & 2, 3rd Revised Edition), (1983), International Labour Organization, Geneva, Switzerland.
3. Jain, R. K. and Rao, S. S. (2006), Industrial Safety, Health and Environment Management Systems, Khanna publishers, New Delhi.

4. Slote, L. (1987), Handbook of Occupational Safety and Health, John Willey and Sons, New York.
5. Hayes, A. W. (1988), Principles and Methods of Toxicology (2nd edition), Raven press, New York.
6. Stewart, C. P. and Stolman A. (1960), Toxicology (Vol. I), Academic press, New York.
7. David A. W. and Pamela, W. (2002), Environmental Toxicology (1st edition), Cambridge Environmental Chemistry Series, Cambridge University Press, New York.
8. Newman, M. C., Lawrence C. A., and Unger M. A. (2002), Ecotoxicology: Fundamentals of Ecotoxicology (2nd Edition), CRC Press, Boca Raton, Florida.
9. Walker, C. H., Hopkin, S. P., Sibly, R. M. and Peakall, D. B. (2001), Principles of Ecotoxicology (2nd Edition), Taylor & Francis, London.
10. Moore, G. S. (2002), Living with the Earth: Concepts in Environmental Health Science (2nd Edition), Lewis publishers, Michigan.

ESW3C15 – BIODIVERSITY AND CONSERVATION

Number of Credits: 3

Course Outline

Module I: Natural resources

Ecological concepts related to natural resources, matter, energy; renewable and non-renewable resources; soil, water, plants, animals etc. Wetlands, water bodies, Forests; ecosystems services etc. Biodiversity concepts and patterns: organic evolution through geological time scale; Microbial diversity, Plant diversity, Soil biodiversity; Levels of biodiversity: Community diversity (alpha, beta and gamma biodiversity), Gradients of biodiversity (latitudinal, insular).

Module II: Biodiversity - scales

Ecosystems diversity - biomes, mangroves, coral reefs, wetlands and terrestrial diversity; Species diversity - richness and evenness; Genetic diversity: sub species, breeds, race, varieties and forms; benefits from biodiversity - direct and indirect benefits, Ecosystems services, Bio-prospecting; Biodiversity hotspots and their characteristics

Module III: Threats to Biodiversity

Habitat loss and fragmentation; disturbance and pollution; introduction of exotic species; extinction of species; human intervention and biodiversity loss: global environmental changes, land and water use changes; national and international programmes for biodiversity conservation; Biodiversity convention and biodiversity Act, IPRs.

Module IV: Biodiversity conservation

Conservation movements - International and National; ecologically relevant parameters (viable population, minimum dynamic area, effective population size, metapopulations); reproductive parameters in conservation

(breeding habitats, mating systems, inbreeding depression, genetic bottlenecks, genetic constraints); IUCN categories -endangered, threatened, vulnerable species; Red Data Book and related documentation; threatened plants and animals of India, ecosystems, people and traditional conservation mechanisms.

Module V: Ex-situ / in-situ conservation

Botanical gardens, Zoos, Aquaria, Homestead garden; Herbarium; In-vitro conservation – Germplasm and Gene bank; Tissue culture - Pollen and spore bank, DNA bank; Wildlife values and eco-tourism, wildlife distribution in India, problems in wildlife protection, organizations involved in conservation (WWF, WCU,CITES, TRAFFIC etc.), Wildlife Protection Act 1972; In-situ conservation: sanctuaries, biospheres reserves, national parks, sanctuaries and nature reserves, preservation plots.

