Journal of ENVIRONMENTAL Treatment Techniques

J. Environ. Treat. Tech.
ISSN: 2309-1185

Journal web link: https://dormaj.org/index.php/jett
https://doi.org/10.47277/JETT/10(4)256

Studies on the Physicochemical Properties and Heavy Metal Load in Water and Sediment from Selected Surface Water of the Niger Delta, Nigeria

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Received: 06/10/2022 Accepted: 07/11/2022 Published: 20/12/2022

Abstract

Environmental pollution by toxic heavy metals does not only elicit concern in metropolitan cities but also in remote and rural communities where anthropogenic activities are taking place. The study was carried out to assess physicochemical properties and heavy metal levels in water and sediment from selected surface water of the Niger Delta. Water and sediment samples were collected from 3 (three) chosen points in each River and were analyzed for physicochemical properties and heavy metal levels of heavy metals using standard analytical methods. The results obtained revealed marked variations and non-uniform distribution of all the physicochemical parameters across the Rivers studied with values that fall below the WHO standard limit for drinking water. Analysis of variance revealed that there was a significant difference ($P < 0.05$) between the parameters based on locations. The concentration of heavy metals in water and sediment around the vicinity of the Rivers revealed a spatial and non-uniform distribution in the concentration of the selected heavy metals in all the locations studied. The concentration of heavy metal determined in water and sediment was generally high in the sampled areas than in the control. Correlated heavy metal in water and sediment connotes that the metals may have similar behavior and implies they could have a common origin. Further study on the actual levels of potential risks to consumers in the vicinity of these Rivers is recommended.

Keywords: Heavy metal, Water, Sediment, Surface water, Niger Delta

1 Introduction

Water pollution is any form of damage to the physical, chemical, and biological characteristics of water which then affect the quality and suitability for any designated use or purpose [1]. Hence, it is an issue of great importance to protect the water resources from fecal, agricultural, and industrial contamination or pollution which is continually threatening terrestrial and aquatic ecosystems due to increasing exposure to untreated wastes and chemical agents that are capable of causing damage to the environment [2-5]. For example, it has been reported that stormwater runoff from urban areas contains numerous pollutants like polycyclic aromatic hydrocarbons (PAHs), heavy metals (HMs), biocides, and suspended solids which are toxic or harmful to the aquatic environment and also have potential negative ecological impacts on receiving waters [6]. Some of the negative impacts include eutrophication, oxygen depletion, and chronic toxic effect on aquatic flora and Fauna [7]. The contamination of the environment, particularly the aquatic ecosystems by harmful waste indicators such as heavy metals is a serious problem in society because the environment is a direct receptacle for waste products generated in the space within the environment [8].

However, heavy metals are of particular concern due to their prevalent toxicity to aquatic organisms and are persistent in the environment [9]. The toxicity of the aquatic environment poses threat to man for the fact that safe and suitable potable water supply for drinking and other uses is lacking especially in the rural settlement in Nigeria which makes rural dwellers depend on rivers, streams, natural ponds, Lakes, shallow hand dug wells and collection of rainfalls to meet their water needs as well as depending on aquatic animals which are capable of bio-accumulating pollutants like Heavy metals (HMs) and polycyclic aromatic hydrocarbons (PAHs) as sources of food [10-13]. Heavy metals (HMs) have been reported to have very carcinogenic, mutagenic, and teratogenic effects on aquatic animals and humans who consume them or have a direct encounter with the pollutants, especially with occupational exposure, therefore it is consequential to take the environmental study of Heavy metals very seriously to avert their possible effect and costly consequence of their contamination effects if not checked [14]. By definition, heavy metals (HMs) are loosely defined as members of a subset of elements that have a density above 5.0 $g.cm^{-3}$, exhibit metallic properties, and are chemically toxic to plants and animals [15]. Heavy metals (HMs) are ubiquitous and are daily being leached into rivers, lakes, and oceans from natural and anthropogenic sources like rock weathering, wastewater, industrial effluents, and incomplete combustion of organic materials, fossil fuel, and petroleum [16]. The pollutants are distributed in the rivers' water, sediments and are bio-accumulated by the fishes and other aquatic animals in the water and this leads to bio-magnification of these pollutants in the food chain [17]. The toxicity of heavy metals depends on the physical and chemical conditions which also affect mobility and bioavailability [18]. These conditions include pH, temperature, water hardness salinity, organic matter, redox, complexing ligands, and ion

