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PHYSICOCHEMICAL CHARACTERISTICS OF SURFACE WATER FROM IDU OGBA RIVER, RIVERS STATE, NIGERIA

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Abstract
The Idu Ogba River in Rivers State, Nigeria, was the subject of the investigation on the physicochemical properties of surface water. Acidity, alkalinity, chlorine, turbidity, conductivity, total dissolved solids (TDS), total suspended solids (TSS), dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), nitrate, phosphate, and sulphate were among the factors considered. Established standard procedures and characterizations were used to prepare three (3) samples of surface water collected in each of the three locations, and their results were analysed with mean and standard deviation. The mean observations for the various water quality parameters in the sampled are pH (5.31±0.18), alkalinity (16.47±0.21), chlorine (7.23±0.15 mg/l), turbidity (6.5±0.19 NUT), conductivity (122±2 µs/cm), TDS (94.48±3.59 mg/l), TSS (65.37±0.25 mg/l), BOD(10.61±0.14 mg/l), COD (51±1.11 mg/l), DO(3.47±0.06 mg/l), nitrate (6.286±0.040 mg/l), phosphate(0.513±0.0305 mg/l), and sulphate (9.4±0.2 mg/l). The physical and chemical properties of the surface water were found to be within WHO's permissible standards, indicating that they offer no possible risk to the residents of the area. The presence of elevated levels of BOD and COD in certain Idu Ogba River-evaluated sites shows the presence of both organic and inorganic pollutants. The nitrate concentration in the river was high, which could promote the growth of planktonic organisms and aquatic plants. The study also discovered lower amounts of phosphate and sulphate, which may have implications for the growth of particular microbial organisms and their role in the nutrient cycle.

Keywords: Nutrient, Organic pollutants, Physicochemical, River, water,

Introduction

Water is an essential component of human existence, playing a vital role in sustaining life. It has a crucial function in the manufacturing and dissemination of food, the functioning of companies, and the transportation of goods and services. Water has a crucial role in promoting human development; nevertheless, its management as an essential resource is grossly inadequate (Rajeshkumar et al., 2018). The level of water deterioration caused by both human activities and natural sources is steadily increasing. The examination of diverse sources of water contamination, the corresponding remediation techniques employed, and the resulting economic ramifications generated by human activities are significant global concerns. The occurrence of natural variables, which typically happen independently, is currently accelerated due to human interventions in the environment. The combined effects of human activities and natural events present a substantial threat to the welfare of plant and animal species (Butler & Ford, 2018; Bolisetty et al., 2019).

The physicochemical properties of water have a significant impact on the ecological dynamics of the ecosystem, consequently influencing the overall state of a water system (Kamboj & Kamboj, 2019). Anthropogenic intervention can modify the chemical composition of the aquatic ecosystem, hence potentially inducing alterations in migratory patterns, habitat displacement, cannibalistic tendencies, and overall feeding behaviours (Sabater et al., 2018). The biochemical activities of various species in the water influence the processes of water regeneration and natural purification. These species can alter their chemical and physical characteristics (without human interference) to preserve the water's original state. The features investigated by Meena et al. (2019) exert a substantial influence on discerning both the explicit and implicit indicators of the condition of the aquatic environment and its capacity to sustain biological populations.

Rivers follow pre-existing channels and constantly interact with the adjacent banks, causing gradual erosion of the bank material into the river water (Meena et al., 2019; Nsude & Orie, 2022a). According to Xiang et al. (2021), rivers receive water from various sources, including glacier runoff and ice melting due to higher temperatures, neighbouring streams, water from waterlogged swamps and lakes, and precipitation in the form of rain and snow. Across history, human societies have consistently settled near river banks globally, mostly because of the immense importance placed on water as an essential and indispensable natural asset. The primary goal of establishing settlements along riverbanks is to harness the multitude of benefits they offer, including transportation, irrigation, fishing, electricity generation, waste management, and agriculture (Bolisetty et al., 2019; Okocha et al., 2023). Moreover, rivers, especially those with freshwater, annually undergo the occurrence of inundating their banks, leading to the formation of extremely fertile areas near the riverbanks that are favourable for agricultural cultivation. Water contamination displays unique attributes in both rural and urban environments. The occurrence of water contamination in rural areas can be attributed to traditional agricultural practices and the associated release of pollutants. On the other hand, urban water contamination is mostly a result of the release of industrial waste (Wokoma & Edori, 2020). The aforementioned variables contribute to a decrease in the quality of water, requiring suitable treatment before it can be used (Diete-Spiff & Kpee, 2022). Hence, the present study was conducted to investigate the fluctuations in certain physicochemical characteristics of surface water in selected sections of the Idu Ogba River.

Materials and Methods

Three (3) surface water samples were collected using clean and dried plastic cans from the surface to a depth of 15cm. After being collected at three different stations, the geographical locations of each sample were recorded. The geographic locations and sample collection stations are listed in Table 1 and Figure 1.

