Aquatic Environment Management- Course Curriculum at a Glance

M.F.Sc.	**MAJOR COURSES**	**20Credits**
	CORE COURSES	**12 Credits**
AEM 501	Fundamentals of Environmental Sciences	2+0
AEM 502	Aquatic Ecosystem and Biodiversity	2+1
AEM 503	Chemical Interactions in the Aquatic Environment	2+1
AEM 504	Aquatic Microbiology	1+1
AEM 505	Analytical Techniques in Environmental Sciences	1+1
	OPTIONAL COURSES	**08 Credits**
AEM 506	Plankton Ecology and Trophic Dynamics	1+1
AEM 507	Management of Inland Aquatic Ecosystem	2+1
AEM 508	Aquatic Pollution and Management of Water Resources	2+1
AEM 509	Eco-toxicology	1+1
AEM 510	Environmental Biotechnology	1+1
AEM 511	Marine Ecology and Coastal Management	2+1
AEM 512	Fisheries Oceanography	1+1
AEM 513	Utilization and management of aquatic algal resources	2+1

AQUATIC ENVIRONMENT MANAGEMENT

Course Contents

M.F.Sc.

AEM 501 FUNDAMENTALS OF ENVIRONMENTAL SCIENCES 2+0

Objective To impart knowledge on fundamentals of environment science and to provide holistic approach

Theory

Unit I Definition and scope of environment science and its interrelationship with other sciences and fisheries; Origin and evolution of the earth and its environs-atmosphere, hydrosphere, lithosphere and biosphere

Unit II Basic ecological concepts - habitat ecology, systems ecology, synecology, autecology; Characteristic features of different biomes

Unit III Air pollution - sources and classification of major air pollutants; smoke, smog, photochemical smog and SPM; Noise pollution-concept and effects.

Unit IV Climate change: Weather and climate; Global warming and greenhouse effect; Stratospheric ozone layer depletion-effect of UV radiation on plants and human health; Adaptation and mitigation strategies of climate change and ozone depletion

Unit V Soil and water pollution: sources and types of soil and water pollutants; Impacts of pollutants on environment and agro-ecosystems; Radioactive pollutants, their life time and disposal; Maximum permissible limits of soil and water pollutants

Unit VI Effects of deforestation on soil erosion; Land degradation; Wasteland: their extent, characteristics and reclamation; Use of green and sustainable technology; Soil and water conservation, and watershed management; Desertification and biological invasion; Rain water harvesting; Mineral resources: use and exploitation, environmental effects of extracting and using mineral resources

Unit VII Disaster management: floods, droughts, earthquakes; Tsunami, cyclones and landslides; Nuclear hazards; Environmental impacts assessment and environmental auditing; Environmental ethics: issues and possible solutions; Environmental policies and laws in India;Role of information technology in environmental and human health

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AEM 502 AQUATIC ECOSYSTEMAND BIODIVERSITY 2+1

Objective To acquaint the students with the theoretical and practical aspects of the aquatic environment and biodiversity.

Theory

Unit I Concepts in aquatic environment: Aquatic environment/ecosystem – components, structure and functions; Concepts of habitat and ecological niche; Productivity and carrying capacity; Trophic relationships, energy flow and nutrient cycling; Ecological succession; Ecological Stability and homeostasis; resistance and resilience; natality and mortality ; r and k selection

Unit II Biodiversity**–** Definition and concept; Factors influencing aquatic biodiversity;Categories of biodiversity - Species diversity, Genetic Diversity; and Habitat Diversity; Biodiversity indices and their significance; Concepts of Index of Biotic Integrity (IBI); Ecosystem services and Economic appraisal of biodiversity

Unit III Biodiversity Conservation - Global diversity patterns and loss of biodiversity; Conservation measures; Biodiversity hotspots, biosphere reserves; national parks, sanctuaries; marine protected areas; Convention on Biological Diversity; IUCN; CITES; WWF; Ramsar Convention; Man and Biosphere Programme; Indian legislations to biodiversity conservation

Unit IV Environmental Economics and auditing; Ecosystem approach to resource management

Unit V Contemporary issues - Organic farming; Eco-labelling; Ocean acidification; Carbon sequestration and trading

Practical Collection and identification of fauna and flora from different ecosystems; Calculation of biodiversity indices – Shannon-Wiener index; Simpson index, Hill index; Case studies. Carbon sequestration studies in different ecosystems

AEM503 CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT 2+1

Objective To acquaint the students with basic principles of physical, chemical, biologicaland geological interactions in the aquatic environment.

