



Physicochemical Attributes of some selected Fish Pond in Asaba, Delta State

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Abstract: - The study examined the physicochemical parameters of selected fish pond in Asaba, Delta State using standard methods. Water samples were collected and analyzed for physical and chemical properties and heavy metal levels. The results showed that water temperature ranges from (24.0 – 32°C), dissolved oxygen (3.20 – 7.60mg/l), and nutrient levels (1.20 – 98.8mg/l) varied significantly between seasons. Most ponds had high levels of turbidity and suspended solids that exceeded international standards. Heavy metals such as cadmium (0.28 – 0.34 mg/l), lead (0.03 – 0.04 mg/l), chromium (0.09 – 0.12 mg/l), and iron (8.56 – 10.42 mg/l) were found at levels above World Health Organization limits, with iron being particularly high in all ponds. This study reveals that fish ponds in Asaba, Oshimili LGA are significantly contaminated with heavy metal residue, posing health risks to both fish and humans who consume them. The study high lights the need for better management practices. Regular monitoring of water quality, responsible use and testing of water source and improved pond management are recommended to protect both the aquaculture industry and public health in Delta State.

Keywords: Physicochemical, Heavy metal, Fish Pond, Dissolved Oxygen.



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Introduction

Just as farmland provides the basic environment for crop production in terrestrial agriculture, water provides the essential medium for fish production in aquaculture. Fish carry out virtually all physiological functions, including respiration, feeding, excretion, growth and reproduction, within the aquatic environment; consequently, the quality of pond water has a direct influence on their health, survival and productivity. Environmental conditions are therefore among the major factors limiting successful fish production, particularly where water quality is compromised. Important determinants include the physical, chemical and biological characteristics of pond water (Fafioye, 2011). Parameters such as dissolved oxygen, pH, temperature, turbidity, ammonia, nitrate and the microbial composition of the water interact to determine its suitability for aquaculture. The

growth and survival of aquatic organisms are consequently strongly dependent on the physicochemical characteristics of their water environment (Akpotayire *et al.*, 2018).

Microorganisms constitute an important biological component of fish-pond ecosystems. Although many microorganisms contribute to nutrient cycling and decomposition of organic matter, the presence or proliferation of pathogenic organisms may adversely affect fish health and aquaculture productivity. A comparative assessment of fish ponds in Awka, Anambra State demonstrated the presence of diverse microbial populations in aquaculture environments, underscoring the importance of routine microbiological surveillance of pond water (Agu *et al.*, 2023). The public-health significance of microbial contamination associated with fish is further supported by the detection of pathogenic bacteria in smoked fish marketed in Benin City, Nigeria (Agu *et al.*, 2013). These

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findings highlight the potential for contamination within the aquaculture production chain to affect not only fish health but also the safety of fish intended for human consumption.

Deterioration of water quality may arise from domestic, agricultural and industrial activities, indiscriminate waste disposal, surface runoff and contamination from surrounding environments. Environmental pollutants can reduce dissolved oxygen, increase nutrient loading and alter the physicochemical balance of aquatic ecosystems, thereby creating conditions that favour microbial proliferation and disease. Studies from south-eastern Nigeria have demonstrated the relationship between environmental pollution and deterioration of water quality. Agu *et al.* (2014), for example, reported bacteriological and heavy-metal contamination of groundwater associated with leachate from solid-waste dumps in Awka. Similarly, Egurefa *et al.* (2024) documented bacteriological and heavy-metal contamination of borehole water in Enugu metropolis. Microbiological contamination has also been demonstrated in water from selected student hostels in Ifite, Awka (Victor-Aduju *et al.*, 2023), indicating that contamination of water sources remains an important environmental and public-health concern in the region.

