**Journal of Agriculture and Environment**
**Vol. 20 No. 2, 2024: 165-176**

# Characterization and heavy metals concentration of sediments from catfish ponds in Monai Cluster Fish Farm, Southern Basin of Kainji Lake, Niger State, Nigeria

**M.M. Mu'azu[1], M. Bashir[2], Y. Sani[2], M. Kasim[3] and R.Y. Atiribom[1]**

[1]National Institute for Freshwater Fisheries Research, P.M.B 6006, New Bussa, Nigeria
[2]Department of Microbiology, Bayero University, Kano, Nigeria
[3]Department of Civil Engineering, Bayero University, Kano, Nigeria

## ABSTRACT

Fishpond sediments play a crucial role in aquaculture systems because they act as both sinks and sources for various nutrients and potential contaminants. In Nigeria's growing aquaculture sector, particularly in cluster fish farms, an understanding the characteristics of pond sediments characteristics particularly sediment quality is essential for sustainable management and environmental protection. This study focused on the Monai cluster fish farm, located in the Southern Basin of Kainji Lake, New Bussa, Niger State, Nigeria, where intensive catfish farming is practiced. The study aimed to characterize bottom sediments and determine the heavy metals concentration from catfish (*Clarias gariepinus* and *Clarias hybrid*) ponds in Monai Cluster Fish Farm. Sediment samples were collected from 90 grow-out catfish ponds across different seasons. Samples were analyzed for pH, nutrients (total nitrogen and phosphorus) and heavy metals following standard procedures. The study established seasonal patterns by comparing wet season (August and September) and dry season measurements. Results showed slightly acidic pH values (6.5-6.8), with phosphorus (orthophosphate) recording the highest nutrient concentration (2.2±6.1mg/l to 59.2±7.9mg/l). Wet season samples exhibited significantly higher concentrations of both total nitrogen and phosphorus, attributed to increased agricultural runoff and pond management practices. Heavy metal concentrations remained within EPA and WHO acceptable limits, indicating minimal contamination. Statistical analysis revealed no significant difference ($p>0.05$) in physicochemical parameters across the cluster farm, likely due to the series connection of pond outlets and other water management and cultural practices. The findings highlight the need for implementing environmentally sustainable methods for sediment management and nutrient recycling within the fish farming value chain, particularly in cluster farm settings.

**Keywords:** Aquaculture sediments; nutrient concentration; catfish ponds

## INTRODUCTION

Fish farming as a system of aquaculture has experienced a significant growth in recent time in Nigeria due to the quest of bridging the existing gap between local demand and importation. The predominant and widely cultured fish in Nigeria is Catfish (*Clarias*

https://www.ajol.info/index.php/jagrenv
ISSN: 1595-465X (Print) 2695-236X (Online)
correspondence: muazu42@gmail.com
https://dx.doi.org/10.4314/jagrenv.v20i2.15

*gariepinus*) or its hybrid. This growth in the aquaculture industry is accompanied by a reciprocal increase in the production inputs and subsequently, in the production output. Monai cluster fish farm is one of the villages with clusters of fish farms along the Southern Basin of Kainji Lake that is located in Monai village, New Bussa, Niger State, Nigeria. This village accommodates around 700-900 fishponds that are constructed in clusters for mutual ease of water management and other related shared benefits.

However, despite the huge economic prospects and livelihood improvements associated with the recent growth in the fish farming industry, it is without its detriment. This is because the intensification of fish farming has been reported to be accompanied by concomitant environmental impacts as it relates to production of effluent, nutrient-dense sediments as well as heavy metals, which all have individual environmental and health consequences when disposed into the environment (Abdulkadir *et al*., 2017; Adeleke *et al.*, 2020; Folorunso *et al*., 2021). Heavy metals are naturally occurring elements that can have toxic effects on aquatic life, even at relatively low concentrations (Bharti and Sharma, 2022). In aquaculture, heavy metals can originate from Catfish ponds due to inputs from feed, medicines and other chemicals used in aquaculture operations (Mannan *et al*., 2018; Hossain *et al*., 2022). Likewise, sediments act as sinks for contaminants, including heavy metals. Heavy metals characterization is crucial for understanding the potential risks associated with these pollutants. The accumulation of heavy metals in sediments can adversely affect the health of aquatic organisms, including catfish, through direct exposure or through the food chain. Furthermore, sediment re-suspension and bioturbation can remobilize and further redistribute these contaminants to other niches, thereby leading to their potential transfer to the water column and biota. Therefore, this study aimed to analyze the properties of bottom sediments and assess the concentration of heavy metals in catfish (*Clarias gariepinus* and *Clarias* hybrid) ponds at the Monai Cluster Fish Farm.

