M.F.Sc & PhD Programs in Aquatic Environment Management - Syllabus

Indian Council of Agricultural Research
New Delhi

COURSES

M.F.Sc. (Aquatic Environment Management)

	CODE	COURSE TITLE	CREDITS
		MAJOR - CORE COURSES	
1.	AEM 501	Aquatic Environment and Biodiversity	2+1
2.	AEM 502	Chemical Interactions in the Aquatic Environment	2+1
3.	AEM 503	Integrated Coastal Zone Management	2+1
4.	AEM 504	Aquatic Pollution and Wastewater Management	2+1
		MAJOR - OPTIONAL COURSES	
1.	AEM 505	Ecology and Management of Limnetic Environment	2+1
2.	AEM 506	Environmental Biotechnology	1+1
3.	AEM 507	Environmental Toxicology	1+1
4.	AEM 508	Analytical Techniques in Environmental Sciences	1+1
5.	AEM 509	Planktonology	1+1
6.	AEM 510	Fisheries Oceanography	1+1
7.	AEM 511	Aquatic Microbiology	2+1

PhD (Aquatic Environment Management)

	CODE	COURSE TITLE	CREDITS
		MAJOR - CORE COURSES	
1.	AEM 601	Advances In Aquatic Environmental Studies	2+1
2.	AEM 602	Biotechnology for Cleaner Environment	2+1
3.	AEM 603	Benthic Ecology	1+1
		MAJOR - OPTIONAL COURSES	
1.	AEM 604	Estuarine And Coastal Oceanography	2+1
2.	AEM 605	Organic Production And Plant Pigments	2+1
3.	AEM 606	Environment Impact Assessment	1+1
4.	AEM 607	Management And Utilization of Wastewater	2+1
5.	AEM 608	Ecotoxicology	2+1
6.	AEM 609	Application of Remote Sensing And GIS In Fisheries	2+1
7.	AEM 610	Dispersal And Fate Of Pollutants In The Ocean	1+1
8.	AEM 611	Restoration Ecology	1+1

M.F.Sc. (Aquatic Environment Management) SYLLABUS

MAJOR - CORE COURSES

AEM 501 AQUATIC ENVIRONMENT AND 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; Ecological concepts – succession, homeostasis, natality and mortality, r and k selection; Concepts of habitat and ecological niche; carrying capacity

Unit II Environmental concerns: Environmental concerns – population explosion, industrialization, urbanization, and natural calamities; Overexploitation of resources; Environmental stresses; Global Warming; Ozone Depletion

Unit III Biodiversity: Biodiversity – Definition and concept; Factors influencing aquatic biodiversity; Types of biodiversity - Species diversity in different ecosystems, Genetic Diversity, and Habitat Diversity; Biodiversity indices and their significance; Concepts of Index of Biotic Integrity (IBI); Economic appraisal of biodiversity; Global diversity patterns and loss of biodiversity

Practical Collection of fauna and flora from different ecosystems; Analysis of Biodiversity at community, population and species levels through different methods; Case studies

Suggested Readings

1. Carter, R.W.G., 1998. Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines. Academic Press, London.
2. Park, C.C., 1980. Ecology and Environmental Management. Butterworths, London.
3. Kormondy, E. J. (1986). Concepts of Ecology, Prentice-Hall, New Delhi.
4. Marine ecology

Journals

1. Environment and Ecology
2. Agriculture, Ecosystem and Management
3. Acta Oecologica – International Journal of Ecology
4. International Journal of Ecology and Environmental Sciences
5. Aquatic Microbial Ecology

Broad Research Areas

1. Biodiversity assessment
2. Biodiversity conservation
3. Environmental monitoring

AEM 502 CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT 2+1

Objective To acquaint the students with basic principles of chemical interactions in the aquatic environment

Theory

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

Unit II Soil properties: Soil structure and texture; Composition of oxide and silicate minerals in relation to surface chemical processes; Charge and double layer, and mineral equilibrium; Silicate weathering, transformation, weathering products; Ion exchange - concept and source of cation exchange capacity (CEC), adsorption on to clay minerals of major cations, specific adsorption of major and minor nutrients, and heavy metal ions

Unit III Nutrient dynamics: Chemistry of soil-nutrient interactions and water permeability; Organic substances - biological processes in the degradation and conversion of organic matter; Humus and biogeochemical substances - structure, reactivity, solubility and mobility; Transport of substances - nutrients (*e.g.,* phosphate, nitrate, ammonia, Ca and K), Soil-water interactions – availability of nutrients and productivity of aquatic ecosystem

Unit IV Pollutant dynamics: Pollutant cycling, bio-accumulation, bio-availability, speciation and transport of contaminants (*e.g.,* pesticides and heavy metals)

Practical Sample Collection techniques; Determination of physicochemical parameters of soil and water - pH, electrical conductivity, redox potential, soil texture, bulk density, particle density, porosity, hydraulic conductivity, organic carbon, total and available nitrogen, phosphorus, potassium and micronutrients; C/N ratio; clay colloids in the soil; CEC; Adsorption/fixation of ions on clay minerals.

Suggested Readings

1. Lindsay, W.L., 1979. Chemical Equilibria in Soils. John Wiley and Sons, New York.
2. Manahan, S.E., 2000. Environmental Chemistry. Lewis Publishers, Boca Raton.
3. McBride, M.B., 1994. Environmental Chemistry of Soils. Oxford University Press, Oxford
4. Stumm, W. and Morgan, J.J., 1996. Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters. John Wiley and Sons, New York.
5. Tan, K.H., 1998. Principles of Soil Chemistry, CRC Press Inc., Boca Raton

Journals

1. Biology and Fertility of Soils
2. Soil Science Society of America Journal

3. Australian Journal of Soil Research
4. Applied Soil Ecology

Broad Research Area

1. Soil- water – Nutrient interaction
2. Nutrients in fish productivity
3. Pollutant cycling in aquatic environment

FET 503 INTEGRATED COASTAL ZONE MANAGEMENT 2+1

Objective To teach the learners about the coastal resources and Integrated coastal zone management strategies and disaster management

Theory

Unit I Coastal resources: Coastal natural resources systems: flora and fauna, trophic relationship, nutrient production, cycle and transport; Mangrove ecosystem - species diversity and distribution of mangroves in India, Other inter-tidal system- Seagrass system, Coral reef system, Sandy beach system, Lagoon and estuary system