Table 1: Coordinates of Sample Area

Location	latitude	Longitude
Station A	5°15'46.0°N	6°34'57.5°E
Station B	5°14'56.5°N	6°35'20.3°E
Station C	5°13'41.0°N	6°33'19.5°E

The samples were immediately placed in containers with ice packs and transported to the Chemistry Laboratory at Ignatius Ajuru University of Education in Rumuolumeni, Port Harcourt, Rivers State, Nigeria.

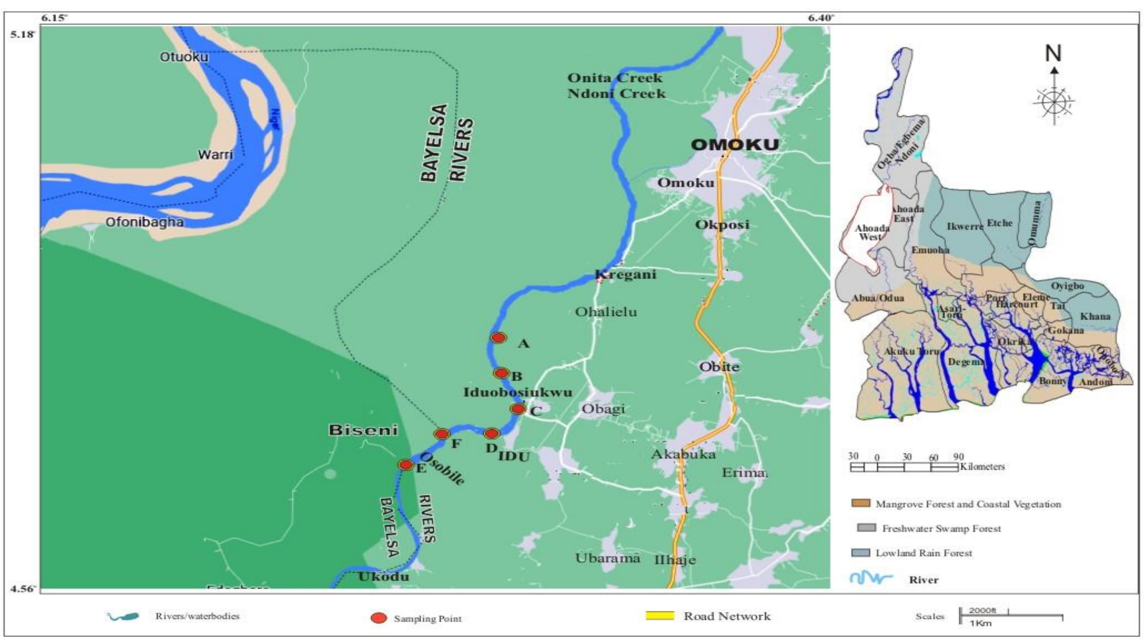

Figure 1: Map of Idu Ogba River

Analysis of the Samples

In situ, pH, conductivity, and total dissolved solids (TDS) were measured using a Jen Way portable metre model 350. The turbidity of the water samples was measured using an on-site turbidity monitor, the HACH Model 2100. TSS was calculated using the filtering technique described by Ramkumar et al. (2013). The collected values were then computed using the proper method.

$$TSS = \frac{W1 - W2}{V\ (ml)} \times 1000ml$$

W1=Post-weight filter, W2=Pre-weight filter, V= Volume of sample used in ml

Dissolved Oxygen (DO) levels in the water were measured using the Winkler's method, and the results were calculated as:

$$\text{Dissolved Oxygen} = \frac{V1 \times 0.2 \times 1000\ ml}{V}$$

V1= Volume of thiosulphate

V= Volume sample taken

By examining the previously examined DO samples, we were able to determine the samples' BOD. For five days, these samples were kept in a dark place at a temperature of 20 oC. As a result, the biochemical oxygen demand (BOD5) was calculated and documented.

Chemical oxygen demand (COD) was determined using the oxidation method and was calculated as:

$$\text{Chemical Oxygen Demand} = \frac{A - B \times N \times 8 \times 1000}{V}$$

A = Volume of ammonium sulphate for blank, B = Volume of ammonium sulphate for the sample, N = Normality of ammonium sulphate, V = volume of sample.

Moderate acid hydrolysis was used to convert the sample's phosphate species into orthophosphate, which was then used for phosphate determination. The phosphate concentration in the sample was then determined by a colorimetric analysis (Diete-Spiff & Kpee, 2022). A mathematical determination was made to ascertain the phosphate concentration;

$$\text{Phosphate concentration} = \frac{\text{Volume of Phosphate} \times 1000}{V}$$

V=Volume of the sample

Nitrate and sulphate concentrations in water samples were determined with the use of a HACH spectrophotometer (model 3900 DR, USA). To finish this task, 25 ml of water with analytical test tablets for nitrate and sulphate were mixed. The final contents were determined using 450 nm and 890 nm spectrophotometers, respectively. The protocols described in the study by Ramkumar et al. (2013) were followed: standard sulphate and nitrate solutions were used to create calibration curves, and the acquired data were compared to them.

