Department of Himalayan Aquatic Biodiversity

Syllabus

for

M.Sc. (Himalayan Aquatic Biodiversity)

in accordance with

National Education Policy- 2020

NEP Course Structure
M. Sc. in the Department of Himalayan Aquatic Biodiversity
(From batches 2026-28 and onwards)

First Semester for 2-year P.G. program
(For practical-based subjects)

Entry requirement	3-year Bachelor's degree (minimum 120 credits) or 4-Year Bachelor's Degree Minimum-160 credits) and candidates who have met the entrance requirements, including specified levels of attainment, in the programme admission regulations.		
Course category	**Semester-I**		**Credits (T + P)**
Discipline Specific Core (DSC)	DSC-1	Biogeography of the Himalaya	3+2
	DSC-2	Aquatic Ecosystems	3+2
	DSC-3	Freshwater Biodiversity and Conservation	3+2
SEC/Vocational	SEC-1	Aquarium Setup and Maintenance	3+2
Discipline Specific Elective (DSE)	DSE-1	Taxonomy & Systematics	3+1
		or	
Multidisciplinary Elective (M.D.E)	M.D.E-1	Climate and Environmental Protection (Swayam course)	3+1
A student may opt for either one Discipline Specific Elective (DSE) or one Multidisciplinary Elective (MDE) as an elective course.			
AEC (Non-CGPA Course)	IKS	Indian Knowledge System	1
Total Credits			24

Note: IKS-Departments may develop and offer a discipline-specific Indian Knowledge Systems (IKS) course or, alternatively, adopt the IKS course prescribed by the University.

Second Semester for 2-year P.G. program
(For practical-based subjects)

Course category	**Semester-II**		**Credits (T + P)**
Discipline Specific Core (DSC)	DSC-4	Freshwater Aquaculture	3+2
	DSC-5	Aquatic Ecology	3+2
	DSC-6	Aquatic Microbiology	3+2
SEC/Vocational	SEC-2	Ornamental Fish Culture	3+2
Discipline Specific Elective (DSE)	DSE-2	Climate Science	3+1
		or	
Multidisciplinary Elective (M.D.E)	M.D.E-2	Environmental Ecotoxicology	3+1
A student may opt for either one Discipline Specific Elective (DSE) or one Multidisciplinary Elective (MDE) as an elective course.			
VAC (Non-CGPA Course)	Constitutional, ethical, and moral values	Constitutional, ethical, and moral values	1
Total Credits			24

Note: The University shall provide a common syllabus for the course titled "Constitution, Ethical and Moral Values."

Third Semester for 2-year P.G. program
(For practical-based subjects)

Course category	Semester-III		Credits (T + P)
Discipline Specific Core (DSC)	DSC-7	Freshwater Invertebrate Fauna of Himalaya	3+2
	DSC-8	Environmental Pollution	3+2
	DSC-9	Aquatic Biotechnology	3+2
	DSC-10	Research Methodology	3+2
Discipline Specific Elective (DSE)	DSE-3	Freshwater Planktonology	3+1
	or		
Multidisciplinary Elective (M.D.E)	M.D.E-3	Environmental Impact Assessment (EIA) and Auditing	3+1
A student may opt for either one Discipline Specific Elective (DSE) or one Multidisciplinary Elective (MDE) as an elective course.			
SEC (Non-CGPA Course)	Academic Library Systems and Services	Academic Library Systems and Services	1
	or		
SEC (Non-CGPA Course)	Entrepreneurship & Startup Awareness	Entrepreneurship & Startup Awareness	1
Total Credits			24

Note:
1.The University shall provide a common syllabus for the course titled "Academic Library Systems and Services".
2.Entrepreneurship & Startup Awareness - Departments may develop and offer an 'Entrepreneurship & Startup Awareness' course or, alternatively, adopt the 'Entrepreneurship & Startup Awareness' course prescribed by the University. Departments shall offer this course to familiarize students with entrepreneurial mindset, startup ecosystem, innovation, and self-employment opportunities. The course may include basic business planning, case studies, interaction with entrepreneurs, and awareness of government startup schemes, with assessment based on participation and practical exercises. The course aims to promote creativity, leadership, and employment generation in alignment with NEP 2020.

Fourth Semester for 2-year P.G. program
(For practical-based subjects)

Course category	Semester-IV		Credits (T + P)
Discipline Specific Core (DSC)	DSC-11	Freshwater Fishery Science	3+2
	DSC-12	Water Analysis and Instrumentation	3+2
	DSC-13	Biostatistics	3+2
	DSC-14	Himalayan River: Status, destruction, and management	3+2
Optional Component (Research / Skill Oriented) in lieu of DSC	**Option–I: Minor Dissertation / Project Work** *(in lieu of any **one** DSC)*	Dissertation	5
	Option–II: Major Dissertation / Project Work *(in lieu of any **two** DSCs)*	Dissertation	10
Discipline Specific Elective (DSE)	DSE-4	Restoration Ecology and Habitat Management	3+1
	or		
Multidisciplinary Elective (M.D.E)	M.D.E-4	Environmental Policy and Regulation	3+1
	A student may opt for either one Discipline Specific Elective (DSE) or one Multidisciplinary Elective (MDE) as an elective course.		
SEC (Non-CGPA Course)	Community outreach activities	Community outreach activities	1
Total Credits			24
NHEQF Level- 6.5	*Students successfully completing a two-year PG program (i.e., securing a minimum of 96 credits will be awarded a "Postgraduate Degree" in the related field/discipline/subject.*		
NHEQF Level 7	*In the case of Engineering programs, students who exit after successfully completing the second year of a 2-year P.G. program (i.e., securing a minimum of 96 credits will be awarded a "Postgraduate Degree" (M.Tech/M.E., etc.) of Two years, in a related field/discipline/subject*		

Semester I

Paper Title: Biogeography of the Himalaya
Course Code: SLS/HAB/DSC-1
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction of Himalaya (15 Hours)

A brief introduction about the origin of the Himalaya and its structure. Concept of Plate Tectonics, tectonic history of India, and origin of the Himalaya. Theories of the formation of the Himalayas. Geology of the Himalaya. Geographical account of the Himalaya. A brief introduction to the physical features of India.

Unit II: Hydrology of the Himalaya (10 Hours)

Hydrology and glaciers of the Himalaya. Rivers and Lakes: Geological perspective. Inventory of Himalayan glaciers with special reference to Uttarakhand Glaciers. Major Rivers and Lakes of the Himalaya. Himalaya as a water tower. Geo-Ecological Problems of the Himalaya created by anthropogenic activities.

Unit III: Climatic divisions of the Himalayas (10 Hours)

Climatic divisions of the Himalayas. Soil and Climate of the Himalaya. Soil formation and classification of soils in the Himalaya. Influence of the Himalaya on the Climate of India. Difference between climatic variability and change.

Unit VI: Biodiversity of the Himalaya (10 Hours)

Biogeographic regions & characteristics, flora & fauna of the Himalaya. Conservation and management of biodiversity of the Himalaya with special reference to the Uttarakhand Himalaya. Importance and future of the Himalaya. Role of Indian Knowledge System for Sustainable Use of Bioresources in the Indian Himalayan Region.

Practical (Credits: 2)

---

1. To interpret geological and tectonic maps of the Indian subcontinent with a focus on Himalayan structure.
2. To prepare an inventory of Uttarakhand glaciers using available data from ICIMOD/NRSC/Bhuvan.
3. To analyze climatic data (temperature and rainfall) across different Himalayan zones.
4. To study the division of the Himalaya using maps.

Suggested Readings:

1. Mani, M.S. (1974). *Biogeography of India,1st Edn.* Springer.
2. Wadia, D. N. *Geology of India* – first published in 1919, with revised and later editions (e.g. 3rd edition in 1966; Macmillan), and a McGraw-Hill edition in 1975
3. Mani, M. S. (Ed.) *Biogeography of India* (*Ecology and Biogeography in India*, Monographiae Biologicae 23) – published in 1974 by W. Junk Publishers, The Hague.
4. Maithani, D. D. *Central Himalaya: Ecology, Environmental Resources & Development* – published in 2022 by Daya Publishing House, India.

Paper Title: Aquatic Ecosystems
Course Code: SLS/HAB/DSC-2
Credits: 3
Total Teaching Hours: 45

Unit I: Aquatic Ecosystems – Concepts and Classification (10 hours)

Definitions and scope of aquatic ecosystems. Types of aquatic ecosystems: Freshwater ecosystems: lentic (lakes, ponds) and lotic (streams, rivers) systems. Himalayan high-altitude wetlands. Chemical composition of freshwater systems (major ions, gases, nutrients) and comparison with marine water.

Unit II: Structure and Function of Lentic Ecosystems (15 hours)

Morphometry of lakes and ponds. Thermal stratification and seasonal mixing patterns. Zonation: littoral, limnetic, profundal zones. Primary productivity and nutrient cycling. Case studies of Himalayan lakes (e.g. Nainital). Eutrophication: Causes, Effects, and Management. High Altitude lakes of Himalaya.

