Assessment of Heavy metals contaminants in Mountain Top University Lake

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Abstract.

This research investigated heavy metals contaminants in Mountain Top University (MTU) Lake. The use of the lake for several agricultural purposes particularly fishing necessitated this project as most people in the community patronize the bay for food. It is expected that the contents of the lake will invariably make up the water animals therein. This report examines the physicochemical quality of the Lake. Lammottee spectrophotometer was used to determine the array of metals present in the body of water. The result from the physicochemical analysis reveals the presence of Chromium (Cr) 4.31 ppm, Lead (Pb) 0.04 ppm, Iron (Fe) 0.49 ppm, Copper (Cu) 0.12 ppm, and Manganese (Mn) 0.03 ppm. Out of these five heavy metals analysed, Only Copper and Manganese were below acceptable consumable levels, Iron, Lead and Chromium were above with Chromium at exceeding concentration. This indicated substantial deviation from the recommended or regulatory limit. The high concentration of chromium in particular in the body of the water rendered the lake unfit for agricultural purposes. Chromated water is toxic to the health of living organisms with minimal benefits.

Keywords: *Lake, Chromium, Heavy metals, Physicochemical analysis, Toxicity*

1.0 Introduction

Domestic and industrial discharges cause water pollution. Water pollution by heavy metals has become an increasing issue of concern both in developed and developing nations. Metals in general have beneficial roles in the body of living organisms. Heavy metals in low concentrations are essential in different formats for various kinds of living life but are harmful to health at high concentrations, they cause toxicity and carcinogenicity. It is the major cause of allergy and also inhibits the activity of sensitive enzymes in living things. They become a threat to health especially human beings at a concentration higher than the amount the body system can accommodate. One of the major heavy metal pollutants found in Lake water is Chromium. Chromium, a naturally occurring element is found in animals, plants, rocks, water, soil, volcanic dust and gases. It enters the environment from both natural and anthropogenic sources (Saputro *et al.,* 2014). It rarely occurs in the Earth's crust as an element (or metal) but as a compound or ions form in Lake water. The main commercial source of Chromium is from the ore of chromite ($FeCr_2O_4$). Chromium exists mostly in two valence states: Hexavalent chromium Cr (VI) and trivalent chromium Cr (III).

Chromium residues find their way into water bodies and soil either through run off or percolation of rainwater. Natural bodies of water have been known to possess dissolved amounts of chromium in the form of oxides. Chromium in the aquatic media exists in the soluble state or as suspended solids adsorbed unto clayish materials and organics and their related substances. Chromium from Lakes comes in oxide forms namely; Chromium (III) oxide and chromium (III) hydroxide as water-soluble compounds. Cr (III) has low solubility whereas Cr (VI) has high solubility and can easily move through the groundwater and get mixed with it (Tripathi and Chaurasia, 2020). Research studies have revealed that total chromium was identified in both surface and ground waters at 427 of 1,699 and 813 of 1,699 cases in previous NPL hazardous waste sites as detected in some environmental media (HazDat, 2007). Land erosion is also a natural contributor of Chromium by which the runoff water empties into a main body of water (Nriagu and Pacyna, 1988). Most of the soluble chromium compounds are present as chromium (VI) or as chromium (III) complexes and these generally account for a small percentage of the total. Soluble chromium (VI) may persist in some bodies of water for a long time, but will eventually be reduced to chromium (III) by other reducing agents or organic matter activities in water (Cary 1982; EPA 1984a; Lide 1998). In the United States, the groundwater concentration of chromium is generally low, with measurements in the range of 2–10 µg/L in shallow groundwater; levels as high as 50 µg/L have been reported in some supplies (WHO, 2020). As reported by Cary, (1982) the mean chromium concentration in ocean water body was 0.3 µg/L. In comparison, oceans and lakes tend to have lower dissolved solids, higher particulate loads, higher biological activities and greater ratio of sediments to water surface areas. Also, there is a very transient transport and mixing features which may be influenced more by inputs from rivers and industrial sources. These features can lead to noticeable trace metals such as Chromium in lakes being quite different from that in oceans (Beaubien *et al.,* 1994). Among the trace chemical components present in natural water, chromium was rated as one of the most concerned heavy metal ions. This has attracted considerable attention due to hydrological circulation processes that strongly depend on its physicochemical forms. CrO has an oxidation number of +2, and is a basic oxide, while CrO_3 is acidic with a (+6) oxidation number. Cr_2O_3 is amphoteric. Even if it is insoluble in water, it dissolves in acid to give hydrated chromium ions $[Cr\ (H_2O)_6]^{3+}$. Conversely, the chromium oxide Cr_2O_3 is an inorganic compound that goes by the chemical name Chromic Oxide.

