

Semester I
(July to November)

PAPER TITLE-BIODIVERSITY: AN INTRODUCTION

CODE- SLS/HAB/C001

CREDIT-03

COURSE TYPE- CORE

Unit-I

Biodiversity: Concept and definition

Scope and Constraints of Biodiversity Science, Composition and Scales of Biodiversity: Genetic Diversity, Species/Organismal Diversity, Ecological/Ecosystem Diversity,

Unit-II

Causes of Biodiversity; measurement of biodiversity

Origin of Species /Speciation: History of the Earth and Biodiversity patterns through Geological times

Unit-III

Values of Biodiversity

Instrumental/Utilitarian value and their categories, Direct use value; Indirect/ Non-consumptive use value, Endemism, Hotspots and megadiversity nations.

Unit-IV

Threats to Biodiversity

Habitat Destruction, Fragmentation, Transformation, Degradation and Loss;

Invasive Species: their introduction pathways, biological impacts of invasive species on terrestrial and aquatic systems

Pollution: Impacts of Water pollution and Air Pollution on biodiversity

Overexploitation: Impacts of Exploitation on Target and Non-target Terrestrial and Aquatic species and Ecosystems

Recommended Books

1. Groom,M.J.,Meffe, G. R. and C. R. Carroll. 2006. Principles of Conservation Biology. Sinauer Associates, Inc.,USA.
2. Krishnamurthy, K. V. 2003. Textbook of Biodiversity. Science Publication.
3. Primack, R.2006. Essentials of Conservation Biology. Sinauer Associates, Inc., USA.
4. Hambler,C.2004. Conservation. Cambridge University Press.
5. Van Dyke,F.2008.Conservation Biology Foundations, Concepts, Applications 2nd Edition, Springer.

UNIT-I

Introduction to taxonomy and systematics; history, conceptual basis role of taxonomy, Types of taxonomy, Significance of systematics and taxonomy in biodiversity, Numerical taxonomy and its applications.

UNIT-II

Major Systems of Classification (artificial and natural systems), Binomial and trinomial nomenclature, Phenetic, Phylogenetic and Evolutionary classification, Species Concept.

UNIT-III

Collection and preservation techniques in animals (Insects-butterfly and moth, Amphibia, Reptiles, and Mammals); Curating collections; Taxonomic keys- Kinds, merits and demerits of different types, The importance of type specimen.

UNIT-IV

The International Code of Zoological Nomenclature (ICZN) and the rules of Zoological Nomenclature; The International Code of Nomenclature (ICBN/ICN) The International Code of Nomenclature of Bacteria (ICNB) or Bacteriological Code (BC)

Recommended Books

1. Simpson, M.G. 2006. Plant Systematics. Elsevier academic Press.
2. Singh, G. 2008. Plant Systematics: Theory and Practice. Oxford & IBH Publishing Co. Pvt. Ltd.
3. Leadley, E. & Jury, S. 2006. Taxonomy and Plant Conservation. Cambridge University Press
4. Hollingworth, P.M., Bateman, R. M., & Gornall, R. J. 1999. Molecular Systematics and Plant Evolution. Systematics Association Taylor & Francis.
5. Crawford, D.J. 2003. Plant Molecular Systematics. Cambridge University Press, Cambridge, UK.
6. Kapoor, V. C. 1998. Theory and Practice of Animal Taxonomy. Oxford and IBH publishing.
7. Mayr, E and P. D. Ashlock. 1991. Principles of Systematic Zoology. MacGraw-Hill, inc., New Delhi.
8. Narendran, T. C. 2006. An Introduction to Taxonomy. Zoological Survey of India, Kolkata.
9. Simpson, G. G. 1962. Principles of Animal Taxonomy. Oxford Book Company, New York

PAPER TITLE- HIMALAYA: AN INTRODUCTION
CREDIT-03

CODE- SLS/HAB/C003
COURSE TYPE- CORE

UNIT-I

A brief introduction about physical features of India
Origin of Himalaya, Geology of Himalaya, geographical location of the Himalaya.
Physiographic division

UNIT-II

Hydrology and glaciers of himalaya
Rivers and Lakes: Geological perspective.
Major Rivers and Lakes of Himalaya.

UNIT-III

Climatic divisions of Himalayas.
Soil and Climate of Himalaya.
Influence of Himalaya on the Climate of India.

UNIT-IV

Biogeographic regions & characteristics flora & fauna of Himalaya.
Importance of Himalaya

Recommended Books

1. Mani, M.S. (1974). *Biogeography of India, 1st Edn.* Springer.
2. Geology of India D N Wadia Tata-McGraw Hill Publishing Co. New Delhi
3. Biogeography of India M S Mani Dr W Junk b v Publishers, The Hague
4. Garhwal Himalaya - Nature, Culture & Society Kandari, O. P. and Gusain, O. P., (Eds.) Transmedia, Srinagar, Uttaranchal, India.

