



GEAVET TRAINING PROGRAMME FOR CSA

CLIMATE SMART AGRICULTURE:

NIGERIA

UNIT 2.3 WATER QUALITY MANAGEMENT FOR FISH PRODUCTION

ENGLISH VERSION

GEAVET Project n° 101129027



Open Educational Resources



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PART I – LEARNING MATERIAL

1. Introduction

Water is the habitat of fish and other aquatic animals. In Nigeria, where aquaculture plays an increasingly significant role in food security, employment generation, and rural livelihoods, maintaining optimal water conditions is essential for improving fish health, growth performance, and overall farm productivity. Poor water quality remains one of the leading constraints to efficient aquaculture systems in the country, contributing to high mortality rates, disease outbreaks, slow growth, and reduced economic returns for both small-scale and commercial farmers.



Image 46. Pond waste water

(Source: Vecteezy)

This curriculum on Water Quality Management in Fish Production has been developed to equip trainees with the knowledge, practical skills, and tools required to monitor, assess, and maintain healthy aquatic environments. It introduces participants to the fundamental physicochemical and biological parameters of water; explores the interactions between water quality, fish physiology, and aquaculture systems; and provides hands-on training in water sampling, testing techniques, data interpretation, and corrective management actions.

Aligned with Nigeria’s aquaculture development priorities and global best practices, the curriculum emphasises climate-smart approaches, environmental sustainability, and cost-effective methods suitable for various production systems—including earthen ponds, concrete tanks, recirculating aquaculture systems (RAS), and cage culture. By

completing this training, learners will be better equipped to make informed decisions that enhance production efficiency, minimise losses, and contribute to a resilient and competitive aquaculture sector in Nigeria.

2. Water and Water Quality Management

Water quality refers to the physical, chemical, and biological characteristics of water that determine its suitability for sustaining aquatic life, particularly fish in aquaculture systems. Key parameters such as temperature, dissolved oxygen, pH, turbidity, ammonia, nitrite, nitrate, alkalinity, hardness, and microbial load collectively influence fish health, growth, reproduction, and overall pond productivity. Good water quality ensures a stable and healthy environment where fish can thrive.

Water quality management involves the continuous monitoring, assessment, and regulation of water conditions to maintain optimal parameters for fish production. It includes activities such as routine testing, adjusting water chemistry, controlling pollution sources, aeration, water exchange, proper feeding practices, waste management, and preventing environmental contamination. Effective water quality management reduces stress, prevents disease outbreaks, enhances feed efficiency, and improves fish survival rates.

2.1. Relevance of Water Quality Management to Climate-Smart Agriculture (CSA) in Nigeria

Water quality management is essential for CSA, particularly in aquaculture systems. It helps these systems adapt to changing weather conditions, minimise environmental impact, and enhance productivity. As climate change leads to temperature fluctuations, variations in rainfall, and increased water scarcity, maintaining stable water quality becomes crucial for the resilience of fish production systems.

2.1.1. Main Pillars of Climate-Smart Agriculture and Their Link to Water Quality Management

- **Productivity Enhancement:** Good water quality directly boosts fish growth rates, feed conversion efficiency, and overall yield (Tumwesigye *et al.*, 2022). By keeping water parameters within optimal ranges, farmers increase the productivity of aquaculture systems even under climate stress. Effective water management also supports year-round production, thus improving food supply and income generation.

- **Climate Adaptation and Resilience:** Ensuring optimal water quality is essential for fish farms to adapt to the impacts of climate change. By establishing more controlled environments, fish stocks can better endure the unpredictable conditions brought on by climate change, such as rising temperatures, droughts, flooding, increased evaporation, and shifts in water chemistry. Utilising monitoring tools, aeration systems, water recycling, and early-warning indicators enhances resilience and reduces vulnerability during climate extremes (Siddique et al., 2023).
- **Climate Change Mitigation:** Good water quality management minimises the release of harmful emissions and pollutants into the environment. Practices such as reducing organic waste loads, optimising feeding, preventing nutrient runoff, and integrating energy-efficient aeration systems help lower greenhouse gas emissions and protect surrounding ecosystems Manea et al., 2024.

2.2. Relationship between water quality management and fish production

Water quality management has a direct and significant influence on the success of fish production in Nigeria. Because fish live entirely in water, their health, growth, feeding efficiency, and survival depend on the stability and suitability of the water environment. When key parameters such as dissolved oxygen, temperature, pH, ammonia, nitrite, and turbidity are properly managed, fish experience less stress, utilise feed more efficiently, and exhibit faster growth rates Ogunji and Wuertz (2023).

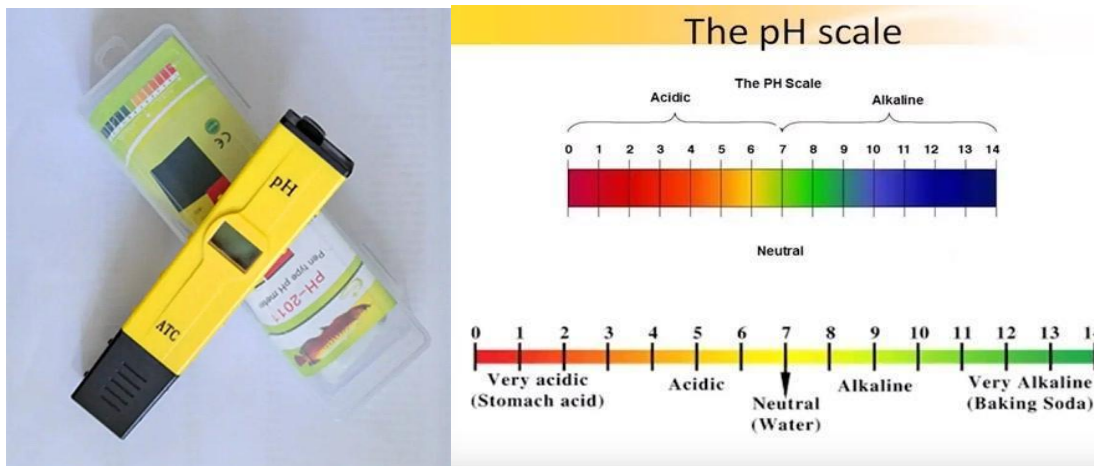
In Nigeria, many production challenges of cultured fish, such as high mortality, slow growth, frequent disease outbreaks, and low yields can be traced to poor water quality arising from overcrowding, inadequate aeration, poor feeding practices, and limited monitoring of water quality. Effective water quality management helps address these constraints by ensuring optimal environmental conditions throughout the production cycle. This leads to improved fingerling survival, higher market-size yield, better profitability, and reduced losses for farmers. Additionally, good monitoring of water quality supports the sustainability of aquaculture systems by preventing pond pollution, reducing dependency on expensive treatments, and enabling farmers to adapt to climate-related stressors such as heat waves and unpredictable rainfall. Thus, the relationship between water quality management and fish production is foundational, as it determines both the biological performance of fish and the economic success of aquaculture enterprises in Nigeria [here](#).

