COURSE STRUCTURE AND SYLLABI

of

Masters of Fisheries Science (Aquaculture)

M.F.Sc.(Aquaculture)

(2024- 2025 Batch)

(PG Degree Programme Syllabus as per BSMA, ICAR)

Centurion UNIVERSITY

Shaping Lives...
Empowering Communities...

SCHOOL OF FISHERIES

CENTURION UNIVERSITY OF TECHNOLOGY & MANAGEMENT
Odisha-761211, INDIA

Web Site: - www.cutm.ac.in

CENTURION UNIVERSITY OF TECHNOLOGY AND MANAGEMENT,

ODISHA

CERTIFICATE

This is to certify that the syllabus of the Programme Masters of Fisheries Science (Aquaculture) of the School of Fisheries is approved in the 15th Academic Council Meeting held on 11th September 2024.

Pro-Vice Chancellor

CUTM, Odisha

M.F.Sc. (Aquaculture)
SCHOOL OF FISHERIES
Centurion University of Technology and Management

Credit Requirement for M.F.Sc Aquaculture as per BSMA,ICAR.

	Credit Requirement
(i) Course work	
Major courses	20
Minor courses	8
Supporting courses	6
Common courses	5
Seminar	1
(ii) Thesis Research	30
TOTAL CREDIT	70

Course Structure

AQC 0511	Commercial Ornamental Fish Breeding and Culture	2(1+1)	23-24
AQC 0512	Computer Application in Aquaculture Data Processing	0(0+1)	24-26
AQC 0513	Inland Saline Aquaculture	2(1+1)	26-27
AQC 0514	Multilevel Integrated Aquaculture Systems	2(1+1)	27-28
AQC 0515	Coldwater Aquaculture and Recreational Fisheries	2(1+1)	28-29
AQC 0516	Recirculating Aquaculture Systems	2(1+1)	30-31
Supporting Courses			
STAT 0502	Statistical Methods for Applied Sciences	4 (3+1)	31-32
STAT 0511	Experimental Designs	3 (2+1)	32-33
STAT 0512	Basic Sampling Techniques	3 (2+1)	34-35
STAT 0522	Data Analysis Using Statistical Packages	3 (2+1)	35-36
Common Courses			
PGSS 0501	Library and Information Services	1 (0+1)	37
PGSS 0502	Technical Writing and Communication Skills	1 (0+1)	37-38
PGSS 0503	Intellectual Property and its Management in Agriculture	1 (1+0)	38-39
PGSS 0504	Basic Concepts in Laboratory Techniques	1 (0+1)	39-40
PGSS 0505	Agricultural Research, Research Ethics and Rural Development Programmes	1 (1+0)	40-41

Objectives of the M.F.Sc. Program

Masters of Fisheries Science in Aquaculture (M.F.Sc. (Aquaculture) is a post graduate course, which involves farming and husbandry of important fishes and aquatic organisms in fresh water, brackish water and marine environment. The course also deals with the breeding habits and habitats of various species of fish. Similarly, the course deals with the art of fish harvesting and the science involved in fish processing; besides fish marketing and conservation of fish. Furthermore, the course deals with the improvement of fishermen's community and recognizes the need to protect and enhance the role of fisherwomen in the fisheries economy.

The main objectives of this Program is

1. To provide quality education for the development of professionally qualified and technically skilled human resource man power to the fisheries sector of the country.

2. To undertake fisheries research and extension activities for enhanced fish production
3. To find out solutions to the problems encountered by the aqua farmers, fisher folk and entrepreneurs
4. To alleviate poverty and ascertain nutritional security of the country
5. To achieve overall development of the fisheries sector and conservation of fish for sustained growth.

Programme Learning Outcomes

1. To know the basis of technologies of aquaculture, to understand the principles of its importance, purpose and application.
2. To know the conditions of development of aquatic organisms and its habitat conditions, formation and change patterns of yielding in relation with the environmental changes of anthropogenic influence.
3. To know the aquaculture schemes used in breeding, rearing and feeding technologies in farms, their purpose and principles of application, be aware of the aquaculture design and construction principles, taking into account the legislation and directives.
4. Describe the aquaculture business management features, methods, and strategies for aquaculture business development, operational funding, fisheries and aquaculture production innovation and marketing issues and strategies.
5. Apply traditional research methods, scientific literature, information technologies and statistical methods of calculation to perform and summarize the research and creative use results of analysis by preparation of the final thesis and oral presentations.
6. Apply modern equipment in laboratories, special computer programs for design of fisheries and aquaculture farms by implementation of innovative ideas for management of farms.
7. Describe the aquaculture technological processes, identify problems and solve them, relate agriculture activity and aquaculture productivity and safety, analyze and evaluate effects of the fisheries and aquaculture on the environment, to provide the preventive safety measures.
8. Apply methods and techniques used in aquaculture design and construction, their management methods and quality assurance principles.
9. Solve the technological challenges related to management of aquaculture farms; organize activities to ensure their entrepreneurship and competitiveness.
10. To critically and logically contemplate, to have a reasoned opinion and be able to defend it, to gather and present scientific information to different audience

Outcome of the Program

Upon successful completion of the Masters of Fisheries Science (M.F.Sc.) degree programme, graduates will be qualified to work as Fisheries Development Officers in the State Governments;

Technical/Specialist/Market Recovery Officers in Banks; Officers in Insurance Companies; Technical officers in States/Central Fisheries Institutions. Post graduates with Ph.D qualification are eligible for Scientist/Assistant Professor in Central/State Organizations and Universities.

The 2 year M.F.Sc. degree course offers a great scope to the students for self-employment in establishing Farms/Hatcheries/Processing Plants and Fish Export Business. The M.F.Sc. (Aquaculture) graduates have very good career opportunities in the respective field, as it is less saturated compared to other agriculture related fields and there is a huge scope for development of fisheries in the county.

MAJOR COURSES

1. Freshwater Aquaculture Production Systems [AQC 0501] 3(2+1)

Objectives:

1. To impart basic knowledge on aquaculture practices.
2. To develop knowledge on sustainable integrated aqua-farming practices.
3. To understand recent innovations and implications in aquaculture.

Outcomes:

1. Understand standard operational procedures in aquaculture systems.
2. Provide knowledge on culture methods for commercially important aquatic organisms.
3. Developed skill on management, methodology and practices in aqua-farming.
4. Understand sustainable ways for aqua-farming.
5. Gained knowledge on modern aquaculture farming systems.

Theory:

Unit I : Introduction: Present status, hindrances / problems / constraints and prospects for fish and prawn farming in global and Indian perspective. Development process, different supports and driving factors forproduction enhancement.

Unit II: Aquaculture systems: Extensive, semi-intensive and intensive culture of fish and prawn. Partitioned aquaculture systems: raceways, tanks, flow-through systems, polyculture, and composite fish culture. Cages and enclosure. Peri-urban aquaculture systems: aquaponics, RAS, flow- through systems, bio-floc technology and land based aquaculturesystems.

Unit III: Aquaculture practices for cultivable species: Carps, Catfish, Snakeheads, Featherbacks, Tilapia, Mahseer, Trouts and freshwater Prawn. Grow out practices: pre stocking, post stocking management, harvesting and BMP. Other alternative species for high production. Species selection and crop planning. Economics of different fish farming systems

Unit IV: Freshwater prawn farming: Monoculture practice of prawn in ponds, all-male 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 methods, handling and BMP.

Unit V: Integrated farming systems: Design, farming practices, constraints and economics of IFS of fish with vegetables, fodder, paddy, cattle, pig, poultry, duck, rabbit and quail. IMTA, Freshwater pearl culture, multi- level integrated system. Resource utilization and conversion of waste to wealth. Unit VI Wastewater-fed aquaculture: Water treatment methods, species selection, culture practices, harvesting and depuration process. Merits and demerits of wastewater fed aquaculture systems. Pre-requisites and precautions to be taken in the technology adoption.

Practicals:

Practical Identification of commercially important cultivable finfish and shellfish species; Assessment of seed quality- stress test; pre-stocking factors evaluation and observation; Calculating carrying capacity of pond and stocking density; Check tray assessment and feed ration calculation; Sampling process and species wise growth estimation; Farm feed production and feeding; Lime and fertilizer requirement calculations; Farm visits and observation; Records keeping and data analysis; Modeling of different culture systems.

Suggested Reading

• *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 and 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 and 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.*

2. Coastal Aquaculture and Mariculture Farming Systems [AQC 0502] 3(2+1)

Objectives:

- To impart basic knowledge on costal Aquaculture Practices.
- To develop knowledge on the culture practices of various marine candidate species for Aquaculture.
- To gain knowledge in establishing and managing different fish/shellfish farming systems in coastal zone and marine waters.

Outcomes:

- Provide knowledge on culture methods for commercially important marine aquatic organisms.
- Developed skill on management, methodology and practices in mari-culture.
- Understand sustainable ways for costal aqua-farming.
- Gained knowledge on recent aquaculture farming systems.

Theory:

Unit I: Introduction: Overview of coastal aquaculture and open sea mariculture; Present trend and future prospects in India. Practices in tropical countries, production levels and adoption of technology. Major bottlenecks in the practices

Unit II : Different farming systems: Cage and pen culture – types, site selection, construction, specifications for different species; Raft and rack culture – Principles, site selection, design and construction; operations and troubles shooting, threats and environmental issues; Land based aquaculture. Principle, design, construction and operations, rules and legislations

Unit III: Aquaculture of finfishes: Distribution, biology, seed collection, nursery rearing, weaning on artificial feed, culture techniques, feeding strategies, constraints and scope (Seabass, milkfish, mullets, pearlspot, sea breams, grouper, snapper, cobia, pompano).

Unit IV: Shrimp farming (Penaeus monodon, P. indicus, P. semisulcatus, and Litopenaeus vannamei): Systems of farming – extensive, semi- intensive, intensive and super intensive (Biofloc, RAS, etc.); site selection, design and construction of culture systems, pond preparation, stocking, feed and water quality management, disease prevention and treatment; use of probiotics and prebiotics: harvesting and handling; continuous stocking and harvesting, staggered harvest, management of differential growth; shrimp farming in undrainable ponds. Mud crab fattening, production of soft-shell crabs and Lobster culture.

