

PROPOSAL FOR
**MASTER OF
SCIENCE
COURSE IN
FRESHWATER
ECOLOGY &
CONSERVATION**



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BACKGROUND

Freshwater ecosystems are among the most endangered biomes. Drivers and pressures such as increased demand for food, energy and water, and conversion of wetland areas for expansion of human habitation have led to changes in hydrology and water chemistry. In the current era, climate change is acting as an overarching threat that is impacting the ecological processes, particularly in context of the freshwater ecosystems. The intricate links and connectivity between terrestrial and freshwater ecosystem further exacerbates the fragility of the freshwater ecosystem.

Thus, freshwater conservation needs to be rooted in scientific evidence based effective and efficient management that can reverse the steep decline that freshwater ecosystems and biodiversity are now experiencing. This is especially important in the face of current socio-ecological and climatic conditions. Given the dramatic declines in global freshwater biodiversity, which far exceed those observed in terrestrial or marine ecosystems, it is pertinent to understand the aquatic ecosystem level processes, their biodiversity and pinpoint the problematic areas that needs ameliorative measures.

Conservation of freshwater ecosystems must be supported by scientific understanding on the status of freshwater biodiversity, drivers of its decline and the effectiveness of different management options to address the impacts of those drivers. There are currently large gaps in all these different arenas that need to be addressed. One of the major hurdle in conservation planning is lack of scientific knowledge on freshwater ecology, particularly in the tropical and sub-tropical regions. The recovery plan urges integration of biodiversity inventory and basic ecosystem science, stressor assessment, systematic restoration and protected area management with links to terrestrial realms as required. The emergency recovery plan for the freshwater ecosystems calls for urgent actions through a set of measures, for which a trained workforce of researchers and ecologists are needed.

It is envisioned that the Master's degree in Freshwater Ecology will create a new generation of field researchers and ecologist who will be equipped to understand the nuances of the freshwater ecosystems, and their conservation management. The matter was discussed during the review meeting of the project "Assessment of the ecological status of select Indian Rivers for conservation planning" under NRCP held on 28th March 2023, at New Delhi under the Chairmanship of the Secretary, Department of Water Resources, River Development & Ganga Rejuvenation (DoWR, RD & GR), Ministry of Jal Shakti, Government of India. The Secretary advised WII to develop a proposal for M.Sc. programme for creating a cadre of freshwater ecologist and main streaming the aquatic biodiversity conservation into water resource management in the country.

Subsequently a detailed syllabus for M.Sc. in Freshwater Ecology and Conservation was prepared and placed for approval by the 45th meeting of the Training, Research & Academic Council (TRAC) of the Wildlife Institute of India held on 15th May 2023 at WII, Dehradun. The members of the TRAC agreed upon the importance of the master's in freshwater ecology and approved initiating M.Sc. course on Freshwater Ecology and Conservation. The course will be conducted through Academy of Scientific & Innovative Research (AcSIR), at the Wildlife Institute of India.

Recently, a MoU was signed between the Wildlife Institute of India (WII) and the All India Council for Technical Education (AICTE), through which the AICTE has given in principle agreement to recognize the course on Freshwater Ecology, and the Centralized Ganga Aqualabs/Centre for River Research as a centre of excellence. The AICTE has also provided in principle agreement to promote advance courses on freshwater ecosystems.

Through the projects of NMCG and NRC, Ministry of Jal Shakti, "Biodiversity Conservation and Ganga Rejuvenation (Phase I & II)" and "Assessment of the ecological status of select Indian Rivers for conservation planning", a workforce of skilled researchers has been created which specializes in various aspects of freshwater ecology. This workforce will be utilized for teaching various courses of the M.Sc. Freshwater Ecology and Conservation Programme.

The total outlay for running the one course with 20 students is Rs. 1,37,28,000/- (Rupees One Crore Thirty Seven Lakh Twenty Eight Thousand only). It is envisioned that the five courses spanning over 10 years' duration will initially be conducted and reviewed for further extension. The total budgetary requirement is Rs. 6,86,40,000 (Rupees Six Crore Eighty Six Lakh Forty Thousand only) to run the course for 10 years. The course will produce 100 professionals for assisting the Ministry of Jal Shakti in respect to water resource conservation and management and main streaming aquatic biodiversity conservation into water resource development and contributing to India's development.