Unit II Developmental activities and biodiversity loss: Ecological issues, Non-sustainable development, Pollution, threats to biodiversity, habitat destruction, Depletion of fisheries resources, impacts of global environment changes, Multiple uses of the Coastal Zone, Urban settlement, Industrial development, waste disposal, Shore protection works, ports and marine transportation. Land transportation infrastructure, Water control and supply projects, sea fisheries, Aquaculture, Coastal forest industries, Coastal agriculture, industries, tourism and recreation

Unit III Coastal Zone Management: Integrated Coastal Zone Management (ICZM): its need and benefits, Principles, Goals and objectives of the ICZM programme; Scope, Extent of jurisdiction, Boundaries of the coastal zone, policies and planning for coastal resource management; Management mechanisms- Pollution control, Protected areas (sanctuaries, marine parks and biosphere reserves), Protection from natural hazards; Socioeconomic impacts and its assessment, Disaster management for coastal environment

Practical Analysis of soil and water characteristics of coastal areas where man made impacts have established; Assessment of damages of water quality; Collection, preservation and identification of coastal biological communities; Survey of different coastal zones; Visit to the protected areas

Suggested Readings

1. Khanna, B. K. (2000). All You Wanted to Know About Disasters. New India Publishing Agency
2. Clark, J. R. (1992). Integrated Management of Coastal Zones. FAO Fisheries Technical Paper 327, Rome, FAO.
3. Cairns, J. Jr. (1994). Implementing Integrated Environmental Management Virginia Tech

Journals

1. Marine pollution Bulletin
2. Journal of Sustainable Agriculture
3. Estuarine, Coastal and Shelf Science
4. Coastal Aquaculture

Broad Research Area

1. Coastal pollution assessment
2. Conservation of ecologically important species
3. Impact of Coastal zone regulations and policies on coastal zone

FET 504 AQUATIC POLLUTION AND WASTEWATER MANAGEMENT 2+1

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

Theory

Unit I Aquatic pollution and its management: Aquatic pollution – sources, types and their impacts; Pollution problems of groundwater resources –sources of contamination, management issues

Unit II Pollutants - sewage, pesticides, oils, metals, radioactive wastes, biomedical wastes, etc. Common transport processes of pollutants in the aquatic environment; dispersal of pollutants; Algal blooms and their management, Methods of pollution surveys

Unit III Waste disposal and water quality criteria used in different parts of world - national and international standards; ISO-14000(EMS), EIA, Management strategies.

Unit IV Wastewater management: Wastewaters - classification and characteristics of sewage and industrial effluents; treatment methods for water and waste water; Principles of aeration, chlorination, ozonation and U.V. irradiation.

Unit V Waste recycling and utilization in aquaculture; Design and construction of water filtration devices; aerobic and anaerobic treatment of wastewater.

Unit VI Wastes from fish processing units and their treatment; solid waste management; removal

of nitrogen and phosphorus from waste water; Role of aquatic macrophytes in treatment of wastewater

Practical Collection and preservation of wastewater samples; Physicochemical analysis of wastewater - total dissolved and suspended solids, colour, odour, DO, BOD, COD, H_2S,, NH_3–N, NO_2-N, NO_3-N, PO_4-P, CH_4, heavy metals and pesticides; Use of algae for organic waste treatment; Visit to sewage treatment plants, fish processing units and other industries; Exercise on interpretation of water quality data for evaluation of aquatic health

Suggested Readings

1. Baird, D.J., Beveridge, M.C.M., Kelly, L.A. and Muir, J.F., 1996. Aquaculture and Water Resources Management. Blackwell Science Ltd., Oxford.
2. Cheremisinoff, N.P., 2002. Handbook of Water and Waste Water Treatment Technologies. Butterworth – Heinemann, Woburn.
3. Eckenfelder, W.W., 2000. Industrial Water Pollution Control. McGraw Hill, New York.
4. Gray, N.F., 2004. Biology of Wastewater Treatment. Oxford University Press, London.
5. Trivedy, R.K., 1998. Advances in Wastewater Treatment Technologies. Global Science, Aligarh

Journals

1. Marine Pollution Bulletin
2. Environmental Pollution
3. Journal of Environmental Quality
4. Science of the Total Environment
5. Water Research
6. Bioresource Technology

Broad Research Area

1. Pollution monitoring
2. Wastewater treatment
3. Pollution remediation

MAJOR - OPTIONAL COURSES

AEM 505 ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT 2+1

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

Theory

Unit I Types: Categorization of different limnetic fisheries resources - lacustrine, riverine and coldwater systems; Wetlands, Floodplain wetlands, swamps - characteristics, flora and fauna

Unit II Characteristics: Physical & chemical characteristics of limnetic environment and its relationship with the organisms; influence on metabolism, behavior and orientation of animals; Biological productivity in relation to fishery potential; Trophic relationships in the wetland ecosystem - nutrient production, and transport, Trophic succession; Dynamics of lentic and lotic systems; Water budgeting in limnetic ecosystems

Unit III Conservation and Management: Functions of wetlands; Habitat degradation- causative factors and controlling/management measures; Destruction of wetlands - causes and consequences; Restoration, conservation and management of wetlands; Resource enhancement; Management of water bodies for economy-driven activities; Management through Biomanipulation studies- top-down and Bottom-up methods; Integrated Environment Management (IEM) Programme-involvement of human element; River continuum concept & new paradigm shift; River linking; International conventions - Ramsar; Environmental laws and regulations; Index of Biotic Integrity (IBI); modeling studies; Wetland mapping using remote sensing; Geographical Information System (GIS)- Definition, Concepts and application

Practical Collection, preservation and analysis of flora and fauna (including phytoplankton, zooplankton and benthos) of wetland ecosystem; Case studies on soil and water quality assessment; Survey and sampling of lentic and lotic waters; Calculation of shoreline development index and morphometry; Determination of carrying capacity; Field visits to selected reservoirs, lakes/wetlands and rivers

