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Analysis of Some Physico-chemical Parameters and Heavy Metals of Abadaba Lake in Imo State, Nigeria.

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Abstract
Analysis of some physico-chemical parameters and heavy metals of Abadaba Lake was conducted. Three points were chosen for the study: point A, upstream, point B, midstream and point C, an area further downstream. All the points were replicated three times. The physical parameters measured were temperature, pH and transparency and they were all done insitu. The chemical parameters were measured in the laboratory, and this includes dissolved oxygen, biochemical oxygen demand, total hardness and nitrate. Iron, zinc and cadmium were analyzed using the Atomic Absorption Spectrophotometer at different wavelengths. There were no significant differences ($p>0.05$) amongst the points in temperature. However, there were significant differences ($p<0.05$) in transparency and pH. Transparency is highest in point A with a value 80.51±0.19 and lowest in point C. Transparency decreases from point A to C while pH increases from point A to C. There were no significant difference ($p>0.05$) between points A and B with respect to dissolved oxygen but they were significant difference ($p<0.05$) from point C. There were significant differences ($p<0.05$) in all the three points for BOD with point C having the highest demand of 3.17±0.71. Nitrate also show a significant differences ($p<0.05$) amongst all the points, with point A having the least value and point C the highest value. There were significant differences ($p<0.05$) in zinc amongst the points. There were also significant differences ($p<0.05$) in cadmium between point A and the other points. Point B has the highest iron content which were significant difference ($p<0.05$) from both points A and C. The results of the physico-chemical analysis as well as the heavy metals serves as a database for further studies as well as shows the impact of human activities like sand excavation on the aquatic ecosystem. Nevertheless, most of the values were still within limits offered by WHO.
Keywords: Aquatic ecosystem, anthropogenic, excavation, standards, turbidity

1. Introduction

Rivers or lakes are to some extent unique, but the quality of an aquatic ecosystem is dependent on the physico-chemical qualities of water and the biological diversity of the system (Irfanullah, 2006). Many of man's activities have a direct and indirect effect upon rivers systems and in extreme cases the consequent environmental changes have been widespread affecting the channel riparian, floodplain delta or estuaries (Akoma, 2007). The freshwater ecosystem can be influenced by a number of physical and chemical parameters as well as heavy metals. Many studies have been carried out on the physico-chemical parameters of Northern waters by Ibrahim, Ibrahim and Samhan (2009) on Kontagora reservoir as well as other rivers like the Imo River estuary (Akoma, 2007).

Lakes are inland depressions that held standing freshwater resulting from runoff or bound water or both all year round. They take depth range from a few materials to over 1600 meters (Ayoade,Fagade and Adebisi, 2006). Lake waters with good qualities are essential in maintaining recreation, fishing and provision of municipal drinking and good water supply (Ayoade *et al*., 2006). Lakes are characterized in terms of production of organic matter and rich in nutrients. Abadaba Lake is one of the largest lakes in Imo State and is presumed to have originated from a natural depression (Ita and Balogun, 1983).

The lake is classified as shallow, eutrophic with relative mixing (Nwufo, Uzoma, Dike and Maduka, 2016). Organic materials in the lake encourage the proliferation of oxygen – consuming decomposers such as bacteria and fungi (Moran and Morgan, 1982). The lake serves the purpose of domestic water supply, dry season irrigation, fishing and other purposes. Aquatic environmental assessment provides the tools necessary to understanding on how water bodies are being disturbed or affected by full range of human activities like sand mining. Most water bodies serve as a source of domestic water supply for the rural communities, hence it has become necessary to have knowledge of their physical, chemical and some amount of heavy metals in them. Check on Abadaba Lake is not out of place, it will provide information for regulations and its effective management. The attainment of good management techniques that ensures proper analysis of the chemical, physical and heavy metals of the aquatic ecosystem will form a baseline study. Furthermore, this study aims to analyze some of the physico-chemical characteristics on the water body, its heavy metal concentration as well as compare the levels with that of the approved standards for safe water.

2. Materials and Methods

2.1. Study Area

Abadaba Lake is situated in Ihitte uboma Local Government Area of Imo State and lies within latitude 5.41°N and 5.45°N, and longitude 6.45°E and 6.50°E and occupies the area between the lower River Niger and the upper and middle Imo River. It has the average rainforest of 2169.8mm which is obtained within the ranges of 148 and 158 rainy days. The relative humidity falls between 50-95%. (NPC, 1991). Hence, is within the humid rainforest zone which is characterized by long duration (7-12 months) of rainfall and short period of dry season. The water flows through the Onu-Imo River to the Onu- Inyu stream and finally channelled to Imo River where it serve so many purposes. The Abadaba Lake has been a source of sand excavation over the years and has been a source of income for the communities situated near the lake.

2.2. Sample Collection

The samples were collected from three sample locations, which were labelled as:

Point A: The upstream, Point B: The midstream and Point C: The downstream. All the sample points were replicated three times.

The water used for sampling were collected using plastic container at the various point sources. The plastic containers were well washed to avoid contamination of the water samples that were collected from the lake. The physical parameters were done in-situ while the chemical parameters and heavy metals were done in the laboratory of the Department of Fisheries and Aquatic Resources Management, Michael Okpara University of Agriculture, Umudike. To avoid changes, water samples were kept in the container containing ice blocks and were taken to the laboratory for analysis.

