An Assessment of Surface Water and Sediment Quality from Elechi Creek, Rivers State, Nigeria

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Abstract

The physicochemistry of surface water and sediment in Elechi creek was investigated to from four sampling stations which were sampled bimonthly for one year (June 2021 to April 2022). Surface water samples were collected following standard procedures. Parameters measured in situ include temperature, pH, Dissolved Oxygen (DO), Electrical conductivity, turbidity, total dissolved solids (TDS), while parameters measured in the laboratory include biological oxygen demand (BOD), Nitrate, sulphate and phosphate. Sediment samples were collected from the intertidal and analyzed in the laboratory for sulphate, phosphate and nitrate. The results showed that the monthly temperature varied from 25.7 (±0.03)^{o}C in October to 29.4(±0.03) in April. Electrical conductivity ranged from 15260 (±1471µs/cm) in October to 30038 (±5645µs/cm) in June. Turbidity values were 1.00 (±0.5NTU) in February to 60.00 (±13.00NTU) in August while pH values varied from 7.00 ((±0.25) in June to 7.40 (±0.08) in August. Total dissolved solids ranged from 8375 (±316) in October to 19688 (±4452) in June. Dissolved oxygen (Do) concentration ranges from 3.33 (±0.07/mg/l) in October to 7.93 (±0.15mg/l) in June Biological Oxygen demand (BOD) ranges from 1.83 (±0.08mg/l in December to 3.05 (±1.73mg/l) in February and April. Sulphate varies from 588.00 (±52.30mg/l) in December to 683.00 (±20.53mg/l) in February. Phosphate varies from 1.5(±0.19mg/l) in October to 2.67 (±0.35mg/l) in June. No significant differences were observed in the mean values of the parameters except for nitrate and BOD, but there were significant temporal variations for most parameters. Anthropogenic activities may have led to some pollution which generally cut across all the study stations. It is recommended that enforcement measures should be carried out to discourage direct discharge of wastes into the Creek.

Key words: *Physicochemistry, Water, Sediment, Elechi Creek, Niger Delta, Nigeria.*

Introduction

Creeks in Port Harcourt are areas where high industrial and municipal wastes are discharged indiscriminately and may lead to deleterious effects from localized inputs, which may be acutely or chronically toxic to aquatic life within the affected areas. Various environmental factors such as temperature, pH, electrical conductivity, turbidity, dissolved oxygen, total dissolved solid, biological oxygen demand and nutrient factor like nitrate, sulphate and phosphate can influence the toxicity of metals in sediment (Bryan *et al*., 1980, Nott and Langstan, 1989). Elechi creek is an important fishing site in Port Harcourt surrounded by various human sources of contaminants including human settlement, livestock, agricultural activities, dredging and discharge of industrial and household effluents. The adjoining swamps and industrial discharges are believed to be carrying loads of toxic chemicals, particularly trace metals (Chindah et al., 2004). The study was therefore aimed to evaluate the current status of physicochemical parameters in the creek to monitor the possible effects of anthropogenic activities on the Creek.

Materials and Methods

Study Area and Sampling Stations

The study was carried out in Elechi Creek, Eagle Island in Port Harcourt City Local Government Area of Rivers State, Nigeria. Geographically, the study site lies between longitude 6^{o}57' 41.3" E- 7^{o}01' 05.2 E and Latitude 4^{o}45' 39.2" N - 4^{o}47' 56.5" N. It is a mangrove intertidal wetland, located within the upper parts of Bonny River system very close to thickly populated municipal environment. The area is a typical wetland dominated by *Avicenna Africana, Rhizophora mangle, Rhizophora racemosa, Nypa fruticans, Phoenix raclineata* and fresh water flora which are *Dalbergia sp., Arepanocarpus sp., Ralphia sp*., etc. The aquatic animals prominent in this environment include mudskippers, crustaceans, mollusk, etc. (Davies et al., 2006). Four sample stations were designated for the study and as follows. Station 1: Elechi creek entrance at Abotoru (control) (human/industrial activities) with coordinates of 6^{o}58'15.8"E and 4^{o}47'45.8"N. Station 2: Eagle Island (dredging and waste disposal) with coordinates of 6^{o}58'23.6"E and 4^{o}47'06.8"N. Station 3: Agip Water Front (marine vessel transportation and runoff) with coordinates of 6^{o}58'38.4"E and 4^{o}46'31.4"N. Station 4: Ayogologo water front (Mgbuosimini) (Effluent from slaughter, incinerated tyres, market and solid waste disposal) with coordinates of 6^{o}59'13.9"E and 4^{o}46'01.7"N (Fig. 1).

