Department of Fisheries Science

B.F.Sc (Aquaculture)

Course Contents & Syllabi

SRI DEV SUMAN UTTARAKHAND University
Badshahithol, Tehri (Grahwal)
Uttarakhand

To,

The Honorable Vice Chancellor,

Sri Dev Suman Uttarakhand University,

Badshahithol,Tehri (Garhwal) Uttarakhand

Sub :- Syllabus of BF.Sc (Aquaculture) in semester system.

Sir,

Please find enclosed the syllabus of BF.Sc (Aquaculture as per the semester system.

Thanking you,

Yours sincerely,

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Department of (Zoology) BioSciences,

Baba Farid Institute of Technology Uttarakhand Technical University

Dehra Dun, Uttarakhand Dehra Dun, Uttarakhand

Bechular Of Fishries Science (Aquaculture)

FIRST SEMESTER (Theory & Practicals)				
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC- 101	SUSTAINABLE AQUACULTURE	60	40
2	BFSc-AQC-102	SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE	60	40
3	BFSc-AQC-103	NUTRITION AND FEED TECHNOLOGY	60	40
4	BFSc-AQC-104	AQUATIC ANIMAL HEALTH MANAGEMENT	60	40
5	BFSc-AQC-105	HATCHERY SEED PRODUCTION OF FINFISHES	60	40
6	BFSc-AQC-106	Practical 1 (Based on paper 1 & 2)	60	40
7	BFSc-AQC-107	Practical 1 (Based on paper 1 & 2)	60	40

SECOND SEMESTER (Theory & Practicals)				
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC- 201	SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES	60	40
2	BFSc-AQC-202	APPLIED GENETICS IN AQUACULTURE	60	40
3	BFSc-AQC-203	NON-FOOD AQUACULTURE	60	40
4	BFSc-AQC-204	FRESHWATER AQUACULTURE	60	40
5	BFSc-AQC-205	FISH FOOD ORGANISMS	60	40
6	BFSc-AQC-206	Practical 1 (Based on paper 1 & 2)	60	40
7	BFSc-AQC-207	Practical 1 (Based on paper 1 & 2)	60	40

THIRD SEMESTER (Theory & Practicals)				
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC- 301	AQUACULTURE ENGINEERING	60	40
2	BFSc-AQC-302	ADVANCES IN AQUACULTURE PRODUCTION SYSTEMS	60	40
3	BFSc-AQC-303	ADVANCES IN SEED PRODUCTION	60	40
4	BFSc-AQC-304	AQUACULTURE AND ECOSYSTEM MANAGEMENT	60	40
5	BFSc-AQC-305	AQUATIC ANIMAL HEALTH MANAGEMENT	60	40
6	BFSc-AQC-306	Practical 1 (Based on paper 1 & 2)	60	40
7	BFSc-AQC-307	Practical 1 (Based on paper 1 & 2)	60	40

	FOURTH SEMESTER (Theory & Practicals)			
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC- 401	FISH AND SHELLFISH PHYSIOLOGY	60	40
2	BFSc-AQC-402	ADVANCES IN FISH GENETICS	60	40
3	BFSc-AQC-403	INTENSIVE FARMING SYSTEM HILL STREAM TROUT	60	40
4	BFSc-AQC-404	AQUACULTURE DEVELOPMENT PLANING AND MANAGEMEN	60	40
5	BFSc-AQC-405	APPLIED AQCUCULTURE BIOTECHNOLOGY	60	40
6	BFSc-AQC-406	Practical 1 (Based on paper 1 & 2)	60	40
7	BFSc-AQC-407	Practical 1 (Based on paper 1 & 2)	60	40

	FIFTH SEMESTER (Theory & Practicals)			
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC- 501	AQUATIC ENVIRONMENT AND BIODIVERSITY	60	40
2	BFSc-AQC-502	CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT	60	40
3	BFSc-AQC-503	AQUATIC POLLUTION AND WASTEWATER MANAGEMENT	60	40
4	BFSc-AQC-504	ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT	60	40
5	BFSc-AQC-505	AQUACULTURE ANALYTICAL TECHNIQUE	60	40
6	BFSc-AQC-506	Practical 1 (Based on paper 1 & 2)	60	40
7	BFSc-AQC-507	Practical 1 (Based on paper 1 & 2)	60	40

	SIXTH SEMESTER (Theory & Practicals)			
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC- 601	AQUACULTURE TOXICOLOGY	60	40
2	BFSc-AQC-602	COSTAL AQUACULTURE	60	40
3	BFSc-AQC-603	AQUACULTURE MICROBIOLOGY	60	40
4	BFSc-AQC-604	ADVANCES IN AQUATIC ENVIRONMENTAL STUDIES	60	40
5	BFSc-AQC-605	BENTHIC ECOLOGY	60	40
6	BFSc-AQC-606	Practical 1 (Based on paper 1 & 2)	60	40
7	BFSc-AQC-607	Practical 1 (Based on paper 1 & 2)	60	40

	SEVENTH SEMESTER (Theory & Practicals)			
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC- 701	ENVIRONMENT IMPACT ASSESSMENT	60	40
2	BFSc-AQC-702	MANAGEMENT AND UTILIZATION OF WASTEWATER	60	40
3	BFSc-AQC-703	CARDIO-VASCULAR SYSTEM AND RESPIRATORY PHYSIOLOGY	60	40
4	BFSc-AQC-704	AQCACULTURE IMMUNOBIOLOGY	60	40
5	BFSc-AQC-705	PHARMACO-BIOLOGY OF AQUACULTUR DRUGS	60	40
6	BFSc-AQC-706	Practical 1 (Based on paper 1 & 2)	60	40
7	BFSc-AQC-707	Practical 1 (Based on paper 1 & 2)	60	40

	EIGHT SEMESTER (Theory & Practicals)			
Sr.No.	Subject Code	Subject Name	External Theory Marks Max. Passing marks 40% in each paper	Internal Theory Marks
1	BFSc-AQC-801	Project training (min 90 days, max.180 days)	150	50

Bechular of Fisheries Science in AQUACULTURE
Course Contents
Semester I

BFSc-AQC- 101 SUSTAINABLE AQUACULTURE 2+1

Objective:To gain in depth knowledge and field exposure on sustainable aquaculture practices.

Theory

UNIT I

Present scenario and problems: Trends in global and Indian aquaculture;different farming systems; intensive systems and constraints -environmental degradation and disease outbreaks.

UNIT II

Sustainability and development: Systems approach and its application in aquaculture with special reference to resource-poor systems; Role of aquatic resources in food and nutrition; Aquatic resource and livelihood systems.

UNIT III

Environmental issues: Exotic species introduction; escapement;contamination of indigenous gene pool; salinization of soil and water;environmental impact; over exploitation of wild stocks; mangrove deforestation.

UNIT IV

Socio-economic issues: Conflicts over water and land use; conflicts of interest between aqua farmers and fishermen; resistance from local public;anti-dumping duties.

UNIT V

Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; integrated farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability.Application of renewable energy in aquaculture - solar energy, wind, and tidal energy.

Practical

Visit to conventional aquafarm to see the management of used water;Survey on environmental impact nearby aquaculture farms; Setting modelfor sustainable aquaculture (organic farm, integrated farm); Applications of remote sensing and GIS (geographical information system); Economic evaluation of aquaculture practices.

Suggested Readings

Bardach JE. 1997. *Sustainable Aquaculture*. John Willey & Sons.

Bardach JE, Rhyther JH & Mc. Larney WO. 1972. *Aquaculture Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.

Beets WC. 1990. *Raising and Sustaining Productivity of Small-Holder Farming Systems in the Tropics*. Agbe Publ.

Edwards P, Little DC & Demaine H. (Eds.). 2002. *Rural Aquaculture*.CABI.

FAO 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO.

Imai T. 1978. *Aquaculture in Shallow Seas. Progress in Shallow Sea Culture*. Amerind Publ.

James PM. 1983. *Handbook of Mariculture*. Vol. I. *Crustacean Aquaculture*. CRC Press.

Leung P, Lee CS & O'Bryen JP. (Eds.). 2007. *Species and System Selection for Sustainable Aquaculture*. Blackwell Publ.

Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*.Chapman & Hall.
Selvamani BR & Mahadevan RK. 2008. *Aquaculture, Trends and Issues*.Campus Books International.

BFSc-AQC 102: SOIL AND WATER QUALITY MANAGEMENT IN AQUACULTURE 2+1

Objective: To learn effective soil and water quality management practices.

Theory

UNIT I

Soil and water interaction: Physical and chemical properties of soil and water, Productivity vs nutrient quality and quantity of soil and water; aquatic microorganisms and their role in carbon, nitrogen, phosphorus and sulphur cycles and impact on aquatic habitats and species.

UNIT II

Soil and water quality monitoring: soil and water quality standards; soil and water quality monitoring and management.

UNIT III

Fertilizers and manures: Different kinds of fertilizers and manures,fertilizer grade, source, rate and frequency of application, Biofertilizers,Use of treated sewage for pond fertilization, Ecological changes taking place after fertilizing, Primary production, degradation of molecules in aquatic environment, Utilization of bioactive compounds by microorganisms.

