



## Research Article

# Evaluation of Physicochemical Variables Following Demolition of Building Structures in and Around Kware Lake, Sokoto, Nigeria

<sup>1\*</sup>Muhammad Musa Tanko, <sup>2</sup>Ibrahim Muhammad Magami, and <sup>1</sup>Suleiman Jafaru

<sup>1</sup>Department of Biological Sciences, Sokoto State University, Sokoto State-Nigeria

<sup>2</sup>Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto-Nigeria

**Corresponding author:** [muhammad.musatanko@ssu.edu.ng](mailto:muhammad.musatanko@ssu.edu.ng), [doi.org/10.55639/607ysmg](https://doi.org/10.55639/607ysmg)

## ARTICLE INFO:

### Keyword:

Demolition,  
Drinking,  
Kware,  
Physicochemical  
Sediment

## ABSTRACT

Physical and chemical factors are dynamic in nature, and anthropogenic activities can affect these changes. The residents have used Kware Lake as a source of drinking water, irrigation, and fishing activities. The destruction of structural buildings inside and surrounding the lake served as the impetus for this investigation. Selected physicochemical factors were identified, and three study locations (Inlet, Mid, and Outlet) were chosen. For a period of six months, monthly samples of water and sediment were taken (October 2021 to March 2022). The amounts of  $\text{Ca}^+$ ,  $\text{Mg}^+$ ,  $\text{SO}_4$ , and  $\text{NO}_3$  were found to be significantly changed across months when measured using standard methods, although,  $\text{Na}^+$  values were not and there was little seasonal variation in electrical conductivity (EC). However, at  $p < 0.05$ , the variables pH, Biological Oxygen Demand (BOD), Dissolved oxygen (DO), and Ammonia ( $\text{NH}_4$ ) indicated a significant difference across months. Additionally, according to a sediment investigation, there were no appreciable variations in electrical conductivity, organic carbon (OC) and clay between the months. However, in February and March of 2022, elevated pH and EC concentrations were observed. To ensure that the Kware residents continue to use the water daily, continuous monitoring is necessary

**Corresponding author:** Muhammad Musa Tanko, Email: [muhammad.musatanko@ssu.edu.ng](mailto:muhammad.musatanko@ssu.edu.ng)  
Department of Biological Sciences, Sokoto State University, Sokoto State-Nigeria

## INTRODUCTION

Every living thing on this planet depends on water, making it one of the most crucial elements. Three per cent of the world's

freshwater supply is sufficient to sustain human needs for millions of years (Mbalassa *et al.*, 2014). The phenomena of water pollution are defined by the degradation of the water's

quality as a result of numerous human activities. Generally, water is utilized for drinking, fishing, and other domestic activities. Depending on their objectives for the water, different people have varied definitions of what "water quality" entails. High-quality laboratory water is defined as being devoid of suspended particles or chemical contaminants. On a wilderness backpacking trip, the same chemist would define good-grade water as water in an unaffected (Mbalassa *et al.*, 2014). If the chemist also enjoys fishing, he might think that water of excellent quality is ideal for fish and other aquatic life (Halegraff, 1993). High-quality water is defined by a manager of a drinking water treatment facility as water that requires the least amount of removal or treatment to produce safe and palatable drinking water. A comprehensive understanding of high-quality water will assess its suitability for specific uses. It might be used for residential purposes, irrigation, fishing, etc. (Weiner, 2008).

Both biotic and abiotic environmental conditions have a significant impact on the succession and abundance of phytoplankton in aquatic environments. Therefore, evaluating the quality of the water using physicochemical factors can provide a comprehensive picture of the combined impact of several water characteristics. The Water Quality Index (WQI) is a helpful tool for categorizing water and can provide a clear indicator of the health of the water (Shashi *et al.*, 2008).

Any surface or groundwater's quality is influenced by both natural and human factors, and both (anthropogenic). Without human intervention, evapotranspiration, wind-borne salt and dust deposition, bedrock mineral weathering, and other atmospheric processes will determine the quality of the water. Water quality is significantly impacted by biological processes within the aquatic environment that changes the physical and chemical composition

of water, the natural leaching of organic matter and nutrients from the soil, hydrological variables that cause runoff, and other factors (Mbalassa *et al.*, 2014).