Suggested Readings

1. Dodds, W.K., 2002. Freshwater Ecology: Concepts and Environmental Applications. Academic Press, New York.
2. Good, R.E., Whigham, D.F. and Simpson, R.L., 1978. Fresh Water Wetlands: Ecological Processes and Management Potential. Academic Press, New York.
3. Mitsh, W.J. and Gosselink, J.G., 1996. Wetlands. John Wiley and Sons, New York.
4. Pattern, B.C., 1990. Wetlands and Shallow Continental Water Bodies. SPB Academic Press, New York.
5. Wong, M.H., 2004. Wetland Ecosystems in Asia: Functions and Management. Elsevier Publications, London
6. Allan, J.D., 1995. Stream Ecology: Structure and Function of Running Waters, Chapman-Hall, London.
7. Hynes, H.B.N., 1970. Ecology of Running Waters. Liverpool University Press, Liverpool.
8. Scheffer, N.M., 1998. Ecology of Shallow Lakes. Chapman-Hall, London.
9. Talling, J. and Lemoalle, J., 1998. Ecological Dynamics of Tropical Inland Waters. Cambridge University Press, London

Journals

1. Hydrobiologia
2. Limnology and Oceanography
3. Estuarine, Coastal and Shelf Science
4. Canadian Journal of Fisheries and Aquatic Sciences

Broad Research Area

1. Wetland Ecology
2. Sustainable management
3. Resource assessment through remote sensing and GIS

AEM 506 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, Interrelationship of xenobiotics with other environmental variables; IPR issues related to environmental biotechnology

Unit II Genetically-improved strains: Genetically-improved strains - basic concepts, application in waste management, pesticide degradation, heavy metal remediation, oil removal; Nitrogen fixation; Phosphate solubilization; Cellular and molecular markers of environmental pollution monitoring and management

Unit III Microbial consortia: Consortia of microbes for environmental protection – Concept, scope and feasibility

Unit IV Biological treatment and utilization of wastes: Bioreactors – principles and application in nitrification, denitrification, reduction of BOD; Production of biofuels, fermented products and biogas from wastes, Nutrient uptake by aquatic organisms

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

Suggested Readings

1. Buck, R.P., Hatfield, W.E., Umana, M. and Bowden, E.F., 1990. Biosensor Technology - Fundamentals and Applications. Marcel Dekker, New York.
2. Fujita, M. and Ike, M., 1994. Wastewater Treatment using Genetically Engineered Microorganisms. Technomic Publishing Co. Inc., Lancaster.

3. Kingsman, S.M. and Kingsman, A.J., 1988. Genetic Engineering: An Introduction to Gene Analysis and Exploitation in Eukaryotes. Blackwell Scientific, Oxford.
4. Sambrook, J. and Russel, D.W., 2001. Molecular Cloning: A Laboratory Manual. CSHL Press, New York.
5. Sayler, G.S., Sanseverino, J. and Kimberely, D.L., 1997. Biotechnology in Sustainable Environment. Plenum Press, New York

Journals

1. Applied Environmental Microbiology
2. Bioresource Technology
3. World Journal of Microbiology and Biotechnology
4. Current Opinion in Biotechnology
5. FEBS Letters
6. Trends in Biotechnology

Broad Research Area

1. Bioreactor development
2. Biosensors
3. Biomonitoring
4. Genetic improvement of microbes

AEM 507 ENVIRONMENTAL TOXICOLOGY 1+1

Objective To impart knowledge on toxicological aspects of various pollutants

Theory

Unit I Toxicity and metabolism: Factors influencing toxicity- environmental, genetic and nutritional; Measurement and evaluation of the ecological effects of toxicants; Metabolism of toxic substances by aquatic organisms - consequences, synergistic and antagonistic effects; Acute poisons and accumulative poisons; Bioaccumulation and biomagnification; Systemic effects of toxic metals, pesticides and herbicides; Effect of select toxicants on aquatic life and detoxification

Unit II 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 oil on selected organisms; Analysis of heavy metals from aquatic ecosystems; Toxicity testing methods

Suggested Readings

1. Hoffman, D.J., 1995. Handbook of Ecotoxicology. Lewis Publication, Boca Raton.
2. Mayer, H., 1977. Aquatic Toxicology and Hazards Evaluation. ASTM Publication, Philippines.
3. Rand, G.M. and Petrocelli, S.R., 1994. Fundamentals of Aquatic Toxicology. Hemisphere Publishing Corporation, Washington.
4. Raymond, J.M., Neisink, R.J.M., de Vries, J. and Hollinger, M.A., 1996. Toxicology: Principles and Applications. CRC Press, New York.
5. Ware, G.W., 2002. Review of Environmental Contamination and Toxicology. Springer – Verlag, New York

Journals

1. Environmental Toxicology
2. Toxicon
3. Bulletin of Environmental Contamination and Toxicology
4. Indian Journal of Environment and Toxicology

Broad Research Area

1. Bioaccumulation of toxicant
2. Biomagnification
3. Effects of toxicant on aquatic biota

AEM 508 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 an analytical technique; Interferences and their removal, Field kits and their application

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

Unit III 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 IV Tracer techniques: Scintillation counters and radio isotopes in environmental research

Practical Quantitative estimation of organic and inorganic pollutants and toxicants by UV-Visible spectrophotometer, AAS, HPLC, GC.

Suggested Readings

1. Eaton, A.D., Clesceri, L.S., Rice, E.W. and Greenberg, A.E., 2005. Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WEF, Washington DC.
2. Fishbein, L., 1973. Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants. Elsevier Publications, Amsterdam.
3. Jeffery, G.H., Basset, J., Mendham, J. and Denney, R.C. (eds.), 1989. Vogel's Textbook of Quantitative Chemical Analysis. Longman Publishers, Singapore.
4. Sparks, D.L., Page, A.L., Helmke, P.A., Loeppert, R.H., Soltanpour, P.N., Tabatabai, M.A., Johnston, C.T. and Sumner, M.E. (eds.), 1996. Methods of Soil Analysis: Part 3 - Chemical Methods. SSSA-ASA, Madison.
5. Wilson, K. and Walker, J., 2002. Practical Biochemistry: Principles and Techniques, Cambridge University Press, Oxford.