Sample Collection and Analysis

Sampling was done according to standard procedures (APHA, 1998). Water samples were collected bimonthly for one year between June 2021 to April 2022 which covers both wet and dry sessions. Surface water samples were collected at ebbing tide during the study period. The composite water samples were collected into 21 capacity plastic containers from the four sampling stations at the depth of 30cm below the water surface by Mayer water sampler. Samples for BOD were collected in Winkler bottles Some physicochemical parameters such as temperature, electrical conductivity, pH, total dissolved solids (TDS) and Dissolved Oxygen (DO) were measured in situ using Horiba model U-10µ meters. Measurement were done by immersing a meter probe into the water body and taking the readings after the dissolved is stable. Samples for other physicochemical parameters such as Biological Oxygen Demand

(BOD) Nigeria, Sulphate and Phosphate were taken to the Anal Concept laboratory, Port Harcourt when analysis took place using standard analytical procedures (BOD - Winkler's method, Phosphate-Titrimetric Method; Sulphate - Turbidimetric Method; Nitrate -Brucine Method).

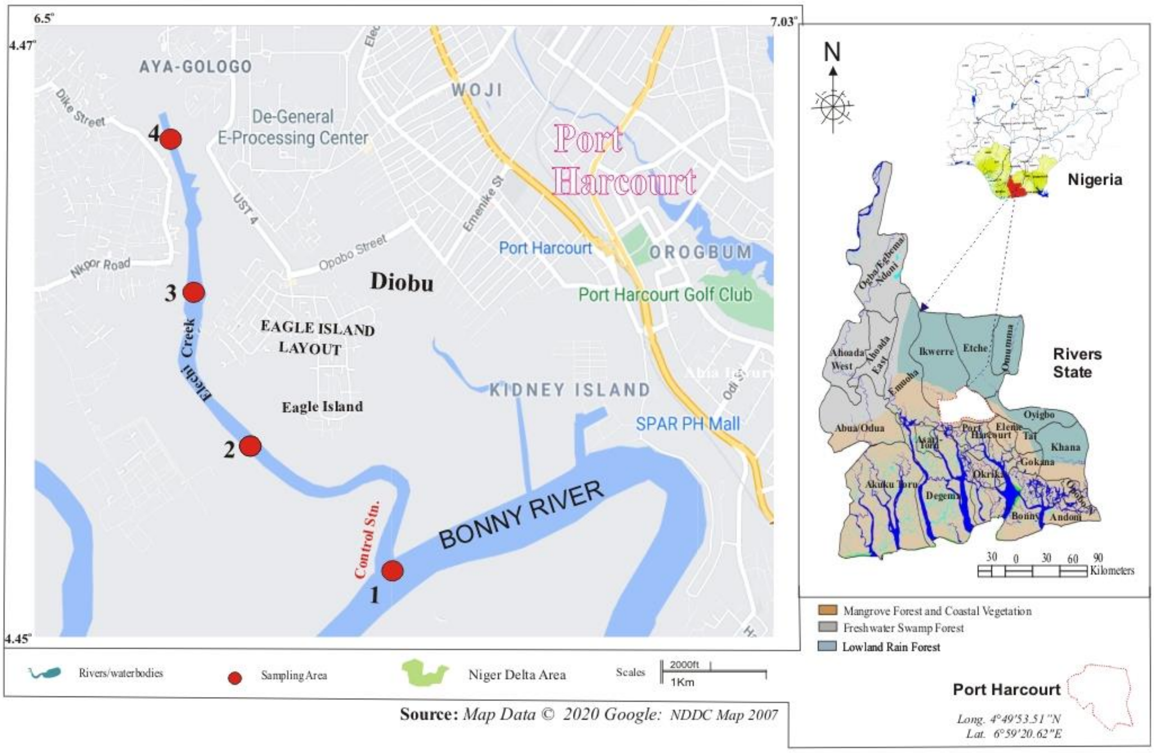

Fig. 1: Map of the Study Area showing Sampling Stations

Sediment samples were also randomly collected from the four locations during low tide. At each location, three replicates of sediment samples were collected at surface layer (10-20cm depth) using stainless Ekman Grab. The three replicate samples were composited and placed in cellophane /polythene bags. The samples were immediately stored in an ice-cooled box and then transferred to the Anal Concepts laboratory, where sulphate, nitrate and phosphate were determined using the HACH DR/890 colorimeter.

Results and Discussion

Surface Water

The results of the physicochemical parameters of water at the study stations in Elechi Creek is given in Table 1; while monthly variations in physiochemical parameters of the water is given in Table.2. Temperature was uniform across the study stations with a mean value of 28.00 ± (3.30)^{o}C in all the stations. There was no significant difference in mean temperature value between stations (p=0.95). However, there was significant difference in mean temperature between months with values ranging from 25.73±0.03 in October to 29.40±0.03^{o}C in April. P > .05. The observed surface creek temperature values (28.0)^{0}c across study stations and monthly values of (25.7^{0}c to 29.4 ^{0}c) are considered normal and within the range reported for the waters of the Niger Delta (18.5 – 34.0^{0}c) (RPI, 1985). These findings corroborate reported works in the Niger Delta Waters (Braide, *et. al.*, 2004). The mean temperature value was generally higher in the dry season months than the wet season. A similar trend has been reported by the Bonny River water by Jamabo (2008) in the new Calabar River. Eke and Sikoki (2003), reported lowest temperature in wet and dry seasons for Andoni River.