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strength [19]. Because of the above-mentioned characteristics of these pollutants, several studies have shown that the sediment is usually more highly toxic than the water component of the aquatic environment hence, sediments are seen to be a repository for these pollutants [20]. Therefore, this study aims to assess the physicochemical and heavy metals levels in water and sediments from selected surface water of the Niger Delta, Nigeria.

2 Materials and Methods

2.1 Study areas

The study was carried out in the Nnembe Creek in Rivers state, Ikot Abasi River in Akwa-Ibom State, Oguta Lake in Imo state and Onuiyi Ukwu stream, Akabor in Ahiazu Mbaise in Imo state areas of Niger Delta Nigeria. The Niger Delta consists of Bayelsa, Delta, Rivers, Akwa-Ibom, Cross River, Abia, Imo, Edo, and Ondo States. This region has a landmass of approximately 27,000 square kilometers. Niger Delta has a population of 31 million people. It lies in an area of moderate relief between 2200 and 2500 meters above sea level. The climate is a tropical wet and dry climate characterized by wet (raining) seasons between May to October and a dry season between December to April, with an annual rainfall of about 1000 mm 132, 133.

2.1 Method of sample collection

All polyethylene containers used for the collection of water and sediment samples analyzed for heavy metals were washed with detergent, treated with dilute Nitric acid (10% HNO_3), and thoroughly rinsed with distilled-deionized water [21]. Control samples were taken from Onuiyi Ukwu stream Akabor in Ahiazu Mbaise in the Imo state areas of the Niger Delta.

2.3 Water

The water samples were collected for the dry and wet seasons in February and August respectively by dipping a two-liter polythene bottle below the water surface at a depth of 1 meter [22]. The sample water was collected at three different points, five meters away from each other to form a composite sample. At each sampling location, the sampling bottles were rinsed three times with the water before collection of the sample. The samples were preserved by acidifying with 2 ml of concentrated HNO_3 to achieve a pH of 2 and prevent metal adsorption onto the inner surface of the container (APHA, 2005). All the samples were returned to the laboratory and analysis was carried out immediately.

2.4 Sediment

The sediment samples were collected for the dry and wet seasons in February and July respectively. About 1 kg of the sediment samples was collected at three different points in each location, five meters away from each other to form a composite sample. Sediment samples were collected using a plastic spoon by scooping the top layer of sediments and then stored in a pre-cleaned 1000ml polyethylene container, labeled, and transported to the laboratory for storage in freezers awaiting analysis. Samples were air-dried in the laboratory and crumbs found in the sediment were removed. Sediments were also sieved through a 2 mm sieve to remove coarse particles.

2.5 Analysis of samples

Metals in water and sediment were analyzed using Atomic Absorption Spectrometry (HG – AAS, ICE 3000AA01122804v1.30 Series**)** while physiochemical variables which were recorded in mg/L; were analyzed using standard methods (APHA, 1998).

2.6 Data Analysis

The obtained water and sediment data were analyzed using the SPSS package (version 20.0) and the descriptive statistics were expressed as mean ± standard deviation and range; using one-way analysis of variance (ANOVA) to test for the significant difference among the groups at a probability level of 0.05. Duncan's multiple range test was employed in ascertaining the actual locations of the significant differences.