Journals

1. Journal of Chromatography
2. Communication in Soil and Water analysis
3. Analytica Chemica
4. Environmental Technology

Broad Research Area

1. Development of methods for efficient and rapid analysis
2. Comparison of different analytical techniques

FET 509 PLANKTONOLOGY 1+1

Objective To impart knowledge on plankton, their ecology and significance

Theory

Unit I Plankton diversity and productivity: Classifications of plankton; Primary and secondary production - estimation, significance, affecting factors; Production - biomass (P/B ratio); Indices of productivity; Community interrelationships

Unit II Ecology of phytoplankton: Phytoplankton (freshwater and marine) - methods of assessment, spatial and temporal variations, succession, diversity; Nanoplankton; Algal blooms; Role in carbon sequestration

Unit III Ecology and life history of zooplankton: Zooplankton (freshwater and marine) – ecology of the major taxa, their food and feeding, reproduction of important zooplankton, life history stages; swarms; Indicator species; Predator-prey relationship; Impact of grazing in

the aquatic ecosystem; Vertical migration of zooplankton; Larval ecology of benthic invertebrates;

Unit IV Sampling and preservation techniques: Plankton nets and recorders, catching efficiency of various nets; Plankton fixatives and preservatives

Practical Collection, preservation and quantitative estimation of phytoplankton and zooplankton; Identification and classification of various phytoplankton and zooplankton; Preparation of permanent slides; Logging, cataloguing and sorting procedures

Suggested Readings

1. Fasset, N.G., 1997. A Manual of Aquatic Plants. Allied Scientific Publishers, Bikaner.
2. Lund, H.C. and Lund, J.W.G., 1995. Freshwater Algae. Biopress Ltd., Bristol.
3. Pillai, N. K., 1986. Introduction to Planktonology. Himalaya Publishing House, Bombay.
4. Sournia, A., 1978. Phytoplankton Manual. UNESCO Publication, Paris.
5. Tomas, C.R., 1997. Identifying Marine Phytoplankton. Academic Press, San Diego.

Journals

1. Hydrobiologia
2. Journal of Phycology
3. Journal of Aquatic Botany
4. Journal of Plankton Research

Broad Research Area

1. Documentation of planktons in diverse aquatic habitats
2. Diversity analysis and algal indices of pollution load
3. Evaluation of plankters for fish food

AEM 510 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: Effects of physicochemical and biological oceanographic factors on adaptation, behaviour, abundance and production of aquatic organisms; Space and time scales in oceanographic analysis; Speed and magnitude of short-term changes in the ocean; Synoptic oceanographic analysis – currents, waves, tides, amplitudes, stratification, related chemical factors, upwelling and circulation patterns

Unit II Forcasting 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

Unit III Coastal fishery: Coastal fishery and hydrography- introduction, scope and factors affecting; shoreline protection and influence of developmental activities on coastal hydrography

Unit IV Factors affecting marine fisheries: Environmental factors influencing the seasonal variations in fish catches in the Arabian Sea and the Bay of Bengal

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

Suggested Readings

1. Kennish, M.J., 1989. Practical Handbook of Marine Science. CRC Press, New York.
2. Laevastu, T. and Hayes, M.L., Fisheries Oceanography and Ecology. Fishing News Books, Farnham.
3. Lalli, C.M. and Parsons, T.R., 1993. Biological Oceanography: An Introduction. Elsevier Science Ltd., Oxford.
4. Miller, C.B., 2004. Biological Oceanography. Blackwell Publications, Oxford.
5. Grasshoff, K., Ehrhardt, M. and Kremling, V., 1983. Methods of Seawater Analysis. Verlag Chemie, Weinheim.

Journals

1. Indian Journal of Marine Sciences
2. Fisheries Oceanography
3. Journal of Marine Research USA
4. Seaweed Research and Utilization

Broad Research Area

5. Marine pollution and fisheries production
1. Seasonality of fish catch and meteorological factors
2. Application of GPS and remote sensing in marine fisheries
3. Bioactive compounds from sea

FET 511 AQUATIC MICROBIOLOGY 2+1

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

Theory

Unit I Cell structure and function: Prokaryotic and eukaryotic cell structure, cell membrane, cell wall, proteins, nucleic acids - structure, properties and interactions, microbial growth.

Unit II Distribution and classification: Microbial community in freshwater, estuary and marine environment (types and abundance). Microbial dependency on physical, chemical and biological factors of the environment; Classification of aquatic microorganisms, Microbes in extreme environments and their significance - thermophiles, psychrophiles, halophiles and barophiles.

Unit III Microbial interaction with matter: Microbial interaction - role of microbial population on the biogeochemical cycles (C, N, P, S, Si and Fe), Xenobiotic and inorganic pollutants; Microbial degradation of natural and synthetic compounds

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

Unit V Microbes and aquatic environment: Principles and applications of bioprocesses – bioremediation, biofertilization, biofilms, bio-leaching, bio-corrosion, bio-fouling; Microorganisms as bioindicators, bioremediators and biosensors; Microbial biomass production - single cell protein; Bioprospecting.

Practical Sampling methods; Isolation, identification and enumeration of algae and bacteria from diverse aquatic habitats; growth kinetics; Management of algal and bacterial cultures; Quantification of microbial activities in nutrient cycles; Microbial sensitivity testing; Demonstration of biofilms.

Suggested Readings

1. Frobisher, M., Hinsdill, R.D., Crabtree, K.T. and Goodheart, C.R., 1974. Fundamentals of Microbiology. WB Saunders Company, Philadelphia.
2. Geesey, G., Lewandowski, Z. and Flemming, H.C. (eds.). 1994. Biofouling and Biocorrosion in Industrial Water Systems. CRC Press Inc., Lewis Publishers, Boca Raton.
3. Prasad, A.B. and Vaishampayan, A., 1994. Nitrogen Fixing Organisms – Problems and Prospects. Scientific Publishers, Jodhpur.
4. Rheinheimer, G., 1992. Aquatic Microbiology. John Wiley & Sons, Chichester.
5. Stanier, R., Ingraham, J.L. and Adelberg, E.A., 1976. General Microbiology. MacMillan Publishers, London.