Unit V: Culture practices for marine molluscs and echinoderms: Present status and future prospects in India, Species cultured (mussels, oysters, pearl oysters, clams, abalone, sea cucumber) distribution, biology, practices followed in India and other Asian countries, farming methods–different types and culture methods; Problems and prospects.

Unit VI: Seaweed farming: Major seaweed species of commercial importance; tissue culture of seaweeds, methods of culture; farming of agar, algin and carragenan yielding species; emerging trends in their farming inopen seas; Integration with other coastal and marine farming systems.

Practicals:

Practical Identification of commercially important cultivable finfish and shellfish species; Assessment of seed quality, rearing techniques; Feeds for nursery rearing, preparation and evaluation; pre-stocking factors in different systems, valuation and observation; Calculating carrying capacity of pond and stocking density; Cage construction, pen construction and identification of bottlenecks; Sampling process and species wise growth estimation; Construction of rafts and mollusc culture; Seaweed collection and identification; Farm feed production and feeding; Disease identification and management; Visits to cage sites and observation; Records keeping and data analysis; Modelling of different culture systems.

Suggested Reading

• Appukuttan KK, Asokan PK, Mohamed KS, Subramaniam S and G Joseph GK. 2003. Manual on Mussel Farming. CMFRI Technical Bulletin 3.

• Bardach EJ, Rhyther JH and Mc Larney WO. 1972. Aquaculture the Farming and Husbandry of Freshwater and Marine Organisms. John Wiley and Sons.

• FAO. 2001. Planning and Management for Sustainable Coastal Aquaculture Development. • FAO Publ. Gilbert B. 1990. Aquaculture. Vol. II. Ellis Horwood.

• Ghosh, P.K., 2010. Brackishwater Aquaculture. Agrobios (India)

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

• James PM. 1983. Handbook of Mariculture. Vol. I. Crustacean Aquaculture. CRC Press. • NFDB, 2018. Guidelines for sea cage farming in India.

• Ottolenghi F, Silvestri C, Giordano P, Lovatelli A and New MB. 2004. Capture-based aquaculture: the fattening of eels, groupers, tunas and yellowtails. FAO Publ.

• Pillay TVR. 1990. Aquaculture, Principles and Practices. Fishing News Books.

• Pillay TVR and Kutty MN. 2005. Aquaculture: Principles and Practices. 2nd Ed. Blackwell. Sekar M, Ranjan R, Xavier B and Ghosh S. 2016. Training manual on cage culture of marine finfish. CMFRI Publ.

• Shepherd J and Bromage N. 1990. Intensive Fish Farming. B.S.P. Professional Books.

• Shepherd J and Bromage N. 1990. Intensive Fish Farming. B.S.P.Professional Books.

• Syda Rao G, Imelda-Joseph, Philipose KK and Suresh Kumar M, 2013. Cage aquaculture in India. CMFRI Publ.

3. Hatchery Technology for Finfishes and Shellfishes [AQC 0503] 3(2+1)

Objectives:

1. To impart adequate knowledge about the life cycle and maturity stages of commercially important finfish.
2. To understand the induced breeding of commercially important finfishes.
3. To understand hatchery management and rearing techniques of commercial finfish.

Outcomes:

1. Understand the life cycle and maturity stages of commercially important finfishes
2. Gain knowledge of Induced breeding of commercially important finfishes.
3. Understand the reproductive hormones and the physiology of different finfish.
4. Develop skills in hatchery management and rearing techniques of commercially important finfishes.
5. Health and feeding management of larval stages of important finfishes in hatcheries.

Theory

Unit I: Introduction: Current status; problems and prospects of seed of different shellfish species – freshwater and marine. Site selection and techniques of collection; identification and segregation of finfish and shellfish seed, handling, packing and transportation. Natural collection processes and their merits and demerits.

Unit II: Reproductive biology: Morphology and reproductive physiology; gonad anatomy; histology of gonad; Hormonal pathways and mode of control; Spermatogenesis and oogenesis; gametology (evaluation of milt and egg); Overview of current developments in reproductive biology of commercially important finfishes and shellfishes.

Unit III: Environmental and nutritional control of reproduction: Reproductive cycles, factors influencing reproduction (Photoperiod, change in water quality and quantity, temperature, lunar cycle, etc.), simulated environment and exogenous hormonal stimuli. Nutritional factors (types of feed - live and prepared feeds, nutritional quality, quantity, feeding management, feed utilisation, etc.) affecting maturation, spawning and nursery rearing.

Unit IV: Induced spawning: Brooder development, quality and its health management, transportation of brooders, hormonal and environmental stimulation, use of different natural, synthetic hormones and analogues and their application; GnRH and LINPE models, PIT tagging, Canulation and volitional spawning, Estimation of spawning efficiency, cryopreservation of gametes.

Unit V: Hatchery management: Indian major and minor carps, exotic carps, catfishes, tilapia, mahseer, murrels, Trout, Seabass, milkfish, mullets, grouper, snapper, breams, pompano, and cobia. Seed production of commercially important prawns (*Macrobrachiumrosenbergii*), shrimps (*Penaeus monodon, P. indicus, P. semisulcatus, and Litopenaeusvannamei*), crabs (*Scylla serrata, Portunuspelagicus*), spiny lobsters (*Panulirus*spp), mussels, edible oysters, pearl oyster and clams. Hatchery protocols, water quality management, larval rearing, estimations, troubleshooting in hatcheries, record keeping, packing and transport of seed, anaesthetics in fish

seed transport. Quarantine and Hatchery protocols and biosecurity principles; sanitary and phytosanitary (SPS) measures; Better Management Practices (BMPs); packaging and transport of seed. SPF brood stock development.

Unit VI: Seed quality: Hatchery protocols, water quality management, larval rearing, estimations, trouble shooting in hatcheries, record keeping, packing and transport of seed, anaesthetics in fish seed transport. Quarantine and Hatchery protocols and biosecurity principles; sanitary and phytosanitary (SPS) measures; Better Management Practices (BMPs); packaging and transport of seed. SPF brood stock development. Economics of seed production of different species

Practicals

Study of primary and secondary sexual characters; Brooder handling and morphological features recording; Gonadal development observation in carps and other cultivable finfishes; Histological observation of gonads and eggs; Estimation of GSI, Fecundity, Absolute fecundity, Egg parameters, Ovarian features; Collection and identification of cultivable finfish seed; Seed quality character identification; Observation and analysis of inducing agents; Induced breeding of fishes through various inducing agents; Evaluation of carp milt and egg; Cryopreservation of gametes; Preparation of brood and larval feed for different cultivable finfish; Packing and transportation of cultivable finfish seed; Visit to different finfish hatcheries.

Suggested Reading

- *Betsy, C.J. and Kumar, J.S.S., 2017. Cryopreservation and Spermatology in Fishes. Narendra Publishing House*
- *Chattopadhay NR. 2016. Induced fish breeding: a practical guide for hatcheries. Elsevier Academic Press.*
- *FAO. 1992. Manual of Seed Production of Carps. FAO Publ.*
- *Gupta SD, Mohapatra PC, Routray P, Sahoo SK, Verma DK, Sarangi N. 2008. Textbook of breeding and management of carps. Narendra Publ. House*
- *ICAR. 2006. Handbook of Fisheries and Aquaculture. ICAR.*
- *Jhingran VG. 1991. Fish and Fisheries of India. Hindustan Publ. Corp.*
- *Jhingran VG and Pullin RSV. 1985. Hatchery Manual for the Common, Chinese and Indian Major Carps. ICLARM, Philippines.*
- *Landau M. 1992. Introduction to Aquaculture. John Wiley and Sons.*
- *Mcvey JP. 1983. Handbook of Mariculture. CRC Press.*
- *Pillay TVR and Kutty MN. 2005. Aquaculture- Principles and Practices. Blackwell.*
- *Rath RK. 2000. Freshwater Aquaculture. Scientific Publ.*
- *Thomas PC, Rath SC and Mohapatra KD. 2003. Breeding and Seed Production of Finfish and Shellfish. Daya Publ. House.*

4. Aquaculture Policy and Planning [AQC 0504] 2(1+1)

Objectives:

Objectives:

1. To learn various policies governing the sustainable development of fisheries in India.
2. To know about various policy interventions and strategies for increasing fish production.
3. To learn about the regulatory regimes in Indian fisheries.

Outcomes:

1. Understanding of public administration principles.
2. Knowledge of fisheries development policies.
3. Understanding of fisheries legislation in India.
4. Knowledge of regulatory activities in Aquaculture and fisheries.
5. Account of historical review of fisheries development..

Theory

Unit I: Sustainability issues: Environmental and Socio-economic issues; Exotic species introduction; escapement; contamination of indigenous gene pool; salinization of soil and water; environmental impact; over exploitation of wild stocks; mangrove deforestation. EIA, eco-system approach to aquaculture. Conflicts over water and land use; conflicts of interest between aqua farmers and fishermen, aquaculture andother enterprises; social issues; anti-dumping duties.

Unit II: Climate Change Impact: Weather elements of concern in aquaculture, Green house gases, global warming and their impact, Carbon sequestration in aquaculture, Microplastics in Aquaculture, measures and tools to reduce energy use and greenhouse gas emission in aquaculture.

Unit III: Strategies for sustainability: Sustainability concept; food security; biosecurity; organic farming; responsible aquaculture; rotational aquaculture; bioremediation; role of biotechnology, traceability. Energy conservation. Application of renewable energy in aquaculture- solar energy, wind, and tidal energy, Seed certification, Sustainable use of antibiotics, minimal water exchange system, natural productivity, preservation of natural resources.

Unit IV: Guiding principles for sustainable aquaculture: Coastal Aquaculture Guidelines Source Book, FAO Code of Conduct for Responsible Fisheries; Holmenskollen Guidelines for Sustainable Aquaculture. BMP, CRZ implications, CAA and it's role, ecolabelling, organic certification. PCB and State water bodies protection guidelines.

Practicals

Visit to conventional aquafarm to see the management of used water; Survey on environmental impact on nearby aquaculture farms; Applications of remote sensing and GIS (geographical information system); Economic

evaluation of aquaculture practices. Case studieson environmental issues of different types of farms.

