B.Sc. FISHERY SCIENCE
LAB MANUAL
3rd Semester

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Fishery Science

MIDNAPORE CITY COLLEGE

BFSC SEMESTER – III LAB MANUAL

BFSC-301: Fish Immunology

Collection, separation and identification of fish leucocytes. Separation of blood plasma and serum. Differential counting - RBC and WBC by Haemocytometer. Study of different types of leukocytes and isolation of macrophages. Precipitin reactions - Agglutination test, immunogel diffusion, double immuno diffusion, radial immuno diffusion assay, ELISA. Methods of vaccine preparation and techniques of fish immunization.

BFSC-302: Marine Biology

Study of common instruments used for collection of phytoplankton, zooplankton and benthos. Collection, preservation and analysis of phytoplankton, zooplankton, sea weeds, Collection preservation and analysis of inter tidal organisms.

BFSC-303: Fishery Oceanography

Field visits and operation of oceanographic instruments- Nansen reversing water sampler, Bathythermograph, Grabs, Corers, Current meters, Tidal gauges, Echo-sounder. Measurement of temperature, Transparency, pH. Determination of DO, Salinity, Ammonia, Nitrate, Nitrite, Phosphate and Silicate in sea water.

BFSC-304: Fish Food Organisms

Methods of collection and identification of different live food organisms. Laboratory scale culture of selected live food organisms (green algae, spirulina, chetoceros, rotifer, Moina, copepod). Evaluation of live food organisms. Decapsulation and hatching method of brine shrimp cyst.

BFSC-305: Ornamental Fish Production and Management

Identification of common ornamental fishes and plants. Fabrication of all-glass aquarium. Setting up and maintenance of Aquarium accessories and equipment. Conditioning and packing of ornamental fishes. Preparation of feed. Setting up of breeding tank for live bearers, barbs, goldfish, tetras, chiclids, gouramis, fighters and catfishes. Identification of ornamental fish diseases and prophylactic measures.

BFSC-306: Genetics and Breeding

Problems on Mendelian inheritance (qualitative genetics) - monohybrid and dihybrid ratios and epistasis. Problems on quantitative traits, response to selection and heritability. Estimation of rate of inbreeding and heterosis. Mitotic and meiotic chromosome preparation. Demonstration of protocol of androgenesis, gynogenesis and polyploidy. Problems on gene and genotypic frequency. Gamete cryopreservation protocols and quality evaluation of fish milt.

BFSC-307: Physiology of Finfish and Shell fish

Estimation of oxygen consumption, Osmoregulation, ammonia excretion and carbon-dioxide output. Influence of temperature and salinity on metabolism. Haematology of fin and shellfishes. Histological techniques.

BFSC-308: Inland Fisheries

Analysis of species composition of commercial catches at landing and assembling centres, sampling and familiarization of commercially important groups. Observations and experimental operations of selected fishing crafts and gears in inland / estuarine waters. Maintenance of records on catch data. Visit to Dept. of fisheries, lakes and reservoirs, net making yards.

BFSC-309: Aquaculture Engineering

Evaluation of potential site for aquaculture. Calculation of area of regular and irregular plane surfaces, Trapezoidal and Simpson's rule, volume of regular and irregular shape as applied to stacks and heaps, calculation of volume of pond. Land survey – chain surveying, compass surveying, leveling, plane table surveying and contouring; soil analysis for farm construction. Design and layout plan of fresh water and brackish water farms and hatcheries. Design of farm structure: ponds, dykes and channels. Earth work calculations- excavation, embankment, longitudinal slope and cross slope, calculation of volume of earth work as applied to roads and channels and water requirement calculation. Visit to different types of farms.

BFSC-301: Fish Immunology

Introduction to Fish Immunology

Fish immunology is a branch of science that explores the immune system of fish, which provides critical insights into maintaining their health in aquaculture systems. This lab manual focuses on the practical aspects of fish immunology, including the study of leukocytes, immune assays, and vaccination techniques.

Experiment 1: Collection, Separation, and Identification of Fish Leukocytes

Objective

To collect, separate, and identify leukocytes (white blood cells) in fish blood.

Materials Required

- Fresh fish blood samples
- EDTA tubes (anticoagulant)
- Phosphate-buffered saline (PBS)
- Ficoll-Paque or Histopaque (density gradient medium)
- Centrifuge
- Microscope
- Hemocytometer
- Giemsa or Wright's stain
- Glass slides and coverslips

Procedure

1. **Collection of Blood:**
    - Extract blood from the caudal vein of the fish using a syringe containing EDTA to prevent clotting.
2. **Separation of Leukocytes:**
    - Dilute the blood 1:1 with PBS.
    - Layer the diluted blood gently over Ficoll-Paque in a centrifuge tube.
    - Centrifuge at 1000g for 20 minutes at room temperature.
    - After centrifugation, leukocytes will form a white buffy coat at the interface between plasma and Ficoll.
3. **Identification of Leukocytes:**
    - Carefully aspirate the buffy coat and transfer it to a clean tube.

- Wash the cells twice with PBS by centrifuging at 500g for 10 minutes.
- Resuspend the leukocytes in PBS.
- Stain a thin smear of cells on a slide using Giemsa or Wright's stain and observe under a microscope to identify lymphocytes, monocytes, neutrophils, and eosinophils.

Observation and Result

- Record the morphological characteristics of different leukocytes observed under the microscope.

Experiment 2: Separation of Blood Plasma and Serum

Objective

To separate plasma and serum from fish blood for further immunological studies.

Materials Required

- Fish blood samples
- Centrifuge
- EDTA tubes
- Plain tubes (no anticoagulant)

Procedure

1. **For Plasma:**
   - Collect blood into an EDTA tube.
   - Centrifuge the sample at 1500g for 10 minutes.
   - Carefully aspirate the supernatant (plasma) without disturbing the buffy coat and red blood cells.
2. **For Serum:**
   - Collect blood into a plain tube and let it clot for 30 minutes at room temperature.
   - Centrifuge at 1500g for 10 minutes.
   - Collect the clear supernatant (serum) into a separate tube.

Observation and Result

- Plasma retains clotting factors, while serum lacks them. Label and store the samples for further use.

Experiment 3: Differential Counting of RBCs and WBCs Using a Hemocytometer

Objective

To perform differential counting of red and white blood cells in fish blood.

Materials Required

- Blood sample
- Hemocytometer
- Diluting fluids (Hayem's solution for RBCs, Turk's solution for WBCs)
- Microscope

Procedure

1. **RBC Count:**
    - Dilute the blood 1:200 using Hayem's solution.
    - Load the hemocytometer with the diluted blood.
    - Count RBCs in the four corners and central large squares under a microscope at 40x magnification.
    - Calculate the total RBC count using the formula: RBC Count=Number of cells counted×10,000Dilution factor\text{RBC Count} = \frac{\text{Number of cells counted} \times 10,000}{\text{Dilution factor}}RBC Count=Dilution factorNumber of cells counted×10,000
2. **WBC Count:**
    - Dilute the blood 1:20 using Turk's solution.
    - Load the hemocytometer and count WBCs in all four large corner squares.
    - Calculate the total WBC count using the same formula as for RBCs.

