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Assessing the impact of heavy metal pollution in Nike River using a life cycle approach

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Abstract

The threat of heavy metals contamination in the aquatic environment is more serious than those of other pollutants due to their non-bio-degradable nature and accumulative properties. This research project investigated some water quality parameters and heavy metals present in Nike Lake. In this study, three different water and sediment samples was collected from the upstream mid-stream and downstream of Nike Lake by submerging the sample bottle at about 0.5ft below the water surface and transferred into metal-free bottle that was used for all the analysis. The results of the physiochemical respectively forupstream, midstream and downstream were pH 5.49, 4.94, 5.41, conductivity was 72.3 µs/cm, 72.1 µs/cm, 72.0 µs/cm respectively, dissolve oxygen was 9.4mg/l, 9.6 mg/l, 10.4 mg/l, biochemical oxygen demand was 4.6 mg/l, 6.0 mg/l, 5.8 mg/l, nitrate was 0.28 mg/l, 0.31 mg/l, 0.32 mg/l and sulphate was 10.40 mg/l, 9.71 mg/l, 9.72. The water and sediment analysis showed that the heavy metals deviated slightly above their respective permissive levels when compared to WHO standard majorly at the upstream. The ecotoxicity potential of the heavy metal in the water sample at the upstream, mid-stream and downstream of Nike Lakewere 274.04 mg, 23.651 and 243.542 while that of the sediment sample were 0.03546 mg, 0.00015 mg and 0.0288 mg respectively. A higher impact of the ecotoxicity implies a higher source of the heavy metals at the points concerned, and higher negative health consequences directly to the aquatic organisms and indirectly to humans through consumption.

Keywords: Bioaccumulation; Heavy metals; Ecotoxicity; Nike Lake; Nike; Enugu state

1. Introduction

Heavy metal pollution of water has become a major global environmental problem almost since the advent of agricultural and industrial revolution and today most water resources are still being contaminated with heavy metals released from domestic, industrial and other man-made activities (Khare and Singh, 2002; Hayat andJaved, 2008, Ujah *et al*., 2017). The threat of heavy metals contamination in the environment is more serious than those of other pollutants due to their non bio-degradable nature, accumulative properties and long biological half-lives. It is difficult to remove them completely from the environment once they enter into it (Aderinola*et al*., 2009). Heavy metal contamination may have devastating impacts on the ecological balance of natural water bodies including the loss of aquatic diversity (Vosyliene and Jankaite, 2006;Farombi*et al*., 2007; Hayat andJaved, 2008). With increased use of a wide variety of metals in industries and in our daily life, there is now a greater awareness of toxic metal pollution of the environment. Many of these metals tend to remain in the ecosystem and eventually move from one compartment to the other within the food chain (Sadasivan and Tripathi, 2001).

Environmental pollution refers to the detrimental modification of our surroundings, resulting from human activities and their direct or indirect impacts on the energy pattern, radiation levels, and chemical and physical composition of organisms (Vinjai and Singh, 2019). Pollution is a global issue that affects both developed and developing countries and is characterized by its significant and long-lasting consequences (Brauer*et al*., 2016; Prüss-Üstün*et al*., 2016).A pollutant

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can refer to various types of substances released by human activities into the environment, including chemical compounds such as toxic metals, radionuclides, organophosphorus compounds, and gases, as well as geochemical substances like dust and sediment. It can also encompass biological organisms or products, and physical substances such as heat, radiation, and sound waves. These substances can be intentionally or unintentionally discharged into the environment, and they have the potential to cause adverse, harmful, unpleasant, or inconvenient effects (Vinjai and Singh, 2019). The detrimental impacts of pollutants can be direct, affecting human health, or indirect, acting through resource organisms or contributing to climate change (Brauer*et al*., 2016; Prüss-Üstün*et al*., 2016). The release of pollutants into the environment poses a significant concern globally, as it can lead to severe and long-term consequences for both the natural world and human well-being.

