# SYLLABUS

# FOR

# Ph.D. (ENVIRONMENTAL SCIENCES)

## DEPARTMENT OF INTERDISCIPLINARY STUDIES

## SCHOOL OF ENVIRONMENTAL SCIENCES

## INSTITUTE OF INTEGRATED HIMALAYAN STUDIES

## (UGC Centre of Excellence)

## Himachal Pradesh University

## Summer Hill, Shimla – 171005

**Ph.D. Course Work in Environmental Sciences**

| Paper No. | Nomenclature | Theory | Internal* assessment | Max. Marks |
|---|---|---|---|---|
| ENV-CW-101 | Research methodology & techniques in Environmental Sciences | 80 | 20 | 100 |
| ENV-CW-102 | Seminar/ Review of literature | 80 | 20 | 100 |
| ENV-CW-103 | Special Paper | 80 | 20 | 100 |

* Following will be criteria for the award of Internal Assessment:-

a) Attendance: 5 Marks

b) Assignment/Presentation: 5 Marks

c) Written Test: 10 marks

**Pass percentage i.e. 50% in each paper (or as per university Ph.D. Ordinance.)**

**EVS-CW -101: Research methodology & techniques in Environmental Sciences**

**(COMPULSORY PAPER)**

**MODULE-1** Meaning of Research in Biological Sciences - Purpose, Characteristics and Types of Research - Process of Research -Formulation of objectives - Formulation of Hypotheses - Types of Hypotheses - Methods of testing Hypotheses - Research plan and its components - Methods of Research (Survey, Observation, case study, experimental, historical and comparative methods) - Difficulties in Biological research.

**MODULE-2** Identification and formation of research problem (Hypothesis). Elements in research methodology: Research design (CRD, RBD, LSD). Scientific database: Science Direct and Pubmed.

**MODULE-3** Writing of Research Proposal, Report and Research Paper: Meaning and types - Stages in preparation - Characteristics - Structure - Documentation: Footnotes and Bibliography - Editing the final draft-Evaluating the final draft- Checklist for a good proposal/report/research paper. Basic knowledge of organizing conferences, symposia, workshop, exhibition etc.

**MODULE-4** Principles and application of Spectrophotometry (UV-Visible spectrophotometry), Titrimetry, Gravimetry, Colourimetry, NMR, ESR, Microscopy-phase, light and flourscence microscopes, Scanning and Transmission electron microscopes, Autoradiography, solid and liquid scintillation ,Ultracentrifugation.

**MODULE-5** Chromatographic techniques (Paper chromatography, thin layer chromatography, ion exchange chromatography, Column chromatography). Gas-liquid chromatography, High pressure liquid chromatography, Atomic absorption spectrophotometry, cytophotometry and flow cytometry, Fixation and staining. Electrophoresis, , X-ray florescence, X-ray diffraction. Flame photometry.

**SUGGESTED READINGS**


1. Research Methodology- G.R. Basotia and K.K. Sharma.
2. Research Methodology- C.H. Chaudhary, RBSA Publication
3. Principles of Biophysical chemistry - Uppadahay –Uppadahay - and Nath.
4. Analytical Techniques - S.K. Sahani

**EVS-CW -102 (I): ADVANCES IN ENVIRONMENTAL POLLUTION (WATER)**

**MODULE-1** Definition and causes of water pollution, impacts of water pollution on plants, animals and aquatic life. Water quality impact analysis: Concepts, water quality for domestic, agricultural and industrial uses, water quality parameters (physical, chemical and biological), water quality impact factors, eutrophication

**MODULE-2** Water quality monitoring: Instrumental techniques involved in water quality monitoring – principles, applications, advantages and disadvantages (UV-VIS spectrophotometer, atomic absorption spectrophotometer, turbidimeter, mass spectrometry, chromatography

**MODULE-3** Water quality modeling: concept, scopes and objectives, role of water quality modeling in water quality management, different types of water quality models and their applications, Limitations of water quality models

**MODULE-4** Public water supply and treatment processes: Demand and supply scenario of water in India, future trends, Different techniques for removal of heavy metals from waste water, Defluoridation techniques, removal of arsenic from ground water, primary, secondary and tertiary treatment of water, Green chemistry principles and their applications in water pollution control

**MODULE-5** Water management: rain water harvesting, inter basin transfer of water, International treaties on water, Water Acts, Social and Economic mechanisms for managing water resources

**SUGGESTED READINGS**


1. Rana, S.V.S. (2003). Essentials of Ecology & Environmental Sciences, Prentice Hall of India, New Delhi.
2. Odum, E. P. (1996) Fundamentals of Ecology, Natraj Pub. Dehradun.
3. Kudesia, V.P. (1990) Air Pollution, PragatiPrakashan, Meerut - 250001.
4. Edward, C. A. (1976) Environmental Pollution by Pestacades, Plenum Press, London & New York.
5. De, A. K. Environmental Chemistry- New Age Intt. Pub. Co., New Delhi, 1990 A Text Book of environmental – C.S. Rao, Wiley Eastern Limited., 1993
6. Dassber, H.S. &Bortitz, S. (1988) Air pollution & its influence on vegetation, Dr. W. Junk Pub. Dordrencht-Bostan Lancaster.
7. Bridgman, H. (1992) Global Air Pollution, CBS Pub. New Delhi.

**EVS-CW -102 (II): ADVANCES IN ENVIRONMENTAL POLLUTION**

**MODULE-1** Water pollution: Sources of surface and ground water pollution; water quality parameters and standards; organic waste and water pollution; eutrophication; COD, BOD, DO; effect of water contaminants on human health; water borne diseases; concept and working of effluent treatment plants (ETPs).

**MODULE-2** Air pollution: types and sources; Air pollutants classification and properties; Meteorological aspects of air pollution; Automobile pollution; sources and diffusion of $SO_2$, CO, $NO_X$ smoke, particulates in air. Sampling techniques: analysis of different gases and solid particulates, effect of air Pollution on human health, control techniques, Levels of air pollution in India, Air pollution standards in India.

