International Journal of Biological Research Advancement

OPEN ACCESS

Abbreviated Key Title: IIARP IJBRA
ISSN 2736-0016 (Online)
Published by International Institute of Academic Research and Practice, Nigeria

Volume-2 | Issue-1 | Jul-Dec-2024. |

Original IJBRA Article

Correlation of Physiochemical Parameters and Heavy Metal Accumulation in The Sediment of Elechi Creek, Port Harcourt, Nigeria.

Anyiamuka-Chinedu Osisioma K. and Amuzie Chidinma C.

Department of Animal and Environmental Biology Rivers State University, Port Harcourt, Nigeria *Email: *anyiamukaosisioma@gmail.com*, *Contact: *+2348037092075*

Article History
Received: Aug. 28, 2024
Accepted: Sept. 05, 2024
Published: Sept. 12, 2024

Journal homepage:

https://www.iiarpub.org

Abstract

Sediments are the highest repository of metals in the aquatic environment. This study investigates the correlation between some physicochemical parameters (temperature, pH and dissolved oxygen) and the concentration of heavy metals (Pb, Cr, Cd, Ni and V) in the sediments of Elechi Creek. Temperature, pH and dissolved oxygen were investigated in the surface water while Pb, Cr, Cd, Ni and V were investigated in the sediment samples of Elechi creek for 12 consecutive months. Five stations were sampled; station1 (Eagle Cement), station2 (Saipem), station3 (Master Energy), station4 (NAOC) and station5 (Ogbakiri). Readings of temperature, Ph and dissolved oxygen were obtained in situ using a mercury in glass thermometer for temperature, pH meters (EIL model 720, Hach Japan) for pH, and Jenway DO meter (Model, 9071) for dissolved oxygen and their mean values were calculated per station. Concentrations of Pb, Cr, Cd, Ni and V in the sediment were determined using GBC Avanti AAC. Microsoft Excel was used to measure strength of the relationship, Simper test was used to show the contribution of physicochemical and heavy metals. Simprof test, PCA and Non-Multidimensional Scaling (n-MDS) were used to test for the significant relationship between the variables. These tests were carried out using PRIMER7. The mean concentrations of temperature for stations 1, 2, 3, 4 and 5 respectively were 30.23±0.89, 30.27±0.91, 30.17±0.92, 30.15±0.88 and 30.03±0.84. The mean concentrations of pH for stations 1, 2, 3, 4 and 5 respectively were 6.22±0.11, 6.19±0.12, 6.29±0.08, 6.37±0.08 and 6.09±0.38. The mean concentrations of dissolved oxygen for stations 1, 2, 3, 4 and 5 respectively were 9.83±1.15, 7.33±0.94, 6.09±1.18, 10.28±1.61 and 6.86±0.37 . The mean concentrations of the heavy metals in stations 1, 2, 3, 4 and 5 respectively were as follows:

Pb- 4.35 ^{a}±1.15, 5.89 ^{a}±0.83, 3.40 ^{a}±0.93, 1.37 ^{b}±0.43 and 1.23 ^{b}±0.63.

Cr- 7.24 ^{a}±1.05,7.74 ^{a}±0.81, 6.37 ^{a}±1.03, 4.39 ^{ab}±0.51 and 2.27 ^{b}±0.85

Cd- 0.03 ^{a}±0.02, 0.02 ^{a}±0.01, 0.03 ^{a}±0.01, 0.02 ^{a}±0.01 and 0.004 ^{b}±0.002

Ni- 2.92 ^{a}±0.91, 3.13 ^{a}±0.79, 3.09 ^{a}±0.57, 0.89 ^{b}±0.39 and 1.01 ^{b}±0.65

V- 0.13 ^{a}±0.05, 0.15 ^{a}±0.04, 0.18 ^{a}±0.03, 0.14 ^{a}±0.06 and 0.07 ^{ab}±0.04

Hierarchical cluster analysis and metric multidimensional scaling grouped the stations into 2; station 1, 2 and 3, and stations 4 and 5. The result of the cluster was higher contribution of Pb and Ni which was not attributed to the physicochemical parameters, but to high industrial activities in the stations.

Keywords: Physiochemical parameters, heavy metals, sediments, Elechi creek.