Suggested Reading

- Bardach JE. 1997. *Sustainable Aquaculture*. John Willey and Sons.
- Bardach JE, Rhyther JH and Mc. Larney WO. 1972. *Aquaculture Farming and Husbandry of Freshwater and Marine Organisms*. John Wiley and Sons.
- Beets WC. 1990. *Raising and Sustaining Productivity of Small- Holder Farming Systems in the Tropics*. Agbe Publ.
- Edwards P, Little DC and 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 ShallowSea Culture*. Amerind Publ.
- James PM. 1983. *Handbook of Mariculture*. Vol. I. Crustacean Aquaculture. CRC Press.
- Leung P, Lee CS and O'Bryen JP. (Eds.). 2007. *Species and System Selection for Sustainable Aquaculture*. Blackwell Publ.
- Midlen and Redding TA. 1998. *Environmental Management for Aquaculture*. Chapman and Hall.
- Selvamani BR and Mahadevan RK. 2008. *Aquaculture, Trends and Issues*. Campus Books International. FAO, 2011. Code of conduct for responsible fisheries. FAO special edition.

5. Fish Nutrition and Feed Technology [AQC 0505] 3(2+1)

Objectives:

1. To impart the basic principle and concept of fish nutrition, feed formulation and different feed processing techniques.
2. To improve the knowledge of feeding methods and feed management.
3. To understand the requirement and availability of ingredients and the function of individual nutrients for aqua-feeds.

Outcomes:

1. Able to classify and identify the feedstuffs into different nutrient groups
2. Understand the chemical compositions of various feedstuffs and supplements
3. Able to identify feed mill equipment and its operating procedure

4. Enable to formulation and preparation of fish feeds of different crude protein composition
5. Able to prepare the species-specific diet sustainably.

Theory

Unit I: Introduction: Need for studying the nutritional requirements of cultivable fishes, feed formulation, Methods to study the nutritional requirements, and its need.

Unit II: Feed ingredients and Feed preparation: Commonly used feed ingredients in aqua feeds, Novel feed ingredients, estimation of quality of feed ingredients, Qualities of feed ingredients that determine feed quality, Selection of ingredients, Formulation of feeds, Feed processing and making. Different feed preparation methods.

Unit III: Types of feeds: Floating, semi-floating, sinking and stable feeds for aquaculture, Feed making methods for different feeds, Nutrient leeching in feeds, feed quality determination and feed making, Evaluation of feeds, Simulated system evaluation, lab analysis.

Unit IV: Advanced feeds: High energy feeds, Alternative protein sources for feeds, maturation diets to enhance breeding efficiency, Larval feeds, bio availability in feeds, High FCE and economic benefits of feeding in the farming, Live feed enrichment, Bio-routing of nutrients, Chemo-therapeutants, Other growth promoting agents through live feeds. Evaluation of bio-accumulation and bio-utilisation.

Unit V: Feed processing technology: Common processes in feed manufacture; Grinding, Dosing, Homogenization; Extrusion cooking; Complimentary processes; Drying, crumbling, coating; Use of binders; Feed manufacture productions with high energy diets vacuum coating with lipid. Equipments used in feed manufacture; Pulverizer, grinder, mixer, pelletizer, crumbler, drier, Extruder/Expander, Vacuum coater, fat sprayer

Unit VI: Quality control in fish feed manufacturing: Quality control procedures, raw materials, finished products; Geometrical, and physical feature; Mechanical characteristics in air, Behavioural characteristics in water, Feed economics and evaluation criteria: FCR, AFCR, SGR, PRE, ERE, PER, NPU.

Practicals

Nutritional requirements determination for different species; Collection and analysis of different feed ingredients; Feed formulation with different feed ingredients; Feed quality analysis; Evaluation process in farms and labs; Visit to feed mills and feed making process; Economic analysis of feeding and non feeding systems; Identification of different feed additives; Observation of novel feeds and their utilization

Suggested Reading

- ADCP (Aquaculture Development and Co-ordination Programme), 1980.*Fish Feed Technology*. ADCP/REP/80/11. FAO.
- Ali SA. 2018. *Nutritional feeding of fish and shrimps in India*. MJP Publ.

- Cyrino EP and Bureau D and Kapoor BG. 2008. *Feeding and Digestive Functions in Fishes.*

Science Publ.

- D' Abramo LR, Conklin DE and Akiyama DM. 1977. *Crustacean Nutrition: Advances in Aquaculture*. Vol. VI. World Aquaculture Society, Baton Roughe.
- De Silva SS and Anderson TA. 1995. *Fish Nutrition in Aquaculture*. Chapman and Hall Aquaculture Series.
- Elena M. 2003. *Nutrition, Physiology and Metabolism in Crustaceans*. Science Publishers.
- Ganguly S. 2014. *Potential and recommended feed additives for sustainable aquaculture, livestock and poultry farming practices*. Narerndra Publ.
- Guillame J, Kaushik S, Bergot P and Metallier R. 2001. *Nutrition and Feeding of Fish and Crustaceans*. Springer Praxis Publ.
- Halver J and Hardy RW. 2002. *Fish Nutrition*. Academic Press.
- Halver JE and Tiews KT. 1979. *Finfish Nutrition and Fish feed Technology*.Vols. I, II Heenemann, Berlin.
- Hertrampf JW and Pascual FP. 2000. *Handbook on Ingredients for Aquaculture Feeds*. Kluwer.
- Houlihan D, Boujard T and Jobling M. 2001. *Food Intake in Fish*. Blackwell.
- Lavens P and Sorgeloos P. 1996. *Manual on the Production and Use of Live Food for Aquaculture*. FAO Fisheries Tech. Paper 361, FAO.
- Lovell RT. 1998. *Nutrition and Feeding of Fishes*. Chapman and Hall.
- Lovell T. 2014. *Nutrition and feeding of fish*. Springer Publ.
- Merrifield D and Ringo E. 2014. *Aquaculture Nutrition: gut health, probiotics and prebiotics*.
- Nates SF, 2016. Aquafeed formulation. Academic Press
- 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*. FAO – ADCP/REP/ 87/26.
- Strasbourg LK. 2013. *Fish feeding in integrated fish farming*. Random Exports.
- Wiley Blackwell. Ninawe AS and Khedkar GD. 2009. *Nutrition in aquaculture*. NarendraPubl.

6. Soil and Water Quality Management In Aquaculture [AQC 0506] 3(2+1)

Objectives:

1. To analyze and explain the physical and chemical composition of soil and water.
2. To understand principles, applications, methods and types on analytical chemistry.
3. To impart knowledge on the interaction between soil and water, including adsorption, desorption and ion exchange.

Outcomes:

1. Understand the water and soil parameters analysis for aquaculture.
2. Aware of optimum ranges of water and soil parameters for aquaculture.
3. Describe soil and water interaction processes.
4. Understand redox reaction and electron transfer.
5. Familiarize with common laboratory techniques for analyzing soil and water samples.

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; Equipment used for soil and water quality estimations, Automated systems for monitoring, Quality checks and management, aeration system for water quality 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 conditioners: Biological indicators, Chemical and physical method of conditioning, Prebiotics, Probiotics, Minerals, Micro-nutrients and additives.

Unit V: Development of suitable soil and water quality: Cat clay/pyrite soil, Seepage, water treatment, Water filtration devices, Aeration, Chlorination, Ozonization and UV radiation, Algal bloom control, Eutrophication, Aquatic weed management, Water quality management in hatcheries.

Unit VI: Waste water treatment practices: Waste discharge standards, Role of microorganisms in fish production, Fish health and fish safety; Microbial load and algal blooms.

Practicals

Preparation of water quality charts and maintenance; 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.

Suggested Reading

1. *Adhikari S and 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, DC.*
2. *Boyd, C. E. and Tucker, C. S. 1992. Water Quality and Pond Soil Analyses for Aquaculture, Alabama Agricultural Experimental Station, Auburn University.*
3. *Boyd CE. 1979. Water Quality in Warm Water Fish Ponds. Auburn University.*
4. *ICAR. 2006. Handbook of Fisheries and Aquaculture. ICAR.*
5. *Mcvey JP. 1983. Handbook of Mariculture. CRC Press.*
6. *Parsons TR, Maita Y and Lalli CM. 1984. A Manual of Chemical and Biological Methods for Seawater Analysis. Pergamon Press.*
7. *Rajagopalsamy CBT and Ramadhas V. 2002. Nutrient Dynamics inFreshwater Fish Culture System. Daya Publ.*
8. *Sharma LL, Sharma SK, Saini VP and Sharma BK. (Eds.). 2008. Management of Freshwater Ecosystems. Agrotech Publ. Academy.*

7. Therapeutics and Health Management in Aquaculture [AQC 0507] 3(2+1)

Objectives:

1. To understand the importance of chemotherapy in promoting fish health
2. To impart knowledge on different classes of drugs used in fish health
3. To familiarize with the proper drug dosage and regulations used for prophylactic and therapeutic purposes

Outcomes:

1. Understand the importance of therapeutics for reducing economic losses due to disease in aquaculture
2. Gain understanding of various therapeutic interventions in promoting fish health
3. Learn about different therapeutic agents, including drugs, vaccines, and chemicals, and their appropriate use in treating aquatic organisms.
4. Understand proper dosage calculations and administration techniques for therapeutic agents to ensure effective treatment.
5. Gain knowledge of regulations and guidelines related to the use of therapeutic agents in aquaculture, including drug approval processes and withdrawal periods

Theory

Unit I: Diseases of fishes: Bacterial, Fungal, Viral diseases of fishes in farm ponds, Natural waters, and incidental outbreaks, Nutritional disorders and environmental diseases, situations for disease outbreaks, Natural immunity and disease control.

Unit II: Control of diseases in aquaculture systems: Control measures for fish diseases, Environmental and nutritional support methods for disease management, Immune modulation, Immunostimulation, Use of vaccines and other preventive methods, Control of diseases in various aquaculture systems, their limitations and benefits.

Unit III: Therapeutics: Concept of therapeutics in aquaculture, effectiveness of medication, Drugs in aquaculture, Herbal therapeutants, Use of and disuse chemicals in aquaculture, Legislation and jurisprudence in therapeutics for aquaculture organisms, Shrimp farming and control mechanism, Drug therapies for ornamental fishes, Biotraceability of antibiotics use in aquaculture.

Unit IV: Health management plans for hatcheries: Special features of hatcheries and health management of brooders, larvae, fry and young ones, Disease impacts on hatchery production, Disinfection protocol, Live feed crash due to diseases, Communicable diseases and their mechanism of spreading, Controlling outbreak of viral infections in all types of hatcheries, Economic benefits of investment in disease management.