**MODULE-3** Solid Waste: Origin, characteristics, Quantity and Analysis; Problems of Solid Wastes; Storage, collection, transportation of solid wastes; Legislation for solid waste. Treatment of solid wastes: composting, vermicomposting, anaerobic digestion; reuse and resource recovery the solid waste; disposal of solid waste.

**MODULE-4** Bio-medical waste: Classification/ type of biomedical Wastes (Infectious, Genotoxic, Cytotoxic, Chemical Toxicity, radioactive hazardous), physical injuries, public sensitivity; Different streams of wastes production; Handling of biomedical wastes; risk involved in handling biomedical waste and Safety Measures in Handling bio-medical wastes

**MODULE-5** Land as a resource, soil health; ecological importance of soil; types and causes of soil degradation; impact of soil loss and soil degradation on agriculture; need for soil conservation and restoration of soil fertility; soil pollution due to mining and mineral extraction, industrial and urban development, toxic organic chemicals, and organic contaminants in soils; fertilizers and pesticides; recycling of soil nutrients.

**SUGGESTED READING**


1. Training Module on Hospital Waste Management by Dr. NeeraKewalramani, Dr.AlkaKarande, Dr. SnehaPalnitkar, Brihan Mumbai MahanagarPalika, Public Health Department.
2. Singh A. and Kaur S. Biomedical Waste Disposal Kindle Edition. Jaypee Brothers Medical Publishers (p) Ltd.; first edition (2012)
3. Rana, S.V.S. (2003). Essentials of Ecology & Environmental Sciences, Prentice Hall of India, New Delhi.
4. Odum, E. P. (1996) Fundamentals of Ecology, Natraj Pub. Dehradun.
5. Kudesia, V.P. (1990) Air Pollution, PragatiPrakashan, Meerut - 250001.
6. Kishore, J. and Ingle,G. K. (2004). Biomedical Waste Management in India. Century Publications
7. Edward, C. A. (1976) Environmental Pollution by Pestacades, Plenum Press,

London & New York.

8. De, A.K. Environmental Chemistry- New Age Intt. Pub. Co., New Delhi, 1990 A Text Book of environmental – C.S. Rao, Wiley Eastern Limited., 1993
9. Dassber, H.S. &Bortitz, S. (1988) Air pollution & its influence on vegetation, Dr. W. Junk Pub. Dordrencht-Bostan Lancaster.
10. Bridgman, H. (1992) Global Air Pollution, CBS Pub. New Delhi.

**EVS-CW -102 (III): ADVANCES IN BIODIVERSITY MANAGEMENT**

**MODULE-1** Importance of biodiversity, social and economic values – medicinal plants, drugs, fisheries and livelihood, social, aesthetic, consumptive; Need of wildlife conservation; role of government, biologists and social scientists in conservation, evolution of the concept of biodiversity conservation in India (traditional and modern); India as a mega biodiversity nation; phytogeographic and zoogeographic zones of the India.

**MODULE-2** Concept and types of speciation; spatial patterns: latitudinal and elevation trends in biodiversity; temporal patterns: seasonal fluctuations in biodiversity patterns; role of biodiversity patterns in conservation.

**MODULE-3** Biodiversity estimation and sampling strategies and surveys: floristic, faunal, and aquatic; qualitative and quantitative methods: scoring, habitat assessment, richness, density, frequency, abundance, evenness, diversity, biomass estimation.

**MODULE-4** Conservation of biodiversity: Threats to biodiversity (causes and effects), Conservation of biodiversity: In-situ conservation/ Types of protected areas (Wildlife Sanctuaries, National Parks, Biosphere Reserves, Sanctuaries, etc.); Ex-situ conservation (botanical gardens, zoological gardens, gene banks, seed banks, pollen culture, tissue culture and DNA banks), role of local/ indigenous communities and traditional knowledge in conservation; biodiversity hotspots; IUCN Red List categorization – guidelines, practice and application; Red Data book.

**MODULE-5** Conservation of biodiversity: Ecological restoration; afforestation; social forestry; agro forestry; joint forest management; role of remote sensing in management of biodiversity. impact of hydropower development on biological diversity; status of protected areas and biosphere reserves in the country; National Biodiversity Action Plan;Biodiversity Act., Wild-life Protection Act of India, Role of National Biodiversity Board & State Biodiversity Board, concept of community biodiversity register, people's biodiversity register

**SUGGESTED READING**

1. Tikader, B.K.(1983) Threatened Animals of India, ZSI, Calcutta

2. Stoddart, A. I. (1975) Range Management, Pub. McGraw Hill, Col. Inc. New York
3. Sparke, J. (1970) Bird Behaviour, Govosset&Dulop, Inc. New York
4. Odum, E.P. (1971) Fundamentals of Ecology, W.B. Saunder Co. / Toppan Co. Ltd.
5. Leopld, A. (1933) Game Management, Charles Scribner's Sons, New York, London
6. Giles, R.H. (1984) Wildlife Management Techniques, The Wildlife Society, Washington, D.C.
7. Dassman, R.F. (1982). Wildlife Biology (II Ed.), Wiley Eastern Ltd., New Delhi
8. Champion, H. C. and Sheth, S.K. (1968) A revised Survey of the Forest Types of India, Pub. Manager, Col. Press- Nasik /Manager of Publication Delhi
9. Berwick, S.H. and Sharma, V.B. (1995) Wildlife Research & Management, Oxford Univ. Press, Delhi.

**EVS-CW - 102 (IV): ADVANCES IN NATURAL RESOURCE MANAGEMENT**

**MODULE-1** Definition and classification of natural resources; renewable and nonrenewable resources; resource degradation; resource conservation; resource availability and factors influencing its availability; human impact on natural resources; ecological, socio-economic dimension of resource management.