2.3. Physical Analysis

The following physical analysis were carried out in the field

2.3.1. Temperature

Temperature was determined using 0-100°C mercury bulb thermometer. These were done by dipping the thermometer into the water and allow for five (5) minutes for it to stabilize and then the temperature was read off in degree Celsius.

2.3.2. Transparency

Transparency was determined using a sechi disc. The disc was allowed to sink into the water until it is no longer visible. The depth at which it became visible was noted and the disappearance depth was also taken note of. The mean between the two gives the transparency of the lake which was recorded in centimetres.

2.3.3. pH

The pH of the water samples were determined using a pH meter, which was calibrated using the pH meter against two buffer solutions, either buffer pH 7.0 and 4.0 or pH 7.0 and 10.0. These are ranges that bracketed the expected pH of the samples that were analyzed. It was then dipped in the water and allowed to stabilize. The pH value was read off.

2.3.4. Chemical Analysis

The chemical analysis of the water samples were analyzed in the laboratory. The following chemical properties were measured.

2.3.5. Dissolved Oxygen

This was determined using a dissolved oxygen meter DO 110 Series Oakton Meter. It is a digital meter with a probe that was immersed into the water sample and allowed to stabilize for about 2 minutes and then, the value is read off in the digital display board. Dissolved oxygen is measured in mg/l

2.3.6. Total Hardness

This was measured using EDTA method. It was done by pippeting 250ml of water samples in a conical flask with one end serving as the control and the other as the test sample. The pH of the system was raised to H10 with 20ml NH4buffer solution and titrated with 0.02N EDTA solution.

2.3.7. Biological Oxygen Demand

Biological oxygen demand test takes 5 days to complete and was performed using a dissolved oxygen test kit. The BOD level was determined by comparing the initial dissolved oxygen level of a water sample taken immediately with the final dissolved oxygen level of a water sample that was incubated in a dark room for 5 days. The difference between them gives the Biological oxygen demand of the water in mg/l.

2.3.8. Nitrate:

This was conducted according to Lyedahl method (ALPHA,1999).

2.3.9. Heavy Metals Analysis

Iron, Zinc and Cadmium were analyzed using an Atomic Absorption Spectrophotometer. The heavy metals were read off in the AAS (Atomic Absorption Spectrophotometer at different calibrated wavelength and hence gives its readings.

2.3.10. Statistical Analysis

The results were analyzed using the Analysis of Variance (ANOVA), and differences in mean separated using the fisher’s Least Significant Difference (LSD)

3. Results and Discussion

Table 1 shows results of the Physical parameters for the entire period. There were no significant differences ($p>0.05$) amongst the points in temperature. However, there were significant differences ($p<0.05$) in transparency and pH. Transparency is highest in point A with a value 80.51±0.19 and lowest in point C.

Figure 1 showed the different variation in temperature, transparency and pH in the different locations in the first month. Temperature shows acceptable (WHO, 2018), a range of 15 - 35°C for fish development and human well being. This is within the recommended range by Mustapha (2008). This result is similar to Fafioye *et al*. (2005) who reported a range of 26.5℃ -31.5℃ in Omi water body, Ago Iwoye, Ogun state, Nigeria and agreed with previous reports for temperatures in the tropics (Atobatele and Ugwumba, 2008; Ayoade *et al*., 2006). Transparency shows the highest value on the point 1 at about 79.17cm. The water maintains the transparency level at that point probably because of the absence of mining activities at the upstream. The water deemed a clean water and safe for drinking using the guideline for water quality Index (WHO, 2018). The other two points, point B and point C showed a low range of transparency of 50.67cm and 41.67cm respectively, and this may be as a result of suspended clay particles caused by machines used for excavation in those points (PeckYen *et al.,* 2010)

The fluctuations in temperature depends mainly on the climatic condition, sampling times, the number of sunshine hours. This can also be affected by specific characteristics of water environments such as transparency, wind force, plant cover and humidity. Decreased temperature is often associated with low Dissolved Oxygen content (Eze & Okpokwasili, 2008). Transparency also shows the same trend in Figure 2. The second month had a high transparency value of 79.91cm in point A and the least value of 37.25 in point C. The same is also true for the third month as shown in figure 3. Suspended particles that reduce clarity can include organic particles such as microbes, plant particles etc and inorganic particles like silt and clay particles. The physical disturbance of the sediment and sand affects the suspended solids and increase transparency of the water. Transparency is affected when there are particles in the water that absorb light and cause backscattering (suprihanyono, 2004). Transparency is a very important factor in water quality. The third point when compared with the first and second point in terms of permissibility limits (WHO, 2018) will not be safe for drinking and will require more effort in its treatment.

Mean pH for all the points in the three months decreased from the point A to point C. It implies that the different treatment is merely acidic. The acidic nature of the pH is attributable to geological and biochemical factors within the rivers catchment (Prati *et al*., 1971). Water migrating from terrains poor in silica or lime usually have pH value close to 7 or slightly lower. Abdo (2005) had shown that the pH value of pure water is at neutral scale of (7.0). Therefore, the different treatment/points can be adjudicated of being abnormal for aquatic life survival because the optimal range of fish survival is pH of 6.5-8.5. Also considering the low pH state of the different points, it is expected that there will be low bacteria load in the lake, because changes in normal pH values range affects microbial physiology and increases inorganic abundance such as silt and clay (Hassamin, 2006).