Unit III: Structure and Function of Lotic Ecosystems (10 hours)

Rivers, types of rivers, geomorphology, longitudinal profile, rivers and ecological continuum, self-purification, riparian and flood plain wetlands; river biodiversity, Stream order, stream Zonation and Communities. Case studies of Himalayan rivers (e.g., Alaknanda, Bhagirathi).

Unit IV: Wetlands and Basic Marine Ecosystem Understanding (10 hours)

Types of wetlands: riverine, lacustrine, palustrine, and man-made wetlands. Ecological and socio-economic importance of wetlands, with examples from the Himalayas. Marine ecosystems: overview of major zones (littoral, neritic, pelagic, benthic); community organization, productivity, nutrient cycling and dynamics, upwelling and downwelling of nutrients; mangroves, coral reefs.

Practical (Credits: 2)

1. To visit a river stretch/wetland and prepare a report on habitat condition, pollution sources, and conservation status.
2. To calculate the TSI of a water body based on chlorophyll a, Secchi disk depth, and total phosphorus.
3. To visit a dam-impacted river stretch (e.g., Alaknanda or Tehri) to observe E-flow (Environmental Flow) status and interact with local people about flow alteration impacts.
4. Field Visit to different freshwater ecosystems in the Himalayas (lakes, rivers, and wetlands) and observe their features and ecological importance through water and ecology sample analysis.

Suggested Readings:

1. Wetzel, R.G. (2001). Limnology: Lake and River Ecosystems. Academic Press.
2. Singh, G. K. and Nautial, K. C. 2009. Biodiversity and Ecology of Aquatic Environment. Narendra Publisihing House
3. Mitsch, W.J. and Gosselink,J.G. 2015. Wetlands, 4th edition, John Wiley & Sons. 744p.
4. Van Der Valk, A. G, and Arnoud Van Der Valk. 2012. The Biology of Freshwater Wetlands. Oxford University.
5. Raymundo E. R. 2008. Wetlands: Ecology, Conservation and Restoration. Nova Science

Paper Title: Freshwater Biodiversity and Conservation
Course Code: SLS/HAB/DSC-3
Credits: 3
Total Teaching Hours: 45

Unit I: Basics of Freshwater Biodiversity in Himalaya (10 hours)

Definition and concept of Freshwater biodiversity, Types of Freshwater biodiversity: genetic, species, ecosystem, Freshwater biodiversity of lotic and lentic systems in the Himalaya region, Importance and value of freshwater biodiversity (ecological, economic, cultural), Role of biodiversity in ecosystem stability and conservation.

Unit II: Components and Ecological Roles of Freshwater Biodiversity (10 Hours)

Major biological groups of freshwaters: aquatic plants and animals. Structure and function of freshwater biological communities, Ecological roles of aquatic animals: producers, consumers, decomposers and nutrient cycling, Himalayan stream bionetwork, detritus processing, effects of sedimentation on aquatic life.

Unit III: Threats and Pressures on Freshwater Biodiversity (10 hours)

Threats to freshwater biodiversity, anthropogenic pressure, pollution, habitat destruction, overfishing, climate change, and altered precipitation patterns. Invasive species and their impact on native species' diversity. Dams, water diversions, and irrigation: their effect on freshwater biodiversity.

Unit: IV Conservation and Management of Freshwater Biodiversity (15 hours)

Conservation and management of freshwater biodiversity; habitat restoration; sustainable management practices; pollution control; captive breeding; reintroduction programs; genetic diversity conservation; policy and legislation to protect freshwater biodiversity. International efforts to conserve freshwater biodiversity, different practices in conserving and managing aquatic habitats, and local community participation.

Practical (Credits: 2)

---

1. Collect samples from a local freshwater body to identify the diversity of organisms like plants, fish, amphibians, and invertebrates, and examine their roles in maintaining ecological balance.
2. Collect water and sediment samples from different order streams and analyze how detritus, sedimentation, and riparian zones affect aquatic biodiversity.
3. Compare water quality and biodiversity between polluted and non-polluted freshwater sites to understand the effects of anthropogenic pressures such as pollution and habitat destruction.

Suggested Readings:

1. Ward, H.B. & Whipple, G.C. (1959). *Freshwater Biology* (2nd Ed.). New York: John Wiley & Sons
2. Groom, M.J., Meffe, G. R., and C. R. Carroll. 2006. *Principles of Conservation Biology*. Sinauer Associates, Inc., USA.
3. Krishnamurthy, K. V. 2003. *Textbook of Biodiversity*. Science Publication.
4. Primack, R.2006. *Essentials of Conservation Biology*. Sinauer Associates, Inc., USA.
5. Van Dyke, F.2008.*Conservation Biology Foundations, Concepts, Applications*, 2nd Edition, Springer.

Paper Title: Aquarium Setup and Maintenance
Course Code: SLS/HAB/SEC-1
Credits: 3
Total Teaching Hours: 45

Unit I: Aquarium Design and Construction (Hill Region Perspective) (15 hours)

Types of aquaria: freshwater aquaria, planted aquaria, community aquaria, and coldwater aquaria. Aquarium shapes and sizes: standard designs; small-scale and low-cost aquaria suitable for hill households and small enterprises. Materials used: comparison of glass and acrylic in terms of durability, insulation properties, and suitability for colder climates. Substrate selection and decoration: use of locally available materials such as gravel, stones, and driftwood; their aesthetic and functional roles. Design considerations for hill regions including temperature stability, portability, and energy efficiency.

Unit II: Aquarium Equipment and Installation (10 hours)

Filtration Systems: Biological, mechanical, and chemical filtration; suitability for coldwater systems. Aeration and Oxygenation: Importance in high-altitude and low-temperature conditions. Lighting Systems: Types of lights and its role in fish health and plant growth. Heating and Temperature Control: Heaters, thermostats, and insulation techniques for hill climates. Installation and Setup: Step-by-step aquarium setup; cycling and stabilization before stocking

Unit III: Water Quality Management (10 hours)

Physico-Chemical Parameters: pH, temperature, hardness, dissolved oxygen (DO) in coldwater aquaria. Nitrogen Cycle: Ammonia, nitrite, nitrate dynamics and biological filtration. Water Exchange and Conditioning: Frequency, dechlorination, and use of local water sources (spring/stream water). Role of Aquatic Plants: Oxygenation, nutrient uptake, and natural filtration. Hill-Specific Challenges: Low temperature effects, seasonal variation, and water source variability

Unit IV: Aquarium Maintenance and Fish Care (10 hours)

Routine Maintenance: Cleaning, siphoning, filter maintenance, and monitoring schedules. Feeding and Stocking Density: Balanced nutrition and avoiding overcrowding in small aquaria. Compatibility of Fish Species: Selection of coldwater and peaceful species for community tanks. Disease Diagnosis and Treatment: Common bacterial, fungal, and parasitic diseases; preventive care. Troubleshooting Common Problems: Algal growth, cloudy water, oxygen deficiency, temperature fluctuations

Practical (Credits: 2)

---

1. To assemble and install an aquarium system with appropriate filtration, aeration, and water conditioning.
2. To identify and classify different ornamental fish species based on observable morphological characteristics.
3. To culture and harvest live feed organisms for use in aquarium fish feeding.
4. To demonstrate breeding techniques in aquarium fishes, including spawning and hatching processes.

Paper Title: Taxonomy & Systematics
Course Code: SLS/HAB/DSE-1
Credits: 3
Total Teaching Hours: 45

Unit I: Fundamentals of Taxonomy and Systematics (10 hours)

Introduction to taxonomy and systematics; history and scope of taxonomy, types of taxonomy, Significance of systematics and taxonomy in biodiversity conservation, importance of taxonomy and its applications, species concepts and their implications.

Unit II: Taxonomic Classification and Nomenclature Systems (15 hours)

Taxonomic hierarchies and classification systems (artificial and natural systems), Binomial and trinomial nomenclature, Phenetic, Phylogenetic, modern approaches in taxonomy, International Code of Zoological Nomenclature (ICZN), International Code of Nomenclature (ICBN/ICN), and International Code of Nomenclature of Bacteria (ICNB) or Bacteriological Code (BC).

Unit III: Collection, Preservation, and Taxonomic Tools (10 hours)

Collection and preservation techniques of taxonomic specimens, specimen preparation, labeling, tagging, and storage, curating collections, museum preparation, taxonomic tools, taxonomic keys-Kinds, merits, and demerits, type specimens.

Unit IV: Molecular Taxonomy and Modern Tools (10 hours)

Molecular taxonomy: Definition and role is species identification, structure and function of nucleic acids (DNA and RNA), methods for DNA/RNA isolation and sequencing, Polymerase Chain Reaction (PCR), Next-Generation Sequencing (NGS), barcoding, phylogenetic tree construction, and software for phylogenetic analysis.