## MATERIALS AND METHOD

### Description of the Study Area

Monai village is located in the Southern Basin of Kainji Lake, New Bussa, Niger State, Nigeria. Monai cluster fish farm comprises of approximately 700-900 fishponds arranged in clusters, with ponds connected in series through their outlets. This interconnected system primarily cultivates *Clarias gariepinus* (catfish) and its hybrids under intensive farming conditions. The farm's location and design are significant from an environmental perspective due to both its proximity to Kainji Lake and the interconnected nature of the pond system, which can influence water quality and sediment characteristics across the cluster. The area experiences distinct seasonal variations (wet and dry seasons) that affect aquaculture operations and environmental parameters. The intensive nature of farming operations in this cluster system presents potential environmental concerns, particularly regarding sediment accumulation, sediment disposal and possible heavy metal contamination from various aquaculture inputs including feed, therapeutants and other operational chemicals.

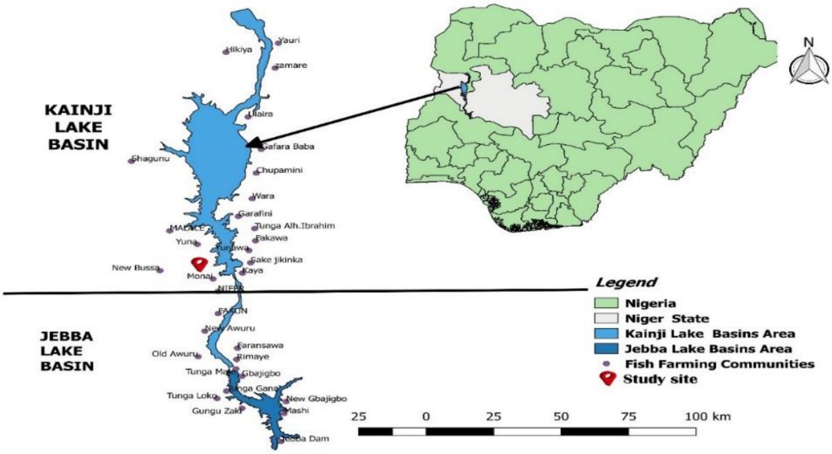


Figure 1: Map of Kanji Lake Basin showing Monai village
Source: Omeiza (2018).

**Sediments Sample Collection**

Sediment samples were collected from Catfish ponds under active grow-out production in the cluster fish farm using stratified random sampling technique (Simpson *et al*., 2005). A total of 90 (ninety) sediment samples were collected using Birge-Ekman grab sampler for wet, hot and harmattan seasons. This was represented by a total of thirty (30) samples per season (15 samples per month of a season). The respective periods of sample collection were grouped into three respectively, with two months each representing each of the seasons. January and February represented the harmattan season while the hot season sample were collected in the months of March and April, 2022. The wet season was represented by samples collected in the months of August and September, 2022. All samples collected were processed by drying them in a well-ventilated room, grounded into powder with a mortar and pestle and finally sieved to remove dead leaves and other particulate materials. Samples were sent to soil analysis laboratory of the National Cereal Research Institute, Badegi, Niger State, Nigeria, for sediment quality and nutrient analyses respectively.

**Sediment Quality Analyses**

Sediment quality analysis involved measurements of sediment pH, organic carbon (OC), total organic matter (TOM) and sediment particle size distribution using standard procedures.

***Sediment pH***

Sediment pH was measured using a handheld digital pH meter (model pH-009, Hanna®, USA). This was done by dipping the electrodes of the meter in a suspension of 10g of sediment in 25ml deionized water after shaking for about 20-30 seconds (Vincent-Akpu *et al*., 2015).

***Total organic matter content (TOM)***

Total organic matter content of sediments was determined by using standard methodology as described by AOAC (1990). In this method, samples were prepared for analysis by drying in an oven for a minimum of 72 hours at 50°C. Representative portion of the dry sediment of a particular sample to be analyzed was then transferred into a pre-weighed crucible and sample weight (A) kilogram (kg) was determined using an analytical balance. Samples were then transferred into a preheated muffle furnace and burned at 450°C for 4 hours to remove organic matter. After cooling in a desiccator, samples were then reweighed (B) in kilograms. The weight/content of organic matter in the sample was finally determined using the equation: OM = A – B kg

***Organic Carbon***

Organic carbon in sediment samples was determined using the method described by Schumacher (2002). In the procedure, organic carbon was determined by the destruction of organic matter present in the sediment samples where all the carbon forms in the sample were converted to carbon dioxide ($CO_2$) which were then measured directly. In the sample preparation phase, sediment samples underwent a controlled drying process to eliminate moisture content by drying in a hot air oven at 60◦C. Once dried, the sediment samples were finely crushed into fine powder using a mortar and pestle. Thereafter, 3g of the fine sediment powder was placed into a combustion tube of an induction furnace. The sample was then subjected to elevated heating in a furnace at 1round 1000◦C, causing all carbonaceous material to combust and convert into carbon dioxide ($CO_2$). This released carbon dioxide was then captured and quantified using a UV-Vis Spectrophotometer (Shimadzu UV-1800, Japan).