Unit V: Modern treatment methods for fishes: Treatment methods currently in practice, isolation, Hospital tanks, Disinfection, Oral drug administration, immersion, Brooder treatment for immunity enhancement, mass treatment protocol, vaccination, advantages and disadvantages.

Unit VI: Other health management aspects: Health improvement through feeds, Medicated feeds, Chemicals for treatment of external and internal diseases, Parasite treatment, health improvement after treatment, SPF, SPR and SPT seeds, their production protocols.

Practicals

Identification of disease conditions: Pathological features observation in cultivable fishes; Collection of diseased specimens and identification; Developing treatment protocols for fishes; Analysis of environmental situation favouring disease outbreaks; Epidemic conditions in farms identification; Preparation of medicated feeds, validation and

observation; Hospital tanks and management; Probiotics and prebiotics identification of their effects; Visit to hatcheries and farms to collect the specimens; Economics of different treatment methods.

Suggested Reading

- Andrews C, Excell A and Carrington N. 1988. *The Manual of Fish Health*. Salamander Books.
- Brunton LL. (Ed). 2005. *Goodman and Gilman's The Pharmacological Basis of Therapeutics*. 11th Ed. McGraw-Hill.
- Felix S, Riji John K, Prince Jeyaseelan MJ and Sundararaj V. 2001. *Fish Disease Diagnosis and Health Management*. Fisheries College and Research, Institute, T. N. Veterinary and Animal SciencesUniversity. Thoothukkudi.
- Humphrey J, Arthur JR, Subasinghe RP and Phillips MJ. 2005. *Aquatic Animal Quarantine and Health Certification in Asia*. FAO Publ.
- Jorge E, Helmut S, Thomas W and Kapoor BG. 2008. *Fish Diseases*. Science Publ.
- Riviere JE and Papich MG. (Eds.). 2013. *Veterinary Pharmacology and Therapeutics* 9th ed. John Wiley and Sons.
- Sandhu HS and Rampal S. 2006. *Essentials of Veterinary Pharmacology and Therapeutics*. 1st Ed. Kalyani Publishers.
- Sindermann CJ. 1990. *Principal Diseases of Marine Fish and Shellfish*.Vols. I, II. 2nd Ed. Academic Press.
- Treves-Brown KM. 2013. *Applied Fish Pharmacology* (Vol. 3). Springer Science and Business Media.

MINOR COURSES

1. Larval Nutrition and Live Feed Production [AQC 0508] 2(1+1)

Objectives:

1. To impart knowledge on identification of live fish food organisms.
2. To impart basic knowledge on morphology, life cycle and culture techniques of live fish food organisms.
3. To impart practical skills of laboratory and mass-scale culture of fish food organisms.

Outcomes:

1. Understand the identification character of phytoplankton and zooplankton for freshwater and marine species.
2. Enhanced knowledge on importance of different live fish food organisms.
3. Develop skills on culture practices of different food organisms.
4. Improve skills on proximate composition of live feed.
5. Understand the morphology and life cycle of live fish food organisms.

Theory

Unit 1: Larval nutrition: Nutritional requirements of finfish and shellfish larvae, Nutritional quality of commonly used live feed, Comparison of live feeds against the prepared feeds, Nutritional disorders in larvae, Larval feeds utilization and advantages.

Unit II: Formulation and preparation of artificial feeds: For larval rearing, Micro particulate diets, Particulate and microencapsulated diets, High energy feeds, energy sparing nutrients in larval feeds.

Unit III: Biology of live feeds: Important live feeds and their biological features, Identification of new live feeds, Live feed use in different forms, Advantages and disadvantages. Important microalgae, rotifers, artemia, infusoria, cladocerans, copepods, oligochaetes, nematode and insect larvae. Bio-enrichment of live feed, Biofilm/periphyton and its use, Culture of single cell proteins and their nutritional quality.

Unit IV: Live feeds research in India, Around the world, New techniques developed in live feed use. Quality determination and cost benefit analysis, Production methods for different micro feeds, lab analysis of quality.

Practical

Collection, identification and isolation of live feed using various techniques, Preparation of various culture media, Preparation and maintenance of stock microalgal culture; Preparation of formulated feeds for rearing finfish and shellfish larvae; Mass culture of microalgae, cladocerans, copepods and rotifers; Hatching of artemia and enrichment; Culture of infusoria, earthworms and chironomidlarvae; Evaluation of different prepared feeds.

Suggested Reading

1. *CIFE. 1993. Training Manual on Culture of Live Food Organisms for AQUA Hatcheries. Central Institute of Fisheries Education, Versova, Mumbai.*
2. *Finn RN and Kapoor BG. 2008. Fish Larval Physiology. Science Publ.*
3. *Gopinathan CP. 1993. Handbook on Aqua Farming - Live Feed. MPEDA Publication*
4. *Hagiwara A, Snell TW, Lubzens E and Tamaru CS. 1997. Live Food in Aquaculture. Proceedings of the Live Food and Marine Larviculture Symposium. Kluwer.*
5. *Joan Holt G. 2011. Larval fish nutrition. Wiley Blackwell Publ.*
6. *Lee CS., O'Bryen, PJ, Marcus NH. 2005. Copepods in aquaculture. Blackwell Publishing.*
7. *MPEDA. 1993. Handbook on Aqua Farming - Live Feed. Micro Algal Culture. MPEDA Publication.*

8. *Muthu MS. 1983. Culture of Live Feed Organisms. Tech. Paper 14.Summer Institute in Hatchery Production of Prawns Seeds. CMFRI, Cochin.*
9. *Ojha JS. 2005. Aquaculture Nutrition and Biochemistry. Daya Publ.*
10. *Santhanam R, Ramnathan M and Venkataramanujum. 1997. A Manual of Methods in Plankton. Fisheries College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Tuticorin.*
11. *Sorgeloos P and Pandian KS. 1984. Culture of Live Food Organisms with Special Reference to Artemia Culture. CMFRI Spl. Publ. No. 15.*
12. *Tonapi GT. 1980. Freshwater Animals of India. Oxford and IBH.*

2. Aquaculture Engineering [AQC 0509] 2(1+1)

Objectives:

1. To learn the basic aspects of successful farm designing for effective management and optimum yield.
2. To improve the technical knowledge of the preparation and management of fish and shrimp ponds.
3. To provide the right knowledge on the selection of species and mode of culture practice.

Outcomes:

1. Knowledge of the basic concepts of farm designing and explain recent trends in aquaculture engineering.
2. Explain site selection, construction, and design of tanks, ponds, cages, and hatcheries.
3. List the equipment used for water treatment in farms and processes of disinfection.
4. Understand the design and fabrication of different types of aerators used in aquaculture farms.
5. List different types of feeding equipment, feed control systems, and instruments for measuring water quality.

Theory

Unit I: Site selection: Criteria for site selection, Correction factors, Survey methods, Earth work calculations and cost estimation; water resources and their suitability, Suitability of soil from stability and productivity point of view; Land conversion effects and Environmental Impact Assessment (EIA).

Unit II: Estimation in farm construction: Area and volume calculations for an aquafarm and water bodies, surveying and leveling (chain, compass and plain table survey, dumpy level and the odolite).

Unit III: Design, layout planning and construction of different types of production systems: Types of ponds, shape, size and orientation, Design of embankments, Ponds and tanks, Water distribution, canals and exchange structures (inlets, outlets, sluice gates, and monks); Design of feeder channels and drainage systems. Pens, cages (fixed, floating, semi-submerged and tray cages) raceways, Flow-through systems and re-circulatory aquaculture systems (RAS),

aquaponics, Feed dispensers, Demand feeders and effluent treatment systems (ETS), Automation in aquaculture.

Unit IV: Design and construction of hatcheries: (carp, freshwater prawn, shrimp and trout). Selection of aquaculture equipment and implement: Selection criteria and maintenance of water pumps, Water filtration systems, Principles of aeration, Aerators, Oxygen budgeting, Aeration grid, Automatic and demand feeders, Soil and water samplers. Aquifers, soil permeability, Hydraulic conductivity, Water budgeting, Water harvesting, Multiple uses of water, Economic impactof modernization in aquafarms

Practical

Estimation in construction, Model development, Visit to aqua farms and hatcheries, Survey - contour survey and mapping, chain and compass survey, Dumpy leveling, Evaluation of performance of seepage control measures, Layout planning and design of hatcheries (carp, freshwater prawn, shrimp and trout) and farms including their costing and evaluation, Estimation of pump capacity, Estimation of construction cost of ponds, Hatchery shed, Aeration devices and Evaluation of their capacity.

Suggested Reading

- Creed R. 2017. *Aquaculture and Fish Farming*. Syrawood Publ.
- Bose AN. 1991. *Coastal Aquaculture Engineering*. Oxford and IBH Publ.
- Ivar LO. 2007. *Aquaculture Engineering*. Daya Publ. House.
- Lekang OI. 2013. *Aquaculture Engineering*. Wiley-Blackwell Publ.
- Pillay TVR and Kutty MN. 2005. *Aquaculture- Principles and Practices*. Blackwell.
- Thomas L. 1995. *Fundamentals of Aquacultural Engineering*. Chapman and Hall.
- Wheaton FW. 1977. *Aquacultural Engineering*. John Wiley and Sons.

3. Open Water Aquaculture [AQC 0510] 2(1+1)

Objectives:

1. To acquire basic knowledge on reservoirs and its classification
2. To impart basic knowledge on hydrographical and limnological features of reservoirs
3. To acquaint with different management regimes and sustainable cultural practices in reservoirs

Outcomes:

1. Fundamental knowledge of reservoir fisheries and related biodiversity.
2. Enhanced knowledge on management and conservation of reservoir fisheries.

3. Understand management of reservoir fisheries through modern aquaculture techniques.
4. Improved problem solving skills through analyzing hydrological and limnological data of the reservoir.
5. Acquaint students to solve constraints occurred in reservoir fisheries.

Theory:

Unit I: Introduction: Overview of global scenario of aquaculture in open waters, open water resources in India, Present status, Utilization, Prospects of production augmentation, Utilization of open water bodies for aquaculture to enhance production.

Unit II: Different culture systems: Cages, pens and enclosures in open waters, Seed stocking, quality and quantity, Cages for sea, estuaries, reservoirs, lakes and canals, Pen culture, Selection of site for sea farming, Different designs of open sea farming structures-construction of cages-bioengineering problems and solutions, Species selection for open water aquaculture, Rearing of fingerlings, advanced fingerlings and table size fish in open water bodies.