UNIT-I

Aquatic ecosystems: Definitions, Fresh water (lentic, and lotic), marine and wetland ecosystems, classification of aquatic ecosystems and wetlands; chemical composition of fresh and marine waters.

UNIT-II

Lakes, ponds and reservoirs: index of biological integrity, eutrophication and trophic state index; biological adaptations, nutrient dynamics, methanogenesis, carbon cycle, climate change and impact on lakes and reservoirs;

UNIT-III

Types of rivers, geomorphology, longitudinal profile, rivers and ecological continuum, selfpurification, riparian and flood plain wetlands; river biodiversity, community organization; trophic structure and food webs; energy flow; negative and positive feedbacks and resilience.

UNIT-IV

Structure and function of marine ecosystems, estuary types and genesis; organisms (plants, animals, microbes) in various ecological zones, community organization, productivity, nutrient cycling and dynamics, upwelling and downwelling of nutrients; mangroves, coral reefs

Recommended Books/References

1. Dobson, M. 2000. Ecology of Aquatic Management. Pearson Education
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

SEMESTER II
(December to April)

PAPER TITLE- TECHNIQUES IN AQUATIC ECOLOGY AND BIODIVERSITY
CREDIT-03

CODE- SLS/HAB/C007
COURSE TYPE- CORE

Unit I

Sampling techniques for algae, zooplankton, macroinvertebrates and fishes in aquatic ecosystems. Analysis of physical (temperature, pH, conductivity, turbidity) and chemical parameters (DO, CO₂, total alkalinity, hardness, nitrate, phosphate, BOD) in lentic and lotic ecosystems.

Unit II

Assessment of Micro flora (bacteria, fungi) in aquatic ecosystems.
Quantitative analysis (density, Abundance, percentage composition) of aquatic producer communities: periphyton, phytoplankton and macrophytes

Unit III

Quantitative analysis (density, abundance, percentage composition) of aquatic consumer communities (zooplankton, benthic invertebrates, fish (population estimates)).
Techniques for determination of primary and secondary productivity.

Unit IV

Variety of diversities, selecting and interpreting diversity measures
Diversity indices (Shannon-Wiener diversity indices, Species Richness index) and species-abundance model.

Recommended Books

1. APHA
2. Limnological Methods P S Welch
3. Practical Methods in Ecology P A Henderson Blackwell
4. Methods for Physical & Chemical Analysis of Freshwaters H L Golterman R S Clymo M A M Ohnstad Blackwell Scientific Publications

PAPER TITLE- FRESHWATER BIODIVERSITY

CODE-SLS/HAB/C008

CREDIT-03

COURSE TYPE- CORE

UNIT-I

Freshwater Bacteria, Fungi.

Freshwater Algae (Motile, Non-motile and Filamentous) and Macrophytes of India.

General characteristics and classification of freshwater protozoans (*Amoeba*, *Paramecium*, *Euglena*).

UNIT-II

Characteristic of important freshwater Acoelomate taxa.

Characteristic of important freshwater coelomates.

UNIT-III

Worms; Flat worms, Round worms, Annelids in India.

Molluscs: Gastropods, Bivalves in India.

UNIT-V

Overview of freshwater Insect fauna, Adults, Nymphal, Larval stages in India.

Overview of freshwater fishes.

Recommended Books:

1. Freshwater Biology, W.T. Edmondson, John Willey & Sons, New York Ephemeroptera (May flies) Freshwater invertebrates of United States, R.W. Pennak, John Willey Sons, New York
2. The Ecology of Aquatic Insects, H. Resh and D.M. Roshnberg, Prager Publishers, New York
3. Aquatic Invertebrates of Ganga River System, Hasko et. Al.
4. Freshwater Algae: Identification and use as bio indicators E. G. Bellinger, D C Sigeo Wiley Blackwell
5. Biodiversity & Ecology of Aquatic Environments. H R Singh and P Nautiyal (eds.) Narendra Publishing House, Delhi

UNIT-I

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, factors affecting productivity, regional differences and seasonal variations.

UNIT-II

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

A general account of marine fungi, Seaweeds and seagrasses.

Periphyton: Importance and significance, Different types in lotic and lentic factors influencing periphyton. Role of periphyton in aquatic system.

UNIT-IV

General introduction to microbiology

Micro organisms in freshwater and marine water systems.

Decomposition of organic matter, recycling of nutrients and their significance as an indicator of Aquatic Pollution.

Aquatic bacteriology –Pathogens, distribution prevention and control.