The benefits of renewable freshwater to humans are vast and encompass various essential uses such as drinking water, irrigation for agriculture, industrial processes, fish production, and in-stream activities like recreation, transportation, and waste disposal (Smith and Johnson, 2018). However, when contaminated by heavy metals, it can become a vector for the spread of harmful substances and diseases (Jones *et al*., 2019). According to the World Health Organization (WHO), an estimated 1.1 billion people lack access to improved water supply, while approximately 780 million people do not have access to clean and safe water, and 2.5 billion people lack proper sanitation facilities (WHO, 2021). These alarming statistics contribute to the prevalence of water-related diseases and disasters, resulting in the loss of approximately 6–8 million lives each year (WHO, 2021). Addressing these water-related challenges is crucial for improving public health and promoting sustainable development.

Various sources contribute to water contamination, including geological conditions, industrial and agricultural activities, and water treatment plants (Johnson and Brown, 2020).Contaminants in water are further classified into different categories, including microorganisms, inorganics, organics, radionuclides, and disinfectants. These substances have the potential to compromise water quality and pose risks to human health (Jones *et al*., 2018). Effective water quality management and monitoring are vital to safeguard public health and ensure the provision of safe and clean water for diverse uses. Water quality control has become a crucial policy agenda worldwide, given its significant impact on human health and well-being. The determination of water quality and suitability for various uses is based on factors such as taste, odor, color, and the concentration of organic and inorganic substances (Smith and Johnson, 2019). Contaminants present in water can adversely affect its quality and, consequently, human health. Various sources contribute to water contamination, including geological conditions, industrial and agricultural activities, and water treatment plants (Johnson and Brown, 2020).

Excessive levels of cadmium, iron, lead, and cobalt have a profound impact on aquatic organisms. These metals significantly disrupt enzyme kinetic parameters and the antioxidant system, which is responsible for protecting organisms from the toxic effects of free radicals and maintaining cellular homeostasis by neutralizing reactive oxygen species (ROS) (Bhatia *et al*., 2019; Rahman *et al*., 2020). When bioindicators resulting from human activities alter the antioxidant system, it becomes imbalanced with the reactive oxygen species, leading to free radicals reacting with biological macromolecules. These reactions have various biochemical implications, including protein oxidation, which disturbs physiological processes, lipid peroxidation, and damage to deoxyribonucleic acid (DNA) (Bhatia *et al*., 2019; Rahman *et al*., 2020). The biochemical consequences of these interactions have far-reaching effects, compromising essential cellular processes and potentially leading to detrimental outcomes for aquatic organisms. It is crucial to address and regulate the levels of these heavy metals to minimize the adverse biochemical impacts on aquatic life and preserve the health and integrity of aquatic ecosystems.

Assessing aquatic pollution is of utmost importance as it serves as a critical preventive and evaluative tool. It allows for the identification and understanding of the environmental impacts resulting from chemical discharges into water bodies. This assessment involves the evaluation of water quality parameters, which play a crucial role in determining the extent of heavy metal toxicity (Dilipand Kumar *et al*., 2016; Ambreen and Javed, 2015). In this study therefore, cadmium, iron, lead, and cobalt were utilized as bioindicators to conduct a life cycle approach to pollution assessment in Nike Lake, located in Abakpa Nike, Enugu State, Nigeria.

2. Material and methods

2.1. The Study Area

Nike Lake is located at Nike Lake resort in Abakpa Nike, Enugu State, Nigeria with GPS: latitude and longitude of6.510481°N, 7.513314°E.