Table 1: The physical parameter across the points at the end of the experiment

Variables	Point A	Point B	Point C
Temperature	28.53 ± 0.21^{a}	28.89 ± 0.35^{a}	28.33 ± 0.17^{a}
Transparency	80.51 ± 0.19^{a}	50.14 ± 0.15^{b}	38.17 ± 0.31^{c}
pH	5.23 ± 0.05^{c}	5.42 ± 0.05^{b}	6.11 ± 0.09^{a}

Mean values with the same superscript letters in the row were not significantly different ($p>0.05$).

Data are mean value of the triplicate of the treatment ± standard error

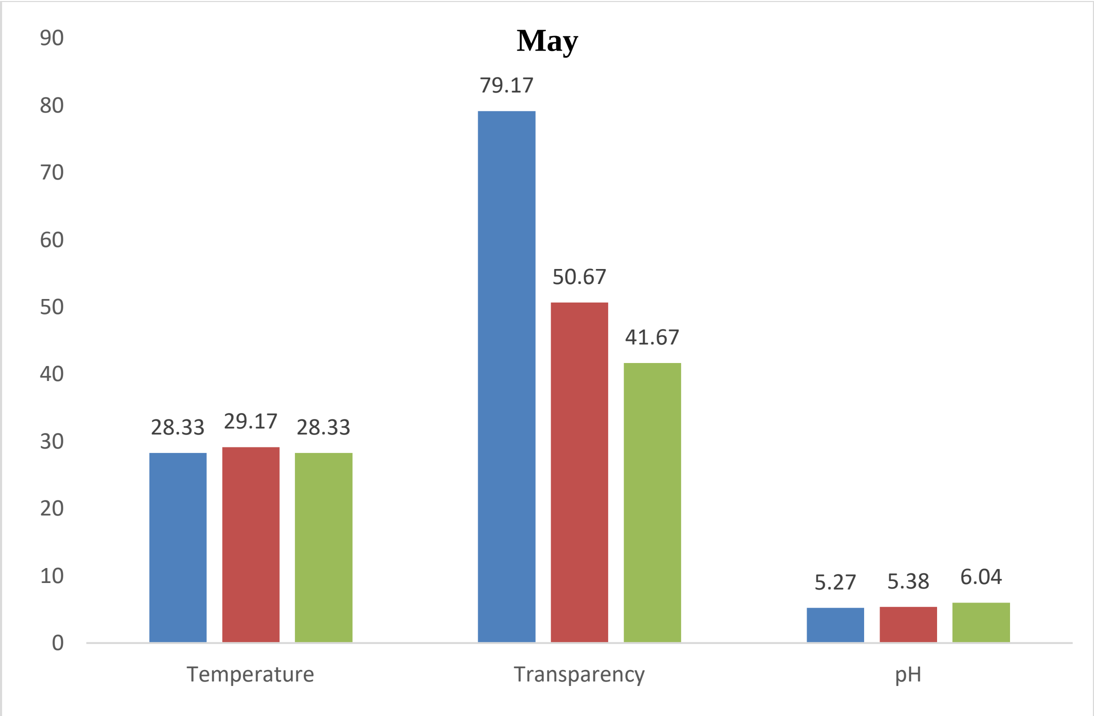

Fig. 1: Variations in the physical properties amongst the points in the first month