3 Results

3.1 Physicochemical parameters of water samples collected from the study locations

The physic-chemical parameters of water samples were collected from Oguta, Nembe Ochen, and Onuiyi (control site). Results obtained showed that there was no significant difference ($p>0.05$) in the temperature of the water samples across the three Rivers and the control (Table 1). In Oguta, Nembe Ochen, and Onuiyi the value of water sample temperature ranged from 25.34-28.21, 25.69-27.34, 26.67-27.45, and 28.23-30.01, respectively. However, the concentration of Temperature in all the study areas falls within the permissible limit of 30.00 - 32.00 which is the standard set by WHO. the pH of the water samples ranged from 7.23-7.98 in Oguta, 7.13-7.39 in Nembe, 7.34-7.51 in Ochen and 7.64-7.79 at the control site. There was no significant difference ($p>0.05$) in pH values of all the study locations concerning pH. The values for pH in water were observed to be within 7.00-8.500 WHO permissible limits. At Oguta, Free CO_2 ranged from 7.23-7.98; at Nembe and Ochen it ranged from 10.45-11.37; 9.67-10.56 while at Onuiyi (control site) the value ranged from 8.26-9.77. There was a significant difference ($P \geq 0.01$) among the values for Free Co_2 across the study areas. The values obtained for Free CO_2 were within < the 10.00 permissible limit by the WHO. The concentration of BOD differed significantly ($p > 0.05$) across the sampling areas and below < 10.00 stipulated by the WHO. The value of TDS ranged between 0.29-0.37 in Oguta, 32.14-36.23 in Nembe, 27-77-31.03 in Ochen, and 1.43-1.72 in the control site. There was a significant difference ($p>0.05$) among the TDS of water samples in all the study areas. However, the value of TDS in all the study areas was within 250.00 permissible limits by the WHO. EC varied from 0.29-0.37 in Oguta, 0.30-0.35 in Nembe, 0.29-0.33 in Ochen, and 0.41-0.46 in Onuiyi. There was no significant difference ($p<0.05$) in the concentration of EC across the study areas. The values obtained for EC were all below WHO 100.00 limit. The mean value for DO recorded in this study ranged from 5.78-6.07 in Oguta, 4.98-5.37 in Nembe, 5.00-5.37 in Ochen, and 6.01-6.40 at the control site. There was a significant difference (at $P \geq 0.01$) in DO value across the study areas. The value obtained for DO was above the > 5.00 limit set by the WHO. The result of Total Hardness (ppm) in Oguta, Nembe, Ochen and Onuiyi ranged from 18.56-20.02; 26.89-27.72; 24.45-27.21, and 15.96-16.56 respectively. The mean value of total hardiness was found to be below the 150.00 limits by the WHO. Oguta area recorded Turbidity (NTU) value in the range of 14.98-16.74; the Nembe area recorded 27.56-29.11; in Ochen, the value ranged from 26.28-28.01 while the control site ranged from 16.00-16.32. Higher values of turbidity were recorded in Nembe (28.45) compared with least value of 16.12 obtained at Ochen River. The turbidity values obtained in the entire study area were low as compared to the WHO permissible limit of 150.00 sets for turbidity in water. The highest Alkalinity (Mg/L) values were recorded in Nembe (25.23) while the least value was gotten from Oguta (16.28). The values for Sulphate, (Mg/L) in Oguta, Nembe, Ochen, and Onuiyi ranged from 2.21-2.75; 5.13-5.37; 4.88-4.26 and 1.14-1.26. These values were within the 250.00 sets by the WHO in water. The highest mean value for Sulphate (5.21± 0.43) was recorded in Nembe while the least value was gotten from Onuiyi River (1.23±0.02). there was no significant difference ($p<0.05$) in Sulphate values across the study areas. Ammonium (Mg/L) concentration recorded in the study areas ranged from 0.23-0.41 in Oguta, 0.48-0.72 at Nembe, 0.36-0.51 at Ochen, and 0.19-0.25 at the control site.