Figure 1 Up stream

Figure 2 Mid-stream

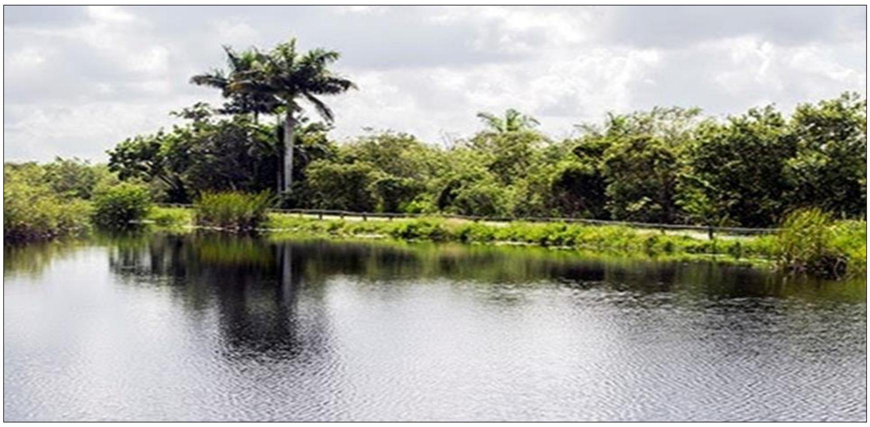

Figure 3 Down stream

2.2. Collection of Water and the Sediment Samples

The water and sediment samples was collected from the sampling location by submerging the sample bottle at about 0.5ft below the water surface and transferring the water into stopper bottle which is metal free.

2.3. pH

The pH was determined by the methods described by American public health association (ALPHA, 1998). The electrodes were rinsed with distilled water and blot dry. The pH electrodes were rinsed in a small beaker with a portion of the sample. Sufficient amount of the sample was poured into a small beaker to allow the tips of the electrodes to be immersed to a depth of about 2cm. the electrode was at least 1cm away from the sides and bottom of the beaker. The pH meter was turned on the pH of the sample and recorded.

2.4. Biochemical Oxygen Demand

The method adopted for determining the biochemical oxygen demand is according to the American public health association (APHA, 1992).

The general equation for the determination of a BOD5 value is:

BOD5 (mg/l) = D1 – D5, where D1 = initial DO of the sample after 5 days, P = decimal volumetric fraction of sample used. If 100 ml of sample are diluted to 300 ml, the P = 0.33.

2.5. Conductivity

The conductivity was determined by the methods described by American Public Health association (APHA, 1992). The conductivity meter was prepared according to the manufacturer's direction. A conductivity standard solution was prepared using NaCl and was used to calibrate the meter to the range to be measured. The probe was then rinsed with deionized water. It was finally read using the probe after which the probe was rinsed again with deionized water and the process was repeated again for all the water samples.

2.6. Nitrate

The nitrate was determined by the methods described by American public health association (APHA, 1992). Nitrate been a form of nitrogen, are found in several different forms in terrestrial and aquatic ecosystems. These forms of nitrogen include ammonia (NH_3), nitrates (NO_3), and nitrites (NO_2). Nitrates in excess together with phosphorus, affects dissolved oxygen, temperature, and other indicators. Low levels of dissolved oxygen are caused by excess nitrate and can become toxic to warm-blooded animals at higher concentrations (10 mg/L) or higher) under certain conditions. The nitrates in both the water and sediment samples were determined using a nitrate electrode (used with a meter) which is similar in function to a dissolved oxygen meter. It was made of a probe with a sensor that measured the nitrate activity in the water; the activity affected the electric potential of the solution in the probe. The change was then transmitted to the meter, which converted the electric signal to a scale that was read in millivolts. The millivolts were then converted to mg/L of nitrate by plotting them from a standard curve.

2.7. Sulphate

Sulphate was determined according to APHA standard method (APHA, 1992). In determination of sulphate, 250 cm^3 of water sample was evaporated to dryness on a dish. The residue was moistened with a few drop of conc. HCl and 30 ml of distilled water was added. This was boiled and then filtered. The dish was rinsed and the filter paper washed with several portion of distilled water and both filtered and the washings added together. This was heated to boiling and then 100 cm^3 of 10 % $BaCl_2$ solution was added, drop by drop with constant stirring. The mixture was digested for about 30 mins and filtered with warm distilled water. Then the filter paper and the residue was dried in oven and weighed immediately.

