UNIVERSITY OF CALCUTTA

Notification No. CSR/ 70 /18

It is notified for information of all concerned that the Syndicate in its meeting held on 13.07.2018 (vide Item No.11) approved the Syllabus of Two-Year (Four-Semester) M.Sc. Course of Study in Environmental Science under CBCS in the Post-Graduate Departments of the University and in the affiliated Colleges offering Post-Graduate Courses under this University, as laid down in the accompanying pamphlet.

The above shall be effective from the academic session 2018-2019.

SENATE HOUSE
KOLKATA-700073
The 17th August, 2018

(Debabrata Manna)
Deputy Registrar (Acting)

UNIVERSITY OF CALCUTTA

Syllabus for M. Sc. course (4 semesters)
in
Environmental Science

Structure of courses in different semesters for M.Sc. in Environmental Science

	Paper	Theory	Practical & Assignments	Credits
1st Semester		**150**	**100**	**20**
ENV C 11	Basics of Environmental science and sustainable development	30	-	2 + 0
ENV C 12	Environmental microbiology	30	25	3 + 2
ENV C 13	Environmental chemistry	30	25	2 + 2
ENV C 14	Ecology	30	25	3 + 2
ENV C 15	Hydrology and water management	30	15	2 + 1
ENV F 11	Field based studies to places of environmental importance	-	10	0 + 1
2nd Semester		**150**	**100**	**20**
ENV C 21	Diversity of life forms and environmental applications	30	-	3 + 0
ENV C 22	Environmental geosciences	30	25	2 + 2
ENV C 23	Environmental biochemistry	30	25	2 + 2
ENV C 24	Energy and environment	30	-	2 + 0
ENV C 25	Pollution: assessment, instrumentation and control technologies	30	25	3 + 2
ENV D 21	Environmental status report, documentation and community outreach activities	-	25	0 + 2
3rd Semester		**150**	**100**	**20**
ENV C 31	Meteorology, remote sensing and GIS	25	20	2 + 1
ENV C 32	Disaster management and risk analysis	25	-	2 + 0
ENV P 31	Project work	-	70	0 + 6
ENV F 31	Industrial visit	-	10	0 + 1
CBCC A	Choice Based Credit Course A	50	-	4 + 0
CBCC B	Choice Based Credit Course B	50	-	4 + 0
4th Semester		**150**	**100**	**20**
ENV C 41	Waste and waste management	25	-	2 + 0
ENV C 42	Toxicology, environmental health and occupational hazards	30	25	3 + 2
ENV C 43	Molecular biology and immunology	25	25	2 + 2
ENV C 44	Statistics, environmental modeling and informatics	25	-	2 + 0
ENV C 45	Environmental legislations and environmental impact assessment	25	-	2 + 0
ENV C 46	Environmental economics and audit	20	-	2 + 0
ENV S 41	Seminar presentation and scientific writing	-	25	0 + 2
ENV V 41	Grand viva	-	25	0 + 1
	Total (4 Semesters)	**600**	**400**	**80**

1st Semester

ENV C 11 Basics of Environmental science and sustainable development

Theory **Marks 30 Credit 2**

Basic concepts of Environmental Science: Concept of environment; Principle and scope of environmental science; Multidisciplinary approach of environmental science; Basic concepts and genesis of global environmentalism; Environmental education and awareness; Environmental ethics and global imperatives; Anthropocentric environmental view.

Environment-civilization interface: Human society and settlement; Process of cultural transmission; Gradual social changes in relation to environment; Nature vs. Nurture; Global environmental problems and initiatives; Global and Indian context of demography.

Current environmental issues in India: Environmental movements and related issues in India-Bishnoism, Silent valley movement, Narmada Dam, Teheri Dam, Almetti Dam, River Linking, Joint Forest Management, Chipko movement, Apikko movement, River cleaning initiatives; Ecological restorations: case studies from Ramsar wetlands and mines; Waste land and their reclamation; Desertification and its control.

Concept of Sustainability: Sustainability indices; Strategies and debates on sustainable development; Concept of Sustainable Agriculture; India's environment action programme: issues, approaches and initiatives towards Sustainability; Sustainable development in practice; Urbanization; Urban sprawling and urban growth; Concept and characteristics of smart city; Urban resources and environmental problems; Carrying capacity analysis; Concept of ecological footprints.