Theory

Unit I Basic principles: Chemical reaction kinetics, chemical equilibrium and redox chemistry; solubility concept; dissolution kinetics; processes controlling elemental cycling in the earth's crust; oceans and atmosphere.

Unit II Sediment properties: Geological considerations and impact of geological factors: Weathering of rocks;soil formation; Soil profile; Mineral weathering; transformation; weathering products; Structure of oxide and silicate minerals;Sources of charge; adsorption on to clay minerals of major cations and anions; Double layer;Ion exchange - concept and source of cation exchange capacity (CEC); Sediment texture

Unit III Nutrient dynamics: Nutrient holding capacity of sediments and fixation; Processes in the degradation and conversion of organic matter; Humus and biogeochemical substances; Transport of nutrients;Mechanism of pore water-nutrient interactions; Availability of nutrients and productivity of aquatic ecosystem

Unit IV Fate of Contaminants: Degradable and non-degradable contaminants; Speciation and transport of contaminants; bio-availability;bio-accumulation and biomagnification.

Practical Sample Collection techniques; Determination of physicochemical parameters of sediment – pH, electrical conductivity, redox potential, soil texture, bulk density, particle density, porosity, total and organic carbon, total and available nitrogen, phosphorus, potassium and micronutrients; C:N:P ratio, CEC; Demonstration of adsorptionions on clay minerals.

AEM 504 AQUATIC MICROBIOLOGY 1+1

Objective To impart knowledge on aquatic microorganisms with reference to their role in the aquatic environment and bioprospecting.

Theory

Unit I Distribution and classification: Microbial community in freshwater; estuary and marine environment (types and abundance);Factors affecting microbial growth

and abundance in aquatic environment; Extremophiles and their significance.

Unit II Microbial interaction: interrelationships, Biogeochemical cycling of C, N, P, S, Si and Fe; Microbial degradation of natural and synthetic compounds, Role of obligate hydrocarbonoclastic bacteria.

Unit III Microorganisms and public health: Water-borne pathogens of public health importance - protozoans, bacteria, enteroviruses; Microbial toxins; Microbial standards for different water uses.

Unit IV Microbes and aquatic environment: Role of microbes in aquatic food chain and wastewater ecosystem; Principles and applications of bioprocesses – bioremediation, biofertilization, biofilms, probiotics, bio-leaching, bio-corrosion, bio-fouling; Microorganisms as bioindicatorsand biosensors; Methods of assessing microbial biomass production; Bioprospecting; Culture-independent approach; Disinfection methods.

Practical Sampling methods; Isolation, identification and enumeration of algae and bacteria (total heterotrophic, nitrogen fixing, nitrifying, denitrifying, phosphate-solubilising, phosphatase- producing) from aquatic habitats; Microbial growth kinetics; Maintenance of algal and bacterial cultures; Quantification of microbial activities in nutrient cycles; Microbial sensitivity testing; use of P:R ratio in assessment of autotrophic/heterotrophic ecosystem. Disinfection methods; Culture-independent approach

AEM 505 ANALYTICAL TECHNIQUES IN ENVIRONMENTAL SCIENCES 1+1

Objective To impart knowledge and skills in analytical techniques employed in environmental studies.

Theory

Unit I Overview and concepts: An overview of qualitative and quantitative analytical techniques used in environmental science; Sampling techniques and procedures; Factors affecting the choice of analytical techniques; Interferences and their minimization; Laboratory safety measures.

Unit II Gravimetric and volumetric analyses: Principles and precautions

Unit III Photometric techniques: Theory, instrumentation and application of colorimetry and spectrophotometry.

