Department of Himalayan Aquatic Biodiversity

Syllabus

for

M.Sc. (Himalayan Aquatic Biodiversity)

in accordance with

National Education Policy- 2020

Course structure for P.G. program under NEP 2020		
Semester I (July to November)		
CODE	**Core courses**	**CREDIT**
SLS/HAB/DSC-1	Biogeography of Himalaya	5
SLS/HAB/DSC-2	Aquatic Ecosystems	5
SLS/HAB/DSC-3	Freshwater Biodiversity and Conservation	5
SLS/HAB/DSC-4	Lab course I (for courses DSC-1, DSC-2 &DSC-3)	3
Electives (any one out of two)		
SLS/HAB/DSE-1	Taxonomy & Systematics	4
SLS/HAB/DSE-2	Climate and Environmental Protection (Swayam course)	
SLS/HAB/DSE-3	Lab course II (for courses DSE-1 or DSE-2)	2
	Total	24
Semester II (December to April)		
CODE	**Core courses**	CREDIT
SLS/HAB/DSC-5	Freshwater Aquaculture	5
SLS/HAB/DSC-6	Aquatic Ecology	5
SLS/HAB/DSC-7	Aquatic Microbiology	5
SLS/HAB/DSC-8	Lab course I (for courses DSC-5, DSC-6 & DSC-7)	3
Electives (any one out of two)		
SLS/HAB/DSE-4	Climate Science	4
SLS/HAB/DSE-5	Environmental Ecotoxicology	
SLS/HAB/DSE-6	Lab course II (for courses DSE-4 or DSE-5)	2
	Total	24
Semester III (July to November)		
CODE	**Core courses**	CREDIT
SLS/HAB/DSC-9	Freshwater Invertebrate Fauna of Himalaya	5
SLS/HAB/ DSC-10	Environmental Pollution	5
SLS/HAB/ DSC-11	Aquatic Biotechnology	5
SLS/HAB/ DSC-12	Lab course I (for courses DSC-9, DSC-10 & DSC-11)	3
Electives (any one out of two)		
SLS/HAB/DSE-7	Freshwater Planktonology	4
SLS/HAB/DSE-8	Environmental Impact Assessment (EIA) and Auditing	
SLS/HAB/DSE-9	Lab course II (for courses DSE-7 or DSE-8)	2
	Total	24
Semester IV (December to April)		
CODE	**Core courses**	CREDIT
SLS/HAB/ DSC-13	Freshwater Fishery Science	5
SLS/HAB/ DSC-14	Water Analysis and Instrumentation	5
SLS/HAB/ DSC-15	Biostatistics	5
SLS/HAB/ DSC-16	Lab course I (for courses DSC-13, DSC-14 & DSC-15)	3
Dissertation (06 credit) or one elective {Theory (04 credit) + Lab Course (02 credit)}		
SLS/HAB/DSE-10	Dissertation	6
SLS/HAB/DSE-11	Restoration Ecology and Habitat Management	4
SLS/HAB/DSE-12	Environment Policy and Regulation	
SLS/HAB/DSE-13	Lab course II (for courses DSE-11 or DSE-12)	2
	Total	24

Semester I (July to November)

Paper Title: Biogeography of Himalaya
Course Code: SLS/HAB/DSC-1
Credits: 5
Total Teaching Hours: 75

Unit I: Introduction of Himalaya **(20 Hours)**

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

Unit II: Hydrology of Himalaya **(20 Hours)**

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

Unit III: Climatic divisions of Himalayas **(15 Hours)**

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

Unit VI: Biodiversity of Himalaya **(20 Hours)**

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

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: 5
Total Teaching Hours: 75

Unit I: Aquatic Ecosystems – Concepts and Classification (15 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 (20 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 (20 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 (20 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.