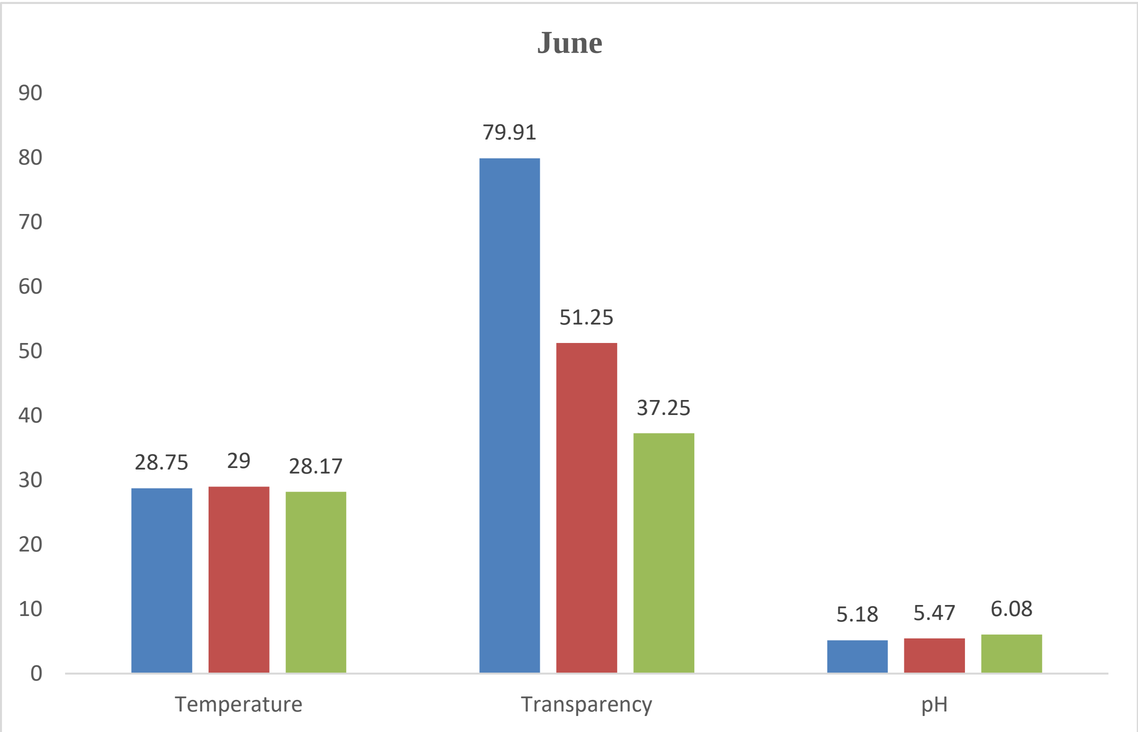

Fig. 2: Variation in the Physical properties in the second month

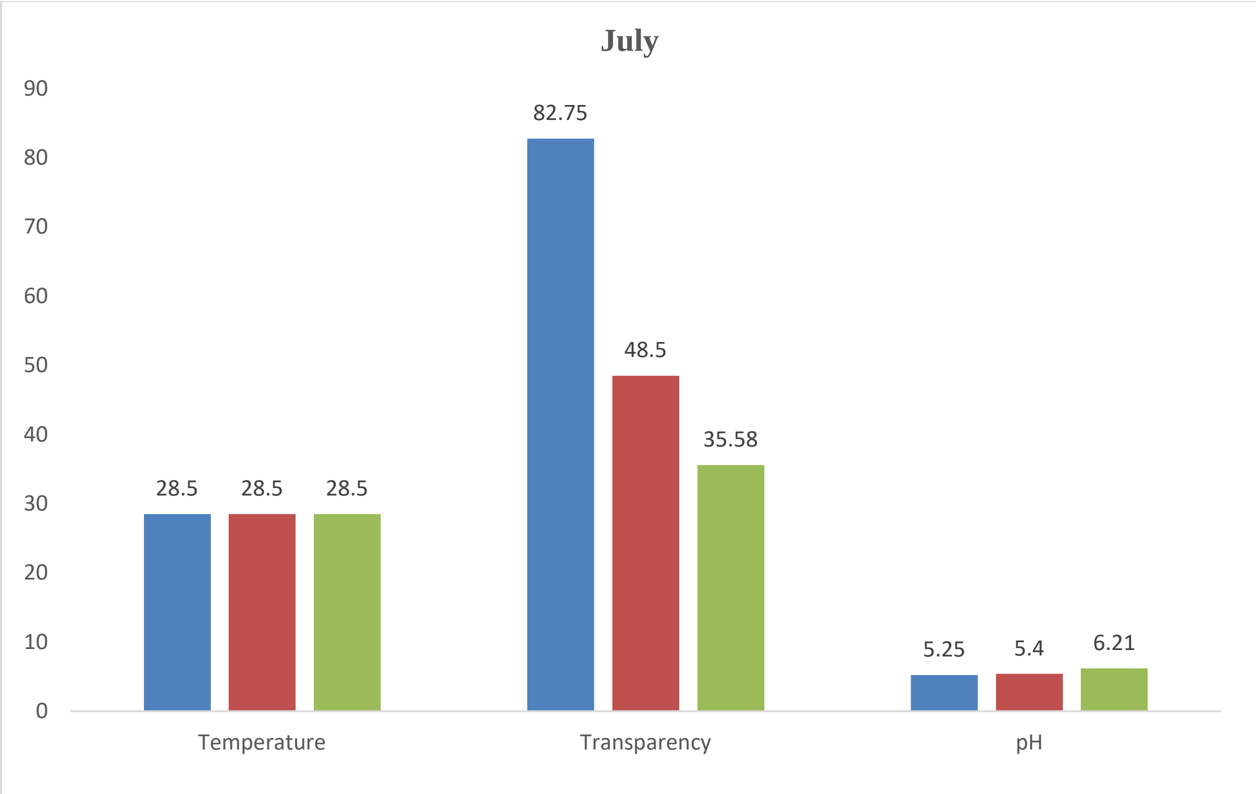

Fig. 3: Variations in the physical properties in the third month

Table 2 showed the chemical parameters of the water under study. There were no significant difference ($p>0.05$) between points A and B with respect to dissolved oxygen but there were significant difference ($p<0.05$) from point C. There were significant differences ($p<0.05$) in all the three points for BOD with point C having the highest demand of 3.17 ± 0.71. Nitrate also show a significant difference ($p<0.05$) amongst all the points, with point A having the least value and point C the highest value. There were no significant difference ($p>0.05$) between points B and C with respect to total hardness, but there exist a significant difference ($p<0.05$) between point A and the rest. Figures 4, 5 and 6 showed the variation in chemical properties of the various points for the months of May, June and July. Dissolved oxygen generally decreased in value from point A to C except in July where the reverse is the case. Dissolved oxygen is an important factor to the aquatic organism, because it affects their biological process, respiration of animal and the oxidation of the organic matter in water and in sediments (Eze and Okpokwasili, 2008), there is high dissolved oxygen at the three points, dissolved oxygen is considered safe for human consumption (WHO, 2018). The lake could be considered safer for drinking as well as good for aquaculture. Point A and point B have low DO in the first month, maybe because of discharge of inorganic materials like soap during washing and agricultural waste by the humans at point A, whereas point B can be as a result of ongoing sand excavation depositing organic matter, as high organic matter and low flow of water limits primary production (Mandal *et al.,*2009).