**MODULE-2** Natural resources and conservation - Forest resources: economic and ecological importance of forests, forest management strategies, sustainable forestry; water resources: supply, renewal, and use of water resources, freshwater shortages, strategies of water conservation; soil resources: importance of soil, soil conservation strategies; food resources: world food problem, techniques to increase world food production, green revolution.

**MODULE-3** Non-renewable energy resources - Oil: formation, exploration, extraction and processing, oil shale, tar sands; natural gas: exploration, liquefied petroleum gas, liquefied natural gas; coal: reserves, classification, formation, extraction, processing, coal gasification; impact of energy consumption on global economy; application of green technology; future energy choices and threats

**MODULE-4** Renewable energy resources - Energy efficiency; solar energy: technology, advantages, passive and active solar heating system, solar thermal systems, solar cells, hydropower, benefits of hydropower development; nuclear power, storage of radioactive waste, radioactive contamination; tidal energy; wave energy; geothermal energy; energybiomass; bio-diesel.

**MODULE-5** Resource management - Approaches in resource management: ecological approach;

economic approach; ethnological approach; integrated resource management strategies; concept of sustainability science;approach towards sustainable development; sustainability of society, resources and framework; sustainable energy strategy; principles of energy conservation; Indian renewable energy Programme.

**SUGGESTED READING**


1. Tiwari, P.C. (1995) Natural Resources & sustainable development in Himalaya, Shree Almora Book Depot., India
2. Singh, M.P. (2004) Natural Resources & renewable Energy, Daya Publishing House, Delhi
3. Rana, S.V.S. (2003) Essentials of ecology & Environmental sciences, Prentice Hall of India
4. Owen, O.S. and Chiras, D.D. (1995) Natural Resources Conservation. Prentice Hall India
5. Negi, S. S. (1992) Himalayan Wildlife, Habitat & Conservation. Indus Publishing Company, New Delhi
6. Nautiyal, S. and Kaul, A. K. (1999) Forest Biodiversity & its Conservation Practices in India, Oriental Enterprises, Dehradun, India
7. MaDicken, K.G. and Vergora, N.T. (1990) Agro forestry: classification & Management, John Wiley & sons, New York
8. Kumar, H.D. (1995) Modern concepts of Ecology, Vikas Pub. House, Pvt. Ltd. New Delhi
9. Kathiresan, S.B. (1986) Essentials of forest management, Natraj Publishers, Dehradun
10. Jairajpuri, M.S. (1991) Animal Resources of India - Protozoa to mammalia - State of the Art, Zoological survey of India. XI-XXVII
11. Jadhav, H. V. (1997) Energy & Environment, Himalaya Publishing House. Delhi.
12. Heywood, V.H. (1995) Global Biodiversity Assessment, Cambridge University Press, UK
13. Gupta,K.C. (2002). Energy & Environment in India - A study of Energy Management, Gyan Publishing House, New Delhi
14. Gautam, A. and Rastogi, S. (2003). Resource Geography, International Publishing House, Meerut
15. Dasmann, R.F. (1981) Wildlife Biology, 2nd edition, John Wiley & Sons, New York
16. Dar, G.H., Bhagat, R.C. and Khan, M.A. (2002) Biodiversity of the Kashmir Himalaya, Anmol Publication, Pvt. Ltd. New Delhi
17. Chaturvedi, A. N. (1994) Management of India's forest resources.

KhannaBandhu, Dehradun

18. Bandhu, D. (1987) Environment Education for conservation & Development, Indian Environment, Society New Delhi

**EVS-CW – 102(V) : ENVIRONMENTAL HYDROLOGY**

**MODULE-1** The Hydrologic Cycle, Water Resources, and Society: Precipitation - causes and types, measurements; Evapotranspiration - process, measurement/estimation; Infiltration, Percolation and Groundwater Recharge, Runoff and Overland Flow, Water Supply. Introduction, Soil Water Relationships, Infiltration and Soil Water Retention, Factors Affecting Water Movement into and through Soils, Soil Water Balance, Estimating Infiltration Rates, Measurement of Soil Properties.

**MODULE-2** **Runoff and Subsurface Drainage:** Introduction, Factors Affecting Runoff Processes, Runoff Characteristics - the Hydrograph, Predicting Volume of Storm flow and Total Runoff, Prediction of Peak Runoff Rate, Storm water Hydrographs.

**MODULE-3** **Stream Processes:** Introduction, Interaction of Streams with the Landscape, Stream Orders, Stream Biota, Stream Characteristics, Stream Stability and Sediment Transport, Meander Migration, Floodplains, and Stream ways, Stream Classification, Channel Evolution; Open Channel Flow - Velocity and Discharge

**MODULE-4** **Soil Conservation and Sediment Budgets:** Introduction, Factors Affecting Erosion by Water, Types of Erosion, Estimating Soil Losses, The Universal Soil Loss Equation, Applications of the Universal Soil Loss Equation, Downstream Sediment Yields, Sediment Budget Concepts

**MODULE-5** **Hydrology of Forests and Wetlands:** Forest Climates, Interception - Rain and Snow; Energy Balance in Forests – Evapotranspiration, Snowmelt; Infiltration, Subsurface Flow (Interflow), Surface Runoff, Stream flow and Watershed Hydrology; Erosion - Sediment Budget; Wetlands - Definitions and Importance, Identification of Wetlands

**SUGGESTED READING**

**EVS-CW – 102(VI) ENVIRONMENTAL METEOROLOGY**

**MODULE-1** **Atmosphere:** Origin of the atmosphere, Structure and composition of the atmosphere. **Atmospheric Thermodynamics:** Application of thermodynamics in atmospheric processes, Adiabatic process, Potential temperature, Temperature lapse rate and inversion, Hydrostatic equation and atmospheric stability.

**MODULE-2** **Atmospheric Dynamics:** Coordinate systems, Forces acting in atmospheric motion, Horizontal equation of motion, Vertical equation of motion, Thermal wind, Thermodynamic energy equation, The continuity equation. **Clouds and Precipitation:** Different types of clouds, Formation of clouds, Cloud seeding, Different kinds of precipitation, Rainfall distribution pattern in Northeast India.