ENV C 12 Environmental microbiology

Theory **Marks 30 Credit 3**

Fundamentals of Microbiology: Classification of microorganisms; Factors controlling growth of microbes; measurement, kinetics and characteristics of bacterial growth in natural and artificial system.

Microbiology of Air: Factors affecting the survival of microorganisms in air; Sources of microorganisms; Air-borne pathogens and its role on public health; Sampling techniques for microbiological air quality.

Microbiology of Water: Common microorganisms encountered in freshwater sources; Self-purification of water; Common sources of microbial pollution in water; Assessment of microbiological quality of water; Characteristics of pollution indicator microorganisms; Selection and quantification of indicator organism in freshwater; Freshwater quality standard; purification of water for human use.

Microbiology of Soil: Beneficial and pathogenic microbes in agriculture; Soil as a microbial growth medium; Characteristics of soil microenvironment for microbes; Interaction of microorganisms and plant in soil; Role of microorganism in maintaining the soil fertility; Concepts of Chemoorganotroph and Chemolithotroph.

Elements of Food Microbiology: Different fermented food (eg. Cheese, curd, wine etc); Harmful food borne microorganism; Detection of food borne pathogens in raw and canned foods; Bacteriology of milk; Outline of the processes of food preservation (Pasteurization, Sterilization, Canning and Blanching).

Practical **Marks 25 Credit 2**

Laboratory safety; Basic microbial techniques; Isolation of microorganisms from air, water and soil; Microbial staining, observation and micrometry; presence of pathogen in waste water; isolation of microorganisms of environmental interest.

ENV C 13 Environmental chemistry

Theory **Marks 30 Credit 2**

Basic Concepts: Classification of elements (emphasis on heavy metals); Biogeochemical cycles; Saturated and unsaturated hydrocarbons in environment; Stoichiometry; Gibb's energy; Chemical Potential and Chemical equilibrium; Mass and energy transfer across various interfaces;

Material balance; Laws of thermodynamics, Heat transfer process, Acid - Base-reactions, Solubility products; Solubility of gases in water; Chemistry of hydrocarbons and its decay.

Environmental aspects of air-chemistry: Chemical composition of air; Particles, ions and radicals in atmosphere; Chemical processes for formation of inorganic and organic particulate matter; Thermochemical and Photochemical reactions in Atmosphere, Photochemical smog; Oxygen and ozone chemistry.

Environmental aspects of water-chemistry: Fundamentals of water chemistry; Concept of DO, BOD, COD, Total hardness, Redox potential; Carbonate system.

Environmental aspects of soil-chemistry: Soil formation, composition and classification; Soil profile; Soil erosion; Inorganic and Organic components of soil -Nitrogen pathways in soil; NPK in soils.

Principles of commonly used analytical methods in environmental quality assessment: Titrimetry; Gravimetry; Colorimetry; Spectrophotometry; Flame photometry; Atomic absorption spectrophotometry; Basic Chromatography; GC; GLC, HPLC; Electrophoresis; X-Ray fluorescence, X-Ray diffraction; Inductive coupled plasma spectroscopy.

Practical **Marks 25 Credit 2**

Sampling techniques and sample preparation; Physico-chemical characterization: water and waste water, soil and sediment; Air quality assessment

ENV C14 Ecology

Theory **Marks 30 Credit 3**

Ecosystem dynamics: Tropic structure and energy flow; Food web complexity, food-web patterns; Guild analysis; Keystone species; Productivity; Thermodynamics and energy flow; Structure and function of forest, lake and agricultural ecosystems.

Population ecology: Survivorship and life table; Population growth models; r and k selection; Concept of carrying capacity; Factors affecting human population size; Population age structure; Populations, adaptation and resilience; Population viability analysis; Metapopulation (Levin's model, metapopulation persistence time, correlated extinction).

Community Ecology: Community structure and dynamics; Theory of Island bio geography; Concept of diversity and stability; Intermediate disturbance hypothesis; Predator-prey-population oscillation; Function and numerical response model (Competition theory and modelling, competitive exclusion and coexistence); Community development: Connell and Slatyer's facilitation, inhibition and tolerance model, Tillman's resource ratio hypothesis.