There was a direct relationship between dissolved oxygen content and BOD. Point A generally has high BOD content than Point C except for the month of June. The minimum value of Biochemical oxygen demand was recorded in point C and this may be due to accumulation of clay and silt particles after mining which decrease the bacteria load in water from this point. The effect of this on aquatic organism may be devastating as fish production in this point may be low since most aquatic organism may not withstand oxygen stress, for long time. Nitrate mean value increases from point A to Point C for all the three months. Nitrate value is generally high, even though is within the recommended value (WHO, 2018) for safe drinking water. The high nitrate values may be as a result of anthropogenic activities, such as mining, waste discharge etc. Water hardness is usually defined as water with a high concentration of calcium and magnesium ions. Water hardness values are high except in the third month were there was a great decline in the value. The water at the third month is said to be soft and maybe because of excess rainfall in July washing out the calcium and magnesium in the experimental site.

Table 2: Chemical parameter across the treatment at the end of the experiment

Variables	Point A	Point B	Point C
Dissolved oxygen	7.43 ± 0.26^{a}	7.46 ± 0.26^{a}	6.10 ± 0.25^{b}
BOD	3.02 ± 0.31^{b}	2.74 ± 0.55^{c}	3.17 ± 0.71^{a}
Nitrates	38.10 ± 0.59^{c}	62.15 ± 0.75^{b}	66.19 ± 0.12^{a}
Total Hardness	81.61 ± 0.65^{b}	90.76 ± 0.69^{a}	88.60 ± 0.68^{a}

Mean values with the same superscript letters in the row were not significantly different ($p>0.05$).