UNIT IV

Soil and water quality management: Cat clay/pyrite soil, seepage, water treatment, water filtration devices, aeration, chlorination, ozonization and UV radiation, Algal bloom control, eutrophication,

UNIT V

Aquatic weed management, Waste water treatment practices, Water quality management in hatcheries, Waste discharge standards, Role of microorganisms in fish production, fish health and fish safety; Microbial load and algal blooms.

Practical

Equipment used in soil and water analysis; Soil sampling, determination of soil moisture and bulk density; pond filling, analyses of mud acidity and soil texture; Measurements of temperature, pH, conductivity, salinity, transparency, turbidity and solids; Analyses of dissolved oxygen, alkalinity and hardness, phosphorus, nitrogen; Estimation of primary productivity and chlorophyll; Application of fertilizers and pond liming; Analysis of toxic elements; Microbial techniques; Visit to effluent treatment plant; Design and operation of biological filters.

Suggested Readings

Adhikari S & Chatterjee DK. 2008. *Management of Tropical FreshwaterPonds*. Daya Publ.

APHA, AWWA, WPCF. 1998. Standard Methods for the Examination of Water and Wastewater, 20th Ed. American Public Health Association, American Water Works Association, and Water Pollution Control Federation, Washington, D. C.

Boyd, C. E. and Tucker, C. S. 1992. Water Quality and Pond Soil Analyses for Aquaculture, Alabama Agricultural Experimental Station, Auburn University.

Boyd CE. 1979. *Water Quality in Warm Water Fish Ponds*. Auburn University.
ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.
Parsons TR, Maita Y & Lalli CM. 1984. *A Manual of Chemical and Biological Methods for Seawater Analysis*. Pergamon Press.
Rajagopalsamy CBT & Ramadhas V. 2002. *Nutrient Dynamics in Freshwater Fish Culture System*. Daya Publ.
Sharma LL, Sharma SK, Saini VP & Sharma BK. (Eds.). 2008.*Management of Freshwater Ecosystems*. Agrotech Publ. Academy.

BFSc.AQC 103: NUTRITION AND FEED TECHNOLOGY 2+1

Objective: To create basic understanding on the nutritional requirements of fish/shellfish and feed manufacture.

Theory

UNIT I

Fish nutrition: Principles of fish nutrition and terminologies, nutritional requirements of cultivable finfish and shellfish: larvae, juveniles and adults.

UNIT II

Nutritional biochemistry: Classification, nutrient quality and evaluation of proteins, lipids and carbohydrates.

UNIT III

Role of nutrients: amino acids, fatty acids, proteins, lipids, carbohydrates,vitamins and minerals.

UNIT IV

Nutritional bioenergetics: Fish as an open thermodynamic system, Energy requirement of fishes, protein to energy ratio, digestible energy, nitrogen balance index, protein sparing effect, high energy feeds, isocaloric diets, Optimal foraging theory, Mathematical modeling of ingestion, Metabolic rate, Energy budgets, Energetic efficiency of fish production.

UNIT V

Nutritional physiology: Digestion, accretions and nutrient flow, Factors affecting digestibility.
Antinutritional factors and antimetabolites, microbial toxins, methods of elimination, nutrient deficiency and symptoms. Nutritional value of feed ingredients and live feed,Contribution from natural food to nutrient requirements of fish

Practical

Formulation and preparation of a balanced fish feed; Feeding trials;Proximate analysis- moisture, crude protein, crude lipid ,ash , acid insoluble ash content of feed; Estimation of crude fibre, nitrogen free extract, calcium and phosphorus content of feed; Estimation of protein and lipid quality; Determination of gross energy content of feed and feed ingredients;Determination of the digestibility of feed using markers; Estimation of FCR from feeding trials and preparation of feeding table; Estimation of growth parameters from feeding trials; Analysis of mycotoxins from feed ingredients/feed; Gut content analysis to study artificial and natural food intake. Visit to feed manufacturing units.

Suggested Readings

ADCP (Aquaculture Development and Co-ordination Programme). 1980.*Fish Feed Technology*. ADCP/REP/80/11. FAO.
Cyrino EP & Bureau D & Kapoor BG. 2008. *Feeding and DigestiveFunctions in Fishes.* Science Publ.

D' Abramo LR, Conklin DE & Akiyama DM. 1977. *Crustacean Nutrition:Advances in Aquaculture*. Vol. VI. World Aquaculture Society,Baton Roughe.
De Silva SS & Anderson TA. 1995. *Fish Nutrition in Aquaculture*.Chapman & Hall Aquaculture Series.
Elena M. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*. Science Publishers.
Guillame J, Kaushik S, Bergot P & Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis Publ.
Halver J & Hardy RW. 2002. *Fish Nutrition*. Academic Press.Halver JE & Tiews KT. 1979. *Finfish Nutrition and Fishfeed Technology*.Vols. I, II Heenemann, Berlin.
Hertrampf JW & Pascual FP. 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer.
Houlihan D, Boujard T & Jobling M. 2001. *Food Intake in Fish*. Blackwell.
Lavens P & Sorgeloos P. 1996. *Manual on the Production and Use of LiveFood for Aquaculture*. FAO Fisheries Tech. Paper 361, FAO.Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Chapman & Hall.
New MB. 1987. *Feed and Feeding of Fish and Shrimp. A Manual on the Preparation and Preservation of Compound Feeds for Shrimp and Fish in Aquaculture*.
NRC (National Research Council). 1993. *Nutrient Requirements of Fish*.National Academy Press, Washington.
Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry*. Daya Publ.

BFSc-AQC 104 :AQUATIC ANIMAL HEALTH MANAGEMENT 2+1

Objective:To provide holistic knowledge on fish and shellfish pathogens and their control measures.

Theory

UNIT I

Basics of fish and shellfish health management: Host-pathogen-environment relationship, Management of culture systems, Environmental stress.

UNIT II

Defence system in fish and shellfish: Defence systems in fish, innate and acquired immunity, inflammation response to diseases. Antibody and cell mediated immunity in fish and shellfish.

UNIT III

Parasitic and mycotic diseases: General characteristics, Epizootiology,Diagnosis, Life cycle, Prevention and treatment. Infectious bacterial and viral diseases: General characteristics, Epizootiology,Diagnosis, Prevention and treatment

UNIT IV

Non-infectious Diseases: Nutritional diseases, water, soil, environmental parameters and their effects on fish health. Disease in hatcheries and growout systems

UNIT V

Techniques in health management: Microbiological, haematological,histopathological, immunological and molecular techniques. Disease surveillance and reporting. Disease control and management: Environment management. Fish health and quarantine systems.Seed certification, SPF and SPR stocks - development and applications

Practical

General procedures for disease diagnosis; Taxonomy and identification of fish parasites; Sampling, preparation of media and culture of pathogenic bacteria;Techniques for bacterial

classification; Histological techniques for disease diagnosis; Molecular and immunological techniques; Biochemical tests;PCR; ELISA; Agglutination test; Challenge tests; Purification of virus; Stress related study of fish and shellfish; Disease treatments.

Suggested Readings

Aline W. 1980. *Fish Diseases*. Springer Verlag.

Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*.Salamander Books.

Austin B & Austin DA. 1987. *Bacterial Fish Pathogens* (Diseases in Farmand Wild). Ellis Harward.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *FishDisease Diagnosis and Health Management*. Fisheries College and Research Institute, T.N. Veterinary and Animal Sciences University. Thoothukkudi.

Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish*.Blackwell.

Iwama G & Nakanishi T. (Eds.). 1996. *The Fish Immune System -Organism, Pathogen and Environment*. Academic Press.

Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.Schaperclaus W. 1986. *Fish Diseases*. Vols. I, II. Oxonian Press.

Shankar KM & Mohan CV. 2002. *Fish and Shellfish Health Management*.UNESCO Publ.

Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*.Vols. I, II. 2nd Ed. Academic Press.

Walker P & Subasinghe RP. (Eds.). 2005. *DNA Based MolecularDiagnostic Techniques: Research Needs for Standardization andValidation of the Detection of Aquatic Animal Pathogens and Diseases*. FAO Publ.

Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.

BFSc-AQC 105: HATCHERY SEED PRODUCTION OF FINFISHES 2+1

Objective:To learn seed production and hatchery management of commercially important cultivable fishes.

Theory

UNIT I

Introduction: History, constraints and current status of natural seed collection and hatchery seed production.

UNIT II

Reproductive biology: Physiology and morphology; Molecular and physiological basis of reproduction, Overview of current developments in reproductive biology.

UNIT III

Gamete maturation and development: Spermatogenesis and oogenesis,Hormonal pathways and mode of control.

UNIT IV

Environmental and endocrine control of reproduction: Reproductive cycles,Seasonality (Photoperiod, change in water quality and quantity, temperature,lunar cycle, etc.), Environmental and exogenous hormonal stimuli.

UNIT V

Induced spawning: Methods of natural and artificial fertilization, GnRH an Linpe models, evaluation of milt and egg, cryopreservation technique, use of different synthetic hormones and

analogues for induced spawning, Egg staging, Stripping and fertilization.Hatchery technology for different species: Indian major and minor carps,Exotic carps, Catfishes, Tilapia, Masheer, Trout, etc.

Practical

Study of gonadal development in carps and other cultivable finfishes;Identification of carp and catfish seed; Collection and identification of cultivable brackishwater finfish seed; Packing and transportation of cultivable finfish seed; Induced breeding of fishes through various inducing agents; Evaluation of carp milt and egg; finfish; Rearing of carp spawn and fry; Visit to different finfish hatcheries.