**MODULE-3** **Weather and climate:** Climatic extremes - environmental implications, Climate of Northeast India, Global climate change and its impact on environment. **Monsoon Circulation:** Origin and mechanism of Asiatic monsoon, Role of monsoon circulation

on Indian agriculture.

**MODULE-4** **Some Important atmospheric circulation:** El-Nino and La-Nina – mechanism of formation and impact on climate, Southern Oscillation.

**MODULE-5** **Satellite Meteorology:** Introduction, Types of satellites, Meteorological satellites, Sensors for monitoring weather, Indian meteorological satellites.

**SUGGESTED READING**

**EVS-CW – 102(VII) SEISMOLOGY AND SEISMIC HAZARD**

**MODULE-1** **Introduction:** Historical development of seismology, Seismographs and seismograms, Seismologic observations and networks, Theory of the seismometer, Accelerographs. **Seismic waves:** Stress and strain, Stress-strain relationship, Elastic waves, Wave equations for an elastic medium, Momentum equation, Equations of continuity, The effect of gravity on wave propagation, Seismic wave equation, Primary and secondary waves, Love and Rayleigh waves, Dispersion of seismic waves.

**MODULE-2** **Ray theory of Seismic waves:** Ray theory for travel time, Snell's Law, Ray paths, Travel time curves and delay times, Low velocity zones, Ray tracing equations, Ray nomenclature, Global body wave observations, Energy in seismic waves, One dimensional velocity model .**Travel times and the structure of the Earth:** Observations and methods, Distributions of velocity, elasticity coefficients and density, Different layers of the earth Inversion of Travel time data, One-dimensional velocity inversion, Earthquake location.

**MODULE-3** **Source of earthquakes:** Concept of plate tectonics, Earthquake and faults, Focal parameters of earthquakes, The location of an earthquake's focus, Seismic moment, Stress drop, Source mechanism, Earthquake magnitude and intensity, Scales of measurement

**MODULE-4** **Earthquake Prediction:** The earthquake cycles, Seismic gap, Different methods of earthquake prediction. **Geotectonic setting of Northeast India:** General geologic structure, Major faults and lineaments, Tectonic blocks, Tectonic movements.

**MODULE-5** **Seismic Hazard and risk:** Seismicity and seismotectonics, Spatial and temporal distribution of earthquakes, Seismic energy, Seismic hazard, Evaluation of seismic hazards. Effects of earthquakes – Primary and secondary effects, Precautionary measures and management of seismic hazard

**SUGGESTED READING**

**EVS-CW – 102(VIII) WASTE RECYCLING AND RESOURCE RECOVERY TECHNOLOGY**

**MODULE-1** **Introduction** Solid waste – Sources – Domestic, industrial and agriculture sources- Industrial wastes- Mineral wastes – Indentification waste – Minimizing options - Recovery and Recycle-Composting- Vermi composting – Incineration – Energy from.

waste- Pyrolysis, chemical processing- Legislative measures for garbage disposal.

**MODULE-2** **Fly Ash** Introduction- Nature- Direct Replacement of Cement- Waste Land Development- Soil Amendment to grow Crops- Utilization of Fly-ash in Afforestation, Limitation of Land Application of Fly Ash.

**MODULE-3** **Plastic Waste, Industrial Waste** Introduction – Amount and types of plastic waste – Recycling of plastic waste-cement manufacture from industrial solid waste – Paper industry waste – Calcium carbide industry waste.

**MODULE-4** **Bio Fuels & Bio Ethanol** Bio ethanol production technologies- Bio hydrogen- its application – Methanogenesis from agroindustrial residues- Bio mass – Gasifier based power plants.

**MODULE-5** **Waste Water** Introduction reuse- Quality, the basic treatment processes – Benefits of reuse in agriculture – The costs of reuse projects and economic justification – Factors essential for the success of reuse projects- Case study.

**SUGGESTED READING**

1. Nemerow N.L., —Industrial Water Pollution‖, Addison – Wesley Publishing Company inc., USA, 1978

2. Wesley Eckenfelder Jr. W, Industrial water pollution control, McGraw Hill book Co, New Delhi, 1989.

3. Mahajan S.P. —Pollution Control in process industries‖, Tata McGraw Hill Publishing Co Ltd., New Delhi, 1989.

**EVS-CW – 102(IX) SOLID AND HAZARDOUS WASTE MANAGEMENT**

**MODULE-1** Introduction: Sources and generation of solid waste, their classification and chemical composition; characterization of municipal solid waste; hazardous waste and biomedical waste. Effect of solid waste disposal on environment: Impact of solid waste on environment, human and plant health; effect of solid waste and industrial effluent discharge on water quality and aquatic life; mining waste and land degradation; effect of land fill leachate on soil characteristics and ground water pollution.

**MODULE-2** Solid waste and Hazardous waste Management: Different techniques used in collection, storage, transportation and disposal of solid waste (municipal, hazardous and biomedical waste); landfill (traditional and sanitary landfill design); thermal treatment (pyrolysis and incineration) of waste material; drawbacks in waste management techniques. Types of industrial waste: hazardous and non-hazardous; effect of industrial waste on air, water and soil; industrial waste management and its importance; stack emission control and emission monitoring; effluent treatment plant and sewage treatment plant.

**MODULE-3** Resource Recovery : R- reduce, reuse, recycle and recover; biological processing - composting, anaerobic digestion, aerobic treatment; reductive dehalogenation;

mechanical biological treatment; green techniques for waste treatment.

**MODULE-4** Waste- to- energy : Concept of energy recovery from waste; refuse derived fuel (RDF); different WTE processes: combustion, pyrolysis, landfill gas (LFG) recovery; anaerobic digestion; gasification.