Unit III: Practices: Ranching in open waters, species quality and quantity, Natural feed enhancement, Supplementary feeding in cages, Stock assessment, Harvesting and conflicts with irrigation, Drinking water and hydroelectric projects on open water farming.

Unit IV: Environmental impact of Open water Aquaculture: Salinity intrusion, Effluent, discharge, Eutrophication, Chemical residues including antibiotics and hormones, Destruction of natural habitat including paddy field and mangroves, Social issues and conflicts with other users on resources

Practical:

Different types of cage materials, fabrication of cages and pens and their installation. Determination of stocking density in cages and pens, Feeding in cages and pens, Stock assessment in cages and pens; Environmental impact of cages and pens, Visit to cages and pen sites.

Suggested Readings

1. *Beveridge MCM. (Ed.). 2004. Cage Aquaculture, 3rdEdition. Blackwell Publishing.*
2. *Beveridge M. 2008. Cage Aquaculture. Oxford Publ.*
3. *Burnell G, Allan G. 2009. New Technologies in Aquaculture. 1st Edition. Woodhead Publishing House.*
4. *Chiu Liao I, Kwei Lin C. 2000. Cage aquaculture in Asia: Proceedings of the First International Symposium on Cage Aquaculture in Asia, AFS and WAS Publ.*
5. *FAO. 2018. The State of World Fisheries and Aquaculture -Meeting the Sustainable development goals. Rome.*
6. *NFDB. 2018. Guidelines for Sea Cage Farming in India.*
7. *Syda Rao G, Imelda-Joseph, Philipose KK and Suresh Kumar M, 2013. Cage Aquaculture in India. CMFRI Publ.*

8. *Tidwell JH. (Ed.). 2012. Aquaculture Production Systems. Wiley-Blackwell.*

4. Commercial Ornamental Fish Breeding and Culture [AQC 0511] 2(1+1)

Objectives:

1. To study about identification and culture of different varieties of exotic and indigenous ornamental fishes
2. To learn the fabrication, setting up and maintenance of freshwater and marine aquarium
3. To understand the basic health management and genetic improvement of ornamental fish.

Outcomes:

1. Understand the identification and breeding of common ornamental fishes.
2. Able to do fabrication, setting up and Aqua-scaping of freshwater and marine aquarium
3. To get knowledge in water quality and health management of common cultured ornamental fishes
4. To understand the application of genetics and biotechnology for producing quality strains of commercial ornamental fishes
5. To understand the conditioning and packing of ornamental fishes.

Theory

Unit I: Introduction: Global status of ornamental fish trade, present status and prospects of ornamental fish farming and trade in India, Indian ornamental fish diversity and its status, Prospects of production of new strains / varieties, Ornamental fish breeding techniques towards strain development.

Unit II: Design and construction: Self-maintained aquarium, species compatibility, High value species, Aquarium maintenance and care, Common aquarium plants and their identification, Gadgets used in freshwater and marine aquarium, aerators, Filters (UV, trickling and biofiltration), Protein skimmers, Ozonizer, thermostatic heater, Chiller, Lighting, Water conditioners, etc.

Unit III: Captive Breeding techniques: Mass production of commercially important freshwater and marine ornamental fishes, Nursery and grow out culture of commercially important ornamental fish species in Raceways, RAS etc., Hybrids development, Feed and feeding, Color enhancement through pigmented feed, Novel feeds, Common diseases, and control, Water quality management.

Unit IV: Transportation and Trading of Ornamental Fishes: Medicines and chemicals used in the ornamental fish industry, Anaesthetics, packing, transportation and marketing strategies. Culture unit for entrepreneurship development, Socio-economic upliftment through backyard ornamental fish farming, Micro-traders in ornamental fish marketing.

Practicals

Identification of common ornamental fishes; Plants and gadgets used in aquariums; Breeding of commercially important ornamental fishes, Visit to ornamental fish units, Aquarium fabrication, Setting and maintenance, Application and use of medicines/chemicals.

Suggested Reading

- Ahilan, B., Felix, N., Santhanam, R., 2008. *Textbook of Aquariculture*. Daya Publishing House, Delhi.
- Axelrod HR and Vorderwinkler W. 1978. *Encyclopaedia of Tropical Fishes*.TFH Publ.
- Axelrod HR and Sweenen ME. 1992. *The Fascination of Breeding Aquarium Fishes*. TFH Publ.
- Axelrod HR. 1967. *Breeding Aquarium Fishes*. TFH Publ.
- Mills D. 1981. *Aquarium Fishes*. Kingfisher Books.
- Sanford G and 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 and Sons.
- Thabrow De WV. 1981. *Popular Aquarium Plants*. Thornbill Press.

5. Computer Application In Aquaculture Data processing [AQC 0512] 1(0+1)

Objectives:

- To enhance efficiency and productivity within the organization through streamlining procedures and improving overall workflow.
- To manage and store data through accessible and secure methods for decision making.
- To reduce operational costs through virtualization, cloud computing and other techniques.

Outcomes:

1. Students are well-versed in the use of modern tools like computers and different software
2. Acquire a strong foundation in technical aspects of ICT including programming languages, hardware and software systems, networking and database management.
3. Effectively manage and manipulate data and information including data collection, storage, data retrieval and analysis.
4. Design, develop and maintain website and application through frameworks.
5. Explore ethical and legal issues related to technology and responsible use of technology.

Practical

Computer application basics; Different common software installation and application; Identification of farm based software; Installation and application; Application of SPSS, SAS, SYSTAT and STATISTICA for analysis and presentation of fisheries data; Basic concepts of database management systems: Introduction to MS-ACCESS, ORACLE (RDBMS); Exercise on analysis of data using MS-EXCEL, SPSS, SAS, FISAT, SYSTAT and STATISTICA; Creation of Database using MS-ACCESS, ORACLE, Linear modelling of Feed formulation software installation and use.

Suggested Reading

- Cody RP and Smith JF. 1997. *Applied Statistics and SAS Programming Language*. Elsevier.
- Economics of vertical integration in hybrid striped bass aquaculture, in *Aquaculture: Models andEconomics* (Ed.) U. Hatch and H. Kinnucan, Boulder: Westview Press, pp. 91-105.
- FAO. 2018. *The State of World Fisheries and Aquaculture -Meeting the sustainable development goals*. Rome.
- Griffin, W.L., Hanson JS, Brick RW and Johns MA. 1981. Bioeconomic modelling with stochastic elements in shrimp culture. *J. World Maric. Soc.* 12: 94-103.
- Griffin, W.L., Jensen LA and Adams C.M. 1983. A generalized budget simulation model for aquaculture. TAMU-SG-83-202, Texas A and M University, 131 pp.
- Haakanson, L. and Wallin M. 1991. Use of ecometric analysis to establish load diagrams for nutrients in coastal areas, in *Marine Aquaculture and the Environment* (Ed.) T. Maekinen, pp. 9-23.
- Johnson, F.C. 1974. Hatch—a model for fish hatchery analysis.U.S. National Bureau of Standards, Washington, D.C. Report NBSIR 74-521, 51 pp.
- Landou S and Everitt BS. 2004. *A Handbook of Statistical Analyses Using SPSS*. Chapman and Hall/CRC.
- Lester, L.J., Perkins S and Wong BT. 1987. *Microcomputer use in aquaculture genetics*.
- Lee, P.G. 1993. *Computer Automation for Recirculating Aquaculture Systems*, in *Techniques for Modern Aquaculture* (Ed.) J. K. Wang, St. Joseph, Minnesota: American Society of Agricultural Engineers, pp. 61-70.
- Paulraj R. 1997. *Aquaculture Feed: Handbook on Aquafarming*. MPEDA Publ.

6. Inland Saline Aquaculture [AQC 0513] 2(1+1)

Objectives:

- To impart basic knowledge on Inland Aquaculture Practices.
- To understand the scope for expanding aquaculture in inland saline waters for effective use

Outcomes:

- Understand the water and soil parameters analysis for aquaculture.
- Aware of optimum ranges of water and soil parameters for aquaculture.
- Describe soil and water interaction processes.
- Understand redox reaction and electron transfer.
- Familiarize with common laboratory techniques for analyzing soil and water samples.
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Theory

Unit I: Introduction: Inland saline waters, surface and ground water, Quality parameters of inland saline water in India, Global and national status of inland saline soils and underground saline water, Causes and process of salinization, geo-morphological changes, Problems of salinization, Potential for aquaculture.

Unit II: Soil and water characteristics: Comparison with coastal waters, Ionic amendment, water conditioning, Technological and engineering interventions for water quality improvement, Nutrient sparing and chelation in inland saline water.

Unit III: Potential candidate species: Sea bass, pearl spot, milk fish, mullet, shrimps, freshwater prawn, tilapia, cobia, pompano and selective carps for culture, Constraints and solutions, Alternate species with breeding possibilities, Metabolic interactions and growth promotion in altered water systems, Different farming systems.

Unit IV: Socio-economic Importance of Inland Saline Aquaculture: Nutritional intervention in inland shrimp farming; Economics of various finfish and shellfish culture in inland saline arenas; Integrated inland saline aquaculture systems; Recommendations for an action plan.

Practicals

Inland saline soil and water sample collection, analysis and ionic amendments, Visit to inland saline water farms, Case studies of inland saline farms, Evaluation of different systems with regard to species cultured, Trials with different species in known inland saline water bodies.

Suggested Reading

- Boyd CE. 2000. *Water Quality: an Introduction*. Kluwer Academic.
- Burnell G and Allan G. 2009. *New Technologies in Aquaculture, Improving Production Efficiency, Quality and Environment Management*. Woodhead Publ.

- CIFE 2014. *Training Manual on Inland Saline Water Aquaculture Management Practices*.
- Garg SK and Arasu ART. 2003. *Proceedings of 3rd Interaction workshop, Fish Production using Brackishwater in Arid Ecosystem*.
- Pillay TVR and Kutty MN. 2005. *Aquaculture - Principles and Practices*. Blackwell.
- Tidwell JH. (Ed.). 2012. *Aquaculture Production Systems*. Wiley-Blackwell.

7. Multilevel Integrated Aquaculture Systems [AQC 0514] 2(1+1)

Objectives:

1. To impart basic knowledge on aquaculture practices.
2. To develop knowledge on sustainable integrated aqua-farming practices.
3 .To understand recent innovations and implications in aquaculture.