INTRODUCTION

Physicochemical parameters or variables refer to the characteristics or features of water or sediment affecting the survival, growth, reproduction, production and general management of aquatic organisms (Stickney and Robert, 1999). According to Stickney and Robert (1999), maintaining an optimum water quality means keeping the water at an optimum for the physiological requirements of aquatic species, precisely, fish and plankton. Boyd (2002) also noted that physicochemical variables include the physical and biochemical factors determining water usage. These variables include the degree of hotness or coldness, its clarity or opaqueness, acidity or alkalinity, concentration of dissolved and charged ions, and the heavy elements. Ademoroti (2006) opined that domestic and commercial waste water alters the water chemistry and increases the toxicity of the aquatic habitat. In the determination of quality of any water body, physicochemical variables should first be considered (USEPA, 2002). Anthropogenic effects on water bodies should also be considered topmost in water management procedures (Douterelo *et al.*, 2004). Diffusion of oxygen from the air into water depends on the solubility of oxygen and is influenced by many other factors like water movement, temperature, salinity, etc. The acceptable range of pH for a brackish water system range from 6.3 to 7.7 (Obire *et al*., 2003; pH, BOD, Nitrate, Sulphate, Chloride and others determine general water quality and influences the speciation of heavy metals (Hakanson, 2000; Bacini and Suter, 2009).

Heavy metals are elements of high atomic numbers with high utilities in industrial application. They get into the water bodies directly from point sources as effluent and non-point sources as runoff and more insidiously as atmospheric deposit that are transported from long distances (Yilmaz and Tilmaz, 2004).

There are basically three reservoirs of metals in the aquatic environment: water, sediment and biota. Metal levels in each of these three reservoirs are dominated by a complex dynamic equilibrium governed by various physical, chemical and biological factors (Murray and Murray, 2003). Among these three reservoirs, sediment is the major repository for metals, in some cases, holding over 99% of the total amount of metal present in the system (Renfro, 2003).

The occurrence of elevated concentrations of trace metals in sediments found at the bottom of the water column can be a good indicator of man-induced pollution rather than natural enrichment of the sediment by geological weathering (Davies *et al*., 1991, Chang *et al.*, 2008) and it has been established that a large part of metals are related with suspended or bottom sediments dependent of sorption processes (Irion, 2001; Wang *et al.*, 2007). Factors that influence bioavailability, bioaccumulation and biological effects of heavy metals on sediments in an estuary include:

- Mobilization of metals in the water and then chemical speciation.
- Transformation (e.g. methylation of metals including As, Hg, Pb and Sn).
- Controlling effects of Iron oxides as a major sediment component to which metals are preferentially bound.
- The influence of physicochemical parameters on the heavy metals. (Bryan and Langston, 1998)

The chemistry of the water itself influences the speciation of heavy metals in both marine and limnic environments. Factors such as hydrogen ion activity (Hakanson, 2000; Bacini and Suter, 2009), hardness (Kinkade and Erdman, 2005; Bell, 2006; McCarthy *et al*., 2008; Calamari *et al*., 2010) and salinity (Somero *et al*., 2007) are reported to be crucial in this respect. Furthermore, the presence of organic compounds and suspended particles may change the activity of free metal ions (Hirose and Sugimura, 2005; Benhard and George, 2006; Gachter and Davis, 2008). Heavy metals occur naturally in sea water in very low concentrations, but these concentrations have increased due to anthropogenic activities that result to increased pollutants over time (Kargin *et al*., 2001). Industrial activities including agriculture and mining constitute potential sources of heavy metal pollution in aquatic environments. Pollution of aquatic ecosystems by heavy metals is an important environmental problem, as heavy metals constitute some of the most dangerous toxicants that can bioaccumulate (Soegianto *et al.*, I999a) Contaminated sediments in both freshwater and marine systems are a significant issue worldwide. Contaminants can persist for many years in sediments, where they have the potential to adversely affect human health and the environment through food chain. Some chemicals continue to be released to surface waters from industrial and municipal sources and polluted run-off streams from urban agricultural areas and build up to harmful levels of contamination in sediments (Mackevičiene *et al*., 2002). The enrichment of metals in sediments is influenced by allochthones influence which is made up of natural and anthropogenic effects and autochthonous influences comprising of precipitation, sorption, enrichment of organism and organometallic completion during sedimentation as well as the post depositional effects of digenesis (Forstner and Witlmann, 2009).

Heavy metals enter into the aquatic environment through various routes like wind, leachates, runoffs, rain, and direct or indirect effluent discharge.

The Elechi Creek system is brackish in nature being a mangrove ecosystem. It is a major tributary of the Bonny Estuary which flows across industrial areas of Port Harcourt with oil-based and agro-allied industries sited along its banks The tidal and brackish water body is believed to receive waste water discharges from a number of facilities associated with industries located along the water body (Obire *et al.*, 2003). The potential industries which contribute to the level of metals in this creek are effluents from Agip oil, Saipem, Master energy, waste water from abattoirs along the creek, wastes from Eagle cement and others which are all sited along the banks of the estuary and whose effluents drain into the creek.