Water quality cannot be determined by monitoring just one parameter, nor is it a static condition of a system (WHO, 2003). Instead, it is variable in both time and space, necessitating regular observation to spot a fertile pattern and changes over time. While certain factors allow for the direct tracking of polluted structures, others provide a broad indicator of water pollution (WHO, 2003). Pollutants including household garbage, industrial effluents, insecticides and pesticides, detergents, and fertilizers can contaminate water. Direct sources of water pollution include companies, waste management facilities, refineries, etc. that release waste and hazardous byproducts into the nearby water sources without first treating them.

Indirect causes of pollution include those that reach aquatic bodies through the soil, groundwater, or acid rain (Khatun, 2017). Diseases like typhoid, cholera, hepatitis, and others can have devastating impacts on our health when we drink or consume dirty water in any form.

Algae create a layer on the surface of a water body due to eutrophication caused by too many chemicals in the water body. As a result, bacteria consume algae which lowers the oxygen content of the water body and negatively impact the aquatic life therein (WHO/UNEP, 1997). If left unchecked, water pollution can lead to the collapse of an entire ecosystem. As a result, the physical and chemical characteristics of the waters are dynamic and dependent on changes in the environment, which let us anticipate the state of the water. This study aimed to evaluate Kware Lake's level of physicochemical variables for both water and sediment after the State

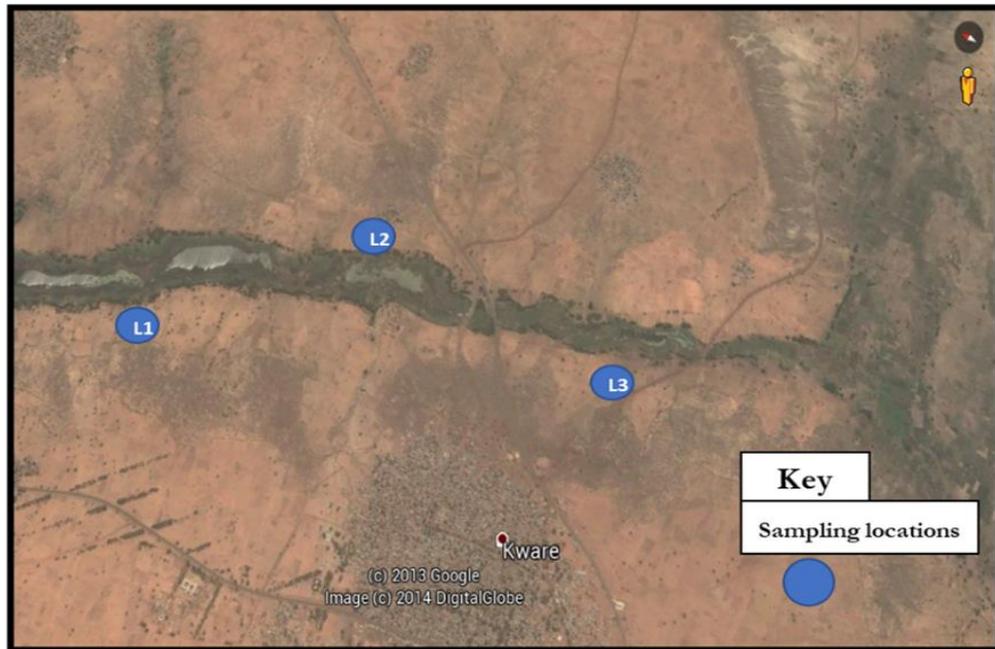
Government demolished the lake's surrounding and internal structural buildings.