Outcomes:

1. Understand standard operational procedures in aquaculture systems.
2. Provide knowledge on culture methods for commercially important aquatic organisms.
3. Developed skill on management, methodology and practices in aqua-farming.
4. Understand sustainable ways for aqua-farming.
5. Gained knowledge on modern aquaculture farming systems.

Theory

Unit I: Integrated fish farming: Global status, integration with agricultural (paddy), horticultural crops (vegetable and fruits) and livestock (cattle, poultry, ducks, pigs and other terrestrial animals). Effective recycling of wastes, nutrient budgeting in different integrated farming systems. Production levels and economics.

Unit II: Bioprocessed manures in integration: Vermicompost, farmyard manure/ compost, biogas slurry, etc. Advantages of biomanures, Control of microbial interactions, Fermentation of manures.

Unit III: Concepts: Integrated multitrophic aquaculture systems and design of an IMTA unit, Aqua tourism. Aquaponics: concept, Principles, types and operation, Multilateral interaction and reserve management.

Unit IV: Bio-resource flow in integrated aquaculture system: Discharge of nutrient wastes from integrated aquafarms; environmental effects, and potential for integrated multi-trophic aquaculture, An economic analysis of different integrated culture systems.

Practicals

Preparation of vermicompost; Analysis of nutrient value of different manures; Design of various integrated farming models; Different models of aquaponics; Nutrient analysis and management in aquaponics; Visit to integrated farms; Economics of different integrated systems with case studies.

Suggested Reading

- Ahilan, B., Ravaneshwaran, K., Kumaravel, P., 2011. *Integrated Aquaculture*. Daya Publishing House.
- Little D, Edwards P. 2003. *Integrated Livestock-fish Farming Systems*. FAO Publ.
- Mathias JA, Charles AT and Baotong H. 1994. *Integrated Fish Farming*. CRCPress
- Pandey N and Davendra SM. 2008. *Integrated Fish Farming*. Daya Publ. House
- Sherman RL, Arancon NQ and Edwards CA. 2010. *Vermiculture Technology: Earthworms, Organic Wastes, and Environmental Management*. CRC Press.
- Soto D. 2009. *Integrated Mariculture a Global Review*. FAO Publ.
- Tidwell JH. (Ed.). 2012. *Aquaculture Production Systems*. Wiley-Blackwell.

8. Cold Water Aquaculture and Recreational Fisheries [AQC 0515] 2(1+1)

Objectives:

- To impart basic knowledge on costal Aquaculture Practices.
- To understand the scope for expanding aquaculture in inland saline waters for effective use
- To learn about the breeding and culture of different cold water fishes and their importance as sport fisheries or sport fish

Outcomes:

- Provide knowledge on culture methods for commercially important marine aquatic organisms.
- Developed skill on management, methodology and practices in mari-culture.

Theory

Unit I: Introduction: Status of cold water fisheries in World with special reference to India, Biology, breeding and culture of trouts (*Oncorhynchus mykiss, Salmo truttafario,*

Schizothoraichthys esocinus, S. longipinnis, S. niger, Schizothorax richadsonii), Mahseer (*Tor putitora, Tor tor, Tor khudree*), Common carp (*Cypinuscarpio cummuinis, Cyprinuscarpio specularis*). Specific environmental parameters pertaining to cold water fish culture and metabolic interaction, Feeds suitable for cold water aquaculture.

Unit II: Culture of coldwater fishes: Construction and management of coldwater fish farms, Effect of exotic fish introduction on indigenous fish fauna, Polyculture of exotic carps in mid hill region based on three Chinese carps, post-harvest and harvest issues in trouts with regards to cold water species, Special factors for consideration in cold water fish seed production and nursery rearing.

Unit III: Introduction to sport fisheries**:** Sports fishes and their life history, Equipments for sports fishing, fishing methods, area suitable for sports fishing, etc. Management and conservation of sports fisheries through aquaculture, Sport fisheries and tourism, recreational aquaculture.

Unit IV: Issues and Desired Interventions: Potential and Innovative Strategies for the Development of Cold water Aquaculture in India- problems encountered in fisheries development of rivers supporting cold water fisheries.

Practical

Identification of cold water fish species; Primary and secondary sexual characters in coldwater fishes; Different breeding methods for coldwater fishes; Identification of larval stages of trout and mahseer; Preparation of hatchery layout for coldwater fishes; Studies on different types of sports fishing equipment; Visit to cold water fish hatchery.

Suggested Reading

- Boghen, A.D., 1989. Cold-water aquaculture in Atlantic Canada. Institut Canadien de recherche sur le developpement regional, Atlantic Coast, Canada
- ICAR. 2006. *Handbook of Fisheries and Aquaculture*.
- Jhingran VG and Sehgal KL. 1978. *Cold Water Fisheries of India*. J.Inland. Fish. Soc. India. Sp. Publ.
- Jhingran VG. 1991. *Fish and Fisheries of India*. 3rd Ed. Hindustan Publ.
- Mahanta, P.C., Sarma, D., 2010. *Coldwater Fisheries Management*. ICAR
- Singh, H.R. and Lakra, W.S., 2008. *Coldwater Aquaculture and Fisheries*. Narendra Publishing House.
- Singh AK, Sarma D, Akhtar, MS and Baruah D. 2017. Souvenir – National seminar on stratagies, innovations and sustainable management for enhancing coldwater fisheries and aquaculture. ICAR-DCFR, Bhimtal.

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

9. Recirculating Aquaculture Systems (RAS) [AQC 0510] 2(1+1)

Objectives:

- To impart basic knowledge on RAS Aquaculture Practices.
- To develop knowledge on the culture practices of various candidate species for Aquaculture.
- To learn basic aspects of different RAS designing for effective management and optimum yield.

Outcomes:

- Provide knowledge on culture methods for commercially important aquatic organisms.
- Developed skill on management, methodology and practices in RAS.
- Understand sustainable ways for RAS aqua-farming.

Theory

Unit I: Introduction: Evolution of intensive culture technologies, Need for intensification in aquaculture, Land and water constraints, Conflicts between enterprises for water use, Need for RAS, Current status and prospects of RAS in world with special reference to Asian countries.

Unit II: System engineering: Basic needs for the construction of RAS, Design of RAS, water re-use methods, Water budgeting, culture tanks, shape and size, Special features, waste solids removal, Cornell dual-drain system, Settling basins and tanks- design, Fabrication and construction, Water collection and sludge removal

Unit III: Filters: Mechanical filters, Biofilters- trickling towers, Floating bead filters, Fluidized sand beds, Down flow micro-bead biofilter, Moving bed bioreactors; aerators.

Unit IV: Management of RAS: Waste management, feeding management. Animal health management in RAS. Economic viability of RAS for various commercially important finfishes. Challenges in uplifting RAS practices.

Practical

Species for RAS; Calculating stocking density of fishes in RAS; Determining the controlling flow rate; Calculating required design flow rate for DO; Calculating tank sizes; Feeding management in RAS; Waste water management in RAS; Visit to RAS units

Suggested Reading

1. *Burnell G, Allan G. 2009. New Technologies in Aquaculture. 1st Edition. Woodhead Publishing House.*

2. *Bregnballe J. 2015. A Guide to Recirculation Aquaculture. FAO Publ.*
3. *Christenson K. 2014. Aquaponics: Aquaculture – An Introduction to Aquaculture for Small farmers.*
4. *Davion A. 2018. Recirculating Aquaculture Systems: a Guide to Farm Design and Operations.*
5. *Hendry lau. 2015. Aqauculture Production system*
6. *Hughston M. 2015. Hydroponics: Hydroponic Gardening And Growing Vegetables Without Soil.*
7. *Kaul SN, Juwarkar AS et al. 2002. Utilization of Wastewater in Agriculture and Aquaculture. Scientific Publishers.*
8. *Tidwell JH. (Ed.). 2012. Aquaculture Production Systems. Wiley- Blackwell.*
9. *Timmons MB, Guerdat, T, Vinci, BJ. 2019. Recirculating Aquaculture. Ithaca Publishing Comp.*
10. *Yoram, A., 2015. Biofloc Technology: a Practical Guidebook. WAS Publ.*

SUPPORTING COURSES

1. Statistical Methods for Applied Sciences [STAT 0502] 4(3+1)

Objectives:

- Student will understanding the concepts involved in data presentation, analysis and interpretation.
- Students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.
- The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics.

Outcomes:

1. Gain knowledge on statistical analysis in fisheries.
2. Develop critical thinking ability in hypothesis formulation, analysis and interpretation.
3. Improved problem-solving skills on fisheries related data.
4. Enhanced skills on problem identification, analyses and interpretation.
5. Able to handle fisheries data and computing.

Theory

UNIT I : Classification, tabulation and graphical representation of data. Box-plot, Descriptive statistics. Exploratory data analysis; Theory of probability. Random variable and mathematical expectation.

UNIT II: Discrete and continuous probability distributions: Binomial, Poisson, Negative Binomial, Normal distribution, Beta and Gamma distributions and their applications. Concept of

sampling distribution: chi-square, t and F distributions. Tests of significance based on Normal, chi-square, t and F distributions. Large sample theory.

UNIT III: Introduction to theory of estimation and confidence-intervals. Correlation and regression. Simple and multiple linear regression model, estimation of parameters, predicted values and residuals, correlation, partial correlation coefficient, multiple correlation coefficient, rank correlation, test of significance of correlation coefficient and regression coefficients. Coefficient of determination. Polynomial regression models and their fitting. Probit regression analysis by least squares and maximum likelihood ethods, confidence interval for sensitivity; Testing for heterogeneity.

UNIT IV: Non-parametric tests - sign, Wilcoxon, Mann-Whitney U-test, Wald Wolfowitz run test, Run test for the randomness of a sequence. Median test, Kruskal- Wallis test, Friedman two-way ANOVA by ranks. Kendall's coefficient of concordance.

UNIT V: Introduction to multivariate analytical tools- Hotelling's T2 Tests of hypothesis about the mean vector of a multinormal population. Classificatory problems and discriminant function, D2-statistic and its applications; Cluster analysis, principal component analysis, canonical correlations and Factor analysis.