Recommended Books:

1. Alexopoulos, 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. Brock, T.D. (1966): Principles of Microbiology. Prentice Hall, Inc.New Jersey
5. Burrows, W (1956): Text Book of microbiology 16th Ed.W.B.Saunders and Co. Philadelphia.
6. Chapman, V.J. (1976) Mangrove vegetation.J.Gramer, Berlin.
7. Davis C.C. (1955): The Marine and freshwater plankton. Michigan state university press USA.
8. Doetseh, R.N.and Cook, T.M.(1973);Introduction to Bacteria and their ecobiology.University Park Press, Baltimore.
9. Droop.M. R. and Wood E.J.F. (1986): Advances in Microbiology of the sea.Vol.I, Academic press London
10. Ernst, W.G.and Morin, J.G.(1982): Environment of the deep sea Vol.II .Prentice Hall ,N.J.
11. Ferguson, W.E.J.(1967): Microbiology of ocean and Estuaries.Elseveer pub.co Amsterdan.
12. Hawker, L.E. and Linton, A.H.(1971): Micro organisms. Function s form and Environment Edward Arnold Ltd.London.
13. Marris, G.P.(1986) : Phytoplankton Ecology, Chapman and Hall London.

PAPER TITLE- BIODIVERSITY CONSERVATION AND MANAGEMENT
CREDIT-03

CODE- SLS/HAB/C010
COURSE TYPE- CORE

UNIT-I

Strategies for biodiversity conservation, IUCN threat categories, Red data book. Major international conventions pertaining to biodiversity protection, Ramsar convention, CITES, Convention on biological diversity, Megadiversity zones and Hot spots, concepts, distribution and importance.

UNIT-II

In-situ management of biodiversity. Wildlife parks, wildlife reserves, privately owned wildlife reserves & Biosphere reserves; Single species / single habitat based conservation programmes (e.g. Project tiger, Valley of flowers). Introduction to protected area system in India and its role in biodiversity management. Ex-situ management of biodiversity. Role of zoos, biodiversity parks, gene banks, tissue culture etc. in biodiversity management. Introduction to the concepts of captive breeding.

UNIT-III

Role of NGOs in conservation UNEP, GEF, WWF, ATREE, BNHS, WTI, Kalpavriksha etc, Important NGO movements, Chipko movement, Narmada Bachavo Aandholan Pani Panchayats, Seed Movement etc.

UNIT-IV

Current practices employed in the conservation and management of aquatic habitats and inhabitants, Endangered species and restoration ecology. Case studies on Conservation Breeding Programme of endangered wild animals. Wildlife Protection Act 1972, Biological Diversity Act, 2002.

Recommended Books:

1. Environmental law in India by P. Leelakrishnan
2. Environmental law case book by P. Leelakrishnan
3. The Wildlife (Protection) Act 1972, The wildlife (as amended up-to 1991)
4. Animal laws of India by Maneka Gandhi
5. Natural Resources Law and Policy by Zafar Mahfooz Nomani
6. Widening Perspectives on Biodiversity by Anatole F. Krattiger ed.
7. Forest Policy and Law by S.S. Negi
8. Environmental Conservation by S.H. Negi

SEMESTER III
(July to November)

PAPER TITLE- BIOSTATISTICS
CREDIT-03

CODE-SLS/HAB/C013
COURSE TYPE- CORE

UNIT-I

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

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

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

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.

RecommendedBooks

- Kothari, C.R (2009)Research Methodology and Techniques, Delhi: New Age international Publisher.
- DonaldH. Mc Burney (2006) Research Methods, 5thEdition,Thomson Learning.
- ElementaryStatistics PG Hoel, John Wiley & Sons
- Biostatistical Analysis J H Zar, Pearson
- Introduction to Biostatistics Sokal & Rohlf Freeman, Toppan

PAPER TITLE- CLIMATE CHANGE AND AQUATIC BIODIVERSITY
CREDIT-03

CODE- SLS/HAB/C014
COURSETYPE- CORE

UNIT-I

Introduction to Climate Science, Introduction to atmosphere. Global temperature, Fundamentals of physical meteorology, Energy budget and greenhouse effect, Radiative forcing of climate change, Global Warming potential

UNIT-II

Carbon cycle, Carbon emission from fossil fuels, Paleoclimatology, Evidences of climate change; Ice and climate change; Isotope evidence for Climate Change; Heinrich events; Dansgaard-Oeschger events.

UNIT-III

Regional impact of climate change; Predicted Biological impacts, Observed Biological impacts on Species and Ecosystems; Projected impacts of changes in Mean Climate and Extreme Climate Events on Aquatic Ecosystems. Impact of climate change on aquatic biodiversity, Predictions on future responses of ongoing Climate Change on Biodiversity.

UNIT-IV

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

Recommended Books

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

UNIT-I

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.

Araphid Fam & genera *Fragilaria*, *Diatoma*, *Meridion*, *Hannae* in Himalaya.

