

## **Ph.D. Entrance Examination**

### **Environmental Science**

#### **Paper I. Research Methodology**

##### **UNIT I: Introduction to Research Methodology**

Research- Definitions, importance, types, essential steps, significance, problems; Experimental design; literature, data collection and citation. Research reports, abstracts, dissertation, thesis, manuscripts, review papers, book reviews, conference and project reports, bibliography & references, acknowledgements, indexing, tables and illustrations.

##### **UNIT II: Elementary Computer and internet Applications**

Concept of computer hardware, languages, and softwares. Introduction to spreadsheet applications, features, using formulas and functions, data storing, features for statistical data analysis, generating charts/graph and other features using Microsoft excel or similar. Introduction to presentation tools, features and functions, power point presentation, internet browsing, WWW, use of search engines, environmental data bases. Computer networking LAN and WAN.

##### **UNIT III: Environmental Statistics**

Attributes and Variables: types of variables, scales of measurement, measurement of Central tendency and Dispersion, Standard error, Moments – measure of Skewness and Kurtosis, Basic concept of probability theory, Sampling theory, Distributions – Normal, log-normal, Binomial, Poisson, t, 2 and F-distribution. Correlation, Regression, tests of hypothesis (t-test, 2-test ANOVA: one-way and two-way); significance and confidence limits.

Approaches to development of environmental models; linear, simple and multiple regression models, validation and forecasting. Models of population growth and interactions: Lotka-Volterra model, Leslie's matrix model.

##### **UNIT IV: Research Ethics & IPR**

Perspective of ethics, personal vs professional ethics. Moral reasoning, ethical theories, deontological, utilitarianism, ethical leadership (integrity and ingenuity). Framework for ethical decision making. Plagiarism software, intellectual property rights, types, patents, copy rights, trade marks, design rights, geographical indications. Patentable and non patentable, legal protection of biotechnological inventions, world intellectual property rights organization (WIPO).

##### **UNIT V: Instrumentation:**

Chromatography and Electrophoresis Chromatography – Thin layer chromatography - Gas chromatography - Column chromatography - Ion exchange chromatography - Gel exclusion chromatography - HPLC Affinity chromatography and Immunoabsorption.

Colorimetry and Centrifugation: Colorimetry - ultraviolet - visible spectrophotometry - principles, instrumentation - applications, Fluorescence spectrophotometry. AAS, FES, IR, Nephelometry, Polarography, GC and HPLC.

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- Wilson and Walker (2000). Practical Biochemistry- Principles and Techniques. J. Cambridge Uni. Press.

## **Paper II. Environmental Science**

### **Unit-I: Fundamentals of Environmental Sciences**

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 biosphere. First and Second Law of thermodynamics, heat transfer processes, mass and energy transfer across various interfaces, material balance.

Meteorological parameters – pressure, temperature, precipitation, humidity, mixing ratio, saturation mixing ratio, radiation and wind velocity, adiabatic lapse rate, environmental lapse rate. Wind roses.

Natural resources, conservation and sustainable development.

### **Unit-II: Environmental Chemistry**

Importance of Environmental Chemistry, types of reactions, redox reactions, Reaction kinetics. Electrochemistry and its applications. Physical and equilibrium chemistry – fundamentals and applications. Trace Contaminants and their analyses.

pH – Principle, Measurement, Numerical Examples, Buffers and Buffer index. Colloidal Chemistry – Properties of colloids, colloidal dispersions, stability of colloids. Applications of colloids in Environmental Management. Colourimetry – Principles, Laws and applications.

Applications of Analytical Chemistry – emission and absorption techniques.

Natural Resources of Water, Pollution parameters of wastewaters, definitions and estimations of COD, BOD, DO, TOC, Nitrogen. Environmental significance of Nitrogen, Phosphorus, COD, BOD, Fluoride and Sulphate as applied to environmental chemistry. Sanitary significance of Phosphorous cycle, carbon cycle and nitrogen cycle. Principles of osmosis, reverse osmosis and electro-dialysis and their applications

Optical Methods-Principles and applications involved in calorimeter and spectrophotometer.

Electrical methods - Principles and applications in potentiometry and conductometry.