Observation and Result

- Record the RBC and WBC counts and compare them with normal ranges for the fish species.

Experiment 4: Study of Different Types of Leukocytes and Isolation of Macrophages

Objective

To identify leukocyte types and isolate macrophages from fish blood.

Materials Required

- Leukocyte suspension
- Glass slides
- Giemsa stain

- Tissue culture plates
- RPMI or DMEM media

Procedure

1. **Leukocyte Identification:**
    - Prepare leukocyte smears on slides and stain with Giemsa.
    - Examine under a microscope and identify different leukocyte types.
2. **Macrophage Isolation:**
    - Plate the leukocyte suspension in tissue culture plates with RPMI or DMEM media.
    - Incubate for 2 hours at 25°C to allow macrophages to adhere.
    - Wash the plate gently with PBS to remove non-adherent cells.
    - Collect the adherent macrophages for further use.

Observation and Result

- Note the morphology of leukocyte types and confirm successful macrophage isolation.

Experiment 5: Precipitin Reactions

Objective

To perform immunological tests like agglutination, immunodiffusion, and ELISA.

A. Agglutination Test

1. Mix fish serum with antigen.
2. Observe for clumping under a microscope, indicating an antigen-antibody reaction.

B. Immunogel Diffusion

1. Perform single and double immunodiffusion assays in agar gel.
2. Place antigens and antibodies in wells and observe precipitation lines.

C. ELISA

1. Coat a microplate with fish antigen.
2. Add fish serum and enzyme-labeled secondary antibodies.
3. Add substrate and measure color development with a spectrophotometer.

Experiment 6: Methods of Vaccine Preparation and Techniques of Fish Immunization

Objective

To prepare vaccines and immunize fish using appropriate methods.

Materials Required

- Fish pathogens
- Formalin
- PBS
- Syringes
- Fish tanks

Procedure

1. **Vaccine Preparation:**
    - Inactivate pathogens using 0.5% formalin.
    - Wash and resuspend in PBS to prepare the vaccine.
2. **Fish Immunization Techniques:**
    - **Injection:** Inject the vaccine intraperitoneally or intramuscularly.
    - **Immersion:** Immerse fish in a vaccine solution for a specific period.
    - **Oral:** Mix the vaccine with feed.

Observation and Result

- Monitor fish for immune response and record mortality or infection rates.

BFSC-302: Marine Biology

Introduction to Marine Biology

Marine biology is the scientific study of organisms in the ocean or other marine environments. This lab manual provides practical methodologies for studying marine organisms and the equipment and techniques used in their collection, preservation, and analysis.

Experiment 1: Study of Common Instruments for Collection of Phytoplankton, Zooplankton, and Benthos

Objective

To familiarize with the instruments used for the collection of phytoplankton, zooplankton, and benthic organisms.

Materials and Instruments Required

- **Phytoplankton:** Plankton nets, water samplers (Niskin bottle), glass/plastic bottles.
- **Zooplankton:** Plankton nets (mesh size 50–200 µm), flowmeters, hauling ropes.
- **Benthos:** Grab samplers (Van Veen grab), dredges, core samplers, sieves.
- Protective gloves, field notebook, and identification guides.

Procedure

1. **Phytoplankton Collection:**
    - Use a plankton net with a fine mesh size (10–20 µm).
    - Lower the net into the water column vertically or tow it horizontally for a set distance.
    - Attach a flowmeter to measure the volume of water filtered.
2. **Zooplankton Collection:**
    - Use a plankton net (mesh size 50–200 µm) equipped with a cod-end to collect zooplankton.
    - Perform vertical or oblique tows in the water column at varying depths.
    - Record environmental data such as water temperature and salinity.
3. **Benthos Collection:**
    - Use a grab sampler to collect sediment from the sea bed.
    - Deploy the grab sampler from a boat and retrieve it with a winch.
    - Transfer collected material to a sieve stack for size sorting.

Observation and Results

- Sketch the instruments and record the types of samples collected.
- Document the operation of each instrument and note its application in marine research.

Experiment 2: Collection, Preservation, and Analysis of Phytoplankton

Objective

To collect, preserve, and analyze phytoplankton samples from marine waters.

Materials Required

- Phytoplankton net (10–20 µm mesh size)
- Lugol's iodine solution or formalin (4%) for preservation
- Microscope
- Hemocytometer
- Glass slides and cover slips

Procedure

1. **Collection:**
    - Conduct vertical or horizontal net tows in the water column.
    - Transfer the concentrate from the net's cod-end into sample bottles.
2. **Preservation:**
    - Add Lugol's iodine solution to the sample (1 ml per 100 ml of sample) to fix the phytoplankton.
    - Store samples in dark, cool conditions to prevent degradation.
3. **Analysis:**
    - Mount a drop of the sample on a glass slide and cover with a slip.
    - Observe under a microscope and identify phytoplankton based on morphology using taxonomic guides.
    - Count cells using a hemocytometer if quantitative analysis is needed.

Observation and Results

- Identify and record common phytoplankton species.
- Note their abundance and any dominant species in the sample.

Experiment 3: Collection, Preservation, and Analysis of Zooplankton

Objective

To collect, preserve, and analyze zooplankton samples.

Materials Required

- Zooplankton net (50–200 µm mesh size)
- Formalin (4%)
- Dissecting microscope
- Petri dishes

Procedure

1. **Collection:**
    - Perform vertical or horizontal tows using a zooplankton net.
    - Concentrate the sample into the cod-end and transfer to labeled containers.
2. **Preservation:**
    - Add 4% formalin to the sample for preservation.
    - Label the sample with location, date, and depth of collection.
3. **Analysis:**
    - Place a small portion of the preserved sample in a Petri dish.
    - Observe under a dissecting microscope and identify zooplankton using taxonomic keys.
    - Categorize species into groups (e.g., copepods, cladocerans, larvae).

Observation and Results

- Record the species diversity and relative abundance of zooplankton.
- Compare the collected sample with reference data to assess ecological health.

Experiment 4: Collection, Preservation, and Analysis of Seaweeds

Objective

To collect, preserve, and analyze seaweeds from coastal habitats.

Materials Required

- Scissors or knives
- Plastic bags
- 5% formalin or drying materials
- Herbarium sheets
- Identification keys

Procedure

1. **Collection:**
    - Visit intertidal or subtidal zones during low tide.
    - Collect seaweed samples by cutting a portion of the thallus.
    - Place samples in plastic bags with seawater to prevent desiccation.
2. **Preservation:**
    - For wet preservation, place seaweed in 5% formalin solution.
    - For herbarium preparation, press the seaweed on herbarium sheets and dry it.
3. **Analysis:**
    - Examine the morphological features such as frond, holdfast, and reproductive structures.
    - Use taxonomic keys to identify seaweed species.