Journals	1. Applied Environmental Microbiology 2. FEMS Microbiology Ecology 3. FEMS Microbiology Letters 4. FEMS Microbiology Reviews 5. Applied Microbiology and Biotechnology 6. Systematic and Applied Microbiology
Broad Research Area	1. Microbial Ecology 2. Bioremediation 3. Microbial pollution indicators

PhD (Fisheries Engineering & Technology) SYLLABUS

MAJOR - CORE COURSES

AEM 601 ADVANCES IN AQUATIC ENVIRONMENTAL STUDIES 2+1

Objective To impart knowledge on various aspects of advances in aquatic environment studies

Theory

Unit I Factors effecting productivity of aquatic ecosystems and their interactions; phosphorus, nitrogen and silica cycles; minor metallic elements; organic matter in lake waters. Dynamics of flowing water; Indices of productivity; pollution index –usefulness and limitations;

Unit II Eutrophication – causative factors, effects on water quality, fish and other biota; measures to control the lake degradation due to eutrophication;

Unit III Biomanipulation: Concept and approaches- studies on Planktivorous, Benthivorous and Omnivorous fish. Biological control of macrophyte and eutrophication;

Unit IV Biomonitoring of aquatic environment, scope and process; Bioindicator organisms and its Characteristics; Assessment of water quality through bioindicators;

Unit V Global warming and green house effects- process and impact on aquatic environment; Integrated environment management (IEM), Role of human element in IEM, Analytical Behavior Analysis Approach (ABAA) for IEM;

Unit VI Natural disasters: formation, causes and effects; effects on aquatic habitat and coastal population; Concerns and management; mitigation process; preparedness, Anthropogenic activities leading to environmental disasters. Man-made aquatic environmental degradation; effects on aquatic life

Practical Analysis of ions; Calculation of shoreline development index and other indices of lake productivity; Studies on eutrophication in natural waters-tanks and ponds; Collection, preservation and estimation (quantitative and qualitative) of bioindicator organisms in polluted water. Demonstration of Biomanipulation experiment; Preparation of disaster kits for coastal fisher; Interaction of the Govt. and Non-Govt. Organizations engaged for disaster management

Suggested Readings

1. Goudie, A., 1993. The Human Impact on the Natural Environment. MIT Press Cambridge.
2. Gates, David, M., 1993. Climate Change and its Biological Consequences. Saunderland, Sinauer.
3. Brudtland, G.H., 1987. Our Common Future: World Commission On Environment and Development. Oxford University Press, New York.

4. IUCN, UNEP, WWE, 1991. Caring for the Earth: Strategies for Sustainable Living. Earthscan, London.
5. WCMC, 1992. Global Biodiversity: Status of the Earth's Living Resources. Chapman and Hall

Journals

1. Indian Journal of Marine Sciences
2. Fisheries Oceanography
3. Journal of Marine Research USA

Broad Research Area

1. Biomonitoring of aquatic environment
2. Microbial indicators of pollution

AEM 602 BIOTECHNOLOGY FOR CLEANER ENVIRONMENT 1+1

Objective To educate the learners about the application of biotechnology in aquatic environment management

Theory

Unit I Pollution Control: Cleaner technologies, Reducing environmental impact of industrial effluents, Toxic site reclamation

Unit II Microbial transformation of toxic metals, Removal of spilled oil and grease deposits, 'Biorational' or 'Environmentally Safe' weed and pest control, Bio-fertilizers, Bio-sensors and biochips to detect environmental pollutants.

Unit III Application of biotechnological tools in biomonitoring of aquatic environment; Renewable or bio-energy and bio-fuels from aquatic environment, Energy and fuel production using micro-organisms; Production of food: Single cell protein, Algal biotechnology for production of food; Use of microbes for improving soil fertility, biodegradation.

Unit IV Biodiversity and its Conservation: Current levels of biodiversity, alpha and beta biodiversity, i*n situ* and *ex situ* conservation-gene banks, species conservation. Intellectual Property rights (IPR) and Protection (IPP): IPP and Aquatic genetic resources (AGR)

Practical Quantification of faunal changes in polluted water; Gel electrophoresis; Total DNA isolation; Mitrochondial DNA isolation, Separation and detection of fragments, Comet assay, Micronucleus test, Sister Chromatid exchange; Assessing the molecular and cellular level changes in the Aquatic organisms; Genomic libraries and the development of species specific probes. Southern hybridization; RFLP analysis, PCR mechanics.

Suggested Readings

1. Buck, R.P., Hatfield, W.E., Umana, M. and Bowden, E.F., 1990. Biosensor Technology - Fundamentals and Applications. Marcel Dekker, New York.
2. Sambrook, J. and Russel, D.W., 2001. Molecular Cloning: A Laboratory Manual. CSHL Press, New York.
3. Sayler, G.S., Sanseverino, J. and Kimberely, D.L., 1997. Biotechnology in Sustainable Environment. Plenum Press, New York.
4. Moo-Young, M., Anderson, W. A. and Chakrabarty , A. M., 2006. Environmental Biotechnology: Principle and Applications, Kluwer Academic Press.
5. Crespi, R.S., 1991. Biotechnology and Intellectual Property, Part 1 and 2, TIBTECH, 9.
6. Yoxen, E. 1988. The Gene Business: Who should Control Biotechnology. Oxford University Press.

Journals

1. Applied Environmental Microbiology
2. Bioresource Technology
3. World Journal of Microbiology and Biotechnology
4. Current Opinion in Biotechnology

Broad Research Area

1. Microbial Biosensors
2. Biomonitoring
3. Use of microbes for improving soil fertility

AEM 603 BENTHIC ECOLOGY 1+1

Objective To impart theoretical and practical knowledge of benthic ecology

Theory

Unit I Benthic habitat- rocks, reefs, marshes and sediments that form the habitat; recycling of nutrients and the burial and storage of organic matter;

Unit II Community ecology; Physical, chemical and biological factors effecting benthic population; abundance and distribution of benthic communities- major groups- their life cycles, food and feeding habits and ecological significance; Role in maintaining ecological balance; Recruitment dynamics; Predator prey interaction; Invasive species;

Unit III Human impacts; modification of coastal habitats, and major alterations of biogeochemical cycles; contaminants; Benthic organisms as pollution indicators and biomonitors

Practical Collection and analysis of soil and water of nearby benthic habitat; collection, identification and preservation of macro and micro benthos; study of food and feeding habit of some benthic population.