Chromatographic methods- Principles and applications of GC and GCMS. Other instrumental methods - Principles and applications of AAS, Flame Photometer and Ionmeter.

### **Unit-III Environmental Biology**

Definition, Principles and Scope of Environmental Science. Evolution of environment, Physico-chemical and Biological Characteristics of environment, Geographical classification and zones. Earth, Man and Environment, introduction to bio-diversity in- situ and ex- situ biodiversity conservation.

Introduction to Biosphere, lithosphere, hydrosphere and atmosphere, Hydrological cycle, Introduction to Sustainable development.

Aquatic and Terrestrial Ecosystems –Diversity and dominance Indices, Ecosystem Models.

Lake ecosystem–Trophic levels, Nutrient loading, nutrient Enrichment, control of eutrophication. Limiting factors and their tolerance Liebig's law of minimum, Shelford's law of Tolerance, measurement of primary productivity.

Definition, Principles and Scope. Biotic and abiotic factors of environment. Principle and concept of ecosystem : wetland, pond, forest, river, grassland and estuary ecosystems. Homeostasis of environment- First and second law of thermodynamics and energy flow; Trophic structure, food chain, food web; Ecological pyramids and ecosystem energetic. Population dynamics : Definition, population density, Natality, Mortality, Age structure, Growth pattern, Fluctuation and equilibrium, Biotic potentials, population dispersion. Density dependent and density independent factors of population regulation. Community: Definitions, characteristics, diversity, dominance, structure, stratification, periodicity, interdependence.

Common flora and fauna in India: Aquatic – Phytoplankton, Zooplankton and Macrophytes, Terrestrial – forests. Endangered, rare and threatened species. Ecotone and Edge effect, Ecological Niche and Equivalents, Ecotype, Ecophene and Ecological indicator, Ecological succession. Food production; Food chain losses, Food from land and sea, increasing yield, pesticides – effects on non target organisms, Effects on predator – prey relationship. Biomes and aquatic life zones. Ecosystem stability, Human impact on ecosystem.

Renewable and Nonrenewable Resource, Introduction, Classification, Importance of Renewable and Nonrenewable Resource. Forest Resources, Forest types and Management, Effect of Deforestation, and Sustainable Forest Management. Water Resources -Introduction, Types, Distribution, Importance of water resources, Methods for management. Food resources- Impacts and Solutions for Food crises, Energy resources-Introduction, Sources of Energy and its importance.

### **Unit-IV: Environmental Geosciences**

Origin of earth. Primary geochemical differentiation and formation of core, mantle, crust, atmosphere and hydrosphere. Concept of minerals and rocks. Formation of igneous and metamorphic rocks. Controls on formation of landforms – tectonic including plate tectonic and climatic. Concept of steady state and equilibrium, Energy budget of the earth. Earth's thermal environment and seasons. Climates of India, western disturbances, Indian monsoon, droughts, *El Nino*, *La Nina*. Concept of residence time and rates of natural cycles. Geophysical fields.

Weathering including weathering reactions, erosion, transportation and deposition of sediments. Soil forming minerals and process of soil formation, Identification and

characterization of clay minerals, Soil physical and chemical properties, soil types and climate control on soil formation, Cation exchange capacity and mineralogical controls.

Natural resource exploration and exploitation and related environmental concerns. Historical perspective and conservation of non-renewable resources.

Natural Hazards: Catastrophic geological hazards – floods, landslides, earthquakes, volcanism, avalanche, tsunami and cloud bursts. Prediction of hazards and mitigation of their impacts.

Principle of Remote Sensing and its applications to Environment, types of sensors spectral reflectance and their characteristics, products used in Remote sensing, GIS and their use for environmental monitoring.

### **Unit-V: Energy and Environment**

Sun as source of energy; solar radiation and its spectral characteristics. Fossil fuels: classification, composition, physico-chemical characteristics and energy content of coal, petroleum and natural gas. Shale oil, Coal bed Methane, Gas hydrates. Gross-calorific value and net-calorific value.

Principles of generation of hydro-power, tidal energy, ocean thermal energy conversion, wind power, geothermal energy, solar energy (solar collectors, photo-voltaic modules, solar ponds).