Data are mean value of the triplicate of the treatment ± standard error

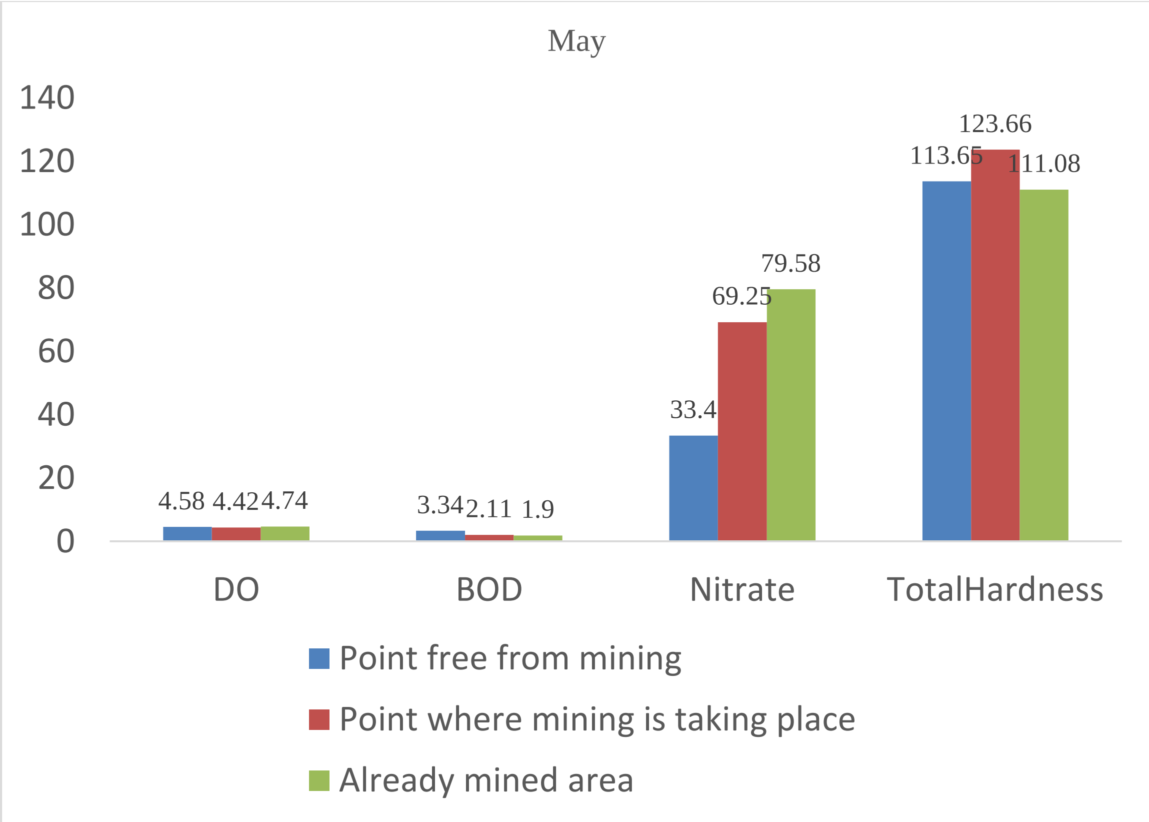

Fig. 4: Variation in chemical properties in the first month

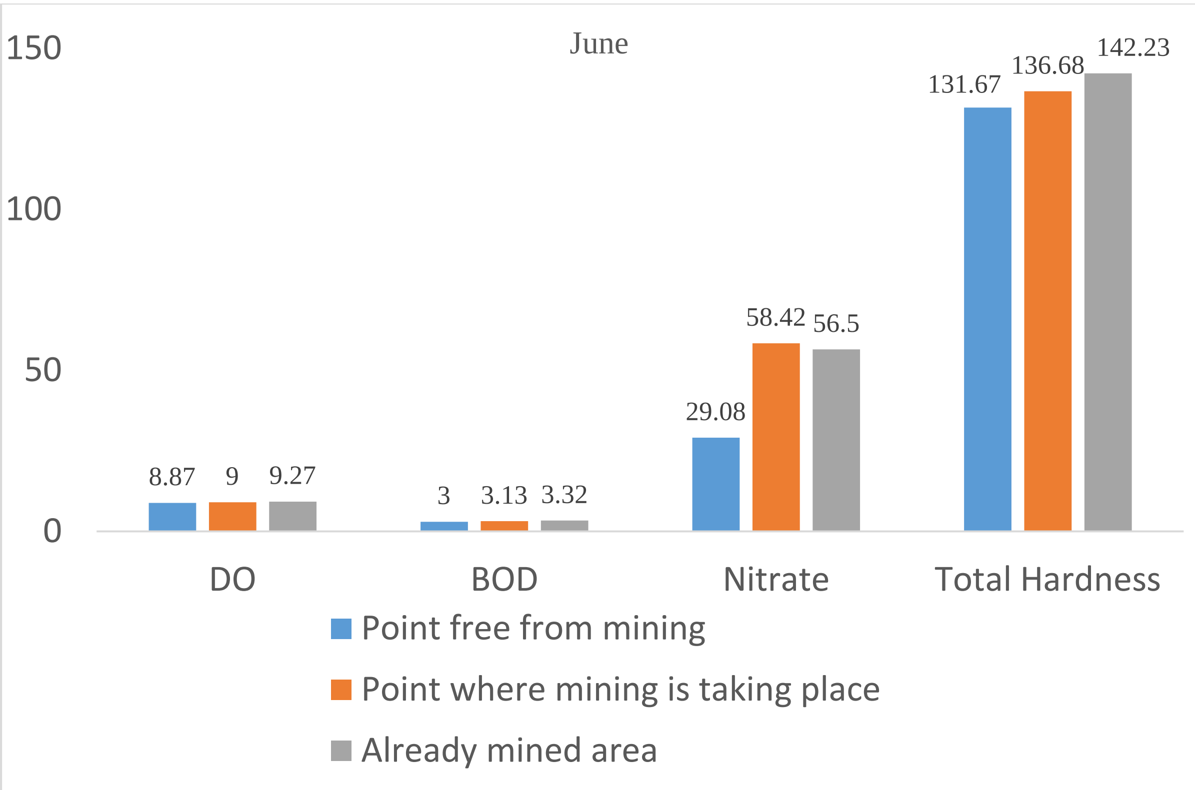

Fig. 5: Variations in chemical properties in the second month

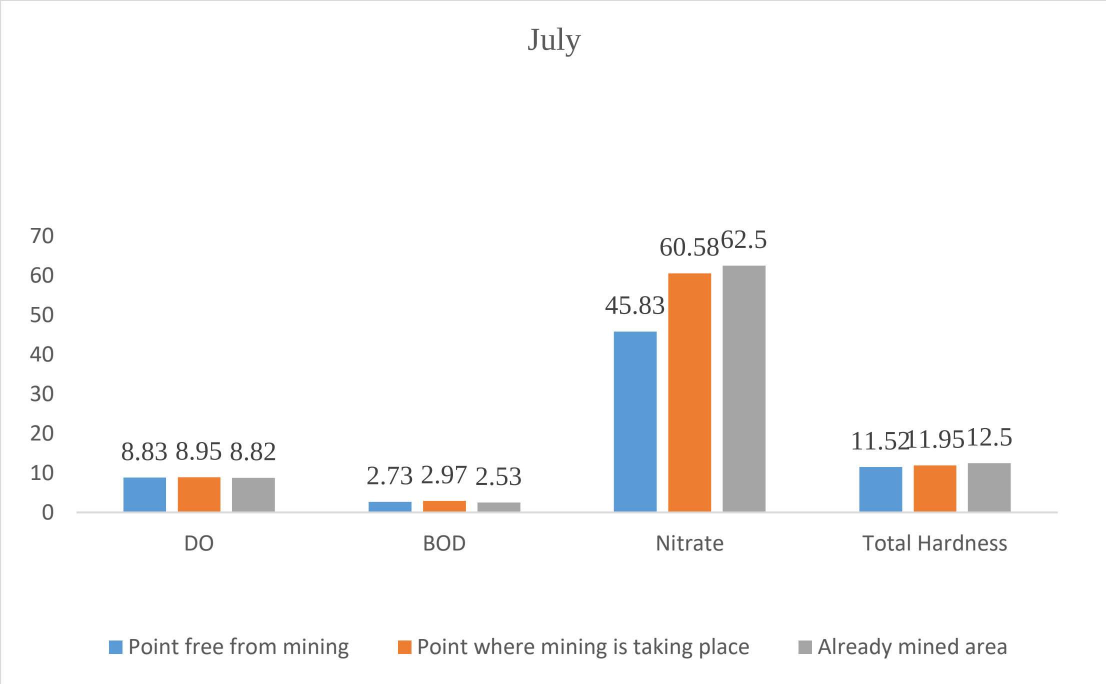

Fig. 6: Variations in the chemical properties at the third month

Table 3 showed the heavy metal of the water under study. There were significant differences ($p<0.05$) in zinc amongst the points. There were also significant differences ($p<0.05$) in cadmium between point A and the other points, however, there exist no significant difference between point B and C. Point B has the highest iron content which was significantly different ($p<0.05$) from both points A and C. However, there exist no significant differences ($p>0.05$) between point A and C for iron. Figure 7 showed the heavy metal concentration for the first month. There was an increase in values from points A to Point C. Zinc increased from 0.025 to 0.05mg/l, cadmium increased from 0.32 to 0.54mg/l and iron increased from 4.11 to 6.15, respectively. Heavy metals are naturally present in water. Zinc is naturally present in water. The zinc concentration obtained in the three sample points meet up World Health Organization (WHO, 2018) standard and Nigeria guideline for zinc set at about 3.0mg/l. It could also be reported that the zinc content could be attributed to natural sources such as rainfall and underground leaching than human activities. Abadaba Lake did not contain excessive levels of heavy metals when compared to results from other studies. This finding is consistent with those of Amoo *et al*. (2005) who reported on the freshwater