2.3. Inventory for Water Quality Management in Fish Production in Nigeria

A functional inventory for water quality management in fish production in Nigeria consists of all tools, equipment, materials, and support systems needed to ensure that aquaculture environments remain healthy, productive, and stable throughout the production cycle. Because fish depend entirely on the quality of their surrounding water, having the right inventory in place is essential for preventing stress, promoting growth, and reducing mortality in ponds, tanks, and recirculating aquaculture systems. The following are the inventory required for water quality management in fish production.

2.3.1. Water Testing Equipment

- **pH meters:** Used to monitor the acidity or alkalinity of water. Stable pH ensures proper metabolic function and reduces fish stress.



Images 47a & b. Digital pH meter and scale

(Source: Afrimash)

- **Dissolved Oxygen (DO) meters:** Critical for measuring oxygen levels. Fish require adequate DO for respiration, growth, and survival.



Image 48. Dissolved Oxygen meter

Source: Allschoollabs (2025)

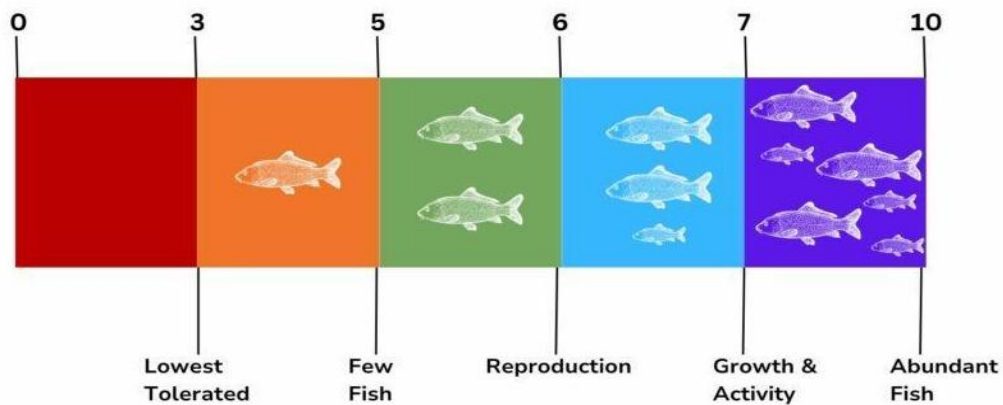


Image 49. Range of Tolerance for Dissolved Oxygen in Fish (mg/l)

Source: Limnoloan (2023)

- **Thermometers or digital temperature probes:** Help farmers track water temperature, which affects feeding rates, oxygen demand, and ammonia toxicity.

- **Ammonia, nitrite, and nitrate test kits:** Used to measure toxic nitrogen compounds that accumulate from feed and waste. These chemicals can kill fish if not managed.
- **Alkalinity and hardness test kits:** Important for evaluating buffering capacity and mineral content, which influence fish health and pond stability.
- **Turbidity meters or Secchi discs:** Help assess water clarity and plankton levels, which affect photosynthesis, oxygen balance, and nutrient management.

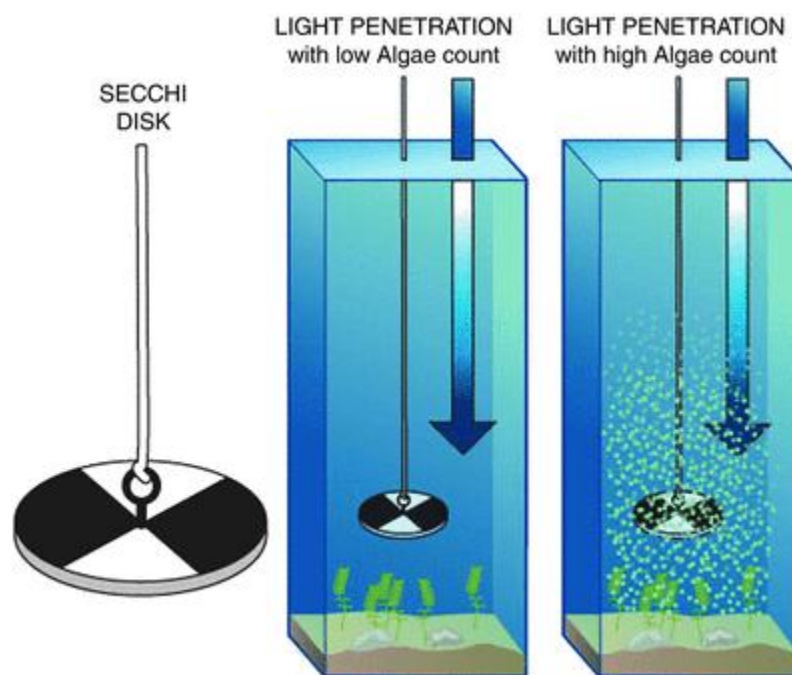


Image 50. Secchi discs

Source: Harrison et al. (2016)

- **Microbial test kits (optional for advanced farms):** Useful for detecting harmful bacteria in hatcheries or intensive systems.

2.3.2. Aeration and Water Movement Devices

- **Paddlewheel aerators:** Used in commercial ponds to increase dissolved oxygen, especially during warm nights and high stocking densities.



Image 51. Paddlewheel aerator

- **Air blowers and diffusers:** Common in tank and RAS systems; they circulate air and help maintain uniform oxygen distribution.
- **Venturi aerators:** Low-cost and efficient for small-scale farms to boost oxygen levels.



Image 52. Venturi aerator

- **Water pumps:** Essential for water exchange, tank refilling, and maintaining pond levels during dry seasons.



Images 53a & b. Fuel and electrically powered water pumps

2.3.3. Filtration and Water Treatment Tools

- **Mechanical filters:** Remove suspended solids, uneaten feed, and fish waste from tank and RAS systems.
- **Biological filters or bio-media:** Encourage nitrifying bacteria that convert toxic ammonia and nitrite into less harmful nitrate.
- **UV sterilisers:** Used in hatcheries to control pathogens and maintain high water quality.