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: 5
Total Teaching Hours: 75

Unit I: Basics of Freshwater Biodiversity in Himalaya (15 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 (20 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 (20 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 (20 hours)

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

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: Lab course I (for courses DSC-1, DSC-2 &DSC-3)
Course Code: SLS/HAB/DSC-4
Credits: 3
Total Teaching Hours: 90

---

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 examine and classify Himalayan soils based on texture, color, and structure.
5. To visit a river stretch/wetland and prepare a report on habitat condition, pollution sources, and conservation status.
6. To calculate TSI of a water body based on chlorophyll-a, Secchi disk depth and total phosphorus.
7. To measure discharge using float method or current meter in a mountain stream.
8. 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.
9. 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.
10. 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.
11. Collect water and sediment samples from different order streams and analyze how detritus, sedimentation, and riparian zones affect aquatic biodiversity.
12. 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. Wadia, D.N. (1975). Geology of India. Tata McGraw-Hill, New Delhi.
2. Valdiya, K.S. (1998). Dynamic Himalaya. Universities Press.
3. Mani, M.S. (1974). Ecology and Biogeography in India. Dr W. Junk B.V., The Hague.
4. Wetzel, R.G. (2001). *Limnology: Lake and River Ecosystems.* 3rd Edition. Academic Press, San Diego.
5. Singh, H.R. (1990). Environmental Biology. Rastogi Publications, Meerut.
6. Goldman, C.R. and Horne, A.J. (1983). Limnology. McGraw-Hill, New York.

Paper Title: Taxonomy & Systematics
Course Code: SLS/HAB/DSE-1
Credits: 4
Total Teaching Hours: 60

Unit I: Fundamentals of Taxonomy and Systematics (15 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 (15 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 (15 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.

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/DSE-2
Credits: 04
Total Teaching Hours: 60
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.

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

Paper Title: Lab Course II (for course DSE-1)
Course Code: SLS/HAB/DSE-3
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-1: Taxonomy and Systematics

---

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 compare diagnostic features of major invertebrate and vertebrate phyla using preserved specimens or educational models.
4. To construct a cladogram or dendrogram based on morphological characters and analyze evolutionary relationships among species.
5. To isolate DNA from a freshwater organism and perform PCR amplification followed by visualization through gel electrophoresis.
6. To prepare a temporary mount of a small invertebrate and observe its anatomical features under a compound microscope.
7. To organize and label biological specimens for museum display using standard cataloguing and mounting protocols.
8. To preserve animal specimens using wet and dry methods with proper tagging and techniques for long-term storage.
9. To visit a museum, observe preserved specimens, and prepare a report on their identification and preservation methods.
10. To study the developmental stages of an aquatic insect using morphological features observed from preserved or live specimens.

Suggested readings:

1. Kapoor, V. C. 1998. *Theory and Practice of Animal Taxonomy*. Oxford and IBH Publishing.
2. Sambrook, J.; Fritsch, E. F.; & Maniatis, T. (1989). *Molecular Cloning: A Laboratory Manual* (2nd ed.). Cold Spring Harbor Laboratory Press.
3. Winston, J. E. (1999). *Describing Species: Practical Taxonomic Procedure for Biologists*. Columbia University Press.
4. Kress, W. J., & Erickson, D. L. (Eds.). (2012). *DNA Barcodes: Methods and Protocols* (Methods in Molecular Biology, Vol. 858). Humana Press.

Paper Title: Lab Course II (for course DSE-2)
Course Code: SLS/HAB/DSE-3
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-2: Swayam Course

1. To measure and analyze local temperature, humidity, and rainfall data to understand regional climate trends.
2. To estimate the carbon footprint of daily human activities (e.g., transport, electricity, diet) and suggest feasible reduction strategies.
3. To assess indoor and outdoor air quality using particulate matter sensors or low-cost air quality monitoring kits.
4. To demonstrate the greenhouse effect through a model experiment simulating global warming conditions.
5. To evaluate the global warming potential (GWP) and environmental impact of major greenhouse gases through case studies or digital simulations.
6. To perform a household or institutional waste audit and develop a sustainable waste management plan based on the 3Rs (Reduce–Reuse–Recycle).
7. To investigate the effects of deforestation or urbanization on local microclimate and habitat diversity using satellite imagery or topographical maps.
8. To conduct a biodiversity audit in a local area (e.g., campus, garden, or park) and assess the health of the ecosystem.
9. To design and execute a community awareness campaign focused on climate change adaptation or environmental protection.
10. To survey public awareness and behavioral responses related to climate change mitigation and prepare an analytical report.