2.8. Determination of heavy metal concentrations in the water sample

The digest of the test sample were assayed for the presence of heavy metals using Atomic Absorption Spectrophotometer spectra AA model number 240 FS under the appropriate wavelength and detection limit for each heavy metal. Heavy metal analysis was conducted according to the method of American public health association (APHA, 1992). The process of sample analysis involves the following, placing the diluted extracts on the bench. The atomic absorption spectrophotometer machine was switched on and set to the required wavelength which is determined by the heavy metal being assayed. The appropriate lamp which is determined by the heavy metal wasplaced in the appropriate place in machine. A tube from the machine was inserted into the instrument. The machine was then set to take the absorbance as well as the concentration which is displayed on the screen at the front of the machine.

2.9. Life cycle impact assessment

This is the effect of toxic substances that can damage plants and fauna. Ecotoxicity can be defined both for water (aqua-ecotoxicity) a terrestrial ecotoxicity which are measured by the volume of water and weight of soil that can be polluted by 1kg of the substance respectively. Ecotoxicity can be evaluated using the equation.

$$EP = \sum Epi \text{ x Concentration in water} + \sum Epi \text{ x Concentration in sediment}$$

EP = Ecotoxicity potential, ∑Epi = summation of ecotoxicity potential of each heavy metal x the concentration of the heavy metals in sediment or water.

3. Results

Table 1 Physicochemical Parameters of the Water

Parameters	**Up stream**	**Mid stream**	**Down stream**	**WHO standard**
pH	5.49	4.94	5.41	6.5-8.5
Conductivity (µs/cm)	72.3	72.1	72.0	500
Dissolve Oxygen (mg/L)	9.4	9.6	10.4	5-14
Biochemical oxygen demand (mg/L)	4.6	6.0	5.8	50
Nitrate (mg/L)	0.28	0.31	0.32	50
Sulphate (mg/L)	10.40	9.72	9.72	500

Table 1 The pH indicated acidity been slightly below neural pH of 7, all the parameters ranging from upstream, mid-stream and downstream were compared with the world health organization standard and value for showed to be within their permissive levels.

Table 2 Concentrations of Cd Fe Pb and Co in water from Nike Lake

Location	**Fe (mg/L)**	**Cd (mg/L**	**Pb (mg/L)**	**Co (mg/L)**
Upstream	0.908 ± 0.007	0.006 ± 001	0.101 ± 0.039	0.66 ± 0.181
Midstream	0.976 ± 0.055	0.004 ± 002	0.022 ± 0.017	0.51 ± 0.076
Downstream	0.811 ± 0.062	0.014 ± 044	0.014 ± 0.023	0.040 ± 0.257

Table 2 shows the concentrations of the heavy metals in water sample. The result indicated that Iron was highest at the midstream and lowest at the downstream, cadmium was highest at the downstream and lowest at the midstream and, lead was highest at the upstream and lowest at the downstream and cobalt was highest at the upstream and lowest at the downstream.

Table 3 Concentrations of Cd Fe Pb and Co in sediments from Nike Lake

Location	**Fe (mg/L)**	**Cd (mg/L**	**Pb (mg/L)**	**Co (mg/L)**
Upstream	0.111 ± 0.000	0.001± 0.000	0.001 ± 0.000	0.003 ± 0.000
Midstream	0.120 ± 0.009	0.001 ± 0.000	0.001 ± 0.000	0.003 ± 0.000
Downstream	0.091 ± 0.011	0.000 ± 0.001	0.000	0.003 ± 0.000

Table 3 showed the concentrations of the heavy metals in the sediment sample. The result indicated that Fe was highest at the midstream and lowest at the downstream, Cadmium had same value at the upstream and midstream and was not detectable at the downstream, Lead had the same value at the upstream and midstream and was not detectable at the downstream and Cobalt had same value at upstream, midstream and downstream.