Observation and Results

- Document the physical characteristics of collected seaweeds.
- Record the distribution and abundance of species in the study area.

Experiment 5: Collection, Preservation, and Analysis of Intertidal Organisms

Objective

To collect, preserve, and analyze intertidal organisms from rocky, sandy, and muddy shores.

Materials Required

- Quadrats and transects
- Hand gloves
- Forceps
- Alcohol (70%) or formalin (4%)
- Identification guides

Procedure

1. **Collection:**
    - Lay transects across the intertidal zone and use quadrats to define sampling areas.
    - Collect organisms such as mollusks, crustaceans, and polychaetes using forceps or by hand.

2. **Preservation:**
    - For soft-bodied organisms, use 4% formalin.
    - For hard-shelled organisms, rinse with fresh water and store in 70% alcohol.
3. **Analysis:**
    - Identify organisms based on external morphology using taxonomic guides.
    - Measure and record physical parameters such as shell size or weight for selected species.

Observation and Results

- Identify the dominant species and their ecological role in the intertidal zone.
- Analyze zonation patterns and biodiversity indices.

Conclusion

This lab manual outlines practical techniques for collecting, preserving, and analyzing various marine organisms. These experiments provide hands-on experience to understand the ecological roles, distribution, and diversity of phytoplankton, zooplankton, seaweeds, and intertidal organisms, which are essential for the sustainable management of marine ecosystems.

BFSC-303: Fishery Oceanography

Introduction

Fishery oceanography focuses on the interconnection between oceanographic conditions and fisheries. This lab manual is designed to provide hands-on experience with oceanographic instruments and techniques for analyzing seawater properties essential for sustainable fisheries management.

Experiment 1: Field Visits and Operation of Oceanographic Instruments

Objective

To learn the operation and application of commonly used oceanographic instruments.

Materials Required

1. Nansen reversing water sampler
2. Bathythermograph (mechanical/digital)
3. Grabs (e.g., Van Veen grab sampler)
4. Corers (e.g., gravity corer)
5. Current meters
6. Tidal gauges
7. Echo-sounder

Procedure

A. Nansen Reversing Water Sampler

1. Lower the sampler to the desired depth using a calibrated wire.
2. Trigger the reversing mechanism to seal water at that depth.
3. Retrieve the sampler and transfer the collected water for further analysis.

B. Bathythermograph

1. Deploy the bathythermograph to measure water temperature profiles.
2. For mechanical models, observe the temperature-depth curve plotted on the coated slide.
3. For digital models, record data using the onboard display or data logger.

C. Grabs and Corers

1. Use the grab sampler to collect sediment from the seabed.
2. For deeper samples, deploy a corer, allowing penetration into sediment layers.

3. Process sediment samples for further biological or chemical analysis.

D. Current Meters and Tidal Gauges

1. Deploy the current meter at specific depths and record velocity and direction.
2. Install tidal gauges at intertidal zones to measure tidal variations over time.

E. Echo-Sounder

1. Switch on the echo-sounder and calibrate for depth measurement.
2. Record seabed profiles to identify fishery zones or underwater topography.

Observation and Results

- Record operation steps for each instrument.
- Document measurements like depth profiles, sediment characteristics, currents, and tides.

Experiment 2: Measurement of Temperature, Transparency, and pH

Objective

To measure seawater temperature, transparency, and pH.

Materials Required

- Thermometer or digital temperature sensor
- Secchi disk
- pH meter or indicator strips

Procedure

A. Measurement of Temperature

1. Immerse the thermometer or sensor at varying depths.
2. Allow equilibration and record the temperature.

B. Measurement of Transparency

1. Lower the Secchi disk into the water until it is no longer visible.
2. Note the depth and slowly retrieve until the disk reappears.
3. Average the two depths to determine transparency.

C. Measurement of pH

1. Collect a water sample in a clean container.

2. Insert the pH meter probe or dip indicator strips into the sample.
3. Record the pH value after stabilization.

Observation and Results

- Document the temperature profile of the water column.
- Note the transparency and pH range of the sampled area.

Experiment 3: Determination of Dissolved Oxygen (DO)

Objective

To determine the concentration of dissolved oxygen in seawater.

Materials Required

- Winkler reagents (Manganous sulfate, alkaline iodide-azide)
- Sodium thiosulfate (0.025 N)
- Starch solution
- Titration apparatus

Procedure

1. Fill a glass-stoppered bottle with seawater, avoiding air bubbles.
2. Add 2 ml of Manganous sulfate and 2 ml of alkaline iodide-azide.
3. Stopper the bottle and mix; allow the precipitate to settle.
4. Add concentrated sulfuric acid to dissolve the precipitate.
5. Titrate the sample with sodium thiosulfate using starch as an endpoint indicator.

Observation and Results

- Calculate the DO concentration using the formula:

$$DO\ (\text{mg/L}) = \text{Volume of thiosulfate used (ml)} \times \text{Normality} \times 8 \times 1000$$

Experiment 4: Determination of Salinity

Objective

To determine the salinity of seawater using a salinometer.

Materials Required

- Salinometer or refractometer
- Seawater sample

Procedure

1. Calibrate the salinometer or refractometer with distilled water.
2. Place a few drops of seawater on the refractometer prism or immerse the salinometer probe in the sample.
3. Record the salinity in parts per thousand (ppt).

Observation and Results

- Note the salinity of the sampled area and compare with typical marine ranges (30–35 ppt).

Experiment 5: Determination of Nutrients (Ammonia, Nitrate, Nitrite, Phosphate, Silicate)

Objective

To analyze nutrient concentrations in seawater.

Materials Required

- Spectrophotometer
- Reagents for each nutrient (e.g., Nessler's reagent for ammonia)
- Standard solutions for calibration

Procedure

A. Ammonia

1. Add Nessler's reagent to the sample.
2. Measure the absorbance at 425 nm using a spectrophotometer.
3. Compare with the standard curve to determine concentration.

B. Nitrate

1. Reduce nitrate to nitrite using a cadmium column.
2. Add sulfanilamide and NED reagents.
3. Measure absorbance at 543 nm.

C. Nitrite

1. Add sulfanilamide and NED reagents directly to the sample.
2. Measure absorbance at 543 nm.

D. Phosphate

1. Add ammonium molybdate and ascorbic acid reagents.
2. Measure absorbance at 880 nm.

E. Silicate

1. Add molybdate reagent and reducing agents (e.g., metol-sulfite).
2. Measure absorbance at 810 nm.

Observation and Results

- Record concentrations of each nutrient in mg/L.
- Compare with standard seawater nutrient ranges.