Practical

Exploratory data analysis, Box-Cox plots; Fitting of distributions Binomial, Poisson, Negative Binomial, Normal Large sample tests, testing of hypothesis based on exact sampling distributions ~ chi square, t and F, Confidence interval estimation and point estimation of parameters of binomial, Poisson and Normal distribution, Correlation and regression analysis, fitting of orthogonal polynomial regression, Applications of dimensionality reduction and discriminant function analysis Nonparametric tests.

Suggested Reading

- *Anderson TW. 1958. An Introduction to Multivariate Statistical*
- *Analysis. John Wiley.Dillon WR & Goldstein M. 1984. Multivariate Analysis - Methods and Applications. John Wiley.*
- *Goon AM, Gupta MK & Dasgupta B. 1977. An Outline of Statistical Theory. Vol. I. The World Press.*
- *Goon AM, Gupta MK & Dasgupta B. 1983. Fundamentals of Statistics. Vol. I. The World Press.*
- *Hoel PG. 1971. Introduction to Mathematical Statistics. John Wiley.304*
- *Hogg RV & Craig TT. 1978. Introduction to Mathematical Statistics.Macmillan.*
- *Morrison DF. 1976. Multivariate Statistical Methods. McGraw Hill. Siegel S, Johan N & Casellan Jr. 1956. Non-parametric Tests for Behavior Sciences. John Wiley. Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Electronic*
- *Statistics Text Book:http://www.statsoft.com/textbook/stathome.html.*

2. Experimental Designs [STAT 0511] 3(2+1)

Objectives:

- Students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data
- Students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.
- The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics.

Outcomes:

1. Gain knowledge on statistical analysis in fisheries.
2. Develop critical thinking ability in hypothesis formulation, analysis and interpretation.
3. Improved problem-solving skills on fisheries related data.
4. Enhanced skills on problem identification, analyses and interpretation.
5. Able to handle fisheries data and computing.

Theory

UNIT I :Need for designing of experiments, characteristics of a good design. Basic principles of designs- randomization, replication and local control.

UNIT II :Uniformity trials, size and shape of plots and blocks; Analysis of variance; Completely randomized design, randomized block design and Latin square design.

UNIT III :Factorial experiments, (symmetrical as well as asymmetrical) orthogonality and partitioning of degrees of freedom, Confounding in symmetrical factorial experiments, Factorial experiments with control treatment.

UNIT IV :Split plot and strip plot designs; Analysis of covariance and missing plot techniques in randomized block and Latin square designs; Transformations, crossover designs, balanced incomplete block design, resolvable designs and their applications ~ Lattice design, alpha design - concepts, randomization procedure, analysis and interpretation of results. Response surfaces. Experiments with mixtures.

UNIT V: Bioassays- direct and indirect, indirect assays based on quantal dose response, parallel line and slope ratio assays potency estimation

Practicals

Uniformity trial data analysis, formation of plots and blocks, Fairfield Smith Law, Analysis of data obtained from CRD, RBD, LSD , Analysis of factorial experiments without and with confounding , Analysis with missing data , Split plot and strip plot designs , Transformation of data , Analysis of resolvable designs . Fitting of response surfaces

Suggested Reading

- *Cochran WG & Cox GM. 1957. Experimental Designs. 2nd Ed. John Wiley. Dean AM & Voss D. 1999. Design and Analysis of Experiments. Springer. Federer WT. 1985. Experimental Designs. MacMillan.*
- *Fisher RA. 1953. Design and Analysis of Experiments. Oliver & Boyd.*
- *Nigam AK & Gupta VK. 1979. Handbook on Analysis of Agricultural Experiments. IASRI Publ.*
- *Pearce SC. 1983. The Agricultural Field Experiment: A Statistical Examination of Theory and Practice. John Wiley. Design Resources Server: www.iasri.res.in/design*

3. Experimental Designs [STAT 0512] 3(2+1)

Objectives:

- Students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data
- Students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.
- The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics.

Outcomes:

- Gain knowledge on statistical analysis in fisheries.
- Develop critical thinking ability in hypothesis formulation, analysis and interpretation.
- Improved problem-solving skills on fisheries related data.
- Enhanced skills on problem identification, analyses and interpretation.
- Able to handle fisheries data and computing.
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Theory

UNIT I : Concept of sampling, sample survey *vs* complete enumeration, planning of sample survey, sampling from a finite population.

UNIT II : Simple random sampling with and without replacement, sampling for proportion, determination of sample size, inverse sampling, Stratified sampling.

UNIT III : Cluster sampling, Multi-stage sampling, systematic sampling; Introduction to PPS sampling,

UNIT IV :Use of auxiliary information at estimation, Ratio product and regression estimators. Double Sampling, sampling and non-sampling errors.

Practical

Random sampling, use of random number tables, concepts of unbiasedness, variance, etc, Simple random sampling, determination of sample size, inverse sampling, stratified sampling, cluster sampling and systematic sampling , Estimation using ratio and regression estimators, Estimation using multistage design, double sampling

Suggested Reading

- *Cochran WG. 1977. Sampling Techniques. John Wiley.*
- *Murthy MN. 1977. Sampling Theory and Methods. 2nd Ed. Statistical Publ. Soc., Calcutta. Singh D, Singh P and Kumar P. 1982. Handbook on Sampling Methods. IASRI Publ.*
- *Sukhatme PV, Sukhatme BV, Sukhatme S and Asok C. 1984. Sampling Theory of Surveys with Applications. Iowa State University Press and Indian Society of Agricultural Statistics, New Delhi.*
- *Cochran WG. 2007. Sampling Techniques, 3rd Edition. John Wiley & Sons Publication*

4. Data Analysis using Statistical Packages [STAT 0522] 3(2+1)

Objectives:

- Students would be exposed to concepts of Design of Experiments so as to enable them to understand the concepts involved in planning, designing their experiments and analysis of experimental data
- Students would get an exposure to presentation of data, probability distributions, parameter estimation, tests of significance, regression and multivariate analytical techniques.
- The students would be exposed to concepts of statistical methods and statistical inference that would help them in understanding the importance of statistics.

Outcomes:

1. Gain knowledge on statistical analysis in fisheries.
2. Develop critical thinking ability in hypothesis formulation, analysis and interpretation.
3. Improved problem-solving skills on fisheries related data.
4. Enhanced skills on problem identification, analyses and interpretation.
5. Able to handle fisheries data and computing.

Theory

UNIT I: Use of Software packages for: Summarization and tabulation of data; Descriptive statistics; Graphical representation of data, Exploratory data analysis.

UNIT II: Fitting and testing the goodness of fit of discrete and continuous probability distributions; Testing of hypothesis based on large sample test statistics; Testing of hypothesis using chi-square, *t* and *F* statistics.

UNIT III: Concept of analysis of variance and covariance of data for single factor, multi- factor, one-way and multi-classified experiments, contrast analysis, multiple comparisons, Analyzing crossed and nested classified designs.

UNIT IV: Analysis of mixed models; Estimation of variance components; Testing the significance of contrasts; Correlation and regression including multiple regression.

UNIT V : Discriminant function; Factor analysis; Principal component analysis; Analysis of time series data, Fitting of non-linear models; Time series data; Spatial analysis; Neural networks.

Practicals

Use of software packages for summarization and tabulation of data, obtaining descriptive statistics, graphical representation of data , Robust Estimation, Testing linearity and normality assumption, Estimation of trimmed means etc. , Cross tabulation of data including its statistics cell is play and table format and means for different sub-classifications, Fitting and testing the goodness of fit of probability distributions, Testing the hypothesis for one sample *t*-test, two sample *t*-test, paired *t*test,st for large samples - Chi-squares test, F test, One way analysis ofvariance , contrast and its testing, pairwise comparisons; Multiway classified analysis of variance - cross-classification, nested classification, factorial set up, fixed effect models, random effect models, mixed effect models, estimation of variance components , Generalized linear models - analysis of unbalanced data sets, testing and significance of contrasts, Estimation of variance components in unbalanced data sets – maximum likelihood, ANOVA, REML, MINQUE , Bivariate and partial correlation, Distances - to obtain a distance matrix, dissimilarity measures, similarity measures; Linear regression, Multiple regression, Regression plots, Variable selection, Regression statistics, Fitting of growth models - curve estimation models, examination of residuals; Discriminant analysis - fitting of discriminant functions, identification of important variables, Factor analysis. Principal component analysis-obtaining principal component, spectral composition; Analysis of time series data - fitting of ARIMA models, working out moving averages. Spatial analysis; Neural networks.

Suggested Reading

- *Anderson CW & Loynes RM. 1987. The Teaching of Practical Statistics. John Wiley. Atkinson AC. 1985. Plots Transformations and Regression. Oxford University Press. Chambers JM, Cleveland WS, Kleiner B & Tukey PA. 1983. Graphical Methods for Data Analysis. Wadsworth, Belmount, California.*
- *Chatfield C & Collins AJ. 1980. Introduction to Multivariate Analysis. Chapman & Hall. 311*
- *Chatfield C. 1983. Statistics for Technology. 3rd Ed. Chapman & Hall. Chatfield C. 1995. Problem Solving: A Statistician's Guide. Chapman & Hall.*
- *Cleveland WS. 1985. The Elements of Graphing Data. Wadsworth, Belmont, California. Ehrenberg ASC. 1982. A Primer in Data Reduction. John Wiley.*

- *Erickson BH & Nosanchuk TA. 1992. Understanding Data. 2nd Ed. Open University Press, Milton Keynes.*
- *Snell EJ & Simpson HR. 1991. Applied Statistics: A Handbook of GENSTAT Analyses. Chapman & Hall.Sprent P. 1993. Applied Non-parametric Statistical Methods. 2nd Ed. Chapman & Hall.Tufte ER. 1983. The Visual Display of Quantitative Information.*
- *Graphics Press, Cheshire, Conn. Velleman PF & Hoaglin DC. 1981. Application, Basics and Computing of Exploratory Data Analysis. Duxbury Press.*
- *Weisberg S. 1985. Applied Linear Regression. John Wiley.*
- *Wetherill GB. 1982. Elementary Statistical Methods. Chapman & Hall. Wetherill GB.1986. Regression Analysis with Applications. Chapman & Hall.*
- *Learning Statistics: http://freestatistics.altervista.org/en/learning.php. Free Statistical Softwares: http://freestatistics.altervista.org/en/stat.php.*
- *Statistics Glossary http://www.cas.lancs.ac.uk/glossary_v1.1/main.html. Course on Experimental design: http://www.stat.sc.edu/~grego/courses/stat706/.Design*
- *Resources Server: www.iasri.res.in/design. Analysis of Data: Design Resources Server. http://www.iasri.res.in/design/Analysis%20of%20data/Analysis%20of% 2 Data.html. 40*

COMMON COURSES

1. Library and Information Services [PGSS 0501] 1(0+1)

Objectives:

- To equip the library users with skills to trace information from libraries efficiently, to apprise them of information and knowledge resources,
- To carry out literature survey, to formulate information search strategies.
- To use modern tools (Internet, OPAC, search engines etc.) of information search.

