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Assessment of heavy metals concentration in surface water from Kolo Creek along Ogbia Axis, Bayelsa State, Nigeria

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Abstract
The contamination of water bodies has become a worldwide issue. Water samples collected from Ogbia axis of Kolo Creek at Imiringi, Emeyal and Otabagi were analyzed for heavy metals concentrations. The samples were analyzed with atomic absorption spectrophotometer (AAS). The results showed that lead varied from 0.729±0.10 - 1.034±0.11 mg/L, copper varied from 0.611±0.03 - 1.136±0.12 mg/L, cadmium varied from undetected - 0.0012±0.00 mg/L, mercury was undetected in all the stations, nickel varied from 0.069±0.01 - 2.413±0.16 mg/L. The values for chromium varied from 0.711±0.11 - 1.360±0.22 mg/L, iron varied from 1.321±0.21 - 2.348±0.41 mg/L and zinc varied from 1.344±0.13 - 2.461±0.42 mg/L. Evaluation of the water using some pollution indices indicted that the water has either been contaminated or polluted by individual heavy metal except mercury that was not detected. The general observation made based on result findings revealed that the water is not fit for human consumption. Therefore adequate measure should be put in place by the different governments (local, state of federal) to preserved this water body from complete deterioration, since it is a mojor source of water supply for the Ogbia tribe of Bayelsa State, Nigeria.

Keywords: Kolo Creek, heavy metals, water pollution, environment, pollution indices

Introduction

Kolo Creek known to be the longest river apart from Orashi, Ase, Forcados, Nun and Taylor Creek in the Forcados and Nun-catchment of Niger Delta. It is a very useful to the entire Ogbia communities settling along the creek. The creek is of importance to the people because it is strategically located and its fresh water nature. The creek takes its course from North-South (Okarki-Engenni) and terminates by Ekolo Creek near to Dorgu-Ama, Okoroma-Tereke in Nembe Local Government Area of Bayelsa State. Despite its significance, the surface water from this creek has been severely affected negatively (Alagoa, 1999; Eli, 2012) [5, 21].

The creek has been associated with different form of chemical contamination (Edori, 2020; Edori and Edori, 2021; Edori and Odoemelam, 2022) [14, 15, 11, 13, 29, 19] resulting from both natural, industrial and domestic activities (Edori *et al*., 2019; Kieri *et al*., 2021) [16, 20, 27, 39, 29]. The uninterrupted oil exploration, exploitation, maintenance and intense agricultural activities have been identified to be the major contributory factors of the observed pollution and contamination of its ecosystem and water bodies (Zaghloul, 2001; Shafei, 2015) [46, 44]. Essentially the intake of water into the human system is accompanied with heavy metals consumption, which in almost all cases are themselves present in water. The intake of both essential and non-essential metals through food web have serious health implications on man and animals (Moore *et al*., 2009) [35]. When heavy metals are present in water bodies either through natural of anthropogenic sources, they produce unwanted effects on water surroundings and afterwards distributed onto the human tissues by food chain (Lavoie, 2013) [31].

Human's incapability to checkmate and maintain the natural environment has caused several indescribable adversity and endangered his coexistence with nature (Wokoma and Edori, 2017; Edori *et al*., 2021) [45, 11, 13, 29]. This situation is occasioned by industrialization and urban renewal programme initiatives (Lu *et al*., 2021). Unrestrained sewage waste into this creek from one of the major oil exploration companies (Shell Petroleum Development Company of Nigeria) has been in existence since when oil was first struck at Imiringi community in 1976 and is today hosts to a number of SPDC subsidiaries.

The presence of heavy metals in water due to petroleum and its allied activities has over the years led to consistent water pollution and in that way making it an unavoidable component of pollution research (Iyama *et al*., 2019) [27, 16]. This is because it is one of the major factors in human health and safety assessment (Abdullah, 2013) [3].

Water possess a unique behavior by acting as a universal solvent, which allows it to dissolve a large number of substances and which may be in the form of suspended particulate matter or dissolved solids. This specific

characteristic property has considerably made water sources to be impure and in some situation contaminated or polluted to levels that becomes harmful when consumed (Nizami and Rehman, 2018) [36].
Therefore, this study was carried out to determine the concentrations of heavy metals and their in surface water of Kolo Creek along the Ogbia axis, Bayelsa State, Nigeria.