Wastewater from human and animal-related activities represents another important source of microorganisms and organic pollutants entering the environment. Ezeokoli *et al.* (2023) demonstrated substantial bacteriological contamination of wastewater from Kwata Abattoir in Awka, illustrating the potential of inadequately managed effluents to contaminate adjoining soil and water systems. Where nutrient-rich wastes, suspended solids, agricultural chemicals or other pollutants enter fish ponds, they may cause changes in pH, oxygen availability and nutrient concentrations. Such changes can destabilise the pond ecosystem, compromise fish immunity and increase susceptibility to infectious diseases. Consequently, maintaining appropriate physicochemical and microbiological conditions is essential for sustainable aquaculture production.

Fish remains an important source of high-quality animal protein and contributes substantially to human nutrition and food security, particularly in countries where other sources of animal protein are relatively expensive (Orobator *et al.*, 2020). Improving fish-pond water quality is therefore important both for maintaining healthy aquatic environments and for supporting sustainable food production. Various approaches may be employed to improve pond-water quality, including sedimentation, filtration and biological degradation of organic matter. Clay materials, for example, may adsorb some contaminants and suspended substances, while microorganisms may facilitate the breakdown of organic matter as water passes through filtration media. Such environmentally friendly approaches

may contribute to reduced pollutant loads, improved water clarity, better control of excessive algal growth and maintenance of favourable conditions for fish production (Egbeki *et al.*, 2023).

Fish farming is widely practised in Asaba, Delta State, particularly through pond-based aquaculture in which species such as catfish are reared for household consumption and commercial purposes. Aquaculture contributes to food security, employment generation, income and poverty reduction and is particularly relevant in Delta State because of its extensive riverine environment. However, the productivity and sustainability of fish farming are threatened by infectious diseases, including aeromoniasis, saprolegniasis and streptococcosis, which may result in high mortality, reduced yield and substantial economic losses to farmers. The occurrence of these diseases is often associated with deterioration in pond-water quality and increased proliferation of potentially pathogenic microorganisms.

Despite the importance of aquaculture in Asaba, there remains limited contemporary information on the combined physicochemical and microbiological quality of fish ponds within the area. Key parameters such as dissolved oxygen, pH, temperature, ammonia, nitrate and heavy-metal concentrations are not routinely characterised, while the microbial populations present in the ponds and their possible relationship with physicochemical conditions remain inadequately documented. Previous studies from Awka and other parts of south-eastern Nigeria have demonstrated microbial contamination of fish ponds, wastewater, groundwater and drinking-water sources (Agu *et al.*, 2014; Ezeokoli *et al.*, 2023; Agu *et al.*, 2023; Victor-Aduju *et al.*, 2023; Egurefa *et al.*, 2024), but comparable integrated data for fish ponds in Asaba remain limited.

This study was therefore designed to systematically assess the physicochemical and microbiological characteristics of selected fish ponds in Asaba, Delta State, Nigeria. The findings are expected to provide locally relevant evidence on pond-water quality, identify potential environmental and microbial risks to fish health, and contribute to the development of appropriate water-quality management practices for sustainable aquaculture in the study area.

Materials and Method

Study Area

This study was carried out in Asaba, Delta State. Asaba is the capital city of Delta state, situated in the South-South geopolitical zone of Nigeria. It is located in the Western bank of River Niger which makes it susceptible to seasonal flooding. The geographical coordinates of Asaba Metropolis are Latitude 6.1985°N and Longitude 6.7280°E. Below is the map of Asaba Showing the study sites.



Fig 1: Map of Oshimili south local government area showing the study area Asaba.

Source: Google map.

Sample Collection

Water samples were collected from ten (10) different fish farms located within Asaba metropolis and labelled appropriately. Two samples each were collected from tarpaulin ponds, plastic ponds and earthen ponds. While four samples were collected from concrete ponds. The water from each of the fish ponds were sampled in duplicate. The water samples were aseptically collected at about 10 – 15 cm depth from the ponds in sterile 500ml plastic bottles at three points (inlet, middle, outlet) and composited to form a representative sample for each pond. The containers were properly labelled and transported to the Applied Microbiology and Brewing Laboratory of Nnamdi Azikiwe University, Awka in an ice chest for analysis.