Suggested Readings

FAO. 1992. *Manual of Seed Production of Carps*. FAO Publ.

ICAR. 2006. *Hand Book of Fisheries and Aquaculture*. ICAR.

Jhingran VG & Pullin RSV. 1985. *Hatchery Manual for the Common, Chinese and Indian Major Carps*. ICLARM, Philippines.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ.

Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.

Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

Pillay TVR & Kutty MN. 2005. *Aquaculture- Principles and Practices*.Blackwell.

Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.

Thomas PC, Rath SC & Mohapatra KD. 2003. *Breeding and SeedProduction of Finfish and Shellfish*. Daya Publ.

Semester-II

BFScAQC 201: SEED PRODUCTION AND HATCHERY MANAGEMENT OF SHELLFISHES 1+1

Objective:To provide overall knowledge of seed production and hatchery management of commercially important cultivable crustaceans and molluscs.

Theory

UNIT I

Introduction: Current status; problems and prospects.

UNIT II

Seed resources: Site selection and techniques of collection; identification and segregation of shellfish seed.

UNIT III

Reproductive biology: Gonad anatomy, endocrinology and reproductive mechanisms in prawns, shrimps, crabs, lobsters, mussels, oysters, scallops and clams; age at first maturity; factors affecting maturation and spawning.

UNIT IV

Broodstock: availability; improvement; nutritional requirements; transport;captive rearing and maturation; induced spawning; physical and chemical inducing agents; physiology and techniques of eyestalk ablation.

UNIT V

Seed production: Seed production of commercially important prawns,shrimps, crabs, lobsters, mussels, edible oysters, pearl oyster, scallops,clams and sea cucumber.Hatchery technology and management: Site selection and facilities required;culture and use of different live feed in shellfish hatcheries; larval diseases.

Practical

Layout and design of prawn and shrimp hatcheries; Study of gonad development in different cultivable crustaceans and molluscs; Collection and identification of shellfish seed; Packing and transportation of shellfish seed; Eyestalk ablation technique; Identification of larval stages of shrimp, prawn, crab, mussel and oyster;

Suggested Readings

CMFRI Bulletin. 1987. *National Seminar on Shellfish Resources and Farming*.

FAO. 2007. *Manual for Operating a Small Scale Recirculation Freshwater Prawn Hatchery*.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Jhingran VG. 1991. *Fish and Fisheries of India*. Hindustan Publ. Corp.

Landau M. 1992. *Introduction to Aquaculture*. John Wiley & Sons.

Mcvey JP. 1983. *Handbook of Mariculture*. CRC Press.

Pillay TVR & Kutty MN. 2005. *Aquaculture - Principles and Practices*.Blackwell.

Thomas PC, Rath SC & Mohapatra KD. 2003. *Breeding and Seed Production of Finfish and Shellfish*. Daya Publ. House.

BFSc:AQC 202: APPLIED GENETICS IN AQUACULTURE 2+1

Objective:To impart knowledge on genetic basis of inheritance and breeding plans for commercially important fishes.

Theory

UNIT I

Introduction: Origin and advancement in genetics; physical basis of heredity; genetic correlation, domestication and local adaptation.

UNIT II

Chromosome manipulation: Ploidy induction methods - triplody and tetraploidy, advantages and disadvantages of polyploids, androgenesis and gynogenesis.

UNIT III

Sex determination: Sex differentiation and sex reversal in fishes, sex control and its role in aquaculture.

UNIT IV

Selection: Scope, application and methods of selection, marker assisted selection-biochemical and molecular markers. Molecular tools for stock differentiation for selection.

UNIT V

Hybridization: Heterosis, hybrid vigour, introgression.Inbreeding: Methods of estimation, inbreeding depression andconsequences, measures to reduce inbreeding in hatcheries.

Conservation genetics: Genetic resources of India and conservation,endangered species, cryopreservation of fish gametes.Cytogenetics: Importance and karyotyping.

Practical

Estimation of gene and genotype frequencies; Exercises on Hardy-Weinberg equation; stimation of inbreeding coefficient; Protocol of androgenesis and gynogenesis; Protocol of ryopreservation of milt;Karyotypic studies; Isolation of DNA from fish blood.

Suggested Readings

Carvalho GR & Pitcher TJ. (Eds.). 1995. *Molecular Genetics in Fisheries*.

Chapman & Hall.Falconer DS & Mackay. 1996. *Introduction to Quantitative Genetics*. 4th Ed. Longman. Kanakaraj P. 2001. *A Text Book on Animal Genetics*. International Book Distributing Co.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*.Dominant Publ.

Padhi BK & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes.Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics and Aquaculture Biotechnology*. Science Publ.

Purdom CE. 1993. *Genetics and Fish Breeding*. Chapman & Hall.

Reddy PVGK. 2005. *Genetic Resources of Indian Major Carps*. FAO Publ.

Reddy PVGK, Ayyappan S, Thampy DM & Krishna G. 2005. *Text book of Fish Genetics and Biotechnology*. ICAR.

Ryman N & Utter F. (Eds.). 1988. *Population Genetics and Fishery Management*. Washington Sea Grant Programmes, USA.

Tave D. 1996. Genetics for Fish Hatchery Managers. 2nd Ed. AVI Publ.Thorpe JE, Gall GAE, Lannan JE & Nash CE. (Eds.). 1995. *Conservation of Fish and Shellfish Resources*, *Managing Diversity*.

BFScAQC 203: NON-FOOD AQUACULTURE 1+1

Objective:To impart knowledge on ornamental fish production, pearl production, bait fish culture and aquatic ornamental plant propagation.

Theory

UNIT I

Aquarium fish trade: Present status; potential; major exporting and importing countries; species-wise contribution of freshwater and marine fishes; contribution of culture and capture;

UNIT II

Breeding techniques: Reproductive biology, captive breeding and rearing of freshwater, brackishwater, marine ornamental fishes and invertebrates.

UNIT III

Aquarium keeping: Design and construction of tanks; species-wise tank size requirement; heating, lighting, aeration and filtration arrangements;decorations used; common aquarium plants and their propagation; Feed,health and water quality management; prophylaxis; quarantine.

UNIT IV

Value addition: Colour enhancement; genetic manipulation and production of new strains; hybrids; acclimatization strategies for marine ornamental fish to freshwater.

UNIT V

Pearl Production: Overview of pearl trade, pearl oysters and mussels of commercial importance; anatomy, biology and seed production, techniques of implantation, method of rearing and harvesting of pearl, Mable pearlroduction, processing and quality evaluation of pearls, pearl production bytissue culture.

Practical

Identification of common freshwater aquarium fishes and breeding trials of selected freshwater fishes; Identification of common brackish water and marine aquarium fishes; Aquarium fabrication, setting and maintenance;Preparation of powdered and pelleted feed for ornamental fishes; Visit to ornamental fish farms; Study of bacterial, viral, fungal diseases of ornamental

Suggested Readings

Axelrod HR & Vorderwinkler W. 1978. *Encyclopaedia of Tropical Fishes*.TFH Publ.

Axelrod HR & Sweenen ME. 1992. *The Fascination of Breeding Aquarium Fishes*. TFH Publ.

Axelrod HR. 1967. *Breeding Aquarium Fishes*. TFH Publ.

ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Mills D. 1981. *Aquarium Fishes*. Kingfisher Books.

Sanford G & Crow R. 1991. *The Manual of Tank Busters*. Salamander Books.

Saxena A. (Ed.). 2003. *Aquarium Management*. Daya Publ.

Spotte S. 1979. *Fish and Invertebrate Culture*. John Wiley & Sons.

Thabrow De WV. 1981. *Popular Aquarium Plants*. Thornbill Press.

BFSc-AQC 204: FRESHWATER AQUACULTURE 2+1

Objective:To gain knowledge on fish and prawn farming in different culture systems.

Theory

UNIT I

Introduction: Present status, problems and scope of fish and prawn farming in global and Indian perspective.

UNIT II

Aquaculture systems: Extensive, semi-intensive and intensive culture of fish, Pen and cage culture in lentic and lotic water bodies, polyculture, composite fish culture.

UNIT III

Fish farming: Nursery and grow-out, pond preparation, stocking, feeding and water quality management in the farming of major and minor carps, magur,singhi, murrels, tilapia, pangasius, freshwater turtle, etc.; Stunted seed production and culture practice.

UNIT IV

Freshwater prawn farming: Monoculture practice of prawn in ponds, allmale culture and its advantages, polyculture with carps, prawn farming in inland saline soils. Nursery rearing, sex segregation, pond preparation,stocking, feeding and water quality management, disease prevention and treatment; harvesting and handling.

UNIT V

Integrated farming systems: Design, farming practices, constraints and economics of IFS of fish with paddy, cattle, pig, poultry, duck, rabbit, etc.Economics of different fish farming systems.

Practical

Identification of commercially important cultivable fish and prawn species;Assessment of seed quality- stress test; Calculating carrying capacity of pond and stocking density; Check tray assessment and feed ration calculation; Sampling procedure and growth assessment; Lime and fertilizer requirement calculations; Farm visits; Modeling of different culture systems.