Conclusion

This manual provides a comprehensive guide for operating oceanographic instruments and analyzing seawater properties. By mastering these techniques, students gain valuable skills for monitoring marine environments and supporting sustainable fishery practices.

BFSC-304: Fish Food Organisms

Introduction

Fish food organisms are critical for the successful rearing of larvae and juveniles in aquaculture. This manual outlines methods for the collection, identification, culture, evaluation, and processing of live food organisms such as green algae, *Spirulina*, *Chaetoceros*, rotifers, *Moina*, copepods, and brine shrimp. Understanding these practices is essential for sustainable aquaculture practices.

Experiment 1: Collection and Identification of Live Food Organisms

Objective

To collect and identify different live food organisms from aquatic environments.

Materials Required

1. Plankton net (mesh size: 40–60 µm for microalgae, 100–200 µm for zooplankton)
2. Sampling bottles (500 mL–1 L)
3. Microscope (10x–40x magnification)
4. Identification guides for algae and zooplankton
5. Lugol's iodine or formalin for sample preservation

Procedure

1. **Collection**:
    - Use a plankton net to collect samples from ponds, reservoirs, or marine environments.
    - Gently tow the net horizontally or vertically in the water column for 2–3 minutes.
2. **Preservation**:
    - Transfer samples into labeled bottles. Add Lugol's iodine or formalin to preserve the organisms temporarily.
3. **Identification**:
    - Under a microscope, observe collected organisms for morphological features like shape, size, and movement patterns.
    - Refer to identification keys to classify organisms such as algae (*Chlorella*, *Spirulina*, *Chaetoceros*), rotifers (*Brachionus*), and crustaceans (*Moina*, copepods).

Observation and Results

- Note the diversity and abundance of collected organisms.

- Sketch or photograph representative species for reference.

Experiment 2: Laboratory-Scale Culture of Green Algae

Objective

To culture green algae for use as live food in aquaculture.

Materials Required

1. Stock culture of *Chlorella* or *Scenedesmus*
2. Glass beakers or plastic tanks (10–20 L capacity)
3. Nutrient medium (e.g., BG-11)
4. Aerators and air stones
5. Light source (fluorescent tubes or LEDs)

Procedure

1. **Preparation of Culture Medium**:
    - Prepare BG-11 medium by dissolving necessary nutrients in distilled water. Sterilize the solution.
2. **Inoculation**:
    - Add 10% stock culture of algae to the medium.
3. **Aeration and Lighting**:
    - Provide continuous aeration to keep algae suspended.
    - Maintain light intensity at 2,000–4,000 lux with a 12:12 light-dark cycle.
4. **Monitoring**:
    - Check for exponential growth phase using optical density (OD) measurements at 680 nm.

Observation and Results

- Document the growth pattern of green algae and calculate biomass yield.

Experiment 3: Culture of Spirulina

Objective

To culture *Spirulina* under controlled laboratory conditions.

Materials Required

1. Stock culture of *Spirulina*
2. Zarrouk's medium
3. Plastic tubs or glass containers (10–20 L)
4. Aeration system
5. pH meter

Procedure

1. **Preparation of Medium**:
    - Prepare Zarrouk's medium and sterilize it.
    - Ensure the pH is adjusted to 9–10 using sodium bicarbonate.
2. **Inoculation and Aeration**:
    - Add *Spirulina* stock culture to the medium (10% of total volume).
    - Provide continuous aeration to prevent settling.
3. **Lighting**:
    - Use light sources providing 2,000–5,000 lux intensity.
4. **Harvesting**:
    - Harvest the biomass during the exponential growth phase using filtration.

Observation and Results

- Measure growth rate by recording OD or dry weight.

Experiment 4: Culture of Rotifers

Objective

To culture rotifers for feeding fish larvae.

Materials Required

1. *Brachionus* sp. stock culture
2. Plastic tanks (10–50 L)
3. Green algae culture (e.g., *Chlorella*) as food
4. Aerators and air stones

Procedure

1. **Stock Preparation**:
    - Inoculate *Brachionus* sp. into a culture tank with aerated seawater or brackish water (15 ppt salinity).
2. **Feeding**:
    - Add *Chlorella* or baker's yeast as food. Maintain daily feeding at a concentration of 1–2 million cells/mL.
3. **Monitoring**:
    - Monitor growth and density daily using a counting chamber.

Observation and Results

- Record population density (individuals/mL).

Experiment 5: Decapsulation and Hatching of Brine Shrimp Cysts

Objective

To decapsulate and hatch brine shrimp (*Artemia*) cysts for larval feeding.

Materials Required

1. *Artemia* cysts
2. Sodium hypochlorite (6%)
3. Seawater or brine (25–30 ppt salinity)
4. Aeration system
5. Sieves (50 µm and 200 µm)

Procedure

1. **Hydration**:
    - Soak cysts in freshwater for 1 hour.
2. **Decapsulation**:
    - Mix hydrated cysts with sodium hypochlorite solution under constant aeration for 5–10 minutes until cysts turn orange.
3. **Washing**:
    - Rinse decapsulated cysts thoroughly with freshwater using sieves.
4. **Hatching**:
    - Transfer decapsulated cysts to brine water with aeration.

- Maintain temperature at 28°C and light intensity of 2,000 lux.

5. **Harvesting**:
    - After 24–36 hours, harvest nauplii using a sieve.

Observation and Results

- Record hatching percentage and nauplii survival rates.

Experiment 6: Evaluation of Live Food Organisms

Objective

To evaluate the nutritional quality and suitability of live food organisms for aquaculture species.

Materials Required

1. Harvested live food organisms (e.g., *Chlorella*, rotifers, *Moina*)
2. Centrifuge
3. Protein estimation kit
4. Lipid extraction solvents

Procedure

1. **Biomass Analysis**:
    - Measure wet and dry weights of live food samples.
2. **Protein Estimation**:
    - Use a protein assay kit to determine crude protein content.
3. **Lipid Analysis**:
    - Extract lipids using solvent extraction methods and calculate lipid percentage.

Observation and Results

- Tabulate nutrient composition (protein, lipid, carbohydrate) for each organism.

Conclusion

This lab manual provides comprehensive guidelines for culturing, evaluating, and processing live food organisms. By mastering these techniques, students can ensure sustainable live food production, critical for the success of larval and juvenile rearing in aquaculture.

BFSC-305: Ornamental Fish Production and Management

Introduction

Ornamental fish production and management is a specialized field within aquaculture that focuses on the breeding, rearing, and care of decorative fish and plants for aesthetic and commercial purposes. This manual outline detailed laboratory experiments and procedures to equip students with practical knowledge in ornamental fishkeeping, aquarium fabrication, fish breeding, and disease management.

Experiment 1: Identification of Common Ornamental Fishes and Plants

Objective

To identify and categorize common ornamental fish species and aquatic plants based on their physical and biological characteristics.