UNIT-II

Characters of raphidiod and monoraphidiod families

Raphidiod: *Eunotia*

Monoraphids, Achnanthaceae – *Achnantheidium*, *Cocconeis*

UNIT-III

Characters of naviculoid biraphid families

Naviculoid diatom flora Naviculaceae: *Navicula* & *Cymbella sensu lato & sensu stricto*, *Gomphonema*

Other naviculoid diatom flora: *Diploneis*, *Pinnularia*, *Caloneis*

UNIT-IV

Characters of non-naviculoid biraphid families

Bacillariaceae *Nitzschia*, *Denticula*

Epithemiaceae: *Epithemia*

Surirellaceae: *Surirella*

Algal communities in Himalayan lotic, lentic systems, wetlands

Ecological preferences of abundant forms of Himalaya (OMNIDIA)

Recommended Books

1. Diatoms of Europe Vol I to IV Krammer
2. Fresh water Diatoms of Central Gujarat (with a review and some others). H P Gandhi, Bishen Pal Singh, Mahendra Pal Singh, Dehradun
3. Algal flora of Andaman & Nicobar Prasad & Srivastava
4. Ganga: A water marvel, A.C. Shukla and A. Vandana, Ashish Publishing House, New Delhi
5. Hand Book of Blue Green Algae, Bishan Singh Mahendra Pal Singh, Dehradun
6. Manua of Freshwater Algae of Tamilnadu, G.M. Perumal, BSMPS, Dehradun
7. Chloroeoceales (Green Algae) K.K. Jaiswal and G.L. Tiwari, Biomed. Research Society, Allahabad
8. Die Kieseialgen Deutschlands, Österrichs und der Schweiz. HUSTEDT, F. Bd.7, Teil 2. Translated by N. G Jensen as The Pennate Diatoms. Koeltz Scientific Books Koenigstein.

PAPERTITLE-ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

CODE-SLS/HAB/E01B

AND AUDITING

COURSETYPE- ELECTIVE

CREDIT-03

UNIT-I

Introduction to EIA: 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 Environmental Impact assessment, Initial screening, rapid environmental impact assessment, comprehensive environmental assessment. Development activities and requiring environmental impact assessment. Public participation in environmental decision making.

UNIT-III

Cost benefit analysis, relationship between cost of damage and cost of control.
Environmental Impact assessment in India
Case studies of EIA.

UNIT-IV

Environment Management Plan: 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.

Recommended Books

1. Text Book: 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. Reference Book: 1. 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.
6. Morris, Peter and RikiTherivel. 2009. Methods of Environmental Impact Assessment (Natural and Built Environment Series). Routledge

UNIT-I

Introduction to ecotoxicology, Principles of toxicology, scope of toxicology. Types of toxic substances - degradable and non-degradable. Factors influencing toxicity, drug toxicity. Biochemical basis toxicity – mechanism of toxicity and receptor mediated events, acute and chronic toxicity. Sigmoid relationships, Corollary of toxicology. Influence of ecological factors on the effects of toxicity.

UNIT-II

Toxic substances in the environment, their sources and entry routes. Transport of toxicants by air and water: Transport through food chain - bioaccumulation and biomagnifications of toxic materials in food chain. Toxicology of major pesticides- biotransformation, biomonitoring, programs and parameters of biomonitoring, concept of bioindicator, bioindicator groups and examples. Environmental impacts of pesticides: Physiological and metabolic effects on flora and fauna.

UNIT-III

Methods used to assess toxicity classification of toxic materials. Concepts of Bioassay- types, characteristics. Importance and significance of bioassay, Microbial bioassay for toxicity testing, Bioassay test models and classification. Threshold limit value, LC50 LD50. Toxicity Testing, Concept of Dosimetry: lethal, sub-lethal & chronic tests. Dose response curves

UNIT-IV

Organ toxicity. Hepatotoxicity: Common examples of hepatotoxicants, injuries caused to liver • Nephrotoxicity: Common examples of nephrotoxicants, injuries caused to kidney • Pulmonary toxicity: Common examples of pulmonary toxicants, injuries caused to lungs. • Neurotoxicity: Common examples of neuro toxicants, injuries caused to nervous tissues.

Recommended Books

1. Principles of Environmental Toxicology: I. C. Shaw and J. Chadwick; Taylor&Francis Ltd
2. Basic Environmental Health (2001): AnnaleeYassi, TordKjellstom, Theo de Kok, Tee Guidotti
3. Environmental Health : Monroe T. Morgan
4. Handbook of Environmental Health and Safety – principle and practices : H. Koren; Lewis Publishers
5. Moore, G.S., 2002, Living with the Earth: concepts in Environmental Health Science (2 nd Ed.), Lewis publishers, Michigan
6. Walker, C.H., Hopkin, S.P., Sibly, R.M., and Peakall, D.B. 2001. Principles of Ecotoxicology. 2 nd Ed. Taylor & Francis, London.
7. Environmental biology and Toxicology, by Sharma P.D. Rastogi and Lamporary., 1994.
8. Environmental pollution and Toxicology by MeeraAsthana and Astana D.K., Alka printers, 1990. 3. Toxicology, by A.Sood, Sarup and sons New Delhi, 1999
9. Text book of Preventive and Social Medicine, by Park J.E. and Park K., Banosidas Bharat Publishers, Jabalpur, 1985
10. Environmental Epidemiology, by AnisaBasheer, Rawat Publication Jaipur, New Delhi 1995

UNIT-I

Introduction to Remote Sensing (RS) Definition, basics, principles and types of remote sensing, electromagnetic spectrum, radiation laws, atmospheric effects, basics of optical, thermal and microwave remote sensing, history of remote sensing, resolution types, EMR interaction, spectral signatures of different objects, platforms and sensors. Visual image interpretation tools and techniques. Indian satellite missions. Digital image processing (DIP) techniques.