Practical (Credits: 1)

---

1. To classify and identify animal specimens up to the class or order level using morphological traits and standard taxonomic keys.
2. To collect and preserve field specimens following standard zoological techniques and documentation protocols.
3. To organize and label biological specimens for museum display using standard cataloguing and mounting protocols.

Suggested readings:

1. Hollingworth, P.M., Bateman, R. M., &Gornall, R. J. 1999. Molecular Systematics and Plant Evolution. Systematics Association Taylor & Francis.
2. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
3. Kapoor, V. C. 1998. Theory and Practice of Animal Taxonomy.Oxford and IBH Publishing.
4. Mayr, E, and P. D. Ashlock. 1991. Principles of Systematic Zoology. MacGraw-Hill, Inc., New Delhi.
5. Narendran, T. C. 2006. An Introduction to Taxonomy.Zoological Survey of India, Kolkata.
6. Simpson, G. G. 1962. Principles of Animal Taxonomy. Oxford Book Company, New York

Swayam course
Paper Title: Climate and Environmental Protection
Course Code: SLS/HAB/ M.D.E-1
Credits: 3
Total Teaching Hours: 45
For more detail and registration click the link below
https://onlinecourses.swayam2.ac.in/ugc25_ge17/preview

Week wise schedule (including the assignment to be kept in the week)

Week 1: Introduction to Arctic, Arctic-definition, Arctic overview-part-1
Week 2: Arctic overview-part-2, Arctic expedition-Part 1, Arctic expedition-Part 2
Week 3: Solar irradiance and Albedo, Albedo, Evapotranspiration, Arctic-amplification
Week 4: Arctic-amplification-contributors, Arctic Aerosols and Mechanisms-Part 1, Arctic Aerosols and Mechanisms-Part 2: Short-lived climate forcers (SLCFs)
Week 5: Arctic Cryosphere and Glacier Change Mechanism, Plant-biodiversity-Part-1, Plant- biodiversity-Part-2
Week 6: Animal-biodiversity-Part-1, Animal-biodiversity-Part-2
Week 7: Marine biodiversity, Biogeochemical cycle and arctic-Part-1
Week 8: Biogeochemical cycle and arctic-Part-2, Carbon cycle and Arctic, Anti-freeze proteins Part 1
Week 9: Anti-freeze proteins Part 2, Persistent Pollutants in the Arctic, Methanogenesis, Mechanisms, Pathways, and its Relevance to the Arctic
Week 10: Ocean Acidification, Ocean Acidification and trace metal biogeochemistry, Organic Carbon Recycling and its Influence on the Arctic
Week 11: Marine Contamination in the Arctic, Permafrost and Biogeochemistry Relationship
Week 12: Arctic Chemical and Climate Stressors, Chemolithotrophy and Arctic Ecosystems
Week 13: Greenhouse Gases and Climate Change Mechanism in the Arctic, Halogens and Atmospheric Chemistry in the Arctic
Week 14: Influence of Ozone and UV Radiation in the Arctic, Arctic Water and Carbon Cycle and Climate Change Mechanisms, Northern Sea route and climate change.
Week 15: Asian countries working in the Arctic region, NCPOR and arctic studies a brief overview, Interaction with researchers, opportunities for student.

Practical (Credits: 1)

1. To measure and analyze local temperature, humidity, and rainfall data to understand regional climate trends.
2. To evaluate the global warming potential (GWP) and environmental impact of major greenhouse gases through case studies or digital simulations.
3. To perform a household or institutional waste audit and develop a sustainable waste management plan based on the 3Rs (Reduce–Reuse–Recycle).

Suggested readings:

1. The Lost Expedition: Franklin and the Northwest Passage, by Scheong (https://www.throughouthistory.com/?p=4617).
2. Climate Change 2007: The Physical Science Basis, Contribution of Working Group I to the Fourth Assessment Report of the IPCC (ISBN 978 0521 88009-1 Hardback; 978 0521 70596-7Paperback).
3. https://onlinecourses.swayam2.ac.in/ugc25_ge17/preview

Semester II

Paper Title: Freshwater Aquaculture
Course Code: SLS/HAB/DSC-4
Credits: 3
Total Teaching Hours: 45

Unit I: Principles and Techniques in Freshwater Aquaculture (15 hours)

Definition, scope of aquaculture, recent advances in aquaculture, Criteria for species selection for aquaculture include extensive and intensive fish culture, monoculture, and polyculture. Culture techniques, procuring stocking material from natural sources, induced breeding in fish, and using new generation drugs, Ovaprim, and different hatching techniques.

Unit II: Fish Farm Preparation, Seed Management, and Culture Practices (10 hours)

Preparation and maintenance of fish farm: Water quality management and maintenance. Selection, transportation, and acclimatization of seed for aquaculture, Carrying capacity of a fish farm. Nursery, rearing, and grow-out form preparation and management. Control of aquatic weeds, predatory and weed fishes, liming, fertilization/ manuring, use of biofertilizers, and supplementary feeding.

Unit III: Emerging Technologies of Aquaculture (10 hours)

Freshwater pearl culture: Biomineralization, Implantation Methods, Collection of mussels, Pre-operative conditioning, Mussel surgery, Post-operative care, Pond culture, Food and Feeding, Pearl harvest Cryopreservation of gametes: implications of cryopreservation in Aquaculture. Bioremediation: Types of bio-remediation and their importance; Role of Probiotics in Aquaculture, Aquaponics.

Unit IV: Aquaculture Economics and Socio-Economic Perspectives (10 hours)

Aquaculture economics: application of economics principles to aquaculture operations, Cost and earnings of aquaculture systems: carp culture, freshwater prawn farming systems, hatcheries, and cost and earnings of fishing Units. Socio-economic conditions of fishermen in Uttarakhand, Role of government and fishery department in uplifting fishery, and fishermen cooperatives. Contribution of fisheries to the national economy. Aquaculture in the central Himalayan region.

Practical (Credits: 2)

1. To study different aquaculture systems (extensive, intensive, polyculture) based on environmental needs and market demands.
2. To design and set up a small-scale aquarium system and manage water quality and stocking density for monoculture or polyculture.
3. To monitor water quality parameters (pH, dissolved oxygen, ammonia etc) in a fish farm/hatchery and analyze their impact on fish health and growth.
4. To prepare and manage nursery or grow-out ponds using liming, fertilization, biofertilizers, and methods to control aquatic weeds and predatory species.

Suggested readings:

1. Pillay TVR. 1990. Aquaculture: Principles and Practices. Fishing News Books, Cambridge University Press, Cambridge.
2. Venugopal S. 2005. Aquaculture. Pointer Publ.
3. Welcomme RL. 2001. Inland Fisheries: Ecology and Management. Fishing News Books.
4. Felix, S. (2007). Aquaculture management techniques, Narendra Publishing House, New Delhi.

Paper Title: Aquatic Ecology
Course Code: SLS/HAB/DSC-5
Credits: 3
Total Teaching Hours: 45

Unit I: Fundamentals of Aquatic Ecology (10 hours)

Definition and scope of aquatic ecology; Ecosystem stability, resistance, and resilience in aquatic environments; Carbon, nitrogen, phosphorus, and sedimentary cycles in aquatic ecosystems. Phenotypic plasticity, ecotypes, acclimation, and thermoregulation in aquatic organisms. Liebig's Law of the Minimum, Shelford's Law of Tolerance, and ecological amplitude in aquatic environments.

Unit II: Population Ecology in Aquatic Systems (15 hours)

Concept of aquatic populations and metapopulations; r- and K-selection strategies in aquatic species. Density, dispersion, natality, mortality, life tables, survivorship curves, and age structure in aquatic organisms. Geometric, exponential, logistic, and density-dependent growth models for aquatic populations. Ruderal, competitive, and stress-tolerance strategies in aquatic environments.

Unit III: Community Interactions in Aquatic Ecosystems (10 hours)

Community Structure: Species composition, diversity, periodicity, biomass, stability, keystone species, ecotones, and edge effects in aquatic communities. Species Interactions: Mutualism, symbiosis, commensalism, amensalism, protocooperation, predation, competition, parasitism, mimicry, and herbivory in aquatic ecosystems. Ecological Succession: Primary and secondary successions in lakes, rivers, wetlands, and coral reefs; succession models and climax communities. Ecological Niches.

Unit IV: Ecosystem Functioning in Aquatic Environments (10 hours)

Ecosystem structure & function: abiotic and biotic components, ecosystem boundaries, and metabolism. Primary & secondary production: energy flow models, trophic efficiency, and ecological pyramids (numbers, biomass, energy) in aquatic ecosystems. Food webs & energy transfer: detritus pathways, decomposition processes, and nutrient cycling in aquatic environments. Nutrient dynamics: biotic accumulation, nutrient supply and uptake, ecosystem inputs, and losses in aquatic systems.