**MODULE-5** Integrated waste management: Concept of Integrated waste management; waste management hierarchy; methods and importance of Integrated waste management.: Life cycle assessment: Cradle to grave approach; lifecycle inventory of solid waste; role of LCA in waste management; advantage and limitation of LCA; case study on LCA of a product.

**SUGGESTED READING**


1. Asnani, P. U. 2006. Solid waste management. *India Infrastructure Report 570*.
2. Bagchi, A. 2004. *Design of Landfills and Integrated Solid Waste Management*. John Wiley & Sons.
3. Blackman, W.C. 2001. *Basic Hazardous Waste Management*. CRC Press.
4. McDougall, F. R., White, P. R., Franke, M., & Hindle, P. 2008. *Integrated Solid Waste Management: A Life Cycle Inventory*. John Wiley & Sons.
5. US EPA. 1999. *Guide for Industrial Waste Management*. Washington D.C.
6. White, P.R., Franke, M. &Hindle P. 1995. *Integrated Solid waste Management: A Lifecycle Inventory*. Blackie Academic & Professionals.
7. Zhu, D., Asnani, P.U., Zurbrugg, C., Anapolsky, S. & Mani, S. 2008. *Improving Municipal Solid waste Management in India.* The World Bank, Washington D.C.


**EVS-CW – 102(X) ECO FRIENDLY BIOPRODUCTS**

**MODULE-1** **General Biofertilizers** Bacterial, fungal and algal biofertilizers; mycorrhiza -types- endo, ectomycorrhiza and orchidaceous mycorrhiza, Problems and prospects of biofertilizers. Rhizobium- Physiology, Rhizobium interactions, mass cultivation.

**MODULE-2** **Production of Biofertilizers** Largescale production of biofertilizers, Blue green algae, VAM fungi- Field application of biofertilizers - method of application; Chlorella biofertilizer-growth parameters-Mushroom cultivation.

**MODULE-3** **Bacterial Biofertilizers** Cyanobacteria as biofertilizers – Azolla- Bacterial biofertilizers - Mass production of Azospirillum, Azotobacter and Phosphobacteria; N2 fixation - Phosphate solubilization and mobilization.

**MODULE-4** **Biopesticides** Definition, kinds and commerce of biopesticide, Bacillus thuringiensis, insect viruses and entomopathogenic fungi – its characters, physiology, mechanism of action and application of bioinsectides - neem and related natural products.

**MODULE-5** **Vermicompost Technology** Introduction to vermiculture, biology, economic important, their value in maintenance of soil structure, production of organic fertilizers by vermiculture- Earthworm farming, Extraction (harvest), vermicomposting- vermiwash collection, composition and use harvest and processing.

**SUGGESTED READING**

1. Altman, A., 1997. Agricultural biotechnology, CRC Press.

2. Ariëns, E.J., Van Rensen J., Welling, W., 1988. Stereo selectivity of pesticides. Biological and chemical problems. Chemicals in agriculture. Volume 1, Elsevier Science Publishers, The Netherland.

3. Blackburn, R.S., 2009. Sustainable textiles: Life cycle and environmental impact. Elsevier Science Publishers, The Netherland.

4. Board, N., 2004. The complete technology book on vermiculture and vermicompost CRC Press.

5. Costanza, R., Norton, B.G., Haskell, B. D., 1992. Ecosystem health: new goals for environmental management, Island Press.USA.

6. Kannaiyan, S. 2002.Biotechnology of Biofertilizer, Narosa Publishing House, New Delhi.

**EVS-CW – 102(XI) RIVER ECOSYSTEM ECOLOGY**

**MODULE-1** Introduction – Stream order – Stream flow – Hydrology- Flow alteration- Environmental Flow- Fluvial Geomorphology – Discharge – Channel Morphology.

**MODULE-2** Stream water chemistry – Nutrient dynamics – Nutrient pollutions –Scaling of Sediment dynamics in the River Environment– Sediment Management - Influence of chemical factors on stream / river biota.

**MODULE-3** Stream / River ecological theories – River continuum concept – importance of connectivity in stream / Riverine Ecology- River Fragmentation- Biogeochemistry of NPC (nitrogen, phosphorus, carbon) – Organic matter budgets.

**MODULE-4** Biotic interactions – Terrestrial aquatic linkage. Primary producer – Heterotrophic energy – Source in stream/river – Trophic relationships – Drift composition and periodicity – Functional basis of drift – Riparian vegetation.

**MODULE-5** Stream/River management – River modifications – Dams and impoundments – Alien species – Climate change – Recovery and restoration of running waters.

**SUGGESTED READING**

**1.** Nancy D. Gordon, Thomas A. McMahon, Brian L. Finlayson, Christopher J. Gippel, Rory J. Nathan. Stream Hydrology: An introduction for Ecologists.

**2.** Barbara A. Hauser. Drinking Water Chemistry: A Laboratory Manual.

**3.** Richard F. Hauer, Gary Lamberti. Methods in Stream Ecology: Volume 1: Ecosystem Structure.

**4.** Walter K. Dodds and Matt R. Whiles. Freshwater Ecology: Concepts and Environmental Applications of Limnology.

**5.** David J. Allan. Stream Ecology: The Structure and Function of Running Waters.

6. Philip J. Boon, Paul J. Raveen. River Conservation and Management.

7. Gary J. Brierley and Kirstie A. Fryirs (2005) Geomorphology and River Management: Applications of the River Styles Framework. Blackwell Publishing,

Oxford, UK, 398pp.

8. Kathleen Weathers, David Strayer, Gene Likens. Fundamental of Ecosystem Science.

9. Vannote et al . The River Continum Concept.

10. Allan, J. David, Castillo, Maria M. Stream Ecology: Structure and function of running waters.

**EVS-CW – 102(XII) RESTORATION ECOLOGY AND MANAGEMENT**

**MODULE-1** Restoration Ecology - Definition, principles, concepts and strategies.(long term vs. short term); physical, chemical and biological restoration; role of ecological principles in restoration, role of pioneer species in restoration and holistic approach in restoration.