The major objectives of the study were to:

1. Measure some physicochemical characteristics (Temperature, pH, and DO) of the surface water in five stations along the Elechi Creek to establish spatial variations.
2. Measure the level of five heavy metals including – Nickel (Ni), Vanadium (V), Chromium (Cr), Cadmium (Cd) and Lead (Pb) in the sediment samples of Elechi Creek to ascertain a correlation between the above named physiochemical parameter and heavy metal accumulation in sediment.

MATERIALS AND METHODS

Study Area: Elechi Creek is within the upper reaches of the Bonny Estuary which lies between longitude 6°58’10.83’’ to 00'23.64’’E and latitude 4°4$^{6'}$11.34’ to 4° 4$^{7'}$43.33’’N and it receives indiscriminate effluent discharges from the heavily industrialized and highly populated Port Harcourt Metropolis.

The study stations include:

Station 1 – Eagle Cement Water Front, situated at latitude 4° 47’41.85” and longitude 6° 56’29.43”.

Station 2 – Saipem Water Front, situated at latitude 4° 46’24.55” and longitude 6° 58’50.49”.

Station 3 – Master Energy Water Front, situated at latitude 4° 46’30.27” and longitude 6° 58’45.80”.

Station 4- Nigerian Agip Oil Company Water Front, situated at latitude 4° 47’55.68’’ and longitude 6° 58’15.76’’

Station 5 - Ogbakiri Water Front, situated at latitude 4° 47’37.69” and longitude 6° 54’37.32”.