Reference

1. Daly, G. C. (1997), Nature's Services: Societal Dependence on Natural Ecosystems, Island Press, Washington D.C.
2. Dobson, A. P. (1996), Conservation and Biodiversity, Scientific American Library, New York.
3. Gaston, K. J. and Spicer, J. I. (1998), Biodiversity - An Introduction, Blackwell Science, London.
4. Groom, B. B. and Jenkins, M. (2000), Global Biodiversity: Earth's Living Resources in the 21st Century, World Conservation Press, Cambridge, UK.
5. IUCN (2004), Red List of Threatened Species - a Global Species Assessment, IUCN, Gland, Switzerland
6. Loreau, M. and Inchausti, P. (2002), Biodiversity and Ecosystem Functioning: Synthesis and Perspectives, Oxford University Press, Oxford.
7. Primack, R. B. (2002), Essentials of Conservation Biology (3rd Edition), Sinauer Associates, Sunderland, SA.
8. Pawar, S. N., Patil, R. B., and Salunkhe, S. A., (2005), Environmental Movements in India: Strategies and Practices, Rawat Publications, Jaipur.
9. Wilson Edward O. (1993), Diversity of Life, Harvard University Press, Cambridge, MA.
10. Klee, G. A. (1991), Conservation of Natural Resources, Prentice Hall, New Jersey.

ESW3C16 – ENVIRONMENTAL DISASTER MANAGEMENT

Number of Credits: 3

Course Outline

Module I: Disaster management system

Flood damage assessment, Environmental Impact Analysis, Trans-boundary air pollution, Site suitability assessment, Pollution monitoring and management, Vehicular pollution assessment, Prediction and forecasting.

Module II: Weather and climate

Climate science, thermal inversion, heat island, natural hazards: volcanoes, earth quake, tsunami, land slide, tornadoes, storms, hurricane and flood. Coastal erosion, Air pollution: sources and impacts, green-house gases; global warming, acid rain, ENSO, EL NINO, LA NINA, Climate change: Treaties and conventions - IPCC.

Module III: Forest protection and management

Objectives and principles; Introduction to silviculture and silvicultural systems; forest protection from fire, injuries by exotic and noxious plants, animals and shifting cultivation; forest cover monitoring.

Module IV: Hydrologic hazards

Earthquake, acid rain, eutrophication, flood, landslides, salt- water intrusion, avalanches, drought, desertification; Urbanization stress and health; Water in relation to human health: case studies.

Module V: Disaster Management

Concept and scope of disaster management / emergency management; Professional activities - Mitigation, preparedness, response, recovery, programme planning and management; Tools of disaster management - Forecasting and warning systems of disasters - Measurement of responses of disasters, Community reaction to disasters, Disaster management - Emergency Management Information Systems (EIMS). Phases of disaster management - Pre disaster phase, Actual disaster phase, Post disaster phase. Disaster assistance - Technological assistance, Relief camps, Camp layout, Food requirement, Water needs, Sanitation and Security; Environmental problems faced by India and the world; Sustainable development - problems and perspectives.

Reference

1. Nyle, C. B. (1996), Nature and Properties of Soil. Collier Macmillan International Editions, New York.
2. John, H. (2004), Global Warming: Complete Briefing. 3rd Ed., Cambridge University Press, New York.
3. Nicholas, S. (2007), The Economics of Climate Change: The Stern Review. Cambridge University Press, New York.
4. Andrew, E. D. and Edward, A.P. (2006), The Science and Politics of Global Climate Change: A Guide to the Debate. Cambridge University Press. New York.
5. Muller, R. N. and Donahue, R. L. (1996), Soils in our environment, Prentice Hall India, Delhi.
6. Mackenzie, A. and Sonia, R.V. (2002), Ecology Instant Notes by Viva Books Private Limited, New Delhi.

ESW3C17 – PRACTICAL - V

Number of Credits: 2

Course Outline

1. Toxicology tests (LC50)

2. Estimation of starch in biological specimens
3. Estimation of amino acids in biological specimens
4. Estimation of protein in biological specimens
5. Estimation of reducing and non-reducing sugars in biological specimens
6. Estimation of primary and secondary metabolites in biological specimens
7. Estimation of phenolic contents in biological specimens
8. Estimation of chlorophyll pigments in plant tissues
9. Analysis of heavy metals and pesticides in water, soil and biological specimens.
10. Comprehensive Environmental Impact Assessment of any project site.
11. Analysis of environmental data using selected statistical tools (Direct and computational)