Hexavalent chromium compounds find extensive application in diverse industries such as Leather tannery and textile industry (Debasis *et al.,* 2002) Hexavalent Chromium (+6) is a toxic by-product of stainless steel and other manufacturing processes (Screemoyee, 2015). Individuals who were exposed to materials containing Cr have been known to experience irritative dermatitis and persistent skin ulcers. Dermatitis is caused by chromates and Cr (III) that are released from alloys and items that have been plated with Cr (Pellerin and Booker, 2000). There have been reports that it results in nasal system perforations. Sino-nasal carcinoma caused by Cr has been reported to the International Agency for Research on Carcinoma. Rhinitis, bronchospasm, and pneumonia have also been traced to individuals exposed to Cr (VI). Lung cancer is another consequence. Tests conducted on animals have verified that Cr (VI) is hazardous by inhalation but not by ingestion or skin contact. (Hemminki and Vainio 1984). Several studies have shown different adsorptions of chromium such as the removal of hexavalent chromium from water using spent tea leaves treated with ascorbic acid (Zaib *et al.*, 2022), and the removal of chromium from water using manganese (II, III) oxides coated sand (Wu *et al.,* 2023).

This study was aimed at assessing the concentrations of selected metals in MTU lake using standard methods and the usefulness of such body of water based on its quality status.

2.0 Materials and Methods

2.1 Tools and Apparatus Used

Lamottee Smart Reagents Test Kits, 75 Cl PET bottles and Durham bottles sourced from MTU, LaMotte Spectrophotometer, Cotton wool, Paper tape

2.2 Study Area and Sampling

2.2.1 Study Area The lake located in the central part of Mountain Top University, Ibafo, Ogun state was selected to investigate the concentration of heavy metals in natural waters.

2.2.2 Sampling: Water samples are collected from the MTU Lake in clean, sterile containers. Each container is properly labelled and recorded. Samples were taken at 5 different locations on the lake.