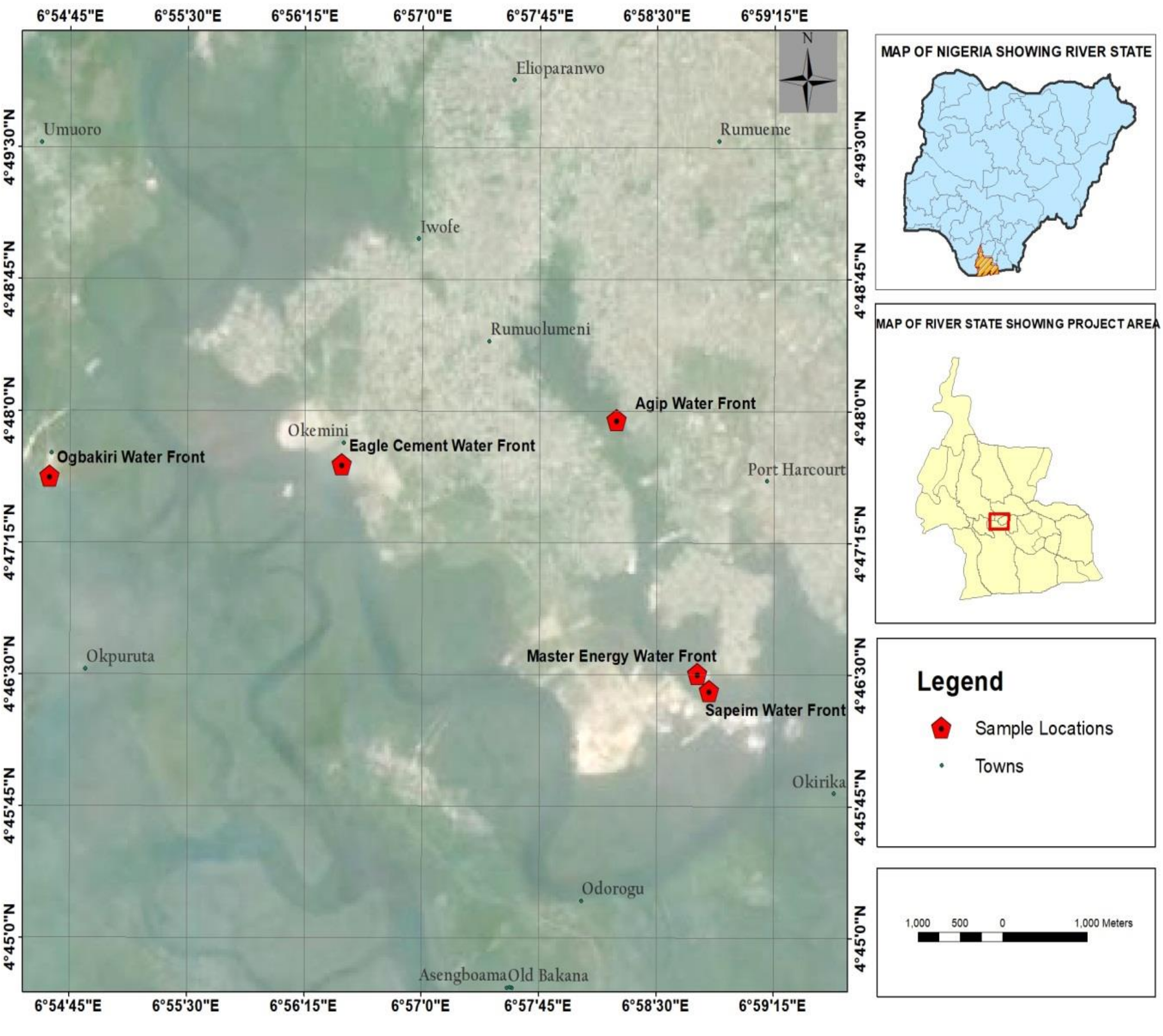

Fig. 1: Map of Elechi Creek

Water Sampling: Monthly surface water samples were collected for twelve consecutive months for physicochemical properties analysis using 500ml plastic containers with screw caps. All the bottles and containers were rinsed, dried and labelled accordingly prior to the sampling day. They were also rinsed three times with the water being sampled at the respective Stations. Collections of samples from the Stations were always done during day time between 9 and 14hrs, and each time samples were taken when the tidal level was low. Water samples were collected just a few centimeters below the water surface at each of the five respective stations by dipping or immersing the containers at a depth of about 20-30cm. The plastic containers were then labelled appropriately water parameters such as temperature, pH, DO, EC, and Salinity were taken *in-situ*.

Sediment Collection: Samples of sediment were collected from the five sampling stations. Sediment sample was collected using a 0.1m square quadrant with the aid of a shovel taken to 0.1m depth on a mudflat Ekweozor (1985). The samples were bagged in foils labelled appropriately and transported to the laboratory where they were air dried. 5gm of air-dried, ground and sieved sediment sample was preserved prior to analysis.

Laboratory Procedure: The various water physicochemical variables were analyzed in the laboratory following the normal APHA (1998) procedures as documented in the standard method.

Water Temperature (ºC)**:** A mercury-in-glass thermometer calibrated in degrees centigrade (0º -100ºC) was used in the determination of water temperature *in-situ*. The thermometer scale was read off after dipping into water. When the thermometer was immersed in water for 5 minutes and readings were taken immediately. An average record was taken after taking three measurements in degree celsius (ºC).

Hydrogen Ion Concentration (pH): The pH value of the water was determined *in-situ* using a pH meters (EIL model 720, Hach, Japan). This was determined by simply dipping the electrode into 200mls of water that had been stirred and the reading was subsequently read off the meter. The mean of two of such readings were recorded as the pH of the water.

Dissolved Oxygen (mg/l): Dissolved oxygen was determined *in situ* using Jenway DO meter (Model; 9071). This was done by inserting the probe in 2 liters of water sample collected from each station and readings taken on the screen of the meter when stable. Readings were in mg/l.

Sediment Analysis

Heavy Metals in Sediment samples: One (1) gram of sediment sample was used for heavy metal extraction through acid digestion principle. Fifty (50) milliliter of distilled water was added to the sediment in a 150ml conical flask. Five (5ml) milliliter of concentrated nitric acid (HNO_3) was added to the mixtures which was then placed on a hot plate to evaporate gradually at 120ºC to a final volume 10ml. Reflux bulbs were added to the mixture to prevent spillage of the contents while being heated up. It was then filtered using filter paper. The filtrate was made up to the 50ml mark with distilled water and stored in 25ml vials until analysis. The filtrate was presented and analyzed using GBC Avanti AAS to determine the concentrations of the metals. It was measured in mg/kg.

Data Analysis: The data obtained from the heavy metal and physicochemical parameters were subjected to Microsoft Excel statistical software which is a non-parametric approach for measuring the strength of the relationship between two variables. Simper test was employed to show the contribution of physicochemical characteristics and heavy metal concentrations to the observed similarities and dissimilarities produced by the cluster analysis. Simprof test was used to test the statistical significance of the results produced by the cluster analysis. Principal component analysis (PCA) and non-multidimensional scaling (n-MDS) were used to test the significant relationships between stations based on physicochemical characteristics, and heavy metal concentrations of sediment. These tests were carried out using PRIMER v7 statistical software.

RESULTS

Physicochemical Parameters in Water: The results of the physicochemical parameters of water were presented below. The mean monthly/seasonal values of the physicochemical parameters were presented in Table 1, and the spatial mean values were presented in Table 2.