Concept of Niche: Hutchinsonian concept; Niche overlapping; Niche breadth and width; Resource partitioning; Character displacement in Galapagos finches.

Landscape ecology: Landscape elements, Landscape geometry, Landscape sustainability; Urban-industrial techno ecosystem.

Practical **Marks 25 Credit 2**

Sampling techniques; Layout of experimental design and statistical analysis; Study of population and community ecology of aquatic and terrestrial ecosystem; Biodiversity documentation

ENV C 15 Hydrology and water management

Theory **Marks 30 Credit 2**

Hydrological cycle and processes: Systems concept of hydrological cycle; Precipitation; Evaporation and transpiration; Runoff; Base flow; Infiltration; Types of water; Origin and composition of sea water; Significant chemical distinction between sea water and river water; Global water balance; Global and Indian distribution of water resources;

Introduction to Groundwater hydrology: Origin of ground water; Subsurface profile of groundwater; Water bearing characteristics of different types of rocks; Geomorphic and geologic controls of ground

water; Ground water provinces in India; Water table and piezometric surface; Genetic classification of groundwater.

Hydrological characteristics of aquifer: Aquifers (unconfined, confined and semi-confined); Porosity, void ratio, permeability, transmissivity, storativity, specific yield, specific retention, diffusivity, velocity; Elasticity of confined aquifer.

Laws of ground water movement: Bernoulli's equation; Darcy's Law; Laplace equation; Flow rates, steady and unsteady unidirectional flow; radial flow,

Groundwater Management: Human use of surface and ground water; Recharge and discharge areas; Safe yield and overdraft; Land subsidence; Rainwater harvesting and artificial recharge; Consumptive and conjunctive use of water; Watershed management

Practical **Marks 15 Credit 1**

Problems related to ground water assessment, development and management; Hydrogeological map interpretation; Water table and piezometric surface measurement.

ENV F 11 Field based studies to places of environmental importance **Marks 10 Credit 1**

2nd Semester

ENV C 21 Diversity of life forms and environmental applications

Theory **Marks 30 Credit 3**

Introduction to evolutionary biology: Evolution of environment and Origin of life; Diversification of life and speciation; Classifying organisms: Concepts of phenetics and cladistics; Principles of ecological organization; Basics of structural & functional ecology; Concept of Population genetics; Basic approach to evolutionary biology and behavioral ecology; Evolutionary principles and stable strategies; types of selections.

Biodiversity: Alpha, beta and gamma diversity; Values and ethics of biodiversity; Global patterns of biodiversity, hotspots of biodiversity and megadiversity country; Biogeographic zones in India; Common aquatic and terrestrial flora and fauna in India (Phytoplankton, Zooplankton, Macrophytes. etc);Factors influencing local and regional biodiversity, Biodiversity documentation; Threat to species diversity, Extinction vortex, Causes of extinction; Population viability analysis; Red Data Book; Biodiversity conservation approaches: Local, National and International, In-situ and ex-situ conservation, Concept of protected area network, Selecting protected areas, criteria for measuring conservation value of areas, Sanctuary, National Park and Biosphere reserves, Design and management of protected areas; Threats to wildlife conservation and wildlife trade; Tools for wildlife research; Use of Radiotelemetry and Remote sensing in wildlife research; Legal binding of biological materials; Concept of Bio-patents.

Environmental biotechnology: Understanding biotechnology; Concept and outlines of various applications, Environmental implications of GM crops and GMO; Biodegradation; Phytoremediation: types and applications; Biofuel production; Biofertilizer; Biopesticides; Integrated Pest Management; Vermicomposting.

Microorganisms and environmental pollutants: Overall process of biodegradation; Environmental bio-monitoring and indicator microorganisms; Biodegradation of organic pollutants; Anaerobic biodegradation; In-situ and ex-situ bioremediation; Case studies of microbial remediation; Lagoon and Vadose zone bioremediation; Surface bioremediation of soils and sludge; Applied bioremediation and industrial applications; Developing bioremediation technologies; Concept of Fermentation technology and bioreactor; Microorganisms and metal pollutants; Metal – microbial interaction and metal remediation; Microbial transformation of pesticides.

Waste treatment: Wastewater treatment (traditional and contemporary methods); Wetlands and aqua-culture systems; Surface Bioremediation of soil and sludge.