**MODULE-2** Restoration of natural resources; restoration of river corridor, water resources and mine spoils. Approaches to Flood Plain Mana4ement, Concepts and Programs related to Restoration and Management of Lakes, Rivers and streams, Riverine = Riparian ecosystem and Wetlands, Fluvial restoration.

**MODULE-3** Planning and evaluating aquatic ecosystem restoration — Project planning, Purpose of evaluation, Selecting assessment criteria and synthesizing data. Introduction to watershed, concept and significance. Physical and hydrological characteristics of watershed. Drain — line treatment; Area treatment — Goals, features and watershed as unit of sustainable development.

**MODULE-4** Integrated Aquatic Ecosystem Restoration- Introduction, Institutional barriers to Integrated Aquatic Restoration, Importance of Integrated restoration to wildlife, Appropriate scale for restoration, Use of Historical records in reconstructing watersheds. Impact of human activities on water resources, climate change threats to water quality, Shifts in freshwater ecosystems

**MODULE-5** National restoration goals, Policy and Program. redesigning for restoration Integrated Water Resource Management (IWRM),. Role of. public participation, government agencies and NGOs in conservation and restoration; environmental education and its role in conservation and restoration. Finish Biotic restoration Landscape ecology and restoration Finish monitoring and adaptive management

**SUGGESTED READING**

1. John CairnS Jr., 1992. Restoration of Aquatic Ecosystems - Science, Technology and Public Policy. National Academy Press. Washington D.C.

2. Adamus, P.R., Clairain, E. J., Smith R.D., Young R. E., 1987. Wetland Evaluation Technuique (WET). Vol II. Methodology Operational Draft. U.S. Army cors of Engineers waterways Experiment Station, Vicksburg, Miss.

3. Barker, LA and E. B. Swain, 1989. Review of lake management in Minne-sota. Lake Reservoir Manage. 5:1-10.

4.Young, T. P. 2000. Restoration ecology and conservation biology. Biological Conservation 92: 73.83.

5. Hobbs, R. J. and Harris, J. A 2001. Restoration ecology: repairing the Earth's ecosystems in the new millennium. Restoration Ecology 9: 239-246.
6. Van Diggelen et al. 2001. Ecological restoration: state of the art or state of the science? Restoration Ecology 9: 115-118.
7. Ehrenfeld, J. G. 2000. Defining the limits of restoration: the need for realistic goals. Restoration Ecology 8: 2-9.
8. McClanahan, T. R. and Wolfe, ft W. 1993. Accelerating forest succession in a fragmented landscape: the role of birds and perches. Conservation Biology 7: 279-288. 9. Palmer et al. 1997. Ecological theory and community restoration ecology. Restoration Ecology 5: 291-300.
10.Cairns, J.Jr., and T. V. Crawford, eds. 1991. Integrated Environmental Management. Lewis Publishers, Chelsea, Mich. 214 pp.

**EVS-CW – 102(XIII) BIOLOGICAL INVASIONS AND MANAGEMENT**

**MODULE-1** Biological invasions – invasive species: impact, overview of the problem and modes of exotics spread both historically and currently, political impacts.

**MODULE-2** Accidental introductions - Aquatic and terrestrial environments - Human mediated spread and other intentional introductions - Epidemics and epizootics

**MODULE-3** Characteristics of successful invasive species - Community and ecosystem - structure and function - Disruption of normal ecosystem function by exotics.

**MODULE-4** Patterns and dynamics of spread of invasive species – overview of invasion models – Case studies – Biosecurity failures - Feral Cat Management in Tasmania – African cat fish in India.

**MODULE-5** Invasive species management – organizations – IUCN – Invasive Species Specialist Group (ISSG) – National biodiversity authority (NBA) - methods of invasive species control – awareness and strategies

**SUGGESTED READING**

1. Shigesada N and K. Kawasaki, 1997, Biological Invasions: Theory and Practice , Oxford University Press, Oxford.
2. Simberloff D 2013 Invasive Species: What Everyone Needs to Know. Oxford University Press,. 352 pp
3. Lockwood, Julie L., Martha F. Hoopes and Michael P. Marchetti. 2007. Invasion Ecology. Malden, MA: Blackwell Publishing.
4. Mooney, Harold A. and Richard J. Hobbs. 2000. Invasive Species in a Changing World. Washington: Island Press.

**EVS-CW – 102(XIV) ENVIRONMENTAL TOXICOLOGY**

**MODULE-1** Introduction – Major Industrial Effluents – Sewage – Characteristics, Fertilizers – Pesticides and other agrochemicals – Heavy metals – Mercury, Cadmium, Chromium,

Lead, Aluminum, Arsenic, Copper, Nickel and their toxicity – Ground water contamination – Soil Pollution –Environmental impacts of use and throw plastics - Hospital wastes and their environmental impacts

**MODULE-2** Air pollution – Sources – Oxides of Carbon, Nitrogen, Sulphur, Hydrocarbons – Transport and Diffusion – Effects of air pollutants on life and properties – Measurement of airborne contaminants-Acid rain – Ozone depletion – Global warming and their consequences – Radioactive Pollution – Thermal pollution – Noise pollution – Sources and effects – Fate of air, water and soil pollutants - Episodes of pollution

**MODULE-3** Principles and Methodologies for the quantitative analyses of TOC, chromium, cadmium, arsenic, mercury, copper, lead, nickel and zinc in waste water – Estimation of NOx, CO2, CO, SO2 and SPM in air.

**MODULE-4** General principles of toxicology - Scope of toxicology - Outlines of toxicological testing methods, cost effective bioassays - Toxicity and Probit Analysis - Bioassays – Mechanism of action of toxicants - Routes of exposure - Routes of entry of xenobiotics - Absorption and Translocation – Biotransformation - Combined action of toxicants - Factors influencing toxicity - Dose effect and Dose response relationship.