***Sediment Electronic Conductivity***

Electronic conductivity (EC) of sediment samples was measured using a hand-held EC digital meter (model: Emcee 1152, USA). This was done by simply measuring about 5g of the dried sediment samples, with which a suspension was made by making a homogenate with 50ml of deionized. Conductivity reading was basically taken by immersing the probe of the conductivity meter into the sediment-water mixture in such a way that the probe was completely submerged into the beaker containing the sediment suspension. The reading was taken ones the figures displayed on the meter had stabilized for at least 5 to 8 seconds (Rhodes *et al*., 1999).

**Nutrient Analyses**

***Nitrogen***

Total Kjeldahl Nitrogen: This was determined using the standard micro Kjeldahl apparatus. The procedure began with digestion of the dried sediment sample in a digestion rack as described in standard methodology by AOAC (1990). TKN was computed using the relation:

$$\%TKN = \frac{\text{milligram of nitrogen found}}{\text{milligram of sample}} \times 100$$

Nitrate Nitrogen (NO3 – N): Nitrogen (NO3-N) was determined using Phenol-disulphonic acid method as described in the standard procedure by AOAC (1990). Samples were digested using the Sulphuric acid-Nitric acid method. Result was read using a UV-Vis Spectrophotometer (Shimadzu UV-1800, Japan).

Nitrite Nitrogen (NO2-N): Nitrite nitrogen (NO2-N) was determined using standard method as described in the standard procedure by AOAC (1990). Samples were also digested using the Sulphuric acid - Nitric acid method. Result was read using a UV-Vis Spectrophotometer (Shimadzu UV-1800, Japan).

Note: Total nitrogen of the samples was computed using the relation described by EPA (2013):

$$Total\ Nitrogen\ (TN) = TKN + NO_3 - N + NO_2 - N$$

***Phosphorus***

Phosphorus was analyzed as orthophosphate (PO4-P), using standard methodology by AOAC (1990). Samples were first digested using the Sulphuric acid - Nitric acid method. The result was also read using spectrophotometry.

**Heavy Metals Analysis of Sediments from Catfish Ponds**

For the purpose of sample collection for this study, the farm was divided into five sub-clusters (CL1 to CL5) according to the farm management activities carried out as well as the direction channel of Kainji Lake around Monai village from which fish farmers pump water into their ponds.

The heavy metal concentrations in sediments from catfish ponds in Monai cluster fish farm were studied during different seasons: Harmattan (January and February), Hot (March and April), and Wet (August and September).

After collection, all samples from the different sampling points were mixed together to make up a composite sample so as to ensure homogeneity. The heavy metals analyzed included $Pb^{2+}$ (Lead), $Cr^{3+}$ (Chromium), $Cd^{2+}$ (Cadmium), $Fe^{3+}$ (Iron), and $Mn^{2+}$ (Manganese). Sediment samples were randomly collected from Catfish ponds using Birge-Ekman bottom grab sampler from each cluster during each sampling. This was done by gently lowering the grab into the pond with a graduated rope in such a way that it hits the bottom of the pond to collect the sediments. A total of thirty (90) samples were collected from January 2022 to September, 2022 to cover three seasons (harmattan, wet and hot) seasons of the year respectively. These samples were collected from Catfish ponds under active production. The samples were dried in a well-ventilated room and crushed using a thick glass pestle and mortar and passed through a 2mm mesh size sieve to sieve out gravels, stones and any vegetative material that may be present in the sample. The results of heavy metals concentration in sediment sample were compared against the limits established by the

Environmental Protection Agency, EPA (2002) and the World Health Organization, WHO (1995).