Materials and methods

Kolo Creek is situated in the central Niger Delta (Alagoa, 1999) [5]. It falls within latitude 4°23 and 4°3''6N and longitude 6°14 and 6°16'E. Kolo Creek develops from Orashi River Okarki, a town in Rivers State. It's a fresh water creek which flows North-South and terminates at Ekole Creek closer to Dorgu-Ama, Okoroma-Tereke in Nembe Local Government Area of Bayelsa State by a mangrove swamp forest. Majority of the stretch of the creek is within the Ogbia Local Government Area of Bayelsa State (from Otuegwe to Oloibiri Town).
Water samples were collected in the cool of the morning when it has not been disturbed. The samples were collected with polythene bottles of a 0.5 litres capacity. Before water samples were collected, they were initially rinsed twice with the water from the river to be sampled. The collected water samples were acidified with nitric acid immediately after collection.
The samples were labeled and put into a container and was moved to the laboratory. In the laboratory, the samples were put into a freezer maintained at 4 °C pending time for analysis. Thereafter, the samples were analyzed for heavy metals with atomic absorption spectrophotometer, Model SE-71.906 at a private laboratory. The analysis of the heavy metals were done using specific lamp for each heavy metal examined, which were set at different spectrophotometric wavelength depending on the metal. The examination of the concentrations of the metals were conducted in accordance with laid down procedures detailed in APHA and AWWA (19). A blank was carried out for each batch of all the samples collected. A triplicate determination was done for a particular metal.
Contamination factor (CF) was used to determine the gradation of contamination or pollution of the creek by individual metals, while pollution index (PLI), contamination degree (CD) and modified contamination degree (mCD) were used to determine the gradation of contamination or pollution of the creek by combined effect of the metals content in the water from the creek.
The descriptions and interpretations of the different classes of the various levels of contamination factor and pollution index were based on the proposed chart of incidence of contamination and pollution by Lacatusu (2000) [30].

The formula for Contamination factor is given as

$$CF = \frac{Cm}{Cb}$$

While the pollution index (PI) was gotten by applying the equation.
Pollution index (PLI) = n√(CF1 x CF2 x CF3 x… x CFn)
(CF) = contamination factor, n = number of metals
Cm = metal concentration in polluted water.
Cb = background value of the metals or maximum commended value of the metals in water.
The interpretations of the values obtained for contamination factor and pollution index are based on the proposed chart proposed by Lacatusu (2000) [30] as follows;
<0.1 is very slight contamination, 0.10-0.25 is slight contamination, 0.26-0.5 is moderate contamination, 0.51-0.75 is severe contamination, 0.76-1.00 very severe contamination, 1.1-2.0 slight pollution, 2.1-4.0 moderate pollution and 4.1-8.0 is severe pollution.
The contamination degree (CD) and modified contamination degree (mCD) were calculated by applying the equations propounded by Hakanson (1980) [24] to express the major effect of pollution by heavy metals in an ecosystem. The values obtained were interpreted on the basis of interpretation value suggested by Hakanson (1980) [24] as follows; CD<8 is termed low contamination degree, 8≤CD<16 is termed moderate contamination degree, 16≤CD<32 is termed considerable contamination degree and CD>32 is termed very high contamination degree

The contamination degree was express as

$$\mathrm{CD} = \sum_{i=1}^{n} C\,F$$

Whereas the modified contamination degree equation is expressed as

$$\mathrm{mCD} = \mathrm{mCD} = \frac{1}{N}\sum_{i=1}^{N} CFI$$

Where,
CD = the degree of contamination

CF = Contamination factor of each metals
n = the number of the heavy metals investigated

The terminologies applied in the classification of the extent of contamination using modified degree of contamination are; mCD < 1.5 represents nil to very low degree of contamination, 1.5≤mCD<2 represent low degree of contamination, 2≤mCD<4 represents moderate degree of contamination, 4≤mCD<8 represents high degree of contamination, 8≤mCD<16 represents very high degree of contamination, 16≤mCD< 32 represent extremely high degree of contamination and mCD≤32 represent ultra-high degree of contamination.