By comparing the chloride concentrations found in the samples with those from blank titrations, the titrimetric methods were used to evaluate the chloride concentrations in the samples. A quantitative analysis of the sample's chloride concentration was performed.

$$\text{Chloride concentration} = \frac{(Vs - Vb) \times N \times 35.5 \times 1000}{V}$$

Vs = Volume of silver nitrate used for the sample Vb = Volume of silver nitrate used for the blank, V=Volume of sample taken, N= Normality

Results

Table 2: Chemical Parameters of surface water

S/N	chemical parameters	Station A	Station B	Station C	Mean±SD	WHO
1.	pH	5.57±0.154	5.25±0.08	5.10±0.32	5.31±0.18	6.5-8.5
2.	Alkalinity	16.70±0.335	16.50±0.11	16.20±0.17	16.47±0.21	100
3.	Chlorine (mg/L)	7.28±0.122	8.12±0.23	6.30±0.10	7.23±0.15	250

n=3

Table 3: Physical Parameters of surface water

S/N	Physical parameters	Station A	Station B	Station C	Mean±SD	WHO
1.	Turbidity (NTU)	6.68±0.23	6.52±0.28	6.30±0.35	6.5±0.19	6.5 – 8.5
2.	Conductivity (µs/cm)	122±2	124±2.2	120±1.9	122±2	100
3.	Total Dissolve Solid (TDS) mg/l	96.68±1.19	96.42±1.02	90.33±0.95	94.48±3.59	500
4.	Total Suspended Solid (TSS) mg/l	65.37±0.24	66.24±0.19	64.50±0.25	65.37±0.25	
5.	Temp (^{O}C)	26.34±0.37	26.20	25.70±0.35	26.08±0.34	20 – 30

n=3

Table 4: Gross Organic Pollutants

S/N	Organic Pollutants	Station A	Station B	Station C	Mean±SD	WHO
1.	Biochemical oxygen demand (BOD_5) mg/L	10.76±0.27	10.60±0.11	10.48±0.15	10.61±0.14	10
2.	Chemical oxygen demand (COD) mg/L	52.00±1.63	50.00±1.01	51.00±1.02	51±1.11	50
3	Dissolve oxygen (DO) mg/L	3.53±0.10	3.47±0.03	3.41±0.07	3.47±0.06	10

n=3

Table 5: Nutrient Parameters

S/N	Nutrient parameter	Station A	Station B	Station C	Mean±SD	WHO
1	Nitrate mg/L	6.33±0.01	6.28±0.06	6.25±0.021	6.286±0.040	1.0
2	Phosphate mg/L	0.54±0.01	0.52±0.032	0.48±0.02	0.513±0.0305	50
3	Sulphate mg/L	9.60±0.31	9.40±0.27	09.20±0.23	9.4±0.2	250

n=3

Discussion

The chemical characteristics of surface water derived from the Idu Ogba River are presented in Table 2. In this study, the researchers measured and analyze pH, alkalinity, and chlorides (Cl^-) were considered. The pH of the surface water was reported as 5.57±0.154, 5.25±0.08, and 5.10±0.32 for stations A–C. The pH mean for all the stations was reported as 5.31±0.18, thus below the acceptable pH of WHO (Table 2). Bilgin (2018) previously recorded a limited pH range in the Coruh River Basin, whereas Bhuyan et al. (2019) discovered a similar pH level in the surface water of the Old Brahmaputra River in Bangladesh. The pH value is a measure of the acidity or basicity of water, which is determined by the quantity of dissolved chemicals and biological processes in the water (Edori & Kpee, 2019). The assessment of pH levels in aquatic environments is frequently conducted to evaluate the ecological unit's health condition and its appropriateness for various purposes such as irrigation, drinking, and industrial and household applications (Nsude & Orie, 2022b; Owhoeke et al., 2023).

The alkalinity of surface water in the Idu River was reported to be 16.700.335, 16.500.11, and 16.200.17 for stations A to C. The mean alkalinity was 16.470.21, which was lower than the WHO limit. This finding is consistent with the findings of Owokotomo et al. (2020), who assessed excessive alkalinity in two urban rivers in Ado-Ekiti, southwest Nigeria. Ekere et al. (2014) recorded an alkalinity of 12.6 and 11.10 for river and well water sources in Abuja, Nigeria. In their analysis of the physicochemical parameters of the Eleyele River in Oyo State, South-West Nigeria, Akinyemi et al. (2014) discovered an alkalinity of 25.9 mg/l, which aligns with the results of this study. The results of this investigation are in agreement with those of Bórquez-López et al. (2020), who also reported an alkalinity of around 11.0. Potapowicz et al. (2020) discovered a similar result for Siodlo II Creek at 9.26 and for Petrified Forest Creek at 8.958.95 on the western side of Admiralty Bay (King George Island, Antarctica).