Practical (Credits: 2)

1. To observe and document the longitudinal zonation patterns of a Himalayan-river or stream, highlighting how altitude and topography influence temperature, flow, substrate type, and aquatic community structure.
2. To estimate primary productivity of a lotic Himalayan aquatic system using the Light and Dark Bottle method, and understand how factors like canopy cover, altitude, and glacier melt influence productivity.
3. To assess leaf litter decomposition rates in a Himalayan lotic system and understand how cold-water temperatures and flow regimes affect nutrient cycling and energy flow in mountain streams.
4. To assess the ecological health of a Himalayan-river or lake by measuring physico-chemical parameters and calculating a Water Quality Index (WQI) relevant to mountain freshwater conditions.

Paper Title: Aquatic Microbiology
Course Code: SLS/HAB/DSC-6
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction of Microbiology **(15 Hours)**

Discovery of microorganisms. General classification of microbes: Kingdom classification of microorganisms. Techniques used in microbial classification (Morphological, chemotaxonomic and genetic methods); Tools for systematics (Phylogenetic, numerical and polyphasic taxonomy). Zonation and microbiota of fresh water and marine habitats. Upwelling and downwelling, Eutrophication.

Unit II: Methods of studying microorganisms **(10 Hours)**

Quantitative estimation of microorganisms from aquatic systems. Culture and Media. Collection isolation cultivation and characterization of microorganisms. Study of Biofilm Nutrition and growth of microorganisms. Measurement of growth Factors affecting growth, control of microbial growth, and physical and chemical agents. Preservation of aquatic microbes. Culture Collection Centres.

Unit III: General Bacteriology & Biogeochemical Cycles **(10 Hours)**

Ultrastructure of bacterial cell: Morphology of bacteria, Structure and properties of cell wall and cell membrane, Cell wall synthesis, Capsule (Types, composition and function), Ultrastructure and functions of flagella, cilia, pili, s-layer, cytoplasmic inclusions, ribosomes and nucleoid; Bacterial reproduction. Role of microbes in biogeochemical cycles: Carbon, Nitrogen, Phosphorus and Sulphur cycles and their significance.

Unit IV: Microbial Assessment & Water-borne Diseases **(10 Hours)**

Sample collection, Treatment, and safety of drinking (potable) water, Water purification, Methods to detect potability of water samples: (a) Standard qualitative procedure (MPN test) (b) Membrane filter technique and (c) Presence/absence tests, Water-borne pathogens; Water-borne diseases.

Practical (Credits: 2)

---

1. To understand and follow microbiology lab safety rules, including culture disposal, and to learn calibration, validation, and maintenance of instruments.
2. To prepare and sterilize different types of microbiological media using appropriate techniques.
3. To isolate and enumerate bacteria and fungi from a given water sample using standard microbiological methods.
4. To perform staining techniques (simple, Gram's, and negative) for observing and differentiating bacterial cells.

Suggested readings:

1. Willey,M.J., Sherwood, L.M. and Woowerton, C.J. (2008). Prescott, Harley and Klein's microbiology, McGraw hill campany, New Delhi.
2. Schaperclaus, W. (2001) : Fish diseases Vol I & Vol II, Oxonian Press Pvt. Ltd., New Delhi.
3. Mitra, A. & K. Banerjee. (2004). Marine Microbiology, Narendra Publishing House, Delhi.
4. Pelezar, M.J., E.C.S. Cahn & H.R. Krieg (1981). Elements of Microbiology. McGraw Hill Book Co., NY.
5. Rosenberg, E.B. & I.R. Cohen (1983). Microbial Biology. CBS College Publ., NY.

Paper Title: Ornamental Fish Culture
Course Code: SLS/HAB/SEC-2
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction to Ornamental Fisheries (15 hours)

Scope and importance of ornamental fisheries with reference to livelihood generation, eco-tourism, and conservation of native fish species in hill regions. Classification of ornamental fishes: coldwater freshwater fishes such as barbs, danios, and loaches; ecological grouping into surface, column, and bottom dwellers. Indigenous vs exotic species: comparison of native and introduced fishes, advantages of indigenous species, and ecological risks associated with exotics. Biology and behaviour: basic morphology, feeding habits, and behavioural patterns including schooling, territoriality, and hill adaptations.

Unit II: Breeding and Rearing Techniques (10 hours)

Breeding biology of ornamental fishes, including reproductive systems and breeding behavior. Natural breeding and induced breeding techniques: use of hormonal induction and environmental manipulation for spawning. Larval rearing and nursery management: feeding strategies, water quality maintenance, and survival enhancement techniques. Broodstock management: selection, conditioning, and maintenance.

Unit III: Nutrition and Health Management (10 hours)

Nutritional requirements of ornamental fishes including proteins, lipids, carbohydrates, vitamins, and minerals. Artificial feeds and feeding practices: types of feeds and appropriate feeding schedules. Common diseases affecting ornamental fishes: bacterial, fungal, and parasitic infections. Disease prevention and control measures: biosecurity, quarantine practices, and treatment methods.

Unit IV: Ornamental Fish Trade and Economics (10 hours)

Aquarium fish trade and export potential with emphasis on global and Indian market trends. Packaging and transportation techniques for live ornamental fishes. Marketing strategies and entrepreneurship: business models, small-scale enterprise development, and startup opportunities in ornamental fisheries.

Practical (Credits: 2)

---

1. To identify and classify different ornamental fish species based on morphological and ecological characteristics.
2. To observe and document breeding behaviour in ornamental fishes.
3. To prepare artificial feed and evaluate appropriate feeding practices for ornamental fishes.
4. To identify common fish diseases and demonstrate suitable management.
5. To understand and perform proper packaging and transportation techniques for ornamental fishes.

Paper Title: Climate Science
Course Code: SLS/HAB/DSE-2
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction to Climate Science **(15 hours)**

Introduction to atmosphere. Global temperature, Fundamentals of physical meteorology, Energy budget and greenhouse effect, Earth's thermal environment and seasons. Coriolis force, pressure gradient force, frictional force, geo-strophic wind field, gradient wind, Radiative forcing of climate change, Global Warming potential.

Unit II: Climate change and its impact **(10 hours)**

Carbon cycle, Carbon emission from fossil fuels, Paleoclimatology, Evidence of climate change; Ice and climate change; Isotope evidence for Climate Change; Climates of India, western disturbances, Indian monsoon, droughts, El Nino, La Nina. Impact of climate change on terrestrial and aquatic ecosystems.

Unit III: Ozone layer **(10 hours)**

Ozone layer or ozone shield; importance of ozone layer; ozone layer depletion and causes; Chapman cycle; process of spring time ozone depletion over Antarctica; ozone depleting substances; effects of ozone depletion; Montreal protocol.

Unit IV: Climate change mitigation **(10 hours)**

REDD+, Synergies between Sustainable Use of Biodiversity and Climate Change. Intergovernmental Panel on Climate Change (IPCC), Ecological footprint, Kyoto protocol, Clean Development Mechanism (CDM).

Practical (Credits: 1)

---

1. To study the occurrence of extreme weather events (floods, droughts, heat waves) using secondary data and prepare a short report.
2. To analyze historical climate data (temperature, precipitation) for a Himalayan watershed or lake basin and interpret trends in aquatic ecosystem health.
3. To study the impact of extreme weather events (cloudbursts, glacial lake outburst floods) on nearby rivers, lakes, and aquatic biodiversity through secondary data and case studies.

Suggested Readings:

1. Barry, R. G., 2003. Atmosphere, weather and climate. Routledge Press, UK Critchfield,
2. Howard J., 1998, General climatology, Prentice Hall India Pvt. Ltd., New Delhi.
3. Firor, J., and J. E. Jacobsen, 2002. The crowded greenhouse: population, climate change and creating a sustainable world. Yale University Press.
4. Harvey D., 2000, Climate and Global Climate Change, Prentice Hall.
5. Gilbert M Masters., 2007. Introduction to environmental Engineering and science. Pearson Education.

Paper Title: Environmental Ecotoxicology
Course Code: SLS/HAB/M.D.E-2
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction to Ecotoxicology **(10 hours)**

Definition, scope, and history of ecotoxicology. Principles of toxicology: dose-response relationship, threshold limits, LD50 & LC50. Classification of pollutants: pesticides, heavy metals, industrial chemicals, emerging contaminants (e.g., microplastics, pharmaceuticals).

Unit II: Fate and Transport of Pollutants **(10 hours)**

Sources and pathways of pollutants in terrestrial and aquatic ecosystems. Processes influencing pollutant behavior: adsorption, volatilization, sedimentation, degradation. Bioavailability and bioaccumulation in aquatic organisms. Biomagnification through food chains.

Unit III: Effects of Pollutants on Biota **(10 hours)**

Mechanisms of toxicity: biochemical, physiological, genetic, and behavioral effects. Acute and chronic toxicity. Sub-lethal effects: reproductive, developmental, endocrine disruption.
Ecotoxicological case studies: heavy metal pollution, pesticide runoff in Himalayan rivers, microplastics in mountain streams.