Results and discussion

Lead (Pb)

The concentrations of lead observed in the creek varied from 0.729±0.10 - 1.260±0.02 mg/L. These values are higher than the values of WHO of 0.05 mg/L for domestic water use. The observed values of Pb in Ogbia axis of the Kolo Creek if higher than the values of Edori *et al*. (2019) [16, 20, 27, 39] in Elelenwo River, Port Harcourt, Rivers State, Nigeria, but are lower than the values of Ekpete *et al*., (2019) [20] in water samples obtained from Silver River, Southern Ijaw, Bayelsa State, Niger Delta, Nigeria. Lead is a dangerous element to both plants and animals and it is not desired in the human body, due to the fact to it has no known beneficial function in both plants and animals (Kieri *et al*., 2020). It has been observed to cause serious health effects in fish at high concentrations through the destruction of cells and tissues (Abdelhamid & El-Ayouty, 1991) [2]. Higher than required values of lead in human body causes toxic effects that may (Nwineewii *et al*., 2018) [38]. Its presence in aquatic plants and animals of both marine and freshwater leads to reduced performance ability and growth complications (Freda, 1991) [23]. High concentrations of Pb in infants and children can cause brain and neuron damage (Edori and Edori, 2012) [12] and impact destructively in body metabolic developmental processes of living organisms, thus slowing down vital components of the natural environment (Edori *at el*., 2019) [16, 20, 27, 39].

Copper (Cu)

Copper (Cu) concentrations in the creek varied from 0.611±0.03 - 1.136±0.12 mg/L. The observed values were lower than the WHO recommended value of 1.50 mg/L for portable water. The values recorded in this work were higher than those of Edori and Iyama (2020) [14, 15] in Edagberi Creek, Engenni, Rivers State, South-South, Nigeria and the values observed in the Engenni axis of Orashi River, Rivers State, Nigeria (Odoemelam *et al*., 2019) [39]. According to (Horne & Dunson, 1995), excessive consumption of Cu beyond the permissible limit or its presence in water environment is poisonous to both man and the aquatic habitation.

Cadmium (Cd)

Cadmium was observed only at Imiringi station with a value of 0.0012±0.00 mg/L, which was lower than the WHO value of 0.005 mg/L for drinking water. The range of values of cadmium observed in the present work is in agreement with the values of Odoemelam *et al* (2019) [39] in surface water of Orashi River whose value ranged from 0.001±0.00-0.006±0.00 mg/L. The probably sources of cadmium input into the creek is agricultural wastes, agricultural fertilizer and pesticides application (the now recent way of farm weeding in the area) from farms. This observation corroborates the findings of Hamed *et al*. (2013) [25] in Lagoon Manzala, Egypt. The values observed is lower than those of Edori *et al*. (2019) [16, 20, 27, 39]. In Elelenwo River State, Nigeria. Cadmium is a non-essential element and is known to be both aquatic and terrestrial toxin, because at even very low concentrations, it has the capacity to cause harmful and mortal effects to marine and freshwater biota (Edokpayi *et al*., 2016) [10]. On the other hand there could be a natural causes of cadmium in our environment. Heavy occurrence of cadmium in the environment portends risk for several diseased conditions which include cardiac and vascular neurology, hematology and kidney dysfunction, destruction of hepatocytes and other vital organs of the body (Iyama *et al*., 2018).

Mercury (Hg)

Mercury was not detected in water from any of the stations in the creek. The values of Hg obtained from the creek were all lower than the permissible limit set by WHO. This observation is in agreement with those of Iyama *et al*., (2018) in Sagbama Creek, Bayelsa State, Nigeria, but lower than those of Odoemelam *et al* (2019) [39] in Orashi River, Rivers State, Nigeria. The presence of mercury (Hg) in both animals and plants is very harmful and alters important metabolic characteristics of biota. Mercury is naturally present in water and the surrounding environment through storm runoffs laden with mercury, atmospheric deposition by precipitation and geological content of shore soil washed into the river through current flow especially in turbulent water. Human sources arises from engineering practices, quarrying, and breaking of rocks in search of minerals. It causes disease such as difficulty in breathing, diarrhea, hypertension and touchiness of the eye.

Nickel (Ni)

The variations in the concentrations of Ni in the three stations along the creek ranged from 0.069±0.01 - 2.413±0.16 mg/L. These values were higher than the WHO value of 0.05 mg/L. the values of nickel observed in water from Ogbia axis of Kolo Creek were the values observed in Edagberi Creek (Edori and Iyama, 2020) [14, 15], but lower than the values of Edori and Kpee (2018) [18] in New Calabar River at effluent discharge points.

Elevated intake of nickel is detrimental to animal used in laboratory tests by infecting the lungs (ATSDR, 2005). The presence of nickel in human organs can lead serious health problems like fibrosis, tumours and lung swelling (Forti *et al*., 2011) [22]. The presence of nickel in acidic or neutral environments allows it to more freely distributed in plants and animals tissues (Loska *et al*., 2004) [32]. Nickel sources in in the Ogbia axis of the Kolo Creek probably originated from combustion of wood and petroluem, agricultural wastes and effluents from homes (Purushothaman and Chakrapani, 2007; Kieri *et al.,* 2021) [43, 29].