Electrical conductivity of the surface water for the entire study stations ranged from 18859.00±2704.00µSkm) in station 4 to 25991.00±3352.00µS/cm in station 2. However, there was no significant difference between stations (p=0.38). Similarly, the monthly electrical conductivity value ranged from 15260.00±1471.00µS/cm in October to 30038.00±5645.00µS/cm in June. The monthly variation was not statistically significant (p> 0.05). The conductivity values in the study stations ranged from 1885gms/cm to 25991gms/cm and monthly values ranged from 15260gms/cm to 30038gms/cm. Stations 2 and 3 were strikingly high and station 4 was low. Uzoekwe and Ogbosanime (2011) reported electrical conductivity range of 1150.41± 0.01 to 151.50 ± 0.71gms/cm for water sample in Ubeji creek. Electrical conductivity value were higher during the wet season than in the dry period. The higher mean electrical conductivity value recorded in wet season, did not agree with the finding of Imevbone *et. al.* (1970) and Egborge, (1971). However, the range of electrical conductivity obtained in the study area is attributed to sea water influence and anthropogenic activities to a smaller extent.

Turbidity Value for the study stations ranged from 13.00±8.00NTU in station 2 to 22.00±16.00 NTU in station 4. Stations 1 and 3 maintained a uniform value of 14.00 (± 7.00 NTU). There was no significant difference between stations P > .05. Similarly, there was significant different in the mean turbidity between months with values of 1.00 ± 0.50 NTU in February to 60.00 ± 13.00 NTU in August. The mean value for the entire months demonstrated a sharp edge pattern of distribution with a rise and fall in concentration P < .05. Turbidity values across the study station ranged from 13.00 – 22. 00 NTU and monthly values of 1.00 – 60.00 NTU. The result depicted that turbidity was high in wet season than in dry season, Abowei (2000), also reported transparency in the wet season, which he attributed to increased water velocity. High turbidity reduce light penetration in the aquatic environment (Payne, 1986). The high turbidity in wet season is an indication of the presence of suspended organic, inorganic particulate matter plankton and other microscopic organism in the water column which leads to the interaction of ions and large load of charged inorganic sediment particles which have been washed down into the creek from the upstream sources and interfere with the passage of light through the water (American Public Health Association, 1998).