Unit IV Separation techniques: Chromatography – theory, instrumentation and applications of thin layer, paper, ion-exchange, size exclusion, high performance liquid and gas; Methods of preparing biological samples for chromatographic analysis; Theory and applications of electrophoresis; Principles and uses of ultracentrifugation.

Unit V Tracer Techniques: isotopes in environmental analysis

Practical Estimation of environmental parameters by gravimetric and volumetric methods, using UV-Visible spectrophotometer, AAS, HPLC, GC, CHNS analyser, etc.

AEM 506 PLANKTON ECOLOGY AND TROPHIC DYNAMICS 1+1

Objective To impart knowledge on plankton, their ecology and their role in trophic dynamics.

Theory

Unit I	Plankton diversity and productivity:Definition, classifications and functions in aquatic ecosystem; Primary and secondary production - Production - Biomass (P/B ratio), factors affecting production; Indices of diversity
Unit II	Ecology of phytoplankton: Phytoplankton (freshwater and marine), spatial and temporal variations, succession; Contribution of nanoplankton to primary production; Algal blooms and algal toxins; nutrient manipulation for algal growth and control; biological control of algal blooms; Mass culture of phytoplankton as a live-feed; Role of microalgae in carbon sequestration.
Unit III	Ecology of zooplankton: Zooplankton (freshwater and marine) –Feeding behaviour and reproduction of important zooplankters; life history stages; swarms; Indicator species; Predator-prey relationship; Impact of grazing on the aquatic ecosystem; Vertical migration of zooplankton in relation to fish catch; Importance of zooplankton in the larval rearing of fish; Environmental manipulation for live-feed production; Mass culture of zooplankton as a live-feed.
Unit IV	Sampling and preservation techniques: Plankton nets and recorders; Plankton fixatives and preservatives; Cryopreservation methods and their significance.
Practical	Collection, preservation and quantitative estimation of phytoplankton and zooplankton; Identification and classification of various phytoplankton and zooplankton; Enclosure experiment demonstrating the relationship between phyto- and zooplankton.

AEM 507 MANAGEMENT OF INLAND AQUATIC ECOSYTEM 2+1

Objective To educate the students on the ecology of wetlands and to impart skill and knowledge on the sustainable management of the ecosystems.

Theory

Unit I	Types of Inland Aquatic Resources: Concept of watershed; Types of different fisheries resources - lacustrine, riverine, wetlands, floodplains, swamps and ponds - habitat characteristics, flora and fauna and economic importance.
Unit II	Characteristics: Physical and chemical characteristics of inland aquatic environment; influence of ecological factors on behaviour, physiology and growth of aquatic organisms; Relationship between productivity (primary and secondary) and fish yield; Trophic relationships in the aquatic ecosystem; Characteristics of lentic and lotic systems
Unit III	Wetlands – Trophic classifications, functions, habitat degradation (causes and management measures), destruction of wetlands (causes and consequences); Constructed wetlands;Restoration, conservation and management of wetlands
Unit IV	Ecological Engineering: Concept, application, and restoration;Resource enhancement; Management of water bodies for economy-driven activities; Biomanipulation - top-down and Bottom-up methods; Integrated Environment Management (IEM) Programme, Ramsar convention
Unit V	River continuum concept and new paradigm shift; River linking; mapping of aquatic resources using remote sensing and GIS.Water budget and its significance in water conservation.
Practical	Collection, preservation and analysis of flora and fauna (phytoplankton, macrophytes, zooplankton and benthos) of wetland ecosystem; Survey and

assessment of lentic and lotic waters; Calculation of shoreline development index and morphometry; Morpho-edaphic index; Field visits to selected reservoirs/lakes/wetlands/rivers.

AEM 508 AQUATIC POLLUTION AND MANAGEMENT OF WATER RESOURCES 2+1

Objective To impart fundamental and advanced knowledge on different aspects of Aquatic pollution and management of water resources.