3.2 Heavy Metal Concentration in Water and sediment Samples from the study locations

The mean concentration of heavy metals from the study locations and the corresponding World Health Organization benchmark are displayed in Table 2. Results obtained showed that the mean values of Pb in Oguta, Nembee, Ochen, and Onuiyi (control) varied as follows: 0.16-0.21 0, 0.28-0.34, 0.25-0.32 with no values obtained at the control site. the highest mean value of Pb was gotten from Ochen(0.27) while the least value was obtained from Oguta lake (0.18). However, these values were below WHO permissible limit for Pb in water. The least value for Cadmium in water was recorded from Oguta (0.43) while the highest value was obtained from Nembe (0.57) with no value recorded from the control site. The concentration of As in Oguta, Nembee, Ochen, and Onuiyi (control) ranged from 0.008-0.02, 0.01-0.04, and 0.01-0.03. No, as was detected at the control site. Oguta lake recorded the least mean value of As (0.01) while Nembe lake recorded the highest mean value (0.03). No concentration of Hg was detected in water across the study locations. The heavy metal concentration of Ni and Mn in all the study locations ranged as follows: 0.52-0.71 0. 0.85-1.0, 0.75-0.90; and 0.01-0.03, 0.02-0.05, 0.02-0.040 and 008-0.02. The highest value of heavy metals in sediment was recorded for Manganese in Oguta Lake (16.63) while the lowest value was recorded for Lead in Oguta Lake (0.27). The variations of heavy metals in sediment across the study locations followed the trend Mn> Ni > As >Cd>>Pd.

3.3 Pearson Correlation Matrix between Heavy Metals in water and Sediment

The interrelationship between heavy metals in water and sediment samples from Oguta, Nembee, Ochen, and Onuiyi (control) were analyzed using Pearson's correction matrix to see if some of the heavy metals are interrelated with each other and the results are presented in Tables 4.11, 4.12 and 4.13. Results obtained showed that a strong positive correlation was observed at $P < 0.05$ for the following metals pairs at Oguta lake: Pbw - Pbs (r=0.977), Cdw- Cds(r=0.511), Asw-Ass(r=0.962), Hgw- Hgs(r=0.569) respectively (Table 3). In Nembe river, significant positive correlations were observed at P=0.01 between Pbw- Pbs(r=0.980), Cdw- Cds(r=0.988), Asw-Ass(r=0.992), and Niw- Nis (r=0.663). Significant positive correlations were observed at P=0.01.

4 Discussion

The measurement of the physicochemical parameters of water is of significance since the toxicity of heavy metals depends on the physical and chemical conditions of the water which also affect the mobility and bioavailability of the heavy metals. Physicochemical parameters were investigated in the three sampling locations and control sites (Onuiyi stream). Water temperature regulates activities (both abiotic and biotic) of an aquatic ecosystem [23]. It remains a major factor that determines primary production in reservoirs [24]. The surface temperatures recorded in this study fall within the range documented for typical tropical lakes and reservoirs. Therefore, the temperature range observed in the study areas during this study falls within the optimal range for fish growth in the tropics. The works of [25-27] corroborated this observation. pH is among the very significant chemical characteristic of all waters, which explains certain significant biotic and abiotic ecological characteristics of aquatic systems in general. The values of the water pH were only slightly acidic but, were however within the acceptable limit for water set by the world health organization and other regulatory agencies. The slightly acidic pH range recorded in this study conformed to values previously reported in Niger Delta freshwaters [28]. This finding also corroborates the report of [29]. Also, there was a slight variation in the values of the other physicochemical parameters assessed which could be due to seasonal variation.