The chloride concentrations at the sampled stations were measured to be 7.28±0.122 mg/L, 8.12±0.23 mg/L, and 6.30±0.10 mg/L for stations A, B, and C, respectively. The collective average value for all the stations was determined to be 7.23 ± 0.15 mg/L. The chloride concentrations measured in the river were determined to be lower than the recommended limit of 250 mg/L for potable water, as stipulated by regulatory agencies such as NAFDAC and WHO. In contrast to the levels found in the Cauveri River in India (Chandra et al., 2011) and the brackish water environment in the Niger Delta, Nigeria (Iyama & Edori, 2014), the chloride concentrations in the Idu Ogba River were found to be lower during the analysis. The presence of high chloride levels in water is indicative of water contamination caused by sewage discharge. Water tainted with chloride is likely to be cleaned up before humans drink it. Soil irrigated with water that is rich in chloride is not likely to produce sufficient food crops. The absence of industrial activity in the area, which would normally discharge wastewater into the river and produce uncontaminated runoff, is likely responsible for the low chloride amounts seen in the current study. Metals corrode more quickly and electrical conductivity is increased when chloride is present in water (Kpee et al., 2009).

The physical properties of surface water obtained from the Idu Ogba River are shown in Table 2. Some of the physical parameters analyzed were turbidity, temperature conductivity, total dissolved solids, and total suspended solids. The recorded turbidity values for the sampled locations were 6.68±0.23 NTU, 6.52±0.28 NTU, and 6.30±0.35 NTU. Hence, it suggests that the substance present in the water was minimally influenced by biological activity. According to the study conducted by Uzamere et al. (2023), the turbidity measurement of the New Calabar River was determined to be 25.23 ± 4.07 NTU. Edori and Nna (2018) documented a range of 9.42 ± 2.68 to 17.90 ± 3.09 NTU at three specific locations along the New Calabar River where waste was dumped. In a study conducted by Ekevwe et al. (2019), the researchers documented turbidity levels ranging from 21 to 190 NTU in the River Jakara and its associated tributaries. The limited variability seen may be ascribed to variations in the discharge of suspended particles within the region, which aligns with the findings of Obasohan et al. (2008) and the research conducted by Ezevwe et al. (2019). These studies reported a turbidity level of 10 in pond water sampled from the Imo River Basin area.

The conductivity of water in the Idu Rivers at various sampled stations was 122±2 µs/cm, 124±2.2 µs/cm, and 120±1.9 µs/cm. This is higher than the 100 µs/cm value that NAFDAC and WHO gave it. This means that the Idu Ogba River has more dissolved salt and organic matter. The mean value of total dissolved solids for water analysis of the Idu Ogba River was estimated at 96.68±1.19 mg/l, 96.42±1.02 mg/l, and 90.33±0.95 mg/l for stations A to C. The total mean for TDS was estimated at 94.48 ± 3.59 mg/l. The result was in line with Hagan et al. (2011), whose Total Dissolved Solids (TDS) values ranged from 67.1 to 113.0 mg/l and were below the WHO-recommended value of 500 mg/l. Singh et al. (2010) reported that water has a maximum TDS of 870 mg/l in the assessment of water obtained from the northeastern state of India bordering Myanmar.

The mean concentration of total suspended solids (TSS) for the three sampling sites in the Idu Ogba River was reported as 65.37±0.24 mg/l, 66.24±0.19 mg/l, and 64.50±0.25 mg/l. In similar research, Ekevwe et al. (2019) recorded a TSS of 0–73.5 mg/l for the rivers along the River Jakara and its tributaries; Nasrabadi et al. (2016) recorded a TSS of 28 ± 1.1 for the Haraz River basin; and Butler and Ford (2018) reported a low TSS for mining-influenced watersheds. The increase in total suspended solids in the Idu Ogba River was probably due to the large amount of silt and debris held in suspension just before the rains (Atiku et al., 2018). This is in line with Edori and Nna (2018), who reported 20.53 ± 3.27–33.51 ± 6.25 mg/l for the water samples of the New Calabar River.

The organic pollutant of surface water obtained from Idu Ogba River is shown in Table 3. Some of the organic pollutants are Biochemical oxygen demand, Chemical oxygen demand and Dissolve oxygen. The amounts of BOD_5 in the Idu Ogba River were found to be 10.76 ± 0.27 mg/L, 10.60 ± 0.11 mg/L, and 10.48 ± 0.15 mg/L, respectively.

In a related study, Edori and Edori (2021) discovered a 7.300.60 mg/l concentration of BOD in the surface water of the Orashi River in Rivers State. In a study conducted by Uzamere et al. (2023), the researchers reported a mean BOD value of 9.17 ± 0.26 mg/l in the New Calabar River. Similarly, Omoboriowo et al. (2012) observed a range of BOD values between 6.8 and 14.00 mg/l in the Asa River. Ekhator (2018) conducted an estimation of the BOD and found that the measured value was within the permissible limit set by WHO. The elevated levels of BOD observed in the Idu Ogba River serve as an indicator of the presence of both organic and inorganic pollutants. The observed elevation in BOD levels during this specific temporal interval can be attributed to the heightened runoff of erosive water. This runoff facilitated the transportation of various substances, including debris from streets and pavements, as well as nutrients originating from fertilizers, lawns, gardens, road surfaces, and residential areas, into the river. This is substantiated by the research outcomes (Amadi, 2010; Jamalianzadeh et al., 2022; Owhoeke et al., 2023).