Chromium (Cr)

The concentrations of Cr varied from 0.711±0.11 - 1.360±0.22 mg/L. The observed values in water from the stations examined in Kolo Creek were higher than the permissible limit of 0.05 mg/L given by WHO. The value of chromium observed in the present work is were slightly lower than the value observed at point of effluents discharge into the New Calabar River (Edori & Kpee, 2018) [18], but slightly higher than the values of Nwineewii *et al*. (2018) [38] in water samples collected along community axis around the New Calabar River. Chromium is principally a pollutant associated with industrial wastewater discharged into the environment and sewage (Pawlisz *et al,* 1997) [42]. Chromium reduces thrombocytes, erythrocytes count and serum hemoglobin in fish (Edori *et al*., 2019) [16, 20, 27, 39]. Chromium in greater than required amounts in human body leads to negative effects on fertility and reproduction in animals and can also promote the development of cancer in animals (Beyene & Berhe, 2015; Edori and Kpee, 2016) [9, 17].

Iron (Fe)

The content of iron in the water from Kolo Creek in the stations varied from 1.321±0.21 - 2.348±0.41 mg/L. The values observed for Fe in the present work is higher than the value of 0.3 mg/L required for portable water by WHO. The observed iron content of surface water from Kolo Creek along the Ogbia axis were lower than the value of Iyama *et al*. (2018) in Sagbama Creek, Bayelsa, Nigeria, but where within the range of values observed in New Calabar River, Port Harcourt, Nigeria (Nwineewii *et al*., 2018) [38]. Iron is present in human body, especially the blood (in the haem complex), but excess of iron in human body especially when transfused can lead to metabolic and genetic disorders (Edori and Kpee, 2016; Iyama *et al*., 2014) [17, 28]. At high concentrations in water, it could cause harm to aquatic flora and fauna (Ajayon & Parameswara, 2014) [4]. The occurrence of iron at high concentration in the creek is discharge from agricultural runoffs and industrial waste. This observation agrees with the observation of Abdel-Moatia and El-Sammak (1997) [1] in lagoons along the Nile River. When Fe occur as iron (III) oxide, it impairs the functions of fish gills by lowering the amount of oxygen intake by the fish (Ogaga, *et al*, 2018) [40].

Zinc (Zn)

The concentrations of zinc in surface water from Kolo Creek in the stations varied from 1.344±0.13 -.4.61±0.42 mg/L. The values observed for Zn in the present work is lower than the value of 5.0 mg/L required for portable water by WHO. The concentrations of zinc in the present work is in lower than the values of Asonye *et al*. (2007) [6] in different water bodies in Nigeria, but are in consonants with the values observed in River Niger at Ajeokuta (Olatunji & Osibanjo, 2012) [41]. Zinc is toxic to the aquatic surroundings (Datar & Vashishtha, 1990) [8]. At concentrations above the required value, it becomes a potential human toxicant (Nriagu, 2007) [37]. Due to the importance of Zn to biota, its lack or presence at elevated concentrations greatly affects organism's health negatively (Ibigoni and Briggs, 2012) [26]. Zinc is indispensable for the development of aquatic creatures and its concentration is affected by the quantity of plankton community available (Masoud *et al*., 2005) [34].