Suggested Readings

1. APHA (American Public Health Association). 1989. Benthic macroinvertebrates, p. 10-95 to 10-113. *In*: Standard methods for the examination of water and wastewater. 17th ed. American Public Health Association, Washington, D.C.
2. S.M. Mandaville, 1999,Bioassessment of Freshwaters Using Benthic Macroinvertebrates- A Primer
3. Benthic Macro invertebrates in Fresh Waters: D.M. Rosenberg, I.J. Davies, D.G. Cobb, and A.P. Wiens
4. Clegg, J. and H. Anthon. 1968. Pond and stream life. Blandford Press, London, England. 108 p.
5. Cole, G.A. 1988. Textbook of limnology. 3rd ed. Waveland Press, Prospect Heights, Illinois.
6. Cuffney, T.F., M.E. Gurtz, and M.R. Meador. 1993. Methods for collecting benthic invertebrate samples as part of the National Water-Quality Assessment Program. U.S. Geological Survey Open-File Report 93-406. U.S.G.S., Raleigh, North Carolina. 65 p.
7. B.A. Whitton (ed.) River ecology. University of California Press, Berkeley, California.
8. J.A. Downing and F.H. Rigler (eds.), 1984, A manual on methods for the assessment of secondary productivity in fresh waters. 2nd ed. IBP Handbook 17. Blackwell Scientific Publications, Oxford, England.
9. Dawson, C.L. and R.A. Hellenthal. 1986. A computerized system for the evaluation of aquatic habitats based on environmental requirements and pollution tolerance associations of resident organisms. EPA/600/S3-86/019. Environmental Research Laboratory, U.S. Environmental Protection Agency, Corvallis, Oregon.
10. Elliott, J.M. 1977. Some methods for the statistical analysis of samples of benthic invertebrates. 2nd ed. Freshwater Biological Association Scientific Publication No. 25. 156 p.

Journals

1. Australian Journal of Ecology
2. Canadian Journal of Fisheries and Aquatic Sciences
3. Marine Ecology

Broad Research Area

1. Factors effecting benthic population
2. Abundance and distribution of benthic communities
3. Benthic organisms as pollution indicators and biomonitors

MAJOR - OPTIONAL COURSES

AEM 604 ESTUARINE AND COASTAL OCEANOGRAPHY 2+1

Objective To impart knowledge on the dynamics of coastal environment

Theory

Unit I Definition of an estuary; Buoyancy input as freshwater;

Unit II Dynamics of the gravitational circulation; Mixing of fresh and salt water; Sources of energy for mixing. Estuarine circulation, Richardson number. Contributions to the salt flux;

Unit III Simplified salt balance using the steady state salinity distribution to predict the concentration of a pollutant. Freshwater fraction. The flushing time of an estuary and methods of determining it

Unit IV Waves in shallow waters, transformation, refraction and reflection; Mass transport. Return flow. Rip current. Long shore currents. Momentum balance.

Unit VI Sediment transport. Base studies on sedimentation in Estuaries effects of man –made structures and breakwaters on coastal sedimentation. Standing waves and harbor resonance

Practical Measurement of tidal currents in estuaries - analyses of tidal heights – Net flow and residence time computations. Computation of salt and nutrient flux. Construction of wave refraction diagrams. Computation of longshore currents and sediment drift beach profiles

Suggested Readings

1. Carter, R.W.G., 1998. Coastal Environments: An Introduction to the Physical, Ecological and Cultural Systems of Coastlines. Academic Press, London.
2. Park, C.C., 1980. Ecology and Environmental Management. Butterworths, London.
3. Kormondy, E. J. (1986). Concepts of Ecology, Prentice-Hall, New Delhi.
4. Clark, J. R. (1992). Integrated Management of Coastal Zones. FAO Fisheries Technical Paper 327, Rome, FAO.

Journals

1. Marine pollution Bulletin
2. Estuarine, Coastal and Shelf Science
3. Coastal Aquaculture

Broad Research Area

1. Measurement of tidal currents in estuaries
2. Dynamics of Estuarine circulation

AEM 605 ORGANIC PRODUCTION AND PLANT PIGMENTS 2+1

Objective To impart advance knowledge on primary productivity and pigments

Theory

Unit I Concepts of production; measurements of rate of production – oxygen technique, radiotracer technique (C14), in-situ measurements

Unit II Phytoplankton production in an isolated, non isolated communities in flowing and standing waters, measurement of rates of production from changes in phytoplankton biomass;

Unit III Measurement of photosynthesis under laboratory conditions; factors regulating aquatic production; The role of Enzymes in relation to photosynthesis; The photosynthetic pigments, their location in the chloroplast, The role of accessory pigments during photosynthesis; Molecular organisation of chlorophylls, phycobilins and carotenoids; Pigment degradation products – phaeopigments – phaeophytin and phaeophorbides.

Unit IV Chloroplast – structure and function of grana and lamellae. Structure of chloroplast membrane – in relation to energy coupling and transport;

Unit VI Application of remote sensing in studies on chlorophyll and other pigments;

Unit VII Production rates – direct measurement of zooplankton reproduction – marking populations. Laboratory measurements of physiology of zooplankton – feeding, respiration and excretion

Practical Estimation of primary production in waters –by Light and Dark Bottle method and radioactive carbon C14 technique. Laboratory studies to understand the impact of nutrients and light on primary production using selected algal cultures. Laboratory studies on the oxygen consumption, filtration and grazing by selected zooplankters.

Collection of water samples from selected aquatic environments for the estimation of different plant pigments – chlorophylls and carotenoids; Estimation of pigments in some of the selected aquatic weeds

Suggested Readings

1. Talling, J. and Lemoalle, J., 1998. Ecological Dynamics of Tropical Inland Waters. Cambridge University Press, London
2. Eaton, A.D., Clesceri, L.S., Rice, E.W. and Greenberg, A.E., 2005. Standard Methods for the Examination of Water and Wastewater. APHA-AWWA-WEF, Washington DC.
3. Fishbein, L., 1973. Chromatography of Environmental Hazards: Metals, Gaseous and Industrial Pollutants. Elsevier Publications, Amsterdam.

Journals

1. Marine Pollution Bulletin
2. Environmental Pollution
3. Journal of Environmental Quality
4. Science of the Total Environment

Broad Research Area

1. Measurement of rates of production from changes in phytoplankton biomass
2. Application of remote sensing in studies on chlorophyll and other pigments

AEM 606 ENVIRONMENT IMPACT ASSESSMENT 1+1

Objective To impart theoretical and practical knowledge of environment impact assessment for sustainable development

Theory

Unit I Environmental Impact Assessment (EIA): Process, Evaluation and methodology; Social Impact Assessment (SIA) as a part of EIA-principals and process; EIA of aquacultural projects, coastal industries and other developmental activities;

Unit II Environmental audit: Concept, setting up an audit programme, Typical audit process, Carrying out the audit, benefits of environmental auditing, Environmental audit programme in India;

Unit III International and national environmental protection standards; Environmental quality monitoring; ISO-14000-Environment Management System (EMS)-present status; Impacts on developing countries.