Nuclear energy – fission and fusion, Nuclear fuels, Nuclear reactor – principles and types.

Bioenergy: methods to produce energy from biomass.

Environmental implications of energy use; energy use pattern in India and the world, emissions of CO<sub>2</sub> in developed and developing countries including India, radiative forcing and global warming. Impacts of large scale exploitation of solar, wind, hydro and nuclear energy sources.

### **Unit-VI: Environmental Pollution and Control**

**Air Pollution:** Sources and types of Pollutants – Natural and anthropogenic sources, primary and secondary pollutants. Criteria air pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequency and duration of sampling. Principles and instruments for measurements of (i) ambient air pollutants concentration and (ii) stack emissions. Indian National Ambient Air Quality Standards. Impact of air pollutants on human health, plants and materials. Acid rain. Dispersion of air pollutants. Mixing height/depth, lapse rates, Gaussian plume model, line source model and area source model. Control devices for particulate matter: Principle and working of: settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator. Control of gaseous pollutants through adsorption, absorption, condensation and combustion including catalytic combustion. Indoor air pollution, Vehicular emissions and Urban air quality.

**Noise Pollution:** Sources, weighting networks, measurement of noise indices (Leq, L10, L90, L50, LDN, TNI). Noise dose and Noise Pollution standards. Noise control and abatement measures: Active and Passive methods. Vibrations and their measurements. Impact of noise and vibrations on human health.

**Water Pollution:** Types and sources of water pollution. Impact on humans, plants and animals. Measurement of water quality parameters: sampling and analysis for pH, EC, turbidity, TDS, hardness, chlorides, salinity, DO, BOD, COD, nitrates, phosphates, sulphates, heavy metals and organic contaminants. Microbiological analysis – MPN. Indian standards for drinking water (IS:10500, 2012). Drinking water treatment: Coagulation and flocculation, Sedimentation and Filtration, Disinfection and Softening. Wastewater Treatment: Primary, Secondary and Advanced treatment methods. Common effluent treatment plant.

**Soil Pollution:** Physico-chemical and biological properties of soil (texture, structure, inorganic and organic components). Analysis of soil quality. Soil Pollution control. Industrial effluents and their interactions with soil components. Soil micro-organisms and their functions – degradation of pesticides and synthetic fertilizers.

**Thermal, Marine Pollution and Radioactive:** Sources of Thermal Pollution, Heat Islands, causes and consequences. Sources and impact of Marine Pollution. Methods of Abatement of Marine Pollution. Coastal management. Radioactive pollution – sources, biological effects of ionizing radiations, radiation exposure and radiation standards, radiation protection.

### **Unit-VII: Solid and Hazardous Waste Management**

Solid Waste – types and sources. Solid waste characteristics, generation rates, solid waste components, proximate and ultimate analyses of solid wastes.

Solid waste collection and transportation: container systems – hauled and stationary, layout of collection routes, transfer stations and transportation.

Solid waste processing and recovery – Recycling, recovery of materials for recycling and direct manufacture of solid waste products. Electrical energy generation from solid waste (Fuel pellets, Refuse derived fuels), composting and vermicomposting, biomethanation of solid waste. Disposal of solid wastes – sanitary land filling and its management, incineration of solid waste.

Hazardous waste – Types, characteristics and health impacts. Hazardous waste management: Treatment Methods – neutralization, oxidation reduction, precipitation, solidification, stabilization, incineration and final disposal.

e-waste: classification, methods of handling and disposal.

Fly ash: sources, composition and utilisation.

Plastic waste: sources, consequences and management.

### **Unit-VIII: Environmental Assessment, Management and Legislation**

Aims and objectives of Environmental Impact Assessment (EIA). Environmental Impact Statement (EIS) and Environmental Management Plan (EMP). EIA Guidelines. Impact Assessment Methodologies. Procedure for reviewing EIA of developmental projects. Life-cycle analysis, cost-benefit analysis. Guidelines for Environmental Audit. Environmental Planning as a part of EIA and Environmental Audit. Environmental Management System Standards (ISO14000 series). EIA Notification, 2006 and amendments from time to time. Eco-labeling schemes.