## MATERIALS AND METHODS

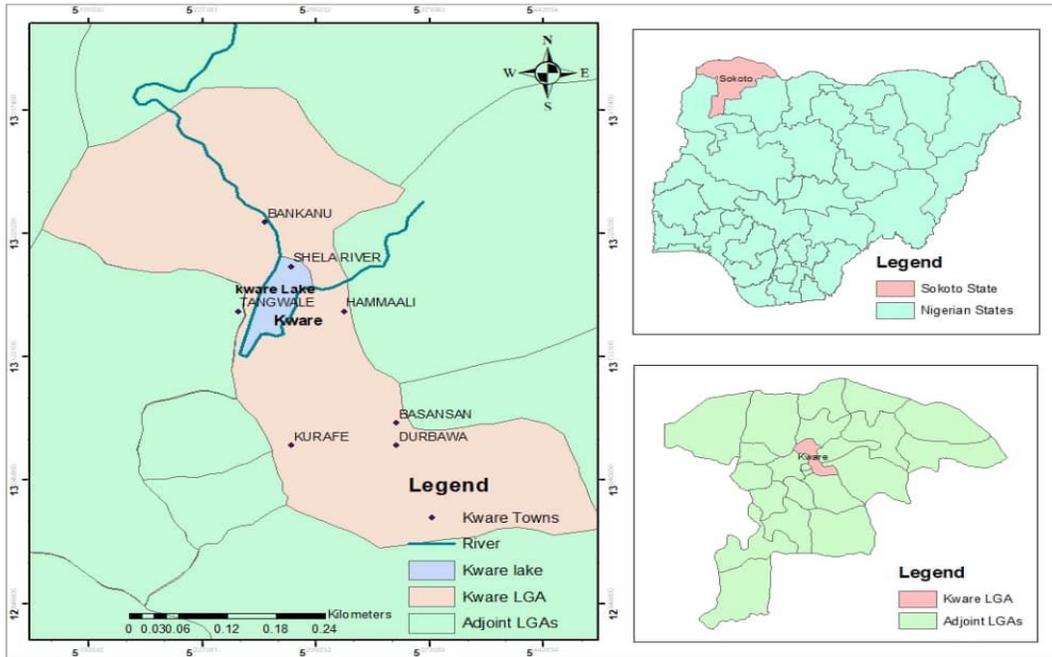
### Study Area

Kware Lake is a naturally occurring body of water that receives its water supply from numerous subsurface water sources. It is situated in latitudes 13° 13'N and 50° 16'E. A lentic (standing) body of water with a clear aspect, Kware Lake is frequently used for

home, agricultural, and fishing reasons. For many years, Kware Lake served as a source of drinking water; before it was abandoned, it served as a raw supply of tap water for a small water treatment facility there that supplied Sokoto Metropolis. For this investigation, the lake was separated into three sample units. Samples of sediment and water were taken for analysis (Plate 1).



**Figure 1:** Map Kware Lake through Google Earth Showing Sampling Locations



**Figure 2:** Map of Kware Lake showing sample collection site



**Plate 1:** Mid Kware Lake (A), Demolished abandoned buildings within and around Kware Lake (B-C), BOD Water sample collection (D) and Sediment sample collection (E-F).

**Sample Collection and Determination**

Water and sediment samples were obtained early in the morning. For sample collection, sterile polytene bags (sediment) and bottles (water) were

employed. The samples were promptly taken to Usmanu Danfodiyo University's Agric Chemical Laboratory in Sokoto for analysis. The following physicochemical characteristics were determined

using Panday et al. 2005 methods: pH, using the JENWAY 3015 Model at 25°C. For dissolved oxygen (DO) and biological oxygen requirement, the Winkler reagent method was used. The EDTA titration method was used to determine calcium and magnesium levels. The Kjeldahl method was used to determine ammonia, and the molybdate method was used to determine phosphorus using a Spectrophotometer Model 300 at 660nm wavelength (UNEP, 2004) and Udo and Ogunwale (2004) titration methods were used for sediment analysis.

### Statistical Analysis

The collected data were statistically evaluated with SPSS statistical software. The ANOVA statistical tool was used, as described by Gelman (2005) and Mukhtar (2008).

## RESULTS AND DISCUSSION

Aquatic life is affected by the level of physicochemical variables; these variables may function singly or in conjunction with others, and the response they elicit may differ depending on the species, location and time (Spatiotemporal). Although the levels of physicochemical variables are known to vary dependent on spatiotemporal considerations, anthropogenic causes of many types may influence these changes. The present study reveals the following; there was no significant difference in electric conductivity (EC) between the months. However, there was a significant difference at  $p < 0.05$  in pH concentration between months. The highest pH concentrations were recorded from January to March 2022, whereas the lowest concentration was recorded in October 2021  $6.987 \pm 0.081$  (Table 1). Significant monthly variations in water pH (at  $p < 0.05$ ) were observed, which falls in a moderately low acidic and moderately lower salinity state, October 2021 had a higher pH concentration than December 2021, January to March 2022. The present study was similar when

compared to those of Omoigberale and Ogbeibu (2006) for the Osse River and other Nigerian water bodies, including the Calabar River (Uttah *et al.*, 2008) and Imo River (Akoma, 2008).