ENV C 22 Environmental geosciences

Theory **Marks 30 Credit 2**

The Earth and its system: Fundamental concept of environmental geosciences; Geological Time Scale, Space and time scales of processes in the solid Earth; Evolution, structure and composition of lithosphere, atmosphere hydrosphere and biosphere; Basic principles of stratigraphy; Fossil records; Earth's gravity and magnetic fields and its thermal structure: Geoid, spheroid; Isostasy.

Rocks and minerals: Gross composition, physical properties and distribution of important minerals and rocks; Processes responsible for mineral concentrations; Different Rock types – igneous, metamorphic and sedimentary; Weathering of rocks - physical, chemical and biological; Mass wasting; Erosion, Transportation and deposition of earth's materials by running water, wind and glaciers;

Mineral deposits: Formation and classification; Environmental problems associated with extraction of mineral deposits; Geological characteristics in relation to mining; Impact of mining on environment; Acid mine drainage; Radioactive and stable isotopes.

Earth's geodynamic processes: Elemental ideas of folds, faults, joints, foliation, lineation, cleavage and schitosity; Physicochemical and seismic properties of Earth's interior, Paleomagnetism; Continental drift, sea floor spreading, plate tectonics and mountain building processes.

Physiography: Development of land forms, land use pattern, land use policy of India; Glaciers: Physical and chemical aspects; Mass balance; Recession of Himalayan glaciers; Glaciers as index of climate change; Physiographic features and river basins in India.

Geoenvironment and health: Geomedicine; Essential Elements in earth's crust, soil and plants; Concept of major, trace, and rare earth elements (REE); Geochemical pathways of essential elements; Intake and absorption of elements; Brief outline of medicinal uses of minerals and rocks.

Practical **Marks 25 Credit 2**

Study of rocks, fossils and geological structures; Interpretation of geological and topographical maps; Basic survey techniques

ENV C 23 Environmental biochemistry

Theory **Marks 30 Credit 2**

Basic chemistry of macromolecules: Carbohydrates, Amino acids, Proteins, Lipids and Nucleic acids of physiological significance.

Structure and function of proteins and enzymes: Amino acids and peptides; Determination of primary structure and higher order structures; Enzyme- mechanism of action, enzyme kinetics, regulation and activities.

Bioenergetics and metabolism of carbohydrates and lipids: Role of ATP; Glycolysis, Citric acid cycle, Glycogenesis, Glycogenolysis, Gluconeogenesis, Pentose Phosphate Pathway and lipid metabolism; Biosynthesis of cholesterol and steroids; Fatty acid oxidation; Electron transport chain and Oxidative phosphorylation.

Metabolism of proteins and amino acids: Transamination-Glucogenic and Ketogenic amino acids; Deamination; Conversion of amino acids to specialized products; In-born errors related to amino acid metabolism.

Micronutrients: Vitamins and Minerals (macro, micro and trace elements)

Biochemistry of extracellular and intracellular communication: Membrane (Structure and function); the diversity of endocrine system; hormone action; receptor structures and signal transduction.

Biochemistry of Diseases: Oxidative stress and role of antioxidants; Role of lipid in cardiovascular disease; Drug metabolism.

Practical **Marks 25 Credit 2**

Bio chemical analysis of basic bio molecules; Stress enzymes; Food adulteration test.

ENV C 24 Energy and environment

Theory **Marks 30 Credit 2**

Energy as resources: Concept of renewable, non-renewable, conventional and non-conventional energy resources; Energy and heat budget of the earth; Global energy use pattern, energy use and prospects in India; Energy security.

Conventional energy sources: Classification of Fossil fuels and their composition; Physio-chemical characteristics and energy values; Green house gas, Global warming, Climate change: Global and Indian perspectives; Energy conservation; Energy efficiency: global and Indian perspectives

Solar energy: Sun as source of energy; Characteristics: irradiation, insolation etc.; Solar ponds; Theory & practice of solar power generation; solar collectors, heliostats, PV cell, solar thermal, CSP; Energy phase change material and environmental impacts.

