

**PHYSICOCHEMICAL ASSESSMENT OF WATER SAMPLES FROM THE
BOTTOM OF AQUACULTURE TANKS AT THE TETFUND CENTRE OF
AQUACULTURE AND FOOD TECHNOLOGY, UNIVERSITY OF BENIN, BENIN
CITY, EDO STATE.**

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DEPARTEMENT OF ANIMAL AND ENVIRONMENTAL BIOLOGY

FACULTY OF LIFE SCIENCES

UNIVERSITY OF BENIN

October, 2025.

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**A PROJECT WORK SUBMITTED TO THE DEPARTMENT OF ANIMAL AND
ENVIRONMENTAL BIOLOGY, FACULTY OF LIFE SCIENCES, UNIVERSITY OF
BENIN, BENIN CITY IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR
THE AWARD OF BACHELOR OF SCIENCE IN ANIMAL AND ENVIRONMENTAL
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October, 2025.

CERTIFICATION

This is to certify that this project was carried out by IZUNYON OFURE BETHEL of the Department of Animal and Environmental Biology, Faculty of Life Sciences, University of Benin, Benin City.

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PROF. MRS. I. TONGO

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DATE

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DR. K. EGUN

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DATE

DEDICATION

This work is dedicated to God almighty.

ACKNOWLEDGEMENT

First, I would love to thank God for his love and mercies towards me. For granting me the strength to go about with my education journey. I would also exceed my appreciation to my parents for their love, care, and financial support so far and to my lovely sibling for their constant love and words of encouragement. To my supervisor, thank you sir for your patience and wisdom in seeing that i do well during my project endeavours. May God bless you all.

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ABSTRACT

This study assessed the physicochemical properties of water collected from the bottom of aquaculture tanks at the TETFund Centre for Aquaculture and Food Technology, University of Benin. The objective was to evaluate the suitability of the water for aquaculture and identify parameters that could affect fish growth and survival. Water samples were collected from Tank 5 and Tank 6 and analysed for twenty key physicochemical parameters, including pH, electrical conductivity, total dissolved solids, turbidity, suspended solids, dissolved oxygen (DO), biochemical oxygen demand (BOD), hardness, chloride, alkalinity, phosphate, nitrate, ammonium, calcium, magnesium, and selected heavy metals (iron, lead, zinc, chromium, and cadmium). The results were compared with Federal Ministry of Environment (FMEnv) permissible limits for aquaculture water quality. Findings revealed that parameters such as pH, electrical conductivity, hardness, chloride, phosphate, and nitrate were within acceptable limits, indicating general water suitability for aquaculture. However, DO, BOD, turbidity, ammonium, iron, and lead exceeded permissible thresholds, suggesting organic pollution, oxygen depletion, and possible metal contamination. These deviations are likely caused by inadequate aeration, accumulation of feed residues, and sediment deposition at the tank bottom. The study concludes that although the tanks provide a controlled environment conducive to fish culture, poor water circulation and organic waste buildup pose challenges to optimal production. It recommends regular water renewal, installation of aeration systems, and continuous monitoring of physicochemical parameters to maintain sustainable and productive aquaculture operations.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Aquaculture, the cultivation of aquatic organisms such as fish, crustaceans, and mollusks under controlled conditions, has become one of the most rapidly expanding sectors of global food production. It provides a reliable source of animal protein for an ever-growing human population while reducing pressure on wild fish stocks that are increasingly threatened by overfishing, habitat destruction, and pollution (FAO, 2020). Fish farming in particular contributes significantly to food security, employment, and income generation in many developing countries, including Nigeria (Omitoyin, 2007). With the global demand for fish projected to increase continuously, the expansion of aquaculture has become indispensable for meeting both nutritional and economic needs.

Fish culture systems are broadly classified into extensive, semi-intensive, and intensive systems, depending on the level of management and control (Ekelemu and Oboh, 2018). In intensive systems, tanks either concrete, plastic, or fiberglass are commonly used because they offer the advantage of easy monitoring and regulation of environmental conditions such as temperature, pH, and dissolved oxygen. Among these, plastic tanks have gained popularity due to their durability, cost-effectiveness, and ease of maintenance. These tanks can be installed in both indoor and outdoor facilities, making them suitable for small- and large-scale aquaculture operations (Gabriel *et al.*, 2007). However, the success of such systems depends largely on the quality of water, which serves as the life-supporting medium for fish and other aquatic organisms.

Water quality is a critical factor influencing fish growth, health, and survival. The physical and chemical properties of water collectively referred to as physicochemical parameters determine its suitability for aquatic life (Boyd, 2017). Parameters such as temperature, pH, turbidity, dissolved oxygen, electrical conductivity, and nutrient concentrations (nitrates, phosphates, and ammonia) directly affect physiological processes including respiration, osmoregulation, feeding, and reproduction (Akinrotimi *et al.*, 2011). For instance, the dissolved oxygen level in water influences metabolic activity and determines the rate of feed utilization, while pH affects enzyme activity and the toxicity of certain compounds such as ammonia. Even slight deviations from the optimal ranges can cause stress, reduced growth rates, or increased mortality among cultured fish (Effiong *et al.*, 2019).

The bottom of aquaculture tanks often accumulates uneaten feed, fish waste, and organic debris over time. As these materials decompose, they may release harmful gases such as ammonia and hydrogen sulfide, thereby altering the water chemistry (Ali *et al.*, 2016). This can create localized zones of poor water quality, particularly near the substrate, where oxygen levels may drop and toxic compounds build up. Continuous monitoring of water at the bottom of tanks is therefore crucial, as the deterioration of physicochemical conditions at this level can have a cascading effect on the entire aquatic system. Regular assessment ensures that potential imbalances are detected early enough to prevent stress or disease outbreaks in the cultured stock (Ugwumba and Adebayo, 2017).

At the TETFund Centre of Aquaculture and Food Technology, located within the University of Benin, aquaculture research is aimed at enhancing fish production through improved environmental management and sustainable techniques. The centre provides a well-controlled environment where fish are reared in tanks under varying conditions for experimental and production purposes. Despite the controlled setting, factors such as temperature fluctuation, feed residue accumulation, and microbial activity can still influence water quality. Conducting a physicochemical assessment of water samples collected from the bottom of these tanks will help to determine the extent of organic buildup and its possible effects on fish health and productivity.