Suggested Readings

AAHRI. 1998. *Health Management in Shrimp Ponds*. Aquatic Animal Health
Research Institute (AAHRI), Department of Fisheries, Thailand.
Agarwal SC. 2008. *A Handbook of Fish Farming*. 2nd Ed. Narendra Publ.House.
Beveridge MCM & Mc Andrew BJ. 2000. *Tilapias: Biology and Exploitations*. Kluwer.
De Silva SS. (Ed.). 2001. *Reservoir and Culture Based Fisheries: Biology and Management*. ACAIR Proceedings.
FAO. 2007. *Manual on Freshwater Prawn Farming*.
Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*
.Kluwer.New MB. 2000. *Freshwater Prawn Farming*. CRC Publ.
Pillay TVR. 1990. *Aquaculture: Principles and Practices*. Fishing News
Books, Cambrige University Press, Cambridge.
Venugopal S. 2005. *Aquaculture*. Pointer Publ.
Welcomme RL. 2001. *Inland Fisheries: Ecology and Management*. Fishing News Books.

BFSc.AQC 205: FISH FOOD ORGANISMS 1+1

Objective: To impart basic understanding of the nutritional requirements of fish/shellfish larvae and knowledge on mass culture and enrichment of live food organisms.

Theory

UNIT I

Larval nutrition: Larval stages, nutritional requirements of fish and shellfish larvae, quality requirements of larval feeds (particle size, digestibility).

UNIT II

Natural food and its importance in aquaculture, nutritional quality of commonly used fish food organisms,

UNIT III

Fish food organisms: Bacterioplankton, phytoplankton and zooplankton and their role in larval nutrition.

UNIT IV

Mass culture techniques: Methods of collection, maintenance and rearing of fish food organisms, Different media used in culture, Mass culture of fish food organisms and their application in hatcheries,

UNIT-V

culture of important microalgae, rotifers, artemia, cladocerans, copepods, oligochaetes, nematodes and insect larvae.

Practical

Collection, identification and isolation of live food organisms using various techniques; Preparation of various culture media; Preparation and maintenance of stock microalgal culture; Preparation of artificial feed for rearing finfish and shellfish larvae

Suggested Readings

CIFE. 1993. *Training Manual on Culture of Live Food Organisms for AQUA Hatcheries*. Central Institute of Fisheries Education,Versova, Mumbai.

Finn RN & Kapoor BG. 2008. *Fish Larval Physiology*. Science Publ.

Hagiwara A, Snell TW, Lubzens E & Tamaru CS. 1997. *Live Food in Aquaculture*. Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer.

MPEDA. 1993. *Handbook on Aqua Farming - Live Feed*. *Micro Algal Culture.* MPEDA Publication.

Muthu MS. 1983. *Culture of Live Feed Organisms*. Tech. Paper 14. Summer Institute in Hatchery Production of Prawns Seeds. CMFRI,Cochin.

Ojha JS. 2005. *Aquaculture Nutrition and Biochemistry*. Daya Publ.

Santhanam R, Ramnathan M & Venkataramanujum. 1997. *A Manual ofMethods in Plankton*. Fisheries College and Research Institute,Tamil Nadu Veterinary and Animal Sciences University, Tuticorin.

Sorgeloos P & Pandian KS. 1984. *Culture of Live Food Organisms with Special Reference to Artemia Culture*. CMFRI Spl. Publ. No. 15.

Tonapi GT. 1980. *Freshwater Animals of India*. Oxford & IBH.

Semester III

B.FSc-:AQC 301: AQUACULTURE ENGINEERING 2+1

Objective: To learn the basic aspects of successful farm designing for effective management and optimum yield.

Theory

UNIT I

Introduction: Technical components of farm designing, future trends in aquaculture engineering.

UNIT II

Aquaculture facilities: Planning process, site selection and evaluation,design, components and construction of tanks, ponds, cages and hatcheries.

UNIT III

Water intake and outlet: Pipe line, water flow and head loss, pumps. Instrumentation and monitoring: Instruments for measuring water quality

UNIT IV

Water treatment: Equipment used for water treatment, filters, ultraviolet light, ozone, heating and cooling and other processes of disinfection.

UNIT V

Aeration and oxygenation: Design and fabrication of aerators, oxygen injection system Recirculation and water use system: Definition, components and design.Feeding system: Different types of feeding equipment, feed control systems, dynamic feeding systems.

Practical

Visit to aqua farms; Contour survey and mappings; Evaluation of performance of seepage controlling devices; Designing of fresh and brackish water fin and shellfish farms; Designing of fresh and brackish water fin and shellfish hatcheries; Estimation of construction cost of FRP and cement hatchery units, inlets, outlets, sluice gate, monks, hatchery sheds, supply channel and drainage systems, gravitational flow;

Suggested Readings

Thomas L. 1995. *Fundamentals of Aquacultural Engineering*. Chapman & Hall.
Wheaton FW. 1977. *Aquacultural Engineering*. John Wiley & Sons.
Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.

BFSc-AQC:302- ADVANCES IN AQUACULTURE PRODUCTION SYSTEMS 2+1

Objective:To impart essential knowledge and skills regarding advanced technologies of different aquaculture production systems.

Theory

UNIT I

An overview of aquaculture production systems: Present status, constraints and future perspectives of aquaculture production systems in India and the world.

UNIT II

Advances in design and construction: Hatcheries; Earthen ponds; Concrete tanks; Pens and cages; Rafts; Racks.

UNIT III

Aquatic plant production systems: Ornamental aquatic plants; microalgae and seaweeds; Long line production system.

UNIT IV

Aquaculture production management: Monitoring of water quality; feeding and monitoring, sampling and harvesting of finfishes and shellfishes.

UNIT V

Advances in farming systems: Enhancing carrying capacity; integrated farming systems; semi-intensive and intensive culture systems;Recirculatory system; Flow-through system.

Practical

Soil and water quality monitoring; Basic software packages for designing aquaculture systems; Preparing a model layout for advanced production system; Working out the economic feasibility of construction and maintenance of different fish production systems; Preparation of project proposal for fish production systems.

Suggested Readings

Dubey SK. 2006. *Fish Farming*. Dominant Publ.
Jhingran VG. 1991. *Fish and Fisheries of India*. Hindhustan Publ. Corp.28
Pandey N & Davendra SM. 2008. *Integrated Fish Farming*. Daya Publ.House.
Pillay TVR & Kutty MN. 2005. *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell.
Rath RK. 2000. *Freshwater Aquaculture*. Scientific Publ.
Selvamani BR & Mahadevan RK. 2008. *Fish Farming Systems*. Campus Books International.
Shepherd J & Brommage N. 1990. *Intensive Fish Farming*. B.S.P. Professional Books.
Sinha VRP & Ramachandran V. 1985. *Freshwater Fish Culture*. ICAR.

BFSc-:AQC 303: ADVANCES IN SEED PRODUCTION 2+1

Objective:To impart knowledge of the various requirements for seed production of commercially important finfish and shellfish.

Theory

UNIT I

Reproductive biology of important fishers, crustaceans and molluscs.Anatomy and morphology of reproductive organs. Reproductive behavior of fishes. Sex determination in fishes.

UNIT II

Reproductive endocrinology: Anatomy and physiology of endocrine glands.Biochemical characteristics of endocrine hormones. Role of endocrine hormone in reproduction.

UNIT III

Broodstock management: Factors affecting the maturation and spawning offin fishes and shell fishes. Nutritional and environmental requirement for broodstock. Nutritional and environmental manipulation for early maturation.

UNIT IV

Induced Spawning: Biochemical characteristics of synthetic hormone analogues and their applications. Comparative evaluation of commercially available inducing agents.

UNIT V

Seed production and hatchery technology: Advances in seed production of commercially important finfishes and shellfishes. Seed production of ornamental fishes. Artificial propagation of seaweeds.

Practical

Insemination; Cryopreservation of fish and shellfish gametes; Project preparation for constructing hatchery; Quantitative and qualitative determination of fish gametes like sperm motility, viability, counts; Digital equipments in broodstock management; Methods to identify quality seeds stress test, microscopic examination.

Suggested Readings

Bardach EJ, Rhyther JH & Mc Larney WO. 1972. *Aquaculture. TheFarming and Husbandry of Freshwater and Marine Organisms*.John Wiley & Sons.

Chakraborty C & Sadhu AK. 2000. *Biology Hatchery and Culture Technology of Tiger Prawn and Giant Freshwater Prawn*. Daya Publ. House.

Diwan AD, Joseph S & Ayyappan S. 2008. *Physiology of Reproduction,Breeding and Culture of Tiger Shrimp*. Narendra Publ. House.

Gilbert B. 1990. *Aquaculture*. Vol. II. Ellis Harwood.

Jhingran VG & Pullin RSV. 1985. *Hatchery Manual for the Common,Chinese and Indian Major Carps*. ICLARM, Philippines.

Thomas PC, Rath SC & Mohapatra KD. 2003. *Breeding and Seed Production of Finfish and Shellfish*. Daya Publ. House.

BFSc-AQC 304: AQUACULTURE AND ECOSYSTEM MANAGEMENT 2+1

Objective:To impart knowledge on interactions between aquaculture and the environment.

Theory

UNIT I

Aquaculture and ecosystem relationship: Ecosystems and productivity,biotic interaction within ecosystems and ecological homeostasis.

UNIT II

Climate: Weather elements of concern in aquaculture, Green house gases,global warming and their impact.

