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The Impacts of Anthropogenic Activities on Agbarho River, Delta State

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ABSTRACT: The study evaluates the physical, chemical and heavy metal properties of the Agbarho River, Delta State, Nigeria using standard methods for analysis with a view of ascertaining the water quality and establishing the correlation with national and international standards. The analyses revealed the water to be slightly acidic (pH - 5.60±0.31). It also recorded a mean temperature of 26.94 ± 0.45, TDS (70.478 ± 1 mg/L), electrical conductivity (90±1μS/cm), Dissolved Oxygen (4.548 ±0.005mg/L), Biological Oxygen Demand (1.35 ±0.002mg/L), Total Hardness (23.2 ± 0.1mg/L), Sulphate (20.397 ±1.2 mg/L) and Total Alkalinity (24.8 ± 1mg/L). The values were within the permissible limits of WHO and FEPA. On the contrary, Total Suspended Solid (7.09 mg/L), Turbidity (46.8776 ± 1NTU), pH and Dissolve Oxygen were above the permissible limits of the regulatory agencies. On the heavy metals, chromium and lead were not detected in the water body. Similarly, iron with 2.2747 ±0.05 showed a very high concentration above the tolerance limit of WHO and FEPA. The study concluded that there is some level of pollution in the river. Hence, adequate treatment is recommended before it can be used for any purpose.

Keywords: Abattoir, Agbarho, Dredging, Effluents, Pollution, Waste dumpsite.

Introduction

Water is a finite resource that is very essential for human existence, agriculture and industry. Thus, inadequate quantity and quality of water have serious impacts on sustainable development. Due to the rapid population growth and accelerated industrialization over the past few decades, there has been a significant increase in the demand for freshwater (Ramakrishnaiah *et al.*, 2019). Human health is threatened by most of the extensive urbanization, agricultural practices, industrialization, and population expansion have led to water quality deterioration in many parts of the world (Mian et al., 2010, Ogeleka *et al.*, 2015). Activities such as dredging, municipal waste and abattoir contain significant spectrum of organic and inorganic substances capable of producing adverse effects on the physical, chemical and biotic components of the environment either directly or indirectly on human health The rapid increase in human population, inadequate infrastructural facilities, lack of good/proper facilities for waste disposal as well as problem of refuse collection and disposal, have contributed to the environmental decay (Okeke, 2014). Although Ezemonye, Ogeleka and Okieimen (2007) and Egborge (2001) did some work in terms of making available data on the physico-chemical characteristics and fish production of the river, there is still need to keep modern trend (extrapolatory studies). Microorganisms, inorganics, organics, radionuclides, disinfectants, and other pollutants can all be found in water (Iwegbue *et al.*, 2022). In comparison to organic contaminants, inorganic compounds are the most prevalent contaminants in water. They are predominantly heavy metals in their mineral form (Rahmanian *et al.*, 2015). Pollutants, on the other hand, are compounds that, when released into the environment, have unfavorable impacts or deplete the quality of water resources.
Owa (2013) recorded that water pollution has dual effect on nature: negative effects of living things and on the environment. Water contamination is estimated to be responsible for 14,000 fatalities per day. This occurs as a result of polluted drinking water (Owa, 2013). The minimata disease, which is caused by eating methyl