Furthermore, physicochemical assessment plays a dual role: it not only serves as an indicator of current water quality status but also provides baseline data for future comparisons. Such information is vital for improving management strategies such as aeration, feeding frequency, and waste removal (Boyd, 2017; Ekelemu and Oboh, 2018). A well-maintained aquatic environment promotes optimal growth performance, reduces the risk of disease, and ensures economic efficiency in aquaculture operations. Therefore, understanding the dynamics of water qualities particularly at the bottom layer where sedimentation and decomposition are most active is essential for developing sustainable aquaculture systems.

This study is particularly relevant in modern aquaculture research because many fish farmers tend to monitor only surface or mid-level water quality while neglecting the bottom strata where deteriorating conditions often begin. Assessing the physicochemical properties from the tank bottom provides a more comprehensive understanding of the aquatic environment, guiding effective water management and enhancing overall production outcomes.

1.2 Aim of the Study

The aim of this study is to conduct a detailed physicochemical analysis of water samples collected from the bottom of aquaculture tanks at the TETFund Centre of Aquaculture and Food Technology, with the purpose of evaluating their suitability for sustaining fish culture and maintaining healthy aquatic conditions.

1.3 Objectives of the Study

The specific objectives of this study are to:

1. Determine key physicochemical parameters of water samples collected from the bottom of aquaculture tanks, including temperature, pH, dissolved oxygen, turbidity, and electrical conductivity.
2. Compare the observed parameters with established standard limits for aquaculture water quality.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The quality of water has continued to be among the most vital determinants of the level of productivity and sustainability of aquaculture systems. The physicochemical properties of a rearing medium have a direct impact on the health, growth rate, and overall performance of cultured fish; thus, water management remains a major concern of a successful aquaculture activity (Boyd, 2017). In the TETFund Centre of Aquaculture and Food Technology, aquaculture in tanks offers a controlled environment, which promotes efficient fish rearing, but it is important to keep water in good condition in order to ensure the survival of species in a culture.

Physicochemical indicators like temperature, pH, turbidity, and dissolved oxygen (DO), electrical conductivity, and nutrient levels are used to define the quality of water and its stability (Gabriel *et al.*, 2007). All these parameters are involved in determining the suitability of a given aquatic environment to support aquatic life. Akinrotimi *et al.* (2011) state that the exposure to non acceptability of the ranges may lead to disruption in metabolic and physiological functions, stress, retarded growth, or mass mortality of fish. Thus, to maintain high-yield aquaculture systems, it is necessary to monitor and manage these parameters on a regular basis.

The value of clean and balanced water has been stressed in a number of studies. Ugwumba and Adebayo (2017) indicated that the accumulation of organic wastes and leftover feed in tanks may stimulate the occurrence of oxygen depletion and emission of harmful gases, thus compromising the quality of water. On the same note, Effiong *et al.* (2019) reported that poor management of pH and temperature may modify the solubility of toxic substances like ammonia, thus elevating their toxicity levels on aquatic organisms. The findings highlight the sensitive nature of the balance to be maintained in the water quality particularly when using closed systems like tanks as the environmental fluctuations are more severe in these systems than in natural water bodies.

Water degradation and pollution are also a major issue in the Nigerian context. Industrial effluents, farm runoffs, and household wastes usually enter the water sources utilized in aquaculture to the detriment of the environment and the health of the population (Adeyemo *et*

al., 2018). Unclean water also decreases the number of fish produced, as well as the market price of aquaculture products and can expose consumers to waterborne illnesses and hazardous elements (Ezenne *et al.*, 2021). Therefore, in-depth knowledge of physicochemical characteristics of the water is essential in enhancing fish health and productivity in addition to the economic sustainability of aquaculture activities.

Monitoring of water quality at the various depths, especially the bottom of the tanks where sediments and wastes settle are very insightful to the dynamics of the rearing environment. It is important to discuss that the bottom tank layer may have even more pollutants and less oxygen, and hence, as Ali *et al.* (2016) note, it is always essential to study these areas and identify the worsening of conditions at the early stages. With the assessment of these parameters, the aqua culturists are able to take corrective measures, including aeration, water exchange, and waste removal in order to sustain a stable freshwater ecosystem.

This chapter thus examines the most important physicochemical parameters that characterize the water quality, how these parameters affect performance of aquaculture and past researches conducted to find out the relationship between water chemistry and fish productivity. It also analyses management plans that are used in ensuring the best conditions in tank-based systems. The review utilizes diverse academic materials in giving an in-depth insight into the role of physicochemical measurements in the practice of sustainable aquaculture.

2.2 Water Quality in Aquaculture.

The quality of water is among the most crucial factors of success in aquaculture systems, as it affects the health of fish, its growth, feed consumption, and mortality (Boyd and Tucker, 2012). Temperature, pH, dissolved oxygen (DO), total dissolved solids (TDS), turbidity, ammonia concentration, and all other physicochemical parameters are maintained in the correct environment to maintain optimum conditions in the species being cultured (Ebeling *et al.*, 2006). These parameters tend to vary due to environmental conditions, management processes, and biological processes occurring in the tanks, and it is necessary to monitor these parameters on a regular basis to ensure sustainability in the aquaculture operation (Adebayo and Ogunleye, 2018).

The holding period as commonly known is one of the key determinants of the water quality in tank-based aquaculture. Prolonged water retention without the correct exchange process causes a decline in dissolved oxygen levels because of the increase in fish respiration, microbial activity, and waste (Hargreaves and Tucker, 2018). Proper circulation and continuous aeration

systems are essential therefore to keep the appropriate level of DO and to avoid hypoxic situations which may endanger the survival of fish. Research has revealed that an effective aeration can not only balance oxygen but also improves the feed policies and reduce the stresses on the fish populations within the intensive rearing systems (Politeklik, 2023).

Another important variable in aquaculture is the temperature which has a direct influence on the metabolic rates, feed activity and the ability of oxygen to dissolve in water (Boyd and Tucker, 1998). Even a small modification of the ambient temperature in controlled tank systems may change the water chemistry and biological equilibrium. Increase in water temperature reduces oxygen solubility resulting in low DO availability and high metabolic demand (Udechukwu and Nwachukwu, 2017). Best temperature control, be it by shading, restricted water inflow or circulation is thus required in order to maintain optimum physiological conditions in the fish.