ESW3C18 – PRACTICAL - VI

Number of Credits: 2

Course Outline

1. Identification of major fauna and flora of terrestrial, freshwater and marine ecosystems.
2. Identification of phytoplankton and zooplankton communities in fresh water and marine ecosystems.
3. Estimation of phytoplankton by Lacky's Drop Method.
4. Estimation of Zooplankton by Sedgwick-Rafter Cell method.
5. Estimation of primary productivity – Light and dark bottle method and effects of depth and light on primary productivity.
6. Community study: quadrat method for the estimation of frequency, density, abundance and IVI of flora and fauna; Studies by line / belt transect and other methods.
7. Estimation of species richness - Fish, Reptilian, Avian, Mammalian.
8. Assessment of various diversity indices.
9. Estimation of Similarity coefficients.
10. Mapping of disaster-prone areas and development of management plans
11. Students are required to undertake visits / arrange field studies in industries / research institutions / conservation areas (Biosphere reserves, national parks, wildlife sanctuaries, ecotourism sites) and heterogeneous ecosystems and to submit a report of the same.

SEMESTER IV

ESW4P01 – PROJECT / DISSERTATION

Number of Credits: 8

Course Outline

The student should undertake a Project / Dissertation work in the Department of Environmental Science of the

Christ College (Autonomous) or in an approved R& D institution outside, under the guidance of an authorized person, with prior permission from the Department / University. The research work undertaken by the student should be original, authentic and related to any field of Environmental Science. There will be an evaluation of the project work, by a committee, including subject expert from outside. The student has to undertake a viva-voce in connection with the evaluation of Project work / Dissertation.

ELECTIVE – 1

ESW4C19 – ENVIRONMENTAL PLANNING POLICIES AND MANAGEMENT

Number of Credits: 4

Course Outline

Module 1: Introduction

Basic principles of environment management, Environment planning and management, Environmental Audit, Environmental quality standards (ISO standards).

Module II: Environmental planning and management

Principles of EPM, Principles, concepts and scope of environmental planning, Ecological aspects of EPM, Steps in environmental planning, Identification and formulation of strategies of EPM, Environmental analysis and EPM, Physical planning in relation to environment and land-use classification, EPM fortown and urban lands, rural and agricultural lands, Lands reclaimed, Wetlands, Mining areas, Industrial areas, Transportation and urban planning.

Module III: Environmental Conventions and Summits

UNCED and its conventions on climate change, biodiversity, desertification, and tropical forests - Stockholm Convention, 1972 & Antarctica Convention; Ramsar Convention, Hague declaration-1989, Rio declaration - 1992 and Agenda 21, Rio+5, Rio+10 and Rio+20. Earth Summit, Kyoto Protocol, Montreal Protocol, Manila Declaration, Global Environment Monitoring System (GEMS).

Module IV: National and International Agencies

UNEP, UNDP, WWF, UNCED, IUCN, GEF &WCN, Earthwatch, other UN organizations, Co-operation on ozone layer, migratory species, wetlands, mangroves, oceans etc.

Module V: Information, education and communication

Environmental education and awareness, information networks- ENVIS centers, INFOTERA etc. Role of NGOs in the implementation of environmental policies, communication and management, various national and international NGOs; Peoples Participation and various movements for environmental protection.

Reference

1. World Commission on Environment and Development (1987), Our Common Future. World Bank: World Development Report (1992).
2. Christian, N. M. (2007), Environmental Planning and Management. Imperial College Press.
3. Edward, S. W., Jean G. S., (2004), Sustainable Strategic Management, M. E. Sharp Inc.
4. Gangstad, E.O. (1990), Natural Resource Management of Water and Land. Van Norstrand Reinhold. New York
5. William, E. G. et al. (2009), Ecology and Natural Resource Management.
6. Mitchell, B. (1997), Resource and Environmental Management, Addison Wesley Longman Ltd, Edinburgh.
7. Puma, B. K. (1994), Tourism Management: Problems and Prospects. Ashish Publishing House, New Delhi.
8. Ryding, S.O. (1994), Environmental Management hand book, IOS Press, Amsterdam.

ELECTIVE – 2

ESW4C20 – INDIAN ENVIRONMENTAL LAWS

Number of Credits: 4

Course Outline

Module I: Environmental ethics

Concepts, ethical theories, consequential theory, deontological theory, virtue ethics, situation ethics, feminist ethics, Illustration cases, DPGs, Bio-piracy, GMO, Stem cell research. Environment and constitution of India, Environmental legislature machinery, Constitutional status of environment, Duty to protect environment.