pH values varied from station to station and between months, thus ranging from 2.02 ± 0.11 in station 4 to 7.38 ± 0.13 in station 1. However, the pH values showed no significant difference P > .05. Similarly, in monthly values, the pH ranged from 7.00 ± 0.25 in June to 7.40 ± 0.08 in August. Apart from August, both the temporal and spatial variations were not statistically significant P > .05. The average values of pH for this study ranged from 7.02 – 7.38 across stations and 7.00 – 7.40 across months which is a characteristic of a total brackish water environment as previously reported by (Ajao and Fagade, 2002; Ngah et. el. 2017). pH Values are higher in dry season than in wet season, this did not correspond with the report of Obunuto et.al (2004) which maintained higher values in wet season than in dry season. However, the study is in agreement with the result of the previous study conducted by Dublin –Green (1990), in Bonny River where the highest values were recorded in the dry season and lower values of pH in the rainy or wet season. Similar trend was reported by Eke and Sikoki (2003) in the new Calabar River and also by Ansa (2005) in the Andoni flats of the Niger Delta Areas. Scenario may be due to the influx and decay of debris and industrial waste litter in the area as well as in balance level of H^+ ions input from surface run-offs during the rains. This however may contribute to the acidic nature of the water. The Range of pH Values depicts that it was changing towards neutral. This indicates evidence of presence of waste material which is an attribute activity. However, the pH profile in all the study area falls within the desirable limit for the survival of shellfish.

Total dissolved solids for the entire study stations ranged from 11190.00 ± 1954.00mg/l in station 4 to 16452.00 ± 2840.00mg/l in station 1. There was no significant difference in mean TDS value between stations P>.05. Nonetheless, the TDS concentration for months ranged from 8375.00 ± 316.00mg/l in October, to 19688.00 ± 4452.00mg/l in June. The TDS distributions were very high in June, August but reduced considerably in October. The monthly difference was statistically significant. TDS Water values across the study stations ranged from 11170 mg/l to 16452 mg/l and monthly values of 8375 mg/l to 19688 mg/l. The values were higher in wet season than dry season. These values were higher than the TDS values of 390.6 mg/l reported by Otokwunfo and Obiukwu (2005) in Okirika axis of Bonny Estuary. Uzokwe and Ogbusarun (2011) reported TDS values of 75.72 (± 0.26) to 575.15 (± 0.07) mg/l.

Dissolved oxygen concentration for the study stations sustains slight steady variations. It ranged from 5.98.00 ± 0.71mg/l in station 4 to 6.32 ± 0.82mg/l in station 1. However, there was no significant difference in DO concentration across the sampled stations P>.05. In the monthly value, the DO concentration ranged from 3.33 ± 0.071mg/l in October to 7.93 ± 0.15 mg/l in June. There was no significant difference between stations P > .05. Comparatively, the DO was relatively constant in all the stations while in the monthly values there was no definite pattern. There was a significant difference between months P < .05. The values of D O ranged from 5.98 to 6.32 mg/l across the stations and 3.33 to 7.93 across the month. The result reviews that the wet season values were higher than the dry season values. This is in agreement with Braide et.al (2004) in their study of Water quality of Miniweja stream in Eastern Niger Delta, Nigeria and with the report of Ngah et.al (2017) in Elechi creek with values of 3.23 mg/l to 4.65 mg/l in the dry season and 6.25 mg/l to 6.53 mg/l in the wet season. The high DO values recorded in the study area can be attributed to the agitation of the surface water within the creek channel due to precipitation, turbidity nature of the water due to inflows from the run off and decomposition of organic matter. DO in water provides a source of oxygen needed for the oxidation of the organic matter when the concentration is high and lack of it causes the water body to be devoid of aquatic life.