mercury-contaminated fish, and the *"itai-itai"* kidney disease, which is caused by eating rice from cadmium-contaminated fields in Japan, are two examples of global mortality caused by water pollution (Iwegbue, 2022). Water is a key source of infection since it is a universal solvent. According to the World Health Organization, waterborne infections account for nearly 80% of all ailments (Ramakrishnaiah *et al.,* 2019). Human health has suffered as a result of this. Annually, 1.1 million children die from diarrheal illness, according to reports. Pollution allows disease-carrying pathogens such as bacteria and viruses to enter surface and ground water. These harm plants directly, compromising the health of animals and humans, as well as affecting human nutrition (Owa, 2013). Fluorisis, dental and skeletal problems (due to fluoride pollution), nephritis and nephrosis, typhoid fever, diarrhea, dysentery, cholera, stringellosis, hepatitis, encleplialitis, crytosporidiosis, vomiting, immune suppression, reproductive failure, acute poisoning, and gastroenteritis are just a few of the diseases caused by contaminated water (Okereke, 2014, Ramakrishnaiah *et al.,* 2019). Respiratory disease, cancer, neurological disorder, and cardiovascular disease, rashes, ear ache, pink eye, respiratory infections, vomiting, and stomach ache are some of the other health risks linked with dirty water. Poor water quality (polluted water) kills crops and contaminates our food, posing a threat to aquatic and human life (Okobiebi and Okobiebi, 2021). It has the potential to interrupt photosynthesis in aquatic plants, affecting ecosystems that rely on these plants (Chukwu, 2008). Water pollution causes water to turn black, especially when it comes from natural sources like earthquakes and landslides (Okereke, 2014). Plant nutrients such as nitrogen, phosphorus, and other compounds that encourage aquatic plant growth may also be in excess as a result of pollution. This results in an algal bloom and an overabundance of weed growth. As a result, it alters the quality of water by adding aroma, flavor, and color to it. As a result, the biological balance in the body of water is disrupted (Owa, 2013). In the aquatic ecology, water pollution causes nutrient deficit. In acidified water, the population of disintegrating microorganisms such as bacteria and fungi diminish, slowing the decomposition of organic materials. This has a significant impact on the nutrition cycle (Singh and Gupta, 2016). Eutrophication is the most serious of all the water quality challenges that face water bodies (particularly lakes). Eutrophication is a word used to describe a lake's aging as a result of nutrients, sediments, silt, and organic matter accumulating in the lake from the surrounding watershed (Asibor and Ofuya, 2019). Agricultural wastes engender eutrophication of water bodies by enriching nutrients, acidifying the water, lowering the photosynthetic rate, uncoupling phosphorylation, and inhibiting the nitrate reductase enzyme. As a result, pollution might be considered to cause water bodies to age. Fly ash and other industrial wastes produce a thick floating cover over the water, preventing light from reaching the deeper layers of water bodies. Furthermore, it causes a rise in water alkalinity and a decrease in the uptake of necessary bases. Aquatic vegetation dies as a result of this. Oil spills inhibit oxygenation of the water body, thus, lowering the oxygen content and reducing light transmission. This prevents plankton development and photosynthesis in macrophytes (Egun *et al 2018*). When water is polluted thermally, aerobic decomposers' activity is substantially hampered by oxygen loss. Increased temperature reduces enzymatic activity in the water body, reducing photosynthetic rate, primary productivity, and variety of aquatic plants (Egun *et al 2018*). Phytotoxicity occurs when pollutants build up in the aquatic and terrestrial environment. These harmful substances are absorbed through their roots, poisoning the plants. Poor growth, withering seedlings, and dead spots on leaves are some of the signs (Egun *et al 2018*). The study is aimed at accessing the physiochemical and heavy metal parameters of the Agbarho River.

Materials and methods

Description of study area: The Agbarho river (Figure 1) serves as the case study with respect to the dredging, municipal waste and abattoir activities. Agbarho is one of the major town in Delta State, Southern Nigeria. It lies between latitude N5º 35’ 00’’ and longitude E5º 52’ 00’’. it is an important economic river in Delta state as various socio-economic activities including vehicle washing and fishing are possible through the river. The river also serves for the purpose of sand resources as it accommodates several dredging activities at various points. People living within the vicinity draw water from the river and even swim in it. The river originates from Orho a hinterland in Warri and stretches down westward to Uvwie Local Government Area of the state where it empties with its creeks into the Atlantic Ocean (Asibor and Ofuya, 2019). The river receives wastes from dredging, municipal dumps and from abattoir sited along its course.