Materials Required

1. Field guides or fish identification manuals
2. Samples of ornamental fishes and plants
3. Hand lens or magnifying glass
4. Observation tank

Procedure

1. Collect or observe samples of common ornamental fishes like guppies, mollies, tetras, goldfish, gouramis, and cichlids.
2. Note distinctive features such as body shape, fin structure, coloration, and patterns.
3. For plants, focus on leaf structure, size, and growth patterns. Examples include *Vallisneria*, *Amazon Sword*, and *Anubias*.
4. Use identification keys and manuals to confirm species names.

Observation and Results

- Record features like size, coloration, habitat, and compatibility for each species.
- Tabulate findings for both fishes and plants.

Experiment 2: Fabrication of an All-Glass Aquarium

Objective

To construct a durable all-glass aquarium for ornamental fishkeeping.

Materials Required

1. Glass sheets (6–10 mm thickness)
2. Silicon adhesive
3. Measuring tape
4. Glass cutter
5. Masking tape
6. Cleaning cloth

Procedure

1. **Measurement and Cutting**:
    - Determine dimensions (e.g., 60x30x30 cm).
    - Cut glass sheets for the base, sides, and top using a glass cutter.
2. **Cleaning**:
    - Clean all glass surfaces with alcohol to remove grease and dust.
3. **Assembly**:
    - Apply silicon adhesive along the edges of the base sheet.
    - Attach side panels one by one, ensuring proper alignment.
    - Secure corners with masking tape until adhesive sets.
4. **Curing**:
    - Allow 24–48 hours for the silicon to cure fully.
5. **Testing for Leaks**:
    - Fill the aquarium with water and observe for leaks. Seal any gaps if necessary.

Observation and Results

- Record dimensions and the volume of the fabricated aquarium.
- Document any issues during assembly.

Experiment 3: Setting Up and Maintenance of Aquarium Accessories and Equipment

Objective

To install and maintain essential aquarium accessories like filters, aerators, heaters, and lighting.

Materials Required

1. Air pump and air stones

2. Submersible filter
3. Aquarium heater
4. Thermometer
5. LED or fluorescent lights
6. Gravel and substrate

Procedure

1. **Substrate and Gravel**:
    - Rinse gravel and lay a 2–3 cm layer at the aquarium base.
2. **Filter Installation**:
    - Place the submersible filter inside the tank and connect to a power source.
3. **Aeration**:
    - Attach the air pump to air stones and place them strategically for even oxygen distribution.
4. **Heating and Lighting**:
    - Install a heater and set it to maintain a temperature of 24–28°C.
    - Place lighting to simulate natural daylight.

Observation and Results

- Monitor water parameters and ensure equipment functions efficiently.
- Record maintenance intervals.

Experiment 4: Conditioning and Packing of Ornamental Fishes

Objective

To prepare ornamental fishes for transportation and packaging.

Materials Required

1. Plastic bags (polyethylene, 6–8 mil thick)
2. Oxygen cylinder
3. Rubber bands
4. Stress-reducing additives

Procedure

1. **Conditioning**:
    - Withhold feeding 24–48 hours before packing to reduce metabolic waste.
2. **Packing**:
    - Fill plastic bags one-third with water and two-thirds with oxygen.
    - Place 2–3 fish per bag, depending on size.
    - Add stress-relieving agents if necessary.
3. **Sealing**:
    - Secure bags tightly with rubber bands to prevent leaks.
4. **Transport**:
    - Keep bags in insulated containers to maintain temperature.

Observation and Results

- Note fish behavior before and after transport.
- Record packaging efficiency and survival rates.

Experiment 5: Preparation of Fish Feed

Objective

To prepare nutritionally balanced feed for ornamental fishes.

Materials Required

1. Fishmeal, soybean meal, wheat flour
2. Vitamin and mineral mix
3. Binding agents (e.g., gelatin)
4. Grinder and pelletizer

Procedure

1. Grind ingredients to a fine powder.
2. Mix ingredients in specific proportions (e.g., 40% protein, 20% carbohydrate).
3. Add binding agents and water to form a paste.
4. Use a pelletizer to create feed pellets.
5. Dry pellets in sunlight or a drier.

Observation and Results

- Evaluate feed size, buoyancy, and acceptance by fish.

Experiment 6: Setting Up Breeding Tanks

Objective

To set up breeding tanks for different ornamental fish species.

Materials Required

1. Separate tanks for livebearers, barbs, goldfish, tetras, cichlids, gouramis, fighters, and catfishes
2. Plants, substrates, and spawning aids

Procedure

1. **Livebearers (e.g., Guppies)**:
    - Use a 20L tank with floating plants for fry protection.
2. **Barbs and Tetras**:
    - Provide fine-leaved plants or spawning mats.
3. **Goldfish**:
    - Use larger tanks with a cooler temperature range (22–25°C).
4. **Cichlids and Gouramis**:
    - Include caves or bubble-nest-building spaces.
5. **Fighters (Betta)**:
    - Use individual compartments to avoid aggression.

Observation and Results

- Record spawning behavior and fry hatching success rates.

Experiment 7: Identification of Ornamental Fish Diseases and Prophylactic Measures

Objective

To identify common ornamental fish diseases and apply preventive measures.

Materials Required

1. Diseased fish samples
2. Microscope
3. Antibiotics and disinfectants

Procedure

1. Observe fish for symptoms like fin rot, ich, or fungal infections.
2. Examine gills, fins, and scales under a microscope for parasites or lesions.
3. Apply treatments:
    - Salt baths for ectoparasites.
    - Antibiotics for bacterial infections.
    - Fungicides for fungal growth.

Observation and Results

- Document disease symptoms and treatment efficacy.

Conclusion

This lab manual provides comprehensive procedures for ornamental fish production and management, covering identification, aquarium setup, feed preparation, breeding, and disease management. By mastering these techniques, students gain practical skills essential for the ornamental fish industry.

BFSC-306: Genetics and Breeding

Introduction

This lab manual covers essential techniques and problem-solving exercises in genetics and breeding with a focus on fisheries. Topics include Mendelian and quantitative genetics, chromosome preparation, gamete cryopreservation, and advanced breeding techniques such as androgenesis, gynogenesis, and polyploidy. These exercises help students understand genetic principles and their applications in aquaculture.

Experiment 1: Mendelian Inheritance Problems

Objective

To solve problems based on Mendelian inheritance, including monohybrid and dihybrid ratios and epistasis.

Materials Required

1. Problem sheets
2. Calculator
3. Genetic charts for reference

Procedure

1. **Monohybrid Cross**:
    - Solve problems based on a single trait with dominant and recessive alleles.
    - Use the Punnett square method to predict offspring genotypes and phenotypes.
    - Example Problem: A heterozygous tall (*Tt*) fish is crossed with a homozygous dwarf (*tt*) fish. Predict the genotype and phenotype ratios.
2. **Dihybrid Cross**:
    - Solve problems involving two traits, each governed by independent genes.
    - Use a 4x4 Punnett square to determine genotypic and phenotypic ratios.
    - Example Problem: Cross heterozygous fish for color (*Rr*) and fin shape (*Ff*). Predict offspring ratios.
3. **Epistasis**:
    - Solve problems where one gene masks the effect of another (e.g., recessive epistasis).
    - Example Problem: In a fish population, gene *A* controls body color (dominant: black, recessive: white), but gene *B* allows pigment deposition (absence leads to albino). Cross *AaBb* with *aabb*.