Module II: Major Indian environment / conservation related acts

Introduction to Water (Prevention and Control of Pollution) Act - 1974, Water (Prevention and Control of Pollution) Cess Act -1974, Wildlife (Protection) Act -1972, Forest (Conservation) Act -1980, Air (Prevention and Control of Pollution) Act -1981. The Environment (Protection) Act -1986, The Public Liability Insurance Act – 1991.

Module III: Laws on water and air pollution control

Powers of Central and State Pollution Control Boards, Prevention and control of Water Pollution, Closure or stoppage of water and electricity supply, Power of Central / State Governments to supersede the respective Central / State Boards; Air Pollution Control Areas, pollution control strategies, Prohibition of Emission of Air Pollutants.

Module IV: Environment (Protection) Act - 1986

Powers of Central Government, Legal Regulation of Hazardous Substance, Hazardous Wastes (Management and Handing) Rules - 1989, The Natural Environment Tribunal Act - 1995, Legal Measures to Control Noise

Pollution, Solid waste management and handling rules-2000; Biomedical wastes (Management and Handling) Rules - 1999; Coastal Regulation Zone Notification – 1991.

Module V: International environmental treaties and conventions

Montreal Protocol, Earth Summit, Agenda 21, Biodiversity Act - 2002, Kyoto Protocol, Copenhagen Summit - 2009, Millennium Development Goals, Basel convention.

Reference

1. Singh, G. (2005), Environmental Law in India, Macmillan India Ltd, New Delhi.
2. Krishnamoorthy, B. (2005), Environmental Management, Prentice Hall of India Private Limited, New Delhi.
3. Agarwal, S.K. (1997), Environmental Issues and themes, APH Publishing Corporation, New Delhi.
4. John, O. N., Turner, R. K. and Bateman, I. J. (2001), Environmental Ethics and Philosophy, An Elgar Reference collection, USA.
5. Trivedi, R. K. (2010), Handbook of Environmental Laws, Rules Guidelines, Compliances and Standards (Vol I and II), BPB Publications, New Delhi.
6. Jadhav, H. and Bhosale, V. M. (1995), Environmental Protection and Laws, Himalaya Publishing House, Delhi

ELECTIVE – 3

ESW4C21 – CURRENT ENVIRONMENTAL ISSUES IN INDIA

Number of Credits: 4

Course Outline

Module I: Realms of Environment

Atmosphere, Hydrosphere, Lithosphere and Biosphere, Solar system, overview of natural resources; Environmental problems faced by India; Sustainable development, concepts, problems and perspectives.

Module II: Weather and climate

Climate science, thermal inversion, heat island; natural hazards: volcanoes, earth quake, tsunami, land slide, tornadoes, storms, hurricane and flood; coastal erosion; green-house gases: global warming, acid rain, Enso, El-nino, La-nina; Climate change, treaties and conventions, impact of climate change on water resources and agriculture.

Module III: Environment, forest and wildlife

Forests in India, forest cover and types of forests, deforestation, conservation of forest resources; Biodiversity, wild life, endangered and threatened species, Biosphere reserves, national parks and sanctuaries, wet lands, mangroves and coral reefs; Wildlife conservation in India, Illegal trade in wildlife – poaching; Recent

measures for wildlife protection and conservation of national heritage - UNESCO's World Heritage list.

Module IV: Social construction of environmental issues

Anthropogenic pressures on natural resources, conflicts and negotiation; Benefit-cost approach to environmental problems; Institutional mode of environmental planning, policy formulation and strategies.

Module V: Environmental movements

History, People's movement for environmental conservation in India - Bishnoi Movement, Chipko Movement, Narmada Bachao Andolan, Apikko movement, Silent Valley Movement, Baliyapal, drivers for environmental movement, popular movements and people's participation.