UNIT III

Impact of environment on aquaculture: Raw water source, physical and chemical characteristics, contaminants and pollutants (algae, pathogens,heavy metals, pesticides) and their effect on productivity.

UNIT IV

Impact of aquaculture on environment: Waste water discharge, its quality and quantity; impacts of effluents on ecosystems, chemical degradation of soil and water.

UNIT V

Environment monitoring: Problems and preventive measures of antibiotic and drug residues, salination of soil and water.Environment management: Introduction of exotics and escape of farmed fish,

Practical

Waste water analysis; Environment impact assessment; Environmental audit; Toxicity assessment studies; Ecolabelling and traceability; Isolation,enumeration and Identification of bacterial population; Physical and chemical characteristics of soil; Design and construction of effluent treatment plant.

Suggested Readings

Holmer M, Black K, Duarte CM, Marba N & Karakassis I. (Eds.). 2008.
Aquaculture in the Ecosystem. Daya Publ. House.
Lagler KP, Bardach JE, Miller RR & Passino MDR. 1977. *Ichthyology*.John Wiley & Sons.
Midlen & Redding TA. 1998. *Environmental Management for Aquaculture*.Chapman & Hall.
Nikolsky GV. 2008. *The Ecology of Fishes*. Academic Press.
Upadhyay AR. 2004. *Aquatic Plants for the Wastewater Treatment*. Daya Publ. House.

BFSC-AQC 305 :AQUATIC ANIMAL HEALTH MANAGEMENT 1+1

Objective:To impart and update knowledge for combating pathogenic diseases in aquatic environment and its management.

Theory

UNIT I

Defence mechanism in fish and shellfish: Specific and non-specific defence mechanism, immunogenicity, immune cells, immune suppressant, ontogeny of immune system; cellular adaptation, pathogen specificity.

UNIT II

Disease diagnostics tools: Histopathological methods, tools used in different types of PCR, Immunoassay, Biochemical assay .

UNIT III

Disease prevention and therapeutics: Vaccines and bactericins, development of vaccines like DNA vaccine, adjuvants, etc; administration and mode of action of pathogen specific drugs, drug resistance, antiviral drugs.

UNIT IV

Quarantine: Biosecurity principles, SPF and SPR, quarantine protocols, and facilities, broodstock and seed quarantine measures, Quarantine of Aquatic Animals and Premises.

Practical

Analysing and reporting legal problems relating to quarantine; Microscopic techniques; Immunisation techniques; Necropsy examination to study internal organs of fish; PCR; ELISA; Agglutination test; Gel electrophoresis; Histopathology; Determination of dosages of chemicals and drugs for treating common diseases.

Suggested Readings

Andrews C, Excell A & Carrington N. 1988. *The Manual of Fish Health*. Salamander Books.
Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*. Vols. I, II. 2nd Ed. Academic Press.
Jorge E, Helmut S, Thomas W & Kapoor BG. 2008. *Fish Diseases*. Science Publ.

Felix S, Riji John K, Prince Jeyaseelan MJ & Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research, Institute, T. N. Veterinary and Animal Sciences University.
Thoothukkudi.Humphrey J, Arthur JR, Subasinghe RP & Phillips MJ**.** 2005. *Aquatic Animal Quarantine and Health Certification in Asia.* FAO Publ.
Inglis V, Roberts RJ & Bromage NR. 1993. *Bacterial Diseases of Fish*.Blackwell.
Iwama G & Nakanishi T. (Eds.). 1996. *The Fish Immune System -Organism, Pathogen and Environment*. Academic Press.
Roberts RJ. 2001. *Fish Pathology*. 3nd Ed. WB Saunders.Shankar KM & Mohan CV. 2002. *Fish and Shellfish Health Management*. UNESCO Publ.
Wedmeyer G, Meyer FP & Smith L. 1999. *Environmental Stress and Fish Diseases*. Narendra Publ. House.
Woo PTK & Bruno DW. (Eds.). 1999. *Fish Diseases and Disorders*. Vol.III. *Viral, Bacterial and Fungal Infection*. CABI.

Semester IV
BFSc-AQC: 401 FISH AND SHELLFISH PHYSIOLOGY 1+1

Objective:To learn functional physiology of fish and shellfish.

Theory

UNIT I

General physiology and endocrinology: Physiology of migration and behaviour, chemical nature of hormones, storage, release and control of hormones, serochemistry, ecophysiology,

UNIT II

Nutritional and digestive physiology: Mechanism of chemo, electro and mechanorecption, gustation, digestive enzymes and isozymes, nutrient tansporters, gut microbial digestion,.

UNIT III

Neurophysiology: Neurosecretory system in fishes, crustaceans and molluscs, neurotransmitters, ecdysis.

UNIT IV

Reproductive physiology: Maturation and spawning, spermatogenesis,oogenesis, yolk formation, mechanism of sex reversal.

UNIT V

Respiratory physiology: Structure and chemical composition of respiratory pigments, gas exchange concept, osmoregulation. stress adaptation.

Practical

Hormone assay –RIA (Radio Immuno Assay); Dissection of fin and shellfish to study endocrine glands; Histological techniques to study endocrine cells; Identification of moult stages; Serological analysis; Application of Electrocardiogram and respirometer.

Suggested Readings

Adiyodi KG & Adiyodi RG. 1971. *Endocrine Control of Reproduction in Decapod Crustacea*. Biology Reviews.
Agarwal NK. 2008. *Fish Reproduction*. APH Publ.
Bell TA & Lightner TA. 1988. *A Handbook of Normal Penaeid Shrimp Histology*. World Aquaculture Society.
Ghosh R. 2007. *Fish Genetics and Endocrinology*. Swastik Publ. & Distr.

Hoar WS, Randall DJ & Donaldson EM. 1983. *Fish Physiology*. Vol. IX.Academic Press.
Maria RJ, Augustine A & Kapoor BG. 2008. *Fish Reproduction*. Science Publ.
Matty AJ. 1985. *Fish Endocrinology*.
Croom Helm.Mente E. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*.
Science Publ.
Nikolsky GV. 2008. *The Ecology of Fishes*. Academic Press.
Thomas PC, Rath SC & Mohapatra KD. 2003. *Breeding and Seed Production of Finfish and Shellfish*. Daya Publ. House.

BFSc-AQC 402 :ADVANCES IN FISH GENETICS 2+1

Objective:To provide knowledge in genetics for improving qualitative and quantitative traits in fish.

Theory

UNIT I

Scope of applied fish genetics: Inheritance of qualitative and quantitative traits in fish; chromosomal polymorphism.

UNIT II

Non chromosomal inheritance: Mitochondrial inheritance. Chromosome banding techniques: C-banding, G-banding, NOR-banding,FISH

UNIT III

Chromosome manipulation: Gynogenesis and androgenesis; production of super-males and transgenic fish.

UNIT IV

Inbreeding and genetic drift: Estimation of genetic parameters. Genetic markers: Use of biochemical and molecular genetic markers in hybridization, selective breeding

UNIT V

Selective breeding: Qualitative and quantitative traits for selection, methods of selection-individual selection, mass selection, family selection and combined selection; Designing of breeding programmes.

Practical

Chi-square test; Estimation of heritability and repeatability; Assessment of genetic gain through selection; Calculation of selection differential;Calculation of selection response; Estimation of inbreeding coefficient and path coefficient; Karyotypic studies; C-banding (hetero chromatin banding); NOR- banding (nucleolar organizer region banding); G-banding (Giemsa banding); Ploidy determination methods.

Suggested Readings

Das P & Jhingran AG. 1976. *Fish Genetics in India*. Today & Tomorrow Publ.
Douglas T. 1998. *Genetics for Fish Hatchery Managers*.
Kluwer. Dunham RA. 2004. *Aquaculture and Fisheries Biotechnology Genetic Approaches*. CABI.
Malvee S. 2008. *Fish Genetics*. SBS Publ.
Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*.Dominant Publ.
Padhi BJ & Mandal RK. 2000. *Applied Fish Genetics*. Fishing Chimes.

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics andAquaculture Biotechnology*. Science Publ.
Reddy PVGK. 2005. *Genetic Resources of Major Indian Carps*. Daya Publ.
Reddy PVGK, Ayyappan S, Thampy DM & Gopalakrishna. 2005. *Text Book of Fish Genetics and Biotechnology*. ICAR.
Sinnot EW, Dunn L & Dobzansky T. 1989. *Principles of Genetics*. McGraw Hill.

BFSc-AQC 403 :INTENSIVE FARMING SYSTEM HILL STREAM TROUT, 1+1

Objective:To learn the techniques of intensive farming of hill stream Fish.

Theory

UNIT I

Intensive Farming Systems: Status and future prospectus of catfishes and tilapia in India, Need for intensification, Development of intensive farming.Disease and its control, constraints in intensive farming.

UNIT II

Hill strem fish: Commercially important Mahaseer, Different culture systems,Means of intensifying fish culture, polyculture of mahaseer with other species, Economics of culture.

UNIT III

SnowTrout: Commercially important snow trout, Different culture systems, Means of intensifying trout culture, polyculture of snow trout, Water quality management in carp culture, feeds and feeding,

UNIT IV

Techniques of sex reversal in trout, mass production of monosex seed and hybrids,Production of carp, Economics of culture.