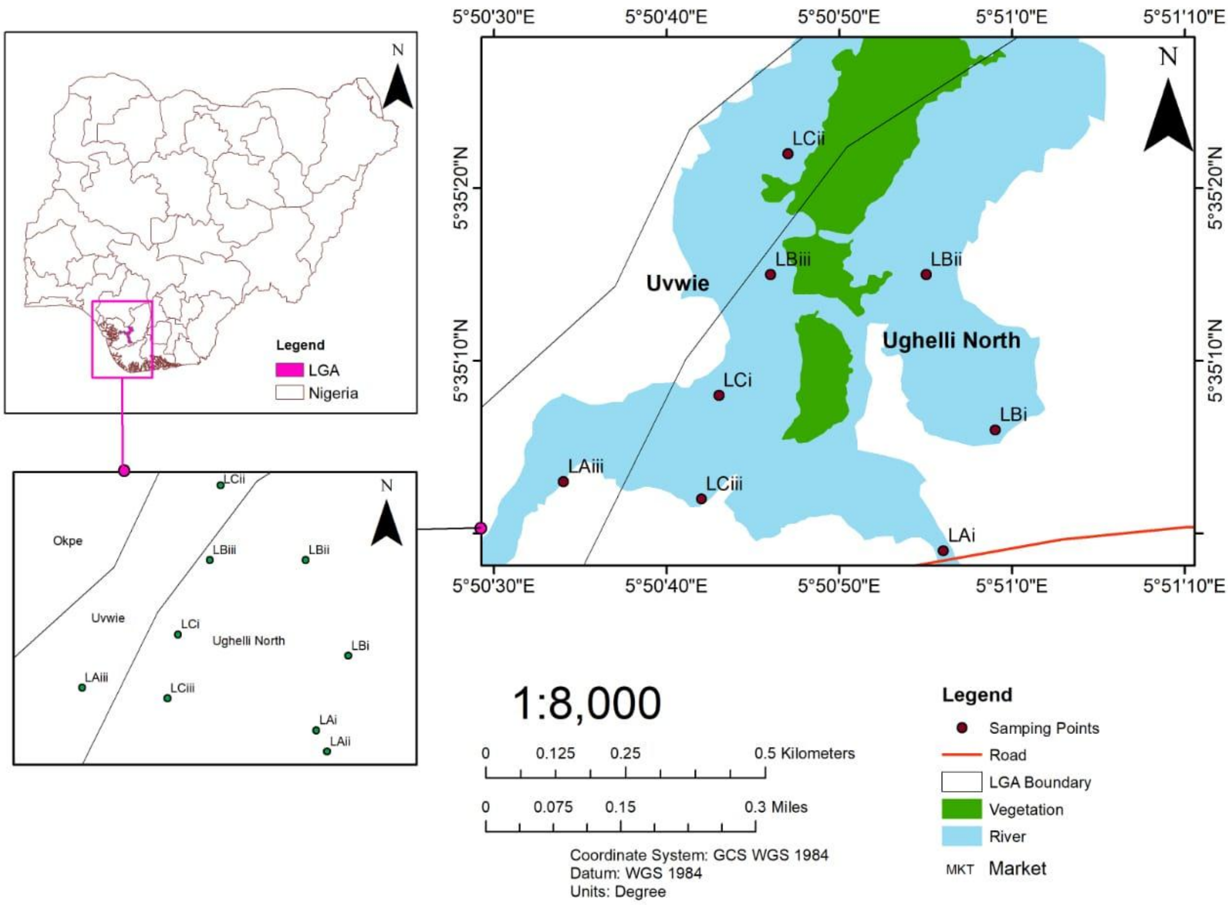

Figure 1: Map of the study area showing the sampling points

Sample collection, handling and preservation sampling: A total number of ten samples were collected in three major anthropogenic (dredging, municipal waste and abattoir) activities site. In addition to sample collection at source point, 500 M upstream and 500 M downstream, a control was collected at Orherhe River. At the point of collection of each of the water samples, each of the sampling containers were labelled appropriately and rinsed twice with the sample before collection. However, samples for Dissolved Oxygen (DO) analysis were collected with DO bottles and fixed with Winkler A and Winkler B solutions, samples for Biochemical Oxygen Demand (BOD) analysis were collected with BOD bottles (amber colour) while samples for metal analysis were collected with heavy metal analysis bottle and were preserved with 1:1 nitric acid solution. Field *in-situ* analysis was carried out on site for temperature, pH, total dissolved solid (TDS) and conductivity. The samples were transferred immediately to the laboratory. All the water samples collected were placed in a cooler containing ice-chest and were transported to the laboratory for analysis. ASTM Standard method of analysis was used to analyze the parameters.