from Lake Kainji on the upper reach of River Niger. Kakulu and Osibanjo (1992) reported higher concentrations of Cadmium, iron and Zinc in water collected from Warri River, and higher Cadmium, lead, Copper, and Zinc levels in waters from Calabar River, than recorded in this study. It has been reported that the differences in geography and geologies, as well as activities in various rivers affects the amount of metals present (Bricker and Jones, 1995).

Figures 8 and 9 showed high cadmium and iron values in point B. Human activity such as mining, flow of water over soil and minerals are also known to contribute heavy metals to aquatic ecosystems (Akpan and Ufodike, 1995). Cadmium concentrations can become elevated in waters that are influenced by sources such as mining, minerals processing, and combustion of fossil fuel. Although rare in surface waters, cadmium is highly toxic to some aquatic life. USEPA (2001) recommended that the highest 4-day average dissolved cadmium concentration not exceed 0.08 to 0.25 µg/L at water hardness of 20 and 100 mg/L as calcium carbonate, respectively. Cadmium metal is used in steel metal and battery industries and its presence in water above the WHO (2018) guideline is dangerous to human and aquatic life, the presence of cadmium in this sample maybe as a result of human activities, this is also true for iron.

Table 3 Heavy metal across the treatment at the end of the experiment

Variables	Point A	Point B	Point C
Zinc	0.02 ± 0.00^{c}	0.17 ± 0.20^{a}	0.12 ± 0.11^{b}
Cadmium	0.24 ± 0.93^{b}	0.41 ± 0.18^{a}	0.31 ± 0.21^{a}
Iron	2.85 ± 0.12^{b}	4.12 ± 0.15^{a}	3.89 ± 0.20^{b}

Mean values with the same superscript letters in the row were not significantly different ($p>0.05$).