Reference

1. Ramachandra, G. M., A. J. (2000), Varieties of Environmentalism, Oxford University Press, Delhi.
2. Ramachandra, G. (2000), The Unquiet Woods: Ecological Change and Peasant Resistance in the Himalaya, University of California Press, California.
3. Agarwal S. K. (1997), Environmental Issues and Themes, APH Publishing Corporation, New Delhi.
4. Edward, S. W. and Jean G. S. (2004), Sustainable Strategic Management, M. E. Sharp Inc., Kerala.
5. Gangstad, E. O. (1990), Natural Resource Management of Water and Land. Van Norstrand Reinhold. New York.
6. William, E. Grant, Ellen K. Pedersen and Sandra L. Marin (2009), Ecology and Natural Resource Management, John Wiley & Sons Inc., New York.
7. Mitchell, B. (1997), Resource and Environmental Management, Addison Wesley Longman Ltd, Edinburgh.
8. Andrew, E. D. and Edward, A.P. (2006), The Science and Politics of Global Climate Change: A Guide to the Debate. Cambridge University Press, New York.
9. Muller, R. N. and Donahue, R. L. (1996), Soils in Our Environment, Prentice Hall of India, Delhi.
10. Mackenzie, A. and Sonia, R.V. (2002), Ecology Instant Notes. Viva Books Private Limited, New Delhi.

ELECTIVE – 4

ESW4C22 – WILDLIFE AND AVIAN BIOLOGY

Number of Credits: 4

Course Outline

Module I: Wildlife and avian biology

Concepts, various taxa, domestic vs. wild, endemism, ecological, economic, ethical and other significance of wild species; vertebrates and invertebrates.

Module II: Biology and Taxonomy of certain wild species

Amphibians, fishes and reptiles - brief taxonomy; Extinct, threatened, endangered and endemic species - Population status, distribution, feeding and breeding habits, major threats to their survival and conservational significance.

Module III: Biology and Taxonomy of certain wild species

Aves - brief taxonomy; Extinct, threatened, endangered and endemic species; Population status, distribution, feeding and breeding habits, major threats to their survival and conservational significance.

Module IV: Biology and taxonomy of certain wild species

Mammals - brief taxonomy; Extinct, threatened, endangered and endemic species; Population status, distribution, feeding and breeding habits, major threats to their survival and conservational significance.

Module V: Environmental Impact on Wildlife

Wildlife conservation and management; Anthropogenic pressures on wild fauna and flora; Habitat loss, Habitat fragmentation, industrialization, urbanization and other threats; extinctions (historical and recent); Risks faced by small populations, minimum viable population, population viability analysis, diagnosis of declines; Biodiversity hot spots, reserve design in theory and practice; Wildlife diseases and their management; Wildlife administration and legislation; Sanctuaries, national parks, biosphere reserves.

Reference

1. William, S. J. (2000), The Conservation Handbook - Research, Management and Policy, Blackwell Science Publishers, New Jersey, USA.
2. Rajesh, G. (1992), Fundamentals of Wildlife Management, Justice Home, Allahabad, India.
3. Grzimek's Animal life Encyclopedia (1972), Vol. 1-13, Van Nostrand Reinhold Company, New York.
4. Giles, R. (1994), Wildlife Management Techniques (3rd Edition), Nataraj Publications, Dehra Dun.
5. Esmond, H. and Harris, J. (1997), Wildlife Conservation in Managed Woodlands and Forests. Basil Blackwell, Oxford, UK.
6. Sálim, A. and Ripley (1983), Handbook of Birds of India and Pakistan (2nd Edition), Oxford University Press, Bengaluru.
7. Prater, S. H. (1990), The Book of Indian Animals, BNHS/Oxford, UK.
8. Alfred, J. R. S., Das, A.K. and Sanyal, A.K. (1998), Faunal Diversity in India, ZSI Calcutta.
9. Daniel, J. C. (2002), The Book of Indian Reptiles and Amphibians, Oxford, UK.
10. Sálim, A. (2002), The Book of Indian Birds (revised edition), BNHS & Oxford University Press, New Delhi.

ELECTIVE – 5

ESW4C23 – ENVIRONMENTAL ECONOMICS

Number of Credits: 4

Course Outline

Module I: Introduction, World environmental history and economic development

Nature and scope, Principles of environmental economics; Interrelationship between economics, environment and ecology; Foundation of environmental economics; Nexus between Ecology and Economics - The Principle of Material Balance - Private versus Social Cost.