The concentration of COD in sample stations A(52.00±1.63mg/L) and C(51.00±1.02 mg/L) surpassed the maximum allowed limits of 50 mg/L set by WHO and EU for drinking water and the protection of aquatic life. The recorded COD value for station B was 50 mg/L. According to Amadi et al. (2017), the range of COD recorded for the water quality index of Otamiri and Oramiri-Ukwa along the Imo River was 10.20 mg/L to 50.00 mg/L. According to the findings of Jamalianzadeh et al. (2022), elevated concentrations of COD have been linked to adverse effects such as fish mortality and the occurrence of dysentery in individuals exposed to contaminated water sources. The concentration of DO in the water of Idu Ogba River exhibited a range of values from 3.53 to 3.41 mg/L, with an estimated mean of 3.47±0.06 mg/L. This observed mean falls below the acceptable levels for DO as set by both the USEPA and WHO. The findings were consistent with the results reported by Omoboriowo et al. (2012), who estimated the range of 4.80 to 5.30 for the Asa River. Singh et al. (2010) made comparable findings, indicating a DO level of 4.43 mg/l in four rivers situated in Manipur, a northeastern state of India that shares a border. Additionally, Edori and Nna (2018) documented a DO range of 2.62 ± 0.02-5.02 ± 0.31 mg/l at three locations where wastewater is discharged into the New Calabar River. The occurrence of fish mortality occurrences is frequently associated with diminished amounts of dissolved oxygen. Dissolved oxygen is an essential indicator in the field of agriculture since it plays a vital role in supporting the respiration and metabolic functions of aquatic organisms, particularly fish (Nasrabadi et al., 2016).

The nutrient parameter of surface water obtained from the Idu Ogba River is shown in Table 4. Some of the nutrient parameters are nitrate, phosphate and sulphate. The nitrate concentrations recorded for stations A, B, and C were 6.33 ± 0.01 mg/L, 6.28 ± 0.06 mg/L, and 6.25 ± 0.021 mg/L, respectively. The values observed in this study exceeded the established limit of 1.0 mg/L set by the World Health Organisation (WHO), although they were lower compared to the range of 55.90-135.0 mg/L reported by Uzamere et al. (2023) in their examination of the New Calabar River. Edori and Nna (2018) observed a lower mean nitrate range of 0.32 0.01-0.53 0.04 mg/l in samples obtained from three distinct effluent discharge locations in the New Calabar River. Similarly, Keke et al. (2020) reported a mean nitrate concentration ranging from 0.44 to 1.44 mg/l in surface water collected from the Kaduna River in Zungeru, Niger State, Nigeria. The presence of elevated nitrate concentrations in river water can lead to the proliferation of planktonic organisms and aquatic vegetation, hence providing a source of nourishment for fish populations. When algae proliferate excessively, it leads to a reduction in oxygen levels, resulting in fish mortality and the occurrence of eutrophication. According to Kaizer and Osakwe (2010), the suggested nitrate concentration in drinking water primarily aims to prevent the occurrence of methemoglobinemia, a condition resulting from the conversion of nitrate to nitrite are 0.30 or greater. This is in contrast to the suggested limit value of 0.10 for rivers and streams (Keke et al., 2020). The significance of phosphates in rivers mostly arises from their role in the process of eutrophication, which leads to the enrichment of lakes and rivers. Phosphates have the potential to stimulate the proliferation of algae and other plant species, leading to the occurrence of algal blooms, significant fluctuations in dissolved oxygen levels over 24 hours, and several associated issues (Edoreh et al., 2021).

The recorded mean sulphate concentrations in surface water from the Idu Ogba River were 9.600.31 mg/L, 9.400.27 mg/L, and 09.200.23 mg/L. The concentration observed in this study is comparatively lower than the concentration of 73.0311.04 mg/l reported by Uzamere et al. (2023) for the New Calabar River, as well as the concentration range of 65.92 12.50-346.72 23.22 mg/l reported by Edori and Nna (2018) for three specific effluent discharge locations into

The average phosphate concentration in the surface water of Idu Ogba River was determined to be 0.54±0.01mg/l, 0.52±0.032mg/l, and 0.48±0.02mg/l, exhibiting little variations across different locations. The levels observed in this study fall below the permissible limit set by WHO, although they exceed the range of 0.01-7.40 mg/L reported by