Observation and Results

- Document the genotypic and phenotypic ratios for each cross.

Experiment 2: Problems on Quantitative Traits

Objective

To calculate response to selection, heritability, and genetic gain in quantitative traits.

Materials Required

1. Data sheets with fish traits (e.g., weight, growth rate)
2. Statistical software or calculator

Procedure

1. **Heritability**:
    - Use the formula:
    - $$h^2 = \frac{\text{Genetic variance}}{\text{Phenotypic variance}}$$
    - Example Problem: If genetic variance is 25 and phenotypic variance is 50, calculate heritability.
2. **Response to Selection (R)**:
    - Use the formula:
    - $$R = h^2 \times S$$
    - Where *S* is the selection differential.
3. **Genetic Gain**:
    - Calculate genetic gain using heritability and observed changes in traits after selective breeding.

Observation and Results

- Present calculated heritability, response to selection, and genetic gain for given datasets.

Experiment 3: Chromosome Preparation

Objective

To prepare mitotic and meiotic chromosomes from fish tissues.

Materials Required

1. Fish gills or testis
2. Hypotonic solution (0.075 M KCl)
3. Fixative solution (methanol:acetic acid, 3:1)
4. Giemsa stain
5. Microscope

Procedure

1. **Mitotic Chromosomes**:
    - Dissect fish gills and prepare a tissue suspension.
    - Treat with hypotonic solution for 20 minutes.
    - Fix cells in methanol-acetic acid.
    - Drop cell suspension on a clean slide and air-dry.
    - Stain with Giemsa and observe under the microscope.
2. **Meiotic Chromosomes**:
    - Dissect testis and follow similar steps as for mitotic chromosomes.

Observation and Results

- Capture images of metaphase plates and count chromosome numbers.

Experiment 4: Protocol for Androgenesis, Gynogenesis, and Polyploidy

Objective

To understand protocols for androgenesis, gynogenesis, and induction of polyploidy.

Materials Required

1. Fish eggs and sperm
2. UV irradiator
3. Heat or cold shock apparatus
4. Flow cytometer

Procedure

1. **Androgenesis**:
    - Irradiate fish eggs with UV light to deactivate maternal DNA.

- Fertilize with untreated sperm.
- Apply temperature shock to restore diploidy.

2. **Gynogenesis**:
   - Irradiate sperm to inactivate paternal DNA.
   - Fertilize eggs with irradiated sperm.
   - Apply heat or cold shock for diploidy restoration.
3. **Polyploidy**:
   - Fertilize eggs normally.
   - Apply pressure or heat shock at the first cleavage to prevent chromosomal separation.

Observation and Results

- Verify ploidy status using flow cytometry or karyotyping.

Experiment 5: Gene and Genotypic Frequencies

Objective

To solve problems related to Hardy-Weinberg equilibrium and calculate gene and genotypic frequencies.

Materials Required

1. Genetic data
2. Calculator

Procedure

1. **Calculate Allele Frequencies**:
   - Use the formula:
     $$p + q = 1$$
     Where p and q are frequencies of dominant and recessive alleles.
2. **Calculate Genotype Frequencies**:
   - Use the formula:
     $$p^2 + 2pq + q^2 = 1$$

Observation and Results

- Solve sample problems and verify equilibrium conditions.

Experiment 6: Gamete Cryopreservation

Objective

To demonstrate cryopreservation protocols and evaluate milt quality.

Materials Required

1. Fresh fish milt
2. Cryoprotectant (DMSO, glycerol)
3. Liquid nitrogen tank
4. Hemocytometer

Procedure

1. **Preparation**:
    - Dilute milt with a cryoprotectant solution.
    - Load the mixture into cryostraws.
2. **Freezing**:
    - Gradually cool straws in a liquid nitrogen vapor phase.
    - Transfer to liquid nitrogen for storage.
3. **Thawing and Evaluation**:
    - Thaw cryostraws in a water bath at 30°C.
    - Assess sperm motility under a microscope.

Observation and Results

- Document motility percentage and post-thaw survival rates.

Conclusion

This manual provides a detailed guide for genetic and breeding experiments in fisheries science. By mastering these techniques, students will be equipped with the knowledge to improve fish breeding programs and enhance aquaculture productivity.

BFSC-307: Physiology of Finfish and Shell fish

Introduction

This lab manual is designed to provide hands-on experience in studying the physiological functions of finfish and shellfish. It covers experiments related to oxygen consumption, osmoregulation, ammonia excretion, carbon dioxide output, and the effects of environmental factors like temperature and salinity on metabolism. Additionally, it includes techniques for analyzing fish hematology and histology.

Experiment 1: Estimation of Oxygen Consumption

Objective

To measure the oxygen consumption rate in finfish and shellfish under controlled conditions.

Materials Required

1. Respirometer or closed water system
2. Dissolved oxygen (DO) meter
3. Specimens (finfish or shellfish)
4. Stopwatch

Procedure

1. Fill the respirometer chamber with aerated water.
2. Measure and record the initial dissolved oxygen level using a DO meter.
3. Place the fish or shellfish in the chamber and seal it to ensure no air exchange.
4. After a fixed interval (e.g., 1 hour), measure the final dissolved oxygen level.
5. Calculate the oxygen consumption rate using the formula:

$$\text{Oxygen Consumption Rate (mg/L/hr)} = \frac{\text{Initial DO} - \text{Final DO}}{\text{Time (hours)}}$$

Observation and Results

- Record oxygen consumption rates and note variations based on fish size or species.

Experiment 2: Osmoregulation

Objective

To study osmoregulatory responses of fish and shellfish to different salinities.

Materials Required

1. Fish or shellfish specimens
2. Salinity-adjusted water (e.g., freshwater, brackish water, seawater)
3. Conductivity meter
4. Haemocytometer and microscope

Procedure

1. Place the specimens in tanks with different salinity levels (e.g., 0 ppt, 15 ppt, 30 ppt).
2. Allow acclimatization for 24–48 hours.
3. Collect blood samples using sterile syringes.
4. Measure osmolarity using a refractometer or calculate by determining blood ion concentrations.
5. Observe and document any physiological changes (e.g., gill activity, behavioral shifts).

Observation and Results

- Note osmoregulatory efficiency in maintaining blood ion balance under varying salinity conditions.

Experiment 3: Ammonia Excretion and Carbon Dioxide Output

Objective

To estimate ammonia excretion and carbon dioxide output in aquatic organisms.