Water Temperature (ºC): The result of the water temperature recorded in the study area ranged between 26.6 – 34.8ºC with an overall mean of 30.17 $\pm$ 0.38ºC. The station with the highest mean temperature was station 2 with a mean of 30.27 $\pm$ 0.90ºC and the station with the lowest mean temperature was station 5 with a mean of 30.03 $\pm$ 0.84ºC. The variation of temperature in the study stations over the study period is presented in Figure 2. There was seasonal variation but no spatial variation.

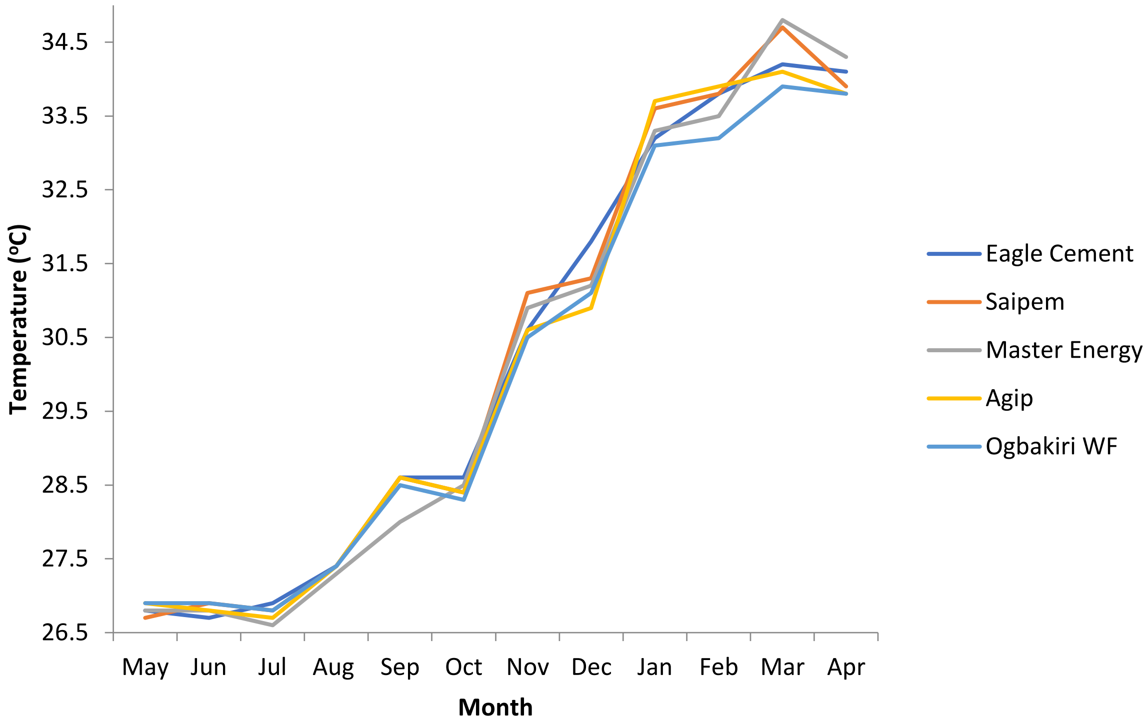

Fig. 2: Temperature in Surface Water in the Study Stations over the Study Period May, 2022 – April, 2023 in Elechi Creek

Table 1: The Physicochemical Parameters (mean ±SE) of **Water from the Five Stations in Elechi Creek May 2022 – April 2023**

Station	Temp(°C)	DO (mg/l)	pH
1	30.23± 0.89	9.83± 1.15[a]	6.22± 0.11
2	30.27± 0.91	7.33± 0.94[ab]	6.19± 0.12
3	30.17± 0.92	6.09± 1.18[b]	6.29± 0.08
4	30.15± 0.88	10.28± 1.61[a]	6.37± 0.08
5	30.03± 0.84	6.86± 0.37[b]	6.09± 0.38

*Comparison along the columns

Dissolved Oxygen (mg/L): The DO in water for the study period ranged between 2.4 – 20.3 mg/L with a mean of 8.09 ± 0.53 mg/L.

The station with the highest DO value was station 4 with a mean of 10.28 ± 1.61 mg/L and the station with the lowest DO was station 3 with a mean of 6.09 ±1.18. The mean value of station 4 and 1 are similar but different from other stations. There is also seasonal variation. Figure 3 shows the variations in DO values in all the stations studied over the period of study.