Practical

Study of aerators and blowers; Experience in breeding and culture of catfish; Experience in breeding and culture of trout; Seed production ofcatfish and tilapia; Formulation of feeds for Snow trout and Mahseer; Stocking density manipulation and fish production; Economics of intensive farming of Mahseer andsnow trout.

Suggested Readings

Bardach EJ, Rhyther JH & Mc. Larney WO. 1972. *Aquaculture TheFarming and Husbandry of Freshwater and Marine Organisms*.John Wiley & Sons.
Gilbert B. 1990. *Aquaculture*. Vol II. Ellis Harwood.
Jayaram KC. 2006. *Catfishes of India*. Narendra Publ. House.
Pillay TVR. 1990. *Aquaculture, Principles and Practices*. Fishing News Books.
Rath PK. 2000. *Freshwater Aquaculture*. Scientific Publ

BFSc:-AQC 404: AQUACULTURE DEVELOPMENT PLANING AND MANAGEMENT 1+1

Objective: To understand different aspects of planning and management processes specific to aquaculture development of aquaculture programmes.

Theory

UNIT I

Importance, principles and processes in developing aquaculture programmes; Planning for sustainable development; Types of planning; Planning strategies at various levels - Top down and bottom up approaches.

UNIT II

Role and relevance of Panchayati Raj institutions in aquaculture development; Plan allocation and performance of FFDA, BFDA and other aquaculture related programmes over the different plan-periods in India.

UNIT III

Project preparation and project appraisal in terms of social benefit analysis,shadow prices; Project management techniques - PERT and CPM; Logical framework approach (LFA), significance, importance and approaches .

UNIT IV

Critical analysis of aquaculture and rural development programmes; design,operation, institutional mechanism and socio-cultural and economic impact of programmes such as NREGA; labour market relations;

UNIT V

Fisheries development *vis-à-vis* fisheries for development; Livelihood Frameworks.

Practical

Need assessment, setting objectives, developing plan of work, Success indicators, Impact assessment of aquaculture development programmes, SWOT analysis; Exercises on PERT and CPM. Fisheries and Aquaculture policies of select countries; Study visits to selected aquaculture project areas – FFDA/ BFDA/ SAUs/ICAR institutes.

Suggested Readings

Agarwal SC. 2004. *Fishery Management*. APH Publ. Corp.
Agarwal SC & Johal S. 2003. *Fishery Development*. Narendra Publ.
Felix S. 2007. *Aquaculture Management Techniques*. Daya Publ. House.
Singh B. 2007. *Fishery Management: Planning and Objectives*. Vista International Publ. House.
Sinha VRP. 2005. *Fisheries Research Planning and Management in Developing Countries*. Narendra Publ. House.

BFSc-AQC 405: APPLIED AQACULTURE BIOTECHNOLOGY 1+1

Objective:To learn various biotechnological applications for enhancing production through sustainable eco-friendly culture.

Theory

UNIT I

Introduction: Scope of biotechnology in fisheries and aquaculture research. Biotechnological instrumentation in Aquaculture.

UNIT II

Transgenics: Principles of transgenic technology and its application in fisheries.

UNIT III

Feed biotechnology: Probiotics, single cell proteins, Nutraceuticals. Anti microbial Peptides and their applications

UNIT IV

Recombinant proteins of commercial importance: enzymes, hormones,bioactive compounds, therapeutic proteins. Applications of biotechnological tools: Recombinant DNA, Monoclonal antibodies, Cell lines and stem cell culture, DNA markers and MAS.

UNIT V

Biotechnological approaches in environmental management:Bioremediation, biosensors, biofouling, treatment of waste water.

Practical

Cell culture and cell lines; Development of hybridoma and production of monoclonal antibodies; Collection, handling and observation of gametes of finfish and shellfish; Preparation of chromosomes from embryos and young fish; Ploidy determination by RBC measurement and chromosomenumbers;

.

Suggested Readings

Felix S. 2007. *Molecular Diagnostic Biotechnology in Aquaculture*. Daya Publ. House.

Fingerman M, Nagabhushanam R & Thompson MF. 1997. *Recent Advances in Marine Biotechnology*. Vols. I-III. Oxford & IBH.

Glick BR & Pasternak JJ. 1999. *Molecular Biotechnology: Principles and Applications of Recombinant DNA Technology*. ASM Press.

Nagabhushanam R, Diwan AD, Zahurnec BJ & Sarojini R. 2004. *Biotechnology of Aquatic Animals*. Science Publ.

Nair PR. 2008. *Biotechnology and Genetics in Fisheries and Aquaculture*.Dominant Publ.

Pandian TJ, Strüssmann CA & Marian MP. 2005. *Fish Genetics andAquaculture Biotechnology*. Science Publ.

Ramesh RC. (Ed.). 2007. *Microbial Biotechnology in Agriculture and Aquaculture*. Vol. II. Science Publ.

Zhanjiang JL. 2007. *Aquaculture Genome Technologies*. Blackwell.

Semester V

BFSc-AQC 501: AQUATIC ENVIRONMENT AND BIODIVERSITY 2+1

Objective:To acquaint the students with the theoretical and practical aspects of the aquatic environment and biodiversity.

Theory

UNIT I

Concepts in aquatic environment: Aquatic environment/ecosystem –components-structure and functions;

UNIT II

Ecological concepts – succession, homeostasis, natality and mortality, and k selection; Concepts of habitat and ecological niche; carrying capacity.

UNIT III

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

UNIT IV

Biodiversity: Biodiversity – Definition and concept; Factors influencing aquatic biodiversity; Types of biodiversity - Species diversity in different ecosystems, Genetic Diversity, and Habitat Diversity;

UNIT V

Biodiversity indices and their significance; Concepts of Index of Biotic Integrity (IBI) Economic appraisal of biodiversity; Global diversity patterns and loss of biodiversity.

Practical

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

Suggested Readings

Carter RWG. 1998. *Coastal Environments: An Introduction to the Physical,Ecological and Cultural Systems of Coastlines*. Academic Press.

Kormondy E.J. 1986. *Concepts of Ecology*. Prentice-Hall.

Park CC. 1980. *Ecology and Environmental Management*. Butterworths.

Simon J, Kaiser MJ & Reynolds JD. 2001. *Marine Fisheries Ecology*.Blackwell.

BFSc-AQC 502: CHEMICAL INTERACTIONS IN THE AQUATIC ENVIRONMENT 2+1

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

Theory

UNIT I

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

UNIT II

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

UNIT III

Nutrient dynamics: Chemistry of soil-nutrient interactions and water permeability; Organic substances - biological processes in the degradation and conversion of organic matter; Humus and biogeochemical substances -structure, reactivity, solubility and mobility;

UNIT IV

Transport of substances -nutrients (*e.g.,* phosphate, nitrate, ammonia, Ca and K), Soil-water interactions – availability of nutrients and productivity of aquatic ecosystem.

UNIT V

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

Practical

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

Suggested Readings

Lindsay WL. 1979. *Chemical Equilibria in Soils*. John Wiley & Sons.
Manahan SE. 2000. *Environmental Chemistry*. Lewis Publ.
McBride MB. 1994. *Environmental Chemistry of Soils*. Oxford University Press.
Stumm W & Morgan JJ. 1996. *Aquatic Chemistry: Chemical Equilibria and Rates in Natural Waters*. John Wiley & Sons.
Tan KH. 1998. *Principles of Soil Chemistry*. CRC Press.

BFSc-AQC 503 :AQUATIC POLLUTION AND WASTEWATER MANAGEMENT: 2+1

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV
Wastewater management: Wastewaters - classification and characteristics of sewage and industrial effluents; treatment methods for water and waste water; Principles of aeration, chlorination, ozonation and U.V. irradiation.
UNIT V
Wastes from fish processing units and their treatment; solid waste management; removal of nitrogen and phosphorus from waste water; Role of aquatic macrophytes in treatment of wastewater.

Practical
Collection and preservation of wastewater samples; Physicochemical analysis of wastewater - total dissolved and suspended solids, DO, BOD, COD, H_2S,, NH_3–N, NO_2-N, NO_3-N, PO_4-P, CH_4, heavy metals and pesticides; Use of algae for waste water treatment; Visit to a sewage treatment plant, fish processing unit and other industries; Exercise on interpretation of water quality data for evaluation of aquatic health.
Suggested Readings
Baird DJ, Beveridge MCM, Kelly LA & Muir JF. 1996. *Aquaculture and Water Resources Management*. Blackwell.
Cheremisinoff NP. 2002. *Handbook of Water and Waste Water Treatment Technologies*. Butterworth – Heinemann.
Eckenfelder WW. 2000. *Industrial Water Pollution Control*. McGraw Hill.
Gray NF. 2004. *Biology of Wastewater Treatment*. Oxford University Press.
Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies* Global Science.

BFSc-AQC 504 :ECOLOGY AND MANAGEMENT OF LIMNETIC ENVIRONMENT 2+1
Objective:To educate the students on the ecology of limnetic wetlands and to impart skill and knowledge on the sustainable management of the limnetic ecosystems.