Edoreh et al. (2021) for the Yelwa River located in southern Nigeria. In a study conducted by Omoigberale et al. (2014), the phosphate levels in the water of Oguta Lake were seen to range from 0.02 to 0.50. Conversely, Ilechukwu et al. (2021) reported phosphate levels ranging from 0.36 to 0.89 in their study. Nevertheless, it is worth noting that in aquatic environments with an abundance of nutrients, the typical phosphate concentrations found in surface waters the New Calabar River. In a study conducted by Ekevwe et al. (2019), it was observed that a concentration of 44.3-83.3 mg/l was detected in River Jakara. Similarly, Sheykhi and Moore (2012) reported a range of 2400-7008 mg/l for the concentration of a certain substance in Kor River, located in the Fars province of Southwest Iran. The observed variations in sulphate concentrations within the Idu Ogba River can be ascribed to several factors, including the application of agricultural fertilisers and manure, modifications in farming techniques, and the implementation of runoff management strategies (Muhammad et al., 2022). The presence of low amounts of sulphate in aquatic ecosystems can exert a significant influence, as sulphate plays a crucial role in the growth of some microbial organisms and is intricately engaged in the nutrient cycle. Sulphate deficiency has been identified as a potential cause of adverse effects on aquatic organisms, such as fish and other aquatic species (Orie et al., 2015; Bilgin, 2018; Barkett & Akün, 2018; Owhoeke et al., 2023).

Conclusion

The study investigates the physicochemical features of surface water at selected stations of the Idu Ogba River. Specifically, the physical and chemical parameters, organic contaminants, and nutrient parameters in surface water. Variations in pH, alkalinity, chlorine levels, turbidity, conductivity, total dissolved solids, and total suspended solids were observed among the studied stations of surface water. The physical and chemical qualities of the substance in question were found to be within the acceptable limits set by WHO, indicating that they do not pose any potential harm to the individuals residing in the area. The presence of enhanced levels of BOD and COD in certain measured stations within the Idu Ogba River indicates the existence of both organic and inorganic contaminants. This phenomenon can be linked to the increased runoff of erosive water. The dissolved oxygen (DO) concentration in the river falls below the permissible range, thereby facilitating the respiration and metabolic processes of aquatic species. The observation indicates that the nitrate concentration in the river was elevated, which has the potential to stimulate the growth of planktonic organisms and aquatic vegetation. Consequently, this can serve as a nutrient source for fish populations. The study additionally presents findings of decreased levels of phosphate and sulphate, which may have implications for the growth of some microbial organisms and their involvement in the nutrient cycle.

References

Akinyemi, L. P., Odunaike, R. K., Daniel, D. E., & Alausa, S. K. (2014). Physico-chemical parameters and heavy metals concentrations in Eleyele River in Oyo State, South-West of Nigeria. *International Journal of Environmental Science and Toxicology*, *2*(1), 1-5.

Amadi, A. N., Olasehinde, P. I., Obaje, N. O., Unuevho, C. I., Yunusa, M. B., Keke, U., & Ameh, I. M. (2017). Investigating the Quality of Groundwater from Hand-dug Wells in Lapai, Niger State, North-central Nigeria using Physico-chemical and Bacteriological Parameters. *Minna Journal of Geoscience*, *1*(1), 77-92.

Atiku, S., Ogbaga, C. C., Alonge, O. O., & Nwagbara, O. F. (2018). Comparative study of the physicochemical and bacteriological qualities of some drinking water sources in Abuja, Nigeria. *Global Journal of pure and applied sciences*, *24*(1), 91-98.

Barkett, M. O., & Akün, E. (2018). Heavy metal contents of contaminated soils and ecological risk assessment in abandoned copper mine harbor in Yedidalga, Northern Cyprus. *Environmental Earth Sciences*, *77*(10), 378.

Bhuyan, M. S., Bakar, M. A., Rashed-Un-Nabi, M., Senapathi, V., Chung, S. Y., & Islam, M. S. (2019). Monitoring and assessment of heavy metal contamination in surface water and sediment of the Old Brahmaputra River, Bangladesh. *Applied Water Science*, *9*(5), 1-13.

Bilgin, A. (2018). Evaluation of surface water quality by using Canadian Council of Ministers of the Environment Water Quality Index (CCME WQI) method and discriminant analysis method: a case study Coruh River Basin. *Environmental monitoring and assessment*, *190*, 1-11.

Bolisetty, S., Peydayesh, M., & Mezzenga, R. (2019). Sustainable technologies for water purification from heavy metals: review and analysis. *Chemical Society Reviews*, *48*(2), 463-487.

Bórquez-López, R. A., Martinez Cordova, L. R., Gil Nuñez, J. C., Gonzalez Galaviz, J. R., Ibarra Gamez, J. C., & Casillas Hernandez, R. (2020). Implementation and evaluation of open-source hardware to monitor water quality in precision aquaculture. *Sensors*, *20*(21), 6112-120.

Butler, B. A., & Ford, R. G. (2018). Evaluating relationships between total dissolved solids (TDS) and total suspended solids (TSS) in a mining-influenced watershed. *Mine water and the environment*, *37*(1), 18-26.

Chandra, S., Singh, A., Tomar, P. K., & Kumar, A. (2011). Evaluation of physicochemical characteristics of various river water in India. *Journal of Chemistry*, *8*, 1546-1555.