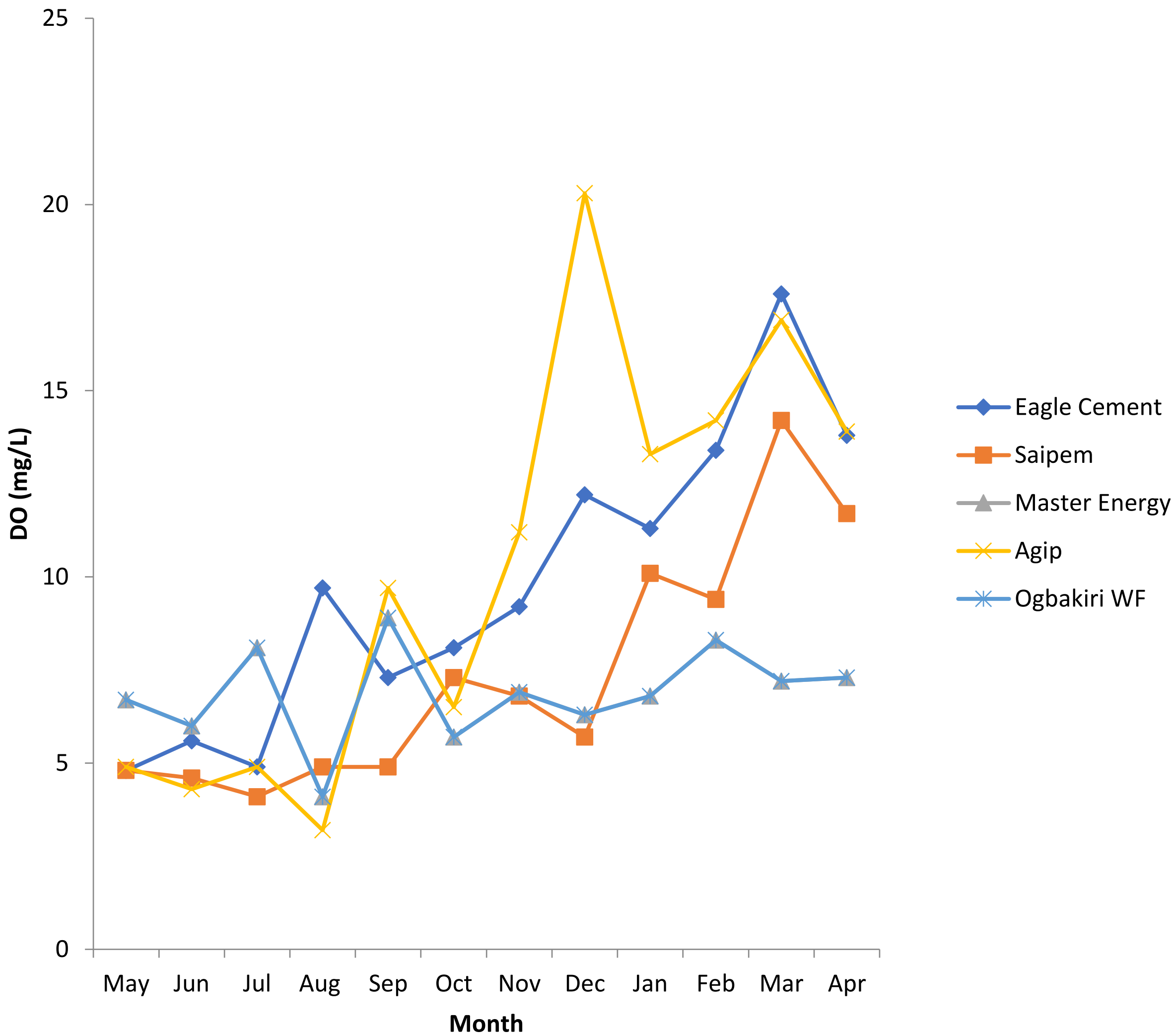

Fig. 3: DO in Surface Water in the Study Stations over the Study Period May, 2022 – April, 2023, in Elechi Creek

Hydrogen ion Concentration (pH)/

The pH in the surface water of the study area ranged between 2 – 6.8.

The station with the highest mean value 6.37 ± 0.09 was station 4 while the station with lowest mean pH was station 5 with a value of 6.09 ± 0.38. There is no spatial variation in the mean values of pH. Figure 4. shows the variations in pH values in all the stations studied over the period of study.