SUMMARY
OF COURSE
STRUCTURE
AND CREDIT
DETAILS

Course Code	Course Title	Total Credit	L-T-P-C	Course Nature
SEMESTER I				
AcSIR-FW-101	Hydrological process	5	3-0-4-5	Compulsory
AcSIR-FW-102	Fundamentals of ecology	5	3-0-4-5	Compulsory
AcSIR-FW-103	Freshwater ecology and methodological approaches	5	3-0-4-5	Compulsory
AcSIR-FW-104	Drivers of change	3	2-0-2-3	Compulsory
AcSIR-FW-105	Self-learning assignments	2	0-1-2-2	Compulsory
AcSIR-FW-106	Tour journal	2	0-1-2-2	Compulsory
AcSIR-FW-107	Laboratory & field practical	2	0-0-4-2	Compulsory
		24	11-2-22-24	
SEMESTER II				
AcSIR-FW-201	Autotrophs in the freshwater ecosystem	5	3-0-4-5	Compulsory
AcSIR-FW-202	Heterotrophs in the freshwater ecosystem	5	3-0-4-5	Compulsory
AcSIR-FW-203	Freshwater ecotoxicology	5	3-0-4-5	Compulsory
AcSIR-FW-204	Self-learning assignments	3	0-2-2-3	Compulsory
AcSIR-FW-205	Tour journal	2	0-1-2-2	Compulsory
AcSIR-FW-206	Laboratory practical	2	0-0-4-2	Compulsory
AcSIR-FW-207	Field practical	2	0-0-4-2	Compulsory
		24	9-3-24-24	
SEMESTER III				
AcSIR-FW-301	Advanced tools and techniques in freshwater conservation	6	4-0-4-6	Compulsory
AcSIR-FW-302	Wetland and river basin management	4	3-1-0-4	Compulsory
AcSIR-FW-303	Human dimensions in freshwater management	4	3-1-0-4	Compulsory
AcSIR-FW-304	Research tools and modeling for freshwater ecosystems	4	3-0-2-4	Compulsory
AcSIR-FW-305	Tour journal	2	0-1-2-2	Compulsory
AcSIR-FW-306	Laboratory practical	2	0-0-4-2	Compulsory
AcSIR-FW-307	Field practical	2	0-0-4-2	Compulsory
		24	13-3-16-24	
SEMESTER IV				
AcSIR-FW-401	Field dissertation	24	0-0-48-24	Compulsory
		24	0-0-48-24	



M.Sc. IN
FRESHWATER
ECOLOGY
AND
CONSERVATION
(COURSE
STRUCTURE)

SEMESTER I		
Course Code	Subjects	Credits
Theory Paper 1	Hydrological process	
AcSIR-FW-101	Hydrological cycle and its components	3
	Ecohydrology concepts	2
Theory Paper 2	Fundamentals of ecology	
AcSIR-FW-102	Fundamentals of ecology	5
Theory Paper 3	Freshwater ecology and methodological approaches	
AcSIR-FW-103	Key concepts of freshwater ecosystem	2
	Types of freshwater ecosystem	1
	Ecological methods	2
Theory Paper 4	Drivers of change	
AcSIR-FW-104	Status and trend of freshwater resources	2
	Drivers of changes in freshwater resources	1
AcSIR-FW-105	Self-learning assignments	2
AcSIR-FW-106	Tour journal	2
AcSIR-FW-107	Laboratory & field practical	2
Total Credits		24
SEMESTER II		
Course Code	Subjects	Credits
Theory Paper 5	Autotrophs in the freshwater ecosystem	
AcSIR-FW-201	Diversity and ecology of periphytons and phytoplanktons	3
	Diversity and ecology of hydrophytes	2
Theory Paper 6	Heterotrophs in the freshwater ecosystem	
AcSIR-FW-202	Diversity and ecology of macroinvertebrates	1
	Diversity and ecology of nektons	4
Theory Paper 7	Freshwater ecotoxicology	
AcSIR-FW-203	Introduction to ecotoxicology	2
	Methodological approach	1
	Risk assessment	2
AcSIR-FW-204	Self-learning assignments	3
AcSIR-FW-205	Tour journal	2
AcSIR-FW-206	Laboratory practical	2
AcSIR-FW-207	Field practical	2
Total Credits		24

SEMESTER III		
Course Code	Subjects	Credits
Theory Paper 8	Advanced tools and techniques in freshwater conservation	
AcSIR-FW-301	Molecular tools in freshwater conservation	2
	Environmental flow concept & assessment methods	1
	Application of One health	1
	Application of GIS and RS for freshwater ecology	2
Theory paper 9	Wetland and river basin management	
AcSIR-FW-302	Wetland management	2
	River basin management	2
Theory Paper 10	Human dimensions in freshwater management	
AcSIR-FW-303	Socio-ecological systems in freshwater conservation and management	2
	Policy and legal dimensions of freshwater conservation and management	2
Theory Paper 11	Research tools and modeling for freshwater ecosystems	
AcSIR-FW-304	Advanced statistical tools and modeling for freshwater ecosystems	2
	Research design & development of proposal	2
AcSIR-FW-305	Tour journal	2
AcSIR-FW-306	Laboratory practical	2
AcSIR-FW-307	Field practical	2
	Total	24

SEMESTER IV		
Course Code	Subjects	Credits
Dissertation		
AcSIR-FW-401	Field dissertation	24



**COURSE
AIM**

To develop a cadre of ecologist and field biologist, with an expertise in freshwater ecology for effectively managing the freshwater resources and its biodiversity in India.