Results

The physical properties, chemical properties, oil and grease and heavy metals of the 10 points sampled in the Agbarho River are shown in Table 1. The results of principal component analysis of the physicochemical properties of the surface water of Agbarho River is displayed in Table 2 while Pearson's correlation matrix is presented in Table 3.

Table 1: Result of physicochemical properties of the surface water of Agbarho River

Parameters	LAi	LAii	LAiii	LBi	LBii	LBiii	LCi	LCii	LCiii	LD	WHO	FEPA
Temp (^{0}C)	26.2	26.5	26.3	26.9	27.21	27.21	27.45	27.31	27.12	27.26	N/A	10-50
pH	5.6	5.8	5.7	5.8	5.97	5.6	5.94	5.99	5.97	6.01	6.5-8.5	
Elec.Cond. (µS/cm)	70	55	60	110	60	124	113	106	113	89	1000*	
DO (mg/L)	2.8	2.98	3.15	1.99	6.3	6.1	3.21	6.2	6	6.75	N/A	3 - 5
BOD (mg/L)	1.7	0.1	1.25	2.35	1.5	1.2	1.4	1.9	1.7	1.6		20- 3000
Oil & grease (mg/L)	0.0046	0.0044	0.0034	0.0032	0.004	0.004	0.007	0.007	0.008	0.007		0.3-500
Chromium (mg/L)	< 0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.05	
Lead (mg/L)	< 0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05	
Iron (mg/L)	3.251	1.822	1.947	4.013	1.829	1.881	1.984	1.823	2.121	2.076	0.3	
Zinc (mg/L)	0.8178	0.2115	0.3261	0.7671	0.2110	0.233	0.3192	0.232	0.101	0.110	5.0	
Total Hardness (mg/L)	26	23	24	29	19	23	31	18	21	18	500	
Magnesium (mg/L)	2.820	2.043	2.366	2.963	2.105	2.401	2.651	2.204	2.344	2.2051	50	
Nitrate (mg/L)	1.251	0.532	0.91	1.64	0.588	0.732	1.02	0.511	0.721	0.455	10.0	
Alkalinity (mg/L)	29	26	24	29	24	23	26	24	24	19	500	
Sulphate (mg/L)	20.43	19.80	21.33	22.62	20.41	21.32	20.44	19.80	19.70	18.12	200	
Salinity (mg/L)	0.10	0.05	0.07	0.08	0.05	0.08	0.07	0.06	0.07	0.04	200	
Turbidity (NTU)	46.11	37.92	43.59	51.55	39.64	45.38	81.25	41.21	44.97	37.156	5.0	
Total Suspended Solid (mg/L)	5.82	4.05	5.05	6.165	5.395	6.165	8.25	4.25	4.65	5.09	N/A	
TDS (mg/L)	79.40	60	61	81.03	41.4	79.36	102.2	60.84			1500	

Table 2: Principal omponent results of the surface water of Agbarho River

	Component			
	1	2	3	4
Magnesium	**.981**		.107	.130
Nitrate	**.960**	-.167	.138	
Total Hardness	**.879**	.257	-.128	-.342
Zinc	**.856**	-.449	.131	
Iron	**.836**	-.400	.246	.172
Salinity	**.796**	-.136	-.260	.330
Alkalinity	**.786**	-.397	.188	-.277
TDS	**.768**	**.513**	-.146	-.103
DO	**-.719**	.340	.100	**.513**
Sulphate	**.638**			**.458**
Temperature	-.202	**.832**	.428	.221
Turbidity	**.554**	**.719**	.110	-.370
TSS	**.651**	**.694**		-.100
EC	.359	**.674**	.168	**.500**
O and G	**.449**	**.577**	-.562	
BOD	**.427**	-.206	**.828**	
pH	-.396	.337	**.784**	-.320
Total	8.29	3.65	2.09	1.39
Eigenvalue % of variance	48.79	21.46	12.35	8.22
Cumulative %	48.79	70.26	82.61	90.82

Note: highlighted bold are the significant loading at 0.05 confidence intervals.