3.1. Life Cycle Assessment

Table 4 Metal characterization factor in water and sediment

Metal	Water	Sediment
Iron	300	0.3
Lead	15	0.01
Cadmium	5	5
Cobalt	4	

Table 5 Ecotoxicity Potential in water

Up stream			
Metal	**Concentration in water**	**Characterization Factor**	**Conc. in water x Characterization factor**
Iron	0.908	300	272
Lead	0.101	15	1.5150
Cadmium	0.006	0.005	0.0003
Cobalt	0.66	0.79	0.5214
			274.04
Mid-stream			
Metal	**Concentration in water**	**Characterization Factor**	**Conc. in water x Characterization factor**
Iron	0.076	300	22.800
Lead	0.022	15	0.33
Cadmium	0.004	0.005	0.00002
Cobalt	0.66	0.79	0.5214
			23.651
Down stream			
Metal	**Concentration in water**	**Characterization Factor**	**Conc. in water x Characterization factor**
Iron	0.811	300	243.300
Lead	0.014	15	0.21
Cadmium	0.014	0.005	0.0007
Cobalt	0.040	0.79	0.0316
			243.542

$\sum EPW = 274.04 + 23.651 + 243.542 = 541.233$

Table 6 Ecotoxicity Potential in Sediment

Up stream			
Metal	**Concentration in sediment**	**Characterization Factor**	**Conc. in water x Characterization factor**
Iron	0.111	0.3	0.0333
Lead	0.001	0.01	0.00001
Cadmium	0.001	2.0	0.002
Cobalt	0.003	0.05	0.00015
			0.03546
Mild stream			
Metal	**Concentration in sediment**	**Characterization Factor**	**Conc. in water x Characterization factor**
Iron	0.120	0.3	0.036
Lead	0.001	0.01	0.00001
Cadmium	0.001	2.0	0.002
Cobalt	0.003	0.05	0.00015
			0.00015
Down stream			
Metal	**Concentration in sediment**	**Characterization Factor**	**Conc. in water x Characterization factor**
Iron	0.091	0.3	0.0273
Lead	0.000	0.01	0.000
Cadmium	0.000	2.0	0.000
Cobalt	0.003	0.05	0.00015
			0.0288

Aquatoxicity =EP = EP = ∑EPW + ∑EPS=541.233 + 0.06441 = 541.29741 mg; The value obtained shows the release of heavy metals which are harmful to both humans and aquatic lives

4. Discussion

This study was carried out with three different water and sediment samples collected from the upstream mid-stream and downstream of Nike Lake. The result for the heavy metals, physiochemical in water and sediment analyses of Nike Lake were presented. The values obtained for pH, conductibility, Dissolve solids, biochemical oxygen demand, Nitrate and Sulphate were clearly tabulated.

From the results of physic-chemical analysis, the pH values recorded were 5.49, 4.94, and 5.41 respectively compared to WHO permissible level of 6.5-8.5. The conductivity levels were 72.3 µs/cm, 72.1 µs/cm, and 72.0 µs/cm for the respective locations compared to WHO permissible level 500. Dissolved oxygen concentrations were measured at 9.4 mg/l, 9.6 mg/L, and 10.4 mg/l for upstream, midstream, and downstream respectively compared to WHO permissible level of 5-14mg/L. The biochemical oxygen demand values were 4.6 mg/L, 6.0 mg/L, and 5.8 mg/L for the three locations compared to WHO permissible level of 50mg/l. Nitrate concentrations were 0.28 mg/l, 0.31 mg/l, and 0.32 mg/l respectively compared to WHO permissible level of 50 mg/L. Sulphate levels were found to be 10.40 mg/L, 9.71 mg/l, and 9.72 mg/L for upstream, midstream, and downstream compared to WHO permissible level of 500. Upon analyzing the water and sediment samples, it was observed that the levels heavy metals slightly exceeded the permissible limits set by the World Health Organization (WHO), primarily at the upstream location.

pH is a dimensionless number that indicates the acidity or basicity of a solution (Hammer *et al*., 2011).In the context of water, pH represents the measure of its acidity or alkalinity. The recorded values of pH in Nike Lake according to this study were at the range of 4.94 – 5.49 which is slightly below the permissible standard range of 6.5 – 8.5 set by the