Bio-energy: Bio-mass characteristics; Different methods of extracting energy from bio-mass, their use, prospects and problems; Concept and use of bio-fuel and environmental impacts,

Alternative energy: Basic Principles, applications and environmental significance of Wind energy, Hydal Energy, Tidal energy, Wave energy, Ocean thermal energy, Geothermal energy, Nuclear energy (fission and fusion), Magneto hydrodynamic power, fuel cell and their techno-economic comparison.

Environmental impacts of energy use: Impacts of large scale exploitation of energy on ecosystem, land use etc.

ENV C 25 Pollution: Assessment, instrumentation and control technologies

Theory **Marks 30 Credit 3**

Air pollution: Natural and anthropogenic sources; Categorization: Primary and secondary pollutants; Transportation and dispersion of pollutants; Indoor air pollution; Vehicular air pollution; SOx, NOx, PAN, photochemical smog, acid rain; Socio-political perspectives of air pollution and health; Basic Gas laws governing the behaviour of pollutants in atmosphere, Stokes law; Reynold's No., viscosity; Methods of monitoring air pollution: sampling and measurement; Air quality criteria and standards, MINAS; Different aspects of air pollution control: engineering control concepts, Control devices and systems, control of stationary and mobile sources; Principle and application of mechanical collectors, Fabric Filters, Gas & Venturi Scrubbers, Electro-static precipitators etc.

Water Pollution: Types, sources and consequences of fresh water, Ground water pollution; Case study of Arsenic contamination of ground water with special references to Bengal basin.; Physico-chemical and bacteriological sampling and characterization of water; Water Standards; Sewage and effluent treatment; Control technologies of water pollution.

Marine and coastal pollution: Types, natural and anthropogenic sources, consequences, effect on human and marine biota; Control and management- significance of CRZ and integrated coastal zone management.

Soil pollution: Sources of soil pollutants; Physico - chemical and biological sampling and analysis of soil quality; Effect and consequences of soil pollution; Interaction of soil pollutants with soil components; Soil reclamation strategies.

Noise pollution: Concept of Noise; Sources of noise pollution; Effect of meteorological parameters on noise pollution; Measurement of noise and noise-indices; Noise exposure levels and standard; Impact of noise on human health; Noise abatement strategies.

Radioactive, thermal and odour pollution: Case studies of specific industrial pollution and mitigation strategies.

Practical **Marks 25 Credit 2**

Application of advanced instruments for monitoring, measurement of pollutants and related studies:

Study includes visits to laboratories with state of art facilities.

ENV F 21 Environmental status report, documentation and community outreach activities

Marks 25 Credit 2

3rd Semester

ENV C 31 Meteorology, remote sensing and GIS

Theory **Marks 25 Credit 2**

Meteorology: Atmospheric stability; Inversion and mixing height; Wind roses; Climate and weather; Scales of meteorology, pressure, temperature, precipitation, humidity, radiation and wind.

Climatology: Fundamental principles; Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts and humidity; cloud formation and precipitation; water balance; air masses; monsoon system; jet streams; tropical cyclones; El-Nino and ENSO.

Atmosphere and its characteristics: Thermal structure and chemical composition of the atmosphere; atmospheric turbulence and boundary layer, lapse rate and stability, scale height, geo-potential; cloud formation and precipitation processes; basic laws of radiation; Rayleigh and Mie scattering and multiple scattering; Radiation from the sun, solar constant, effect of clouds and surface and planetary albedo; emission and absorption of terrestrial radiation, radiation windows, radiative transfer; greenhouse effect, net radiation budget; Air-sea interaction on different space and time scales.

Tropical meteorology: Trade wind inversion; ITCZ; Monsoon trough tropical cyclones, their structure and development theory; Monsoon depressions; Tropical Easterly jet stream; Monsoonal circulation in the Indian Ocean.

Remote sensing and its applications: Concept and foundation of Remote Sensing (RS); Energy sources and radiation principle; Energy interaction in the atmosphere; Concepts of platform and sensors, remote sensing systems, types of sensors, their characteristics and application;

GIS: Historical development of GIS; Objective, components and elements of GIS; Geological and Geographical mapping; soil mapping; Land use/Land cover mapping.

Practical **Marks 20 Credit 1**

Presentation and interpretation of wind data (wind rose); Satellite image interpretation; Application of global positioning system; Land use and land cover study.