**COURSE
OBJECTIVES**

- 1. To develop capacity to study the freshwater ecosystems and understand the impact of drivers on these ecosystems.
- 2. To enhance capacity to understand the linkages of freshwater resources and its biodiversity with terrestrial and socio-ecological systems.
- 3. To develop capacity for using advanced contemporary and modern tools, techniques, and applications for freshwater conservation and management.
- 4. To enhance ability to link regional and global issues, priorities, policies and actions for efficient freshwater and its biodiversity conservation.

**COURSE
DURATION**

The course will be carried out over a period of 2 years and would be delivered through four semesters. Each of the semester would be of 6 months' duration, and will focus on specific topics. Each semester would comprise of class room teaching, practical in field and labs, field tours, exams and semester breaks.

**PLACE OF
IMPLEMENT-
ATION**

The course will be taught at the Ganga Aqualife Conservation Monitoring Centre/Centre for River Research, located within the campus of WII, Dehradun, Uttarakhand. The field tours will be undertaken to understand the freshwater ecosystems across different biogeographic zones of the country.

**SELECTION
OF STUDENTS**

Twenty meritorious students will be selected on the basis of written exam, followed by personal interview as per the rules and guidelines laid by WII and AcSIR.

**MONITORING
COMMITTEE**

- Monitoring Committee to monitor the progress of the course would comprise of
- 1) Director General, NMCG or his/her representative
 - 2) Dr. B.K. Das, Director, CIFRI or his nominee
 - 3) Head of the Department, Wildlife Science, Aligarh Muslim University or his/her nominee
 - 4) Shri Suresh Babu, Director, Rivers, Wetlands and Water Policy
 - 5) Dr. Syed Ainul Hussain, Former Scientist G, WII
 - 6) Dr. Ruchi Badola, Dean, Faculty of Wildlife Science, WII (Member Secretary)



SYLLABUS

1st SEMESTER - ECOLOGICAL CONCEPTS AND APPLICATION



AcSIR-FW-101: ◀ **Hydrological process (05 Credits)**

Course objective

To provide an insight into basic concept of water cycle, properties of water and enable the students to have an in-depth understanding of various components of hydrological cycle and inter connectedness of the aquatic and terrestrial ecosystem.

COURSE 1: — **Hydrological cycle and its components (03 Credits)**

An introduction to the hydrologic cycle and its components, including precipitation, interception, soil water storage, runoff, streamflow, and groundwater flow. Properties of water and types of water resources. Hydrological budget - Global and India's perspectives. Understanding floods and drought cycle. Basin and groundwater hydrology - watersheds, aquifers, springs

COURSE 2: — **Ecohydrology concepts (02 Credits)**

Ecohydrology and e-flow concepts and their applicability. Interdependencies between hydro morphological processes and aquatic habitat requirements and conditions. Multi-sectoral linkages, Food-water-energy nexus and Decision Support Systems. Techniques for obtaining hydrological data and its availability at different spatial scales

Suggested readings

Eslamian, S. (2014). Handbook of Engineering Hydrology: Fundamentals and Applications.
Singh, V.P. (2017). Handbook of Applied Hydrology, Second Edition. McGraw Hill.
Reddy, P.J.R. (2005). A textbook of hydrology. Laxmi Publication.

AcSIR-FW-102: ◀ **Fundamentals of ecology (05 Credits)**

Course objective

To develop an understanding of the basic ecological concepts.

COURSE 3: — **Fundamentals of ecology (05 Credits)**

Basic concepts and structure of ecosystems: abiotic and biotic components. Concepts of productivity - energy flow in ecosystems and law of thermodynamics. Processes within ecosystems - photosynthesis, decomposition. Food chains, food webs and trophic levels. Metabolism and size of individuals. Trophic structure and ecological pyramids. Biogeochemical cycling. Principles pertaining to limiting factors. Communities, ecological dominance, measures of diversity. Population, carrying capacity. Inter and intra-specific interactions. Concepts of habitat and ecological niche. Systems approach to ecological functioning

Suggested readings

Odum, E.P. (1971). Fundamentals of Ecology. Saunders' International Student Edition.
Smith, R.L. (1980). Ecology and Field biology. Third Edition. Harper and Row.

Course objective

To provide an insight into the ecological principles of aquatic ecosystems, fundamental properties of lentic (lake, pond, reservoir ecosystem) and lotic ecosystem (stream and river ecosystems) and their functioning. To provide hands-on training on the ecological methods, including basic statistical analysis. To develop an ability to select appropriate methodologies for data analysis, formulate statistical hypotheses, understand differences of parametric and non-parametric analyses, use different software for data management and data analyses.

COURSE 4:**Key Concepts of Freshwater ecosystems (02 Credits)**

Ecological principles of aquatic ecosystem. Types of freshwater ecosystem and limiting factors. The importance of freshwater ecosystems. Geomorphology, hydrology & structure of freshwater ecosystems.