Image 54. UV Steriliser

- **Sediment traps and screens:** Prevent debris, predators, and contaminants from entering ponds.

2.3.4. Pond and Tank Management Materials

- **Agricultural lime (calcium carbonate):** Stabilises pH, increases alkalinity, and improves the overall productivity of earthen ponds.
- **Salt (sodium chloride):** A simple treatment for mild stress, parasites, and maintaining osmotic balance in fish.
- **Fertilizers (organic and inorganic):** Used in semi-intensive ponds to boost natural phytoplankton production for young fish.
- **Probiotics:** Improve water microbial balance and reduce harmful ammonia buildup.

- **Alum (aluminium sulphate):** Reduces turbidity caused by clay particles, improving water clarity and pond performance.

2.3.5. Water Supply and Distribution Infrastructure

- **Boreholes and wells:** Provide reliable water sources for tanks, hatcheries, and dry-season pond operations.
- **Overhead tanks and reservoir systems:** Ensure constant gravity-fed water flow for hatcheries and nurseries.
- **Pipes, valves, and hoses:** Used to control water movement, regulate flow rates, and manage water exchange.



Image 55. PVC Pipes

- **Sluice gates and monk structures:** Control inflow and outflow in earthen ponds, allowing effective pond drainage and water level management.



Image 56. Sluice gates

2.3.6. Waste and Sediment Management Tools

- **Siphoning tubes:** Remove settled waste from tanks and nursery ponds.



Image 57. Siphoning tubes

- **Desilting equipment:** Prevents excessive sediment buildup that can reduce pond depth and affect productivity.



Image 58. Desilting equipment

- **Organic waste collectors:** Useful in RAS or intensive tank systems for solid waste removal.



Image 59. Organic waste collector

2.3.7. Sampling and Monitoring Accessories

- **Water sampling bottles:** Used to collect water samples for laboratory or routine testing.
- **Scoop nets and observation bowls:** Help in monitoring fish behaviour, which is often the earliest indicator of deteriorating water quality.



Image 60. Scoop net and observational bowl

- **Measuring buckets and beakers:** Support accurate application of treatments, salts, and lime.

2.3.8. Backup Power and Safety Equipment

- **Generators or solar backup systems:** Prevent aerator and pump failure during power outages, which can cause mass fish mortality.

- **Protective gloves and boots:** Ensure safety during handling of chemicals and equipment.

2.3.9. Institutional Support and Documentation Tools

- **Standard Operating Procedures (SOPs):** Guide farmers on best practices for water testing, treatment, and management.
- **Record-keeping tools or water quality logbooks:** Allow farmers to track water parameters and make informed decisions.
- **Access to trained extension officers:** Provides technical support for diagnosing problems and improving management practices.

2.4. Planning and Layout for Water Quality Management System in Fish Production in Nigeria

Water quality management in fish production is not just about tools and layout; it also involves quantitative monitoring and calculations to ensure optimal conditions. Below is an expanded discussion that integrates key calculations into each aspect of planning and layout for Nigerian farmers.

2.4.1. Assessment of Water Source

- **pH adjustment with lime:** Lime (CaCO_3) is often used to adjust acidic pond water. It is important to take water samples to the laboratory for analysis and get expert advice.
- **Dissolved oxygen (DO) capacity:** Oxygen solubility varies with temperature and salinity. Farmers may use tables or formulas to calculate expected DO levels at a given temperature to determine aeration needs.

Table 6. Relationship between water temperature and dissolved oxygen

Water temperature ($^{\circ}\text{C}$)	Maximum available DO (mg/L)	Minimum DO (mg/L)
5	12.8	9.1
10	11.3	8.8
15	10.2	8.3
20	9.2	7.8
25	8.2	7.5
30	7.4	6.9

2.4.2. Determination of Farm Type and Stocking Density

Stocking density calculations are critical for water management:

- **Pond stocking density:**

Example: For a 500 m³ pond, desired biomass 20 kg/m³, and average fingerling weight 0.05 kg:

Calculation

1. Desired total biomass

$$500\text{m}^3 \times 20\text{kg}/\text{m}^3 = 10,000\text{kg}$$

2. Number of fingerlings

$$10,000\text{kg}/0.05\text{kg fingerling} = 200,000 \text{ fingerlings}$$

Result: You would need to stock 200,000 fingerlings to achieve the target biomass of 20 kg / m³ in a 500 m³ pond.

If you want to account for expected mortality, add a safety margin—e.g., 5 % extra \approx 210,000 fingerlings.

Stocking too high can deplete oxygen quickly and increase ammonia levels.

2.4.3. Aeration and Oxygen Calculations

Aeration systems are sized based on oxygen demand:

Oxygen requirement calculation:

For a 1,000 kg biomass of catfish:

For a 1,000 kg biomass of catfish, ensuring sufficient oxygen supply is crucial, especially during low Dissolved Oxygen (DO) periods.

Typical oxygen requirements:

Catfish generally require about 0.3-0.5 kg of oxygen per kg of feed per day.

For a rough estimate, let's assume a feeding rate of 2% body weight per day (20 kg feed for 1,000 kg biomass), which translates to about 6-10 kg O₂/day or roughly 250-420 g O₂/hour.

Aerators are then selected based on capacity in g O₂/hour, ensuring sufficient supply during low DO periods.

2.4.4. Water Exchange and Flow Rate

Water exchange calculations prevent ammonia buildup:

Exchange rate calculation: Water exchange (m³/day) = Pond volume (m³) × Exchange rate (% per day)

Example: For a 500 m³ pond with 20% daily exchange: $500 \times 0.2 = 100$ m³/day

Flow rates for pumps can then be calculated as:

Pump capacity (m³/h) = Daily exchange/Hours of operation

If operated 5 hours/day:

$$100 / 5 = 20 \text{ m}^3/\text{h pump required}$$

2.4.5. Waste and Filtration Calculations

Ammonia load estimation:

Example: Feeding 50 kg/day with 30% protein:

$$50 \times 0.3 \times 0.031 = 0.465 \text{ kg ammonia/day}$$

Filtration or water exchange must be designed to remove this load.

Settling basin volume for solids removal:

Where Q = flow rate (L/h), t_s = settling time (h), V = basin volume (m³).

2.4.6. Chemical Treatment Dosages

Salt for disease prevention:

Required salt (kg) = Pond volume (m³) × Desired concentration (g/L)

Example: 500 m³ pond at 1 g/L: $500 \times 1 = 500$ kg of salt

Alum for turbidity control: Dose depends on turbidity (NTU). Approximate: 10–30 mg/L for moderate turbidity.