Suggested readings:

1. Bharucha, E. (2013). *Textbook of Environmental Studies for Undergraduate Courses* (2nd ed.). University Press.
2. Sharma, P. D. (2020). *Environmental Biology And Toxicology* (Revised Ed.). Rastogi Publications.
3. Trivedi, R. K., & Goel, P. K. (1986). *Chemical and Biological Methods for Water Pollution Studies*. Environmental Publications.
4. Reddy, M. A. (2008). *Textbook of Environmental Science and Technology*. BS Publications.
5. Manahan, S. E. (2005). *Environmental Chemistry* (8th ed.). CRC Press.

Semester II (December to April)

Paper Title: Freshwater Aquaculture
Course Code: SLS/HAB/DSC-5
Credits: 5
Total Teaching Hours: 75

Unit I: Principles and Techniques in Freshwater Aquaculture (20 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 (20 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 (15 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 (20 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.

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.
5. Krjstjonsson, H. 1959. Modern fishing gear of the world Vol.

Paper Title: Aquatic Ecology
Course Code: SLS/HAB/DSC-6
Credits: 5
Total Teaching Hours: 75

Unit I: Fundamentals of Aquatic Ecology **(15 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 **(20 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 **(20 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 **(20 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.

Suggested readings:

1. Ecosystem: Analysis & Prediction, Simon- Editor Levin.
2. Dobson, M. 2000. Ecology of Aquatic Management. Pearson Education
3. Marris, G.P. (1986): Phytoplankton Ecology, Chapman and Hall London.
4. Ecology and Field Biology, by Robert L. Smith.
5. Elements of Ecology, Thomas M. Smith.

Paper Title: Aquatic Microbiology
Course Code: SLS/HAB/DSC-7
Credits: 5
Total Teaching Hours: 75

Unit I: Introduction of Microbiology (20 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 (20 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 Physical and chemical agents. Preservation of aquatic microbes. Culture Collection Centres.

Unit III: General Bacteriology & Biogeochemical Cycles (20 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 (15 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.

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: Lab Course I (for courses DSC-5, DSC-6 & DSC-7)
Course Code: SLS/HAB/DSC-8
Credits: 3
Total Teaching Hours: 90

---

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.
5. 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.
6. 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.
7. 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.
8. 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.
9. To understand and follow microbiology lab safety rules, including culture disposal, and to learn calibration, validation, and maintenance of instruments.
10. To prepare and sterilize different types of microbiological media using appropriate techniques.
11. To isolate and enumerate bacteria and fungi from a given water sample using standard microbiological methods.
12. To perform staining techniques (simple, Gram's, and negative) for observing and differentiating bacterial cells.

Suggested Readings:

1. Krebs, C.J. (2009). *Ecology: The Experimental Analysis of Distribution and Abundance.* 6th Edition. Benjamin Cummings.
2. Allan, J.D. and Castillo, M.M. (2007). *Stream Ecology: Structure and Function of Running Waters.* 2nd Edition. Springer.
3. Moss, B. (2010). *Ecology of Freshwaters: A View for the Twenty-First Century.* 4th Edition. Wiley-Blackwell
4. Cappucino, J. and Sherman, N. Microbiology: A laboratory manual. Benjamin/Cummings Publishing Company, San Francisco.
5. Prescott, L.M. and Harley, J.P. Laboratory exercises in microbiology. William C. Brown, Dubuque.

Paper Title: Climate Science
Course Code: SLS/HAB/DSE-4
Credits: 4
Total Teaching Hours: 60

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 (15 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 (15 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 (15 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).

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/DSE-5
Credits: 4
Total Teaching Hours: 60

Unit I: Introduction to Ecotoxicology (15 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 (15 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 (15 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.

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.