Risk Assessment – Hazard identification, Hazard accounting, Scenarios of exposure, Risk characterization and Risk management.

Overview of Environmental Laws in India: Constitutional provisions in India (Article 48A and 51A). Wildlife Protection Act, 1972 amendments 1991, Forest Conservation Act, 1980, Indian Forest Act, Revised 1982, Biological Diversity Act, 2002, Water (Prevention and Control of Pollution) Act, 1974 amended 1988 and Rules 1975, Air (Prevention and Control of Pollution) Act, 1981 amended 1987 and Rules 1982, Environmental (Protection) Act, 1986 and Rules 1986, Motor Vehicle Act, 1988, The Hazardous and Other Waste (Management and Transboundary Movement) Rules, 2016, The Plastic Waste Management Rules, 2016, The Bio-Medical Waste Management Rules, 2016, The Solid Waste Management Rules, 2016, The e-waste (Management) Rules 2016, The Construction and Demolition Waste Management Rules, 2016, The Manufacture, Storage and Import of Hazardous Chemical (Amendment) Rules, 2000, The Batteries (Management and Handling) Rules, 2010 with Amendments, The Public Liability Insurance Act, 1991 and Rules 1991, Noise Pollution

(Regulation and Control) Rules, 2000, Coastal Regulation Zones (CRZ) 1991 amended from time to time.

National Forest Policy, 1988, National Water Policy, 2002, National Environmental Policy, 2006.

Environmental Conventions and Agreements: Stockholm Conference on Human Environment 1972, Montreal Protocol, 1987, Conference of Parties (COPs), Basel Convention (1989, 1992), Ramsar Convention on Wetlands (1971), Earth Summit at Rio de Janeiro, 1992, Agenda-21, Global Environmental Facility (GEF), Convention on Biodiversity (1992), UNFCCC, Kyoto Protocol, 1997, Clean Development Mechanism (CDM), Earth Summit at Johannesburg, 2002, RIO+20, UN Summit on Millennium Development Goals, 2000, Copenhagen Summit, 2009. IPCC, UNEP, IGBP.

### **Unit-IX: Contemporary Environmental Issues**

Global Environmental Issues – Biodiversity loss, Climate change, Ozone layer depletion. Sea level rise. International efforts for environmental protection.

National Action Plan on Climate Change (Eight National missions – National Solar Mission, National Mission for Enhanced Energy Efficiency, National Mission on Sustainable Habitat, National Water Mission, National Mission for Sustaining the Himalayan Ecosystem, National Mission for a ‘Green India’, National Mission for Sustainable Agriculture, National Mission on Strategic Knowledge for Climate Change).

**Current Environmental Issues in India:** Environmental issues related to water resource projects – Narmada dam, Tehri dam, Almatti dam, Cauvery and Mahanadi, Hydro-power projects in Jammu & Kashmir, Himachal and North-Eastern States.

Water conservation-development of watersheds, Rain water harvesting and ground water recharge.

National river conservation plan – Namami Gange and Yamuna Action Plan.

Eutrophication and restoration of lakes. Conservation of wetlands, Ramsar sites in India.

Soil erosion, reclamation of degraded land, desertification and its control.

Climate change – adaptability, energy security, food security and sustainability.

Forest Conservation – Chipko movement, Appiko movement, Silent Valley movement and Gandhamardhan movement. People Biodiversity register.

Wild life conservation projects: Project tiger, Project Elephant, Crocodile Conservation, GOI-UNDP Sea Turtle project, Indo-Rhino vision.

Carbon sequestration and carbon credits.

Waste Management – Swachha Bharat Abhiyan.

Sustainable Habitat: Green Building, GRIHA Rating Norms.

Vehicular emission norms in India.

Epidemiological Issues: Fluorosis, Arsenocosis, Goitre, Dengue.

Environmental Disasters: Minnamata Disaster, Love Canal Disaster, Bhopal Gas Disaster, 1984, Chernobyl Disaster, 1986, Fukusima Daiichi nuclear disaster, 2011.

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- D.O.Tyagia and M. Mehra, 1990. A Text Book Environmental chemistry - Anmol publication.
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