Theory

Unit I Aquatic pollution – sources, types and their impacts; Pollution problems of groundwater resources (arsenic, fluoride, nitrate, pesticides) –sources of contamination and management issues.

Unit II Pollutants - sewage, pesticides, hydrocarbons, nutrients, metals, radioactive wastes, biomedical wastes, hazardous chemicals,nanoparticles; Dispersal and fate of pollutants; Eutrophication

Unit III Methods of waste disposal, water quality criteria - national and international standards; ISO-14000(EMS), EIA, Management strategies.

Unit IV Wastewaters –Types and characteristics of sewage and industrial effluents and their nutrient potentials - Scope and limitations; Conventional treatment methods - stabilization ponds, oxidation ponds; Biological and chemical methods for recovery of nutrients from liquid and solid wastes; Ecological sanitation - closing the loop.

Unit V Integrated water management: Water conservation measures, water use and reuse in aquaculture, aquaponics and irrigation; Water use efficiency;Ecological engineering–Concepts and applications, biomanipulation, bioremediation; Restoration ecology and rehabilitation.

Practical Collection and preservation of water samples; Physicochemical analysis of water - total dissolved and suspended solids, DO, BOD, COD, Sulphide, NH_3–N, NO_2-N, NO_3-N, PO_4-P, SiO_4-Si, metals and pesticides; Visit to a sewage treatment plant/fish processing unit/industries.Assessment of ecosystem health and its improvement.

AEM 509 ECO-TOXICOLOGY 1+1

Objective To impart knowledge on toxicological aspects of various pollutants.

Theory

Unit I Toxicity: Factors influencing toxicity- environmental, genetic and nutritional; Measurement and evaluation of the ecological effects of toxicants; Genotoxicity; neurotoxicity

Unit II Metabolism: Metabolism of toxic substances by aquatic microbes and other organisms - consequences, synergistic and antagonistic effects; Acute poisons and accumulative poisons

Unit III Bioaccumulation, bioconcentration and biomagnification; Systemic effects of toxic metals; pesticides and herbicides; Effect of select toxicants on aquatic life and detoxification mechanisms; Interrelationship of xenobiotics with other environmental variables;biofilter organisms.

Unit IV Toxicity evaluation: Toxicity Testing - Microcosm and Mesocosm Tests; Dose-Response Relationships; Toxicity Bioassay

Practical Toxicity evaluation of heavy metals on selected organisms by bioassay techniques; Toxicity assessment of pesticides; PCBs and hydrocarbon on selected organisms; Toxicity testing methods.

AEM 510 ENVIRONMENTAL BIOTECHNOLOGY 1+1

Objective To impart basic knowledge on biotechnological applications of microorganisms and demonstration of their potential for environmental management.

Theory

Unit I Fundamentals of environmental biotechnology: Environmental biotechnology-concepts and scope; conventional and modern approaches; IPR issues related to environmental biotechnology.

Unit II Environmental Monitoring: Cellular and molecular markers of environmental pollution monitoring; Bioindicators; Biosensors and nanosensors

Unit III Remediation: Bioremediation; Genetically-improved organisms - basic concepts; applications in remediation of metals, pesticide and hydrocarbon; limitations; Consortia of microbes for environmental protection – Concept, scope and feasibility

Unit IV Bioproduction: Bioreactors – principles and application in production of biofuels, biofertilizers, enzymes, single cell protein, biogas and biocosmetics

Practical Genomic and plasmid DNA isolation; PCR and gel electrophoresis, Cloning; BLAST analysis of sequences; Single-cell protein production; Case studies on wastewater treatment/recirculatory systems; Quantification of N fixation;nitrification; Screening of microbes for biodegradation properties

AEM 511 MARINE ECOLOGY AND COASTAL MANAGEMENT 2+1

Objective To impart knowledge on marine ecology and coastal resources management.

Theory

Unit I Marine ecology: Ocean topography; primary productivity, secondary productivity, types of primary and secondary producers, productivity assessment,scope and potentials.