**MODULE-5** Toxicity – Cytotoxicity, Immunotoxicity, Hepatotoxicity, Molecular toxicity, Neurotoxicity - Carcinogens, mutagens and teratogens. Ecotoxicology and human toxicology, Behaviour of toxicants in the environment – Occupational exposure to industrial toxicants - Bioaccumulation, Biomagnification – Toxic residues - Residual analytical methods - Safety evaluation of toxic chemicals .

**SUGGESTED READING**

1.Josephy, P. D., Mannervik, B., de Montellano, B.O., 1997. Molecular Toxicology. Oxford University Press, UK.

2.Tomlin, C., 2000. The Pesticide Manual. 11th edition,. British Crop Protection Council. Several editions. updated every few (2-4) years.

3.Bryant, R., Bite, M., Hopkins, WL., 1999. Global insecticide directory, 2nd ed. Ed.. Ag. Chem. Inform. Services, Agranova.

4.Krishnan Kannan, K., 1997. Fundamentals of Environmental Pollution, S. Chand Company, New Delhi.

5.Sharma, B. K., Kaur, H., 2000. Environmental Chemistry, Goel Publishing House, Meerut, India.

6.Anderson, K., Scott, R., 1981. Fundamentals of industrial toxicology, Ann. Arbor. Science Publishing Inc. Michigam. USA.

7.Ecobicham, D., 2004. The basis of toxicity testing, CRC press, USA.

8.Prasad, D.N., Kashyap, V., 1999. Introduction to toxicology, S. Chand Company, New Delhi

9.De Matters, F., Smith, L., 1995. Molecular and Cellular Mechanisms of Toxicity CRC Press, USA

10.Dara, S.S., 2000. A text book of environmental chemistry and pollution control. S.

Chand Company, New Delhi.
11.Sharma, P. D., 1993. Environmental Biology and Toxicology, Rastogi Publications, New Delhi.
12.A.G.Murugesan and C.Rajakumari, Environmental Science and Biotechnology – Theory and Techniques, MJP Publishers.
13.Nation, J. L., 2008. Insect Physiology and Biochemistry, Second Edition, CRC Press, USA.
14.Josephy, P. D., Mannervik, B., de Montellano, P.O., 1997. Molecular Toxicology, Oxford University Press, UK.
15.Finney, D. J., 1971. Probit Analysis. 3rd edition. Cambridge University Press, UK.
16.Subramanian, M.A., 2004. Toxicology: Principals and methods, MJP Publishers.
17.APHA. 1975. Standard methods for the examination of waste water. AWWA, New York.
18.A.K. Gupta. Industrial Safety and Environment. 2013. University Science Press.

**PHD Entrance Test**

**Syllabus: Environmental Science**

**Unit-I**

Definition, Principles and scope of Environmental Science.

Earth, Man and Environment, Ecosystems, Pathways in Ecosystems. Physico-chemical and Biological factors in the Environment. Geographical classification and zones.

Structure and composition of atmosphere, hydrosphere, lithosphere and bio-sphere. Mass and Energy transfer across various interfaces, material balance. First and Second law of thermodynamics, heat transfer processes. Scales of Meteorology: pressure, temperature, precipitation, humidity, radiation and wind. Atmospheric stability, inversions and mixing heights, windroses. . Natural resources, conservation and sustainable development.

**Unit-II**

**Fundamentals of Environmental Chemistry**: Stochiometry, Gibbs' energy, Chemical potential, chemical equilibria, acid base reactions, solubility product, solubility of gases in water, the carbonate system, unsaturated and saturated hydrocarbons, radionuclides.

**Chemical composition of Air:** Classification of elements, chemical speciation. Particles, ions and radicals in the atmosphere. Chemical processes for formation of inorganic and organic particulate matter. Thermochemical and photochemical reactions in the atmosphere. Oxygen and ozone chemistry, Chemistry of air pollutants, Photochemical smog.

**Water Chemistry:** Chemistry of water, concept of DO, BOD, COD, sedimentation, coagulation. filtration, Redox potential.

**Soil Chemistry:** Inorganic and organic components of soil, Nitrogen pathways and NPK in soils.

**Toxic Chemicals in the environment - Air, Water:** Pesticides in water. Bio-chemical aspects of Arsenic, Cadmium, Lead, Mercury, Carbon Monoxide, O3 and PAN Pesticides, Insecticides, MIC, carcinogens in the air.

**Unit-III**

Definition, Principles and scope of ecology, Human ecology and Human settlement, Evolution, Origin of life and speciation.

**Ecosystems :** Structure and functions, Abiotic and Biotic components, energy flows, Food chains, Food web, Ecological pyramids, types and diversity.

Ecological Succession, Population, Community ecology and arasitism, Prey-predator relationships.

**Common flora and fauna in India**

**Aquatic** : Phytoplankton, Zooplankton and Macrophytes

**Terrestrial** : Forests

**Endangered and Threatened Species**

**Biodiversity and its conservation:**. Definition, 'Hotspots' of Biodiversity, Strategies for Biodiversity conservation. National Parks and Sanctuaries. Gene pool. Man and biosphere reserves.

**Microflora of Atmosphere:** Air Sampling techniques. Identification of aeroallergens. Air-borne diseases and allergies.

**Environmental Biotechnology:** Fermentation Technology, Vermiculture technology, Biofertilizer technology.

**Unit-IV**

**Environmental Geosciences-** Fundamental concepts.

**The earth system:** Conservation of matter in various geospheres-lithosphere, hydrosphere, atmosphere and biosphere. Energy-budget of the earth. Earth's thermal environment and seasons. Ecosystems flow of energy and matter. Coexistence in communities-food webs., Earth's major ecosystems-terrestrial and aquatic. General relationship between landscape, biomes and climate. Climates of India, Indian monsoon, EI Nino, Droughts. Tropical cyclones and Western Disturbances.

**Earth's Processes and Geological Hazards :** Earth's processes; concept of residence, time and rates of natural cycles. Catastrophic geological hazards. Study of floods, landslides, earthquakes, volcanism and avalanche. Prediction and perception of the hazards and adjustments to hazardous activities.