Chemical properties of water especially that of ammonia, nitrite as well as nitrate are major factors that can be used in establishing the water quality. The ammonia, which is mainly produced during fish excretion and the decay of the uneaten feed can build up quickly in an environment where it is not managed (Ebeling *et al.*, 2006). Water exchange may be limited or the filtration units fail in closed systems, resulting in numerous ammonia accumulation and consequently nitrite then nitrate (Adeniyi and Adeyemi, 2017). High ammonia concentration is harmful to fish and may lead to, damage of gills, low growth, and death (Okafor and Eze, 2016). Frequent water replenishment and bio-filtration are thus, essential parts of effective management of water (Chukwuma and Eze, 2018).

Aquaculture tanks also vary in water parameters based on seasonal and environmental variations. Evaporation rates are more active during dry seasons or when the temperature is high in oceans, which causes an increase of dissolved substances, low amount of DO and variable values of pH (Ghosh *et al.*, 2021). On the other hand, the rainy season can cause the effect of dilution that could lead to a lower level of salinity and nutrient levels but can also cause pollution through runoffs (Balogun and Adebajo, 2015). Such seasonal processes demand consistent monitoring and dynamic management to ensure that water is kept within reasonable ranges that can be used in aquaculture (Akinwumi and Musa, 2014).

The presence of high biochemical oxygen demand (BOD) is also another indicator of the accumulation of the organic matter and the existence of microorganisms and bacteria in aquaculture systems. Feed wastes, fish wastes and detritus increase in the waters as organisms

decay them, leading to oxygen depletion (Rahman *et al.*, 2013). Uncontrolled high BOD may cause stressful and anaerobic conditions in tanks. Good water quality should be maintained and suffered adverse effects of organic overloading mitigated by effective feeding methods, regular removal of sediments, and efficient aeration, thus suggested (Adeyemi and Adewale, 2016).

Turbidity and transparency, besides these parameters, offer visual measurements of the state of the water. Light penetration can be minimized by an increase in turbidity due to suspended particles and algal blooms, which inhibit photosynthesis in aquatic plants (Hargreaves and Tucker, 2018). It is also capable of disrupting fish respiration and feeding. To keep the aquatic environment in balance, it is always beneficial to maintain moderate levels of turbidity with the assistance of frequent water changes, filtration, and sedimentation (Bello and Ajayi, 2015).

Lastly, good water quality in aquaculture tanks is still based on proper management practice. The accumulation of harmful compounds can be stopped by frequent temperature, pH, and DO tests and regular cleaning of tanks, as well as timely waste products removal (Folarin and Olawale, 2014). The use of mechanical aeration, biological filtration, and partial water exchange with frequent intervals has been observed to enhance rates of fish growth and minimization or elimination of mortality (Ndukwe and Uche, 2017). A properly regulated aquaculture system where the physicochemical parameters are stable would guarantee sustainable production, maximum growth performance and minimized environmental stress on aquatic organisms (Wedemeyer, 1996).

2.3 Aquaculture in Plastic Tanks

Plastic tanks have gained popularity as an option of fish farms in most of the small and medium-scale fish farms because of its low cost, longevity, and management. These are tanks that are typically made of high-density polyethylene (HDPE) materials and bring in a more controlled environment when it comes to maintaining the desired physicochemical conditions due to their capacity which can be as little as 2,000 litres or as much as 5,000 litres (Olawale and Folarin, 2019). The benefits of plastic tanks include ease of cleaning, mobility and increase in the control of feeding and stocking density. Performance is, however, highly reliant on the source of water, their retention time, aeration, colour, and general management practices (Adeyemi and Adewale, 2016).

Retention time of water is very important in physicochemical equilibrium in aquaculture tanks. Adeniyi and Adeyemi (2017) explain that the longer the water is not replenished, the worse its quality is; this is due to the decrease in dissolved oxygen (DO) and ammonia as well as the rise

of biochemical oxygen demand (BOD). Odewale (2014) also indicated that the extended retention times increase the turbidity and nitrate concentration, especially in tank that are densely stocked. The restricted amount of water also hastens the accumulation of wastes due to feed and excreta that were not consumed as noted by Ajayi (2004), and increases the total dissolved solids (TDS) and organic load. To curb this, regular partial water replacement is still a necessary action on ensuring that conditions are favourable.

Plastic tanks have a physical shape that has a great impact on water temperature and light absorption of intensity such as the material type, texture, and coloration of the tanks. Research conducted by Chukwu and Okoro (2017) indicated that black and dark-green tanks are more likely to absorb heat, raising the water temperature as compared to the light-coloured ones. On the same note, Akinwumi and Musa (2014) established that high-water temperature lowers the DO solubility but increases the fish metabolic rates, which increase faster wastes. All these thermal differences also emphasize the importance of appropriate shading and ventilation, especially in the open tank systems that are subjected to direct sunlight (Roberts and White, 2018).

Quality and water source are the centre of successful aquaculture in plastic tanks. The commonly used water is borehole water because it is stable, has low microbial load, and neutral pH (Ihekweazu and Okorie, 2018). Nevertheless, when storing water over long periods in plastic tanks it is possible that water temperature may rise by up to 1.5degC and decrease the oxygen content (Udechukwu and Nwachukwu, 2017). Moreover, seasonal changes particularly in hot and dry seasons are also increasing the levels of ammonia and nitrate sometimes by up to 50 percent (Balogun and Adebajo, 2015). Thus, the control of retention time and temperature control is also very essential to reduce stress and preserve the health of fish.

Prolonged retention of waters has also been attributed to a decrease in pH and a rise in toxic metabolites. Chinedu and Emeka (2015) noted that pH decreased gradually with retention time more than 18 hours, and Akinwumi and Musa (2014) found that the increase in ammonia concentration was 0.05 mg/L after the same type of retention. Similarly, Nwachukwu and Eze (2016) observed that the temperature of stagnant tanks could increase more than 1degC within 24 hours and result in a decrease in the level of DO and an increase in metabolic stress. In order to avoid such negative implications, Adeogun and Fashola (2015) and Bello and Ajayi (2015) have stressed the importance of frequent water renewal, proper aeration, and sufficient filtration.

Plastic tanks can never have their water conditions maintained without aeration and water movement. Politekik (2023) showed that mechanical aerators, including diffusers and paddle wheels, promote the circulation of oxygen in the water and inhibit the stratification of water. Poor aeration or long periods of stagnation, however, favour the growth of ammonia and sediments (Chukwuma and Eze, 2018). Uche and Onyekachi (2016) proposed that aeration plus intermittent water exchange is more effective to enhance clarity and efficiency of oxygenation, which guarantee a healthier aquatic environment.