UNIT-II

Geographic Information System (GIS) Basic, principles and components of GIS, spatial information and spatial data types, geographic phenomena, geographic field, geographic objects and boundaries, raster based GIS data processing with both regular and irregular tessellations, vector based GIS data processing and topology, spatial relations, spatial analysis. Map projections and coordinate systems.

UNIT-III

Global Positioning Systems (GPS) Basics of GPS, satellite generation, positioning services, types of Survey of India (SOI) topographical maps, numbering systems of SOI maps, interpretation of SOI topographical maps.

UNIT-IV

Applications and case studies Natural resource management, coastal zone management, forestry and wildlife conservation and management, biodiversity loss due to mining, biodiversity mapping and modelling. The future possible techniques and applications.

Books Recommended:

1. Jensen, John R. 2009. Remote Sensing of the Environment: An Earth Resource Perspective, 2nd Edition. Dorling Kindersley.
2. Joseph, George. 2005. Fundamentals of Remote Sensing, 2nd Edition. University Press India.
3. Lillisand, Thomas, Ralph W. Kiefer and Jonathan Chipman. 2007. Remote Sensing and Image Interpretation. Wiley India.
4. Sabins, Floyd F. 2007. Remote Sensing: Principle and Interpretation. Waveland Press.
5. Jensen, John R. 2004. Introductory Digital Image Processing: A Remote Sensing Perspective. Prentice Hall.
6. Janssen, Lucas L.F., and Grit C. Huurneman. 2001. Principle of Remote Sensing. ITC Educational Text Book series 2. International Institute of Geoinformation Science and Earth Observation (ITC). Enschede.
7. Lo, C.P., and Albert K.W. Yeung. 2009. Concepts and Techniques of Geographic Information Systems, 2nd Edition. PHI Learning.

PAPER TITLE- ENVIRONMENTAL POLLUTION
CREDIT-03

CODE- SLS/HAB/E02B
COURSE TYPE- ELECTIVE

UNIT-I

Air pollution- natural and anthropogenic sources of pollution, primary and secondary pollutants, transport and diffusion of pollutants, gas laws governing the behaviour of pollutants in the atmosphere, Methods of monitoring and control of air pollution, SO₂, NO_x, CO, SPM.

UNIT-II

Water pollution - types sources and consequences of water pollution, physico-chemical and bacteriological sampling, Analysis of water quality, standards, sewage and wastewater treatment and recycling, water quality and standards.

UNIT-III

Soil pollution chemical and bacteriological sampling as analysis of soil quality, soil pollution control, industrial waste effluents and heavy metals and their interactions with soil components.

UNIT-IV

Noise pollution - sources of noise pollution, measurement and indices, Marine pollution, sources of marine pollution and its control, Effects of pollutants on human beings, plants, animals and climate, air quality standards and air pollution.

Recommended Books

1. Air pollution and control - K.V.S.G. Murlikrishan
2. Industrial noise control - Bell & Bell
3. Environmental engineering -Peary
4. Introduction to environmental engineering and science - Gilbert Masters.
5. Watt, K.E.F. (1973). *Principles of Environmental Science*, McGraw – Hill Book Company
6. Achanta, A.N. (1993). *Climate Change Agenda: An Indian Perspective*, Tata Energy Research Institute, New Delhi.

PAPER TITLE- FISHERY SCIENCE

CODE- SLS/HAB/E02C

CREDIT-03

COURSE TYPE- ELECTIVE

UNIT-I

General Morphology and outline classification of fishes - major groups of fishes of the world and their characteristics Identification of fishes of Andaman & Nicobar Islands.

UNIT-II

Basic Anatomy of fish- digestive, circulatory, respiratory, nervous and reproductive systems. Maturation and spawning marine fishes- process of maturation- methods of assessment of spawning- biotic and abiotic factors affecting spawning in fishes.

UNIT-III

Population Dynamics- theory of fishing- unit stock- recruitment- mortality. Migration- fish tagging and marking. Marine fisheries of India- methods of fishery resources survey- acoustic method, survey of fish eggs and larvae, analyzing population features.

UNIT-VI

Principle methods of exploitation of marine fishes- indigenous and modern crafts and gears. Principle methods of fish preservation and processing in India- freezing, canning, pickling, smoking - types of fish spoilage- causative factors.