Table 3: Pearson Correlation Matrix

	Temp	pH	EC	DO	BOD	O and G	Cr	Pb	Fe	Zn	TH	Mg	Nitrate	alkalinity	sulphate	salinity	turbidity	TSS	TDS
temp	1.00																		
pH	0.64	1.00																	
EC	0.68	0.04	1.00																
DO	0.59	0.31	0.19	1.00															
BOD	0.07	0.38	0.11	-0.23	1.00														
O and G	0.18	-0.38	0.33	-0.15	-0.39	1.00													
Cr	-0.32	-0.31	0.17	-0.63	0.60	0.05	1.00												
Pb	-0.46	-0.42	0.06	-0.65	0.58	0.07	0.95	1.00											
Fe	-0.10	-0.24	0.31	-0.78	0.18	0.62	0.55	0.56	1.00										
Zn	-0.14	-0.36	0.43	-0.61	0.54	0.36	0.86	0.88	0.79	1.00									
TH	-0.26	-0.34	0.26	-0.72	0.56	0.28	0.92	0.90	0.78	0.96	1.00								
Mg	-0.42	-0.20	-0.05	-0.79	0.50	0.06	0.87	0.90	0.63	0.75	0.80	1.00							
Nitrate	-0.07	-0.37	0.36	-0.37	0.28	0.31	0.65	0.50	0.48	0.65	0.75	0.29	1.00						
Alkalinity	-0.35	-0.71	0.32	-0.39	0.24	0.36	0.66	0.79	0.53	0.83	0.72	0.55	0.45	1.00					
Sulphate	0.42	0.21	0.51	-0.33	0.20	0.58	0.10	0.13	0.78	0.52	0.40	0.23	0.13	0.24	1.00				
Salinity	0.40	-0.02	0.54	-0.23	0.16	0.79	0.23	0.25	0.77	0.63	0.51	0.23	0.34	0.42	0.90	1.00			
Turbidity	0.17	-0.24	0.66	-0.46	0.07	0.61	0.36	0.41	0.85	0.73	0.58	0.43	0.29	0.61	0.83	0.80	1.00		
TSS	-0.29	-0.28	0.22	-0.54	0.72	-0.06	0.96	0.94	0.47	0.87	0.91	0.78	0.66	0.70	0.10	0.21	0.34	1.00	
TDS	0.32	0.00	0.46	-0.37	-0.08	0.78	0.07	0.10	0.83	0.47	0.36	0.22	0.14	0.27	0.94	0.90	0.86	0.00	1.00

Discussion

Temperature distribution: Temperature is a water property that aids in the regulation of metabolism in the aquatic environments and oxygen availability (Aliyu *et al*., 2021). The water's temperature ranged from 26.2 °C -27.45 °C. The minimum temperature recorded was 26.2 °C at waste dumpsite source point (LAi) while the maximum temperature was 27.45 °C at dredging site source point (LCi). It was observed that the temperature falls within FEPA permissible limit with an overall mean temperature of 26.94 ± 0.45. It is observed as well that there is no substantial difference in the average level of temperature of the water across the three sample points but a differential variation in temperature near Dredging sites is higher. This temperature is optimum for irrigation and drinking water as it fell within the FEPA limit. This is in consonance with the results obtained by Asibor and Ofuya (2019), Aliyu *et al*. (2021) and Okobiebi and Okobiebi, (2021). Usually, high temperature engenders chemicals reactions and decreases gas (oxygen) solubility in water leading to decreased dissolved oxygen (Okobiebi and Okobiebi, 2021).