Theory
UNIT I
Types: Categorization of different limnetic fisheries resources - lacustrine, riverine and coldwater systems; Wetlands, Floodplain wetlands, swamps -characteristics, flora and fauna.
UNIT II
Characteristics: Physical and chemical characteristics of limnetic environment and its relationship with the organisms; influence on metabolism, behavior and orientation of animals; Biological productivity in relation to fishery potential; Trophic relationships in the wetland ecosystem

UNIT III
Conservation and Management: Functions of wetlands; Habitat degradation- causative factors and controlling/management measures; Destruction of wetlands - causes and consequences; Restoration, conservation and management of wetlands.

UNIT IV
Resource enhancement;Management of water bodies for economy-driven activities; Management through Biomanipulation studies- top-down and Bottom-up methods;Integrated Environment Management (IEM) Programme-involvement of human element;
UNIT V
River continuum concept and new paradigm shift;Riverlinking; International conventions - Ramsar; Environmental laws and regulations; Index of Biotic Integrity (IBI);

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

Suggested Readings
Allan JD. 1995. *Stream Ecology: Structure and Function of Running Waters*. Chapman & Hall.
Dodds WK. 2002. *Freshwater Ecology: Concepts and Environmental Applications*. Academic Press.
Good RE, Whigham DF & Simpson RL. 1978. *Fresh Water Wetlands:Ecological Processes and Management Potential*. Academic Press.
Hynes HBN. 1970. *Ecology of Running Waters*. Liverpool UniversityPress, Liverpool.
Mitsh WJ & Gosselink JG. 1996. *Wetlands*. John Wiley & Sons.
Nath S. (Ed.). 2008. *Recent Advances in Fish Ecology Limnology and Eco Conservation*. Vol. VII. Narendra Publ. House.
Pattern BC. 1990. *Wetlands and Shallow Continental Water Bodies*. SPB Academic Press.
Scheffer NM. 1998. *Ecology of Shallow Lakes*. Chapman & Hall.
Talling J & Lemoalle J. 1998. *Ecological Dynamics of Tropical Inland Waters*. Cambridge University Press, London.
Wong MH. 2004. *Wetland Ecosystems in Asia: Functions andManagement*. Elsevier.

BFSc-AQC 505: AQUACULTURE ANLYTICAL TECHNIQUE 1+1

Objective:To impart knowledge and skills in analytical techniques employed in environmental studies.
Theory
UNIT I
Overview and concepts: An overview of qualitative and quantitative analytical techniques used in environmental science; Sampling techniques and procedures; Factors affecting the choice of an analytical technique;Interferences and their removal, Field kits and their application.
UNIT II
Photometric techniques: Theory, instrumentation and application of colorimetry and spectrophotometry.
UNIT III
Separation techniques: Chromatography – theory, instrumentation and applications of thin layer, paper, ion-exchange, size exclusion, high performance liquid and gas;

UNIT IV
Methods of preparing biological samples for chromatographic analysis; Theory and applications of electrophoresis;Principles and uses of ultracentrifugation.
UNIT IV
Tracer techniques: Scintillation counters and radio isotopes in aquaculture research.

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

Suggested Readings
Eaton AD, Clesceri LS, Rice EW & Greenberg AE. 2005. *Standard Methods for theExamination of Water and Wastewater*. APHAAWWA-WEF, Washington DC.
Fishbein L. 1973. *Chromatography of Environmental Hazards: Metals,Gaseous and Industrial Pollutants*. Elsevier.
Jeffery GH, Basset J, Mendham J & Denney RC. (Eds.). 1989. *Vogel'sTextbook of Quantitative Chemical Analysis*. Longman.
Sparks DL, Page AL, Helmke PA, Loeppert RH, Soltanpour PN, Tabatabai MA, Johnston CT & Sumner ME. (Eds.). 1996. *Methods of Soil*
Analysis: Part 3. *Chemical Methods*. SSSA-ASA, Madison.Welch PS. 2003. *Limnological Methods*. Narendra Publ. House.
Wilson K & Walker J. 2002. *Practical Biochemistry: Principles and Techniques*. Cambridge University Press, Oxford.

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Semester VI

BFSc:AQC 601: AQUACULTURE TOXICOLOGY 1+1

Objective:To impart knowledge on toxicological aspects of various pollutants.

Theory

UNIT I
Toxicity and metabolism: Factors influencing toxicity- environmental, genetic and nutritional; Measurement and evaluation of the ecological effects of toxicants;

UNIT II
Metabolism of toxic substances by aquatic organisms -consequences, synergistic and antagonistic effects; Acute poisons and accumulative poisons;

UNIT III
Bioaccumulation and biomagnification; Systemic effects of toxic metals, pesticides and herbicides; Effect of select toxicants on aquatic life and detoxification.

UNIT IV
Toxicity evaluation: Toxicity Testing - Microcosm and Mesocosm Tests,Dose-Response Relationships, Toxicity Bioassay.

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

Suggested Readings

Hoffman DJ. 1995. *Handbook of Ecotoxicology*. Lewis Publ.
Kumar A. (Ed.). 2008. *Aquatic Environment and Toxicology.* Daya Publ.House.
Mayer H. 1977. *Aquatic Toxicology and Hazards Evaluation*. ASTM Publ.
Rand GM & Petrocelli SR. 1994. *Fundamentals of Aquatic Toxicology*.Hemisphere Publ. Corp.
Raymond JM, Neisink RJM, de Vries J & Hollinger MA. 1996.*Toxicology: Principles and Applications*. CRC Press.
Ware GW. 2002. *Review of Environmental Contamination and Toxicology*.Springer Verlag.

BFSc-AQC 602: COASTAL AQUACULTURE 2+1

Objective

To gain knowledge in establishing and managing different fish/shellfish farming systems in coastal waters.

Theory

UNIT I

Introduction: An overview of the status of coastal aquaculture; Present trend and scope in India.

UNIT II

Different farming systems: Cage and pen culture – type, site selection,construction specifications for different species; Raft and rack culture – site selection, design and construction.

UNIT III

Important cultivable finfishes: Distribution, biology, seed collection,nursery rearing, culture techniques, problems and prospects (seabass, milkfish, mullets, pearlspot, sea breams, rabbitfish, grouper, yellowtail, eel,cobia, salmon, flatfish).

UNIT IV

Culture of marine molluscs and echinoderms: Present status and scope in India, Species cultured (mussels, oysters, pearl oysters, scallops, clams, cockles, abalones, sea cucumber) distribution, biology, practices followed in India, farming methods - off-bottom and on-bottom culture; Problems and prospects.

UNIT V

Culture of crustaceans: Shrimp farming: systems of farming – extensive,semi-intensive and intensive; site selection, infrastructure requirement,design and construction of culture systems, pond preparation, stocking, feed and water quality management, disease prevention and treatment; harvesting and handling;

Practical

Identification of cultivable marine and brackishwater finfish and shellfish;Identification of cultivable seaweeds; Designing of different farming systems – cages, pens, rafts and racks; Visit to coastal aqaufarms.

Suggested Readings

Bardach EJ, Rhyther JH & Mc Larney WO. 1972. *Aquaculture the Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley & Sons.
FAO. 2001. *Planning and Management for Sustainable Coastal Aquaculture Development*. FAO Publ.
Gilbert B. 1990. *Aquaculture*. Vol. II. Ellis Horwood. ICAR. 2006. *Handbook of Fisheries and Aquaculture*. ICAR.

Pillay TVR. 1990. *Aquaculture, Principles and Practices*. Fishing News Books.
Pillay TVR & Kutty MN. 2005. *Aquaculture: Principles and Practices*. 2nd Ed. Blackwell.

BFSc-AQC-603: AQUACULTURE MICROBIOLOGY 2+1

Objective:To impart knowledge on aquatic microorganisms with reference to their role in the aquatic environment and bio-prospecting.

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

UNIT V

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

Practical

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

Suggested Readings

Dhevendaran K. 2008. *Aquatic Microbiology*. Daya Publ. House.
Frobisher M, Hinsdill RD, Crabtree KT & Goodheart CR. 1974.*Fundamentals of Microbiology*. WB Saunders.
Geesey G, Lewandowski Z & Flemming HC. (Eds.). 1994. *Biofouling and Biocorrosion in Industrial Water Systems*. CRC Press.
Prasad AB & Vaishampayan A. 1994. *Nitrogen Fixing Organisms –Problems and Prospects*. Scientific Publ.
Rheinheimer G. 1992. *Aquatic Microbiology*. John Wiley & Sons.

Stanier R, Ingraham JL & Adelberg EA. 1976. *General Microbiology*.MacMillan.
Vernam AH & Evans M. 2000. *Environmental Microbiology*. Blackwell.

BFSC:AQC 604 -ADVANCES IN AQUATIC ENVIRONMENTAL STUDIES 2+1

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

Theory

UNIT I

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

UNIT II

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

UNIT III

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

UNIT IV

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

STUDIES

Global warming and green house effects- process and impact on aquatic environment; Integrated environment management (IEM), Role of human element in IEM, Analytical Behavior Analysis Approach (ABAA) for IEM. Natural disasters: formation, causes and effects; effects on aquatic habitat

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Practical

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

Suggested Readings

Brudtland GH. 1987. *Our Common Future: World Commission on Environment and Development*. Oxford University Press.
Gates DM. 1993. *Climate Change and its Biological Consequences*.Saunderland.
Goudie A. 1993. *The Human Impact on the Natural Environment*. MIT Press.
IUCN, UNEP, WWE. 1991. *Caring for the Earth: Strategies for Sustainable Living*. Earthscan.
Sakhare VB. (Ed.). 2007. *Advances in Aquatic Ecology* Vol. I. Daya Publ.
WCMC. 1992. *Global Biodiversity: Status of the Earth's Living Resources*. Chapman & Hall.