## Sample Digestion for Heavy Metals Analysis

To extract metals from the sediment samples, an acid digestion method was employed. The procedure followed the aqua-regia digestion technique as described by Bamgbose (1990). In this method, 5 g of composite sediment samples were accurately weighed into a clean beaker, covered with a watch glass and heated on a hot plate for 45 minutes. The watch glass was then removed, and the contents were evaporated to dryness. Subsequently, 5 mL of aqua-regia reagent (a mixture of hydrochloric acid and nitric acid in a 3:1 ratio) was added to the residue and evaporated to dryness again. After complete evaporation, 10 mL of 1 M nitric acid was added to the residue and the resulting suspension was filtered. The filtrate was cooled and diluted to the 50 mL mark using distilled-deionized water in a volumetric flask. Reagent blanks and standard solutions for each element were prepared using the same procedure. The final analysis of heavy metals in the sediment samples, standards, and reagent blanks was conducted using an Atomic Absorption Spectrophotometer (Agilent 240FS/280FS AA, U.S.A).

$$Concentration\ of\ metal\ in\ \mu g/g = \frac{\mu g//ml\ \text{metal from the curve x sample solution x dilution factor}}{Weight\ of\ sample\ taken}$$

Source**:** APHA (1995).

## Statistical Analyses

Data obtained were analyzed using ANOVA to evaluate the significance of differences in sediment quality, physicochemical variables and heavy metal status of sediments across the catfish ponds in the three seasons (Harmattan, hot, and dry).

# RESULTS

## Sediment Physicochemical Parameters

The analysis of sediment physicochemical parameters showed a dynamic trend over time, particularly in pH, organic carbon (OC), nutrient loads and total organic matter (TOM). The hot season (March–April) exhibited the highest organic carbon concentration, with a mean value of 2.35 mg/L and total organic matter of 4.02 mg/L, compared to the Harmattan and wet seasons. However, statistical analysis revealed no significant difference in TOM concentrations across the three seasons. The pH values remained relatively stable throughout the seasons, ranging from 6.5 - 6.8, indicating slightly acidic to neutral conditions in the sediment environment. Similarly, electrical conductivity (EC) varied across the seasons, with the highest value recorded during the hot season (38 µs/cm) and the lowest in the wet season (24 µs/cm). Likewise, the organic carbon concentration followed a similar trend, with the highest during the hot season and dropping to its lowest level in the wet season (1.57 mg/L). This seasonal variation suggests that factors such as temperature, rainfall and organic matter decomposition rates influence sediment quality in catfish ponds. (Table 1).

Table 1: Mean seasonal physicochemical characteristics of sediments from catfish ponds

| Parameters | Harmattan | Hot | Wet |
|---|---|---|---|
| pH | 6.8±0.6[a] | 6.7±0.1[b] | 6.5±0.1[c] |
| OC (mg/L) | 1.86±0.4[a] | 2.35±0.3[b] | 1.57±0.6[c] |
| TOM (mg/L) | 3.35±0.6 [a] | 4.02±0.9[b] | 3.48±1.0[c] |
| EC (µs/cm) | 31±4.8 | 38±5.7 | 24±3.2 |

*Values are means ± SD.
*****Means on same column with same superscripts are not significantly different ($p>0.05$).
TOM **=** Total organic matter, OC = Organic carbon

## Sediment Nutrient Concentration

The analysis of sediment nutrient concentrations revealed consistently high levels of total nitrogen (TN) and phosphorus ($PO_4^{3-}$) across all seasons, while potassium (K) remained relatively low. Total nitrogen concentrations ranged between 18.0 mg/L and 20.4 mg/L, with the highest values observed during the wet season. Similarly, Phosphorus, which recorded the highest concentration among the nutrients analyzed, varied from 42.2 mg/L to 59.2 mg/L, also reaching the highest in the wet season. This seasonal trend suggests that nutrient accumulation in sediments was influenced by rainfall and organic matter deposition, which may enhance nutrient retention during the wet period. However, Potassium concentrations were consistently lower than those of nitrogen and phosphorus across all seasons and it ranged from 0.33 mg/L to 4.08 mg/L. Despite its generally low presence, potassium levels were highest in the wet season, just like the trend observed for nitrogen and phosphorus. Generally, this trend in seasonal variations in nutrient concentrations actually showed the potential influence of environmental factors such as precipitation, temperature and organic input on nutrient dynamics in catfish pond sediments. (Table 2).

Table 2: Mean seasonal nutrient characteristics of sediments from catfish ponds

| Parameter | Harmattan | Hot | Wet |
|---|---|---|---|
| $NO_2$-N (mg/L) | 4.17±0.1[a] | 4.45±0.5[a] | 4.51±0.5[a] |
| $NO_3$-N (mg/L) | 13.35±0.7[b] | 13.28±0.2[a] | 17.07±1.0[c] |
| $PO_4^{3-}$ (mg/L) | 42.21±6.1[a] | 45.35±8.3[b] | 59.15±7.9[c] |
| $NH_3$-N (mg/L) | 0.47±0.1[a] | 0.50±0.1[a] | 0.54±0.1[a] |
| TN (mg/L) | 18.00±3.1[a] | 18.20±4.1[b] | 20.40±1.7[c] |
| K (mg/L) | 0.39±0.1[b] | 0.33±0.1[a] | 4.08±0.6[c] |

*Values are means ± SD.
*Means on same rows with different superscript letters are significantly different ($p < 0.05$)
TN = Total Nitrogen, K = Potassium, $PO_4^{3-}$ = orthophosphate, $NH_3$-N = Ionized ammonia

## Sediment Particle Size Distribution

Particle size distribution in sediments, however, revealed relatively unvarying particle size distribution in sediment samples collected throughout the sampling period for various sizes of sand, silt and clay respectively. The pattern of distribution was Sand > Silt > Clay throughout the study period (figure 1).