Materials Required

1. Water samples from fish tanks
2. Reagents for ammonia estimation (e.g., Nessler's reagent)
3. pH meter
4. Reagents for CO2 estimation (e.g., phenolphthalein, sodium hydroxide)

Procedure

1. **Ammonia Excretion**:
    - Collect water samples from the tanks at fixed intervals (e.g., every 2 hours).
    - Add Nessler's reagent to the water sample and record the color intensity using a colorimeter.
    - Calculate ammonia concentration using a calibration curve.

2. **Carbon Dioxide Output**:
    - Collect water samples before and after the experiment.
    - Titrate the water sample with sodium hydroxide using phenolphthalein as an indicator.
    - Calculate CO2 concentration using the volume of NaOH used.

Observation and Results

- Record ammonia excretion and CO2_22 levels under normal and stressed conditions.

Experiment 4: Influence of Temperature and Salinity on Metabolism

Objective

To study the effects of temperature and salinity on the metabolic rate of fish.

Materials Required

1. Specimens (finfish or shellfish)
2. Respirometer or metabolic chamber
3. DO meter
4. Thermometer
5. Salinity-adjusted water

Procedure

1. Prepare water at different temperatures (e.g., 20°C, 25°C, 30°C) and salinity levels.
2. Place fish in the respirometer and allow acclimatization.
3. Measure oxygen consumption at each temperature and salinity level using a DO meter.
4. Record behavioral changes and metabolic rates.

Observation and Results

- Document variations in metabolic rates and correlate them with temperature and salinity changes.

Experiment 5: Haematology of Finfish and Shellfish

Objective

To study the blood parameters of finfish and shellfish.

Materials Required

1. Blood collection syringes
2. Anticoagulant (e.g., EDTA)
3. Hemocytometer
4. Microscope
5. Staining reagents (e.g., Giemsa stain)

Procedure

1. Collect blood samples from fish using a sterile syringe.
2. Dilute the blood sample with anticoagulant solution.
3. For RBC and WBC counts, load the diluted blood onto a hemocytometer.
4. Count cells under a microscope.
5. Prepare blood smears on glass slides, stain with Giemsa, and examine for differential counts.

Observation and Results

- Record RBC, WBC counts, and identify different leukocyte types.

Experiment 6: Histological Techniques

Objective

To prepare and study tissue sections from finfish and shellfish.

Materials Required

1. Fixative solution (e.g., 10% formalin)
2. Microtome
3. Paraffin wax
4. Staining reagents (e.g., hematoxylin and eosin)
5. Microscope

Procedure

1. Fix tissues in formalin for 24–48 hours.
2. Dehydrate tissues using a graded alcohol series.
3. Embed tissues in paraffin wax and section using a microtome.
4. Mount sections on glass slides and stain with hematoxylin and eosin.
5. Observe tissue morphology under a microscope.

Observation and Results

- Capture images of tissue sections and identify structural features.

BFSC-308: Inland Fisheries

Introduction

This lab manual is designed to provide practical knowledge and skills in inland fisheries, focusing on species composition analysis, fishing operations, catch data maintenance, and visits to relevant facilities. The experiments and exercises included aim to familiarize students with commercially important species, crafts, and gears, as well as the operational aspects of inland fisheries management.

Experiment 1: Analysis of Species Composition of Commercial Catches

Objective

To identify and analyze the species composition in commercial fish catches at landing and assembling centers.

Materials Required

1. Fish identification guides or keys
2. Measuring board
3. Weighing scale
4. Recording sheets
5. Sampling nets

Procedure

1. **Selection of Sampling Site**: Visit a local landing or assembling center.
2. **Sampling**: Randomly select fish samples from the catch for analysis.
3. **Identification**:
    - Use fish identification keys to identify species.
    - Note distinguishing features, size, and weight for each species.
4. **Data Recording**:
    - Record the species name, weight, and abundance in a tabular format.
5. **Analysis**:
    - $$\text{Species Composition (\%)} = \frac{\text{Weight of species}}{\text{Total catch weight}} \times 100$$
6. **Preparation of a Report**: Summarize the findings, highlighting the dominant species and their economic significance.

Observation and Results

- Identify species with the highest composition in the commercial catch and compare across locations or seasons.

Experiment 2: Familiarization with Commercially Important Groups

Objective

To recognize and document commercially important fish and shellfish groups from inland fisheries.

Materials Required

1. Specimens of fish and shellfish
2. Identification keys and charts
3. Recording sheets

Procedure

1. Collect or observe specimens at local fish markets or landing centers.
2. Identify major groups such as carps, catfishes, prawns, and mollusks.
3. Record morphological features, habitat preferences, and economic importance.
4. Create a chart listing each group, its species, and commercial significance.

Observation and Results

- Prepare a catalog of commercially important groups with photographs or sketches.

Experiment 3: Sampling and Observations of Fishing Crafts and Gears

Objective

To study and document the design, operation, and maintenance of fishing crafts and gears used in inland and estuarine waters.

Materials Required

1. Access to local fishing crafts and gears (e.g., nets, traps, boats)
2. Measuring tape
3. Notebook and camera

Procedure

1. Visit an inland or estuarine fishing area to observe crafts and gears in operation.

2. Document the types of fishing crafts (e.g., plank-built boats, dugout canoes) and their construction materials.
3. Study fishing gears such as cast nets, gill nets, and drag nets. Note their mesh size, length, and method of operation.
4. Sketch or photograph the crafts and gears.
5. Discuss their suitability for specific fish species and habitats.

Observation and Results

- Prepare a comparative chart of crafts and gears, highlighting their advantages and limitations.

Experiment 4: Maintenance of Records on Catch Data

Objective

To learn the process of maintaining accurate records of fish catch data for monitoring and management.

Materials Required

1. Logbooks
2. Electronic devices (optional)
3. Sample catch data sheets

Procedure

1. Collect sample data from fishing operations, including species, weight, effort, and location.
2. Enter the data into a logbook or spreadsheet, ensuring accuracy and clarity.
3. Calculate key metrics such as catch per unit effort (CPUE):

$$\text{CPUE} = \frac{\text{Total catch (kg)}}{\text{Fishing effort (hours or number of trips)}}$$

4. Analyze trends in catch data over time.

Observation and Results

- Generate graphs or charts to depict seasonal or spatial variations in catch data.

Experiment 5: Visits to Department of Fisheries, Lakes, and Reservoirs

Objective

To gain practical insights into the management and operations of inland fisheries facilities.

Materials Required

1. Notebook and pen
2. Camera or smartphone (for documentation)

Procedure

1. **Department of Fisheries Visit**:
    - Observe administrative and technical processes.
    - Interact with officials to understand policy implementation and fisheries management practices.
2. **Lakes and Reservoirs Visit**:
    - Study the ecological characteristics of the waterbody.
    - Document fish stocking methods, harvesting techniques, and water quality monitoring practices.
3. **Net Making Yard Visit**:
    - Observe the construction and repair of fishing nets.
    - Learn about materials used (e.g., nylon, polyethylene) and techniques for ensuring durability.