BFSc-AQC 605: BENTHIC ECOLOGY 1+1

Objective: To impart theoretical and practical knowledge of benthic ecology.

Theory

UNIT I

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

UNIT II

Community ecology; Physical, chemical and biological factors effecting benthic population; abundance and distribution of benthic communities major groups- their life cycles, food and feeding habits and ecological significance;

UNIT III

Role in maintaining ecological balance; Recruitment dynamics; Predator prey interaction; Invasive species.

UNIT IV

Human impacts; modification of coastal habitats, and major alterations of biogeochemical cycles;

UNIT V

contaminants; Benthic organisms as pollution indicators and biomonitors.

Practical

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

Suggested Readings

APHA (American Public Health Association). 1989. *Standard Methods for the Examination of Water and Wastewater*. 17th Ed. American

Public Health Association, Washington, D.C.Clegg J & Anthon H. 1968. *Pond and Stream Life*. Blandford Press.

Cole GA. 1988. *Textbook of Limnology*. 3rd Ed. Waveland Press.Cuffney TF, Gurtz ME & Meador MR. 1993. *Methods for Collecting Benthic Invertebrate Samples as Part of the National Water-Quality*

Assessment Programme. U.S. Geological Survey Open-File Report 93-406. U.S.G.S., Raleigh, North Carolina.

Dawson CL & Hellenthal RA. 1986. *A Computerized System for the Evaluation of Aquatic Habitats Based on Environmental Requirements and Pollution Tolerance Associations of Resident*

Organisms. EPA/600/S3-86/019. Environmental Research Laboratory, U.S. Environmental Protection Agency, Corvallis,Oregon.

Downing JA & Rigler FH. (Eds.). 1984. *A Manual on Methods for the Assessment of Secondary Productivity in Fresh Waters*. 2nd Ed. IBP Handbook 17. Blackwell.

Elliott JM. 1977. *Some Methods for the Statistical Analysis of Samples of Benthic Invertebrates*. 2nd Ed. Freshwater Biological Association Scientific Publication No. 25.

Whitton BA. (Ed.). 1975. *River Ecology*. University of California Press,Berkeley, California.

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SEMESTER VII

BFSc-AQC-701: ENVIRONMENT IMPACT ASSESSMENT 1+1

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

Theory

UNIT I

Environmental Impact Assessment (EIA): Process, evaluation and methodology; Social Impact Assessment (SIA) as a part of EIA-principals and process; EIA of aquacultural projects,

UNIT II

Environmental audit: Concept, setting up an audit programme, typical audit process, carrying out the audit, benefits of environmental auditing, Environmental audit programme in Uttrakhand.

UNIT III

International and national environmental protection standards;Environmental quality monitoring; ISO-14000-Environment Management System (EMS)-present status;

Practical

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

Suggested Readings

Canter LW. 1994. *Environmental Impact Assessment*. Mc-Graw Hill.

Grilbert M & Gould R. 1998. *Achieving Environmental Standards*. Pitman Publ.

Wathern P. (Ed.). 1988. *Environmental Impact Assessment: Theory and Practice*. World Research Institute, Routledge, London.

BFSc-AQC 702: MANAGEMENT AND UTILIZATION OF WASTEWATER 2+1

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

Theory

UNIT I

Advance treatment methods-Principles and procedures; ozonation, U.V.irradiation etc; Oxidation of sediment;

UNIT II

Aerobic and anaerobic treatment process; Role of aquatic macrophytes in biological treatment of waste water.

UNIT III

Waste recycling and waste management in aquaculture; Design and construction of water filtration devices;

UNIT IV

Utilization of wastewater for mass cultivation of algae and other fish food organisms; Utilization of waste water for aquaculture.

UNIT V
Waste disposal criteria used in different parts of world - national and international standards; Production of biogas from sewage;Advances in Pollution prevention, Environmental management.

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

Suggested Readings
Baird DJ, Beveridge MCM, Kelly LA & Muir JF. 1996. *Aquaculture and Water Resources Management*. Blackwell.
Cheremisinoff NP. 2002. *Handbook of Water and Waste Water Treatment Technologies*. Butterworth-Heinemann.
Eckenfelder WW. 2000. *Industrial Water Pollution Control*. McGraw Hill.
Fujita M & Ike M. 1994. *Wastewater Treatment using Genetically Engineered Microorganisms*. Technomic Publ. Co.
Gray NF. 2004. *Biology of Wastewater Treatment*. Oxford University Press.
Trivedy RK. 1998. *Advances in Wastewater Treatment Technologies*. Global Science.

BFSc-AQC 703: CARDIO-VASCULAR SYSTEM AND RESPIRATORY PHYSIOLOGY

Objective:T**o impart knowledge on the dynamics of cardiovascular system and adaptation of the salt transporting mechanism in Hill Strem fish and their physiology.**

Theory

UNIT I
Types of heart, morphological structure, blood vascular system. Lymph and lymphatic circulation. Regulation of cardiac activity, Neural and autoregulatory control of heart and haemodynamics, cardiac output circulation time, blood pressure.

UNIT II
Definition of respiration, basal metabolic rate (BMR), external respiration,internal respiration. Types of respiratory organs, gill structure.

UNIT III
Respiratory pigments and their functions
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UNIT IV
Mechanism of gaseous exchange, CO2 transport, countercurrent principle,water flow across the gills, respiratory pumps, pump musculature and skeleton, ammonia quotient. Chloride cells and their role in respiration.

UNIT V
Metabolic effects in response to environmental factors (biotic and abiotic). Hypoxia and metabolic rate, anoxic layers and habitats. Oxygen requirements at larval stages.

Practical

Assay of Na+-K+ ATPase activity. Study of rate of oxygen consumption in relation to abiotic factors (pH, temperature, salinity). Differential count of blood cells and estimation of haemoglobin concentration, haematocrit value.

Suggested Readings

Chavin W. (Ed.). 1973. *Responses of Fish to Environmental Changes***.** Charles C Thomas Publ**.**
Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.Hoar WS & Randall DJ. 1988. *Fish Physiology*. Academic Press.
Prosser CL. 1950. *Comparative Animal Physiology*. WB Saunders.
Rankin JC & Pitcher TJ.1983. *Control Processes in Fish Physiology*.Springer.

BFSc-AQC-704 :AQACUTURE IMMUNOBIOLOGY 2+1

Objective: To understand different aspects of immunostimulants and their effect on fish immunity, stress resistance and disease resistance.

Theory

UNIT I

Basic principles of immune system in Hill stream fishes and shell fishes.

UNIT II

Cell and organ involved in immunity.

UNIT III

Humoral and cell mediated immunity, Mechanism of immunity. Cytokines,interferon, lymphokine, chemokines, their role in immune response.

UNIT IV

Immunoprophylaxis, toxin, toxoid and vaccines. Immuno-stimulant,immunomodulation.

UNIT V

Biosynthesis of antibody. Endocrine control of immune system.Role of nutraceuticals *viz.,* levan, β-glucan, w3- fatty acid, levanisole, nucleotide, alginates, bovine lactoferine, etc. on fish/ shellfish immunity and mechanism of their action.

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Practical

Lysozyme activity. Estimation of NBT. Estimation of CBC. Estimation of prophenol oxidase. Estimation of superoxide dismutase. Estimation of IgM.

Suggested Readings

Conn EE & Stumpf PK. 1987. *Outline of Biochemistry*. Wiley.
Evans DH & Claiborne JB. 2006. *The Physiology of Fishes*. CRC Press.
Houlihan DF, Carter CG, McCarthy ID & Hochachka PW. 1995.*Biochemistry and Molecular Biology of Fishes.* Elsevier.
Iwama G & Nakanishi T. 1996. *The Fish Immune System. Organism Pathogen and Environment*. Academic Press.

Murray RK, Granner DK, Mayes PA & Rodwell VW. 2000. *Harper's Biochemistry*. Appleton & Lange.
Van Oss CJ & Van Regenmortel MHV. 1994. *Immunochemistry*. CRC Press.

BFSc-AQC 705: PHARMACO-BIOLOGY OF AQUACULTUR DRUGS, 2+1
Objective:To acquaint students with the aquaculture drugs and their delivery mechanism.
Theory
UNIT I
An introduction to pharmaco-dynamic agents.
UNIT II
Anaesthetics.Chemotherapeutic agents: antiprotozoal agents, ectoparasiticide, antihelmenthic.
UNIT III
Antibacterial, antifungal and antiparsitic drugs.

UNIT IV
Delivery system of drugs, Nanotechnology and nanoparticles.

UNIT V
ISO standards of levels of drugs. GMO, GLP, IPR.
Practical
Estimation of residual level of different drugs .Pharamaco-kinetics.
Suggested Readings
Brown KMT. 2000. *Applied Fish Pharmacology*. Springer.
Noga EJ. 1996. *Fish Disease: Diagnosis and Treatment.* Blackwell.
Stockoff MK. 1993. *Fish Medicine*. WB Saunders

SEMESTER VIII

BFSc 801 Industrial training

To acquaint the students with practical aspects related to the operations of Fisheries equipments and processing of Fish products.