In recirculating aquaculture systems (RAS), globally water management has been established as a pinnacle of proper and sustainable tank system settings. As noted by Johnson (2009) and Wedemeyer (1996), RAS technologies are based on the general principle of constant water quality control, mechanical filtration, and biological treatment in order to maintain the fish productivity. These conclusions support the concepts that can be applied to local plastic tank systems, in which the efficiency of management is the key to the overall success. Plastic tanks are a cost-effective and versatile system that can be applied in fish farming, but their effectiveness is only sustainable over time when they are operated in accordance with the best management practices that address the requirements of frequent water exchange, sufficient aeration, mechanical mixing, and temperature regulation (Folarin and Olawale, 2014). When these methods are properly applied, they are good in maintaining good physicochemical conditions, lowering mortality, and improving the growth performance of fish in tank-based aquaculture.

2.4 Impact of Physicochemical Parametric factors on fish health and productivity.

The performance of aquaculture activities mainly relies on the preservation of appropriate physicochemical conditions of the rearing environment. The parameters that affect fish health, growth performance, and overall productivity directly include variations in the parameters like temperature, dissolved oxygen (DO), pH, ammonia concentration, turbidity and total dissolved solids (TDS). Boyd and Tucker (2012) state that despite the fact that small deviations in the range of optimal parameters can cause physiological stress, decreased feeding efficiency, and exposure to diseases. Poorly managed water or water that becomes poor in quality interferes with the metabolic and osmoregulatory processes of fish leading to a stunted growth and increased rates of mortality (Akinwumi and Musa, 2014).

Temperature is an important element in controlling the metabolism, growth rate, and the feeds used up by fish. *Clarias gariepinus* is among the most cultivated species of fresh water fish in

Nigeria that flourishes well in the temperature range of 25degC to 30degC. Any temperature that is below this or exceeding this may hamper enzyme functioning and the use of oxygen (Erondu and Chindah, 1991). High temperature increases ammonia toxicity and decreases the solubility of DO whereas low temperatures slow up digestion and decreases appetite. In particular, dissolved oxygen is an essential factor of fish survival and growth. Adeyemo *et al.* (2018) found that concentrations of below 4.0mg/L were associated with respiratory distress, whereas the optimal growth and reproduction occurred at concentrations of above 6.0mg/L. An extended exposure to low DO may cause hypoxia, causing irregular swimming patterns, surface gasping and death.

Another important parameter that determines the physiology of fish and nutrient availability is pH. The pH of 6.5 to 8.0 is considered normal in fish, whereas a sudden shift out of the same may impair the gill membranes, ion exchange, and amplify the toxicity of ammonia (Chukwu and Okoro, 2017). Toxic metals are more soluble in acidic conditions, whilst in an alkaline condition the ammonium ions (NH_4^+) are transformed to more toxic unionized ammonia (NH_3). Equally, the build up of ammonia and nitrite, frequently due to degradation of organic matter and ineffective water exchange, has been cited to be one of the leading causes of stress in fish and fish death. Ebeling *et al.* (2006) also found out that oxygen delivery to the blood is seriously impaired by the concentrations of ammonia greater than 1.0 mg/L, which damages gill structures.

Other indicators like the turbidity and the total dissolved solids (TDS) also affect fish performance. Thick turbidity limits the light penetration, and hence decreases the photosynthesis of oxygen and blocks the fish gills. The high level of TDS shows the high presence of minerals or organic load that may cause disruption of the osmoregulation and physiological stress (Rahman *et al.*, 2013). Balogun and Adebajo (2015) assert that fish cultured in the water containing high turbidity and TSS grow slower and have a low ratio of feed to ratio of growth than those cultured in clear and well-aerated water.

A balance of the physicochemical parameters is then necessary to make the most out of the aquaculture. Measures like frequent water replacement, proper aeration, application of bio filters, and routine feeding systems play a critical role in the maintenance of environmental balance. Uche and Onyekachi (2016) noted that the constant monitoring of the water quality is important to detect early deviations and implement changes in time. Properly controlled, quality water will be directly related to better fish health, growth rate, and yield, thereby raising

the economic potential of the aquaculture system in plants such as the TETFund Centre of Aquaculture and Food Technology.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Description of Study Area

The study took place at the TETFund Centre of Aquaculture and Food technology, which is within the University of Benin, Ugbowo Campus, Benin City, Edo state, Nigeria. The Centre lies approximately on Latitude 6°24'18.68" N and Longitude 5°37'31.16" E. It is a research and training centre specifically focused on food production and aquaculture. The centre has a number of plastic tanks, where the quality of water and feed trials are done. The conditions created in the environment are appropriate to investigate the connection between fish development and water quality parameters in controlled conditions.