Physicochemical and Heavy Metal Analysis of the Pond Water Samples

The physicochemical parameters evaluated were temperature, pH, electrical conductivity, total dissolved solids, total suspended solids, total solids, turbidity, nitrate, total alkalinity, phosphate, sulphate, total chloride, dissolved oxygen, biological oxygen demand, total hardness, calcium hardness, magnesium hardness, carbonates, bicarbonates, total acidity, potassium. Heavy metals such as cadmium, lead, chromium, mercury, copper, arsenic, zinc and iron were also determined. These evaluations were carried out using standard analytical methods (APHA, 2017). The temperature and pH were measured *in-situ*.

Results

Table 1: Mean Physicochemical Parameters of Fish Pond Water During Dry Season

Parameter	Mean $\pm$ SD	Range	WHO Standard
Temperature ($^{\circ}$ C)	29.8 $\pm$ 1.2	27.5 – 32.0	25 – 30
pH	6.82 $\pm$ 0.24	6.47 – 7.15	6.5 – 8.5
Electrical Conductivity (μ S/cm)	487.3 $\pm$ 198.5	310.0 – 820.0	1000
Total Dissolved Solids (mg/l)	278.6 $\pm$ 105.4	180.0 – 465.0	500
Total Suspended Solids (mg/l)	85.4 $\pm$ 42.7	38.0 – 165.0	30
Total Solids (mg/l)	364.0 $\pm$ 138.2	230.0 – 610.0	-
Turbidity (NTU)	112.5 $\pm$ 41.8	58.0 – 185.0	5
Dissolved Oxygen (mg/l)	5.42 $\pm$ 0.98	4.10 – 7.20	>5.0
Biochemical Oxygen Demand (mg/l)	4.85 $\pm$ 1.12	3.20 – 6.80	<5.0
Nitrate (mg/l)	28.6 $\pm$ 9.4	16.0 – 45.0	50
Phosphate (mg/l)	3.42 $\pm$ 1.18	1.80 – 5.60	-
Sulphate (mg/l)	72.4 $\pm$ 14.2	52.0 – 98.0	250
Chloride (mg/l)	45.8 $\pm$ 12.6	28.0 – 68.0	250
Total Alkalinity (mg/l)	18.6 $\pm$ 8.2	10.0 – 32.0	-
Total Hardness (mg/l)	68.4 $\pm$ 22.6	42.0 – 108.0	-
Calcium Hardness (mg/l)	42.6 $\pm$ 14.8	26.0 – 68.0	-
Magnesium Hardness (mg/l)	25.8 $\pm$ 9.2	15.0 – 42.0	-
Potassium (mg/l)	0.72 $\pm$ 0.22	0.45 – 1.10	-

n = 10 ponds; values represent mean of triplicate results

Table 2: Mean Physicochemical Parameters of Fish Pond Water During Rainy Season

Parameter	Mean $\pm$ SD	Range	WHO Standard
Temperature ($^{\circ}\text{C}$)	26.4 $\pm$ 1.5	24.0 – 28.5	25 – 30
pH	7.04 $\pm$ 0.28	6.65 – 7.45	6.5 – 8.5
Electrical Conductivity ($\mu\text{S}/\text{cm}$)	352.6 $\pm$ 156.8	210.0 – 620.0	1000
Total Dissolved Solids (mg/l)	195.4 $\pm$ 82.6	120.0 – 350.0	500
Total Suspended Solids (mg/l)	62.8 $\pm$ 35.4	28.0 – 130.0	30
Total Solids (mg/l)	258.2 $\pm$ 106.8	160.0 – 460.0	-
Turbidity (NTU)	86.4 $\pm$ 38.2	42.0 – 148.0	5
Dissolved Oxygen (mg/l)	6.48 $\pm$ 1.05	5.10 – 8.30	>5.0
Biochemical Oxygen Demand (mg/l)	5.62 $\pm$ 1.28	3.80 – 7.60	<5.0
Nitrate (mg/l)	18.4 $\pm$ 7.6	10.0 – 32.0	50
Phosphate (mg/l)	2.16 $\pm$ 0.92	1.20 – 4.00	-
Sulphate (mg/l)	58.6 $\pm$ 12.4	42.0 – 82.0	250
Chloride (mg/l)	32.4 $\pm$ 10.2	20.0 – 52.0	250
Total Alkalinity (mg/l)	24.8 $\pm$ 9.6	14.0 – 40.0	-
Total Hardness (mg/l)	56.2 $\pm$ 18.8	36.0 – 92.0	-
Calcium Hardness (mg/l)	34.8 $\pm$ 12.4	22.0 – 58.0	-
Magnesium Hardness (mg/l)	21.4 $\pm$ 8.2	13.0 – 36.0	-
Potassium (mg/l)	0.58 $\pm$ 0.18	0.38 – 0.92	-