There was a substantial difference in BOD concentrations across the research periods, with the greatest concentration recorded in March 2022 and the lowest concentration reported in October 2021, with  $27.000 \pm 5.689$  and  $15.200 \pm 2.122$  respectively. The biological oxygen demand (BOD) varied significantly (at  $P < 0.05$ ), these results point to a somewhat high BOD value. Which was contrary to the findings of Ekhatior *et al.* (2015), who throughout their study recorded a range of 1.66 to 3.71mg/l in several locations. Since values, less than 1.2 mg/l are regarded as clean, 3 mg/l is fairly clean. In contrast to the rainy season, BOD drastically increases during the dry season, according to this study, absorption of decomposing organic matter from surface runoff during the irrigation period may be responsible for high levels during the dry season.

There was a significant difference in DO between the months, though the highest concentration was obtained in March 2022 ( $6.200 \pm 1.1014$ ). According to Ekhatior *et al.* (2015), low dissolved oxygen levels and high BOD levels both harm the health of freshwater. Dissolved oxygen (DO) significantly varied between the study periods ( $p < 0.05$ ). The lowest concentration was measured from October 2021 to February 2022, while the maximum concentration was observed in March 2022. The present findings are therefore in line with the findings of Imoobe and Oboh (2003) for the Jamieson Lake, Chindah *et al.* (2006) for the Rivers State municipal stream, and Mustapha (2008) for the Oyun reservoir, which found that dissolved oxygen is typically higher in the wet season in tropical waters. The highest value of dissolved oxygen was recorded during the wet season. This result, however, is consistent with those made for the Great Kwa River by Kadiri

(2000) and Akpan *et al.* (2002), who observed greater dissolved oxygen levels in the dry season than in the wet season.

Ammonia (NH<sub>4</sub>) values obtained across months differ considerably (at  $p < 0.05$ ). December 2021 to March 2022 had the highest concentration, and October 2021 had the lowest concentration. This study was consistent with that of Amare *et al.* (2019). In which the level of ammonia (NH<sub>4</sub>) in this study significantly differs between the period of study, while the highest concentration was recorded in December 2021 to March 2022 and the lowest concentration was recorded in October 2021 ( $1.000 \pm 0.200$ ).

The hardness of the lake may be explained by the presence of calcium and magnesium, exactly as Boyd (1979) observed that calcium and magnesium ions in the water produce their overall hardness. He goes on to say that higher overall hardness levels could be caused by increased calcium and magnesium ion concentrations in the rain. The decrease in total hardness concentration during the dry season must have been caused by creatures that use these ions. The concentrations of Ca<sup>+</sup>, Mg<sup>+</sup>, SO<sub>4</sub>, and NO<sub>3</sub>, were observed to be significantly different between the months, while Na<sup>+</sup> didn't express any significant difference between months (Table 1). Ca<sup>+</sup> has the highest concentration of  $10.866 \pm 0.371$  mg/l in March 2022 and  $2.533 \pm 0.033$  mg/l in October 2021 with the least concentration. However, there is a significant difference ( $p$ -value=0.000) between the concentration of Ca<sup>+</sup>. Magnesium has the highest concentration of  $6.233 \pm 0.203$  mg/l in March 2022 and  $1.733 \pm 0.033$  mg/l in October 2021 with the lowest concentration. There was a significant difference between the monthly concentrations of Mg<sup>+</sup>.

The ionic composition of the Kware Lake was dominated by calcium, followed by magnesium, just like the normal freshwater in which calcium is the dominating cation (Golterman and Kouwe,

1980). This scenario, which was described by Lesack and Melack (1991), most likely explains why the two ions were most concentrated in the month of March 2022.

Numerous human activities were observed throughout the study periods, these include; washing clothing and even automobiles, fishing, and farming, which had an impact on the concentration of nitrate, phosphate, and sulphate. The highest concentration of phosphorus was found to be  $0.711 \pm 0.002$  mg/ml in March 2022 and  $0.039 \pm 0.002$  mg/ml in October 2021. However, there was a significant difference between the months. The highest concentration of SO<sub>4</sub> was  $0.606 \pm 0.002$  mg/ml obtained in March 2022 and the least was  $0.010 \pm 0.001$  mg/ml in October 2021. The highest concentration of NO<sub>3</sub> was  $0.717 \pm 0.001$  mg/ml in March 2022 and the lowest was  $0.039 \pm 0.001$  mg/ml obtained in October 2021. The highest concentration of Na<sup>+</sup> was  $53.000 \pm 10.974$  in March 2022 and  $39.333 \pm 17.510$  was the least. However, it was observed that there was no significant difference in Na<sup>+</sup> since the  $p$ -value (0.398) is greater than 0.05 (Table 1).