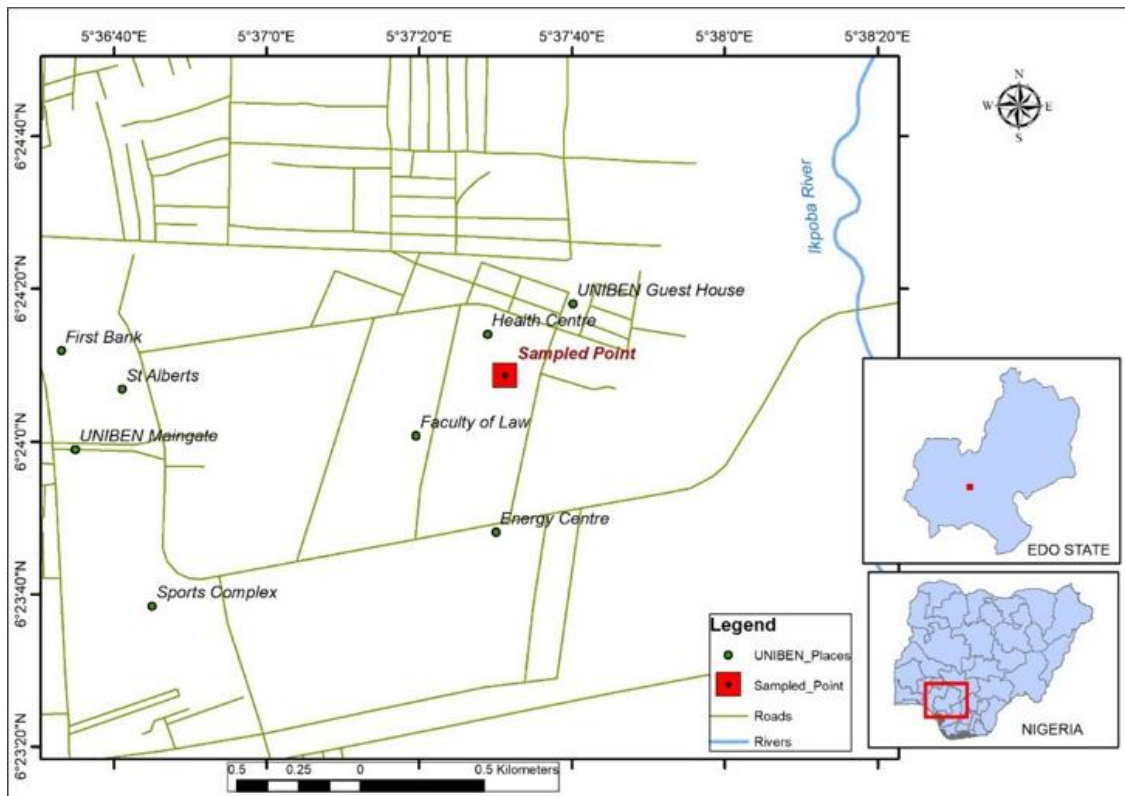


Fig 3.1: Map showing sample location

3.2 Climate Condition in the Study Area

The area of study is in the humid tropical region of southern Nigeria with a tropical equatorial climate with two definite seasons; rainy season (April to October) and dry season (November to March). The rainfall in the region is between 2,300 mm and 2,500 mm and the mean annual temperature is between 25°C and 38°C.

In the early mornings and evenings, the temperature may go as low as 21°C–28°C, and during the day, it may go as high as 35°C–38°C. Humidity is favourable and there is a constant supply of raw precipitation which favours the process of aquaculture although the temperatures of the dry season may cause a decrease of dissolved oxygen in the waters. These climatic conditions have a direct impact on the water quality parameters in aquaculture system.

3.3 Sampling Collection

A one-month period of water sampling was done at the TETFund Centre of Aquaculture and Food Technology. Two aquaculture tanks were sampled Tank 5 (5UP and 5DOWN) and Tank 6 (6UP and 6DOWN), which were the surface and bottom sampling points respectively. The collections were made in clean 80 cl plastic bottles. Prior to sampling, each bottle was rinsed twice with water from the sample tank to ensure uniformity between the sample and container.

The obtained samples were corked immediately, labelled by the tank number and the depth of sampling and was transferred to the Benin-Owena River Basin Laboratory where they were analysed for physicochemical parameters including pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), total dissolved solids (TDS), and ammonia levels. Each of the analyses was run in accordance with standard APHA (2017) protocols to make the results reliable and accurate.

3.4 Determination of Physicochemical Parameters

Physicochemical parameters testing is vital in determining the quality and applicability of water in aquaculture systems. The parameters affect the survival, growth and reproduction of cultured fish species. The analyses were performed according to the general standards stipulated by the American Public Health Association (APHA, 2017), based on the procedures presented by Boyd (2015) and Eze and Chima (2020). Laboratory determination of all the determinations was done at the Benin-Owena River Basin Laboratory under controlled conditions.

pH

Digital pH meter was used to determine the pH of the water samples calibrated with a digital pH meter. Before the meter could be used, buffer solutions of pH 4.0, 7.0, and 10.0 were used to standardize the meter. The electrode was dipped into the sample until stabilization was achieved and pH is an important parameter that is used to determine the quality of water, which affects the chemical solubility and biological activity of the fish culture system. The optimal pH level in the majority of freshwater fish species is neutral to slightly alkaline (6.5-8.5) (Boyd, 2015; Eze and Chima, 2020).

Electrical Conductivity (EC)

Conductivity was observed in electrical conductivity meter, and the values were given in microsiemens per centimeter (uS/cm). The parameter is the concentration of the dissolved ionic substances like calcium, sodium, potassium, and chloride in the water. Higher values of conductivity indicate greater ionic concentrations that can affect osmoregulatory processes in fish (APHA, 2017; Nwankwo and Akpan, 2021).

Total Dissolved Solids (TDS)

A TDS meter was used in the determination of TDS. It is the sum of the concentration of organic and inorganic matter at any point that has been dissolved in water. When TDS is too high (more than 1000 mg/L), it may disrupt the osmotic balance and impair the growth performance of such a fish species as *Clarias gariepinus* (Boyd, 2015; Effiong and Mohammed, 2018).

Turbidity

The turbidity was also determined by the use of a turbidimeter, and the values were expressed in Nephelometric Turbidity Units (NTU). It measures the extent of scattering of light by suspended particles like the plankton, silt and organic matter. When the turbidity is high (>25 NTU), it may decrease the level of penetration, prevent photosynthesis, and reduce the dissolved oxygen amount in aquaculture systems (Eze and Chima, 2020).

Suspended Solids (SS)

The suspension solids were found gravimetrically by filtering the known amount of water using a pre-weighed filter paper and then drying it at temperatures of 103–105°C to a constant mass. SS concentration was calculated based on the difference between the final and initial weights.

A high suspended solid means that the filtration is low or that it is over-fed, and this may block fish gills and decrease oxygen absorption (Effiong and Mohammed, 2018; APHA, 2017).

Dissolved Oxygen (DO)

The Winkler titrimetric method was used to determine the DO concentration. Respiration, metabolism and decomposition require sufficient oxygen in the aquaculture systems. Stress, low feed ratio, and fish death may occur due to low levels of DO (<4 mg/L) (Boyd, 2015; Ogbeibu and Ogiesoba-Eguakun, 2019).

Biochemical Oxygen Demand (BOD)

The BOD was established by incubating water samples at 20°C in the dark and observing the change in the concentration of the DO at the end of the incubation period. BOD is an approximation of the degradation of organic matter by microorganisms. The organic pollution is indicated by a high level of BOD (>10 mg/L) and may involve exhausting oxygen and inhibiting the respiration of fish (APHA, 2017; Nwankwo and Akpan, 2021).

Hardness

Titrimetric method was used to identify water hardness using EDTA. It is the summation of the concentration of divalent cations, mainly; calcium (Ca^{2+}) and magnesium (Mg^{2+}). The medium level of hardness of the water (50-150 mg/L as CaCO_3) is considered favourable in fish growth because it maintains the pH and promotes the creation of bones (Boyd, 2015; Effiong and Mohammed, 2018).