Module II: Environmental Economics

Basics and trends, Environment and economy, environmental and economic growth, environmental and development. Basic concept of sustainable development, Measures for sustainable development. Main characteristics of environmental goods- Pure public goods, Mixed collective goods, public bads, externalities, consumption and demand, production and supply, Marginal analysis. Market and market failure, externalities – marginal social cost, marginal private cost, marginal external growth, cost and solution to externality. Principles of maximum social welfare - Pareto Criterion.

Module III: Resource Economics

Economics of natural resources. Population growth and its impact on environment; The concept of common property resource and issues in global environmental resource sharing; World trade and the environment – International trade, Intellectual Property rights.

Social CBA (Cost Benefit Analysis). Economic CBA, Environmental pollution- control, private cost and socialcost; Application of CBA-Technology versus Environment - Coase Theorem - Simon Kuznets's inverted 'U' shaped curve.

Module IV: Economics of Pollution Control

Environmental Impact Assessment - Evaluation of Project and Programme – Benefit / Cost Analysis - Contingent valuation method - Measurement of environmental damages - Valuing environmental benefits: Hedonic price approach - Ecological footprint approach, Systems approach.

Module V: Renewable resources

Growth curves - the rate of exploitation - open access and common property solutions - exhaustible resources - monopoly and the rate of extraction - ecosystem services – Institutional approaches to environmental problems.

Reference

1. Ramprasad S. (2001), Ecology and Economics - an approach to sustainable Development, Oxford.

2. Adiseshiah M. S. (1987), Economics of Environment, Lancer International, India International Center, New Delhi.
3. Pearce D. W. and Kerry R. T. (1990), Economics of Natural Resources and the Environment, Harvester Wheat Sheaf, New York.
4. Seneca J. J. and Michael K. T. (1974), Environmental Economics, Prentice Hall, New Jersey.
5. Kerr J. M. K., Marothia D., Katar S., Ramasamy C. and Bentley, R. W. (1997), National Resource Economics – Theory and Application in India, Oxford & IBH Publishing Co, New Delhi.
6. Charles, D (2000), Environmental Economics, Oxford University Press, New York
7. David, P. and Moran, D. (1994), The Economic Value of Biodiversity, Earthscan Publications Ltd, London.

ELECTIVE – 6

ESW4C24 – NATURAL RESOURCES: CONSERVATION AND MANAGEMENT

Number of Credits: 4

Course Outline

Module I: Sustainable Management- Introduction

Concepts and dimension, Theories and definitions, Role of environmental Planning and management in Sustainable Development.

Module II: Introduction

Natural resources – definition, classification, types, concepts and approaches of natural resource conservation - Natural resources of India, Natural resources degradation - types and causes, loss of biodiversity, land degradation, deforestation, ecological and social impact of resource depletion.

Module III: Soil (land) Resources Management

Distribution of Soil resources – Role of agricultural practices in soil degradation - Soil erosion – Soil fertility and nutrient management: Role of organic matter and its significance in soil quality – Diagnosis of soil nutrient deficiencies – Organic farming: Principles, benefits and methods of organic farming; Green manuring, Animal manures and composting - Wasteland development strategies.

Module IV: Mineral Resources Management

Resources and reserves – Origin, distribution and uses of economic minerals - Exploration of mineral resources from oceans - Steps in mineral exploitation, Impact of exploitation of economic minerals on environment - Conservation of economic mineral resources. Management strategies.

Module V: Water Resources Management

Integrated water resource management - Watershed management – Rain water harvesting – Interlinking of rivers and river basin management - Wetland conservation – Coastal zone management strategies - Ecological significance of mangroves, Coral reefs and its conservation, Management strategies.

Module VI: Forest Resources Management

Significance for the conservation of forest resources – Distribution of forests, Wood production, Forest land use changes in India, Future demand of forest land, Carbon sequestration - Forest management tools: Social forestry, Agro-forestry and Urban forestry - Eco development committees, Ecotourism, Climate change reduction, Carbon trading and Management of grasslands, Management strategies.