Diete-Spiff, T. M., & Kpee, F. (2022). Some heavy metals content of sediment and two species of crabs of the lower reaches of New Calabar River, Nigeria. *Faculty of Natural and Applied Sciences Journal of Scientific Innovations*, *3*(2), 91-99.

Edori, O., & Edori, E. (2021). Profile of total petroleum hydrocarbons in the water and sediment columns of the Orashi river, Engenni, rivers state, Niger delta, Nigeria. *J. Glob. Ecol. Environ*, *11*(2), 12-21.

Edori, E. S., & Kpee, F. (2019). Total petroleum hydrocarbon concentration in surface water from Taylor Creek, Rivers State, Nigeria. *Chemistry Research Journal*, *4*(5), 1-8.

Edori, O. S., & Nna, P. J. (2018). Determination of physicochemical parameters of effluents at discharge points into the New Calabar River along Rumuolumeni axis, Niger Delta, Nigeria. *Journal of Environmental and Analytical Toxicology*, *8*(3), 2161-0525.

Edoreh, J. A., IMoobe, T. O. T., Ikpokpo, E., Ubrei-Joe, M. M., & Ubrei-Joe, C. M. (2021). Zooplankton Diversity, Dynamics and Correlation with Physicochemical Parameters at Ugbevwe Pond in Delta State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *25*(6), 1047-1052.

Ekere N., R., Ihedioha Janefrances, N., Eze Ifeanyi, S., & Agbazue Vitus, E. (2014). Health risk assessment in relation to heavy metals in water sources in rural regions of South East Nigeria. *Inter. J. Phys. Sci*, *9*(6), 109-116.

Ekevwe, A., Aloba, I., Mathew, O., & Aroh, A. O. (2019). Comparative Physicochemical Pollution Index of Rivers along River Jakara and Its Tributaries. *East African Scholars Journal of Agriculture and Life Sciences, 2*(20), 88-91

Ekhator, O. (2018). Application of Water Pollution Indices in the Comparative Assessment of Two Rivers in the Niger Delta Region of Southern Nigeria. *FUPRE Journal of Scientific and Industrial Research (FJSIR)*, *2*(1), 88-108.

Hagan, G. B., Ofosu, F. G., Hayford, E. K., Osae, E. K., & Oduro-Afriyie, K. (2011). Heavy metal contamination and physico-chemical assessment of the Densu River basin in Ghana. *Research Journal of Environmental and Earth Sciences*, *3*(4), 385-392.

Ilechukwu, I., Osuji, L. C., Okoli, C. P., Onyema, M. O., & Ndukwe, G. I. (2021). Assessment of heavy metal pollution in soils and health risk consequences of human exposure within the vicinity of hot mix asphalt plants in Rivers State, Nigeria. *Environmental Monitoring and Assessment*, *193*(8), 461-75.

Iyama, W. A., & Edori, O. S. (2014). Seasonal variation in water quality during dredging of brackish water habitat in the Niger Delta, Nigeria. *Trends in Applied Sciences Research*, *9*(3), 153-159.

Jamalianzadeh, S. F., Rabieifar, H., Afrous, A., Hosseini, A., & Ebrahimi, H. (2022). Modeling DO and BOD5 Changes in the Dez River by Using QUAL2Kw. *Pollution*, *8*(1), 15-35.

Kamboj, N., & Kamboj, V. (2019). Water quality assessment using overall index of pollution in riverbed-mining area of Ganga-River Haridwar, India. *Water Science, 33*(1), 65-74.

Kaizer, A., & Osakwe, S. (2010). Physicochemical characteristics and heavy metal levels in water samples from five river systems in Delta State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *14*(1),12-21.

Keke, U., Arimoro, F., Ayanwale, A., Odume, O., & Edegbene, A. (2020). Biodiversity patterns along seasonality and environmental factors of stream macroinvertebrate communities of North-Central Nigeria. *Egyptian Journal of Aquatic Biology and Fisheries*, *24*(4), 521-534.

Kpee, F., Ozioma, E., & Ihunwo, L. (2009). Seasonal variation of Cd, Ni, Cu and Pb in catfish, sediment and water samples from Ipo stream in Ikwerre District of Rivers State, Nigeria. *Journal of Applied Sciences and Environmental Management*, *13*(2),63 - 67.

Meena, M. D., Yadav, R. K., Narjary, B., Yadav, G., Jat, H. S., Sheoran, P., & Moharana, P. C. (2019). Municipal solid waste (MSW): Strategies to improve salt affected soil sustainability: A review. *Waste management*, *84*, 38-53.

Muhammad, S., Ullah, S., Ali, W., Jadoon, I. A., & Arif, M. (2022). Spatial distribution of heavy metal and risk indices of water and sediments in the Kunhar River and its tributaries. *Geocarto International*, *37*(20), 5985-6003.