World Health Organization (WHO). This shows that Nike Lake is slightly acidic. Acidic water contains an excess of hydrogen ions (H+), while basic water contains an excess of hydroxyl ions (OH^-). The pH level plays a crucial role in the survival and well-being of aquatic animals and plants, as they have adapted to specific pH ranges. Even a slight change in pH can have detrimental effects on these organisms (EPA, 2021). Moderately acidic water, characterized by low pH, can result in decreased hatching of fish eggs, irritation to fish and aquatic insect gills, and damage to cell membranes. Water with extremely low or high pH levels is fatal to aquatic life. Most fish species cannot tolerate a pH below 4 or above 10, and only a few species can endure water with a pH below 3 or above 11 (EPA, 2021). To ensure the safety of individuals consuming water, it is important to maintain pH within the range of 6.5 to 8.5, as recommended by the World Health Organization (WHO) standards (WHO, 2017). This pH range helps protect the lives of individuals and ensures the overall health and well-being of aquatic ecosystems.

The conductivity measurements obtained from the samples collected from Nike Lake indicate that the water falls within the acceptable range according to the World Health Organization (WHO) standards, which have set the limit at 500 µs/cm (APHA, 1992). This suggests that the concentration of ions present in the water is relatively low. It is important to note that low conductivity levels typically indicate that the water is not heavily contaminated with dissolved substances or ions. Consequently, this indicates that the water poses no significant threat to the organisms living within it.

The nitrate ion (NO_3^-) is the stable form of combined nitrogen for oxygenated systems (Smith, 2010). Although chemically unreactive, it can be reduced by microbial action (Johnson *et al*., 2015). The nitrite ion (NO_2^-) contains nitrogen in a relatively unstable oxidation state. The nitrate concentration recorded in this study showed that the values are within the permissible standards and have no harm on the aquatic organisms and individuals using it. The nitrate ion (NO_3^-) is the stable form of combined nitrogen for oxygenated systems. Although chemically unreactive, it can be reduced by microbial action. The nitrite ion (NO_2^-) contains nitrogen in a relatively unstable oxidation state (Brown and Jones, 2018).The nitrate concentration recorded in this study (0.28 mg/L, 0.31 mg/L, and 0.32 mg/L) showed that the values are within the permissible standards of 50 mg/L.

Sulfate is second to bicarbonate as the major anion in hard water reservoirs (Smith, 2018). Sulfates (SO_4^{2-}) can be naturally occurring or the result of municipal or industrial discharges (Johnson and Brown, 2020). It also occur naturally in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4.7H_2O$) and gypsum ($CaSO_4{\cdot}2H_2O$)(White, 2016).The sulfate concentration recorded in this study (10.40 mg/l, 9.71 mg/L, and 9.72 mg/L) showed that the values are within the permissible standards of 50mg/L.

The biological oxygen demand (BOD_5) is the measure of dissolved oxygen consumed by aerobic microorganisms over a five-day period to degrade oxidizable organic matter in streams (Smith, 2017). The recorded values for biological oxygen demand in Nike Lake indicated that they were satisfactory (4.6 mg/l, 6.0 mg/l, and 5.8 mg/l) and within the permissible standards set by the World Health Organization (WHO) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) for effluent discharges into surface water(Jones *et al*., 2020; NESREA, 2018), which is 50mg/l. A reduction or decline in dissolved oxygen levels in Nike Lake can have severe implications for the health of aquatic organisms. Low levels of dissolved oxygen can result in the reduction or elimination of sensitive fish and invertebrate species (Brown and Johnson, 2019).

According to the resultheavy metals, the concentration of cadmium recorded was within the range of 004 ± 002 mg/l - 0.014 ± 044mg/l compared to WHO permissible level of 0.003 mg/l. Iron recorded was within the range of 0.811 ± 0.062 mg/L - 0.976 ± 0.055 mg/l compared to WHO permissible level of 0.3 mg/L. Lead recorded was within the range of 0.014 ± 0.023 mg/L - 0.101 ± 0.039 mg/L compared to WHO permissible level of 0.01mg/l. Cobalt recorded was within the range of 0.040 ± 0.257 mg/L - 0.66 ± 0.181 mg/L. Based on the provided concentrations, the iron and lead concentrations slightly exceed the WHO permissible limits. However, the cadmium concentration is within the permissible limit, and cobalt does not have a specific limit established by WHO.