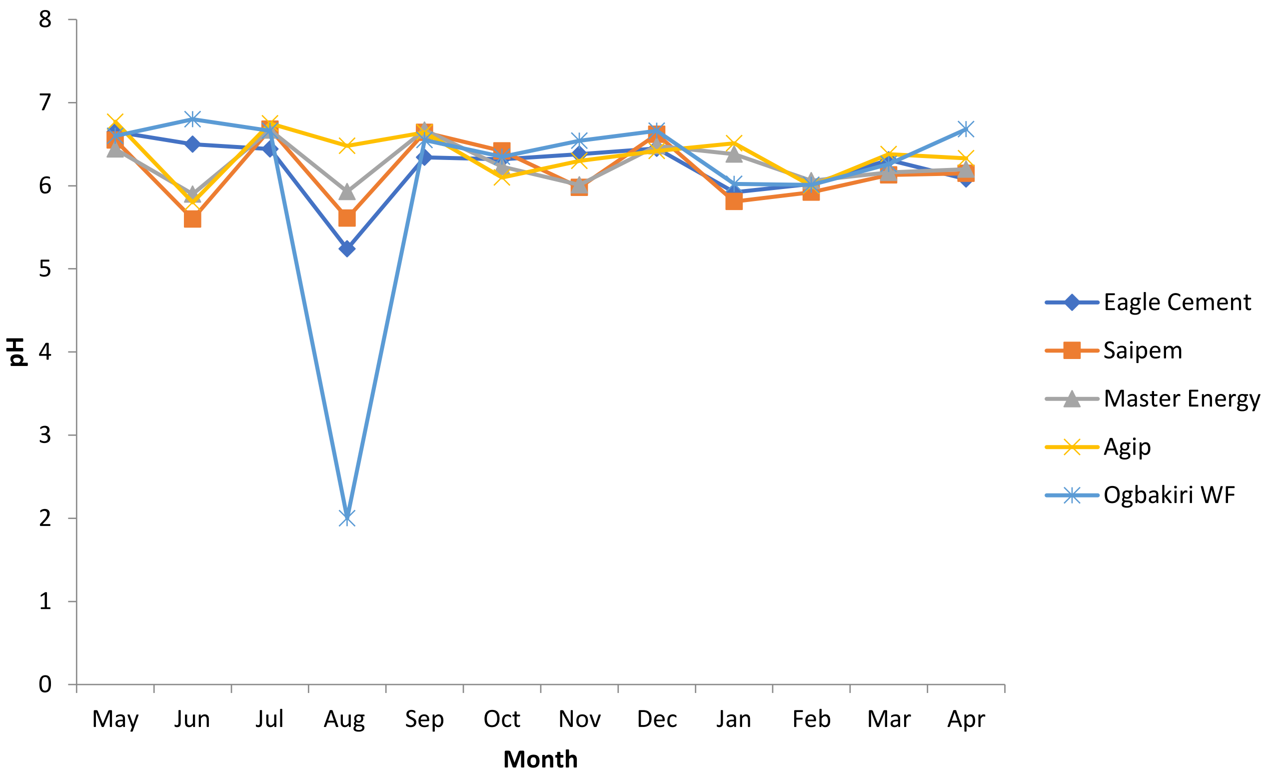

Fig. 4: pH in Surface Water in the Study Stations over the Study Period May, 2022 – April, 2023, in Elechi Creek

Heavy Metals in Sediment

The following heavy metals were measured in the sediment of the study area.

Chromium Cr (mg/kg): The Cr concentration in the sediment of the study area ranged 0.001 – 13.68 mg/kg with a mean of 5.61 ± 0.09 mg/kg. The station with the highest mean concentration was station 2 with a value of 7.74 ± 0.81 mg/kg & the station with the lowest mean concentration was station 5 with 2.27 ± 0.85 mg/kg. There was spatial variation, stations 3, 2, and 1 were similar but are different from station 5. There was no patterned variation in the seasons. The concentrations of Cr recorded from the sediment samples of the study stations over the study period were illustrated in Figure 5. Tables 2 and 3 shows the seasonal and spatial variation of heavy metals in sediment respectively.