Practical Field visits for EIA and SIA of certain aquacultural projects; EIA report preparation; Setting of the Environmental audit programme.

Suggested Readings

1. Canter, L.W., 1994. Environmental Impact Assessment. Mc-Graw Hill, New York.
2. Grilbert, M and Gould R., 1998. Achieving Environmental Standards. Pitman Publishing, London.
3. Wathern, Peter (Ed.), 1988. Environmental Impact Assessment: Theory and Practice, World Research Institute, Routledge, London.

Journals

1. Marine Pollution Bulletin
2. Environmental Pollution
3. Journal of Environmental Quality

Broad Research Area

1. Principles and practices of EIA
2. Preparation of environmental audit

AEM 607 MANAGEMENT AND UTILIZATION OF WASTEWATER 2+1

Objective To impart theoretical and practical knowledge on management and utilization of wastewater for sustainable development

Theory

Unit I Advance treatment methods-Principles and procedures; ozonation, U.V. irradiation etc; Oxidation of sediment; Aerobic and anaerobic treatment process; Role of aquatic macrophytes in biological treatment of waste water; Wastewater treatment through the use of solar energy; Basic design of water and wastewater treatment plants. Removal of nitrogen and phosphorus from wastewater;

Unit II Waste recycling and waste management in aquaculture; Design and construction of water filtration devices; Utilization of wastewater for mass cultivation of algae and other fish food organisms; Utilization of waste water for aquaculture and Agriculture.

Unit III Waste disposal criteria used in different parts of world - national and international standards; Production of Biogas from sewage; Advances in Pollution Prevention: Environmental Management

Practical Estimation of physico-chemical Characteristics of wastewater. Estimation of nutrients and contaminant of wastewaters. Analysis of living communities associated with treatment processes; Demonstration of wastewater treatments (ozonisation, chlorination, aeration, precipitation, coagulation etc.).

Suggested Readings

1. Baird, D.J., Beveridge, M.C.M., Kelly, L.A. and Muir, J.F., 1996. Aquaculture and Water Resources Management. Blackwell Science Ltd., Oxford.
2. Cheremisinoff, N.P., 2002. Handbook of Water and Waste Water Treatment Technologies. Butterworth – Heinemann, Woburn.
3. Eckenfelder, W.W., 2000. Industrial Water Pollution Control. McGraw Hill, New York.
4. Gray, N.F., 2004. Biology of Wastewater Treatment. Oxford University Press, London.
5. Trivedy, R.K., 1998. Advances in Wastewater Treatment Technologies. Global Science, Aligarh
6. Fujita, M. and Ike, M., 1994. Wastewater Treatment using Genetically Engineered Microorganisms. Technomic Publishing Co. Inc., Lancaster.

Journals

1. Marine Pollution Bulletin
2. Environmental Pollution
3. Journal of Environmental Quality
4. Aquaculture
5. Environmental Science

Broad Research Area

1. Role of aquatic macrophytes in biological treatment of waste water
2. Removal of nitrogen and phosphorus from wastewater
3. Utilization of wastewater for mass cultivation of algae

AEM 608 ECOTOXICOLOGY 2+1

Objective To impart theoretical and practical knowledge on the eco-toxicological aspects of aquatic environment

Theory

Unit I Measurement and evaluation of the ecological effects of toxicants; Mode of Entry of Toxicants

Unit II Toxicity Testing - Microcosm and Mesocosm Tests, Bioassay –types, terminology, analyses of data and interpretation; Dose-Response Relationships;

Unit III Biotransformation and conjugations of toxicants; Metabolism of toxic substances by aquatic organisms - uptake, excretion, chemical and physiological localization, and their consequences; Synergistic and antagonistic effects; Bioconcentration, Bioaccumulation and biomagnifications; Metal transfer between solid and aqueous phases;

Unit IV Systemic effects of some selected toxic metals, pesticides and herbicides; Metal toxicity – catastrophic episodes of metal poisoning; Effect of selected toxicants on aquatic life and detoxification mechanism

Unit VI Environmental Risk Assessment: Definition, process of risk assessment, identification of hazards, risk estimation, Risk management; Regulatory policies and International treaties.

Practical Toxicity evaluation of heavy metals on selected organisms by bioassay techniques; Toxicity assessment of pesticides and oil on selected organisms; Analysis of heavy metals from aquatic ecosystems; Toxicity testing methods

Suggested Readings

1. Hoffman, D.J., 1995. Handbook of Ecotoxicology. Lewis Publication, Boca Raton.
2. Mayer, H., 1977. Aquatic Toxicology and Hazards Evaluation. ASTM Publication, Philippines.

3. Rand, G.M. and Petrocelli, S.R., 1994. Fundamentals of Aquatic Toxicology. Hemisphere Publishing Corporation, Washington.
4. Raymond, J.M., Neisink, R.J.M., de Vries, J. and Hollinger, M.A., 1996. Toxicology: Principles and Applications. CRC Press, New York
5. Ware, G.W., 2002. Review of Environmental Contamination and Toxicology. Springer – Verlag, New York.

Journals

1. Journal of Ecotoxicology
2. Toxicon
3. Ecotoxicology and environmental safety
4. Functional Ecology

Broad Research Area

1. Effect of selected toxicants on aquatic life and detoxification mechanism
2. Environmental Risk Assessment
3. Toxicity assessment of pesticides and oil on selected organisms

AEM 609 APPLICATION OF REMOTE SENSING AND GIS IN FISHERIES 1+1

Objective To impart theoretical knowledge and practical skill on application of remote sensing and GIS in oceanographic studies and Aquatic Environment Management Planning

Theory

Unit I General consideration, Survey planning, Position fixing; Sampling frequency and duration, Data storage and transmission;

Unit II Sensors for temperature and salinity (Via conductivity); The measurement of depth (via pressure); CTD units for estuarine and open ocean work; Sensor calibration techniques; Sensors for measuring flow; Tracking of drogue buoys. Acoustic Doppler current measurements; Optical measurements; transmittance and subsurface reflectance;

Unit III *In situ* fluorescence for the determination of pigment concentration; Remote sensing optical methods; Satellite measurements of temperature (via thermal I.R.), the interpretation of Microwave (geotropic currents, waves, surface winds).