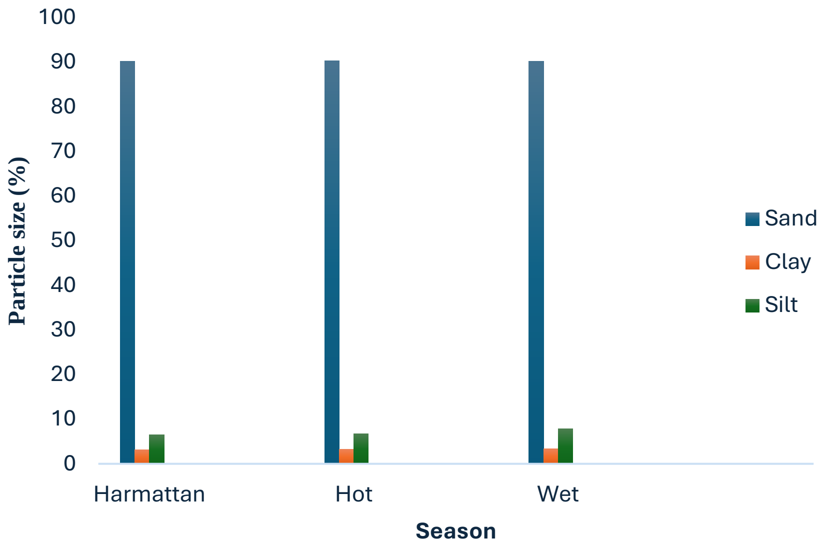


Figure 1: Mean seasonal particle size distribution of sediments
Pattern of sediment distribution: Sand > Silt > Clay

## Heavy Metals

Heavy metals concentration in sediment samples collected from Catfish ponds during the study period are shown on table 4, which represents the concentrations of the metals over three seasons (wet, hot and harmattan) in the five sub-clusters of Monai cluster fish farm respectively.

## January and February (Harmattan Season)

During the Harmattan season, the concentrations of heavy metals in the sediments of catfish ponds varied across the five sub-clusters. For $Pb^{2+}$ concentrations that range from 12.6 mg/kg to 18.95 mg/kg were recorded across CL 1 to CL5 (Table 3). The highest concentration of $Pb^{2+}$ was recorded for cluster 4 (CL4). Similarly, for Cr3+, the concentrations in each cluster varied, with Cluster 5 (CL5) recording the highest concentration with a mean value of 40.11 mg/kg while the lowest chromium concentration was recorded in cluster 3 with a mean value of 11.83 mg/kg. The concentration of Cd2+ was consistently low across all clusters, ranging from 0.32 mg/kg to 0.53 mg/kg. Generally, during the Harmattan season, the concentrations of Pb2+, $Cr^{3+,}$ $Cd^{2+,}$ $Fe^{3+}$ and $Mn^{2+}$ in the sediments across all clusters were found to be well below the respective limits set by EPA (2002) and WHO (1995).

## March and April (Hot Season)

Generally, the heavy metals concentrations in each sub-cluster during the wet season also remained within acceptable limits, with minor disparities reflecting seasonal interactions.

**August and September (Wet Season)**

During the Wet season, the concentrations of heavy metals in the sediments maintained a consistent pattern. For Lead ($Pb^{2+)}$ concentrations ranged from 17.40 mg/kg to 28.60 mg/kg, with Cluster 5 (CL5) recording the highest concentration of Lead (Table 3). For Chromium ($Cr^{3+}$)' concentrations ranged from 13.50 mg/kg to 34.80 mg/kg, again with Cluster 5 (CL5) exhibiting the highest values. Generally, the heavy metals concentrations in each cluster during the wet season also remained within acceptable limits, with slight differences indicating seasonal influences.