Paper Title: Lab course II (for course DSE-4)
Course Code: SLS/HAB/DSE-6
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-4: Climate Science

---

1. To monitor ambient air quality (PM2.5, PM10) using low-cost sensors or secondary data and relate findings to climatic factors.
2. To study the occurrence of extreme weather events (floods, droughts, heat waves) using secondary data and prepare a short report.
3. To analyze historical climate data (temperature, precipitation) for a Himalayan watershed or lake basin and interpret trends in aquatic ecosystem health.
4. 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.
5. To determine soil moisture content in riparian zones or wetland catchments and relate it to stream or wetland hydrology.
6. To design and conduct a community survey on local awareness about climate change impacts on Himalayan rivers, lakes, and aquatic biodiversity.
7. To calculate personal (self) carbon footprint using household energy, transport, and lifestyle data; interpret results and suggest individual actions for reduction.
8. To visit a Climate Observatory/IMD Station to observe data collection techniques, instruments, and weather monitoring systems relevant for Himalayan aquatic studies.
9. To demonstrate the greenhouse effect in a lab setup using transparent boxes/bottles to show how trapped heat raises temperature.
10. To analyze pH and conductivity of water samples collected from local rivers or lakes to see seasonal variation related to climate.

Suggested readings:

1. Barry, R. G., & Chorley, R. J. (2009). Atmosphere, Weather and Climate (9th ed.). Routledge.
2. Wallace, J. M., & Hobbs, P. V. (2006). Atmospheric Science: An Introductory Survey (2nd ed.). Academic Press.
3. Peixoto, J. P., & Oort, A. H. (1992). Physics of Climate. American Institute of Physics.
4. Lutgens, F. K., & Tarbuck, E. J. (2019). The Atmosphere: An Introduction to Meteorology (14th ed.). Pearson.
5. Houghton, J. (2009). Global Warming: The Complete Briefing (4th ed.). Cambridge University Press.

Paper Title: Lab course II (for course DSE-5)
Course Code: SLS/HAB/DSE-6
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-5: Environmental Ecotoxicology

---

1. To determine LC_{50} (Median Lethal Concentration) for a common pollutant (e.g., detergent) on a local aquatic organism under lab conditions.
2. To perform a simple seed germination bioassay using different concentrations of a pollutant (e.g., pesticide or heavy metal solution).
3. To observe bioaccumulation using a model experiment, such as dye uptake in plant tissues
4. To prepare a toxicity profile for a household chemical (detergent, phenyl, pesticide) and discuss its ecological risk.
5. To conduct a field survey to identify visible signs of aquatic pollution (dead fish, algal bloom, foul smell) in a local water body.
6. To visit a local wastewater discharge site or effluent treatment plant and prepare a report on effluent characteristics and pollution control measures.
7. To demonstrate biomagnification through a simple food chain model, relating it to local fish species that communities consume.
8. To demonstrate eutrophication by enriching local pond or lake water in jars and observing algal growth — linking to fertilizer runoff from mountain farms.
9. To examine pollutant effects on plankton communities by collecting plankton from a local lake or river and exposing them to low concentrations of a pollutant.
10. To assess microplastics presence in a Himalayan water body

Suggested readings:

1. Rand, G. M. (Ed.). (1995). *Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment* (2nd ed.). Taylor & Francis.
2. Newman, M. C. (2014). *Fundamentals of Ecotoxicology: The Science of Pollution* (4th ed.). CRC Press.
3. Walker, C. H., Sibly, R. M., Hopkin, S. P., & Peakall, D. B. (2012). *Principles of Ecotoxicology* (4th ed.). CRC Press.
4. Connell, D. W., Lam, P., Richardson, B., & Wu, R. (1999). *Introduction to Ecotoxicology*. Wiley-Blackwell.
5. Peakall, D. B. (1992). *Animal Biomarkers as Pollution Indicators*. Springer

Semester III (July to November)

Paper Title: Freshwater Invertebrate Fauna of Himalaya

Course Code: SLS/HAB/DSC-9

Credits: 5

Total Teaching Hours: 75

Unit I: Introduction to Aquatic Invertebrates and Aquatic Fauna (15 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 (15 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 (25 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 (20 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).