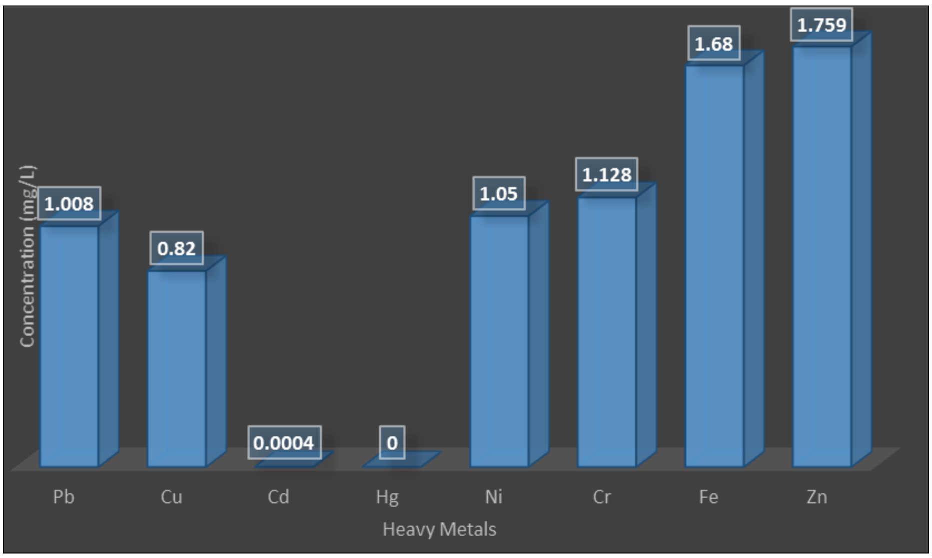

Fig 1: Mean concentrations of Heavy metals in Kolo Creek

Table 1: Concentrations of heavy metals in surface water from different stations in Kolo Creek

Heavy metals (mg/kg)	Stations			WHO (2011)
	Imiringi	Emeyal I	Otabagi	
Pb	1.034±0.11	0.729±0.10	1.260±0.02	0.05
Cu	0.712±0.02	1.136±0.12	0.611±0.03	1.50
Cd	0.0012±0.00	ND	ND	0.005
Hg	ND	ND	ND	0.03
Ni	0.069±0.01	0.667±0.23	2.413±0.16	0.05
Cr	0.711±0.11	1.312±0.31	1.360±0.22	0.05
Fe	1.321±0.21	2.348±0.41	1.370±0.05	0.3
Zn	1.344±0.13	1.471±0.06	2.461±0.42	5.0

The contamination factor in heavy metals from water collected from Kolo Creek is shown in Table 2. The results of contamination factor observed from the three different stations of Kolo Creek were expressed based on interpretations proposed by Lacatusu (2000) [30]. The values observed in the stations showed that the water was severely polluted with lead and chromium in all the stations, the water was moderately polluted with nickel at Imiringi station, but severely polluted at Emeyal I and Otabagi stations. The water was not contaminated with mercury and cadmium in any of the stations except at Imiringi where the water was slightly contaminated with cadmium. As for copper, the values indicated slight contamination at Imiringi and Otabagi stations, but moderate contamination at Emeyal station. The results obtained for zinc (Zn) showed very slight contamination of the creek water with the metal, while that of iron in the water indicated severe pollution of the water in all the stations.

Table 2: Contamination factor of heavy metals from Kolo Creek

Heavy metals	Stations		
	Imiringi	Emeyal I	Otabagi
Pb	20.68	14.58	25.20
Cu	0.475	0.757	0.407
Cd	0.24	-	-
Hg	-	-	-
Ni	2.3	13.34	48.26
Cr	14.22	26.23	27.20
Fe	4.403	7.827	4.567
Zn	0.269	0.294	0.492

The overall results of the pollution index, contamination factor and modified contamination degree from three different stations in Kolo Creek are shown in Table 3. Pollution index of the water from the creek indicated that all the stations were slightly polluted with heavy metals. Contamination degree and modified contamination degree of surface water samples from three different stations in Kolo Creek indicated very high contamination degree by heavy metals in all the examine stations along the creek. The evaluation of the values obtained for modified contamination degree of the water from Kolo Creek revealed that the surface water was at level of high degree of contamination by heavy metals in Imiringi and Emeyal I stations, while the value obtained for Otabagi was at the level of very high degree of contamination by heavy metals.

Table 3: Pollution index, contamination degree and modified contamination degree of surface water samples from Kolo Creek

Assessment Index	Stations		
	Imiringi	Emeyal I	Otabagi
PLI	1.078	1.170	1.364
CD	42.607	55.903	102.066
mCD	5.326	6.988	12.758

Conclusion

The data obtained in this study showed that the level of contamination of the surface water with heavy metals is very high. Most of the metals were above the WHO standard for drinking water. The order of concentrations of the metals in the creek are Zn > Fe > Cr > Ni > Pb > Cu > Cd >Hg. Therefore, the water is not fit for consumption by humans. To cub the continuous deterioration of the water, the indigenes should desist from direct dump of refuse into the creek and also the multi-nationals should employ adequate methods to dispose their effluents rather than discharging it to the water body. For effective restoration of the creek water, there should be affective monitoring and evaluation of the creek together with proper enlightenment of the local dwellers on good waste disposal management practices so that its natural state could be re-instated.

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