Total dissolved solids: The values of total dissolved solids (TDS) ranged from 41.4 mg/L in LCiii to 102.2 mg/L in LCi. Across the sample points, the sample locations with the highest rate of TDS is LCii at 102.2 mg/L. This is followed by LBi at 81.03 mg/L, 79.03 mg/L (LAi), 71.42 mg/L (LD) and 60.84 mg/L (LCiii) and 41.4 mg/L (LCii) as the lowest. The sample location of dredging site appeared to have had higher dissolved solids than other sites compared with dumpsite and abattoir with mean 70.478 ± 1. The higher rate of TDS closer to the dredging sites could be as a result of the fine particles from the site. Given the standards of the WHO and FEPA for portable water, the values were within the permissible limits. With the TDS being an indication of dissolved salt content of the water, the low values suggest low concentration of these salts in the water body. Asibor and Ofuya (2019) reported similar range for TDS. TDS and salinity exhibit a strong positive correlation (r=0.90). As TDS levels rise, the salinity of the water also tends to increase. This relationship indicates that dissolved substances contribute to the overall salinity of the water.

Total suspended solids: The average total suspended solids of the River is 7.09 mg/L. The values ranged from 4.05 mg/L – 8.25 mg/L. The highest suspended solids were recorded at the dredging sites source point (LC1) and waste dumpsites downstream (LBiii) as a result of release and accumulation of solids. These points are all within the permissible limit for FEPA. The relative high values maybe due to the proximity to the dredging site (Okobiebi and Okobiebi, 2021). TSS and turbidity demonstrate a positive correlation (r value of 0.72). Higher levels of TSS are associated with increased turbidity, indicating that suspended particles in the water contribute to its cloudiness or opacity.

Electrical conductivity: The electrical conductivity (EC) property of the water is seen to be within the limits of portable water set by the WHO. The EC values ranged from 55 µS/cm – 124 µS/cm with an overall mean value of 90 ±1 µS/cm. The dredging downstream is more charged electrically with 124 µS/cm which is higher than dredging source point conductivity rate of 113 µS/cm, abattoir source point (LBi) of 110 µS/cm. The dredging sites downstream and source points of the water have more average electrical charge. These low values correlate with the low values of TDS as it is the ions of the dissolved salts that are responsible for electrical conductivity. Okobiebi and Okobiebi, (2021), Aghoghovwia (2011) and Aliyu *et al.* (2021) reported similar correlation of electrical conductivity. This confirms its usability as drinking water and for irrigation purposes. Furthermore, TDS and salinity exhibit a strong positive correlation (r=0.90). As TDS levels rise, the salinity of the water also tends to increase. This relationship indicates that dissolved substances contribute to the overall salinity of the water. the values recorded in the parameters are in agreement as they fell within the limits of the standards with coherent values. According to Enitan *et al*. (2018), high EC is indicative of low water quality (Enitan *et al*., 2018). Thus, the low EC of the water can be said to a measure of good quality of the water.

Turbidity: According to the US Geological survey (USGS, 2018), turbidity is the measure of relative clarity of a liquid. It measures the quantity of light dispersed by the materials in the water when a light source is shone through a water sample and is an optical property of water. The level of turbidity of the water sample would increase in proportion to the intensity of scattered light. The Agbarho River recorded a high turbidity above the permissible limits of WHO and FEPA. The range of turbidity of the sampled water obtained in this study is from 37.156 NTU - 81.25 NTU. The mean turbidity of the river is 46.8776 ±1 NTU and it is important to cross examine the level of turbidity of the water across the three sample locations. The dredging site source (LCi) water sample had a high level of turbidity with 81.25 NTU. This is more than the abattoir source point (LBi) turbidity rate of 51.55 NTU. The implication here is that the more debris is dumped into the water, the more the water becomes turbid and unfit for household use. Also, turbidity and salinity demonstrate a strong positive correlation (r=0.80). As salinity levels increase, turbidity also tends to increase. This relationship suggests that high salinity may contribute to the presence of suspended particles in the water, leading to increased turbidity. High turbidity corresponds to the high values of suspended solids. The corresponding correlation coefficient of turbidity with TSS in this study is estimated as: It confirms that turbidity is a reflection of the total suspended solids (Keke *et al.,* 2016). From This could be as a result of runoff effect from the dredging site, abattoir and waste dumpsite. This tally with the results obtained from Asibor and Ofuya (2019), Enitan *et al*. (2018) and Aliyu *et al*. (2021) in their study.