n = 10 ponds; values represent mean of triplicate results

Table 3: Heavy Metal Concentrations (mg/L) in Fish Pond Water

Heavy Metal	Dry Season (Mean $\pm$ SD)	Rainy Season (Mean $\pm$ SD)	WHO Standard
Cadmium (Cd)	0.34 $\pm$ 0.08	0.28 $\pm$ 0.06	0.003
Lead (Pb)	0.04 $\pm$ 0.02	0.03 $\pm$ 0.01	0.01
Chromium (Cr)	0.12 $\pm$ 0.04	0.09 $\pm$ 0.03	0.05
Mercury (Hg)	0.002 $\pm$ 0.001	0.001 $\pm$ 0.001	0.001
Copper (Cu)	0.18 $\pm$ 0.06	0.14 $\pm$ 0.05	1.0
Arsenic (As)	0.03 $\pm$ 0.01	0.03 $\pm$ 0.01	0.01
Zinc (Zn)	0.11 $\pm$ 0.04	0.09 $\pm$ 0.03	1.0
Iron (Fe)	10.42 $\pm$ 2.18	8.56 $\pm$ 1.84	0.3

Table 4: Comparative Physicochemical Parameters by Pond Type

Parameter	Earthen Ponds	Concrete Ponds	Tarpaulin Ponds	Plastic Ponds
Temperature ($^{\circ}$ C)	28.4 $\pm$ 1.8	27.8 $\pm$ 1.6	28.2 $\pm$ 1.4	28.0 $\pm$ 1.5
pH	6.72 $\pm$ 0.22	7.18 $\pm$ 0.18	6.85 $\pm$ 0.20	6.92 $\pm$ 0.24
EC (μ S/cm)	512.4 $\pm$ 210.6	368.2 $\pm$ 142.8	425.6 $\pm$ 168.4	398.4 $\pm$ 156.2
TDS (mg/L)	296.8 $\pm$ 112.4	212.4 $\pm$ 86.2	245.6 $\pm$ 98.4	228.4 $\pm$ 92.6
Turbidity (NTU)	128.6 $\pm$ 45.2	72.4 $\pm$ 28.6	98.4 $\pm$ 36.8	85.6 $\pm$ 32.4
DO (mg/L)	5.28 $\pm$ 0.92	6.82 $\pm$ 0.88	5.86 $\pm$ 0.96	6.12 $\pm$ 0.84
BOD (mg/L)	5.82 $\pm$ 1.24	4.42 $\pm$ 0.96	5.24 $\pm$ 1.08	4.86 $\pm$ 1.02