2.4.7. Water Testing and Monitoring Frequency

Sampling frequency can be calculated using pond size and production intensity:

Number of samples/day = Number of ponds × Sampling frequency per pond

Example: 4 ponds, sampling twice daily → 8 samples/day.

2.4.8. Summary

Integrating these calculations into planning and layout ensures:

- Optimal **stocking densities**
- Adequate **oxygen supply**
- Efficient **waste removal**
- Correct **chemical treatment doses**
- Reliable **water exchange rates**

By applying quantitative methods, Nigerian fish farmers can optimise water quality, reduce mortality rates, enhance growth rates, and achieve more sustainable production.

3. European Case Studies for Nigerian Learners and Farmers on Water Management for Fish Production

3.1. AQUALITY Project (EU-funded RAS Monitoring System)

- The AQUALITY project developed a multi-sensor automated water quality monitoring and control system for recirculating aquaculture systems (RAS). (Kolarevic et al. 2015)
- It included a miniaturised automated colourimeter analyser (MACA) to continuously measure ammonia and nitrite, key toxic compounds in RAS.
- A web application allowed farmers to upload their data to a centralised expert database, receive advice, and compare their farm's water quality profile with similar systems.
- **Lesson for Nigeria:** Shows how real-time monitoring + data-driven advice can improve water quality control, reduce risk, and optimise RAS performance, even under resource constraints.

3.2. AQUAS Project (Water Quality & Sustainable Aquaculture, EU FP6)

- The AQUAS project (Water Quality and Sustainable Aquaculture: Links and Implications) studied how aquaculture affects local water bodies and vice versa.
- In coastal systems in Spain (Valencia), the project analysed nutrient fluxes (nitrogen, phosphorus) from fish farms and identified carrying capacities of water bodies to absorb these nutrients safely.
- Based on findings, they developed guidelines for sustainable aquaculture, helping to reduce environmental damage and maintain water quality in sensitive regions.
- **Lesson for Nigeria:** Useful for designing systems near sensitive water ecosystems (lagoons, rivers) and planning nutrient management to avoid eutrophication.

3.3. Long-Term Water Quality Improvement in Rainbow Trout Farming (Italy)

- A 10-year study (2009–2019) in a rainbow trout farm in Central Italy tracked water-quality parameters like suspended solids, biochemical oxygen

demand (BOD), ammonia, nitrates, etc., before and after switching to extruded feed.

- Results showed significant improvements in these parameters, suggesting that **changes in feeding strategies** (extruded feed) can reduce waste, improve water quality, and enhance sustainability. Read more at <https://www.aquafeed.co.uk/italys-aquaculture-renaissance-bridging-tradition-with-innovation-in-trout-farming/>.
- **Lesson for Nigeria:** Feed formulation and efficiency are critical levers. Optimising feed can reduce nitrogenous waste and improve water quality in ponds or tanks.

3.4. Environmental Impact of Marine Cage Aquaculture – Eastern Adriatic Sea (Croatia)

- Researchers assessed the environmental impact of cage fish farming in the Adriatic Sea, studying nutrient release, microbial water quality, and sediment changes across seasons.
- Findings highlighted that feed management and hydrodynamics (water flow around cages) strongly influence how nutrients disperse and whether they accumulate. Aquafeed (2025). Read more at <https://ribarstvo.agr.hr/en/issues/article/242>.
- **Lesson for Nigeria:** For cage or pen systems (especially in rivers or large lakes), site selection, hydrodynamic studies, and feed management are vital to manage nutrient loads.

3.5. DEXiAqua Sustainability Model (French Salmon Farm)

- The DEXiAqua model is a decision-support tool developed to assess the *sustainability* of aquaculture systems. It was applied to a salmon farm in France to evaluate environmental performance, including water quality impacts. Read more at <https://hal.science/UNAM/hal-03291115v1>.
- The model integrates economic, environmental, and production data to guide optimisation – e.g., reducing effluents, improving resource efficiency.
- **Lesson for Nigeria:** Adopting sustainability assessment tools helps aquaculture businesses make decisions that balance growth with water quality and environmental health.

3.6. How These Case Studies Are Relevant for Nigerian Learners:

- **Adaptation of Technologies:** The AQUALITY project illustrates how sensor-based water monitoring can be cost-effective and adapted to different scales; Nigerian farmers can learn to customise similar systems.
- **Feed Management:** The Italian trout farm study shows that feed choices (e.g., extruded feed) can significantly improve water quality – a lesson highly transferable to Nigerian pond-based and tank systems.
- **Environmental Regulation & Policy:** Projects like AQUAS demonstrate the importance of understanding nutrient limits of local water bodies. Nigerian aquaculture policy makers and extension workers can draw from these frameworks when developing local best practices.
- **Sustainability Tools:** The use of sustainability assessment models (like DEXiAqua) can guide Nigerian producers in planning operations that are both productive and environmentally responsible.
- **Health Monitoring:** Integrating fish health management with water-quality surveillance (as in Mediterranean farms) helps prevent disease and improve survival rates, especially important in regions with variable climate stress.
- **Water Efficiency:** Aquaponics projects show how water reuse and nutrient recycling can reduce environmental impact, which is relevant for small-scale farmers or regions facing water scarcity.

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PART 2 - CURRICULUM

Learning Objectives

KNOWLEDGE	SKILLS	ATTITUDES
<p><i>Students should be able to:</i></p> <ul style="list-style-type: none"> ● Identify and describe key water quality parameters essential for fish production: <ul style="list-style-type: none"> ○ Dissolved oxygen (DO) ○ pH ○ Temperature ○ Ammonia, nitrite, and nitrate ○ Turbidity ○ Hardness and alkalinity ● Biological and chemical contaminants (e.g., coliforms, heavy metals) ● Determine the effects of water quality on fish health, including stress, growth performance, feeding efficiency, reproduction, and mortality. ● Identify the sources of water pollution (agricultural runoff, waste accumulation, feed residues, chemicals, etc.) and their impacts on aquaculture systems. ● Describe basic principles of water 	<p><i>Students should be able to:</i></p> <ul style="list-style-type: none"> ● Use water quality testing tools and equipment such as: <ul style="list-style-type: none"> ○ pH meter ○ DO meter ○ Thermometer ○ Secchi disk ○ Turbidity tubes ○ Test kits for ammonia, nitrite, nitrate, and hardness ○ Multiparameter water quality meter (where available) ● Collect water samples accurately from ponds, tanks, and raceways. ● Analyze and interpret water quality data, compare with recommended limits, and identify possible problems. ● Carry out corrective actions, including: <ul style="list-style-type: none"> ○ Aeration (manual or mechanical) ○ Water exchange procedures ○ Liming of ponds ○ Use of filtration systems 	<p><i>Students should be able to:</i></p> <ul style="list-style-type: none"> ● Appreciate the importance of water quality as a foundation for sustainable fish production ● Develop responsible behaviour towards fish welfare. ● Demonstrate accuracy and attention to detail during water sampling, measurement, and record-keeping. ● Develop cleanliness and hygiene practices in the aquaculture environment. ● Demonstrate teamwork and collaboration during group monitoring and problem-solving tasks. ● Exhibit responsibility and environmental sensitivity, understanding the need to maintain healthy aquatic ecosystems. ● Adopt a proactive mindset toward regular monitoring rather than waiting for fish mortality or stress signs.