Cadmium at the range of 0.004 ± 002 - 0.014 ± 044 in the water sample, showed to be within EPA permissible standard of 0.003 mg/l (EPA, 2019). Similar range of results were obtained by Ujah *et al. (*2023*) in a research carried out in River Niger.* Acute exposure to significantly higher levels of cadmium can result in a range of negative health effects. Nordberg (2004) states that acute exposure to elevated levels of cadmium can lead to symptoms such as diarrhea, vomiting, fever, lung damage, and muscle pain. These effects are associated with the toxicological properties of cadmium and its ability to interfere with various physiological processes in the body. To ensure the safety of individuals and the environment, it is important to monitor cadmium levels in water sources and take appropriate measures to prevent excessive exposure.

Iron concentrations obtained from this study were within the range of 0.811 ± 0.062 mg/L - 0.976 ± 0.055 mg/L, compared to the World Health Organization's (WHO) permissible limit of 0.3 mg/L (EPA, 2019). The results showed that iron levels slightly exceeded the permissible limit of 0.3 mg/L as recommended by WHO. In research carried in River Niger, Anambra state Nigeria iron was similarly high in concentrations (Ujah, 2023). Iron deficiency can lead to various symptoms, including weakness; dizziness, headaches, and shortness of breath, pale skin, and chest pain (Beckman et al., 1999). On the other hand, excess iron accumulation in vital organs increases the risk for liver disease (cirrhosis, cancer), heart failure, diabetes mellitus, depression, osteoarthritis, osteoporosis, infertility, hypothyroidism, abdominal pain, hypogonadism, and numerous other symptoms, and in some cases, it can be a cause of premature death (Parkkila *et al*., 2001).These findings emphasize the importance of maintaining iron levels within the recommended limits to prevent both deficiency and excess, and to promote overall health and well-being.

Lead recorded was within the range of 0.014 ± 0.023mg/l - 0.101 ± 0.039 mg/L compared to WHO permissible level of 0.01mg/l.(EPA, 2019).This indicates that the lead concentrations exceeded the permissible limit according to WHO, hence raising concerns about potential health risks. Lead is a toxic heavy metal that can have detrimental effects on human health, particularly when present in drinking water above permissible levels. Concentrations of lead were detectable in a similar research in water, fish and sediments of River Niger (Ujah *et al*., 2020). Chronic exposure to elevated lead levels has been associated with various adverse health effects, especially in children, including developmental delays, neurological impairments, and behavioral problems (Agency for Toxic Substances and Disease Registry [ATSDR], 2020).

Cobalt recorded was within the range of 0.040 ± 0.257mg/l - 0.66 ± 0.181 mg/l. According to the concentrations provided, the levels of iron and lead exceed the permissible limits set by the World Health Organization (WHO). However, the concentration of cadmium falls within the acceptable limit. It is worth noting that the WHO has not established a specific limit for cobalt.

The ecotoxicity potential of the heavy metal in the water sample at the upstream, mid-stream and downstreamwere 274.04 mg, 23.651 and 243.542 while that of the sediment sample were 0.03546 mg, 0.00015 mg and 0.0288 mg respectively. A higher impact of the ecotoxicity implies a higher source of the heavy metals at the points concerned, and higher negative health consequences directly to the aquatic organisms and indirectly to humans through consumption.

5. Conclusion

Nike Lake in Abakpa Nike Enugu state Nigeria as recipient of chemical discharge and dump from Nike Lake Hotel Resort is slightly impaired and this may have negative effect on the aquatic lives and individuals using the water. However, while Nike Lake Hotel Resort is an encouraging venture from the economic perspective, their waste should be properly treated and effectively managed, as the general physiochemical results showed that there may be discharge arising from the hotel that contaminates the River.

Recommendation

With the increased level of the heavy metals in Nike Lake aquatic organisms and individuals who use this water for various household purposes are at the risk of suffering the health implications associated with heavy metals and acidic pH. There should be awareness campaign on the pollution of the river and the treatment of wastes before discharge in the river.

Compliance with ethical standards

Disclosure of conflict of interest

There is no conflict interest.

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