Chloride (Cl⁻)

Mohr titration method was used to analyse chloride, where silver nitrate (AgNO_3) was used as the titrant and potassium chromate as an indicator. Chloride is also a key electrolyte in the osmoregulation and acid-base homeostasis of fish. Nevertheless, high levels can be caused by domestic or agricultural discharge (APHA, 2017; Eze and Chima, 2020).

Alkalinity

The alkalinity was identified through the use of phenolphthalein and methyl orange indicators, whose titration against standard sulfuric acid (H_2SO_4) was used. It is the buffering ability of water to withstand pH variations. Aquaculture systems have an ideal alkalinity of between 50-200 mg/L in the form of CaCO_3 (Boyd, 2015; Nwankwo and Akpan, 2021).

Phosphate (PO_4^{3-})

A spectrophotometer was used to measure phosphate at a wavelength of 660 nm through the ascorbic acid colorimetric technique. Phosphates are necessary nutrients that may lead to algal growth and dissolution of oxygen at excessive levels (>5 mg/L). Feed residues and fertilizers runoff are their primary sources (APHA, 2017; Effiong and Mohammed, 2018).

Nitrate (NO_3^-)

The phenoldisulfonic acid method was used to determine nitrate and measured spectrophotometrically. It is the oxidized state of nitrogen and is usually produced by the decomposition of organic matter or as a result of leaching of fertilizers. A level of nitrate above 50 mg/L may lead to toxicity and contribute to the growth of algae (Eze and Chima, 2020; Nwankwo and Akpan, 2021).

Ammonium (NH_4^+)

The concentration of the ammonium was determined by employing Nesslerization method, in which colour intensity parallels concentration of ammonia. High ammonium (>1 mg/L) is lethal to fish, particularly in high pH circumstances, because it alters the balance to unionized ammonia (NH_3), which harms gill tissues (Boyd, 2015; APHA, 2017).

Calcium (Ca^{2+}) and Magnesium (Mg^{2+})

The analysis of calcium and magnesium was complexometric titration through EDTA. The two ions play a crucial role in the development of bones and scales, activation of enzymes, and osmoregulation in fish. Low levels will cause stress and poor development, whereas the high levels will also play a role in the hazard of an unbalanced hardness (Boyd, 2015; Eze and Chima, 2020).

Iron (Fe)

Colorimetric analysis of iron was done using 1, 10 phenanthroline reagent. Although some minor amounts of iron are desirable, high levels (>0.3 mg/L) may result in discolouration of water, gills blockage, and lack of oxygen solubility (APHA, 2017; Effiong and Mohammed, 2018).

Lead (Pb), Zinc (Zn), Chromium (Cr) and Cadmium (Cd).

The levels of heavy metals were ascertained by the help of an Atomic Absorption Spectrophotometer (AAS). These metals, despite its trace quantities, are very toxicological to aquatic life, as they accumulate in tissues and interfere with the functions of the enzymes. Most frequently, they may be a result of industrial effluents, corroded pipes, or agricultural runoff (Boyd, 2015; Nwankwo and Akpan, 2021).

3.5 Data Analysis

The physicochemical characteristics of the water were analysed through descriptive statistical procedures. Python 3.7 and the Microsoft Excel were used in the data processing.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter provides the findings of the physicochemical analysis of water samples taken from tank 5 and tank 6 at TETFund Centre of Aquaculture and Food Technology University of Benin Ugbowo Campus. The analyses were made to establish the major parameters of physicochemical parameters needed to determine quality of water used in fish culture.

The findings are in the form of Mean \pm Standard Deviation (SD) and the lowest and highest (Min-Max) values of each of the parameters. The findings are compared to the Borehole Reference (BH) values and Federal Ministry of Environment (FMEnv) allowable limits of aquaculture water quality. These comparisons give a clear indication of any parameters of water quality which may be acceptable to support the growth of fish and overall aquaculture practices.

4.2 Physio-Chemical Parameters of Water Samples

Table 4.1 and 4.2 respectively show the results of the analysed Tank 5 and 6 water samples. The parameters that were measured are pH, electrical conductivity, total dissolved solids, turbidity, suspended solids, dissolved oxygen, biochemical oxygen demand, hardness, chloride, alkalinity, phosphate, nitrate, ammonium, calcium, magnesium, iron, lead, zinc, chromium, and cadmium. All these parameters are very important when it comes to estimating the overall appropriateness of aquaculture water. There was also an observation of differences between the top and bottom layers of water, which was due to the effect of organic matter, aeration and sedimentation at the base of the tanks.

Table 4.1: Physicochemical Characteristics of Water Sample from Tank 5

Parameter	Unit	Mean ± SD	Min–Max	Borehole (BH)	FMEnv Limit
pH	-	5.9 ± 0.28	5.7–6.1	5.3	6.0–9.0
Electrical Conductivity	μS/cm	108 ± 22.63	92–124	32	250–500
Total Dissolved Solids	mg/L	54 ± 11.31	46–62	16	500
Turbidity	NTU	63 ± 9.90	56–70	1.0	25
Suspended Solids	mg/L	55 ± 31.11	33–77	0.0	30
Dissolved Oxygen	mg/L	0.5 ± 0.17	0.0–0.1	3.9	5.0–8.0
BOD	mg/L	46.98 ± 0.82	46.4–47.6	0.7	≤10
Hardness	mg/L	32 ± 2.83	30–34	30	150
Chloride	mg/L	28.24 ± 9.98	21.18–35.3	14.12	250
Alkalinity	mg/L	127 ± 74.25	74–180	20	200
Phosphate	mg/L	4.23 ± 1.17	3.40–5.06	0.013	5.0
Nitrate	mg/L	1.21 ± 0.06	1.17–1.25	0.610	50
Ammonium	mg/L	7.38 ± 1.34	6.42–8.32	0.854	0.5
Calcium	mg/L	10.02 ± 0.57	9.62–10.42	5.611	75
Magnesium	mg/L	1.70 ± 1.10	0.97–2.43	5.35	50
Iron	mg/L	0.386 ± 0.001	0.385–0.387	0.275	0.3
Lead	mg/L	0.016 ± 0.010	0.009–0.023	0.0	0.01

Zinc	mg/L	0.279 ± 0.022	0.263–0.294	0.07	5.0
Chromium	mg/L	0.045 ± 0.014	0.035–0.055	0.014	0.05
Cadmium	mg/L	0.00 ± 0.00	0.00–0.00	0.00	0.003