Recommended Books:

1. Peter B. Moyle, Joseph J. Cech 1990 Fishes: An Introduction to Ichthyology, Prentice Hall.
2. Carl E. Bond 1979 Biology of Fishes. W.B. Saunders Company, Philadelphia. York. 3. Bensam, P., 1999
3. Development of Marine Fisheries Science in India. Daya Publishing House. Simpson G.G.A. Roe & R.C.
4. Lewontin 1966 Quantitative Zoology. Harcourt Brace and Company, New 2. Bal. D.V and K.V Rao 1990.
5. Marine Fisheries of India Tata Mcgraw Hill Pub Co. 3. Biswas K.P 1996. A textbook of Fish, Fisheries and Technology 2nd Edition Narendra Publishing House New Delhi.

SEMESTER IV
(December to April)

PAPER TITLE- FRESHWATER INVERTEBRATE FAUNA OF HIMALAYA
CREDIT-03

CODE- SLS/HAB/C016
COURSE TYPE- CORE

UNIT-I

Characteristics of Acoelomates and Coelomates.
Characters of Protozoa and Rotifers.
Characters of Flat worm, Round worm, Annelid fauna in the Himalaya.

UNIT-II

Characters of Molluscs, Gastropod, Bivalves.
Characters of Insect and Crustacea .
Insect fauna: Adults, Nymphal, Larval stages.

UNIT-III

Characters of insect nymph; Ephemeroptera, Plecoptera, Odonata.
Families of Ephemeroptera in Himalaya, their taxonomy terminology and characters.
Families of Plecoptera, Odonata in Himalaya, their taxonomy terminology and characters.

UNIT-IV

Characters of insect larvae: Trichoptera, Diptera, Lepidoptera, Neuroptera, Coleoptera
Families of Trichoptera larvae, keys.
Families of Diptera larvae, keys.
Families of Lepidoptera, Neuroptera, Coleoptera, Megaloptera larvae, keys.
Characters of adult: Hemiptera, Coleoptera, keys.
Other insect/arthropod/Invertebrate Orders/Class/Phyla.

Recommended Books

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

PAPER TITLE- FRESHWATER FISH FAUNA OF HIMALAYA
CREDIT-03

CODE- SLS/HAB/C017
COURSE TYPE- CORE

UNIT-I

Overview of mountain Fish fauna.

Hill stream adaptations.

Subdivision-Euteleosti, Superorder Ostariophysii: Order Cypriniformes, important characters.

UNIT-II

Family-Cyprinidae, Subfamilies (Rasborinae, Tribe Danionini – *Barilius*, *Danio*, *Rasbora*; Cyprininae Tribe Cyprinini; Subtribe Tores Mahseer; Tribe Systomini

Sub tribe Osteobramae, Sub Tribe Poropunti, Sub Tribe Systomi Puntius; Tribe Semiplotini; Tribe Labeonini; Subtribe Labeones; Subfamily Schizothoracinae (snow trout), Garinae

UNIT-III

loaches: balitoridae subfamily balitorinae and nemacheilinae, cobitidae, subfamily –botinae and cobitinae
order siluriformes family sisoridae

other families bagridae, siluridae, schilbedae, pangasiidae, claridae

UNIT-IV

Other endemic species Superorder Protacanthopterygii, Order Symbranchiformes, Mastacembelidae,
Order Families Perciformes , Channidae

Exotics fish species in Himalaya

Endemic fish fauna of Himalaya

Recommended Books

1. The fauna of British India, including Ceylon and Burma. Fishes 1, Day, F. Taylor and Francis, London, p. 548
2. Fish catching in the Himalayan waters of Nepal. Shrestha, T. K.. R. K. Printers Pvt. Ltd., Teku, Kathmandu, Nepal, 247 pp.
3. Himalayan Ecosystem Series: Fauna of Western Himalaya Part I Uttar Pradesh. (Ed. Director Zoological Survey of India) Zoological Survey of India. Calcutta
4. Fauna of Conservation Area 5: Rajaji National Park.(Ed. Director Zoological Survey of India). Zoological Survey of India. Calcutta.
5. Inland Fishes of India and Adjacent Countries. P. K. Talwar and A. Jhingran, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi Volumes I-II
6. The Freshwater Fishes of the Indian Region. K. C. Jayaram, Narendra Publishing House, Delhi India.
7. Fish and Fisheries of India, V.G. Jhingran, Hindustan Publishing Corporation (India) Delhi.
8. Fishes of North East India - a field guide to species identification. W. Vishwanath, Department of Life Sciences, Manipur University and NATP.

UNIT-I

Research Formulation – Definition, scope and objective, types, approaches, significance; scientific investigation. The research process – The broad problem area, preliminary data collection, problem, selection and definition, theoretical framework, hypothesis development and elements of research design. 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 – 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: 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: Basic concept of paper/thesis writing, Ethical issues, Copy right, Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism; Citation and acknowledgement.

Recommended Books

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.

UNIT-I

Ecology: Basic concepts; scope; multidisciplinary nature and relevance; biosphere and ecosystem; the biosphere concept and its significance; concept, organization and significance of ecosystems; cybernetic nature of ecosystems.