Module VII: Management of Biological Resources

Biological Resource for health Management- Medicinal plants, Identification of problems and development of sustainable management strategies for biological resource with particular reference to Kerala.

Module VIII: Social Issues and the Environment Management

Basic concepts of Social and human interference, management of social environmental issues and urban problems related to energy; Water conservation, rain water harvesting and watershed management; Resettlement, rehabilitation of people, its problems and concerns; Pollution impacts to environment (Climate change, global warming, acid rain, ozone depletion), nuclear accidents and holocaust, wasteland reclamation, consumerism and waste products, public awareness, population growth and family welfare programme, human rights, women and child welfare; Role of information technology in environmental conservation and management.

Reference

1. Dutta, A. (2001), Biodiversity and Ecosystem Conservation, Kalyani Publishers, Kolkata.
2. Jha, L. K. (1997), Natural Resource Management, APH Publishing Corporation, New Delhi.
3. Kumar, H. D. (1995), Modern Concepts of Ecology, Vikas Publishing House (P) Ltd., New Delhi.
4. Dicken, K. G. M. &Vergora, N. T. (1990), Agroforestry: Classification & Management. John Wiley & Sons, New York.
5. Nalini, K. S. (1993), Environmental Resources and Management, Anmol Publications (P) Ltd., New Delhi.
6. Nautiyal, S. & Kaul, A. K. (1999), Forest Biodiversity & its Conservation Practices in India. Oriental Enterprises, Dehra Dun, India.
7. Owen, O. S. & Chiras, D. D. (1995), Natural Resources Conservation, Prentice-Hall India, New Delhi.
8. Sarah, F. (2011), Natural Resource Management, Oriental Enterprises, Dehradun, India.
9. Ian, N. (2009), Agroforestry for Natural Resource Management, CSIRO publishing, Oxford.

ELECTIVE – 7

ESW4C25 – GREEN CHEMISTRY

Number of Credits: 4

Course Outline

Module I: Introduction to Green Chemistry

The basics of sustainability, green chemistry and general chemistry; Chemical production (the old and new), Energy (Fossil fuel, batteries, bio-fuels, solar), Plastics (petroleum and biopolymers); The fate of chemicals in the environment: Pesticides, heavy metals, pharmaceuticals and personal care products; prevention of chemical accidents.

Module II: Green Chemistry and Industrial Processes

Principles of Green Chemistry, Evaluating the effects of Chemistry, Waste: production, problems & prevention; Designing greener processes; Sustainable industrial chemistry; Renewable resources; Emerging Green Technologies & Alternative Energy Sources; Sustainable Industrial Chemistry- Bio-diesel.

Module III: Pollution Prevention, Green Chemistry and Green Engineering

Introduction to concepts - Properties and fates of environmental contaminants - types of compounds and where they end up; Humans - Industrial activity and the environment; Types of pollutants produced by humans with case study; Improving, manufacturing though green alternatives; Economic perspectives on pollution prevention and minimization; Sustainability and recycling; Water - Sources of water pollution, types of contaminants, treatment techniques; Air - Sources of air pollution, acidic aerosols and the ozone hole, climate change and global warming. Energy - Types of energy sources and their environmental impact, treatment of energy, production waste and alternative energy sources; Agriculture - Pollution from fertilizers and pesticides; Impact on nature (wildlife and food supplies). - Green alternatives for fertilization and pest control.

Reference

1. Ahuluwalia, V. K. (2013), Green Chemistry, Alpha Science International, Oxford, UK.
2. Ahuluwalia, V. K. and Kidwai, M. (2007), New Trends in Green Chemistry, Anamaya Publications, New Delhi.
3. Bhatia, S.C. (2006), Environmental Chemistry, CBS Publications, Mumbai, India.
4. Anil Kumar De (2007), Environmental Chemistry, New Age Publications, Kochi, India.
5. Bharucha, E. (2001), Text Book of Environmental Chemistry, Oxford & IBH, Delhi.
6. Ahuluwalia,V. K. and Sunita, M. (2008), Environmental Science, Ane Books Pvt. Ltd., New Delhi.
7. Misra, S. P. and Pandey, S. N. (2009), Essential Environmental Studies, Ane Books Pvt. Ltd., New Delhi.