Unit IV: Ecotoxicological Assessment and Biomonitoring **(15 hours)**

Methods for toxicity testing: acute and chronic bioassays. Biomarkers of exposure and effect. Bioindicators and sentinel species in freshwater systems. Ecotoxicological risk assessment: concepts and steps. Regulatory guidelines and environmental standards (Indian and international). Conservation and management strategies to mitigate ecotoxicological risks in Himalayan aquatic systems.

Practical (Credits: 1)

---

1. To perform a simple seed germination bioassay using different concentrations of a pollutant (e.g., pesticide or heavy metal solution).
2. To visit a local wastewater discharge site or effluent treatment plant and prepare a report on effluent characteristics and pollution control measures.
3. To assess microplastics presence in a Himalayan water body

Suggested Readings:

1. Connell, D.W. and Miller, G.J. (1984). *Chemistry and Ecotoxicology of Pollution.* Wiley-Interscience.
2. Newman, M.C. (2015). *Fundamentals of Ecotoxicology.* 4th Ed., CRC Press.
3. Rand, G.M. (Ed.) (1995). *Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment.* Taylor & Francis.
4. Walker, C.H., Sibly, R.M., Hopkin, S.P., & Peakall, D.B. (2012). *Principles of Ecotoxicology.* 4th Ed., CRC Press.
5. Moriarty, F. (1988). *Ecotoxicology: The Study of Pollutants in Ecosystems.* Academic Press.

Semester III

Paper Title: Freshwater Invertebrate Fauna of Himalaya
Course Code: SLS/HAB/DSC-7
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction to Aquatic Invertebrates and Aquatic Fauna (10 hours)

Freshwater invertebrate: Overview and life cycle of aquatic insect fauna: Adults, nymphs, Larval stages, adaptation of aquatic insects. General character and classification of aquatic insects up to the order level. Outline of other aquatic invasive invertebrates and their role in the ecosystem.

Unit II: Taxonomic Diversity of Major Freshwater Invertebrate Phyla (10 hours)

Major freshwater invertebrate groups: Protozoa (Single-celled animals), Porifera (Sponges), Platyhelminthes (Flatworms), Nematoda (Roundworms), Annelida (Segmented worms), Mollusca (Snails, clams, mussels), Arthropoda (Crustaceans, insects, spiders, Copepods, amphipods, isopods).

Unit III: Systematics and Bioindicator Role of EPT Insects (15 hours)

Ephemeroptera (Mayflies): Key to Ephemeroptera Families (Larvae), Ephemeroptera Family Descriptions, their taxonomy terminology, and species diversity. Plecoptera (Stoneflies): Key to Plecoptera Families (Larvae), Family Descriptions, their taxonomy terminology, and species diversity. Trichoptera (Caddisflies): Key to Trichoptera families (Larvae), their taxonomy, and family descriptions of families, species diversity. EPT Index: Definition, method of calculation, ecological importance, and its role in assessing freshwater ecosystem health, especially in Himalayan streams.

Unit IV: Taxonomic Assessment of Non-EPT Insect Fauna of the Himalaya (10 hours)

Odonata (Dragonflies & Damselflies) in the Himalaya: Key to Odonata Families (Larvae), Family Descriptions, taxonomy, and species diversity.Hemiptera (Aquatic & Semiaquatic True Bugs): Key and descriptions up to families (Larvae), their taxonomy and species diversity. Key and descriptions up to families (Larvae), their taxonomy, and species diversity of Diptera (Aquatic & Semiaquatic True Flies), Coleoptera (Aquatic Beetles), Lepidoptera (Aquatic Moths), Neuroptera (Spongillaflies), and Megaloptera (Fishflies, Alderflies & Dobsonflies).

Practical (Credits: 2)

---

1. To collect and preserve different aquatic invertebrates from nearby freshwater streams and record their habitat conditions.
2. To classify aquatic insects up to the order level using identification keys and field guides, with emphasis on morphological features.
3. To examine prepared slides or live samples of microinvertebrates under a microscope and describe their structure and life cycle stages.
4. To collect EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa from a freshwater site and calculate the EPT Index as a measure of water quality.

Paper Title: Environmental Pollution
Course Code: SLS/HAB/DSC-8
Credits: 3
Total Teaching Hours: 45

Unit I: Air Pollution **(15 hours)**

Sources and types of Pollutants - Natural and anthropogenic sources, primary and secondary pollutants. Criteria air pollutants. Sampling and monitoring of air pollutants (gaseous and particulates); period, frequency and duration of sampling. Impact of air pollutants on human health, plants and materials. Acid rain. Photochemical smog Dispersion of air pollutants. Mixing height/depth, lapse rates, Wind roses. Control devices for particulate matter: Principle and working of: settling chamber, centrifugal collectors, wet collectors, fabric filters and electrostatic precipitator. Control of gaseous pollutants through adsorption, absorption, condensation, and combustion, including catalytic combustion. Indoor air pollution.

Unit II: Water Pollution **(10 hours)**

Types of sources and consequences of water pollution, physico-chemical and bacteriological sampling, Analysis of water quality, standards, and Drinking water treatment: Coagulation and flocculation, Sedimentation and Filtration, Disinfection and Softening. Sewage and wastewater treatment and recycling, water quality and standards, Plastic pollution.

Unit III: Soil Pollution **(10 hours)**

Physico-chemical and biological properties of soil (texture, structure, inorganic and organic components). Analysis of soil quality. Soil Pollution control. Industrial effluents and their interactions with soil components. Soil micro-organisms and their functions - degradation of pesticides and synthetic fertilizers. Toxic chemicals: Pesticides and their classification and effects. Biochemical aspects of heavy metals (Hg, Cd, Pb, Cr) and metalloids (As, Se). CO, O3, PAN, VOC and POP.

Unit IV: Noise Pollution **(10 hours)**

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

Practical (Credits: 2)

1. To determine nitrate and phosphate concentrations in a Himalayan aquatic system receiving agricultural runoff.
2. To detect and quantify microplastic particles in water samples from a Himalayan river or lake.
3. To conduct a rapid environmental impact assessment of a local pollution source affecting a Himalayan aquatic ecosystem and suggest mitigation measures.
4. To measure levels of particulate matter (PM2.5 and PM10) in a Himalayan valley and relate air quality to impacts on nearby aquatic ecosystems.

Suggested Readings:

1. Peavy, H. S., Rowe, D. R., & Tchobanoglous, G. (1985). Environmental Engineering. McGraw-Hill.
2. Masters, G. M., & Ela, W. P. (2008). Introduction to Environmental Engineering and Science (3rd ed.). Prentice Hall.
3. Watt, K.E.F. (1973). Principles of Environmental Science, McGraw – Hill Book.

Paper Title: Aquatic Biotechnology
Course Code: SLS/HAB/ DSC-9
Credits: 3
Total Teaching Hours: 45

Unit I: Fundamentals of Biotechnology (15 Hours)

Introduction of Biotechnology. DNA as a genetic material. Structure and Types of DNA and RNA. DNA replication and Mutations. Transcription. Protein synthesis. Introduction to Recombinant DNA technology and its applications.

Unit II: Application of Biotechnology in aquaculture (10 Hours)

Biotechnology in aquaculture product development. Bio-fertilization and bio-fermentation. Application of biotechnology in aquaculture. Genetically engineered microbes for industrial application: Bacteria and yeast.

Unit III: Bio-energy and Environment (10 Hours)

Bio-ethanol and bio-diesel production. Commercial production from lignocellulosic waste and algal biomass. Aquatic microorganisms in bioremediation. Degradation of xenobiotics, Removal of heavy metals from the aquatic system (Superbug).

Unit IV: Advance conservation approaches in aquatic biodiversity (10 Hours)

In Situ and Ex Situ Conservation of Threatened Freshwater Fauna. Molecular Tools for Aquatic Species Identification and Conservation Genetics. Cryopreservation, Gene Banking, and Gene Pool of endangered aquatic Species. Community-Based Conservation and Co-Management of flora and fauna. Intellectual Property Rights (IPR) and protection (IPP). Biological databases.

Practical (Credits: 2)

---

1. To isolate genomic DNA from a bacterial culture using standard laboratory procedures.
2. To enumerate the total viable microbial count in a water sample using serial dilution and plating techniques.
3. To isolate and enumerate bacteriophages from sewage water using plaque assay method.
4. To study and identify the colony morphology of E. coli on EMB (Eosin Methylene Blue) agar.

Suggested Readings:

1. Lakra WS, Abidi SAH, Mukherjee SC & Ayyappan S. 2004. Fisheries Biotechnology. Narendra Publ. House
2. Subbaram NR. 1998. Handbook of Indian Patent Law and Practice. Viswanathan Printers & Publ.
3. Cloud JG & Thorgaard GH. 1993. Genetic Conservation of Salmonid Fishes. NATO ASI Series, Life Sciences, Springer. Frankham R, Ballou JD & Briscoe DA. 2004. A Primer of Conservation Genetics. Cambridge University Press.
4. Butler M & Dawson M. (Ed.). 1992. Cell Culture. Bios Scientific Publ. Clynes M. 1998. Animal Cell Culture Techniques. Springer.