**Mineral Resources and Environment:** Resources and Reserves, Minerals and Population. Oceans as new areas for exploration of mineral resources. Ocean ore and recycling of resources. Environmental impact of exploitation, processing and smelting of minerals.

**Water Resources and Environment :** Global Water Balance, Ice sheets and fluctuations of sea levels. Origin and composition of seawater. Hydrological cycle. Factors influencing the surface water. Types of water. Resources of oceans. Ocean pollution by toxic wastes. Human use of surface and groundwaters. Groundwater pollution.

**Landuse Planning :** The Iand use plan. Soil surveys in relation to Landuse planning. Methods of site selection and evaluation. Traditional practices of conservation of water, flora and fauna.

**Environmental Geochemistry:** Concept of major, trace and REE. Classification of trace elements, Mobility of trace elements, Geochemical cycles. Biogeochemical factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of lead.

Principles of Remote sensing and its application in Environmental Sciences. Application of GIS in Environmental Management.

**Unit-V**

Sun as source of energy; solar. radiation and its spectral charactertstics: Fossil fuels-classification. Composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas. Principles of generation of hydroelectric power, tidal, Ocean Thermal Energy Conversion, wind, geothermal energy; solar collectors, photovoltaics, solar ponds; nuclear energy-fission and fusion; magnetohydrodynamic power, bio-energy-energy from biomass and biogas, anaerobic digestion; energy use pattern in different parts of the world.

Environmental implication of energy use; CO2 emission, global warming; air and thermal pollution; radioactive waste and radioactivity from nuclear reactors. Exploitation of Solar, Wind, Hydro and Ocean energy.

**UNIT-VI**

**Air :** Natural and anthropogenic sources of pollution. Primary and Secondary pollutants. Transport and diffusion of pollutants. Gas laws governing the behaviour of pollutants in the atmosphere. Methods of monitoring and control of air pollution .SO2, NO2, CO, SPM. Effects of pollutants on human beings, plants, animals, materials and on climate. Acid Rain. Air Quality Standards.

**Water :** Types, sources and consequences of water pollution. Physico-chemical and Bacteriological sampling and analysts of water quality. Standards, sewage and waste water treatment and recycling. Water quality standard.

**Soil :** Physico-chemical as bacteriological sampling as analysis. of soil quality. Soil Pollution Control. Industrial waste effluents and heavy metals, their interac-tions with soil components. Soil micro-organisms and their functions, degradation of different insecticides, fungicides and weedicides in soil. Different kinds of synthetic fertilizers (N, P & K) and their interactions with different components of soil.

**Noise :** Sources of noise pollution, measurement of noise and Indices, effect of meteorological parameters on noise propagation. Noise exposure levels and standards. Noise control and abatement measures. Impact of noise on human health.

**Marine :** Sources of marine pollution and control. Criteria employed for disposal of pollutants in marine system--coastal management. .

Radioactive and Thermal Pollution.

**UNIT-VII**

Introduction to environmental impact analysis.

Environmental impact Statement and Environmental Management Plan.

EIA guidelines 1994, Notification of Government of India.

Impact Assessment Methodologies. Generalized approach to impact analysis.

Procedure for reviewing Environmental impact analysis and statement. Guidelines for Environmental audit.

Introduction to Environmental planning.

Base line information and predictions (land, water, atmosphere, energy, etc.)

Restoration and rehabilitation technologies.

Land use policy for India. Urban planning for India. Rural planning and land use pattern.

Concept and strategies of' sustainable development. Cost-Benefit analysis.

Environmental priorities in India and sustainable development.

**Unit-VIII**

Sources and generation of solid wastes, their charactertzation, chemical composition and classification. Different methods of disposal and management of solid wastes (Hospital Wastes and Hazardous Wastes), Recycling of waste material. Waste minimization technologies.

Hazardous Wastes Management and Handling Rules, 1989, Resource Management, Disaster Management and Risk analysis.

Environment protection-issues and problems. International and National efforts for Environment Protection, Provision of Constitution of India regarding Environment (Article 48A and 51A (g)).

Environmental Policy Resolution. Legislation, Public Policy Strategies in Pollution Control; Wildlife Protection Act 1972 amended 1991; Forest Conservation. Act 1980; Indian Forests Act (Revised) 1982. Air (Prevention and Control of Pollution) Act ·1981 as amended by Amendment Act 1987 and Rule 1982, Motor Vehicle Act 1988. The Water (Prevention and Control of Pollution) Act 1974 as amended up to 1988, and Rules 1975. The Environment (Protection) Act 1986 and Rules 1986. Biological diversity Act 2002.

Scheme of labelling of environment friendly products (Ecomark), Public Liability Insurance Act 1991 and Rules 1991.

**Unit-IX**

Basic elements and tools of statistical analysis. Introduction to environmental system analysis; Approaches to development of models; linear simple and multiple regression models" validation and forecasttug. Models of population growth and interactions-Lotka-Volterra model, Leslie's matrix model, point source stream pollution model, box model. Gaussian plume model.

**Unit-X**

Environmental Education and Awareness. Environmental Ethics and Global imperatives.

Global Environmental problems-ozone depletion, global warming and climatic change.

Current Environmental issue in Indian Context : Narmada Dam, Tehri Dam, Almetti Dam, Soil Erosion. Formation and reclamation of Usar, Alkaline and Saline Soil. Waste lands and their reclamation. Desertification and its control.

Vehicular pollution and urban air quality.

Depletion of Natural resources.

Biodiversity conservation and Agenda-21.

Waste disposal, recycling and power generation. Fly ash utilization.

Water Crises-Conservation of water. Rain water harvesting.Wetlands conservation. Eutrophication and restoration of Indian lakes.

Environmental Hazards.

Environmental disaster and management.

Epidemiological issues (e.g., Goitre, Fluorosis, Arsenic, Silicosis).