Table 4.2: Physicochemical Characteristics of Water Sample from Tank 6

Parameter	Unit	Mean ± SD	Min–Max	Borehole (BH)	FMEnv Limit
pH	-	6.1 ± 0.00	6.1–6.1	5.3	6.0–9.0
Electrical Conductivity	μS/cm	108 ± 2.83	106–110	32	250–500
Total Dissolved Solids	mg/L	54 ± 1.41	53–55	16	500
Turbidity	NTU	76.5 ± 3.54	74–79	1.0	25
Suspended Solids	mg/L	45.5 ± 0.71	45–46	0.0	30
Dissolved Oxygen	mg/L	0.1 ± 0.14	0.0–0.2	3.9	5.0–8.0
BOD	mg/L	39.44 ± 8.16	33.64–45.24	0.7	≤10
Hardness	mg/L	37 ± 4.24	34–40	30	150
Chloride	mg/L	17.65 ± 4.99	14.12–21.18	14.12	250
Alkalinity	mg/L	163 ± 69.30	114–212	20	200
Phosphate	mg/L	4.34 ± 0.53	3.96–4.72	0.013	5.0
Nitrate	mg/L	1.40 ± 0.16	1.28–1.51	0.610	50
Ammonium	mg/L	7.47 ± 0.34	7.23–7.71	0.854	0.5
Calcium	mg/L	11.23 ± 1.13	10.43–12.02	5.611	75
Magnesium	mg/L	1.70 ± 1.10	0.97–2.43	5.35	50
Iron	mg/L	0.533 ± 0.166	0.415–0.650	0.275	0.3
Lead	mg/L	0.020 ± 0.008	0.014–0.025	0.0	0.01

Zinc	mg/L	0.222 ± 0.068	0.174–0.270	0.07	5.0
Chromium	mg/L	0.038 ± 0.004	0.037–0.040	0.014	0.05
Cadmium	mg/L	0.00 ± 0.00	0.00–0.00	0.00	0.003

CHAPTER FIVE

5.1 Discussion

Water quality is a critical factor influencing the survival, growth, and productivity of fish in aquaculture systems. Physicochemical parameters such as pH, dissolved oxygen (DO), biochemical oxygen demand (BOD), nutrients, and heavy metals determine the overall suitability of the aquatic environment for fish culture (Boyd and Tucker, 2012). In this study, the physicochemical properties of water samples from the bottom of Tanks 5 and 6 at the TETFund Centre for Aquaculture and Food Technology were analysed and compared with the Federal Ministry of Environment (FMEnv) permissible limits for aquaculture water. The assessment revealed varying degrees of conformity among the parameters, indicating that while some fell within acceptable limits, others deviated significantly. This chapter discusses the implications of these findings in relation to aquaculture water quality, highlighting how these parameters influence fish health and pond management.

The physicochemical parameters analysed in this study revealed distinct variations in water quality between Tanks 5 and 6. The pH levels ranged between 5.7 and 6.1, with mean values of 5.9 ± 0.28 in Tank 5 and 6.1 ± 0.00 in Tank 6. These slightly acidic readings are marginally below the FMEnv recommended range of 6.0–9.0, indicating minor deviations that could affect the solubility of nutrients and the availability of essential ions (Akpan and Offem, 2016). The slightly acidic conditions could be attributed to the breakdown of organic matter and the release of carbon dioxide at the bottom of the tanks (Eze and Omoigberale, 2019).

The electrical conductivity and total dissolved solids (TDS) values, recorded at 108 $\mu\text{S}/\text{cm}$ and 54 mg/L respectively, were well within FMEnv permissible limits, suggesting that the water contains minimal dissolved salts and low ionic concentrations. This is beneficial for freshwater aquaculture, as excessive salinity can adversely affect fish osmoregulation. However, the relatively low conductivity may also imply limited nutrient content, which could constrain natural productivity and algal growth necessary for food chain support in aquaculture systems (Boyd, 1998).

Turbidity levels were found to be 63 NTU in Tank 5 and 76.5 NTU in Tank 6, both exceeding the FMEnv limit of 25 NTU. High turbidity and suspended solids values (55 mg/L in Tank 5 and 45.5 mg/L in Tank 6) indicate the presence of suspended particles, feed residues, and organic debris. These can hinder light penetration, affect photosynthetic activity, and reduce water clarity, thereby impacting the aquatic environment's ability to sustain balanced biological

processes (Sipaúba-Tavares *et al.*, 2010). High turbidity is also associated with the accumulation of sediments, which in turn can promote anaerobic decomposition at the tank bottom (Olawale and Folarin, 2020).

Dissolved oxygen (DO) concentrations were critically low in both tanks, ranging between 0.05 and 0.1 mg/L far below the FMEnv standard of 5.0–8.0 mg/L. Such oxygen depletion can severely impair fish respiration and may lead to mass mortalities if left unmanaged. The high biochemical oxygen demand (BOD) observed in both tanks, ranging from 39.44 mg/L in Tank 6 to 46.98 mg/L in Tank 5, further supports the inference of organic overloading and microbial decomposition. Elevated BOD values typically result from excessive feeding, poor aeration, and accumulated organic wastes that increase microbial activity (Hargreaves and Tucker, 2018). This high oxygen demand suggests the tanks may be experiencing hypoxic or near-anoxic conditions unfavourable for aquaculture productivity.

Water hardness values ranged between 32 and 37 mg/L, falling within the FMEnv acceptable range. Adequate hardness contributes to pH stability and provides essential calcium and magnesium ions required for fish bone and scale formation (Hogue, 2017). Alkalinity values, on the other hand, were moderately high 127 mg/L in Tank 5 and 163 mg/L in Tank 6—but remained below the permissible limit of 200 mg/L. Such alkalinity provides a buffering effect that prevents drastic pH fluctuations, though persistent high values may indicate limited water renewal and carbonate accumulation.

The nutrient concentrations also varied across the tanks. Phosphate levels (4.23–4.34 mg/L) were within the FMEnv permissible limit of 5.0 mg/L, and nitrate values (1.21–1.40 mg/L) were also low, suggesting that there was no excessive nutrient enrichment or eutrophication risk. However, ammonium concentrations were significantly high, ranging between 7.38 and 7.47 mg/L, far exceeding the FMEnv limit of 0.5 mg/L. The elevated ammonium levels point to incomplete nitrification and poor biological waste conversion, likely stemming from uneaten feed, fish excretion, and inadequate aeration (Adeyemi and Adewale, 2016). High ammonia concentrations can damage fish gills, suppress growth, and increase mortality rates (Wedemeyer, 1996).