ENV C 32 Disaster management and risk analysis

Theory **Marks 25 Credit 2**

Disasters: Definition, nature, scale and types of disasters; Causes and impacts of natural disasters: Flood, Drought, Landslides, Coastal Hazards, Earthquake, Volcanic eruption and Avalanche; Earthquake hazard zoning; Environment management of earthquake hazards; Slope failure, landslides and subsidence; Landslide hazard management; Tropical cyclones; Anthropogenic Disasters : industrial disasters, mine disasters, war and fire disasters; Few case studies: Chernobyl, Bhopal, Exon-Valdez, Minamata, Nepal earthquake, Aila etc.

Disaster management: Prediction and forecasting of natural disaster and brief outline of their management with special references to social and economic impacts of natural disaster; Protection against climate extremities; Role of Information systems and Technology in disaster management; Assessment of disaster vulnerability; Principles of disaster management, preparation of disaster management plans; Mitigation of different natural and anthropogenic disaster; Post Disaster Relief & Logistic Management; Community Participation at various stages of disaster management.

Risk analysis: Concept of Risk; Risk assessment methodologies; Hazard-risk evaluation and management; Environmental Safety measurements (on site and off site).

ENV P 31 Project Work **Marks 70 Credit 6**

ENV F 31 Industrial visit **Marks 10 Credit 1**

CBCC A: Choice Based Credit Course A * **Marks 50 Credit 4**

CBCC B: Choice Based Credit Course B* **Marks 50 Credit 4**

*For details see Annexure 1 at Page No. 12

4th Semester

ENV C 41 Waste and waste management

Theory **Marks 25 Credit 2**

Basic concept of waste management: Concept of waste management; Classification of wastes; Waste minimization technologies; Industrial waste water quality control and management; Reduce, reuse and recycle of waste; Integrated waste management.

Hazardous waste: Resource, conservation and recovery; Land disposal; Alternatives; Ocean dumping; Handling and management of radioactive waste; Environmental impacts.

Municipal solid waste management: Composition; Onsite disposal; Incineration; Open dumps; Sanitary land-fills; Environmental consequences.

Bio medical waste: Generation; Segregation; Colour codes; Disposal and treatments; Health consequences.

E-waste: Generation; Segregation; Disposal and treatments; Environmental impacts.

Waste to wealth: Energy from waste; Value added products from waste; Fly ash utilization and disposal Garbage farming; Sewage fed fisheries; Composting.

Waste Disposal: Criteria for waste disposal in riverine, marine and coastal system; Waste handling, transportation, compaction and disposal.

ENV C 42 Toxicology, environmental health and occupational hazards

Theory **Marks 30 Credit 3**

Concept of Xenobiotics: Toxic materials; Xenobiotic induced oxidative stress; Cell injury; Mode of action: Types of exposure, Absorption, Distribution, Metabolism and Excretion of toxicants (Phase I and Phase II reaction).

Toxicity assay: Acute and chronic toxicity; Dose- Response Relationship- Median lethal concentration (LD_{50} and LC_{50}); Sublethal concentration and safe concentration (NOEL, MATC); Whole Effluent Toxicity (WET) test; Bioassay - types, methodologies and application; Toxico Kinetics and toxicokinetic analysis.

Ecotoxicology: Biomarkers; Bioaccumulation; Biomagnification; Bioconcentration factor; Risk assessment; Effects on population and ecosystems; Damage process and action *of* toxicants; Toxicity of heavy metal (Pb, Cd, Hg and As); Predictive toxicology and Quantitative Structured Activity Relationship (QSAR).

Cytotoxicity and Genotoxicity: Molecular mechanism of cell death; chromosomal aberration; sister chromatid exchanges; Micronucleus and Nuclear abnormalities; DNA damage and repair mechanism.

Carcinogenesis: Classification of carcinogens; Metastasis and metabolism *of* chemical carcinogens; cancer risk evaluation; Brief outline of cancer therapy.

Reproductive toxicology: Teratology; Reproductive toxicity; Invitro fertilization

Environmental health:; Epidemiological issues: Goitre, Fluorosis, Arsenicosis and vector borne diseases; Etiology of diseases related to trace elements; Disease ecology: Air, water, soil; Exposure monitoring; Health monitoring.