<p>quality correction, such as aeration, filtration, water exchange, liming, and the use of probiotics.</p> <ul style="list-style-type: none"> ● Explain Fish species tolerance levels for different water quality ranges. 	<ul style="list-style-type: none"> ○ Managing feeding rates to reduce organic loading ● Develop a simple water quality monitoring schedule for a fish farm. ● Record and maintain water quality logbooks and prepare short technical reports. 	
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Transversal Skills

- **Critical Thinking and Problem-Solving**

- Ability to identify water quality problems (e.g., low DO, high ammonia) and propose appropriate corrective measures.
- Evaluating multiple solutions and choosing the most effective intervention. Teamwork and Collaboration

- **Digital Literacy**

- Using digital water quality meters, mobile apps, spreadsheets, and simple databases for recording and analysing results.
- Accessing online resources for water quality standards and management techniques.

- **Communication Skills**

- Clear verbal communication when presenting observations or explaining water quality findings.
- Writing technical notes, water quality reports, logbook entries, and corrective action summaries.

- **Teamwork and Collaboration**

- Working in groups to collect pond water samples, carry out measurements, and analyse data.
- Sharing responsibilities and supporting peers during fieldwork.

- **Planning and Organisational Skills**

- Scheduling regular water monitoring activities and following systematic procedures.
- Properly organising sampling equipment, test kits, and digital tools.

- **Environmental and Sustainability Awareness**

- Recognising the environmental impacts of poor water quality and irresponsible aquaculture practices.

- Promoting sustainable pond management and resource conservation.
- **Numeracy and Data Interpretation**
 - Reading measurement scales accurately, calculating averages, and interpreting trends in water quality data.
 - Comparing data against recommended thresholds for fish health.
- **Ethics and Professional Responsibility**
 - Practicing honesty and accuracy when recording data.
 - Respecting farm protocols and maintaining integrity in reporting findings.

Digital Skills

- **Use of Digital Water Quality Measuring Devices**
 - Operating digital pH meters, digital thermometers, dissolved oxygen (DO) meters, and multiparameter water testers.
 - Calibrating and troubleshooting digital equipment.
- **Digital Data Recording and Management**
 - Entering water quality results into mobile data collection apps or spreadsheets (Excel, Google Sheets).
 - Creating electronic logbooks and backing up data using cloud storage.
 - Organizing datasets for easy retrieval and analysis.
- **Data Analysis and Visualization**
 - Using spreadsheet software to:
 - Generate charts and graphs of pH, DO, temperature, ammonia, etc.
 - Calculate trends, averages, and compare values with recommended standards.
 - Basic interpretation of visual outputs to guide management decisions.
- **Digital Communication Skills**
 - Sharing water quality data and reports through email, WhatsApp, Google Drive, or other platforms.
 - Preparing digital presentations (PowerPoint, Google Slides) to report findings after practical sessions.
- **Basic Troubleshooting of Digital Tools**
 - Identifying and correcting common issues with faulty sensors or device calibration.
 - Safely handling batteries, cables, and electronic equipment in wet aquaculture environments.
- **Safe and Responsible Use of Digital Technology**

- Following data privacy and responsible-use principles when collecting and sharing digital information.
- Practicing good digital hygiene (password protection, backing up files, safe handling of devices around water).

Green Skills Associated with Water Quality Management

● Sustainable Water Resource Management

- Efficient use of water through controlled water exchange, recycling, and reduction of wastage.
- Understanding how to maintain pond/tank water quality with minimal environmental impact.

● Environmental Monitoring and Stewardship

- Regular monitoring of water quality parameters to maintain healthy aquatic ecosystems.
- Early detection of pollution or harmful environmental changes.

● Waste Reduction and Eco-friendly Practices

- Managing feed responsibly to reduce feed waste and minimize ammonia buildup.
- Implementing proper disposal or reuse of sludge and organic waste (e.g., composting).

● Pollution Prevention

- Reducing nutrient overloads that lead to eutrophication.
- Avoiding harmful chemical use and promoting safe alternatives.

● Ecosystem Awareness and Biodiversity Protection

- Recognizing the role of water quality in supporting fish health, beneficial microorganisms, and overall pond ecology.
- Encouraging the preservation of natural water bodies and surrounding habitats.

● Climate-Smart Aquaculture Practices

- Understanding how climate variables (temperature, rainfall, evaporation) affect water quality.
- Adjusting management practices to climate changes to protect fish stocks.

● Environmental Ethics and Responsibility

- Adopting a stewardship mindset that values clean water and environmental protection.
- Practicing accountability when working in aquaculture environments (e.g., no dumping of chemicals, maintaining hygiene).

Implementation plan of pedagogical activities (Scheme of work / Session plan)

Duration: 3 hours 5 minutes				
Description of participants: Secondary school leavers, diploma trainees, or vocational learners with basic literacy and numeracy skills between the ages of 18 and 35 who require hands-on competency-based training on water quality management for systems.				
No of Activity	Timing	Training Methods/Activity	What do trainers do	What do participants do
1	25 min	Introduction & Safety Briefing	<ul style="list-style-type: none"> • Explain course expectations, responsibilities on water quality management, safety rules around ponds and testing chemicals. • Demonstrate proper handling of tools. 	<ul style="list-style-type: none"> • Listen and take notes.
2	25 min	Demonstration of Water Parameters and Quality Testing Equipment	<ul style="list-style-type: none"> • Show how to use pH meters, DO meters, thermometer, Secchi disk, ammonia test kits, etc. • Explain calibration and maintenance. 	<ul style="list-style-type: none"> • Listen and take notes • Observe demonstration.
3	35 min	Demonstration/ Videos on Field Sampling Activity in Ponds/Tanks	<ul style="list-style-type: none"> • Guide students on proper sampling methods and sample handling. • Guide students on field movement and safety. 	<ul style="list-style-type: none"> • Watch videos and take notes