Table 1: Physico-chemical parameters of water samples collected from the study locations

Parameters	WHO LIMIT	Oguta	Range	Nembee	Range	Ochen	Range	Onuiyi (control)	Range
Temperature (°C)	30.00 - 32.00	$27.13^a±3.24$	25.34-28.21	$26.56^a±3.13$	25.69-27.34	$27.34^a±3.32$	26.67-27.45	$28.43^a±3.44$	28.23-30.01
pH	7.00 - 8.50	$7.67^a±1.78$	7.23-7.98	$7.35^a±1.43$	7.13-7.39	$7.49^a±1.52$	7.34-7.51	$7.76^a±1.84$	7.64-7.79
Free CO_2 (ppm)	<10.00	$10.33^b±1.75$	9.11-10.44	$11.26^a±1.82$	10.45-11.37	$10.45^b±1.93$	9.67-10.56	$9.37^c±1.63$	8.26-9.77
BOD (Mg/L)	< 10.00	$10.26^b±1.88$	10.25-10.59	$11.34^a±1.91$	11.23-11.40	$10.43^b±1.90$	10.23-10.51	$9.56^c±1.57$	9.49-10.00
TDS (Mg/L)	250.00	$24.32^c±2.35$	21.54-27.32	$34.23^a±3.11$	32.14-36.23	$29.31^b±3.03$	27-77-31.03	$1.56^d±0.24$	1.43-1.72
EC(µs/CM)	100.00	$0.34^a±0.22$	0.29-0.37	$0.32^a±0.02$	0.30-0.35	$0.31^a±0.02$	0.29-0.33	$0.35^a±0.04$	0.41-0.46
DO (Mg/L)	> 5.00	$6.04^a±0.63$	5.78-6.07	$5.26^b±0.49$	4.98-5.37	$5.23^b±0.34$	5.00-5.37	$6.08^a±0.72$	6.01-6.40
Total Hardness (ppm)	150.00	$18.51^b±2.09$	18.56-20.02	$27.53^a±2.27$	26.89-27.72	$25.52^a±2.23$	24.45-27.21	$16.32^b±1.99$	15.96-16.56
Turbidity (NTU)	150.00	$16.56^b±2.06$	14.98-16.74	$28.45^a±2.38$	27.56-29.11	$27.67^a±2.38$	26.28-28.01	$16.12^b±1.75$	16.00-16.32
Alkalinity (Mg/L)	200.00	$16.28^b±1.99$	15.78-16.40	$25.23^a±2.22$	23.48-26.33	$24.02^a±2.20$	23.29-25.44	$15.08^b±1.56$	14.66-15.43
Sulphate, (Mg/L)	250.00	$2.34^b±0.37$	2.21-2.75	$5.21^a± 0.43$	5.13-5.37	$4.20^a±0.31$	4.88-4.26	$1.23^c±0.02$	1.14-1.26
Ammonium (Mg/L)	-	$0.36^b±0.16$	0.23-0.41	$0.67^a±0.08$	0.48-0.72	$0.58^a±0.04$	0.36-0.51	$0.23^c±0.03$	0.19-0.25

Mean along the row having different superscripts of alphabets differ significantly at $P \geq 0.01$ according to Duncan Multiple Range Test

Table 2: Heavy metal contents in water and sediment samples collected from the study locations