Higher concentrations of nitrate, phosphate, and sulfate may have resulted from surrounding farmlands' surface runoff and leaching of nitro-phosphate sources and fertilizers. This corroborates with Mustapha (2008), who stated that fluctuations in nitrate and phosphate are strongly correlated with the effects of human activities on Oyunlake and its watershed. He further reported high levels of nitrate (6.4 mg/L), phosphate (2.2 mg/L), and sulphate (16.9 mg/L) which could have resulted from the leaching and run-off of nitro-phosphate and sulphate fertilizers from surrounding farmlands. Mustapha (2008) further stated that washing cow manure, using phosphate-based soaps and detergents while bathing, and washing into the lake could have contributed to the high ion concentration. While Armengol *et al.* (1999) linked sulfate to the eutrophication of reservoirs, Carpenter *et al.* (1998) and Carignan *et al.* (2000) found that

non-point source nutrients inputs from watershed are the main cause of eutrophication.

October and November of 2021 also saw lower levels of nitrates, phosphate, and sulphate. This is similar to the findings of Chindah *et al.* (2006) who reported that lower levels of nitrate have also been reported for other Nigerian freshwaters. Kadiri and Omozusi (2002) also reported the same findings, indicating that nitrates are crucial for the growth of plants and aquatic organisms such as algae, therefore, nitrate concentrations don't need to be high to encourage phytoplankton growth.

The present study indicated no variation in electric conductivity (EC) across the months at

$p > 0.05$  (Table 1). Therefore, differs from that of Ekhaton *et al.* (2015) who claimed that concentrations of electric conductivity significantly decreased during the rainy season and increased during the dry season. According to his hypothesis, conductivity varied seasonally, reaching high levels during the dry season and low levels during the rainy season. Onyema *et al.* (2010) reported a similar trend in numerous African rivers. This report does not, however, contradict the findings of Mustapha (2008) and Kadiri (2000) who found that the wet season had higher conductivity levels than the dry season, possibly due to the concentration of nutrients caused by evaporation, therefore dry season's high ionic content was caused (Edokpayi, 2005, Essien-Ibok *et al.*, 2010; Akan *et al.* 2009).

**Table 1:** Status of Water Variables of Kware Lake after Demolition of Structural Buildings

Variables	Oct. 2021	No. 2021	Dec. 2021	Jan. 2022	Feb. 2022	Mar. 2022
<b>pH</b>	6.99±0.081b	7.013±0.023b	7.453±0.068a	7.307±0.272a	7.453±0.068a	7.453±0.068a
<b>EC (µs/cm)</b>	420.67±111.40	486.000±30.01	569.000±28.05	569.000±28.05	569.000±28.05	569.000±28.05
<b>BOD (mg/l)</b>	15.20±2.12b	20.600±0.64b	24.600±0.64a	24.600±0.64a	24.600±0.64a	27.000±5.69a
<b>DO (mg/l)</b>	4.20±0.40b	4.200±0.40b	4.200±0.11b	4.200±0.11b	4.200±0.11b	6.200±1.01a
<b>NH4 (mg/l)</b>	1.00±0.21b	2.867±0.46b	3.400±0.41a	3.400±0.41a	3.400±0.41a	3.400±0.41a
<b>NO3 (mg/l)</b>	0.04±0.001f	0.086±0.002e	0.329±0.002d	0.422±0.005c	0.634±0.003b	0.717±0.001a
<b>P(mg/l)</b>	0.04±0.002f	0.149±0.001e	0.316±0.003d	0.483±0.004c	0.515±0.002b	0.711±0.002a
<b>Na (mg/l)</b>	39.33±17.510	39.667±19.974	40.666±11.259	40.666±11.836	47.000±17.387	53.000±10.974
<b>Ca(mg/l)</b>	2.53±0.033f	3.433±0.088e	4.367±0.088d	5.266±0.088c	7.133±0.088b	10.866±0.371a
<b>Mg (mg/l)</b>	1.73±0.033f	2.166±0.088e	2.600±0.202d	3.333±0.153c	4.266±0.067b	6.233±0.203a
<b>SO4 (mg/l)</b>	0.01±0.001f	0.134±0.001e	0.183±0.002d	0.257±0.002c	0.364±0.001b	0.606±0.002a