pH: The Agbarho River has a mean pH of 5.83 ± 0.16 which ranged from 5.99 at Point LCii to 5.6 LAi. The pH is observed to be below the WHO and FEPA standards of 6.5-8.5 and 6.0-9.0 respectively. The pH of the water at the dredging sites and the overall average pH of the water are the same. This shows that the water is acidic. This may not constitute a serious issue when ingested since the contents of the stomach are naturally acidic. Contrarily, it will pose significant problems in industries and domestic uses because of its potential to aid corrosion (Asibor and Ofuya, 2019). Wastes generated and dumped into the water body from anthropogenic activities (dredging, municipal waste and abattoir) happening around the water body could have a significant contribution to the acidic nature of the water body. The lower pH values can also be linked with the entrance of humic materials from the dredging site (Okobiebi and Okobiebi, 2021). Similar trend on the low hydrogen ion concentration was also observed by Asibor and Ofuya, (2019).

Dissolved oxygen: The values of dissolved oxygen varied from 1.99mg/L - 6.75mg/L with a mean dissolved oxygen of 4.548 ±0.005mg/L. These values were within the permissible limits of the WHO with the exception of LBii, LBiii, LCii, LCiii and LD. The level of DO at the control location was the highest with 6.3mg/L. The low values observed for DO at the sampling location of LAi, LAii and LBi, could be as a result of incessant introduction of organic materials into the water bodies from the waste dumpsite and abattoir. This results in oxygen uptake or oxidation and decomposition of the organics. Aghoghovwia (2011) recorded similar results in his seasonal assessment of Warri River. In the same vein, the results of DO by Okobiebi and Okobiebi (2021), Aliyu *et al*. (2021) and Aliyu *et al*., (2016) fell in the same range.

Biological oxygen demand: The concentration of biological oxygen demand ranged from 0.1 mg/L to 2.35 mg/L with a mean value of 1.35 ±0.002 mg/L. The BOD at the dredging sites source point, upstream and downstream are 1.4 mg/L, 1.9 mg/L and 1.7 mg/L respectively. For waste dumpsite 1.7 mg/L, 0.1 mg/L and 1.25 mg/L respectively. For Abattoir 2.25 mg/L, 1.5 mg/L and 1.2 mg/L respectively. Abattoir sites' BOD is greater than that of the dredging sites and waste dumping sites. As an index for water quality assessment, it is the quantity of oxygen needed for biological decomposition of organic matter in an anaerobic condition by microbes. The highest values of BOD occurred at sample LBi. Though, the values recorded were below the permissible limits for all the standards. Since high BOD values are noted for threatening aquatic lives through depletion of oxygen (Aliyu *et al.*, 2021), the low BOD of the sampled water body will enhance their growth. Also, based on the BOD classification where 1-2 mg/L is very good, 3-5 mg/L as moderately clean and 6-9 mg/L as poor (Keke *et al*., 2016).

Water hardness: Low levels of total hardness were observed. This ranged from 18 mg/L-31 mg/L. These concentrations were below the WHO permissible limit. The low levels recorded were in consonance with the TDS values. This shows that very little or no metals were dissolved (Keke *et al*, 2016). It can also be noted that hard water does not lather easily with soap and contributes to scaling in boilers and industrial equipment (Okobiebi and Okobiebi, 2021). Following the classification to categorize water where 0-60 mg/L is soft, 61-120 mg/L is moderately hard, 121-180 mg/L is hard and above 280 mg/L is very hard ($CaCO_3$) (Keke *et al*., 2016). The water from Agbarho River can be said to be a soft water.