Table 3: Mean Heavy metals concentration in sediments

| Sample Location | Heavy metals concentrations (mg/kg) n = 90 | | | | | |
|---|---|---|---|---|---|---|
| | Seasons | Pb | Cr | Cd | Fe | Mn |
| CL1 | Harmattan | 15.34±4.2 | 12.07±2.0 | 0.34±0.1 | 8.12±0.8 | 0.43±0.2 |
| | Hot | 15.11±1.3 | 11.86±0.7 | 0.41±0.1 | 9.03±0.2 | 0.57±0.1 |
| | Wet | 18.25±1.8 | 14.20±1.0 | 0.50±0.1 | 11.50±0.4 | 0.65±0.1 |
| | Max. Limit (mg/kg) | ** ≤36 | **≤43 | ** ≤0.99 | **≤20,000 | **≤460 |
| CL2 | Harmattan | 12.68±1.5 | 17.74±4.3 | 0.39±0.1 | 8.54±0.1 | 0.52±0.1 |
| | Hot | 14.05±1.5 | 11.10±0.6 | 0.34±0.5 | 8.34±0.1 | 0.56±0.2 |
| | Wet | 17.40±2.0 | 13.50±0.8 | 0.42±0.1 | 10.80±0.3 | 0.64±0.1 |
| | Max. Limit (mg/kg) | ** ≤36 | **≤43 | ** ≤0.99 | **≤20,000 | **≤460 |
| CL3 | Harmattan | 17.41±0.7 | 11.83±3.2 | 0.32±0.1 | 9.83±0.8 | 0.62±0.5 |
| | Hot | 19.70±6.0 | 24.50±4.0 | 0.70±1.2 | 10.19±0.4 | 0.64±0.1 |
| | Wet | 23.50±4.0 | 28.75±7.0 | 0.85±1.5 | 12.75±0.6 | 0.72±0.1 |
| | Max. Limit (mg/kg) | ** ≤36 | **≤43 | ** ≤0.99 | **≤20,000 | **≤460 |
| CL4 | Harmattan | 18.95±0.4 | 26.49±1.5 | 0.35±0.1 | 10.39±1.2 | 0.68±1.3 |
| | Hot | 19.22±3.0 | 25.78±2.5 | 0.50±0.1 | 9.48±0.2 | 0.63±0.5 |
| | Wet | 22.75±1.8 | 30.45±3.0 | 0.62±0.1 | 12.00±0.4 | 0.70±0.1 |
| | Max. Limit (mg/kg) | ** ≤36 | **≤43 | ** ≤0.99 | **≤20,000 | **≤460 |
| CL5 | Harmattan | 17.25±3.4 | 40.11±5.3 | 0.53±0.1 | 11.89±1.5 | 0.73±0.1 |
| | Hot | 25.50±0.5 | 29.46±1.3 | 0.75±0.2 | 9.26±0.5 | 0.67±0.1 |
| | Wet | 28.60±0.8 | 34.80±2.3 | 0.90±0.1 | 11.80±0.7 | 0.75±0.1 |
| | Max. Limit (mg/kg) | ** ≤36 | **≤43 | ** ≤0.99 | **≤20,000 | **≤460 |

**CBSQG (2000)

CL1 = Sub-cluster 1, CL2 = Sub-cluster 2, CL3 = Sub-cluster 3, CL4 = Sub-cluster 4, CL5 = Sub-cluster 5

## DISCUSSION

Sediment quality is a good indicator of pollution because heavy metals, organic matter and other organic pollutants are absorbed in the pond sediments. Amongst the sediment quality parameters in a pond or lake, the sediment pH is considered one of the most important factors in determining the chemical and biological processes that take place in the pond bottom (Saeed and El-Gammal, 2009). In a fish pond, pH of sediments is an important factor to consider for the health and productivity of fish. The pH values recorded in this study is in strong agreement with the pH values reported in several studies on characterization of sediments from catfish ponds in Nigeria. Ayoola *et al.* (2021) reported a pH range of 5.8 to 6.8 in sediments from Catfish ponds in Southwestern Nigeria. Similarly, Onyema and Nwankwoala (2021), also reported a pH range of 6.3 to 6.8 in a study on physicochemical properties of sediments from Catfish ponds in a study location at Southeastern Nigeria. Olayiwola *et al*. (2021) also reported a pH range of 6.2 to 6.8 in a study on the effect of stocking density on water quality and sediment characteristics in catfish ponds in southwestern Nigeria. However, the pH value recorded in this study is slightly below the optimum pH range of 7.5-8.0, reported to be the optimum pH range for aquaculture pond sediments (Saeed and El-Gammal, 2009). This is because microbial activity is the most rapid in the pH range of 7.5-8.0 (Boyd and Pipoppinyo 1994). A number of factors influence the pH of sediments from catfish ponds. The slightly acidic pH values recorded in this study can be attributed to the fast decomposition of organic matter loads in the sediments. Adeyemo *et al.* (2021) reported that the organic matter content of sediments in catfish ponds can significantly influence the pH. This is so because, as the organic matter decomposes, it releases acids, which can lower the pH of the sediment. Another possible reason as to why the pH of sediments recorded in this study was slightly acidic can be related to the dissolved oxygen concentration in the sediments. Lawal *et al*. (2021), reported that, in the absence of oxygen, the decomposition of organic matter can produce acidic compounds that lower the pH of the sediment. Lawal *et al.* (2021) reported that sediment samples from catfish ponds with low dissolved oxygen had lower pH values compared to those with high dissolved oxygen.