Physical and chemical characteristics of freshwater. Functional role of riparian vegetation in freshwater ecosystem. Salt-water balance mechanism of freshwater organisms (osmoregulatory mechanism). Nature of communities in the littoral, limnetic and profundal zones.

COURSE 5:**Types of Freshwater ecosystems (01 Credits)**

Sediment regime and river morphology. Ecology of lakes. Ecology of subterranean freshwater habitats. Ecology of streams and rivers (type, characteristics, network, connectivity - River Continuum Concept, Flood Pulse Concept). Wetlands - type, structure, hydrology and function. Restoration of wetlands and riverscapes.

COURSE 6:**Ecological methods (02 Credits)**

Sediment regime and river morphology. Ecology of lakes. Ecology of subterranean freshwater habitats. Ecology of streams and rivers (type, characteristics, network, connectivity - River Continuum Concept, Flood Pulse Concept). Wetlands - type, structure, hydrology and function. Restoration of wetlands and riverscapes.

River habitat inventory and mapping to study habitat availability and utilization. Procedure for developing Habitat Suitability Criteria Curves for conservation significant species. Measures of physical environment, and hydraulic and hydrological characteristics, including temperature, current (flow velocity), turbidity, conductivity, BOD, pollutants. Benthos, Planktons, Diatoms and Nekton - methods for sampling and ethology. Sorting and preparation of samples. Preservation of different freshwater groups for voucher specimens and long-term storage. Techniques of aquatic vegetation surveys and quantification. Measures of species diversity, genetic diversity, habitat diversity, diversity indices, niche width. Measures of aquatic productivity. Application of rapid bio assessment tool for monitoring freshwater ecosystem and assessment of freshwater health using bio-indicators. Basic statistical procedures and analyses using R and SPSS (distribution tests and transformations, t-tests, ANOVAs, non-parametric tests, simple and multiple regression).

Practical

Field visits for habitat evaluation, visit to wetland areas and demonstration of habitat quantification, Riparian vegetation index (RVI) assessment, primary production and biological sampling techniques.

Suggested readings

Allan, J.D. & Castillo, M.M. (2007). Stream Ecology: Ecology of running waters. Springer.

Dodds, W.K. & Whiles, M.R. (2020). Freshwater ecology: concepts and environmental applications of limnology. Academic Press.

Hynes, H.B.N. (1970). Ecology of running water, University of Toronto press.

Hughes, J.M.R. (2019). Freshwater ecology and conservation: Approaches and techniques. Oxford University Press.

Odum, E.P. (1971). Fundamentals of Ecology. Saunders' International Student Edition.
 Smith, R.L. (1980). Ecology and Field biology. Third Edition. Harper and Row.
 Zar von Ende, B. (1998). Field and Laboratory Methods for General Ecology. McGraw-Hill.

AcSIR-FW-104: Drivers of change (03 Credits)

Course objective

To develop an understanding on the status of freshwater resources, and the drivers impacting the freshwater resources.

COURSE 7: Status and trend of freshwater resources (02 Credits)

Global and national status of freshwater resources. Concepts of spatial and temporal scales in relation to freshwater resources. Major controlling factors of river systems across multiple spatio-temporal, multi-sectoral and multi-stakeholderscales.

COURSE 8: Drivers of freshwater resources (01 Credit)

Role of environment factors and anthropogenic impacts on nutrient conditions and chemical characteristics of freshwater ecosystem. Direct and indirect drivers impacting the freshwater resources. Nutrient enrichment and Eutrophication. Human impacts in riverine landscape - economics and policy. Effect of climate change on the on hydro-ecological systems and freshwater biota. Climate change mitigation and adaptation strategies. DPSIR framework.

Suggested readings

O'Higgins, T.G., Lago, M., & DeWitt, T. H. (2020). Ecosystem-based management, ecosystem services and aquatic biodiversity: Theory, tools and applications (p.580). Springer Nature.

Schröter, M., Bonn, A., Klotz, S., Seppelt, R., & Baessler, C. (Eds.). (2019). Atlas of ecosystem services: drivers, risks, and societal responses. Springer.

AcSIR-FW-105: Self-learning assignment in FW - 101/102/103/104 (02 Credits)

AcSIR-FW-106: AcSIR-FW-106: Tour Journal (02 Credits)

AcSIR-FW-107: AcSIR-FW-107: Laboratory and field practical (02 Credits)

Orientation tour (2 weeks)

Field visit to understand the ecology of glacier-fed Himalayan rivers and rain-fed rivers of Central Indian or Western Ghats, the drivers of change, and integrated conservation and management of river basins.



AcSIR-FW-201:

Autotrophs in the freshwater ecosystem (05 Credits)

Course objective

To introduce students to the structure, ecology and identification of autotrophs in freshwater ecosystem and provide students with practical skills in the field sampling of aquatic autotrophs.