UNIT-II

Factors affecting ecosystem: Major environmental factors (biotic and abiotic)- influences on organism at various ecosystems; concept of limiting factors; Liebig law of the minimum; Shelford law of tolerance.

UNIT-III

Energy flow and trophic dynamics: Energy flow in ecosystems; concept of trophic dynamics and trophic cascade; food chains, food webs and trophic levels; ecological pyramids; energy transfer; ecological efficiencies; biogeochemical cycles (water, oxygen, carbon, nitrogen, phosphorus and sulphur) and man's impact.

UNIT-IV

Productivity: Primary and secondary productivity; methods of estimating productivity; factors affecting primary productivity; world patterns of primary productivity; man's exploitation of primary and secondary production.

Recommended Books

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

UNIT-I

Principle, Methodology and Applications: Electrophoresis, Polymerase Chain Reaction (PCR), Real time PCR

UNIT-II

Introduction to Molecular Markers: Allozyme, Randomly Amplified Polymorphic DNA (RAPD), Restriction Fragment Length Polymorphism (RFLP), Amplified Fragment Length Polymorphism (AFLP), Single Sequence Repeats (SSR), DNA fingerprinting, Single Nucleotide Polymorphism (SNP); Cryopreservation.

UNIT-III

Microscopy: Principle, Types – Light, Phase, Confocal, Fluorescence, Electron Microscopy: Principle, Types SEM, TEM

UNIT-IV

Spectroscopy: Principle, UV-VIS, AAS; Chromatography: Principles, Types – Paper, HPLC, Gas; Electrophoresis: Principle, Gel, Disc-Gel, Slab Gel

Recommended Books:

1. D.A. Skoog,(2000), Principles of Instrumental analysis, fifth edition , Saunders college publication. D.H. Williams and J.Fleming(1995), Spectroscopic methods onn organic chemistry, Sixth edition , McGraw Hill.
2. B.K. Sharma (2007), Instrumental methods of chemical analysis, Krishna prakash media
3. J.Willard(1999), Instrumental methods of analysis, seventh edition , CBS publishers.

SUBJECTS UNDER SELF STUDY COURSES

PAPER TITLE-WETLAND MANAGEMENT

CODE- SLS/HAB/SS01

CREDIT-03

COURSE TYPE- SELF STUDY

UNIT-I

Wetlands: Definitions, origin of wetlands, types, wetland classification systems, Ramsar Convention, Ramsar sites in India) Wetland ecosystems ecology: Freshwater, marine, estuarine, with respect to hydrology, productivity, detrital accumulation, and biodiversity, biological adaptations to the wetland environment (plants and animals)

UNIT-II

Wetlands biogeochemistry: Nutrient cycling (carbon, phosphorous, nitrogen), eutrophication, Trophic State Index, greenhouse gas emissions, methanogenesis- paddy field, carbon sequestration, carbon models, wetlands as treatment filters, wetlands and climate change, permafrost.

UNIT-III

Wetland bioassessment and biocriteria: biological assemblages, Index of Biological Integrity (IBI), functional assessment of wetlands Wetland conservation and action plans: Landscape ecology, wetland metrics, rate of wetland loss, wetlands catchments and water storage, wetlands and flood control, GAP analysis, wetland conservation in India, Management effectiveness of Ramsar sites, national parks and bird sanctuaries, wetland regulations. Add few case studies.

UNIT-IV

Remote sensing and GIS applications: Wetland inventories, information systems, biodiversity conservation, greenhouse gas emissions, nutrient cycling, measuring wetlands loss.

Recommended Books

1. Mitsch, W.J. and J.G. Gosselink, 2007. Wetlands, 4th edition, John Wiley & Sons.
2. Van Der Valk, Arnold G., and Arnoud Van Der Valk. 2012. The Biology of Freshwater Wetlands. Oxford University.
3. Reference Book:1. Odum, Edward U. 1973.Fundamentals of Ecology, 3rd Edition, W.B. Saunders.
4. Maltby, Edward, and Tom Barker. 2009. The Wetlands Handbook, Wiley–Blackwell.
5. Reddy, K. Ramesh, and Ronald D. Delaune. 2008. Biogeochemistry of Wetlands: Science and Applications, CRC

UNIT-I

Earth Resources: Atmosphere, lithosphere, hydrosphere Interior of Earth, geological work of wind and water, underground water, igneous, sedimentary and metamorphic rocks, mineral types, mineral resources of India, erosion and weathering, soil formation, soil profiles, types of erosion, estimation of soil loss, landuse and landuse planning, earth resource mapping and the use of remote sensing and GIS

UNIT-II

Water Resources: hydrology, the hydrological cycle and its components, drainage systems, classification of water resources, characteristics of water resources. Surface run-off, stream flow estimation, problems of water and ground water resource depletion, watershed types and Functions