Suggested Readings:

1. Odum, E. and Barrett, G. 2005. *Fundamentals of Ecology*. Thomson Brooks/Cole.
2. Aquatic Insects, D. Dudley Williams and Blair W. Feltmate, Blackburn publications.
3. Patric W. Patrick McCafertty Aquatic Entomology: The Fisherman's And Ecologist's Illustrated Guide To Insects And Their Relatives,
4. Reese J., Voshell, McDonald & Woodward Pub., 2002 A Guide to Common Freshwater Invertebrates of North America

Paper Title: Environmental Pollution
Course Code: SLS/HAB/DSC-10
Credits: 5
Total Teaching Hours: 75

Unit I: Air Pollution **(20 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 **(20 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 **(20 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 **(15 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.

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-11
Credits: 5
Total Teaching Hours: 75

Unit I: Fundamentals of Biotechnology (20 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 (15 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 (20 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 aquatic system (Superbug).

Unit IV: Advance conservation approaches in aquatic biodiversity (20 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.

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: Lab Course I (for courses DSC-9, DSC-10 & DSC-11)
Course Code: SLS/HAB/DSC-12
Credits: 3
Total Teaching Hours: 90

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.
5. To determine nitrate and phosphate concentrations in a Himalayan aquatic system receiving agricultural runoff.
6. To detect and quantify microplastic particles in water samples from a Himalayan river or lake.
7. To conduct a rapid environmental impact assessment of a local pollution source affecting a Himalayan aquatic ecosystem and suggest mitigation measures.
8. To measure levels of particulate matter (PM2.5 and PM10) in a Himalayan valley and relate air quality to impacts on nearby aquatic ecosystems.
9. To isolate genomic DNA from a bacterial culture using standard laboratory procedures.
10. To enumerate the total viable microbial count in a water sample using serial dilution and plating techniques.
11. To isolate and enumerate bacteriophages from sewage water using plaque assay method.
12. To study and identify the colony morphology of E. coli on EMB (Eosin Methylene Blue) agar.

Suggested Readings:

1. Trivedi, R.K. and Goel, P.K. (1986). *Chemical and Biological Methods for Water Pollution Studies.* Environmental Publications, Karad, India.
2. APHA (2017). *Standard Methods for the Examination of Water and Wastewater.* 23rd Edition. American Public Health Association, Washington, D.C.
3. Sharma, R.C. and Rawat, J.S. (2009). *Monitoring of Aquatic Ecosystems.* Daya Publishing House, New Delhi.

Paper Title: Freshwater Planktonology
Course Code: SLS/HAB/DSE-7
Credits: 4
Total Teaching Hours: 60

Unit I: Introduction of Plankton (15 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 (15 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 (15 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.

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/DSE-8
Credits: 4
Total Teaching Hours: 60

Unit I: Introduction to EIA **(15 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 **(15 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 **(15 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.

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.

Paper Title: Lab Course II (for course DSE-7)
Course Code: SLS/HAB/DSE-9
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-7: Freshwater Planktonology

1. To collect and identify major groups of phytoplankton from a freshwater ecosystem.
2. To collect and identify major groups of zooplankton from a freshwater ecosystem.
3. To understand the structural and physiological adaptations of plankton for floatation and survival in water.
4. To observe the seasonal variation in plankton diversity and abundance in a lentic or lotic water body.
5. To study the morphology and taxonomy of green algae, blue-green algae, and diatoms found in aquatic habitats.
6. To assess the role of periphyton in aquatic ecosystems by analysing its composition and habitat preference.
7. To compare the productivity of periphyton in lentic (still) and lotic (flowing) aquatic systems.
8. To study the effect of abiotic factors (light, temperature, nutrients) on the distribution of aquatic microorganisms.
9. To identify key diatom genera (e.g., *Melosira, Cyclotella*) and interpret their ecological indicators in water quality assessment.
10. To evaluate the ecological significance of red tide phenomena and its impact on aquatic biodiversity.