COURSE 9:

Diversity and ecology of periphytons and phytoplanktons (03 Credits)

Definition, characteristics and classification of periphytons and phytoplanktons. Structural and functional attributes of periphytons. Habitat specialization, adaptations, and species composition. Importance in aquatic ecosystems. Sampling and identification. Harmful Algal Blooms and fish kills

COURSE 10:

Diversity and ecology of hydrophytes (02 Credits)

Definition, characteristics and classification of hydrophytes, including riparian vegetation. Growth forms and adaptive mechanisms. Limiting factors. Structural and functional attributes of aquatic and riparian vegetation. Sampling and identification. Ecological functions. Harmful Algal Blooms, invasive species, weeds and impact on aquatic biodiversity.

Lab and Field work :Field visits for identification of periphytons, phytoplanktons, zooplanktons, macrophytes. Methods for collection, preservation and enumeration of periphytons, phytoplanktons, zooplanktons, plankton, observation under compound microscope, identification and enumeration using Sedgewick Rafter and Haemocyto meter.

Suggested reading

Azim, M. E., Verdegem, M. C., van Dam, A. A., & Beveridge, M. C. (Eds.). (2005). Periphyton: ecology, exploitation and management. CABI.

Capello, R. (2014). Macrophytes: Biodiversity, Role in Aquatic Ecosystems and Management Strategies. Novinka.

Reynolds, C. S. (2006). The ecology of phytoplanktons. Cambridge University Press. Available online at http://www.jlakes.org/ch/book/Ecology-of-phytoplankton_2006.pdf

Wu, Y. (2016). Periphyton: functions and application in environmental remediation. Elsevier.

AcSIR-FW-202:

Heterotrophs in the freshwater ecosystem (05 Credits)

Course objective

To introduce the students to structure, ecology and identification of freshwater heterotrophs and provide students with practical skills in the field sampling of freshwater autotrophs, such as macroinvertebrates, fishes, amphibians, aquatic reptiles, aquatic birds and mammals. Provide students with practical skills in the field sampling of different groups of heterotrophs.

COURSE 11:

Diversity and ecology of macroinvertebrates (01 Credits)

Definition and characteristics of macroinvertebrates. Classification based on life history, nature of substrate and size of major benthos group. Adaptations of major benthos groups including arthropods, molluscs, nematodes and annelids. Roles in aquatic ecosystem and food web. Importance of macroinvertebrates.

Lab and field work

Methods for taxonomic identification, sampling design & kick-net sampling. Visits to natural water bodies, collection of benthos, identification and observation under compound microscope.

Suggested reading

Murugan, T., Arumugam, N. & Ragunathan, M.G. A text book of invertebrates, non-chordates. Saras Publication.

COURSE 12:

Diversity and ecology of nektons (04 Credits)

Definition, characteristics, classification and biology of major nekton groups including fish, reptiles, mammals and birds with special reference to habitat and life history. Adaptations; aestivation, locomotion and water regulation. Metabolism and thermo-regulation; ectothermy, homeothermy and cold stress, body size versus homeothermy. Avian systematics, classification and ecology of aquatic residential and migratory birds. Biology of major Indian freshwater mammals, fishes, amphibians, freshwater turtles, crocodilians, lizards and snakes. Nektons across the biogeographic zones. Basic concept of entomology, aquatic insect taxonomy and diversity, ecology of aquatic insects, adaptation, role of insects as indicator for biodiversity monitoring, diversity patterns across various freshwater ecosystems. Role of nektons in the aquatic ecosystem, migration and threats. An overview of conservation problems and issues related to fishing with reference to aquatic biodiversity of India.

Practical

Sampling and identification of aquatic faunal species in field sites and labs. Systematic study of common aquatic plants, field and herbarium techniques, demonstration/on-site discussion on habitat features and corresponding vegetation types, study the successional stages in aquatic systems.

Suggested reading

Chandra, K., K.C. Gopi, D.V. Rao, K. Valarmathi & J.R.B. Alfred (eds.). Current Status of Freshwater Faunal Diversity in India. Zoological Survey of India, Kolkata, 624pp.

Daniel, J.C. (2002). The book of Indian reptiles and amphibians. BNHS.

Day, F. (1875). The fishes of India, being a Natural History of the fishes known to inhabit the seas and fresh water of India, Burma and Ceylon. Francis and Taylor, London. Part 1-4.

Director, ZSI (eds.) (1991). Animal Resources of India Protozoa to Mammalia. Zoological Survey of India, Kolkata, 694pp

Francis, C.M. (2019). Field guide to the mammals of South-East Asia. Bloomsbury publication.

Grigg G. & Krishner, D. (2015). Biology and evolution of crocodilians. CSIRO Publishing.

Mani, M.S. (1974). Ecology and Biogeography in India. Springer.

AcSIR-FW-203:

Freshwater Ecotoxicology (05 Credits)

Course objective

To provide an understanding into various water quality parameters, sampling techniques for pollutants. To provide insights into the emerging pollutants and associated ecological risks.