Unit IV Geographical Information System (GIS): Definition, Concepts, Spatial data management. Data base management system. Data Capture, Digitization, Data integration, Projection and Registration, Data Structure, Data Modeling. Visual Image Interpretation; Applications of GIS in aquatic Resource identification; Digital Image Processing (DIP): Different Methods and Approaches

Practical Position fixing techniques. Operation of C.T.D. units and their calibrations. Various types of current meters and measurement of currents. Wave recorders and measurements. Determination of pigment concentrations. Remote sensors – interpretation of data. Practical on visual interpretation of data from map, Practical on Digital Image Processing (DIP). Field practical on the Application of GPS. Mapping of aquatic environment resources through GIS softwares (ARCVIEW, MAPINFO etc.).

Suggested Readings

1. Lillesand, T. M., Kiefer, R. W., Chipman, J. W. (2004). Remote Sensing and Image Interpretation. John Wiley & Sons (Asia) Pte Ltd., Singapore.
2. Meaden, G.J. and Do Chi, T. (1996). Geographical Information System: applications to Marine Fisheries. FAO Technical Paper No. 356, Rome, FAO.
3. Meaden, G.J. and Kapetsky, J. M. (1991). Geographical Information System and Remote Sensing in Inland Fisheries and Aquaculture. FAO Technical Paper No. 318, Rome.
4. ESRI (2007). Understanding GIS, the ARC/INFO Method, Environmental System Research Organization, Inc., USA.
5. Elangovan, K. (2005). GIS: Fundamentals, Applications and Implementations. New India Publishing Agency

Journals

1. Aquaculture Engineering
2. Fisheries Science
3. Marine Pollution Bulletin
4. Environmental Studies
5. Oceans

Broad Research Area

1. Applications of GIS in aquatic resource identification
2. Application of remote sensing and GIS in oceanographic studies

AEM 610 DISPERSAL AND FATE OF POLLUTANTS IN THE OCEAN 1+1

Objective To impart theoretical and practical knowledge on dispersal and fate of pollutants

Theory

Unit I Common transport processes of pollutants in the ocean;

Unit II Influence of winds, tides, Waves and currents on the dispersal of pollutants, mixing due to waves and Wave induced currents; Principles of design of marine waste disposal system

Unit III Pollutant dispersion in coastal waters and estuaries, dispersion near outfall sites;

Methods of pollutant dispersal dye diffusion studies

Practical Techniques of computation of dispersion coefficients; Calculation of Richardson number, tidal exchange calculation at the estuarine mouth; Numerical analysis of estuarine dispersion; Simple plume experiments – designs of waste discharge and thermal systems.

Suggested Readings

1. Laevastu,T. ; Clancy,M. ; Stroud,A. 1974. Computation of Tides, Currents and Dispersal of Pollutants in Lower Bay and Approaches to New York with Fine Medium Grid Size Hydrodynamical-Numerical Models. Part 3. National Technical Information Service Springfield, Virginia.
2. John James William Rogers, P. Geoffrey Feiss, 1998, People and the Earth: Basic Issues in the Sustainability of Resources, Cambridge University Press
3. Wlodzimierz Czernuszenko, Pawel Rowinski, 2005. Water Quality Hazards And Dispersion Of Pollutants, Springer
4. Roy M. Harrison Edt. 1982. Pollution: causes effects and control, The Royal Society of Chemistry, Distribution Center, Blackhorse Road,Letchworth, Herts SG6 lHN, England.

Journals

1. Geo-Marine Letters
2. Marine Biology
3. Spill Science and Technology Bulletin
4. Marine Pollution Bulletin
5. Environmental Studies
6. Oceans

Broad Research Area

1. Computation of dispersion coefficients
2. Analysis of estuarine dispersion
3. Design of marine waste disposal systems

AEM 611 RESTORATION ECOLOGY 1+1

Objective To acquire theoretical and practical knowledge on ecological restoration

Theory

Unit I Ecological restoration- Need, concept and definition; Approaches; Rationale for restoration; Differences between conservation and restoration; critical ranges of variability in biodiversity,

Unit II Ecological processes and structures, regional and historical contexts, and sustainable cultural practices; Ecosystem integrity; community ecological principles; Disturbance, Succession, Fragmentation, Ecosystem auditing; Ecosystem function

Unit III Emerging concepts-Assembly, Stable states; Biotic and abiotic flows and cultural interactions; Application of theory-Invasion, competitive dominance and resource use; IV Restoration planning; Wetland Assessment, Delineation, and Regulation; Recovery process, Mitigation, Rehabilitation**,** and Reclamation; Dynamics and restoration of degraded wetlands; Removal of threats to the health and integrity of the restored ecosystem

Unit IV Individuals participation in a restoration program; different human participatory program; Sustainable cultural practices; constraints and opportunities; Economics of recovery process

Practical Collection and segregation of native and non native species from a damaged environment; Making list of historical and cultural interactions; Status of assemblages; calculation of Index of Biotic Integrity; Listing of the threats to the integrity of the ecosystem; Organizing different participatory program

Suggested Readings

1. Perrow M.R. & Davy, A.J. (Eds.), Handbook of Ecological Restoration, Volume 1 Principles of Restoration, Cambride: Cambridge University Press.
2. Jordan, W.R., Gilpin, M.E. & Aber, J.D. (Eds.), Restoration Ecology: A Synthetic Approach to Ecological Research, Cambridge: Cambridge University Press.
3. Luken, J.O. (1990). Directing Ecological Succession. New York: Chapman and Hall. ISBN 0-412-34450-5
4. SER (2004). The SER Primer on Ecological Restoration, Version 2. Society for Ecological Restoration Science and Policy Working Group.
5. Van Andel, J. & Aronson, J. (Eds.), Restoration Ecology, Massachusetts: Blackwell.
6. Temperton, V.K., Hobbs, R.J., Nuttle, T. & Halle, S. (Eds.), Assembly Rules and Restoration Ecology: Bridging the Gap Between Theory and Practice, Washington, DC: Island Press.
7. Wilson, E. O. (1988). Biodiversity. Washington DC: National Academy.
8. Young, T.P. (2000). "Restoration ecology and conservation biology." Biological Conservation. 92, 73–83

Journals

1. Society for Ecological Resoration International
2. *Ecological Restoration*- Journal published by the University of Wisconsin Press
3. *Restoration Ecology* - Journal published on behalf of the Society for Ecological Restoration International

Broad Research Area

1. Dynamics and restoration of degraded wetlands
2. Removal of threats to the health and integrity of the restored ecosystem