Paper Title: Research Methodology
Course Code: SLS/HAB/ DSC-10
Credits: 3
Total Teaching Hours: 45

Unit I: Research Formulation **(15 Hours)**

Definition, scope and objective, types, approaches, significance; scientific investigation. The research process, preliminary data collection, Types of research: Descriptive vs. Analytical, Applied vs. Fundamental, Quantitative vs. Qualitative, and Conceptual vs. Empirical Experimental design The laboratory experiment, variables, validity, Types of experimental Designs, Instrumental methods of Environmental analysis.

Unit II: Data collection **(10 Hours)**

Sources of data; data collection methods; Methods for selecting sampling locations and times; Simple random sampling, Stratified random sampling, Systematic sampling Processing and Analysis of Data.

Unit III: Presenting and Publishing paper **(10 Hours)**

Format, choosing Journal, Title, Running Title, Writing Abstract, Keywords, Introduction section, Materials and Methods selection, Result section, Figures, tables, graphs, Discussion Section, References, preparing posters for scientific presentation, Preparing and delivering of oral presentation, Research Grant Funding Agencies.

Unit IV: Technical writing and Report Generation **(10 Hours)**

Basic concept of paper/thesis writing, Ethical issues, Copyright, Intellectual property rights and patent law, Trade Related aspects of Intellectual Property Rights, Plagiarism, Citation and acknowledgment.

Practical (Credits: 2)

---

1. To perform basic data analysis using statistical methods (mean, standard deviation, correlation) and interpret the results.
2. To conduct literature review and practice scientific writing, including citation, referencing, and preparation of research reports.
3. To prepare basic questionnaires and collect data.
4. To calculate simple statistics like average and present data in tables or graphs.

Suggested Readings:

1. Kothari, C.R (2009) Research Methodology and Techniques, Delhi: New Age international Publisher.
2. Donald H.McBurney (2006) Research Methods, 5th Edition, Thomson Learning.
3. Donald R. Cooper, Pamela S. Schindler (2006) Business Research Methods, 8/e, Tata McGraw-Hill Co.Ltd.
4. P. Oliver (2004) Writing Your Thesis, New Delhi: Vistaar Publications,.
5. Gregory(2005) Ethics in Research, Continuum, 2005.
6. Malkote, S.R. (1991), Communication for Development, New Delhi: Sage Publication.

Paper Title: Freshwater Planktonology
Course Code: SLS/HAB/DSE-3
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction of Plankton **(10 Hours)**

Classifications of plankton based on size, mode of life, life cycle and feeding habits. Luminous plankton, biology of important plankton. Phyton and Zooplankton- Method of collection of plankton and estimation of primary and secondary productivity.

Unit II: Structure of Plankton **(15 Hours)**

Adaptation of plankton structural (weight increases of surface area, floatation) and physiological (specific gravity, water content, fat content, defensive vacuoles) mechanisms. Phytoplankton and Zooplankton inter relations. Red tide phenomenon- its causes and effects.

Unit III: Role of Periphyton **(10 Hours)**

Periphyton: Importance and significance, Different types in lotic and lentic factors influencing periphyton. Factors affecting productivity, regional differences and seasonal variations. Role of periphyton in aquatic system.

Unit VI: Characteristics of Algae and Diatoms **(10 Hours)**

Characters & Keys: Green and Blue-Green Algae: Taxonomy terminology, flora in Himalaya Macrophytic vegetation. Centrale and Pennale diatoms, diatom taxonomy terminology. Centrale diatom Families and Genera *Melosira*, *Cyclotella* in Himalaya.

Practical (Credits: 1)

---

1. To collect and identify major groups of phytoplankton, zooplankton from a freshwater ecosystem.
2. To observe the seasonal variation in plankton diversity and abundance in a lentic or lotic water body.
3. To study the morphology and taxonomy of green algae, blue-green algae, and diatoms found in aquatic habitats.

Suggested Readings:

1. Alexopocules, C.J, C.J, (1967): Algae and fungi, Mac Milan Co, London.
2. Boney, A.D. (1975): Phytoplankton, Edward Arnold, and London.
3. Borgis, P. (1976): Marine plankton ecology. North Holland Amer.Elsevier, N.York.
4. Chapman, V.J. (1976) Mangrove vegetation.J.Gramer, Berlin.
5. Davis C.C. (1955): The Marine and freshwater plankton. Micihigan state university press USA.

Paper Title: Environmental Impact Assessment (EIA) and Auditing
Course Code: SLS/HAB/M.D.E-3
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction to EIA **(10 hours)**

Definition and objectives of EIA, purpose of EIA, terminology, hierarchy in EIA. Basic data collection for EIA Legislation and framework. National Environmental Policy Act and implementation.

Unit II: Methods of the Environmental Impact Assessment **(15 hours)**

Initial screening, rapid environmental impact assessment, comprehensive environmental assessment. Development activities and requiring environmental impact assessment. Public participation in environmental decision-making.

Unit III: Economical Analysis **(10 hours)**

Cost-benefit analysis, the relationship between the cost of damage and the cost of control. Life-cycle analysis, Environmental Impact Assessment in India, Case studies of EIA.

Unit IV: Environment Management Plan **(10 hours)**

Environmental Management System Standards (ISO14000 series) Planning, selection of appropriate procedures, introduction to budget, minimizing environmental impacts. The Environmental Audit: Environmental auditing and its importance, types of audits, general audit methodology and basic auditing structure. Eco-labeling schemes.

Practical (Credits: 1)

---

1. To conduct a preliminary Environmental Impact Identification for a proposed small hydroelectric project on a Himalayan River using checklists/matrices.
2. To prepare a simple Environmental Baseline Data Sheet for a local aquatic site (river, lake, wetland) covering water, soil, air, and biodiversity features.
3. To conduct a field visit to an ongoing or completed project (e.g., dam, bridge, riverside road) and prepare a report on visible environmental impacts.

Suggested Readings:

1. Canter, Larry W. Environment Impact Assessment. McGraw-Hill. 2. Rau, G.J. and C.D. Weeten. 1980. Environmental Impact Analysis Handbook. McGraw Hill.
2. Glasson, John, Rikki Therievel and Andrew Chadwic. 1996. Introduction to Environmental Impact Assessment, 2nd edition UCL Press.
3. Kulkarni, Vijay and T.V. Ramchandra. Date Environmental Management. Capital Publishing.
4. Mhaskar, A.K.Environmental Audits.Enviro Media Publications.
5. Eccleston, Charles H. 2011. Environmental Impact Assessment: A Guide to Best Professional Practices. CRC Press.

Semester IV

Paper Title: Freshwater Fishery Science
Course Code: SLS/HAB/DSC-11
Credits: 3
Total Teaching Hours: 45

Unit I: Taxonomy, Diversity, and Identification of Himalayan Fishes (15 hours)

Fish Taxonomy and outline classification of fish, identification of fish species, including their morphometric and meristic analysis. Determination of age and growth in fishes by hard parts (Scale, otolith, and operculum). Fish of Garhwal Himalaya, Hill stream adaptations in fishes, Exotic and Endemic fish fauna of the Himalaya. Computation of indices: Species richness, Species diversity, Margalef diversity index. Similarity index, Identification of fish fauna; use of keys, monographs.

Unit II: Fish Population and Harvesting Management (10 hours)

Population Dynamics- theory of fishing: Unit stock, recruitment, mortality. Migration in fish, fish tagging and marking. Fishing methods and related problems in the Himalayan region, Fish preservation and processing techniques. Fish by-products and their uses, type of fish spoilage and their causative agents, Nutritional value of fish, and biochemistry of fish flesh of Indian major carps. Storage, transportation, and marketing of fish.

Unit III: Anatomy, Biology, and Ecology of Hill Stream Fishes (10 hours)

Basic fish anatomy: digestive, circulatory, respiratory, nervous, and reproductive systems. Process of maturation: methods of assessment of spawning and breeding periods, biotic and abiotic factors affecting spawning in fishes. Stages of sexual maturity, spawning season, and frequency (Gonado-Somatic index, Dobriyal Index), fecundity of hill stream fishes. Food and feeding analysis: Qualitative and quantitative estimation of dietary components; Numerical, volumetric, gravimetric, Points method.

Unit VI: Coldwater Fisheries and Conservation Biology (10 hours)

Coldwater fisheries in India: Concept and scope. Natural and man-made cold-water fishery resources, their distribution, and their extent in various states of India (the Himalaya region). Cultivable fish fundamentals of cold-water fish culture, fish farm for trout and mahseer. Coldwater fish fauna in India and the Nepal Himalaya and their threat status. Conservation strategies of fishes in the Himalayan region and their economic value.