COURSE 13: Introduction to Ecotoxicology (02 Credits)

Basics of Ecotoxicology. Properties, sources, behavior, and the fate of the major classes of toxic pollutants in the freshwater environments. Uptake and distribution of pollutants in organisms. External Exposure assessment (concentrations in water, air, soil & sediment), Internal Exposure assessment (bioconcentration, bioaccumulation & biomagnification). Harmful Algal Blooms (HABs): Definition and terminology, classification, toxicity, fish kills, management and mitigation case studies.

COURSE 14: Methodological approach (01 Credit)

Introduction to water quality parameters and their measurement. Biomonitoring - design and principles; standardization (ISO, OECD, US EPA, BIS); factors affecting test results; data analysis and interpretation. Sampling, handling and preparation of samples from various environmental matrices for ecotoxicological assessment, sampling design and strategies. Case studies of successful freshwater monitoring programmes.

COURSE 15: Risk assessment (02 Credits)

Introduction to Aquatic Risk Assessment; Risk Analysis and Risk Management case studies of toxic pollutants with a focus on the situation in developing countries. Case studies of Emerging environmental pollutants, and endocrine-disrupting compounds in freshwater environments. Environmental management/regulation of toxic pollutants. Biological effects of pollutants at the biomolecular, individual, population, and community levels

Practical

Freshwater Monitoring Programme Design including sampling methodologies, Quality Assurance, Data Handling, and presentation; Hands-on training (Field exercise) on monitoring and assessment tools of the ecotoxicological quality of water in the freshwater system.

Lab work

Hands-on training on trace analysis of organic and inorganic pollutants in abiotic and biotic samples using advanced Instrumental techniques (LC/GC-MS, ICP-MS, Spectrophotometry)

Suggested reading

Sparling, D.W. (2018). Basics of ecotoxicology. CRC press, Taylor & Francis.

Casarett and Doull (1975). Toxicology: The Basic Science of Poisons.

Rand, G M; Petrocelli, S R. (1985). Fundamentals of aquatic toxicology: Methods and applications.

AcSIR-FW-204: Self-learning assignment in FW- 201/202/203 (03 Credits)

AcSIR-FW-205: Tour Journal (02 Credits)

AcSIR-FW-206: Laboratory Practical (02 Credits)

AcSIR-FW-207: Field Practical (02 Credits)

Techniques tour (2 weeks)

The students will undertake tour to study the aquatic diversity in a variety of ecological situations across the biogeographic zones of India. The tour will aim to develop hands on ability to undertake rapid biodiversity monitoring of freshwater resources. The tour will also focus on the ecological processes and functions in the freshwater ecosystem.

**3rd
SEMESTER-**

**FRESHWATER
CONSERVA
-TION**



AcSIR-FW-301:

Advanced tools and techniques in Freshwater conservation (06 Credits)

Course objective

To develop an understanding of basics concepts of genetics, hands-on training on tools and techniques for genetic analysis, and their application to freshwater conservation planning, environmental flow and the ways for its assessment; principles of remote sensing, the concepts and various components of GIS and its applicability to freshwater conservation planning; One health concept, and global scenario on zoonotic diseases vis-à-vis freshwater ecosystem.

COURSE 16:

Molecular tools in freshwater conservation (02 Credits)

Introduction to Bio-molecules-DNA, RNA and proteins; central dogma of molecular biology- replication, transcription and translation; mendelian genetics- mendal's laws; genetic code- characteristics and feature of genetic code; molecular markers. PCR, DNA sequencing, genotyping; allelic variation; interpretation of genetic data. Application of genetics for freshwater conservation; loss of genetic diversity, resolving taxonomic uncertainties. e DNA application. Freshwater wildlife crime case studies.

Practical

Extraction of DNA from biological sample, PCR amplification by mtDNA, sex and micro satellite markers, DNA sequencing and genotyping, Phylogenetic tree formation, molecular clocking and interpretation of genetic data

Suggested reading

Allendorf et al. (2012). Conservation and the genetics of populations. Wiley.

Allendorf et al. (2022). Conservation and the Genomics of Populations. Oxford University Press.

Gardner et al. (2006). Principles of Genetics. Pearson

Klug et al. (2018). Concepts of genetics

COURSE 17:

Environmental flow concept & assessment methods (01 Credit)

Concept of environmental flow and ecohydrology. Introduction on Inflow Incremental Methods (IFIM). Flow estimation based on Environmental Management Classes. Different e-flow assessment methods (hydraulic rating, habitat rating and holistic approaches) and its implementation, with suitable national and international examples.

Practical

Collection of field data and demonstration of e-flow assessment procedures

Suggested reading

Ward, A.W. et al. (2015). Environmental Hydrology 3rd Edition. Taylor & Francis.