Occupational hazards:

Health consequences of different occupations- Anthracosis, Silicosis, Asbestosis; Concept of stress, Stress related diseases, Stress management, Stress, strain and general adaptive syndrome; Industrial Environmental Psychology; Cardio-respiratory response during high altitude acclimatization; Effect of climate on performance.

Practical **Marks 25 Credit 2**

Experiments on eco-toxicocity, genotoxicity and cytotoxicity; Invitro toxicity assay.

ENV C 43 Molecular biology and Immunology

Theory **Marks 25 Credit 2**

Basic concepts of Mendelian and non-Mendelian inheritance

Gene functions and regulation: Replication, transcription and translation; Concept of Operon; basics of eukaryotic gene regulation.

Recombinant DNA technology and its applications: Restriction enzymes; Expression system and genetic engineering; Transformation and molecular cloning; DNA sequencing; Transgenic plants and animals; Concept of gene therapy; Molecular basis of recombination and mutagenesis.

Overview of the Immune system: Cells and organs of Immune system.

Innate and Adaptive Immunity: Innate immunity - mechanism of immune response (anatomic, physiological, phagocytic and inflammatory barriers); Adaptive immunity: Humoral and Cell-mediated immunity, Cell-mediated effectors function, Cytokines, Chemokines, primary and secondary immune modulation, clonal selection of lymphocytes.

Antigen-Antibody interactions: Immunoglobulins: structure and function, Immunoglobin genes, generation of diversity, affinity maturation, Isotype switching; Antigens: chemical nature, antigenicity and immunogenicity, hapten, epitopes, mitogens (definition, properties, examples); Adjuvant (definition, examples, function); Monoclonal and polyclonal antibody, antibody engineering; Antigen-Antibody interactions: Precipitation reactions, Radial immunodiffusion, double immunodiffusion, immune-electrophoresis; Agglutination reactions-Hemagglutination, passive agglutination, bacterial agglutination, agglutination inhibition, Radio immunoassay, ELISA, Immunofluorescence: FACS, Immuno-histochemistry, ELISPOT.

Major histocompatibility complex: MHC antigens, allograft rejection, inbred and congenic mice, MHC locus in mice and human, MHC antigen structures and genes, HLA typing and disease association. Antigen processing and presentation.

T cell and B cell maturation and activation: B-cell maturation, activation and differentiation, T dependent and independent antigen, allelic exclusion, Ig receptor of B-cells, Idiotype network; T cell activation: MHC restriction, T cell receptor complex and genes, TCR gene rearrangement, T-cell differentiation, thymic selection, superantigens, T-cell cytotoxicity.

Complement: The complement components, function, complement activation- Classical, Alternate and lectin pathways; Regulation of complement activation pathways.

Hypersensitivity reactions: Type I, II, III and IV

Vaccines: Concept and application.

Practical **Marks 25 Credit 2**

Basic techniques of recombinant DNA technology; Basic immunological assays

ENV C 44 Statistics, environmental modeling and informatics

Theory **Marks 25 Credit 2**

Basic elements and tools of statistical analysis: Probability; Sampling; Measurement and distribution of attributes; Distribution- Normal, t and r, Poisson and Binomial; Arithmetic, Geometric and Harmonic means; Moments; Matrices; Equation; Tests of hypothesis and significance.

Environmental modelling: Introduction to environmental system analysis; Concept of environmental modelling; Approaches to development of models, linear simple and multiple regression models; Validation and forecasting Modelling techniques; Model performance, accuracy and utilization; Models of population growth and interactions- Lotka-Volterra model, Leslie's matrix model, point source stream pollution model, box model, Air pollution modelling and prediction, Gaussian plume model; Modelling of non-reacting pollutants, pollutant transformations.