Practical (Credits: 2)

1. To identify fish species using morphometric and meristic analysis of freshwater fish species by recording body parameters, fin counts, and scale rows with the help of standard fish identification keys and monographs.
2. To study the breeding and feeding biology of hill stream fish using different indices and methods
3. To determine the age and growth of fishes using hard parts such as scales, otoliths.
4. To analyze the structure and form of freshwater crustacean native to the Himalayan region.

Suggested Readings

1. Nelson, J. S. (2006). *Fishes of the World* (4th ed.). John Wiley & Sons.
2. Day, F. (1889). *The Fauna of British India, including Ceylon and Burma: Fishes* (Vols. I & II). Edited by W. T. Blanford. London: Taylor and Francis
3. Srivastava, C.B.L. (1999). *A Textbook of Fishery Science and Indian Fisheries*. Allahabad: Kitab Mahal

Paper Title: Water Analysis and Instrumentation
Course Code: SLS/HAB/DSC-12
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction to Water Quality and Sampling (15 hours)

Concept and significance of water quality. Physical, chemical, and biological characteristics of water. Water quality standards for different uses. Principles and methods of water sampling. Types of samples: grab, composite. Selection of sampling sites and frequency. Sample preservation and transportation. Sampling challenges in Himalayan aquatic systems.

Unit II: Physico-Chemical Analysis of Water (10 hours)

Methods for the determination of: pH, Temperature, Electrical conductivity, Total dissolved solids (TDS), Turbidity, Total hardness, Alkalinity and acidity, Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Chemical oxygen demand (COD), Chlorides, nitrates, and phosphates. Interpretation of results for water quality status.

Unit III: Biological methods in water analysis (10 hours)

Introduction to Biological Indicators of Water Quality, Microbiological Analysis of Water, Water quality index, Biotic index: Definition and rationale of biotic index, Types: BMWP (Biological Monitoring Working Party), FBI (Family-level Biotic Index).

Unit IV: Advanced Analytical Techniques and Microscopy (10 hours)

Introduction to Analytical Instruments: Classification, principles, and role in environmental analysis, Principle and Applications: Atomic Absorption Spectroscopy (AAS), Inductively Coupled Plasma–Mass Spectrometry (ICP-MS), High Performance Liquid Chromatography (HPLC), Fourier Transform Infrared Spectroscopy (FTIR), Gas Chromatography–Mass Spectrometry (GC-MS).

Practical (Credits: 2)

1. To determine the pH, total dissolved solids (TDS), and electrical conductivity of water samples collected from a Himalayan River or stream, and to observe the impact of temperature on each parameter.
2. To determine the total hardness and alkalinity of water samples from a Himalayan aquatic system, and to interpret their ecological significance for aquatic life and water quality.
3. To determine the dissolved oxygen (DO) and biochemical oxygen demand (BOD) of water samples collected from a Himalayan River or stream, and to interpret their significance for aquatic ecosystem health.
4. To determine the concentrations of nitrate and phosphate in water samples collected from a Himalayan River or stream, and to interpret their implications for nutrient pollution and eutrophication

Suggested Readings:

1. APHA (American Public Health Association). (2017). *Standard Methods for the Examination of Water and Wastewater* (23rd ed.). Washington, D.C.: APHA, AWWA, WEF.
2. Sawyer, C. N., McCarty, P. L., & Parkin, G. F. (2003). *Chemistry for Environmental Engineering and Science* (5th ed.). McGraw-Hill.

Paper Title: Biostatistics
Course Code: SLS/HAB/ DSC-13
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction of Biostatistics **(15 Hours)**

Biostatistics: Definition and its applications in Biological Sciences. Statistical Data: Different methods of data collection and data representation, tabular and Graphical representations including line graphs, bar graphs, pie charts, histograms, boxplots. Sample and sampling techniques (random and non-random).

Unit II: Central Tendencies **(10 Hours)**

Descriptive statistics: Measurement of central tendency (mean, median and mode), Measures of dispersion including Coefficients of variation, differences between standard deviations, standard errors, covariance.

Unit III: Probability and Correlations **(10 Hours)**

Normal distribution and its application, deviation from normality. Parametric vs. Nonparametric methods, skewness and kurtosis. Correlation and Regression: Correlation analysis, Spearman's rank correlation and its applications. Regression, Differences between correlation and regression.

Unit IV: Statistical Tests **(10 Hours)**

Test of significance: Students t distribution, test of significance of single mean, two means (2t) and paired t test, Z test, Chi square test, goodness of fit, F test and ANOVA, one way and Two-way ANOVA.

Practical (Credits: 2)

---

1. To apply basic statistical measures (mean, median, mode) for analyzing species richness and abundance data from Himalayan aquatic ecosystems.
2. To assess variability and reliability in ecological data by calculating standard deviation and standard error.
3. To visualize and interpret ecological data patterns through normal distribution curves and probability analysis.
4. To examine relationships between biodiversity indicators and environmental variables using correlation and regression techniques.

Suggested Readings:

1. Edmondson, A. and Druce, D. (1996). Advanced biology statistics. Oxford University Press, New York.
2. Danial, W. (2004). Biostatistics: A foundation for analysis in health sciences. John Wiley and Sons, New York.
3. Ron, W. (2000). How computer work? Techmedia Publishers.
4. Preston, G. (2000). How internet work? Techmedia Publishers.
5. Bliss, C.I.K. (1977). Statistics in biology. Mc Graw Hill, New York, vol. I.
6. Campbell, R.C. (1974). Statistics for biologists. Cambridge University Press, Cambridge.
7. Wardlaw, A.C. (1985). Practical statistics for experimental biologists. John Wiley and Sons, New York.

Paper Title: Himalayan River: Status, destruction, and management
Course Code: SLS/HAB/ DSC-14
Credits: 3
Total Teaching Hours: 45

Unit 1: Introduction **(10 Hours)**

Drainage system of India, Himalayan drainage system, general characteristics of Himalayan Rivers, Evolution and Geomorphology of Himalayan rivers, Drainage pattern of Himalayan Rivers.

Unit 2: Himalayan rivers status **(10 Hours)**

River Ganga, Indus, and Brahmaputra and their major tributaries, stream order of streams, Water quality, Self-purification capacity, and major fish species of the Himalayan rivers. Importance of Himalayan Rivers.

Unit 3: Destruction of Himalayan River Ecosystems **(15 Hours)**

Natural and anthropogenic disturbance in the river, cloud burst and flash flood, Impact of climate change on Himalayan Rivers, Impact of Hydropower plant on Rivers, Case study of River Ganga.

Unit 4: Conservation of Himalayan Rivers **(10 Hours)**

Laws related to river protection in India, Ganga Action Plan, Namami Gange programme: Implementation and status; Environmental Flows: Definition, purpose, ecological integrity; Case studies.

Practical (Credits: 2)

---

1. To assess water quality and evaluate the self-purification capacity of a Himalayan river.
2. To determine stream order and calculate river discharge.
3. To analyze the drainage pattern and morphometric characteristics of a selected Himalayan river basin.

Suggested Readings:

1. Sharad Singh Negi, Himalayan Rivers, Lakes, and Glaciers. Indus Publishing, 1991.
2. Sharad Singh Negi, Himalayan Fishes and Fisheries. Indus Publishing, 1994.
3. Sharad Singh Negi, Cold Deserts of India. Indus Publishing, 2002.
4. Biyani, AK. Dimension of Himalayan Geology, SSPH,2007
5. Rashmi Sanghi, Our National River Ganga: Lifeline of Millions, Springer 2013.
6. Kalyan Rudra, Rivers of the Ganga-Brahmaputra-Meghna Delta: A Fluvial Account of Bengal (Geography of the Physical Environment, Springer; 1st ed. 2018 edition (13 April 2018)
7. Pal Saroj K. Geomorphology of River Terraces Along Alaknanda Valley, Garhwal Himalaya.

Paper Title: Dissertation
Option–I: Minor Dissertation / Project Work *(in lieu of any **one** DSC)*
Credits: 5

The dissertation will be based on original research work conducted by the student on a topic relevant to Himalayan Aquatic Biodiversity. It will focus on understanding, conserving, or sustainably managing the unique aquatic ecosystems, species, or water resources of the Himalayan region. The work may involve field studies, laboratory analyses, data generation, and interpretation on aspects such as aquatic ecology, biodiversity assessment, conservation strategies, pollution impacts, emerging contaminants, climate change effects, or sustainable resource use in Himalayan water bodies.

Students will identify a specific research problem in consultation with their supervisor and prepare a detailed research proposal. The dissertation must include a comprehensive review of existing literature, clear research objectives or hypotheses, and a well-defined methodology. Data collection may involve sampling from rivers, lakes, wetlands, or other Himalayan aquatic habitats, and should follow ethical and scientific guidelines.

The final dissertation must demonstrate the student's ability to conduct independent scientific inquiry and to contribute to the knowledge and management of Himalayan aquatic biodiversity. It must be prepared in accordance with the departmental format, with proper referencing and plagiarism checks.