Biochemical Oxygen Demand (BOD) ranged from 1.66 ± 0.24mg/l in station 2 to 2.37 ± 0.13 mg/l in station 1. Statistically, station 1, 3, and 4 showed no significant difference P>.05, however, station 2 showed a significant difference when compared with the other stations P<.05. similarly, the monthly values of BOD concentration varied from 1.83 ± 0.08mg/l in December to 3.05 ± 1.73mg/l in June. BOD showed regular declining pattern from the month of August to February and pick up in April (2.09 ± 0.02 mg/l). Monthly BOD concentration was statistically significant P < .05. BOD represents the amount of oxygen required for the biological decomposition of organic matter. It is an expression of how much oxygen is needed of microbes to oxidize a given quantity of organic matter (Chukwu, 2008). The mean value of (BOD) in the study stations ranged from 1.66 mg/l to 2.37 mg/l and 1.83 mg/l to 2.09 mg/l across months. Biochemical oxygen demand values were found to be higher during wet season than the dry season. Based on the observed results for both stations and months, it could be considered as clean and fairly clean. This assertion followed the classification of more and more (1996) which accentuated that water bodies with BOD concentrations between 1.0 and 2.0 mg/l were considered clean and fairly clean, 5.0 mg/l doubtfully and 10.0 mg/l definitely bad and polluted. BODs concentration in the creek may therefore serve as measure organic solution or pollution of the creek. This agreement with the observation of Braide et.al (2004) in their study of water quality in Miniwoji stream of Niger Delta.

Nitrate concentration ranged from 2.13 ± 0.113mg/l in station 1 to 2.85 ± 0.12 mg/l in station 2. In all, nitrate appeared to have a similar distribution pattern in all the stations. There was significance difference between stations P < .05. Nevertheless, the concentration of Nitrate for month ranged from 1.73 ± 0.36mg/l in June to 2.85 ± 0.16mg/l in February and April. Nitrate also maintained a progressive pattern having a minimum value of (1.73) mg/l in June and maximum value of (2.85) mg/l in February and April. There was significant difference between months P < .05. Nitrate values as a nutrient parameter in this study stations were generally low. They range across all the study stations from (2.13 – 2.85 Mg/l) and across the months from (1.75 – 2.85 mg/l). These values are lower than the range of 4.50 – 11.00 mg/l recorded by Chinda et.al (1993) in the upper reaches of Elechi creek. Bonny estuary and also below the internationally accepted value of 45.0 mg/l. Low nutrient levels have been reported for the Niger Delta system (Chinda *et.al.*, 1999 and Chinda and Braide, 2003). The reason for low nutrient level have been attributed to high activity rate of organism and their ability to generally use the nutrient in water columns and also the nature of the drainage substratum. It could also be attributed to be discharged of organic matter from sewage effluent of the water front settlement. The overall low concentration of nitrate in this study depict that they are below the threshold limit of 45.00 mg/l (Jagessar and Scokunndun, 2009). Nitrate feed plankton (microscopic plant and animal that lives in water), aquatic plant an algae, which are then eaten by fish (Eze, 2008). It is also observed that low nutrient concentration does not constitute any threat by the current load of anthropogenic input and the current characteristics and other instinct factors enable it adequately purify itself. However, the nutrient higher values show a buildup of nitrate in the surface water.

The concentration of sulphate ranged from 591.00±56.00 mg/l in Station 1 to 695.00 ± 18.00 mg/l in Station 2. There was no significant difference in sulphate concentration between stations P > .05. Similarly, there was no significant different in mean sulphate between months with value of 58800.00 ± 52.30 mg/l in December to 683.00 ± 20.53 mg/l in February P > .05.

Sulphate Values vary from 591 to 695 mg/l across the stations and ranged from 588.00 to 683.00 mg/l across the months. The values were higher in wet season than dry season except the month of February. The generally high value of sulphate, naturally occurring anions in the water, could be attributed to the combined effect of the effluents from the industrial activities, leachates from dump site and run off (Ogamba *et al.* 2004).