Outcomes:

1. Students are well-versed in the use of modern tools like computers and different software
2. Acquire a strong foundation in technical aspects of ICT including programming languages, hardware and software systems, networking and database management.
3. Effectively manage and manipulate data and information including data collection, storage, data retrieval and analysis.
4. Design, develop and maintain website and application through frameworks.
5. Explore ethical and legal issues related to technology and responsible use of technology

Practicals

Introduction to library and its services, Role of libraries in education, research and technology transfer Classification systems and organization of library, Sources of information- Primary Sources, Secondary Sources and Tertiary Sources, Intricacies of abstracting and indexing services (Science Citation Index, Biological Abstracts, Chemical Abstracts, CABI Abstracts, etc.), Tracing information from reference sources; Literature survey, Citation techniques/Preparation of bibliography, Use of CD-ROM Databases, Online Public Access

Catalogue and other computerized library services, Use of Internet including search engines and its resources, E-resources access methods.

2. Technical Writing and Communications Skills [PGSS 0502] 1(0+1)

Objectives:

- To equip the students/scholars with skills to write dissertations, research papers, etc. To equip the students/scholars with skills to communicate and articulate in English (verbal as well as writing).
- To carry out literature survey, to formulate information search strategies.
- To use modern tools (Internet, OPAC, search engines etc.) of information search.

Outcomes:

1. Students are well-versed in the use of modern tools like computers and different software
2. Acquire a strong foundation in technical aspects of ICT including programming languages, hardware and software systems, networking and database management.
3. Effectively manage and manipulate data and information including data collection, storage, data retrieval and analysis.
4. Design, develop and maintain website and application through frameworks.
5. Explore ethical and legal issues related to technology and responsible use of technology

Practicals

Practical Technical Writing, Various forms of scientific writings- theses, technical papers, reviews, manuals, etc, Various parts of thesis and research communications (title page, authorship contents page, preface, introduction, review of literature, material and methods, experimental results and discussion), Writing of abstracts, summaries, précis, citations etc. , Commonly used abbreviations in the theses and research communications , Iillustrations, photographs and drawings with suitable captions , Pagination, numbering of tables and illustrations,Writing of numbers and dates in scientific write-ups, Editing and proof-reading; Writing of a review article, Communication Skills - Grammar (Tenses, parts of speech, clauses, punctuation marks); Error analysis (Common errors), Concord, Collocation, Phonetic symbols and transcription, Accentual pattern: Weak forms in connected speech: Participation in group discussion: Facing an interview, Presentation of scientific papers.

Suggested Reading

- *Harper Collins. Gordon HM & Walter JA. 1970. Technical Writing. 3rd Ed.*
- *Holt, Rinehart & Winston. Hornby AS. 2000. Comp. Oxford Advanced Learner's Dictionary of Current English. 6th Ed. Oxford University Press.*
- *James HS. 1994. Handbook for Technical Writing. NTC Business Books.*
- *Joseph G. 2000. MLA Handbook for Writers of Research Papers. 5th Ed. Affiliated East-West Press.*
- *Mohan K. 2005. Speaking English Effectively. MacMillan India.*
- *Richard WS. 1969. Technical Writing.*

- *Barnes & Noble. Robert C. (Ed.). 2005. Spoken English: Flourish Your Language.*
- *Abhishek. Sethi J & Dhamija PV. 2004. Course in Phonetics and Spoken English. 2nd Ed. Prentice Hall of India.*
- *Wren PC & Martin H. 2006. High School English Grammar and Composition. S. Chand & Co.*
- *Chicago Manual of Style. 14th Ed. 1996. Prentice Hall of India.*
- *Collins' Cobuild English Dictionary. 1995.*

3. Intellectual Property and its Management in Agriculture [PGSS 0503] 1(1+0)

Objectives:

- The main objective of this course is to equip students and stakeholders with knowledge of intellectual property rights (IPR) related protection systems, their significance and use of IPR as a tool for wealth and value creation in a knowledge-based economy.
- To carry out literature survey, to formulate information search strategies.
- To use modern tools (Internet, OPAC, search engines etc.) of information search.

Outcomes:

1. Students are well-versed in the use of modern tools like computers and different software
2. Acquire a strong foundation in technical aspects of ICT including programming languages, hardware and software systems, networking and database management.
3. Effectively manage and manipulate data and information including data collection, storage, data retrieval and analysis.
4. Design, develop and maintain website and application through frameworks.
5. Explore ethical and legal issues related to technology and responsible use of technology

Theory

Historical perspectives and need for the introduction of Intellectual Property Right regime; TRIPs and various provisions in TRIPS Agreement; Intellectual Property and Intellectual Property Rights (IPR), benefits of securing IPRs; Indian Legislations for the protection of various types of Intellectual Properties; Fundamentals of patents, copyrights, geographical indications, designs and layout, trade secrets and traditional knowledge, trademarks, protection of plant varieties and farmers' rights and biodiversity protection; Protectable subject matters, protection in biotechnology, protection of other biological materials, ownership and period of protection; National Biodiversity protection initiatives; Convention on Biological Diversity; International Treaty on Plant Genetic Resources for Food and Agriculture; Licensing of technologies, Material transfer agreements, Research collaboration Agreement, License Agreement. The Indian Acts - Patents Act, 1970 and amendments; Design Act, 2000; Trademarks Act, 1999; The Copyright Act, 1957 and amendments; Layout Design Act, 2000; PPV and FR Act 2001, and Rules 2003; National Biological Diversity Act, 2003.

Suggested Reading

- *Intellectual Property Rights: Key to New Wealth Generation. 2001. NRDC & Aesthetic Technologies.*
- *Ministry of Agriculture, Government of India. 2004. State of Indian Farmer. Vol. V. Technology Generation and IPR Issues. Academic Foundation.*
- *Rothschild M & Scott N. (Ed.). 2003. Intellectual Property Rights in Animal Breeding and Genetics. CABI.*
- *Saha R. (Ed.). 2006. Intellectual Property Rights in NAM and Other Developing Countries: A Compendium on Law and Policies. Daya Publ. House.*
- *Erbisch FH & Maredia K.1998. Intellectual Property Rights in Agricultural Biotechnology. CABI.*
- *Ganguli P. 2001. Intellectual Property Rights: Unleashing Knowledge Economy. McGraw-Hill.*

4. Basic Concepts in Laboratory Techniques [PGSS 0504] 1(0+1)

Objectives:

- To acquaint the students about the basics of commonly used techniques in laboratory.
- To carry out literature survey, to formulate information search strategies.
- To use modern tools (Internet, OPAC, search engines etc.) of information search.

Outcomes:

- Provide knowledge on laboratory
- Developed skill on management, methodology and practices in laboratory.

Practical

Safety measures while in Lab ,Handling of chemical substances, Use of burettes, pipettes, measuring cylinders, flasks, separatory funnel, condensers, micropipettes and vaccupets; washing, drying and sterilization of glassware ,Drying of solvents/chemicals, Weighing and preparation of solutions of different strengths and their dilution ,Handling techniques of solutions; Preparation of different agro-chemical doses in field and pot applications, Preparation of solutions of acids , Neutralisation of acid and bases, Preparation of buffers of different strengths and pH values , Use and handling of microscope, laminar flow, vacuum pumps, viscometer, thermometer, magnetic stirrer, micro-ovens, incubators, sandbath, waterbath, oilbath, Electric wiring and earthing. Preparation of media and methods of sterilization,Seed viability testing, testing of pollen viability , Tissue culture of crop plants; Description of flowering plants in botanical terms in relation to taxonomy

Suggested Reading

- *Furr AK. 2000. CRC Hand Book of Laboratory Safety. CRC Press.*

- *Gabb MH & Latchem WE. 1968. A Handbook of Laboratory Solutions. Chemical Publ. Co.*

5. Agricultural Research, Research Ethics and Rural Development Programmes [PGSS 0505] 1(1+0)

Objectives:

- To enlighten the students about the organization and functioning of agricultural research systems at national and international levels, research ethics, and rural development programmes and policies of Government.
- To carry out literature survey, to formulate information search strategies.
- To use modern tools (Internet, OPAC, search engines etc.) of information search.

Outcomes:

- Provide knowledge on Agricultural organizations and its mandate
- Developed skill on writing papers
- Understand sustainable ways for agri-production.

Theory

UNIT I: History of agriculture in brief; Global agricultural research system: need, scope, opportunities; Role in promoting food security, reducing poverty and protecting the environment; National Agricultural Research Systems (NARS) and Regional Agricultural Research Institutions; Consultative Group on International Agricultural Research (CGIAR): International Agricultural Research Centres (IARC), partnership with NARS, role as a partner in the global agricultural research system, strengthening capacities at national and regional levels; International fellowships for scientific mobility.

UNIT II: Research ethics: research integrity, research safety in laboratories, welfare of animals used in research, computer ethics, standards and problems in research ethics.

UNIT III: Concept and connotations of rural development, rural development policies and strategies. Rural development programmes: Community Development Programme, Intensive Agricultural District Programme, Special group – Area Specific Programme, Integrated Rural Development Programme (IRDP) Panchayati Raj Institutions, Co-operatives, Voluntary Agencies/Non-Governmental Organisations. Critical evaluation of rural development policies and programmes. Constraints in implementation of rural policies and programmes.

Suggested Reading

- Rao BSV. 2007. Rural Development Strategies and Role of Institutions - Issues, Innovations and Initiatives. Mittal Publ.
- Singh K.. 1998. Rural Development - Principles, Policies and Management. Sage Publ.
- Bhalla GS & Singh G. 2001. Indian Agriculture - Four Decades of Development. Sage Publ.
- Punia MS. Manual on International Research and Research Ethics. CCS, Haryana Agricultural University, Hisar.