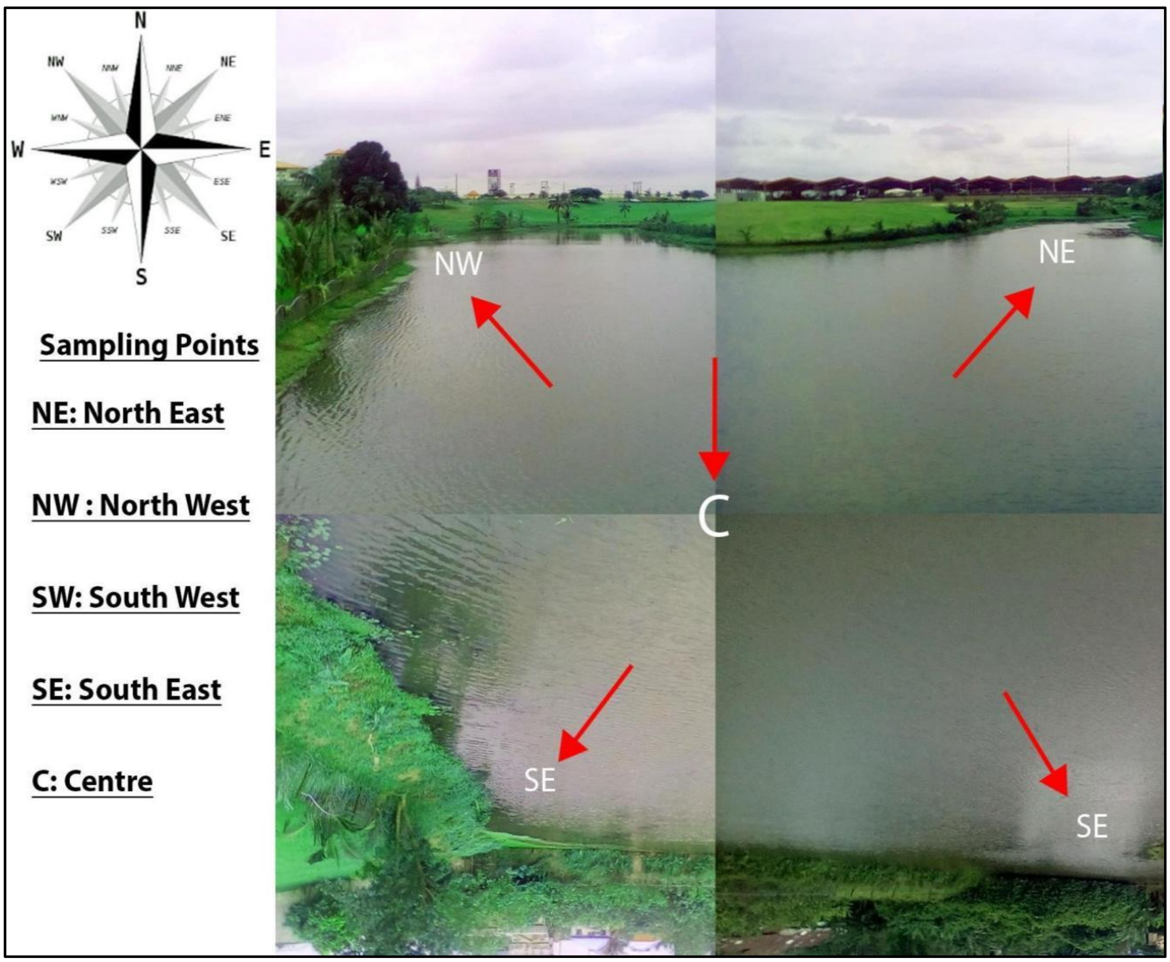

Fig 1: Pictorial view of MTU Lake

2.3 Test Procedure:

The Lamottee spectrophotometer was uses the principle of comparison of a standard with a solution mix of the sample with appropriate reagents to determine the Alkalinity, Iron, Manganese, copper, lead, chromium and chloride of the samples

2.3.1 Iron Total: By addition o 0.5ml Iron Reagent #1 [V-4450] was added to it and mixed followed by 0.1g Iron reagent #2 powder [V4451]. The mixture was capped and shaken vigorously for 30 seconds. The solution was left for 3 minutes for maximum colour development. At the end of 3 minutes, the tube was inserted into the spectrophotometer to read the concentration of Iron in ppm present in the sample.

2.3.2 Manganese**:** 1ml pipet was used to add 2ml of hardness buffer reagent. The mixture was swirled and 2 drops of sodium cyanide, 10% [6565]. The mixture was capped and shaken with 0.5ml of manganese indicator reagent [3956]. The mixture was inserted into the spectrophotometer to read the manganese concentration in ppm. Then the result was recorded.

2.3.3 Chromium. **A mixture was prepared of the sample and** capped and shaken vigorously until the powder dissolved and was left for 3 minutes for maximum colour development. A filter paper [0465] was folded into a cone and was used to push corners together to open the and a funnel was inserted. The mixture was inserted into the spectrophotometer to read the chromium concentration. The result gotten was converted to chromate [CrO_2^{-4}] multiplied by 2.23. Then the result was recorded.

2.3.5. Lead: **A**ddition 5ml Ammonium Chloride Buffer [4032] was added to fill the tube to the 10ml line. The mixture was swirled and 3 drops of sodium cyanide, 10% [6565]. 0.5ml PAR indicator [4033] was added to the mixture with 0.5ml stabilizing reagent [4022]. The mixture was capped and mixed. The mixture was further inserted into the spectrophotometer to read the Lead concentration in ppm as reading A, 3 drops DDC Reagent [4034] was added. The mixture was shaken to mix; the tube was inserted into the spectrophotometer to read the concentration of Lead in ppm present in the sample. Then the result was recorded as reading B, to get total ppm Lead reading B was deducted from reading A (reading A- reading B).

2.3.6. Copper**:** 5 drops of copper 1 [6446] were added to the sample. The mixture was capped and shaken vigorously. The solution turned yellow to indicate the presence of copper. The mixture was inserted into the spectrophotometer to read the copper concentration in ppm. Then the result was recorded**.**

3.0 Results and Discussion

Physicochemical Quality of the MTU Lake water

The results from the physicochemical analysis of water samples in which five (5) metals were analysed, revealed the presence of Lead, Iron, chromium, copper and Manganese.

The concentrations of Lead (Pb) in the five spacely marked sampling points on lake ranged from 0.02 to 0.05ppm with an average of 0.04 ppm, which is above the NIS standards of < 0.01 ppm. Accumulation of Pb in the body of aquatic animals that serves as food for human beings can cause damage to the brain and kidneys, and can interfere with the production of red blood cells that carry oxygen to all parts of your body (WHO, 2022).