COURSE 18:**Application of One Health (01 Credit)**

Introduction to One Health concept, and Manhattan and Berlin principles. Epizootiology, determinants of disease and disease transmission. Disease and population dynamics with reference to the freshwater species. Common ecto and endo parasites of aquatic organisms. Surveillance mechanisms to monitor, prevent and respond. Major aquatic vector species for transmitting human diseases. Protocol for handling of freshwater species and mortality monitoring. Handling of freshwater species. Rescue, rehabilitation and reintroduction of freshwater species

Practical

Handling of aquatic mammals, reptiles, amphibians, birds; visit to rescue and transit centres for aquatic species specific housing, collection of biological samples

COURSE 19:**Application of GIS and RS for freshwater ecology (02 Credits)**

Concept of space, basics of cartography. Introduction to the concept of GIS, range of software options available to undertake GIS. Potential data sources for GIS analyses in freshwater ecology. Principles of cartography; Coordinate systems and projections. GIS for riverscape planning. Data entry and preparation, spatial data generation. Concept of database and metadata, spatial modeling and data visualization. Examples of freshwater mapping. Application of suitable GIS tools for monitoring, management, planning, and analyses of riverine ecosystems and create GIS maps.

Lab work

Data input - digitization of maps and projection. Remote sensing - geo-rectification and radiometric correction. Image classification technique for mapping of earth resources. Basin delineation, LU&LC, change detection, wetlands and zone of influence mapping. Geo -spatial analysis including DEM, river zonation.

Suggested reading

Bhattacharjee, N. (2020) Hydrology Application of Remote Sensing and GIS. Synergy books India.

AcSIR-FW-302:**Wetland and river basin management (04 Credits)****Course objective**

To understand the ecology of the wetlands and rivers, and their contribution to human well-being. To develop an ability to understand issues related to best practices in Wetland Management and conservation and apply knowledge and skills to carry out management planning for wetland and river conservation.

COURSE 20:**Wetland management (02 Credits)**

Wetland types and definition. Wetlands across the biogeographic zones. Biotic communities in a wetland Wetland hydrology. Ecological Integrity, ecological indicators/health of aquatic systems. Wetland Management. Key aspects of Wetland management planning, including multi-sectoral consultations. Wetland restoration. Design, construct, operate and maintain constructed wetland for wastewater treatment. Application of ecological models for management of constructed wetlands. Wetland conservation in India

Wetland tour

Visit to wetlands to understand the wetland ecology. Prepare wetland restoration and management plans.

Suggested reading

Keddy, P. A. (2023). Causal Factors for Wetland Management and Restoration: A Concise Guide (Vol. 8). Springer Nature.

Prusty, B. A. K., Chandra, R., & Azeez, P. A. (2017). Wetland Science. Springer, New Delhi.

COURSE 21: — River Basin Management (02 Credits)

River characterization. The hydrological, morphological and sedimentological characteristics of river - floodplain systems at different spatial scales. Rivers across the biogeographic zones. Linkages of aquatic and terrestrial ecosystems. Concepts of watershed, springshed and basin. Methodological approaches for river/stream restoration/conservation concepts and strategies. Multisectoral strategic planning of water resources development, prioritize limited resources, managing irrigation, industrial and drinking water demands, protection of sensitive water bodies, riparian areas. Trans-boundary river management and integrated river basin management. Environmental Impact Assessment methods for river valley projects & mitigation measures.

River Tour

Visit to the mainstem river to understand the basic characteristics of rivers and conduct a rapid ecological assessment of the river for river conservation planning. The field tour will also include rapid spatial mapping of basin, drainage, threats, fragmentation areas, pollution hotspots, agriculture areas and collection of baseline data on the same to develop on ground conditions of the basin and its processes.

Suggested reading

Kemper, K. E., & Blomquist, W. A. (2007). Integrated river basin management through decentralization (p. 36). A. Dinar (Ed.). Berlin: Springer.

Squires, VR., Milner, H.M., Daniell, K.A. (2015). River Basin Management in the Twenty-First Century Understanding People and Place. Routledge.

AcSIR-FW-303: ◀ Human dimensions in freshwater management (04 Credits)

Course objective

To provide an insight into the human dimensions of freshwater management. To develop an understanding of socio-ecological linkages with the freshwater ecosystem, the concepts related to stakeholder analysis, and ecosystem services. To provide an insight into the global scenario on legal and multi-national frameworks and governance mechanisms for freshwater conservation.

COURSE 22: — Socio-ecological systems in freshwater conservation and management (02 Credits)

Human dependence on aquatic systems. Integrative river management concepts, considering socio-cultural aspects, multi-sectoral linkages, legal background and socio-economics. Stakeholder identification and engagement, participation in freshwater conservation. Sustainable livelihood framework for aquatic conservation, including sustainable agriculture and fisheries. Ecosystem services of the freshwater ecosystems, trade-offs and synergies associated with river resource planning and methods and tools for assessment and evaluation (including RAWES, MEA). Tools and techniques for studying socio-ecological systems and development planning. Participatory methods for river restoration/ conservation, examples from field on community participation; Community led river and wetland health assessment.