Sulphate and oil and grease: The sulphate values ranged from 18.12 mg/L - 22.62 mg/L. The mean sulphate concentration is 20.397 ± 1.2 mg/L. The concentrations were within the maximum permissible limits of WHO and FEPA. The mean salinity value of the Agbarho river is 0.067 ± 0.001 mg/L with variation from 0.04 mg/L-0.1 mg/L. Oil and Grease values were below the permissible limit of FEPA with a range of 0.0032 mg/L - 0.008 mg/L and an average oil and grease concentration of 0.00526 ±0.001 mg/L.

Water alkalinity: Total alkalinity for the water body in this study were low and within the permissible limits of the WHO and FEPA. This ranged from 19 mg/L-29 mg/L. Alkalinity and its significance showed that 0-9 is strongly acidic, 10-50 is low alkalinity, and 50-200 is high alkalinity and 211-500 is optimum alkalinity (Keke *et al*., 2016). Given this classification, the sampled points can be said to be acidic and with very low alkalinity. This was also in conformity with the pH values which indicated acidic and very low alkaline region. The study by Keke *et al*. (2016) & Okobiebi and Okobiebi (2021) agreed with this result.

Heavy metals concentration: The heavy metals concentration in water is an important parameter owing to their detrimental effects to human on consumption. Chromium and lead were not detected in the water body. Zinc values were within the WHO and FEPA standards. The iron concentration ranged from 1.822 mg/L - 4.013 mg/L. The values observed were above WHO and FEPA permissible limits. The high values maybe attributed to the different waste components from the dredging and Abattoir. Also, there is possibility of leachates from the dumpsites contaminating the water body as a result of disposal of batteries, scraps found at the dumpsite (Keke *et al*., 2016). Some of the concentrations recorded are similar to the results by Asibor and Ofuya (2019) in Agbarho River. However, the variation could be attributed to some factors such as pH, temperature, chelating agents etc (Onosemuode and Makun, 2022).

Physicochemical parameters and heavy metal concentration relationship: There is a potential relationship among the level of heavy metal concentration in the water and the trend of some physicochemical characteristics. Heavy metals can contaminate wells through groundwater movement and run-off. Hence, People that consume high levels of heavy metals risk acute and chronic toxicity, liver, kidney, and intestinal damage, anaemia, and cancer. From the result in the correlation matrix in Table 3 shows that there is a relationship between electrical conductivity (EC), and some metal concentration at such the level of metal concentration is expected to spur electrical conductivity of the water. Dissolved oxygen levels exhibit a moderate negative correlation with iron concentrations ($r = 0.78$). As iron levels increase, dissolved oxygen levels tend to decrease. This correlation suggests that high iron concentrations may contribute to oxygen depletion in the water. Dissolved oxygen levels demonstrate a moderate negative correlation with magnesium concentrations ($r= -0.79$) Higher magnesium levels are associated with lower dissolved oxygen content. This correlation suggests that elevated magnesium concentrations may impact the oxygenation capacity of the water. Also, there is positive correlation of 0.54 (54%) between EC and the level of salinity of the water. Here, the higher the level of water salinity, which denotes the amount of dissolved salt in the water, could enhance the extent of electrical conductivity of the water.

Conclusion

Agbarho River is a very important source of water with a multivariate usage to the host community and this study revealed the current physical and chemical properties as well as heavy metal concentrations of the Agbarho river, through study, it was established that anthropogenic activities such as dredging, municipal waste and abattoir located around the river contain significant spectrum of organic and inorganic substances which are important factors affecting the water quality. The results obtained was compared with the standard of national and international regulatory agencies (FEPA and WHO respectively). Some of the parameters did not correlate with the permissible limits. Thus, the water is unfit for human consumption. Appropriate treatment is advised if it must be used for portability.

Recommendation

It is recommended that the municipal waste dumpsite should be relocated and the abattoir effluent should be controlled because of its possibility of contaminating the surface water. The numerous dredging activities should be monitored and controlled. Additionally, consistent monitoring of the water quality of the river is recommended.

Declaration of competing interest

The authors declare that they have no competing interests.

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