4	20 min	Data Recording & Entry Session	<ul style="list-style-type: none"> ● Teach structured data entry using log sheets or spreadsheets ● Explain standard limits for fish species. ● 	<ul style="list-style-type: none"> ● Watch videos and take notes ● Enter collected data. ● Organize measurements into tables. ● Compare to recommended water quality standards.
5	20 min	Data Analysis and Interpretation Workshop	<ul style="list-style-type: none"> ● Guide students in analyzing trends (e.g., detect low dissolved oxygen, high ammonia). ● Provide examples of real farm scenarios. 	<ul style="list-style-type: none"> ● Watch videos and take notes ● Generate graphs/charts. ● Interpret trends and identify potential problems. ● Discuss implications for fish health.
6	15 min	Corrective Action Practical Session	<ul style="list-style-type: none"> ● Demonstrate methods such as aeration, liming, filtration, and controlled water exchange. ● Provide materials and supervision. 	<ul style="list-style-type: none"> ● Watch the demonstration and understand and feedback

7	20 min	Case Study & Problem-Based Learning (PBL)	<ul style="list-style-type: none"> ● Present a scenario of water quality crisis (e.g., sudden fish mortality). ● Ask guiding questions to stimulate problem solving. 	<ul style="list-style-type: none"> ● Watch videos and take notes ● Analyze the case study. ● Identify causes and propose solutions. ● Present group findings.
8	20 min	Presentation & Reflection Session	<ul style="list-style-type: none"> ● Assess group reports and presentations. Facilitate reflective discussion about lessons learned. 	<ul style="list-style-type: none"> ● Present their water quality monitoring report. ● Reflect on challenges and successes ● Provide feedback on peers' work.

Materials (What trainers need to have prepared):

Teaching & Presentation Materials

- **PowerPoint Slides**

- Introduction to water quality
- Key parameters (pH, DO, temperature, ammonia, nitrite, alkalinity, turbidity)
- Fish species tolerance ranges
- Water sampling procedures
- Corrective management practices

- **Printed or Digital Handouts**

- Water quality threshold values for common fish species (e.g., catfish, tilapia).
- Step-by-step protocols for using pH meter, DO meter, ammonia test kits.
- Safety guidelines for handling testing chemicals.

- Data-recording templates.
- **Instructional Videos**
 - Demonstration of water sampling techniques.
 - How to use each testing device.
 - Fish behavior under stress due to poor water quality.
- **Case Studies**
- Water quality problem scenarios for class discussion.
- Sample farm records showing deteriorating water quality.

Practical Laboratory / Field Materials *(For on-site or virtual demonstrations)*

- **Water Quality Testing Tools**
 - pH Meter or pH Test Strips
 - Dissolved Oxygen (DO) Meter
 - Thermometer (Digital or Analog)
 - Ammonia (NH₃), Nitrite (NO₂⁻), Nitrate (NO₃⁻) Test Kits
 - Alkalinity and Hardness Test Kits
 - Turbidity Tube or Secchi Disk
 - Conductivity Meter / TDS Meter
- **Sampling Equipment**
 - Water Sampling Containers (sterile if possible)
 - Long-handle sampling scoop
 - Labeling materials (waterproof markers, labels)
 - Portable cooler (for sample storage if required)

Digital Materials & Tools (for Online Classes)

- **High-quality camera or webcam** for live demonstration.
- **Mobile apps** for virtual water quality testing/simulations (optional):
 - AquaCheck
 - FAO Aquaculture Sim tools
 - Aquaponics Water Quality Apps
- **Data entry templates** in Google Sheets / Excel Online.
- **Learning Management System (LMS) uploads:**
 - PDFs
 - Videos
 - Worksheets
 - Quizzes

- **Breakout-room instructions** for group tasks.
- **Classroom Supplies for Hands-On Practice**
- **Disposable gloves**
- **Safety goggles**
- **Lab coats or aprons**
- **Clean water samples** from:
 - Fish pond
 - Recirculating aquaculture system (RAS)
 - Borehole/well
 - River/stream (optional for comparison)
- **Waste bins** for used reagents/test strips
- **Distilled water** for calibrating meters

Stationery & Administrative Materials

- **Attendance sheets (digital or printed)**
- **Rubrics for assessing practical performance**
- **Evaluation forms** for students
- **Feedback sheets** for continuous assessment
- **Session schedule & lesson plan**

Emergency & Safety Materials

- First aid kit
- MSDS (Material Safety Data Sheets) for chemical reagents
- Neutralising agents (baking soda, clean water)

PART 3 – ACTIVITY GUIDE

DESCRIPTION OF ACTIVITIES

1. Introduction & Safety Briefing

The objectives of this activity are to orient learners to the course on water quality management for fish production and to establish a strong foundation of safety awareness before practical sessions begin. Learners will be introduced to the importance of water quality in fish health, growth, and survival, and how poor water conditions can lead to stress, disease outbreaks, and production losses. The activity aims to build learners' understanding of key water quality parameters and their relevance to aquaculture systems such as ponds, tanks, and cages.

A major focus of the activity is to promote safe working practices in aquaculture environments. Learners will be made aware of potential hazards, including slippery surfaces, electrical equipment near water, chemical handling, and biological risks. Proper use of personal protective equipment (PPE) and safe behavior around water bodies are emphasized.

The activity also sets expectations for learner participation, teamwork, and responsible conduct during training. By the end of the activity, learners are expected to understand the importance of water quality management, recognize common safety risks in fish production, and adopt safe practices that protect themselves, others, and the production environment.

1. Aim of the activity: To introduce water quality concepts and promote safe practices in fish production.

2. Duration: 25 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Welcome and Orientation:** The facilitator welcomes learners and introduces the course objectives and structure.
- **Overview of Water Quality in Fish Production:** Key water quality concepts and their importance to fish health and productivity are explained.
- **Identification of Hazards:** The facilitator highlights common safety risks in fish farming environments.
- **Safety Rules and PPE Demonstration:** Proper use of PPE and safe handling of equipment are demonstrated.
- **Emergency Procedures:** Learners are briefed on emergency response, first aid, and reporting of incidents.
- **Interactive Discussion:** Learners ask questions and share experiences related to safety and water management.