Chloride concentrations (17.65–28.24 mg/L) were within permissible limits and pose no immediate threat to freshwater fish. The calcium and magnesium concentrations remained low, consistent with the observed moderate hardness levels and characteristic of soft water aquaculture systems. In contrast, metal concentrations revealed some deviations from

acceptable limits. Iron levels ranged from 0.386 to 0.533 mg/L, surpassing the FMEnv limit of 0.3 mg/L. This may be due to metallic corrosion or mineral leaching from the tanks and associated equipment (Udechukwu and Nwachukwu, 2017). Lead concentrations (0.016–0.020 mg/L) also exceeded the permissible limit of 0.01 mg/L, signalling potential contamination from anthropogenic sources. Although zinc, chromium, and cadmium levels were within acceptable limits, the elevated iron and lead concentrations raise potential health and toxicity concerns, as these metals can bioaccumulate in fish tissues and pose risks to both aquatic organisms and human consumers (Akintayo and Oladejo, 2016).

Overall, the analysis shows that while most parameters and such as pH, conductivity, hardness, chloride, phosphate, and nitrate—fall within acceptable ranges, a few key parameters including dissolved oxygen, BOD, turbidity, ammonium, iron, and lead deviate substantially from the FMEnv standards. These deviations reflect excessive organic matter decomposition, weak aeration, and potential heavy metal inputs, all of which compromise water quality and fish health.

The overall comparison between Tanks 5 and 6 shows notable spatial variation. Tank 6 generally exhibited higher turbidity, alkalinity, and iron concentrations, while Tank 5 recorded higher BOD and ammonium levels. These differences may be influenced by factors such as stocking density, sedimentation rate, and the frequency of water renewal (Rahman *et al.*, 2013). The consistently low DO values across both tanks indicate poor oxygenation and an excess of organic load, which create conditions conducive to anaerobic bacterial activity.

Several water quality concerns emerged from the results. The elevated BOD and ammonium concentrations, combined with low DO, highlight oxygen depletion and organic pollution as major issues. Additionally, the high concentrations of iron and lead suggest trace metal contamination that could affect fish physiology and food safety. To maintain optimal conditions for aquaculture, it is essential to implement regular monitoring, aeration, and water replacement schedules (Adeogun and Fashola, 2015).

5.2 Recommendations

Based on the findings of this study, the following recommendations are made to enhance water quality management and improve fish productivity in aquaculture systems at the TETFund Centre for Aquaculture and Food Technology:

1. **Regular Monitoring of Water Quality Parameters:** Routine analysis of physicochemical parameters such as dissolved oxygen, pH, BOD, and ammonia should

be conducted at least twice a month. This will enable early detection of water quality deterioration and facilitate prompt corrective actions.

2. **Installation of Aeration Systems:** Mechanical or electrical aerators should be installed to increase dissolved oxygen concentration and promote continuous water circulation. This will minimize oxygen depletion caused by microbial decomposition and enhance fish respiration and metabolism.
3. **Frequent Water Exchange and Sediment Removal:** Water in the tanks should be renewed periodically to prevent accumulation of organic waste and suspended solids. Regular desilting of the tank bottom will also help reduce anaerobic conditions and maintain water clarity.
4. **Improved Feeding and Waste Management Practices:** Overfeeding should be avoided to reduce organic load buildup. Feed should be administered in quantities appropriate to fish biomass, and uneaten feed residues should be promptly removed to prevent increased BOD and ammonia levels.
5. **Metal Contamination Control:** The elevated iron and lead concentrations observed suggest possible leaching from metallic pipes or equipment. It is recommended that plastic or non-corrosive materials be used in plumbing systems and tanks to minimize heavy metal contamination.
6. **Nutrient Management:** High ammonium levels indicate poor nitrification. The introduction of biological filtration systems or the use of beneficial nitrifying bacteria is advised to convert harmful ammonia to less toxic nitrate forms, improving overall water quality.
7. **Training and Capacity Building:** Aquaculture personnel and students should receive continuous training on sustainable water quality management techniques, emphasizing the importance of maintaining optimum physicochemical conditions for fish health.
8. **Regular Environmental Assessment:** Periodic environmental evaluations should be carried out to assess long-term impacts of aquaculture practices on surrounding water sources and to ensure compliance with FMEnv environmental standards.

5.3 Conclusion

The results of this study provide valuable insights into the physicochemical quality of water from the bottom of aquaculture tanks at the TETFund Centre for Aquaculture and Food Technology. The analysis revealed that while certain parameters such as pH, electrical conductivity, total dissolved solids, hardness, chloride, phosphate, and nitrate fall within the Federal Ministry of Environment (FMEnv) permissible limits for aquaculture, others including dissolved oxygen (DO), biochemical oxygen demand (BOD), turbidity, ammonium, iron, and lead exceeded acceptable levels. These deviations indicate the presence of organic pollution, poor aeration, and trace metal contamination that could negatively impact fish health, growth, and overall productivity.

The consistently low DO and high BOD values suggest oxygen depletion resulting from microbial decomposition of organic matter and inadequate aeration. This condition poses a serious risk to fish survival by impairing respiration and increasing susceptibility to diseases. Similarly, the high ammonium concentrations observed across the tanks point to excessive organic waste accumulation and poor nitrification processes. Elevated iron and lead levels indicate possible contamination from corroded metallic materials or other anthropogenic sources, which, if left unchecked, could lead to heavy metal bioaccumulation in fish tissues and compromise food safety.

Therefore, maintaining optimal water quality in aquaculture systems is crucial for sustainable production. Regular monitoring and management of key parameters such as DO, BOD, and ammonium are necessary to ensure that the aquatic environment remains conducive for fish growth. The introduction of aeration systems, frequent water exchange, and filtration mechanisms is strongly recommended to improve oxygen levels and minimize organic load accumulation. Additionally, periodic desilting and cleaning of the tanks should be carried out to prevent sediment buildup and the proliferation of anaerobic conditions.

In conclusion, while the aquaculture tanks at the TETFund Centre provide a viable medium for fish culture, improved water management practices are required to maintain the delicate balance of the aquatic environment. Implementing these recommendations will not only enhance water quality but also support higher fish survival rates, better feed utilization, and overall aquaculture sustainability.

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