Unit II Coastal resources: Characteristics of coastal ecosystems (flora and fauna, trophic relationship, nutrient production, cycle and transport); Mangrove ecosystem - species diversity, distribution and importance; Other inter-tidal systems - Seagrass, Sandy beach, Lagoon and estuary.

Unit III Developmental activities and biodiversity loss: Human settlements, industries, shore protection works, ports, transport systems and waste disposal; Ecological issues,impacts of environment changes, threats to biodiversity, habitat destruction; Depletion of fisheries resources

Unit IV Coastal Zone Management:Integrated Coastal Zone Management (ICZM) - its

benefits, Principles, Goals and objectives, scope, zonation; National and international policies and planning for coastal resource management; Natural hazards and disasters -protection and management; Socioeconomic impacts and its assessment

Practical Analysis of soil and water characteristics of coastal areas and determination of different factors; Collection, preservation and identification of coastal biological communities; Survey of different coastal zones.

AEM 512 FISHERIES OCEANOGRAPHY 1+1

Objective To educate the students on the oceanographic concepts related to fisheries and impart skill to operate oceanographic equipment.

Theory

Unit I Oceanographic factors in fisheries: Marine topography, Effects of physicochemical and biological oceanographic factors on adaptation, behaviour, abundance and production of aquatic organisms;Space and time scales in oceanographic analysis; Magnitude of short-term productivity changes in the ocean; Synoptic oceanographic analysis – currents, waves, tides, El Nino and Southern Oscillation; stratification, related chemical factors, mudbanks, upwelling and circulation patterns.

Unit II Forecasting systems: Fisheries forecasts – interpretation and use of ocean thermal structure in fisheries; Fisheries forecasting system in India and other countries – remote sensing; Global Positioning System (GPS). Application of Remote Sensing in fisheries; Application of echo-sounders and SONAR; Potential fishing zones.

Unit III Factors affecting marine fisheries: Environmental factors influencing the seasonalvariations in fish catch in the Arabian Sea and the Bay of Bengal.

Unit IV Fisheries enhancement: Artificial upwelling, ranching, artificial reefs, FADs, ocean fertilization

Practical Use of tide tables, Oceanographic data analysis – water temperature, salinity, pH, nutrients, benthos and sediment characteristics; Fisheries forecasting systems; Oceanographic equipment and fish finding devices.

AEM 513 UTILIZATION AND MANAGEMENT OF AQUATIC ALGAL RESOURCES 2+1

Objective To educate the students on theutilization and management of aquatic algal resources

Theory

Unit I Algal resources- an overview; Classification of algae, Trophic classification of aquatic resources (Oligo-, meso- and eutrophic), ecological services by algae, role of algae in fisheries, aquaculture of algae - batch and mass cultivation, selection of culture medium, isolation and maintenance of algal cultures; water quality for algal culture

Unit II Bio-prospecting of algal resources for value added compounds/products-pigments, agar agar, carrageenan, single cell protein, pharmaceuticals, production of nanoparticles; biofuels, food and feed, algal compounds in cosmetics and natural colorants, bioremediation through algae, algae as bio-

	indicator of pollution; polar algal resources and their applications
Unit III	Value addition through food chain; algal culture as a livelihood option; utilization of algae in aquaculture, Impact of habitat degradation (industrialization, siltation, reclamation, trawling) on algal resources, Enhancement of productivity of phytoplankton - use of thermal energy, artificial upwelling, artificial reefs, substratum, wastewater utilization for algal cultivation
Unit IV	Application of algal density in identifying potential fishing zones (PFZ) and economic relevance of PFZ advisories, Role of algae in global warming mitigation; iron fertilization of sea for productivity enhancement
Unit V	Exotic algal species, preventive measures for bio-invasion, Ballast water as a source of invasive species, international regulations for discharge of ballast water, algal blooms, algal toxins and fisheries, Control of algal bloom
Practical	Identification and documentation of algae from freshwater and marine habitats (local), techniques for algal cultivation and maintenance of pure cultures, *Spirulina* and *Chlorella* cultivation – indoor and outdoor, extraction of pigments from algae (Carotenoids and Phycocyanin), Heavy metal removal by algae