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: Lab Course II (for course DSE-8)
Course Code: SLS/HAB/DSE-9
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-8: Environmental Impact Assessment (EIA) and Auditing

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.
4. To identify and list stakeholders for an EIA study of an aquatic habitat — e.g., local community, fishermen, forest department, tourism operators.
5. To carry out a mock scoping exercise for an EIA — defining key issues and impacts for a hypothetical project affecting a stream or lake.
6. To prepare a basic Environmental Management Plan (EMP) proposing mitigation measures for negative impacts on aquatic ecosystems.
7. To prepare a checklist for Environmental Auditing of a small institution/campus focusing on water use, waste discharge, energy use, and compliance.
8. To perform a simple water audit of your department/campus — measure usage, leakage points, and suggest conservation measures.
9. To practice a Rapid EIA using available data for a small local issue (e.g., waste discharge into a stream) and prepare a short impact report.
10. To prepare an Environmental Audit Statement for a local tourism activity near a lake/river, highlighting gaps in waste management or pollution control.

Suggested Readings:

1. Canter, L. W. (1996). Environmental impact assessment (2nd ed.). McGraw-Hill.
2. Glasson, J., Therivel, R., & Chadwick, A. (2012). Introduction to environmental impact assessment (4th ed.). Routledge.
3. Noble, B. F. (2015). Introduction to environmental impact assessment: A guide to principles and practice (3rd ed.). Oxford University Press.
4. Lawrence, D. P. (2003). Environmental impact assessment: Practical solutions to recurrent problems. Wiley-Interscience.
5. Eccleston, C. H. (2011). Environmental impact assessment: A guide to best professional practices. CRC Press.

Semester IV (December to April)

Paper Title: Freshwater Fishery Science
Course Code: SLS/HAB/DSC-13
Credits: 5
Total Teaching Hours: 75

Unit I: Taxonomy, Diversity, and Identification of Himalayan Fishes (20 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 (20 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 (20 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 (15 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.

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
4. Badola S P. 2009. *Ichthyology of the central Himalaya*, Transmedia Publication, Srinagar, Garhwal, UK.
5. Talwar, P. K., & Jhingran, A. G. (1991). *Inland Fishes of India and Adjacent Countries*. Oxford & IBH.
6. King, M. (2007). *Fisheries Biology, Assessment and Management* (2nd ed.). Wiley-Blackwell

Paper Title: Water Analysis and Instrumentation
Course Code: SLS/HAB/DSC-14
Credits: 5
Total Teaching Hours: 75

Unit I: Introduction to Water Quality and Sampling (20 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 (20 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 (15 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 (20 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).

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.
3. Trivedi, R. K., & Goel, P. K. (1986). *Chemical and Biological Methods for Water Pollution Studies*. Environmental Publications.
4. Bartram, J., & Balance, R. (Eds.). (1996). *Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes*. UNEP/WHO.

Paper Title: Biostatistics
Course Code: SLS/HAB/ DSC-15
Credits: 5
Total Teaching Hours: 75

Unit I: Introduction of Biostatistics (20 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 (15 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 (20 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 (20 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.

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: Lab Course I (for DSC-13, DSC-14 & DSC-15)
Course Code: SLS/HAB/DSC-16
Credits: 3
Total Teaching Hours: 90

---

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
5. 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.
6. 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.
7. 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.
8. 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.
9. To apply basic statistical measures (mean, median, mode) for analyzing species richness and abundance data from Himalayan aquatic ecosystems.
10. To assess variability and reliability in ecological data by calculating standard deviation and standard error.
11. To visualize and interpret ecological data patterns through normal distribution curves and probability analysis.
12. To examine relationships between biodiversity indicators and environmental variables using correlation and regression techniques.

Suggested Readings:

1. APHA (2017). *Standard Methods for the Examination of Water and Wastewater.* 23rd Ed. American Public Health Association.
2. Maiti, S.K. (2004). *Handbook of Methods in Environmental Studies, Vol. 1: Water and Wastewater Analysis.* ABD Publishers.
3. Trivedi, R.K. and Goel, P.K. (1986). *Chemical and Biological Methods for Water Pollution Studies.* Environmental Publications.
4. Edmondson, A. and Druce, D. (1996). Advanced biology statistics. Oxford University Press, New York.