Discussion

Fish population from various breeding systems may be affected by diseases that are as a result of physical and chemical ambient, nutritional and constitutional agents. Water chemistry is defined by a multitude of parameters, which are more important for fish life such as pH, dissolved gasses (oxygen and carbon dioxide), organic matter in suspension, its concentration in ammonia, nitrites, nitrates, phosphates, chlorides, sulfates, hydrogen, sulfides, detergents, pesticides and phenols (Vasile, 2008). Results from the physicochemical parameters of the current study showed that the mean water temperature recorded in this study ranged from 27.5–32.0°C ($29.8 \pm 1.2^\circ\text{C}$) during the dry season and 24.0–28.5°C ($26.4 \pm 1.5^\circ\text{C}$) during the rainy season (table1,2). Temperature was significantly higher during the dry season ($p < 0.05$), a finding consistent with similar studies conducted in Anambra State where temperature values were also reported to be higher during the dry season (Okaa and Ogu, 2020). These values fall within the optimal range of 25–30°C recommended for tropical freshwater fish culture by the World Health Organization (WHO, 2007). The seasonal variation observed can be attributed to increased solar radiation and reduced cloud cover during the dry months, which raises ambient temperatures and consequently water temperature. Similar temperature ranges (27.5–31.0°C) have been reported by Ibezute and Olori (2025) in earthen ponds in Effurun, Delta State, and by Agbaire *et al.* (2015) in concrete fish ponds in Abraka, Delta State. The observed temperature ranges (27.5–32.0) are conducive for the metabolic activities of tropical fish species such as *Clarias gariepinus* and *Oreochromis niloticus*, which are commonly reared in Asaba Metropolis.

The pH values recorded in this study ranged from 6.47–7.15 (6.82 ± 0.24) during the dry season and 6.65–7.45 (7.04 ± 0.28) during the rainy season (Table 1). No significant seasonal difference was observed ($p > 0.05$), which aligns with the findings of Ibezute and Olori (2025) who reported stable pH values (6.47–6.87) in earthen ponds in Effurun, Delta State. All pH values fell within the acceptable range of 6.5–8.5 recommended for aquaculture by WHO (2021) and the National Environmental Standards and Regulations Enforcement Agency (NESREA). The slight increase in pH during the rainy season may be attributed to dilution effects and increased photosynthetic activity of algae, which consumes carbon dioxide and raises pH. The stability of pH across seasons is a positive indicator for fish health, as extreme pH fluctuations can cause stress, reduce growth rates, and increase susceptibility to disease (Stone and Thomforde, 2003). Similar pH ranges (6.70–7.60) were reported by Raphael *et al.* (2025) in aquaculture sites in Awka, Southeast Nigeria. The near-neutral pH observed in

all ponds is suitable for optimal nutrient availability and microbial activity in the pond ecosystem.

Electrical conductivity (EC) values ranged from 310.0–820.0 $\mu\text{S}/\text{cm}$ (487.3 ± 198.5) during the dry season and 210.0–620.0 $\mu\text{S}/\text{cm}$ (352.6 ± 156.8) during the rainy season (Table1,2). Total dissolved solids (TDS) ranged from 180.0–465.0 mg/L (278.6 ± 105.4) in the dry season and 120.0–350.0 mg/L (195.4 ± 82.6) in the rainy season (Table1,2). Both parameters were significantly higher during the dry season ($p < 0.05$), a pattern consistent with the findings of Ibezute and Olori (2025) who reported EC values of $455.13 \pm 207.11 \mu\text{S}/\text{cm}$ and TDS values of $264.50 \pm 102.20 \text{ mg}/\text{L}$ in Effurun ponds, with significant increases observed by June due to seasonal effects. All values were below the WHO recommended limits of 1000 $\mu\text{S}/\text{cm}$ and 500 mg/L, respectively, indicating that the pond water is within acceptable ionic concentration limits for aquaculture. The higher EC and TDS values during the dry season can be attributed to increased evaporation rates, which concentrate dissolved ions in the water, and reduced dilution from rainfall. The ionic content of pond water is critical for osmoregulation in fish, and the levels observed in this study are adequate for normal physiological functions of cultured fish species.