COURSE 23: — Policy and legal dimensions of freshwater conservation and management (02 Credits)

International treaties and conventions with regard to the freshwater ecosystems, such as CBD, RAMSAR, CMS. National legal framework and policies impacting the freshwater ecosystems, Programmes/schemes of the Government of India, such as Namami Gange, Project Dolphin, AMRUT, SBM, NRCD, National Programme for Conservation of Aquatic Ecosystems, Amrit Dharohar, Mishti. Local institutions and governance of freshwater, success stories, and initiatives on community - led/supported/participated conservation of freshwater/natural resources. Links with SDGs, and Global Biodiversity Framework.

Suggested reading

O'Higgins, T. G., Lago, M., & DeWitt, T. H. (2020). Ecosystem-based management, ecosystem services and aquatic biodiversity: Theory, tools and applications (p. 580). Springer Nature.

Schröter, M., Bonn, A., Klotz, S., Seppelt, R., & Baessler, C. (Eds.). (2019). Atlas of ecosystem services: drivers, risks, and societal responses. Springer.

Squires, VR., Milner, H.M., Daniell, K.A. (2015). River Basin Management in the Twenty-First Century Understanding People and Place. Routledge.

AcSIR-FW-304: Wetland and river basin management (04 Credits)

Course objective

To develop an ability to select appropriate methodologies for data analysis, formulate statistical hypotheses, apply multivariate statistical analyses, utilize and integrate the GIS and statistical tools for data management, data analyses and representation. To develop an understanding of the fundamentals of multidimensional and applied ecosystem modelling at different spatial scales.

COURSE 24: Advanced statistical tools and modeling for freshwater ecosystems (02 Credits)

Data analysis using time series plots, scatter plots and descriptive statistics in MS Excel. Principles of Bayesian statistics and application. Multivariate statistical analyses such as factor analysis, cluster analysis. Multidimensional scaling. Basic hydraulic modelling to ascertain river and wetland inundation patterns and probabilities across seasons and over the years. Dynamic simulation model of a freshwater ecosystem. Use of online tools such as InVEST, Soil and Water Assessment Tool (SWAT).

Practical

Use of data analysis software and data representation

Suggested reading

Westfall, P. & Henning, K.S.S. (2013). Understanding Advanced Statistical Methods. Routledge

Field tour

Visit to community residing along the freshwater bodies and conduct surveys and participatory mapping techniques

COURSE 25: Research design and development of proposal (02 Credits)

Ecological pathways in aquatic systems and application of standard assessment methods. Framing research questions with an appropriate experimental design, analyze data to answer the research question using statistical or modelling techniques. Scientific reporting, and critically analysis, using scientific Logic. Ethics in Science. Methods of Reasoning in research. Principles of measurements and experiment. Role of criticism in science. Conceptualization and development of research plan. Development of proposal for field dissertation.

Conservation Practice Tour Journal (2 weeks)

The tour will be undertaken to examine freshwater conservation issues across the biogeographic zone of India. The tour will aim at developing an understanding of the best practices in aquatic ecosystems management; including wetland and river basin management. The students will also gain an understanding of the need for incorporating human dimensions in freshwater management.

AcSIR-FW-305: AcSIR-FW-305: Tour Journal (02 Credits)

AcSIR-FW-306: AcSIR-FW-306: Laboratory Practical (02 Credits)

AcSIR-FW-307: AcSIR-FW-307: Field Practical (02 Credits)

4th SEMESTER-

FIELD DISSERTATION

AcSIR-FW-401:

Field dissertation (24 Credits)

Six-month field project work, which involves intense field activity and hands on training, which would end with a presentation on learning during the internship period.

BUDGET / COURSE FEES/ PROJECT LAYOUT

Sr. No.	Budget Heads	Rate/Semester (Rs.)	Total (Rs.)
1	AcSIR Charges	28,000	1,12,000
2	WII Tuition Fee	10,000	40,000
3	Field Dissertation	1,00,000	1,00,000
4	Field gears/equipment (Lump sum)	25,000	25,000
5	Library Computer & Lab.	1000	4,000
6	Sports and allied activities	1000	4,000
7	Stationery/General Items	5000	20,000
8	Contingencies/Miscellaneous	10,000	40,000
9	Field Exercises/Tours	25,000	1,00,000
10	Medical Expenses (Lump sum)	25,000	25,000
11	Insurance (Lump sum)	10,000	10,000
12	Hostel	18,000	72,000
13	Monthly Fellowship@3,000 per month	18,000	72,000
Total			6,24,000
14	Institutional charges @10%		62,400
Grand Total			6,86,400

Estimated Total cost for 10 years (05 M.Sc. Courses)

- Total course fee per candidate: Rs. 6,86,400
- Total number of candidates per courses: 20
- Total estimated cost per course with 20 students: Rs. 1,37,28,000
- Total costs for 05 courses spanning over 10 years: Rs. 6,86,40,000
- Total Output: 100 professionals in 10 years



जल संसाधन, नदी विकास और गंगा संरक्षण विभाग

**Department of Water Resources, River Development and
Ganga Rejuvenation**



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Wildlife Institute of India**

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GACMC / CRR

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