Iron (Fe) concentrations in the five points sampled on the lake were within the range of 0.11 to 0.80 ppm with an average of 0.49 ppm, which is over ten folds higher than the tolerable level of < 0.03 ppm according to National Industrial standards. This is either consumed by humans directly or indirectly through aquatic animals. Depending on the concentration and bioaccumulation, adverse effects such as gastro-intestinal constipation are likely to manifest. However the presence of Iron is very essential in human body because it is a required element for the natural production of two naturally manufactured compounds which are hemoglobin, a protein in red blood cells that carries oxygen from the lungs to all parts of the body, and myoglobin, a protein that provides oxygen to muscles. The prolongedd consumption of Iron in its compound form of Ferric hydroxide can lead to liver disease (Ranjana, 2010)

Copper (Cu) concentrations of measured values that ranges from 0.05 to 0.28 ppm for the five locations sampled were observed with an average of 0.12 ppm. Manganese (Mn) of concentrations that ranges from 0.01 to 0.08 with an average of 0.03 ppm. Out of these five metals analysed, only Copper and Manganese were below tolerable levels < 1.0 ppm and < 0.05 ppm respectively. But then manganese are as highly concentrated as 0.08 ppm at a sample point which is even higher than the tolerable standards. (Zucker and Gollan, 1996). Iron, Lead and

Chromium were above the permissible limit with Chromium at exceeding concentration among the three. This indicates substantial deviation from the government regulatory limit.

The Chromium (Cr) concentration obtained from the physicochemical analysis carried out for MTU Lake of measured values that ranges from 2.01 to 7.36 ppm with an average of 4.81 ppm, this is comparatively higher than < 0.05ppm tolerable limited in such body of water where animals therein that can be consumed by humans. The chromium is Cr^{3+} ions in its trivalent form oxidations state of +3 is the soluble type in natural waters. This chromium concentration with the average calculated value of 4.81 ppm is considerably higher than the specified standard for drinking water (< 0.05 ppm). This indicates a potential water quality challenge, as the chromium content surpasses the recommended or permissible level. (Pellerin and Booker, 2000).

Table 1: Analysis Results of Heavy Metals

S/N	Heavy metals	Concentrations of Heavy metals (ppm) in different point of MTU LAKE WATER						
		South West	South East	Central	North West	North East	Average	NIS standard For consumable water
1	Iron Total (Fe)	0.38	0.64	0.11	0.53	0.80	0.49	< 0.3
2	Lead (Pb)	0.04	0.05	0.02	0.05	0.05	0.04	< 0.01
3	Copper (Cu)	0.07	0.28	0.16	0.05	0.08	0.12	< 1.0
4	**Chromium (Cr)**	**2.90**	**6.24**	**7.36**	**5.58**	**2.01**	**4.81**	**< 0.05**
5	Manganese (Mn)	0.01	0.01	0.04	0.08	0.01	0.03	< 0.05

*All concentrations given in part per million (ppm). The chromium average was found to be higher in value as compared with other heavy metal present in the lake. The referenced are for Nigeria Industrial Standards. (NIS).

The metals above regulatory standards for human consumption can be treated and brought down if to be used for human consumption purposes. Aeration as part of the preliminary treatment process reduces the level of concentration of soluble metal compounds to their insoluble forms through oxidation process with oxygen such as Manganese and Chromium in the form of contaminants by oxidation reactions. All the metals present in the body of lake water can be effectively removed from the water stream through the Reverse Osmosis equipment.

4.0 Conclusion

In this study, it can be concluded that the presence of Iron (Fe) can be beneficial to living organisms. But Lead (Pb) concentration of 0.04 ppm as against the tolerable standard of < 0.01 ppm and Chromium (Cr) of concentration 4.81ppm as against the tolerable limit of <0.05ppm is toxic to health issues to human being and water animals if it eventually finds its ways into the living bodies. The high concentration of chromium in particular in the water boy makes it unsuitable for growing edibles. In addition, hexavalent chromium is a known carcinogen. Chromated water are toxic on the health of living organisms. Continued agricultural use of a chromium-contaminated lake can exacerbate the problem. Plants grown in such water may uptake the chromium, leading to bioaccumulation in the food chain, posing health risks to consumers. Additionally, irrigation with contaminated water can further spread chromium to surrounding soil, potentially rendering larger areas unsuitable for agriculture. Long-term consequences may include decreased crop yields, soil degradation, and environmental pollution, necessitating costly remediation efforts.

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