Nasrabadi, T., Ruegner, H., Sirdari, Z. Z., Schwientek, M., & Grathwohl, P. (2016). Using total suspended solids (TSS) and turbidity as proxies for evaluation of metal transport in river water. *Applied Geochemistry*, *68*, 1-9

Nsude, O. P., & Orie, K. J. (2022a). Microcrystalline cellulose of oil bean pod: Extraction, physicochemical, brunauer–emmett–teller (BET), and flow-ability analysis. *Asian Journal of Applied Chemistry Research*, *12*(4), 1-12.

Nsude, O. P., & Orie, K. J. (2022b). Phytochemical constituent and anti-corrosion properties of the root extract of Phyllanthus mellerianus (Nvo-nkwu) plant on mild steel in 1.5 M HCl medium. *Chemical Science International Journal*, *31*(2), 21-34.

Obasohan, E. E., Oronsaye, J. A. O., & Eguavoen, O. I. (2008). A comparative assessment of the heavy metal loads in the tissues of a common catfish (Clarias gariepinus) from Ikpoba and Ogba Rivers in Benin City, Nigeria. *Afr. Sci*, *9*, 13-23.

Okocha, B. I., Orie, K. J., Duru, R. U., & Ngochindo, R. L. (2023). Analysis of the active metabolites of ethanol and ethyl acetate extract of Justicia carnea. *African Journal of Biomedical Research*, *26*(1), 109-117.

Orie, K. J., James, A. O., & Akaranta, O. (2015). The Corrosion Inhibition of Mild Steel in 0.5 m Phosphoric Acid and Crown Cork in Water By Folic Acid. *International Journal of Science and Research (IJSR)*, *4*, 1380-1385.

Omoigberale, M. O., Oboh, I. P., Erhunmwunse, N. O., Ezenwa, I. M., & Omoruyi, S. O. (2014). An assessment of the trace metal contents of Owan River, Edo State, Nigeria. *European International Journal of Science and Technology*, *3*(5), 88-98.

Omoboriowo, A. O., Chiadikobi, K. C., & Chiaghanam, O. I. (2012). Depositional Environment and Petrophysical Characteristics of" LEPA" Reservoir, Amma Field, Eastern Niger Delta, Nigeria. *International Journal of Pure & Applied Sciences & Technology*, *10*(2) 38-61.

Owhoeke, E., Ali, A., Nnaemeka, O. J., Orie, K. J., Ehiwario, J. N., & Rashid, A. (2023). Index model equation analysis: A case study of the risk and source of inorganic contaminants in roadside uncontaminated soil of the Egi oil producing area, Niger Delta. *International Journal of Sediment Research*, *38*(6), 891-900.

Owokotomo, A. I., Ajayi, O. O., Alabi, O. O., & Chukwuka, A. V. (2020). Watershed land use, surface water vulnerability and public health risks of two urban rivers, Ado-Ekiti, South-West Nigeria. *SN Applied Sciences*, *2*, 1-21.

Potapowicz, J., Szumińska, D., Szopińska, M., Czapiewski, S., & Polkowska, Ż. (2020). Electrical conductivity and pH in surface water as tool for identification of chemical diversity. *Ecological Chemistry and Engineering S*, *27*(1), 95-111.

Rajeshkumar, S., Liu, Y., Zhang, X., Ravikumar, B., Bai, G., & Li, X. (2018). Studies on seasonal pollution of heavy metals in water, sediment, fish and oyster from the Meiliang Bay of Taihu Lake in China. *Chemosphere*, *191*, 626-638.

Ramkumar, T., Venkatramanan, S., Anithamary, I., & Ibrahim, S. M. S. (2013). Evaluation of hydrogeochemical parameters and quality assessment of the groundwater in Kottur blocks, Tiruvarur district, Tamilnadu, India. *Arabian Journal of Geosciences*, *6*, 101-108.

Sabater, S., Bregoli, F., Acuña, V., Barceló, D., Elosegi, A., Ginebreda, A., & Ferreira, V. (2018). Effects of human-driven water stress on river ecosystems: a meta-analysis. *Scientific reports*, *8*(1), 11462.

Sheykhi, V., & Moore, F. (2012). Geochemical characterization of Kor River water quality, fars province, Southwest Iran. *Water quality, exposure and health*, *4*, 25-38.

Singh, M. R., Gupta, A., & Beeteswari, K. H. (2010). Physico-chemical properties of water samples from Manipur river system, India. *Journal of Applied Sciences and Environmental Management*, *14*(4).21-30

Uzamere, O., Kpee, F., & Momta, P. N. (2023). Determination of levels of physicochemical parameters in water samples of New Calabar River, Rivers State, Nigeria. *Faculty of Natural and Applied Sciences Journal of Scientific Innovations*, *4*(1), 55-63.

Wokoma, O. A. F., & Edori, O. S. (2020). Some Physicochemical Parameters of Wastewater from an Oil Industry at Point of Discharge in Port Harcourt, Rivers State, Nigeria. *Journal of Physical Science and Environmental Studies*, *6*(2), 23-28.

Xiang, X., Li, Q., Khan, S., & Khalaf, O. I. (2021). Urban water resource management for sustainable environment planning using artificial intelligence techniques. *Environmental Impact Assessment Review*, *86*, 106515.