The concentration of phosphate ranged from 1.31 ± 0.43mg/l in Station 1 to 1.63 ± 0.28mg/l in Station 2. There was no significant difference in phosphate concentration between stations $P > .05$. Nevertheless, the monthly distribution of PO_4 showed that it ranged from 1.15 ± 0.19 mg/l in October to 2.67 ± 0.35mg/l in June. Differences in concentration between months were statistically significant $P < .05$. Phosphate is an essential mineral for plant growth but excessive concentration in water leads to plankton bloom, which possess high risk to other aquatic organism.

Table 1: Mean± SE of Physicochemical Parameters of Water at the Study Stations in Elechi Creek

Parameter	Station					
	Stn1 Mean±SEM	Stn2 Mean±SE	Stn3 Mean±SE	Stn4 Mean±SE	F	P
Temp	28.00±0.60[a]	28.00±0.60[a]	28.00±11.40[a]	28.00±0.60[a]	0.11	0.95
EC	22872.00±5693.00[a]	25991.00±3352.00[a]	25306.00±1764.00[a]	18859.00±2704.00[a]	0.11	0.38
Turb	14.00±7.00[a]	13.00±8.00[a]	14.00±7.00[a]	22.00±16.00[a]	0.87	0.48
pH	7.38±0.13[a]	7.29±0.12.00[a]	7.15±0.13[a]	7.02±0.11[a]	1.82	0.19
TDS	16452.00±2840.00[a]	15588.00±2472.00[a]	13692.00±1377.00[a]	11170.00±1954.00[a]	2.32	0.12
DO	6.32±0.82[a]	6.25±0.83[a]	6.17±0.81[a]	5.98±0.71[a]	1.35	0.30
BOD	2.37±0.13[a]	1.66±0.24[b]	2.26±0.19[a]	2.17±0.22[a]	14.79	0.01
Nitrate	2.13±0.13[b]	2.85±0.12[a]	2.63±0.24[ab]	2.18±0.33[b]	6.35	0.01
Sulph	591.00±56.00[a]	695.00±18.00[a]	682.00±15.00[a]	616.00±31.00[a]	2.28	0.12
Phos	1.31±0.43[a]	1.63±0.28[a]	1.43±0.20[a]	1.35±0.10[a]	0.95	0.44

Means along a row that do not share a letter are significantly different.

Table 2: Mean (± SE) Values of Physicochemical Parameters of Water in Elechi Creek with Months

Parameter				**Month/Year**				
	Jun. 2021	**Aug. 2021**	**Oct. 2021**	**Dec. 2021**	**Feb. 2022**	**Apr. 2022**	**F**	**P≤**
Temp	26.58±0.03[d]	28.70±0.00[c]	25.73±0.03[e]	28.58±0.05[c]	29.23±0.03[b]	29.38±0.03[a]	2434	0.01
EC	30038.±5645[a]	26545.00±215[a]	15260±147[a]	27535±107[a]	15878±6559[a]	24288±2967[a]	2.77	0.06
Turbidity	8.00±2.00[b]	60.00±13.00[a]	3.00±1.00[b]	20.00±2.00[b]	2.00±2.00[b]	1.00±0.50[b]	15.92	0.01
pH	7.00±0.25[a]	7.40±0.08[a]	7.07±0.10[a]	7.39±0.08[a]	7.22±0.22[a]	7.17±0.09[a]	1.30	0.31
TDS	19688±4452[a]	18550±119[ab]	8375±316[c]	15072±49[abc]	11050±2018[bc]	12619±1373[abc]	5.44	0.01
DO	7.93±0.15[a]	5.13±0.19[b]	3.33±0.07[c]	5.13±0.09[b]	7.90±0.13[a]	7.68±0.24[a]	161.53	0.01
BOD	3.05±0.10[a]	1.95±0.27[b]	1.91±0.15[b]	1.83±0.08b	1.89±0.22[b]	2.09±0.2[b]	21.55	0.01
Nitrate	1.73±0.36[a]	2.78±0.22[a]	2.35±0.24[ab]	2.15±0.18[a]	2.85±0.17[a]	2.85±0.16[a]	7.31	0.01
Sulphate	662.5±68.1[a]	670.0±41.4[a]	590.0±50.2[a]	588.0±52.3[a]	683.0±20.5[a]	682.8±11.32	1.21	0.35
Phosphate	2.67±0.35[a]	1.17±0.11[b]	1.15±0.19[b]	1.18±0.16[b]	1.22±0.04[b]	1.19±0.03[b]	11.17	0.01

Means along a row that do not share a letter are significantly different.