References/Sources/Further materials

2. Demonstration of Water (Parameters and Quality Testing Equipment)

The objectives of this activity are to introduce learners to essential water quality parameters that influence fish health, growth, and survival, and to demonstrate the equipment used to measure them. Learners will understand the significance of parameters such as temperature, dissolved oxygen, pH, turbidity, ammonia, and salinity in aquaculture systems. The activity emphasizes how changes in water quality directly affect fish behavior, feed utilization, and overall productivity.

Learners will gain practical exposure to common water quality testing equipment, including thermometers, pH meters, dissolved oxygen meters, test kits, and transparency tubes. The activity aims to develop learners' ability to correctly handle, operate, and maintain these instruments to obtain accurate and reliable measurements. Emphasis is placed on proper sampling techniques, calibration checks, and correct reading and recording of results.

In addition, the activity reinforces safe handling of equipment and water samples, promoting good laboratory and field practices. By the end of the activity, learners are expected to identify key water quality parameters, explain their importance in fish production, and demonstrate basic competence in using water quality testing equipment to support effective water quality management decisions.

1. Aim of the activity: To demonstrate key water quality parameters and testing equipment for fish production.

2. Duration: 25 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Introduction to Water Quality Parameters:** The facilitator explains key water quality parameters relevant to fish production and their effects on fish health.
- **Demonstration of Testing Equipment:** Various water quality testing instruments are introduced such as pH meters, DO meters, Thermometer etc., and their functions are explained.
- **Equipment Handling and Setup:** The facilitator demonstrates proper handling, basic calibration checks, and preparation of equipment before use.
- **Water Sample Collection:** Learners observe correct procedures for collecting water samples from ponds or tanks.
- **Measurement and Reading:** The facilitator demonstrates how to take measurements for different parameters and record results accurately.
- **Learner Practice Session:** Learners practice using selected equipment under supervision.
- **Discussion and Review:** Results are discussed, common errors are highlighted, and questions are addressed.

References/Sources/Further materials

3. Demonstration/ Videos on Field Sampling Activity in Ponds/Tanks

The objectives of this activity are to equip learners with practical knowledge and skills for proper water sampling in aquaculture systems such as ponds and tanks. Learners will understand the importance of representative and timely water sampling in monitoring water quality and maintaining healthy fish production systems. The activity highlights

how poor sampling techniques can lead to inaccurate water quality results and ineffective management decisions.

Learners will be introduced to standard field sampling procedures, including selection of sampling points, appropriate sampling depth, and timing of sample collection. Through demonstrations and instructional videos, learners will observe correct methods for collecting water samples without contamination or disturbance of sediments. Emphasis is placed on safe working practices around water bodies, including awareness of slippery surfaces, electrical hazards, and safe handling of sampling equipment.

The activity also aims to improve learners' understanding of how field sampling links to laboratory testing and on-site measurements. By the end of the activity, learners are expected to identify correct sampling methods for different aquaculture systems, explain the purpose of each step in the sampling process, and apply safe and standardized procedures when collecting water samples for quality analysis in fish production.

1. Aim of the activity: To demonstrate correct water sampling procedures in fish ponds and tanks.

2. Duration: 35 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Introduction and Orientation:** The facilitator explains the purpose of water sampling and its role in water quality management for fish production.
- **Video Demonstration Session:** Learners watch short instructional videos showing correct water sampling in ponds and tanks.
- **Explanation of Sampling Points and Depths:** The facilitator discusses where and how deep to collect water samples in different systems.
- **Live Demonstration (Where Possible):** A practical demonstration of water sampling techniques is conducted using ponds or tanks.
- **Safety Emphasis:** Safe behavior around water bodies and correct use of sampling tools are reinforced.
- **Question and Discussion Session:** Learners ask questions and discuss key observations from the demonstrations.

References/Sources/Further materials

4. Data Recording & Entry Session

The objectives of this activity are to equip learners with practical skills in recording, organizing, and entering water quality data for effective fish production management. Learners will understand the importance of accurate and consistent data recording in

monitoring water conditions and making timely management decisions. The activity emphasizes how reliable data supports early detection of water quality problems that can affect fish health, growth, and survival.

Learners will be introduced to standard data recording formats, including field logbooks, data sheets, and simple digital tools such as spreadsheets. They will learn how to record key water quality parameters such as temperature, dissolved oxygen, pH, turbidity, and ammonia, along with sampling dates, times, and locations. Emphasis is placed on clarity, accuracy, and completeness of records to avoid errors and misinterpretation.

The activity also aims to build learners' confidence in entering collected data into digital platforms for storage, analysis, and reporting. Learners will understand basic data organization, labeling, and validation practices. By the end of the activity, learners are expected to accurately record and enter water quality data, maintain organized records, and appreciate the role of data management in supporting sustainable and productive fish farming operations.

1. Aim of the activity: To develop accurate data recording and entry skills for water quality monitoring.

2. Duration: 20 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Introduction and Purpose of Data Recording:** The facilitator explains why accurate data recording is essential in water quality management for fish production.
- **Overview of Recording Tools:** Field logbooks, data sheets, and digital spreadsheets are introduced and explained.
- **Demonstration of Data Recording:** The facilitator demonstrates how to correctly record water quality measurements, including dates and locations.
- **Learner Practice Session:** Learners practice recording sample data from demonstrations or previous sampling activities.
- **Data Entry Demonstration:** The facilitator shows how to enter recorded data into a spreadsheet or simple digital system.
- **Learner Data Entry Practice:** Learners enter sample data and check for accuracy and completeness.
- **Review and Feedback:** The facilitator reviews entries, highlights common mistakes, and provides corrective guidance.

References/Sources/Further materials

5. Data Analysis and Interpretation Workshop

The objectives of this activity are to equip learners with practical skills to analyze and interpret water quality data collected from fish ponds and tanks. Learners will understand how different water quality parameters—such as temperature, dissolved oxygen, pH, turbidity, and ammonia—interact and influence fish health, growth, and survival. The activity emphasizes the importance of data-driven decision-making in preventing stress, disease outbreaks, and production losses in aquaculture systems.

Learners will develop the ability to organize water quality data using simple tables and charts, identify trends and variations, and compare observed values with recommended standards for fish production. The activity aims to build learners' competence in recognizing early warning signs of water quality problems and understanding their possible causes. Emphasis is placed on interpreting data in relation to daily management practices such as feeding, water exchange, aeration, and stocking density.

The workshop also promotes critical thinking and communication skills through group discussions and interpretation exercises. By the end of the activity, learners are expected to confidently analyze water quality data, explain its implications for fish production, and recommend appropriate management actions to maintain optimal water conditions and improve productivity.