**Footnote:** Values are expressed as mean ± Standard Error of Mean for three replicates. One-way ANOVA followed by Duncan Multiple Comparisons Test. Values with the same super script in column are not statistically significant ( $p < 0.05$ )

Sediment variable analysis of Kware Lake was found to be more or less uniformly varied between the periods of study (Figure 2). Sediment geochemical analysis can reveal changes in the

ecosystem both inside and outside of a lake. An excellent indicator of the total amount of organic matter in the sediment and a suitable surrogate for a water body's biomass output are phosphorus,

nitrate, and organic carbon (Burgess, 2007; Wilson *et al.*, 2013). It is also a result of erosion processes in which soil degrades into the sand, silt, clay, and organic debris, which is then transported and settles at the bottom of bodies of water (Alloi *et al.*, 2022).

Sedimentation governs the dispersion of living things as well as their overall growth. Silt, on the other hand, has lower bottom stress than sand and will stay suspended for considerably longer (Wright, 1995). The present study shows that electric conductivity (EC), organic carbon (OC), and clay did not significantly differ between the months of study at  $p > 0.05$  (Table 2). This is in contrast to Garadjou and Kannan's (2007) study, which found that clay, had a diverse composition during their investigation and was portrayed as the primary component of the sediments, followed by silt and sand. In their investigation, Alloi *et al.* (2022) reported that the bottom sediments' textural class was dominated by clay. October 2021 to January 2022 recorded the lowest concentration, while March 2022 has the highest concentration. Similar findings with a larger percentage of sand fractions were reported by Vinithkumar *et al.* (1999). Similar findings were also reported by Alloi *et al.* (2022) using sediments from the reservoir's upper bottom that was primarily made up of clay and sand particles.

Sand particles reveal a significant difference between the period of study, with the highest concentration recorded in March 2022 ( $95.03 \pm 1.707$ ) and the lowest concentration recorded in October 2021 ( $86.72 \pm 0.653$ ). Values recorded for Silt were significantly different at  $p < 0.05$  between the months. The highest concentration of silt was recorded from December 2021 to March 2022 ( $10.600 \pm 1.131$ ) and the lowest concentration was recorded in October 2021 at  $3.533 \pm 0.800$ . Clay particles were more or less uniformly distributed between the months of study, only October and November

2021 recorded monthly means of 1.43(g/Kg) and 1.46(g/Kg) respectively (Table 2).

A report by Alloi *et al.* (2022) stated that particle size distribution of sediments demonstrates longitudinal variation, with coarse material, primarily sand and silt, dominating the upstream region and fine grains, primarily silt and clay, accumulating in the deep parts and close to the dam wall, which corroborates with the present findings. According to than Garadjou and Kannan's (2007) studies, silt composition fluctuated between 3.10 and 9.44 per cent, they also noted that the silt composition ranged between 4.00 and 12.42%, dry season and lowest percentage and the rainy season recorded the highest.

The highest pH concentration was recorded in February and March 2022, however, there was a significant difference (at  $p < 0.05$ ) between the months. Similar findings were made known by Alloi *et al.* (2022), who noted that the pH of the sediments at the bottom had a mean value of 6.63. Boyd (1995) also stated that lakes have a pH range between 4 and 9, hence the study's findings were observed to fall within that range. Similar values for pH in reservoirs have been reported by other researchers according to Alloi *et al.* (2022). The sediments in the Maruba dam reservoir were found to have an average pH value that was slightly acidic, which was a sign of soil additions and nutrients as reported by Donahue *et al.* (1983) and for the present study possibly due to demolished structural building particles that might found their way into the lake.

According to Alloi *et al.* (2022), the acidic conditions of pH may be caused by the acidic character of organic materials as well as large concentrations of aluminium and iron oxides. The presence of aquatic life under various environmental conditions can be related using a pH test for bottom sediments Alloi *et al.* (2022). The variables related to the nutrient release, the physical status of the soil, and the effects of

harmful compounds are all reflected by pH Sharma *et al.* (2013). As a result, pH is crucial in

determining the qualitative status of the sediment's water bodies such as Kware Lake.