Sediment

The results of the physicochemical parameters in sediment at the study stations in Elechi Creek is given in Table 3 for spatial differences while monthly variations are presented in Table 4. The concentration of nitrate in sediment at the study stations ranged from 1.80 ± 0.20mg/kg in stations 1 and 4 to 2.50 ± 0.20mg/kg in station 3. There was significant difference in nitrate concentration between stations (p=0.03). Comparably, in a monthly variation, nitrate ranged from 1.7.00 ± 0.20mg/kg in August, to 2.40 ± 0.40mg/kg in December. There was no significant difference in nitrate concentration between months (p=0.25). The mean value (45.30 ± 3.96 mg/kg) reported by Uzoekwe and Ogbosanine (2011) were higher and not in agreement with the value in this study.

The sulphate value of sediment in the study stations ranged from 184.00 ± 57.00mg/l in station 1 to 241.00 ± 33.00mg/l in station 3. There was no significant difference in sulphate concentration between stations (p=0.12). However, the monthly concentration of sulphate in sediment ranged from 143.00 ± 29.00 mg/kg in August to 468.00 ± 27.00mg/kg in June. The peak value was the month of June with a very high mean value of 468.00 ± 27.00 mg/kg. There was a significant difference in sulphate concentration between months (p<0.01).

The phosphate of the sediment for the study stations ranged from 0.67 ± 0.23mg/kg in station 4 to 1.08 ± 0.28mg/kg in station 3. There was no significant difference in phosphate concentration in sediment between stations (p=0.09). However, there was significant difference in the mean of phosphate between months (p<0.01) with values of 0.51 ± 0.31mg/kg in August to 2.13 ± 0.31mg/kg in June.

Table 4.3: Mean±SE of Physicochemical Parameters of Sediment at the Study Stations in Elechi Creek

Parameter	Station					
	Stn 1	**Stn 2**	**Stn 3**	**Stn 4**		
	Mean±SE	**Mean±SE**	**Mean±SE**	**Mean±SE**	**F**	**P**
Nitrate	1.80±0.20[b]	2.00±0.20[ab]	2.50±0.20[a]	1.80±0.20[b]	3.84	0.03
Sulphate	184.00±57.00[a]	224.00±56.00[a]	241.00±33.00[a]	185.00±68.00[a]	2.34	0.12
Phosphate	0.88±0.39[a]	0.73±0.14[a]	1.08±±0.28[a]	0.67±0.23[a]	2.62	0.09

Means along a row that do not share a letter are significantly different.

Table 4: Mean (±SE) Values of Physicochemical Parameters of Sediment in Elechi Creek with Months

Parameter	Month/Year						F	P≤
	Jun. 2021	Aug. 2021	Oct. 2021	Dec. 2021	Feb. 2022	Apr. 2022		
Nitrate	1.90±0.20 a	1.70±0.20[a]	1.90±0.30[a]	2.40±0.40 a	2.00±0.20[a]	2.20±0.10[a]	1.50	0.25
Sulphate	468.±27.[a]	143.±29[b]	145.±31[b]	145±31[b]	162±20[b]	188.00±5[b]	30.95	0.01
Phosphate	2.13±0.31 a	0.51±0.09[b]	0.57±0.10[b]	0.57±0.10 b	0.62±0.12b	0.64±0.04[b]	21.54	0.01

Means along a row that do not share a letter are significantly different.

Conclusion

The results of the physicochemical parameters showed that any influence of industrial and anthropogenic activities on the water quality of the creek Indiscriminate disposal of wastes into the creek should be discouraged by government regulatory agencies.

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