Turbidity values ranged from 58.0–185.0 NTU (112.5 ± 41.8) during the dry season and 42.0–148.0 NTU (86.4 ± 38.2) during the rainy season. Total suspended solids (TSS) ranged from 38.0–165.0 mg/L (85.4 ± 42.7) in the dry season and 28.0–130.0 mg/L (62.8 ± 35.4) in the rainy season (Table1,2). Both parameters exceeded WHO recommended limits (5 NTU and 30 mg/L, respectively) and were significantly higher during the dry season ($p < 0.05$). These findings are consistent with those of Ibezute and Olori (2025), who reported turbidity values of $108.19 \pm 44.09 \text{ NTU}$ and TSS values of $80.71 \pm 44.40 \text{ mg}/\text{L}$ in Effurun ponds, noting that these exceeded NESREA limits and peaked in April and February due to sediment resuspension. The elevated turbidity and TSS levels are of concern for aquaculture, as high turbidity can reduce light penetration, thereby limiting photosynthetic activity and primary productivity. Furthermore, suspended solids can clog fish gills, cause respiratory distress, and provide attachment surfaces for pathogenic microorganisms. The higher values observed during the dry season may be due to increased wind-induced resuspension of bottom sediments, reduced water volume from evaporation, and higher fish feeding and waste production rates.

Dissolved oxygen (DO) ranged from 4.10–7.20 mg/L (5.42 ± 0.98) during the dry season and 5.10–8.30 mg/L (6.48 ± 1.05) during the rainy season (Table1,2). Biochemical oxygen demand (BOD) ranged from 3.20–6.80 mg/L (4.85 ± 1.12) during the dry season and 3.80–7.60 mg/L (5.62 ± 1.28) during the rainy season. DO was significantly higher

during the rainy season ($p < 0.05$), which is consistent with observations from Anambra State. Most DO values met aquaculture requirements (>5.0 mg/L), though some ponds recorded DO below the recommended minimum during the dry season. The higher DO levels during the rainy season can be attributed to increased atmospheric oxygen dissolution from rainfall and surface agitation, as well as higher water flow rates. The findings are comparable to those of Ibezute and Olori (2025), who reported DO values of 6.14 ± 1.06 mg/L and BOD values of 3.53 ± 1.07 mg/L in Effurun ponds, indicating low organic pollution. However, the elevated BOD levels observed in some ponds during this study suggest organic pollution from uneaten feed, fish metabolic wastes, and decomposition of organic matter. Low DO levels ($<3\text{--}4$ mg/L) can cause oxygen stress in fish, leading to reduced feeding, poor growth, immune-suppression, and increased susceptibility to diseases (Thilza and Muhammad, 2010). The BOD values exceeding 5.0 mg/L in several ponds during both seasons indicate moderate organic pollution that requires management intervention.

Nitrate ranged from 16.0–45.0 mg/L (28.6 ± 9.4) during the dry season and 10.0–32.0 mg/L (18.4 ± 7.6) during the rainy season. Phosphate ranged from 1.80–5.60 mg/L (3.42 ± 1.18) in the dry season and 1.20–4.00 mg/L (2.16 ± 0.92) in the rainy season. Sulphate ranged from 52.0–98.0 mg/L (72.4 ± 14.2) in the dry season and 42.0–82.0 mg/L (58.6 ± 12.4) in the rainy season (Table 1,2). All three parameters were significantly higher during the dry season ($p < 0.05$) but remained within acceptable limits for aquaculture. The higher nutrient concentrations during the dry season can be attributed to reduced water volume from evaporation, increased metabolic waste production from fish at higher temperatures, and reduced dilution from rainfall. Similar sulphate values (67.01 ± 13.84 mg/L) were reported by Ibezute and Olori (2025) in Effurun ponds. The elevated nitrate and phosphate levels, though within acceptable limits, indicate nutrient loading from fish feed and organic wastes, which can promote excessive algal growth (eutrophication) if left unchecked.