Parameters	WHO LIMIT	Oguta	Range	Nembee	Range	Ochen	Range	Onuiyi (control)	Range
Pbw (Mg/l)	-	0.18^{c}±0.04	0.16-0.21	0.31^{a}±0.06	0.28-0.34	0.27^{b}±0.05	0.25-0.32	ND	-
Cdw (Mg/l)	-	0.43^{c}±0.08	0.37-0.45	0.57^{a}±0.12	0.48-0.63	0.52^{a}±0.11	0.49-0.55	ND	-
Asw (Mg/l)	-	0.01^{c}±0.001	0.008-0.02	0.03^{a}±0.002	0.01-0.04	0.02^{b}±0.001	0.01-0.03	ND	-
Hgw (Mg/l)	-	ND	-	ND	-	ND	-	ND	-
Niw (Mg/l)	-	0.68^{c}±0.1	0.52-0.71	0.94^{a}±0.19	0.85-1.0	0.83^{b}±0.16	0.75-0.90	ND	-
Mnw (Mg/l)	-	0.02^{b}±0.007	0.01-0.03	0.04^{a}±0.008	0.02-0.05	0.03^{ab}±0.007	0.02-0.04	0.01±^{c} 0.001	0.008-0.02
Pbs (Mg/g)	-	0.27^{c}±0.05	0.23-0.30	0.43^{a}±0.08	0.39-0.47	0.35^{b}±0.07	0.33-0.38	ND	-
Cds (Mg/g)	-	1.13^{b}±0.24	1.07-0.21	1.43^{a}±0.44	1.38-1.50	1.37^{a}±0.26	1.25-1.39	ND	-
Ass (Mg/g)	-	1.03^{c}±0.18	1.00-1.06	1.43^{a}±0.29	1.37-1.42	1.26^{b}±0.24	1.19-1.31	ND	-
Hgs (Mg/g)	-	ND	-	ND	-	ND	-	ND	-
Nis (Mg/g)	-	1.20^{a}± 0.23	1.16-1.24	1.37^{a}±0.28	1.31-1.43	1.28^{a}±0.41	1.23-1.31	ND	-
Mns (Mg/g)	-	16.63^{b}±1.56	16.46-18.23	17.54^{a}±2.26	16.53-18.06	17.21^{a}±2.17	16.34-17.98	1.63^{c}± 0.59	1.52-2.01

Mean along the row having different superscripts of alphabets differ significantly at P ≥ 0.01 according to Duncan Multiple Range Test, ND = Not detected

Table 3: Correlation matrix of heavy metals in water and sediment samples in Oguta lake

	Pbw	Cdw	Asw	Hgw	Niw	Mnw	Pbs	Cds	Ass	Hgs	Nis	Mns
Pbw	1											
Cdw	.054	1										
Asw	.012	.045	1									
Hgw	.026	.032	.019	1								
Niw	.311	.037	.010	.365	1							
Mnw	.044	.012	.014	.178	.264	1						
Pbs	.977**	.453	.278	.321	.035	.243	1					
Cds	.067	.511*	.433	.412	.446	.077	.533*	1				
Ass	.032	.237	.962**	.078	.276	.218	.423	.322	1			
Hgs	.056	.219	.328	.569*	.285	.159	.421	.325	.238	1		
Nis	.135	.164	.278	.104	.678*	.287	.234	.216	.276	.106	1	
Mns	.104	.167	.367	.289	.255	.765*	.261	.034	.192	.121	.078	1

**Correlation is significant at the 0.01 level (2- tailed)
*Correlation is significant at the 0.05 level (2- tailed)

Table 4: Correlation matrix of heavy metals in water and sediment samples in Nembee river

	Pbw	Cdw	Asw	Hgw	Niw	Mnw	Pbs	Cds	Ass	Hgs	Nis	Mns
Pbw	1											
Cdw	.382	1										
Asw	.275	.421	1									
Hgw	.284	.337	.025	1								
Niw	.102	.414	.013	.463	1							
Mnw	.266	.016	.019	.212	.361	1						
Pbs	.980**	.417	.367	.473	.135	.468	1					
Cds	.384	.988**	.091	.074	.446	.068	.449	1				
Ass	.489	.174	.992**	.347	.273	.349	.237	.032	1			
Hgs	.345	.432	.456	.731*	.342	.235	.274	.289	.357	1		
Nis	.456	.378	.319	.123	.663*	.342	.318	.390	.498	.128	1	
Mns	.231	.346	.498	.327	.349	.729*	.459	.063	.284	.157	.162	1

**Correlation is significant at the 0.01 level (2- tailed)
*Correlation is significant at the 0.05 level (2- tailed)

Table 5: Correlation matrix of heavy metals in water and sediment samples in Ochen river