The accumulation of organic matter in sediments can have negative impacts on the pond ecosystem. Organic matter can reduce dissolved oxygen levels in the water, leading to fish kills and reduced productivity (Oyekunle *et al.,* 2021). Furthermore, the low organic matter content in sediments recorded in this study are far below the range reported by Nwachukwu *et al*. (2021), who reported a range of 7.2% to 22.4% as well as 12.3% to 17.5% reported by Oyekunle *et al.* (2021) respectively. This can be explained in terms of the management practices conducted by fish farmers that operate the ponds. The constant flow-through system of water into the ponds and practice of de-mudding can all be related to the low organic matter content recorded in the study.

Seasonal variation has been shown to significantly affect the organic matter content of sediments in aquatic environments such as catfish ponds. This is because several studies have investigated the effect of seasons on organic matter content in catfish pond sediments (Adeoye and Ogunfowokan, 2017; Adekunle *et al.,* 2018; Sharma *et al.*, 2019).

With regards to heavy metals, results from this study across all the clusters for the respective seasons; Harmattan (January and February), Hot (March and April), and Wet (August and September) remained consistently within safe limits when compared with sediment quality guidelines for freshwater ecosystems, specifically the consensus based sediment quality guidelines (CBSQG) (2002), developed by the Wisconsin Department of Natural Resources, Madison, USA. This finding is in close agreement with a similar study conducted by Ehiemere *et al*. (2022) for heavy metals concentrations in sediment samples from fish ponds in a cluster fish farm in the Niger Delta region of Nigeria. During the Harmattan season, characterized by dry and dusty conditions, the concentrations of heavy metals exhibited minimal variations across clusters. This suggested a stable environmental condition within the catfish ponds during this period, with no alarming signs of heavy metal pollution. The consistently low concentrations of $Cd^{2+}$ and $Mn^{2+}$ across all clusters could be attributed to numerous potential reasons such as; geological composition of the area where the fish ponds are located (Opaluwa *et al*., 2012), low impact of anthropogenic inputs such as washing of clothes and crop farming activities that serve as a source of Cadmium and

Manganese pollution as well as absence of factories and industries that manufacture batteries (Oyeleke *et al*., 2016; Kinta, 2021) and biological uptake (Chen *et al*., 2014).

In Hot and Wet seasons, the slight variations observed in metal concentrations could be attributed to seasonal influences, such as increased incidences of point and non-point sources of pollution during the Wet season (Yohanna *et al*., 2020) as well as the effect of high concentration due to low water volumes in ponds during hot seasons (Kamari *et al*., 2017) respectively. However, these variations remained within acceptable limits, highlighting the insignificant or low impact of anthropogenic inputs in the cluster fish farm as it relates to environmental health. However, Cluster 5 consistently recorded higher concentrations of heavy metals across all seasons, emphasizing the importance of continuous monitoring and targeted interventions to mitigate potential sources of contamination.

In this study, there was no statistical difference between the organic matter concentrations across the three seasons. This finding is in agreement with the work of Adekunle *et al*. (2018), who reported no significant difference in organic matter content between the rainy and dry seasons.

With respect to particle size distribution, the pattern of distribution was sand > Silt > Clay in sediment samples analyzed throughout the study period. This implies that the sediments samples had more sand than silt, than clay, meaning that the quantity of sand was highest in all samples.

## CONCLUSION

The study showed that sediment quality in catfish ponds varied seasonally, with slightly acidic pH influenced by organic matter decomposition. Organic matter content remained low, likely due to effective pond management and sediment composition was predominantly sandy, in terms of particle size distribution. However, the indiscriminate disposal of pond sediments along shorelines poses a risk of nutrient runoff into the lake and should be addressed. Heavy metal concentrations were within safe limits, though higher levels in Cluster 5 highlight the need for ongoing monitoring.

## REFERENCES

Abdulkadir, J., Sadiku, S. and Tiamiyu, L. (2017). Environmental impact assessment of fish farm hatcheries management in lower Niger Basin Area of Nigeria. *Journal of Agricultural Research and Development*, 15, 110-125.