1. Aim of the activity: To analyze and interpret water quality data for informed fish management.

2. Duration: 20 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Introduction and Workshop Overview:** The facilitator explains the purpose of the workshop and reviews key water quality parameters.
- **Data Review and Organization:** Learners organize collected water quality data into tables or simple spreadsheets.
- **Data Analysis Exercise:** Learners calculate averages, identify trends, and observe variations in parameters.
- **Interpretation Session:** Learners compare data with recommended water quality ranges for fish production.
- **Problem Identification:** Groups identify potential water quality issues and their possible causes.
- **Management Recommendation Exercise:** Learners propose practical actions such as aeration, water exchange, or feeding adjustments.

- **Group Presentation and Discussion:** Groups present findings and receive feedback from peers and the facilitator.

References/Sources/Further materials

6. Corrective Action Practical Session

The objectives of this activity are to equip learners with practical skills to implement corrective actions when water quality parameters fall outside recommended ranges in fish production systems. Learners will understand how poor water quality affects fish health, behavior, growth, and survival, and how timely interventions can prevent losses. The activity focuses on linking analyzed water quality data to appropriate management responses.

Learners will gain hands-on experience in applying corrective measures such as adjusting aeration, modifying feeding practices, carrying out partial water exchange, and managing waste accumulation. The activity emphasizes selecting corrective actions based on specific water quality problems, including low dissolved oxygen, high ammonia levels, unsuitable pH, or excessive turbidity. Safety and environmental responsibility are highlighted during practical interventions.

The session also aims to strengthen learners' problem-solving and decision-making skills through guided practice and observation. Learners will learn to monitor the effects of corrective actions and understand the importance of follow-up measurements. By the end of the activity, learners are expected to confidently apply suitable corrective measures, evaluate their effectiveness, and maintain optimal water conditions that support healthy and productive fish farming operations.

1. Aim of the activity: To apply corrective actions for improving water quality in fish production.

2. Duration: 20 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Introduction and Review of Water Quality Results:** The facilitator reviews water quality data and identifies parameters outside acceptable ranges.
- **Identification of Problems:** Learners discuss observed water quality issues and their possible causes.
- **Selection of Corrective Actions:** Appropriate corrective measures are selected based on identified problems.
- **Demonstration of Corrective Practices:** The facilitator demonstrates actions such as aeration adjustment or water exchange.

- **Learner Practical Application:** Learners apply corrective actions under supervision.
- **Monitoring and Observation:** Changes in water conditions and fish behavior are observed.
- **Review and Discussion:** Outcomes are discussed, and lessons learned are summarized.

References/Sources/Further materials

7. Case Study & Problem-Based Learning (PBL)

The objectives of this activity are to enable learners to apply theoretical and practical knowledge of water quality management to a real-life aquaculture scenario using a problem-based learning approach. Learners will analyze a case involving an integrated fish–vegetable farm in Ogun State aiming to produce 10 tonnes of tilapia annually using earthen ponds and a small recirculatory system for broodstock. The activity focuses on designing a sustainable water quality management system that minimizes water use while effectively controlling waste.

Learners will develop skills in identifying water quality challenges associated with pond systems and recirculatory aquaculture systems, including waste buildup, oxygen demand, and nutrient management. They will learn to evaluate suitable water quality parameters, monitoring strategies, and corrective measures that support fish health and productivity. The activity also strengthens learners’ ability to integrate sustainability principles such as water reuse, waste recycling, and environmental protection into aquaculture management plans.

Through collaborative group work, learners will enhance problem-solving, critical thinking, and communication skills. By the end of the activity, learners are expected to propose realistic, data-informed water quality management solutions that balance productivity, sustainability, and cost-effectiveness in integrated fish production systems.

1. Aim of the activity: To apply water quality management knowledge to solve real aquaculture problems.

2. Duration: 20 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Presentation of the Case Scenario:** The facilitator presents the Ogun State integrated fish–vegetable farm scenario and clarifies the production goals and constraints.

- **Problem Identification:** Learners identify key water quality challenges related to earthen ponds, recirculatory systems, and waste management.
- **Group Analysis and Planning:** Learners work in groups to design a water quality management plan addressing monitoring, waste control, and water conservation.
- **Development of Proposed Solutions:** Groups propose practical strategies such as water reuse, filtration, aeration, and integration with vegetable production.
- **Presentation of Group Solutions:** Each group presents its proposed water quality management system and justifies decisions.
- **Facilitator Review and Feedback:** The facilitator provides feedback, highlights best practices, and links solutions to course concepts.
- **Reflection and Key Lessons:** Learners reflect on lessons learned and the application of water quality management principles.

References/Sources/Further materials

8. Presentation and Reflection Session

The objectives of this activity are to provide learners with an opportunity to consolidate their understanding of water quality management for fish production, demonstrate their learning, and reflect on practical experiences gained during the course. Learners will enhance their ability to communicate findings, justify management decisions, and link theoretical knowledge to real-world aquaculture scenarios. The activity emphasizes critical reflection, self-assessment, and collaborative learning.

Learners will present results from practical exercises, including water sampling, testing, data analysis, corrective action implementation, and case study problem-solving. They will articulate key observations, challenges encountered, solutions applied, and outcomes achieved, demonstrating their understanding of water quality parameters, monitoring techniques, and management strategies. The activity also encourages learners to evaluate their own performance, identify knowledge gaps, and suggest areas for improvement.

Through group discussions and facilitator feedback, learners will reflect on the relevance of sustainable water quality practices, problem-solving approaches, and decision-making processes in fish production. By the end of the session, learners are expected to confidently present practical and analytical findings, critically reflect on lessons learned, and integrate acquired knowledge into future aquaculture management strategies.

1. Aim of the activity: To review learning outcomes and reflect on water quality management practices.

2. Duration: 20 min

3. Step-by-step instruction of the task/practical exercise/case study:

- **Introduction and Purpose:** The facilitator explains the session's objectives, emphasizing presentation and reflective learning.
- **Group Presentations:** Learners present findings from practical exercises, case studies, and data analysis.
- **Peer Discussion and Feedback:** Groups discuss each other's presentations, ask questions, and provide constructive feedback.
- **Facilitator Feedback:** The facilitator highlights strengths, addresses gaps, and reinforces key water quality management concepts.
- **Individual Reflection Exercise:** Learners reflect on personal learning, challenges faced, and strategies for improvement.
- **Summary of Key Lessons:** The facilitator summarizes lessons learned and links them to practical fish production management.

References/Sources/Further materials