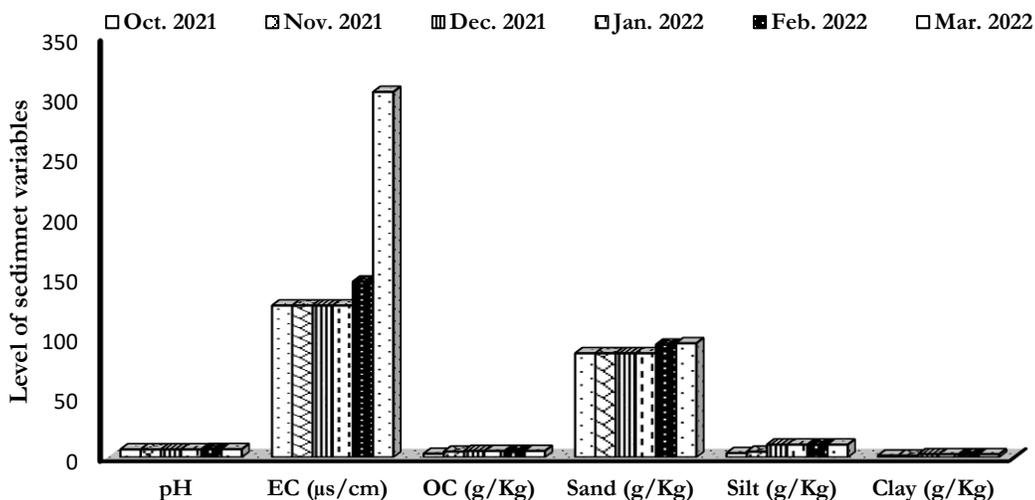


Figure 2: Monthly mean variations of sediment variables at Kware Lake

**Table 2.** Status of Sediment Variables of Kware Lake after Demolition of Structural Buildings

Variables	pH	EC (µs/cm)	OC(g/Kg)	Sand (g/Kg)	Silt (g/Kg)	Clay (g/Kg)
Oct. 2021	6.62±0.049 <sup>b</sup>	126.47±25.941	3.00±1.251	86.72±0.653 <sup>b</sup>	3.53±0.800 <sup>b</sup>	1.43±1.033
Nov. 2021	6.62±0.049 <sup>b</sup>	126.47±25.941	4.78±1.629	86.72±0.653 <sup>b</sup>	4.70±2.406 <sup>b</sup>	1.46±1.018
Dec. 2021	6.62±0.049 <sup>b</sup>	126.47±25.941	5.33±0.458	86.72±0.653 <sup>b</sup>	10.60±1.131 <sup>a</sup>	2.60±1.300
Jan. 2022	6.62±0.049 <sup>b</sup>	126.47±25.941	5.33±0.458	86.72±0.653 <sup>b</sup>	10.60±1.131 <sup>a</sup>	2.60±1.300
Feb. 2022	6.83±0.071 <sup>a</sup>	146.40±51.869	5.33±0.458	93.87±3.437 <sup>a</sup>	10.60±1.131 <sup>a</sup>	2.60±1.300
Mar. 2022	6.83±0.071 <sup>a</sup>	304.40±124.266	5.33±0.458	95.03±1.707 <sup>a</sup>	10.60±1.131 <sup>a</sup>	2.60±1.300

**Footnote:** Values are expressed as mean ± Standard Error of Mean for three replicates. One-way ANOVA followed by Duncan Multiple Comparisons Test. Values with the same super script in column are not statistically significant (p<0.05).

## CONCLUSION

Kware Lake's level of physicochemical variables was assessed, following the demolition of constructed structures within and surrounding the lake. The study discovered minor variations in physicochemical characteristics in both water and sediments. The results, however, differ marginally from previous research (before demolition), which is most likely owing to the removal of structural buildings around the lake

and other anthropogenic activities. As a result, we urge that Kware Lake be monitored regularly.

## CONFLICT OF INTEREST

We declare that no conflict of interest exists.

## ACKNOWLEDGEMENT

This work was supported by the Tertiary Education Trust Fund (Tetfund) Institution Based Research (IBR) Normal Intervention 2020.

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