Concept of environmental informatics: Information tools for Environmental Data Management; Priority areas: Pollution, Epidemiology, toxicology etc.; Android based environmental applications

ENV C 45 Environmental legislations and environmental impact assessment

Theory **Marks 25 Credit 2**

Laws and Acts guarding environmental concerns: Provision of Constitution of India regarding Environment; Environmental Policy Resolution; Enviro-Legal system in India: PIL and Public Hearing, National Green Tribunal; Public Policy Strategies in Pollution Control; Indian Forests Act, 1927; Wildlife (Protection) Act, 1972; The Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act, 1980; Air (Prevention and Control of Pollution) Act, 1981; The Environment (Protection) Act, 1986; Motor Vehicle Act, 1988; Hazardous Wastes (Management and Handling) Rules, 1989; Public Liability Insurance Act, 1991; Biological diversity Act, 2002; Disaster Management Act, 2005; Environmental Impact Assessment Notification, 2006; Coastal Regulation Zone Notification, 2011;

Introduction to Environmental Impact Assessment: Scope and principle of Environmental Impact Assessment; Methodologies of Environmental Impact Assessment; Official guidelines for EIA; Basic mechanism required for data collection, subsequent analysis and report making for a proposed project; Different techniques adopted for impact evaluation; Concept and preparation of Environmental Impact statement (EIS) and Environment Management Plan (EMP).

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ENV C 46 Environmental economics and audit

Theory **Marks 20 Credit 2**

Environmental economics: Economics and Development; Economic efficiency and Cost benefit analysis; Concept of Consumerism; Poverty and globalization; Monitoring economic and environmental progress; Application of economics to improve environmental quality; Rural planning and development; Environmental valuation (Hedonic pricing, Contingent valuation and Travel cost method) and decision making; Theory of externalities and public good; International negotiations on climate change and North-South debate; Environment Kuznet Curve (EKC).

Dimensions of natural resources: Basic services of natural resources; Natural resource as national capital; Natural resource potential of India; Natural resources and sustainable development; Resource economics; Issues and challenges of SEZ and EEZ in India

Environmental audit: Concept of environmental audit; Guidelines of environmental audit; Methodologies adopted along with some industrial case studies; Environmental standards: ISO 14000 series; Scheme of labelling of environment friendly products (Ecomark); Life cycle analysis; Concept of energy and green audit

ENV S 41 Seminar presentation and scientific writing **Marks 25 Credit 2**

ENV V 41 Grand viva **Marks 25 Credit 1**

CBCC offered by Dept. of Environmental Science

Perspectives of Environmental Science

1. **Understanding the environment**
   - 1.1. Multidisciplinary approach of environment
   - 1.2. Rise of environmentalism
   - 1.3. Environmental ethics
   - 1.4. Concepts of sustainability
2. **Environmental systems**
   - 2.1. Concept of atmosphere, lithosphere, hydrosphere and biosphere
   - 2.2. Natural Resources
   - 2.3. Carbon footprint and low carbon economy
   - 2.4. Biogeochemical cycles
   - 2.5. Scale of meteorology
3. **Ecology and Biodiversity**
   - 3.1. The order of the natural world
   - 3.2. Ecosystem energetics
   - 3.3. Population dynamics; Concept of community, niche and community development
   - 3.4. Biomes, biogeography and landscape ecology
   - 3.5. Behavioral ecology and sociobiology
   - 3.6. Biodiversity: extinction, conservation and restoration
4. **Disaster Management**
   - 4.1. Types of disasters
   - 4.2. Case studies of natural and anthropogenic disasters
   - 4.3. Disaster prediction, prevention
   - 4.4. Pre and post disaster management
5. **Environmental vulnerability**
   - 5.1. Air pollution: source, impacts and remedial measures
   - 5.2. Water pollution: source, impacts and remedial measures
   - 5.3. Soil pollution: source, impacts and remedial measures
   - 5.4. Waste: solid, biomedical, electronic and radioactive wastes
   - 5.5. Climate change mitigation and adaptation
6. **Environmental Health**
   - 6.1. Disease ecology with special reference to vector and water borne diseases
   - 6.2. Genotoxicity and epigenetic approach
   - 6.3. Occupational toxicology and health
   - 6.4. Xenobiotics and endocrine disruption
7. **Prioritizing environmental concerns**
   - 7.1. Global and National initiatives
   - 7.2. Recent Environmental Concerns and Debates
   - 7.3. Environmental Regulations: Acts and Laws
   - 7.4. Environmental Impact Assessment
   - 7.5. Ecomark and Ecolabelling
8. **Modern tools for addressing environmental challenges**
   - 8.1. Bio remediation
   - 8.2. Analytical tools for solving environmental problems
   - 8.3. Environmental applications of remote sensing and GIS
   - 8.4. Environmental informatics and modeling