	Pbw	Cdw	Asw	Hgw	Niw	Mnw	Pbs	Cds	Ass	Hgs	Nis	Mns
Pbw	1											
Cdw	.342	1										
Asw	.146	.342	1									
Hgw	.257	.337	.021	1								
Niw	.321	.321	.016	.310	1							
Mnw	.264	.043	.025	.032	.243	1						
Pbs	.973**	.387	.265	.136	.321	.257	1					
Cds	.421	.954**	.248	.244	.041	.055	.420	1				
Ass	.365	.327	.964**	.243	.145	.158	.067	.376	1			
Hgs	.312	.388	.311	.641*	.265	.214	.175	.328	.321	1		
Nis	.387	.241	.263	.133	.532*	.237	.318	.203	.376	.222	1	
Mns	.138	.263	.339	.275	.277	.529*	.261	.047	.188	.142	.153	1

**Correlation is significant at the 0.01 level (2- tailed)
*Correlation is significant at the 0.05 level (2- tailed)

Table 6: Correlation matrix of heavy metals in water and sediment samples in Onuiyi stream

	Pbw	Cdw	Asw	Hgw	Niw	Mnw	Pbs	Cds	Ass	Hgs	Nis	Mns
Pbw												
Cdw												
Asw												
Hgw												
Niw												
Mnw	.000	.000	.000	.000	.000	1						
Pbs												
Cds												
Ass												
Hgs	.											
Nis												
Mns	.000	.000	.000	.000	.000	.503*	.000	.000	.000	.000	.000	1

**Correlation is significant at the 0.01 level (2- tailed)
*Correlation is significant at the 0.05 level (2- tailed)

The concentration of Heavy Metals (Pb, Mg, Cd, As, Hg, Ni, and Mn) in Water and sediment samples from the study areas also varied. Although there are no benchmark values for heavy metals in water and sediment samples, results revealed a gradual build-up of heavy metals in all the study areas compared to the control site in this order: Nembee>Oguta>Ochen>Onuiyi. Generally, higher levels of heavy metals were detected in water samples than in sediment samples. A similar trend in heavy metal levels had been reported [30]. The mean concentration values of the heavy metals in water and sediment were subjected to correlation analysis to reduce the data without any loss to understand if there is any hidden trend between the data from the study areas. Correlation analysis provides information about associations between sites and between individual metal compounds to determine common origin. The table of the correlation matrix showed the varying correlation between the various heavy metals in water and sediment from -0.977 to 1.000 at 0.05 and 0.01 levels of significance. Correlated heavy metal in water and sediment connotes that the metals may have similar behavior and implies they could have a common origin. [32] reported that two compounds with a strong positive correlation between their concentrations are likely to have a common source. This observation aligns with the result of this study.

5 Conclusion

The physicochemical and heavy metals levels in water and sediment from selected Rivers within Niger Delta were assayed in this study. Results obtained from this study indicated an alteration in the physicochemical properties and heavy levels in the Rivers which could potentially affect the aquatic life and render the waters unsuitable for domestic use. However, the consumption of fish in the Rivers may pose some levels of chronic threats to the consumers. It is hereby recommended that further in-depth study be carried out to ascertain the actual risks consumption of the fish may pose to the health of the consumers. Regulation of anthropogenic activities, immediate standard remediation processes, and constant bio-monitoring studies of the aquatic environment are highly recommended. A further deeper study to ascertain the actual levels of risks to consumers is recommended.

Ethical issue

Authors are aware of and comply with, best practices in publication ethics specifically about authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. Authors adhere to publication requirements that the submitted work is original and has not been published elsewhere in any language. Also, all procedures performed in studies involving human participants were following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. All procedures performed in this study involving animals were following the ethical standards of the institution or practice at which the studies were conducted.

Competing interests

The authors declare that no conflict of interest would prejudice the impartiality of this scientific work.

Authors' contribution

All authors of this study have a complete contribution to data collection, data analyses, and manuscript writing.

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