UNIT-III

Natural Hazards: Flood types and causes, drainage basins, nature and frequency of floods, effects. Flood hydrographs., types and causes of landslides, coastal hazards including cyclones, tsunamis, the effects of tides and tidal effect prediction, earthquake seismology, causes, intensity and magnitude of earthquakes, geographic distribution of earthquakes zones, nature of destruction, causes and consequences of forest fires

UNIT-IV

Applications for management: Soil and water conservation measures, erosion control, case studies in water resource conservation and management, flood management and control, landslide control and mitigation measures, coastal zone management, watershed management and case studies, earthquake mitigation for buildings and dams, forest fire mitigation and management,

Recommended Books

1. Text Book: 1. Roy, A.B. 2010.Fundamentals of Geology.
2. Singh, Rajvir. 2000. Watershed Planning and Management. Yash.
3. Wallace, John M., and Peter V. Hobbs. 1997. Atmospheric Science : An Introductory Survey, Academic Press.
4. Bocker, Egbort, and Rienk Van Grondille, 1999.Environmental Physics.John Wiley & Sons.
5. Murthy, V.V.N. 2009. Land and Water Management, 5th edition.Kalyani Publishers.
6. Heathcote, I.W. 1988. Integrated Watershed Management: Principles and Practice.John Wiley.
7. Raganuth, H.M. 2007. Hydrology: Principles, Analysis and Design, 3rd edition. New Age International. Dennen, William H., and Bruce R. Moore. ?Geology and Engineering.Wm C Brown Publisher.

PAPER TITLE- ENVIRONMENTAL POLICY, EDUCATION AND ETHICS

CODE- SLS/HAB/SS03

CREDIT-03

COURSE TYPE- SELF STUDY

UNIT-I

Important national policies: National environmental policy, 2006; national forest policy-1894,1952,and 1988; national water policy 2002 and other policies e.g. national biotechnology policy, national agricultural policy etc.

UNIT-II

Legislation: The wildlife protection act 1972 with amendment; the Indian forest act,1927; biodiversity act,2002; environment protection act,1986

UNIT-III

Environmental education: Goals and objectives of environmental education; components of environmental education; environmental education in India; value education; objectives, environmental values, valuing nature and cultures. Environment awareness and action: Role of NGOs in environmental awareness; environmental movements in India- silent valley movement, chipko movement, narmada bachao andolan; environmental movements in the west- greenpeace, sierra club etc.; international efforts and government action.

UNIT-IV

Environmental ethics: Definition, history, scope and basic concepts; anthropocentrism, biocentrism and ecocentrism; deep ecology; ecofeminism; ecocentrism in indigenous societies and culture; ethics of pollution by xenobiotics; ethics of global climate change; ethics of pesticide use. Essential readings

Recommended Books:

1. Anonymous (1997). The Indian forest act, 1927 along with forest conservation act, 1980. Natraj Publisher's Dehradun. Guha, R. (1989).
2. The Unquiet woods. Oxford University Press. Guha, R. (Ed.). (1994). Social ecology. Oxford University Press Martell, L. (1994).
3. Ecology and society: an introduction. Polity press, Cambridge, U.K. Hayward, I.M. (1995).
4. Ecological thought:an introduction. Polity press, Cambridge.

PAPER TITLE-ENVIRONMENTAL BIOLOGY

CODE- SLS/HAB/SS04

CREDIT-03

COURSE TYPE- SELF STUDY

UNIT I

Introduction to Environmental biology, its multidisciplinary nature and scope.
Components of Environment: atmosphere, lithosphere & hydrosphere.
Climate (micro, regional and global); Hydrological cycle; Soil profile.
Changing interactions between man and environment (cultural, political, ecological).

UNIT II

Terrestrial biomes of the world their characteristics and major biota (Grassland, Desert, Forest, Tundra).
Aquatic biomes (lotic, lentic, marine, estuaries, coral reef), their status.
Wetlands of India. Environmental adaptations: Aquatic, Aerial, Desert, Arboreal, Fossorial, Defensive.

UNIT III

Island biogeography theory.
Habitat fragmentation, Habitat selection, Corridors, Community patterns (gradients and Continuum),
Community indices. Ecological niche.
Population cycles and fluctuations; Dispersal. Intra & Inter specific relationship.
Models of succession; Pioneer & climax concept.

UNIT IV

Concept of biological indicators; biological monitoring; Indicator organisms.
Invasive species and its impact.
Biological control: Biomagnification, Bioassimilation & Bioaccumulation.
Xenobiotics: Carcinogenic (heavy metals, pesticides).

Recommended books

1. Ecology and Field Biology, by Robert L. Smith
2. Ecology and Biogeography in India, Mani, M.S
3. Fundamental of ecology, Eugene Odum.
4. Essentials of Conservation Biology, Primack, R. 2006. Sinauer Associates, Inc., USA.
5. Smith, R. L. and Smith, T. M. 2014. Elements of Ecology. Benjamin-Cummings Publishing Company.
6. Hamilton, M. 2009. Population Genetics. Wiley-Blackwell Publications, USA