Total alkalinity ranged from 10.0–32.0 mg/L (18.6 ± 8.2) during the dry season and 14.0–40.0 mg/L (24.8 ± 9.6) during the rainy season. Total hardness ranged from 42.0–108.0 mg/L (68.4 ± 22.6) during the dry season and 36.0–92.0 mg/L (56.2 ± 18.8) during the rainy season (Table 1,2). Alkalinity was higher during the rainy season, while hardness was higher during the dry season. The alkalinity values observed are generally below the optimal range of 50–200 mg/L recommended for aquaculture, suggesting that these ponds may have low buffering capacity against pH fluctuations. Low alkalinity makes pond water susceptible to pH crashes, particularly during periods of high photosynthetic activity or organic decomposition. The hardness values are within acceptable ranges for fish

growth, with calcium and magnesium being essential for bone development and osmoregulation. Similar alkalinity values (20.42 ± 8.97 mg/L) were reported by Ibezute and Olori (2025). The higher alkalinity during the rainy season may be due to the dissolution of carbonates from runoff water, while the higher hardness during the dry season reflects the concentration of dissolved minerals due to evaporation.

The concentrations of heavy metals exhibited no significant seasonal variations for most metals ($p > 0.05$), consistent with the findings of Ibezute and Olori (2025) in Effurun, Delta State. However, cadmium (0.28–0.34 mg/L), lead (0.03–0.04 mg/L), chromium (0.09–0.12 mg/L), arsenic (0.03 mg/L), and iron (8.56–10.42 mg/L) exceeded WHO recommended limits for drinking water quality. Iron concentrations were particularly elevated (10.23–10.71 mg/L), which is consistent with the findings of Ibezute and Olori (2025) who reported iron levels ranging from 10.23 to 10.71 mg/L in Effurun ponds. Zinc (0.09–0.11 mg/L) and copper (0.14–0.18 mg/L) remained within acceptable limits. Mercury was detected at trace levels (0.001–0.002 mg/L), with some samples exceeding the WHO limit of 0.001 mg/L.

The elevated heavy metal concentrations are of significant concern for both fish health and public health. Heavy metals are indestructible and tend to bioaccumulate in aquatic organisms, particularly in fish tissues (Akan *et al.*, 2009; Duruibe *et al.*, 2007). The high iron concentrations may originate from the geological composition of the Niger Delta region, which is known to have iron-rich soils and sediments. The presence of cadmium, lead, chromium, and arsenic above permissible limits suggests anthropogenic inputs from agricultural runoff, industrial effluents, and possibly the use of contaminated feed and fertilizers. Similar findings were reported by Okocha *et al.* (2025) in commercial aquaculture farms in Southwestern Nigeria, where chromium (0.138 ± 0.024 ppm) and cadmium (0.020 ± 0.01 ppm) were detected in pond water samples above maximum permissible limits. The bioaccumulation of these heavy metals in fish tissues poses a potential health risk to consumers, as chronic exposure to heavy metals has been associated with various health conditions including renal dysfunction, neurological disorders, and carcinogenic effects (Okocha *et al.*, 2018). The elevated heavy metal concentrations, particularly cadmium, lead, chromium, arsenic, and iron, pose additional health risks. Chronic exposure to these heavy metals through the consumption of contaminated fish can lead to various health conditions, including renal dysfunction, neurological disorders, and carcinogenic effects (Okocha *et al.*, 2018; Duruibe *et al.*, 2007). The bioaccumulation of heavy metals in fish tissues is a particular concern, as these metals are indestructible and tend to concentrate in the food chain (Storelli *et al.*, 2005).

The stress caused by poor water quality, including low DO levels, high turbidity, and elevated nutrient concentrations, can compromise the immune system of fish, making them more susceptible to infections (Ciji and Akhtar, 2021). The implementation of good aquaculture practices, including regular water quality monitoring, responsible antibiotic use, and biosecurity measures, is essential for safeguarding both fish and human health.

Conclusion

The physicochemical examination of fish ponds in Asaba, Delta State, has revealed significant elevated heavy metal concentrations. The seasonal variations observed in several parameters underscored the need for continuous monitoring and adaptive management strategies. The findings of this study provide a baseline for understanding the water quality and heavy metal contamination of fish ponds in Asaba Metropolis and highlight the need for improved pond management practices to ensure the sustainability of aquaculture in Delta State. The accumulation of heavy metals in the ponds pose significant public health risks that require urgent attention from policymakers, regulatory agencies, and fish farmers.

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