Each student is required to present their work in seminars, submit periodic progress reports, and defend their dissertation before an evaluation committee. The dissertation will carry 6 credits and will be evaluated on the basis of scientific content, quality of analysis, originality, presentation, and the student's ability to discuss and defend the work.

Guidelines:

- The dissertation topic must be relevant to the specialization and approved by the departmental committee.
- Regular progress must be reported to the supervisor.
- Plagiarism must be avoided; a plagiarism check certificate must be submitted along with the final dissertation.
- The final dissertation must be submitted in the prescribed format.
- Students must follow all ethical norms related to research on human subjects, animals, or the environment.

Paper Title: Dissertation
Option–II: Major Dissertation / Project Work *(in lieu of any **two** DSC)*
Credits: 10

The dissertation will be based on original research work conducted by the student on a topic relevant to Himalayan Aquatic Biodiversity. It will focus on understanding, conserving, or sustainably managing the unique aquatic ecosystems, species, or water resources of the Himalayan region. The work may involve field studies, laboratory analyses, data generation, and interpretation on aspects such as aquatic ecology, biodiversity assessment, conservation strategies, pollution impacts, emerging contaminants, climate change effects, or sustainable resource use in Himalayan water bodies.

Students will identify a specific research problem in consultation with their supervisor and prepare a detailed research proposal. The dissertation must include a comprehensive review of existing literature, clear research objectives or hypotheses, and a well-defined methodology. Data collection may involve sampling from rivers, lakes, wetlands, or other Himalayan aquatic habitats, and should follow ethical and scientific guidelines.

The final dissertation must demonstrate the student's ability to carry out independent scientific inquiry and contribute to the knowledge and management of Himalayan aquatic biodiversity. It must be prepared according to the departmental format, with proper referencing and plagiarism checks.

Each student is required to present their work in seminars, submit periodic progress reports, and defend their dissertation before an evaluation committee. The dissertation will carry 10 credits and will be evaluated on the basis of scientific content, quality of analysis, originality, presentation, and the student's ability to discuss and defend the work.

Guidelines:

- The dissertation topic must be relevant to the specialization and approved by the departmental committee.
- Regular progress must be reported to the supervisor.
- Plagiarism must be avoided; a plagiarism check certificate must be submitted along with the final dissertation.
- The final dissertation must be submitted in the prescribed format.
- Students must follow all ethical norms related to research on human subjects, animals, or the environment.

Paper Title: Restoration Ecology and Habitat Management
Course Code: SLS/HAB/DSE-4
Credits: 3
Total Teaching Hours: 45

Unit I: Principles of Restoration Ecology (10 hours)

Definition, scope, and historical development of restoration ecology. Concepts: degradation, damage, destruction, and ecological resilience. Principles of ecosystem recovery, reference conditions, and ecological thresholds. Restoration goals, strategies, and standards (SER Primer, IUCN guidelines).

Unit II: Restoration Approaches and Techniques (10 hours)

Passive vs. active restoration. Techniques for soil restoration and erosion control in fragile Himalayan terrain. Reforestation, afforestation, and vegetation management. River and stream habitat restoration: in-stream structures, bank stabilization, riparian buffer zones. Wetland creation and rehabilitation.

Unit III: Planning, Implementation, and Monitoring (15 hours)

Phases of a restoration project: site assessment, planning, design, and stakeholder involvement. Adaptive management and ecological engineering approaches. Monitoring ecological success: indicators and benchmarks. Socio-economic and policy aspects of restoration: community participation and co-benefits. Cost-benefit analysis of habitat restoration projects.

Unit IV: Case Studies and Legal Framework (10 hours)

National and global case studies: Ganga Rejuvenation Mission, Ramsar site restoration, forest landscape restoration. Community-led restoration examples: joint forest management, wetland user groups. Legal and policy frameworks supporting restoration: CAMPA, Compensatory Afforestation, Forest Rights Act, National Mission for Green India. Emerging trends: Nature-based Solutions (NbS) and ecosystem-based adaptation.

Practical (Credits: 1)

---

1. To visit a degraded riverbank, wetland, or forest patch and prepare a field report describing signs of degradation, major threats, and local ecological conditions.
2. To conduct a basic vegetation survey at the site using quadrat or transect methods and prepare a species inventory.
3. To collect soil samples from the site and determine soil pH using a pH meter.
4. To measure water quality parameters (temperature, pH, dissolved oxygen, turbidity) in a nearby stream or wetland.

Suggested Readings:

1. Clewell, A.F. & Aronson, J. (2013). Ecological Restoration: Principles, Values, and Structure of an Emerging Profession. Island Press.
2. Hobbs, R.J. & Norton, D.A. (1996). Towards a Conceptual Framework for Restoration Ecology. Restoration Ecology.
3. Gopal, B. (2013). Wetland Restoration: Challenges and Opportunities. Springer.
4. SER International (2004). The SER International Primer on Ecological Restoration.
5. Bradshaw, A.D. (1997). Restoration of Mined Lands — Using Natural Processes. Ecological Engineering

Paper Title: Environmental Policy and Regulation
Course Code: SLS/HAB/M.D.E-4
Credits: 3
Total Teaching Hours: 45

Unit I: Introduction to Environmental law **(10 hours)**

Historical background of Environmental Law and Policy in India, Environmental laws, environmental Policy in India, Indian Constitution and Environmental Protection, Environmental Protection: Issues and Problems, Key International Efforts for Environmental protection, UN Framework Conventions on Climate Change, 1992, Kyoto Protocol, 1997.

Unit II: National Environmental Regulations **(15 hours)**

Wildlife (Protection) Act, 1972 and its successive amendments, Indian Forest Act 1927; The Forest Conservation Act 1980, and Forest conservation Rules 2003, Air (Prevention and Control of Pollution) Act 1978 and Rules 1982 and successive amendments, The Environmental (Protection) Act 1986 and its amendment in 1991, Environment (Protection) Act, 1986: Salient Features , Biological Diversity Act 2002 and Biological Diversity Rules 2004, Water (Prevention and Control of Pollution) Act 1974 and Rules 1975 and subsequent amendments.

Unit III: Waste Management & Pollution Control Regulation **(10 hours)**

Solid waste management rules 2016, Bio-Medical Waste Management Rules, 2016 Plastic waste management rules 2016, Water (Prevention and Control of Pollution) Act, 1974: Salient Features, Air (Prevention and Control of Pollution) Act, 1981, Noise pollution (Regulation and Control) Rules, 2000.

Unit IV: Environmental Treaties and Conventions **(10 hours)**

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

Practical (Credits: 1)

---

1. To conduct a plastic waste audit in your campus or a local bazaar near a river/lake.
2. To carry out a compliance checklist for a local institution (college, hostel) on rules related to water use, waste disposal, and eco-friendly practices.
3. To compare two states' policies (e.g., Uttarakhand and Himachal Pradesh) on river conservation — highlight differences and similarities.

Suggested Readings:

1. Divan, S. and Roscencranj, A. Environmental Law and Policy in India, Oxford Pub.New Delhi. 2001.
2. Lal, S. Commentaries on Water, Air pollution and Environment (protection) Law,Law Pub. Pvt. Ltd. India. 1990.
3. Leelakrishnan, P. Environmental Law in India. Butterworths Publications,New Delhi.1999
4. Singh, G. Environmental Law: International and National Perspectives. 1995.

Paper Title: Community Outreach Activities
Credits: 1
Total Teaching Hours: 30

Course Description

This course is fully field-based. Students will design and implement outreach activities in nearby villages, schools, and aquatic sites, focusing on awareness, conservation, and community participation related to Himalayan aquatic ecosystems. The following activities will be conducted by the department for students:

1. River/Stream Clean-up Drive
    - Identification of polluted stretch
    - Collection and segregation of waste (plastic, glass, organic)
    - Awareness interaction with locals during activity
2. Microplastics Awareness Campaign
    - Explaining sources (household plastics, textiles, packaging)
    - Demonstration using samples/images
    - Promoting reduction strategies (reuse, alternatives)
3. Spring (Naula/Dhara) Conservation Activity
    - Cleaning of spring surroundings
    - Awareness on recharge zones and protection
    - Interaction with local users on sustainable practices
4. School Awareness Program
    - Interactive sessions (charts/models)
    - Quiz, poster-making, or small competitions
    - Demonstration on water conservation methods
5. Aquatic Biodiversity Documentation
    - Rapid observation of fish, plankton, macroinvertebrates
    - Use of basic identification guides
    - Preparation of a simple biodiversity checklist
6. Community Meeting / Gram Sabha Interaction
    - Discussion on local water issues and solutions
    - Encouraging community participation
    - Recording key concerns and suggestions
7. Poster/Pamphlet Awareness Campaign
    - Preparation of locally relevant IEC materials
    - Distribution and explanation in community
    - Display at schools/public places
8. Water Quality Awareness & Testing Demo
    - Demonstration of basic parameters (pH, turbidity, temperature)
    - Explanation of safe water standards
    - Community involvement in simple testing