Data are mean value of the triplicate of the treatment ± standard error

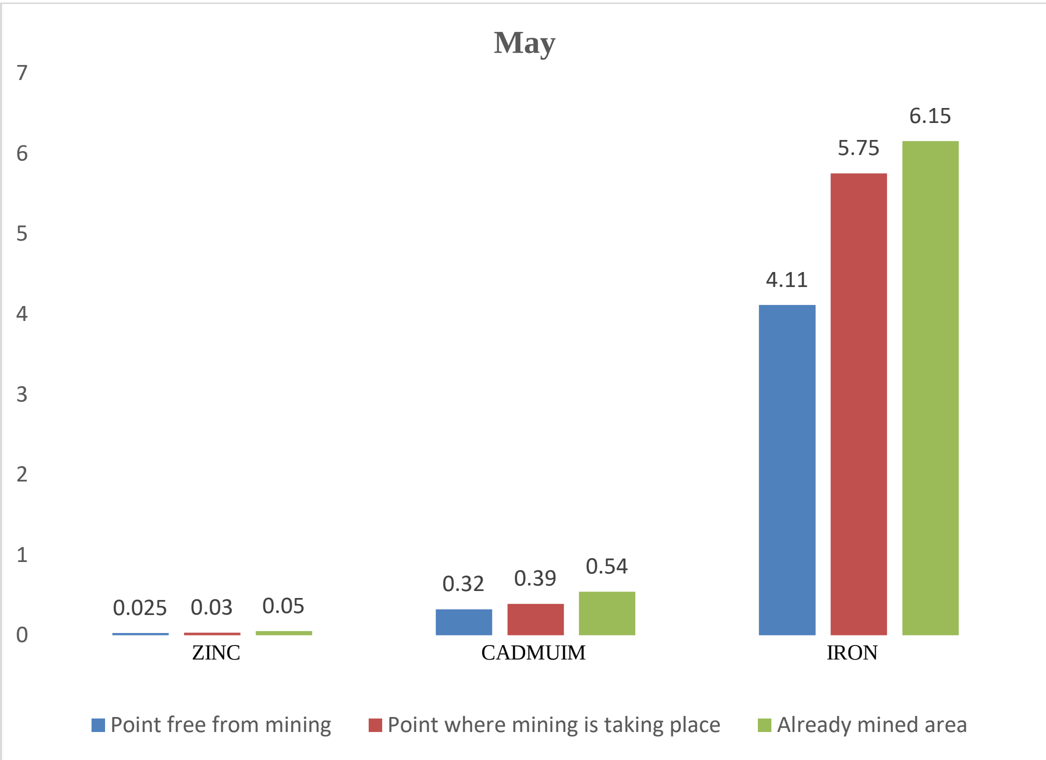

Fig. 7: Variations in the heavy metals properties in the first month

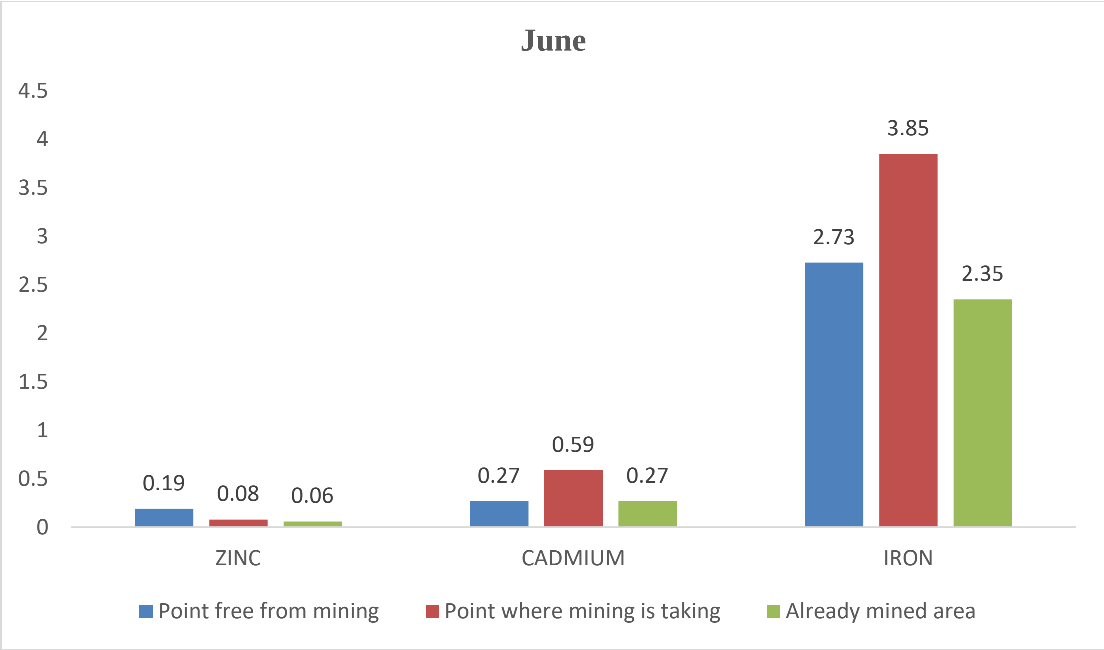

Fig. 8: Variations in the heavy metal properties in the second month.

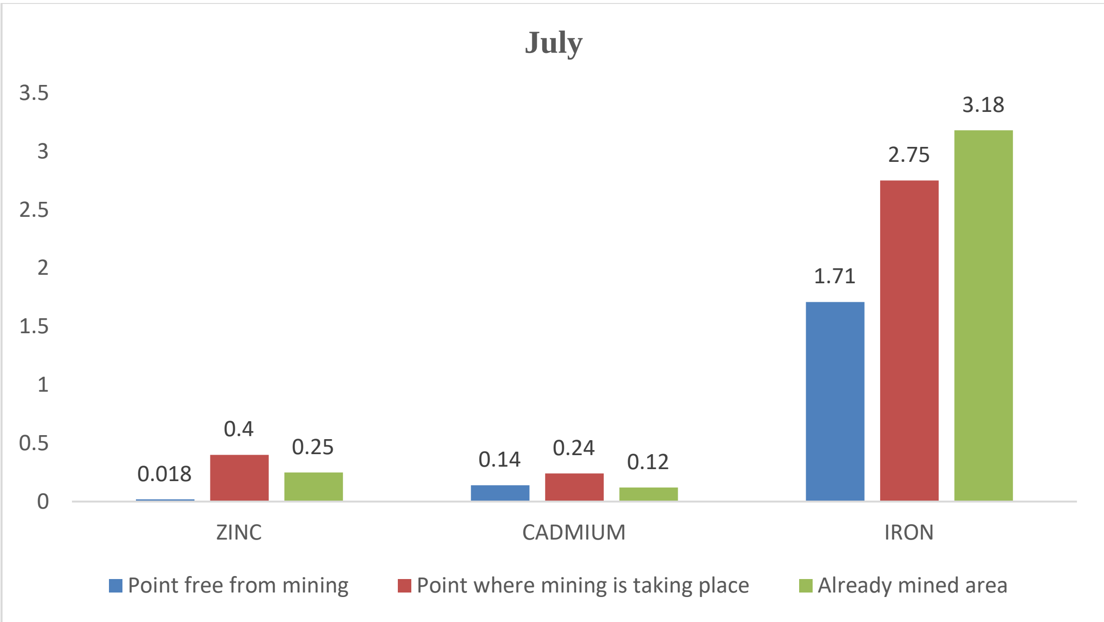

Fig. 9: Variations in the heavy metal properties in the third month

KEYS

Point A upstream Point B midstream Point C downstream

Table 4. WHO Water Quality Standard Guideline (2018)

Parameters	Permissible value
Temperature (°C)	15 – 35
pH	6.5 – 8.5
Transparency (cm)	50
Dissolved oxygen (mg/l)	4 – 9
Biochemical Oxygen Demand (mg/l)	10 - 50
Nitrate (mg/l)	40 -50
Total hardness (mg/l)	100 - 500
Zinc (mg/l)	1 - 5
Cadmium (mg/l)	0.001 – 0.05
Iron (mg/l)	0.2 – 2

4. Conclusion

The results of the physico-chemical analysis as well as the heavy metals serves as a database for further studies as well as shows the impact of human activities like sand mining on the aquatic ecosystem. Nevertheless, most of the values were still within limits offered by WHO (2018). A long term monitoring program should be embraced to minimize the release of sediments to the lake and further studies should be carried out on the lake.

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