Observation and Results

- Prepare a detailed report summarizing observations from each site, focusing on practical applications in inland fisheries.

Experiment 6: Observations and Experimental Operations of Fishing in Inland Waters

Objective

To participate in fishing operations and evaluate catch efficiency.

Materials Required

1. Fishing boat or crafts
2. Nets and other gears
3. GPS device (optional)

Procedure

1. Join a fishing operation in inland or estuarine waters.
2. Observe gear deployment, fishing duration, and retrieval methods.
3. Record details of the catch, including species, size, and weight.
4. Assess the efficiency of fishing gear based on catch composition and quantity.

Observation and Results

- Evaluate the sustainability of fishing practices and propose improvements if necessary.

BFSC-309: Aquaculture Engineering

Introduction

Aquaculture engineering involves the application of engineering principles to design and manage aquaculture systems and facilities effectively. This lab manual covers practical aspects of evaluating potential aquaculture sites, performing land surveys, calculating volumes and areas, designing aquaculture systems, and analyzing soils for farm construction. The manual also includes methods for earthwork calculations, farm structure designs, and water requirement assessments, along with field visits to aquaculture farms.

Experiment 1: Evaluation of Potential Sites for Aquaculture

Objective

To assess and evaluate the suitability of a site for aquaculture based on environmental, physical, and economic criteria.

Materials Required

1. GPS device
2. Soil sampling kit
3. Water testing kit
4. Topographic maps
5. Notebook and pen

Procedure

1. **Site Selection Criteria**:
    - Assess proximity to water sources.
    - Evaluate soil type and water holding capacity.
    - Check for potential environmental impacts and legal constraints.
2. **Soil and Water Analysis**:
    - Collect soil samples at different depths and locations for texture and pH testing.
    - Test water quality parameters such as pH, salinity, dissolved oxygen, and temperature.
3. **Topography Assessment**:
    - Use GPS or maps to analyze the elevation, slopes, and drainage patterns.

Observations and Results

- Tabulate soil and water test results.

- Summarize the suitability of the site based on collected data.

Experiment 2: Calculation of Areas and Volumes

Objective

To calculate the area of regular and irregular surfaces and the volume of ponds and heaps using mathematical rules.

Materials Required

1. Measuring tape
2. Calculator
3. Graph paper

Procedure

1. **Regular Plane Surfaces**:
    - Measure the length and width of rectangular areas.
    - Use the formula:

$$\text{Area} = \text{Length} \times \text{Width}$$

2. **Irregular Plane Surfaces**:
    - Divide the surface into smaller regular shapes and sum their areas.
    - Apply **Trapezoidal Rule** or **Simpson's Rule** for complex shapes. Area (Trapezoidal Rule)

$$\text{Area (Trapezoidal Rule)} = \frac{h}{2}(y_0 + 2y_1 + 2y_2 + \ldots + y_n)$$

3. **Volume Calculation**:
    - For heaps or stacks, estimate the base area and height, and use the formula: Volume

$$\text{Volume} = \text{Base Area} \times \text{Height}$$

Observations and Results

- Calculate and compare results for different surfaces and volumes.

Experiment 3: Land Survey Techniques

Objective

To perform chain surveying, compass surveying, leveling, plane table surveying, and contouring for aquaculture farm design.

Materials Required

1. Chain and tape
2. Compass
3. Dumpy level
4. Plane table
5. Surveying rods

Procedure

1. **Chain Surveying**:
    - Lay chains along the boundaries and mark distances between points.
    - Record in a field book.
2. **Compass Surveying**:
    - Align the compass to determine bearings of lines.
    - Note angles and distances between survey points.
3. **Leveling**:
    - Set up a dumpy level and measure elevation differences between points.
    - Record readings in a leveling sheet.
4. **Plane Table Surveying**:
    - Mount a plane table on a tripod, and plot survey points directly on the sheet.
5. **Contouring**:
    - Determine elevations at grid intervals and draw contour lines.

Observations and Results

- Prepare maps showing boundaries, elevations, and contour lines.

Experiment 4: Soil Analysis for Farm Construction

Objective

To analyze soil properties for suitability in aquaculture farm construction.

Materials Required

1. Soil auger
2. Moisture analyzer
3. pH meter
4. Sieves

Procedure

1. Collect soil samples from multiple locations and depths.
2. Test for parameters like:
    - Texture (sand, silt, clay proportions).
    - pH (using a pH meter).
    - Permeability (using soil permeability tests).
3. Evaluate soil properties for pond construction and water retention.

Observations and Results

- Document the findings in tabular form and recommend suitable soil amendments if necessary.

Experiment 5: Design and Layout Plan of Aquaculture Farms and Hatcheries

Objective

To design freshwater and brackish water aquaculture farms and hatcheries.

Materials Required

1. Drawing sheets
2. Scale and ruler
3. Blueprints of existing farms

Procedure

1. Study the requirements for freshwater and brackish water systems.
2. Create layout plans showing ponds, dykes, channels, water inlets, and outlets.
3. Include hatchery facilities, feed storage, and waste management systems.
4. Use scale diagrams to ensure proportionality.

Observations and Results

- Prepare detailed and labeled diagrams for farm structures.

Experiment 6: Earthwork Calculations

Objective

To calculate excavation and embankment volumes for pond construction.

Materials Required

1. Field measurements
2. Graph paper
3. Calculator

Procedure

1. Measure dimensions of ponds, dykes, and channels.
2. Use formulas:
   - Excavation Volume:
   $$\text{Volume} = \text{Base Area} \times \text{Depth}$$
   - Embankment Volume:
   $$\text{Volume} = \frac{1}{2} \times \text{Base Length} \times \text{Height} \times \text{Top Width}$$
3. Calculate total earthwork required for farm construction.

Observations and Results

- Present calculations for the estimated earthwork volume.

Experiment 7: Water Requirement Calculations

Objective

To estimate water requirements for aquaculture systems.

Materials Required

1. Pond dimensions
2. Evaporation and seepage data
3. Rainfall records

Procedure

1. Measure pond dimensions and calculate the volume.
2. Account for water losses due to evaporation and seepage.
3. Estimate water requirements using the formula:

$$\text{Water Requirement} = \text{Pond Volume} + \text{Losses} - \text{Rainfall Contribution}$$

Observations and Results

- Compare calculated water requirements with available water sources.

Experiment 8: Visits to Aquaculture Farms

Objective

To observe and document the design, construction, and operation of aquaculture farms.

Procedure

1. Visit freshwater and brackish water farms.
2. Observe pond construction, water management, and feed practices.
3. Interact with farm managers to learn about challenges and solutions.

Observations and Results

- Prepare a detailed report summarizing observations and learnings.