Paper Title: Dissertation
Course Code: SLS/HAB/DSE-10
Credits: 6
Total Teaching Hours: 60

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 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: Restoration Ecology and Habitat Management
Course Code: SLS/HAB/DSE-11
Credits: 4
Total Teaching Hours: 60

Unit I: Principles of Restoration Ecology **(15 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 **(15 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 **(15 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.

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: Environment Policy and Regulation
Course Code: SLS/HAB/DSE-12
Credits: 4
Total Teaching Hours: 60

Unit I: Introduction to Environmental law (15 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 (15 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 (15 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.

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: Lab Course II (for course DSE-11)
Course Code: SLS/HAB/DSE-13
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-11: Restoration Ecology and Habitat Management

---

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 estimate organic carbon content in collected soil samples using the Walkley-Black titration method.
5. To prepare a simple riparian buffer strip design for riverbank restoration using native plant species.
6. To demonstrate seed collection, treatment, and nursery bed preparation techniques for native species.
7. To study bioengineering methods by demonstrating a small model for slope stabilization using live plants or bioengineering materials.
8. To measure water quality parameters (temperature, pH, dissolved oxygen, turbidity) in a nearby stream or wetland.
9. To design simple habitat monitoring indicators for vegetation recovery and erosion control success.
10. To develop a basic site-specific restoration plan including objectives, strategy, species list, and timeline, and present it in a group seminar.

Suggested Readings:

1. Clewell, A.F. & Aronson, J. (2013). *Ecological Restoration: Principles, Values, and Structure of an Emerging Profession*. Island Press.
2. SER International. (2004). *The SER International Primer on Ecological Restoration*.
3. Bradshaw, A.D. (1997). *Restoration of Degraded Lands*.
4. Gopal, B. (2013). *Wetland Restoration: Challenges and Opportunities*. Springer.

Paper Title: Lab Course II (for course DSE-12)
Course Code: SLS/HAB/DSE-13
Credits: 2
Total Teaching Hours: 60

SLS/HAB/ DSE-12: Environment Policy and Regulation

1. To conduct a case study of a local or regional court judgment related to aquatic ecosystem protection (e.g., NGT orders on river pollution).
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 prepare an awareness poster or leaflet on citizens' rights and duties under the Environment Protection Act or Water Act.
4. To study a key international agreement (e.g., Ramsar Convention, UNEP) and present its relevance for Himalayan wetlands or glacial lakes.
5. To compare two states' policies (e.g., Uttarakhand and Himachal Pradesh) on river conservation — highlight differences and similarities.
6. To prepare a timeline of key environmental policy milestones in India, highlighting those related to water, forests, wetlands, and rivers.
7. To prepare a flowchart showing the process of Environmental Clearance for a small hydropower project in the Himalayas.
8. To conduct a mini survey of local households, asking about awareness of water laws, plastic ban rules, or wetland protection rules — analyze and present findings.
9. To prepare a simple policy brief addressing an issue like illegal sand mining in riverbeds
10. To conduct a plastic waste audit in your campus or a local bazaar near a river/lake.

Suggested Readings:

1. Divan, S., & Rosencranz, A. (2001). *Environmental Law and Policy in India* (2nd ed.). Oxford University Press.
2. Shastri, S. C. (2021). *Environmental Law*. Eastern Book Company.
3. Leelakrishnan, P. (2020). *Environmental Law in India* (5th ed.). LexisNexis
4. Sahu, G. (2020). *Environmental Regulatory Authorities: Issues and Problems in Environmental Governance in India*. Economic and Political Weekly, 55(10).
5. Central Pollution Control Board (CPCB). (2016). *Guidelines for Implementation of Plastic Waste Management Rules, 2016*. CPCB, Ministry of Environment, Forest and Climate Change