Adeleke, B., Robertson-Andersson, D., Moodley, G. and Taylor, S. (2020). Aquaculture in Africa: A comparative review of Egypt, Nigeria, and Uganda vis-a-vis South Africa. *Reviews in Fisheries Science and Aquaculture*, 29(2), 167-197.

Bamgbose, O., Odukoya, O. and Arowolo, T.O.A. (2000). Earthworms as bio-indicators of metal pollution in dumpsites of Abeokuta city, Nigeria. *Revistrade Biologia Tropical*, 48(1), 221-226.

Bharti, R. and Sharma, R. (2022). Effect of heavy metals: An overview. *Materials Today: Proceedings*, 51, 880-885.

Chen, Y. M., Li, H. C., Tsao, T. M., Wang, L. C. and Chang, Y. (2014). Some selected heavy metal concentrations in water, sediment, and oysters in the Er-Ren estuary, Taiwan: chemical fractions and the implications for biomonitoring. *Environmental Monitoring and Assessment*, 186, 7023-7033.

E.P.A (2002). Cadmium, Copper, Zinc, Nickel and Zinc: Proposed sediments guidelines for the protection of benthic organisms: Technical Basis and Implementation. *United States Environmental Protection Agency Library*, mail code: 3201, 1200 Pennsylvania avenue, NW Washington DC, 20460.

Folorunso, E. A., Rahman, M. A., Sarfo, I., Darko, G. and Olowe, O. S. (2021). Catfish farming: a sustainability study at Eriwe fish farming village in southwest Nigeria. *Aquaculture International*, 29, 827-843.

Gilbert, B.M. and Avenant-Oldewage A. (2014). Arsenic, chromium, copper, iron, manganese, lead, selenium and zinc in the tissues of the largemouth yellowfish, Labeo barbuskimberleyensis (Gilchrist and Thompson, 1913), from the Vaal Dam, South Africa, and associated consumption risks. *Water SA*, 40 (4), 739–748.

Hossain, M. B., Miazie, M. R., Nur, A. A. U., Paul, S. K., Bakar, M. A., Paray, B.A. and Arai, T. (2022). Assessment of metal contamination in water of freshwater aquaculture farms from a South Asian tropical coastal area. *Toxics*, 10(9), 536.

Kamari, A., Yusof, N., Abdullah, H., Haraguchi, A. and Abas, M.F. (2017). Assessment of heavy metals in water, sediment, *Anabas testudineus* and *Eichhornia crassipes* in a former mining pond in Perak, Malaysia. *Chemistry and Ecology*, 33(7), 637-651.

Kinta, M. J. (2021). Secological Risk of Heavy Metals In Surface Water, Sediment and Dominant Fish Species from Tungan Kawo Reservoir, Kontagora, Niger State, Nigeria, *Doctoral Dissertation, Federal University of Technology, Minna, Niger State, Nigeria*.

Mannan, M., Hossain, M., Sarker, M., Hossain, M., Chandra, L., Haque, A. and E-Zahan, M. (2018). Bioaccumulation of toxic heavy metals in fish after feeding with synthetic feed: A potential health risk in Bangladesh. *Journal of Nutrition and Food Sciences*, issue 08. https://doi.org/10.4172/2155-9600.1000728.

Opaluwa O.D, Aremu M.O, Ogbo L.O, Magaji J.I, Odiba I.E, Ekpo E.R. (2012). Assessment of Heavy Metals in Water, Fish and Sediments from UKE Stream, Nasarawa State, Nigeria. *Curr World Environ*, 7(2), 213-220.

Oyeleke, P. O., Abiodun, O. A., Salako, R. A., Odeyemi, O. E. and Abejide, T. B. (2016). Assessment of some heavy metals in the surrounding soils of an automobile battery factory in Ibadan, Nigeria. *African Journal of Environmental Science and Technology*, 10(1), 1-8.

Rhoades, J.D., Corwin, D.L. and Lesch, S.M. (1999). Soil electrical conductivity and soil salinity: New formulations and calibrations. *Soil Science Society of America Journal*, 63(6), 1557-1567. https://doi.org/10.2136/sssaj1999.6361557x

Schumacher, B.A. (2002). Methods for the determination of total organic carbon (TOC) in soils and sediments. *United States Environmental Protection Agency, Environmental Sciences Division, National Exposure Research Laboratory*, NCEA-1282, EMASC-001.

Yohanna, A.R., A.O. Peter, S.Y. Daniyan, O.O. Rashed and Y.I. Yakubum (2020). Limnological qualities and heavy metal status of water from southern basin of Kainji Lake, Nigeria. J. Fish. Aquat. Sci., issue 15, pp. 51-58.