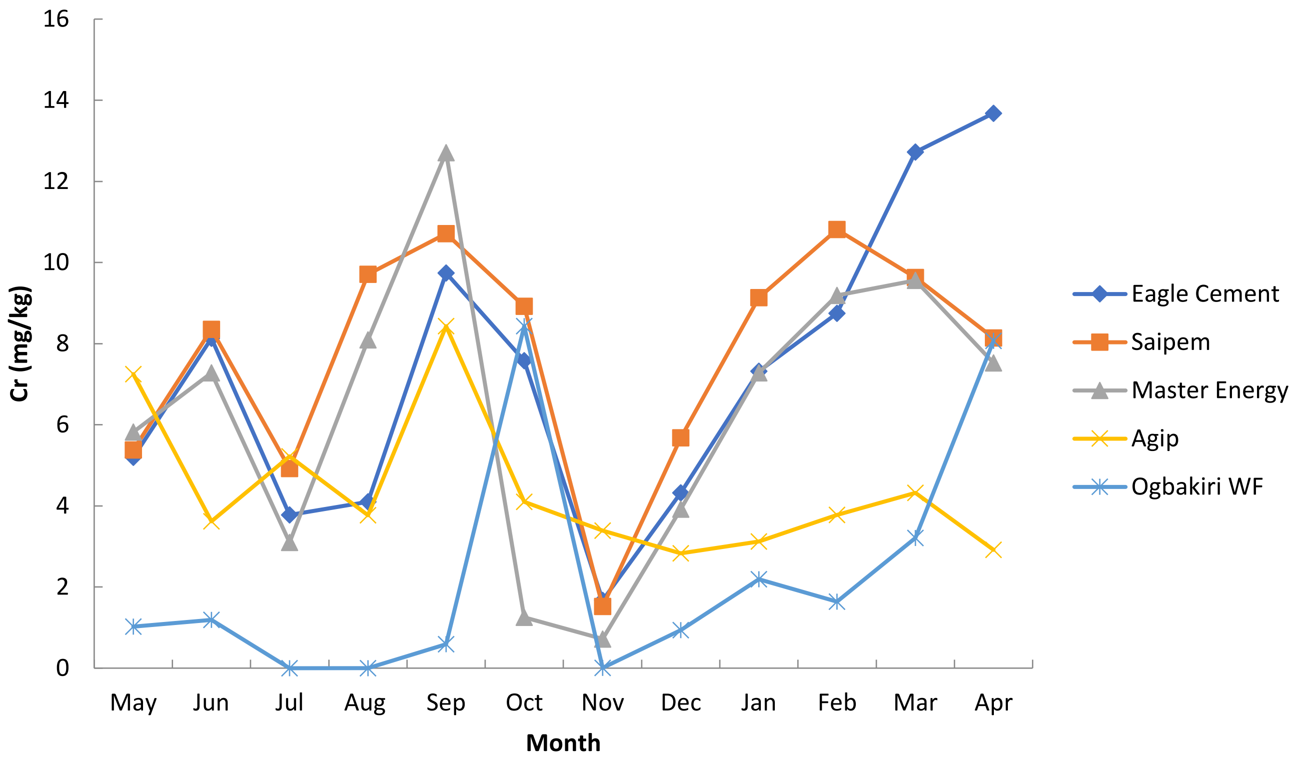

Fig. 5: Cr in Sediment in the Study Stations over the Study Period May, 2022 – April, 2023 in Elechi Creek

Table 2: Heavy Metals Parameters (mean ±SE) of Sediment from the Five Stations in Elechi Creek May, 2022 – April 2023.

STATION	Cr	Pb	Cd	Ni	V
1	$7.25^{a}\pm$ 1.05	$4.35^{a}\pm$ 1.15	$0.03^{a}\pm$ 0.02	$2.92^{a}\pm$ 0.91	$0.13^{a}\pm$ 0.05
2	$7.74^{a}\pm$ 0.81	$5.89^{a}\pm$ 0.83	$0.02^{a}\pm$ 0.01	$3.13^{a}\pm$ 0.79	$0.15^{a}\pm$ 0.04
3	$6.37^{a}\pm$ 1.03	$3.40^{a}\pm$ 0.93	$0.03^{a}\pm$ 0.01	$3.09^{a}\pm$ 0.57	$0.18^{a}\pm$ 0.03
4	$4.39^{ab}\pm$ 0.51	$1.37^{b}\pm$ 0.43	$0.02^{a}\pm$ 0.01	$0.89^{b}\pm$ 0.39	$0.14^{a}\pm$ 0.06
5	$2.27^{b}\pm$ 0.85	$1.23^{b}\pm$ 0.63	$0.004^{b}\pm$ 0.002	$1.01^{b}\pm$ 0.65	$0.07^{ab}\pm$ 0.04

***Comparison along the column**

Lead Pb (mg/kg): The Pb concentration in the sediment of the study area ranged between 0.001 – 13.36 mg/kg, with a mean of 3.25 ± 0.43 mg/kg. The station with the highest and lowest mean concentration of Pb was stations 2 and 5 with means of 5.89 ± 0.83 mg/kg and 1.23 ± 0.63 mg/kg respectively. There is spatial variation, stations 1,2 and 3, are similar but different from stations 4 and 5. There is no pattern in seasonal variation. The concentrations of Pb recorded from the sediment samples of the study stations over the study period were illustrated in Figure 6.

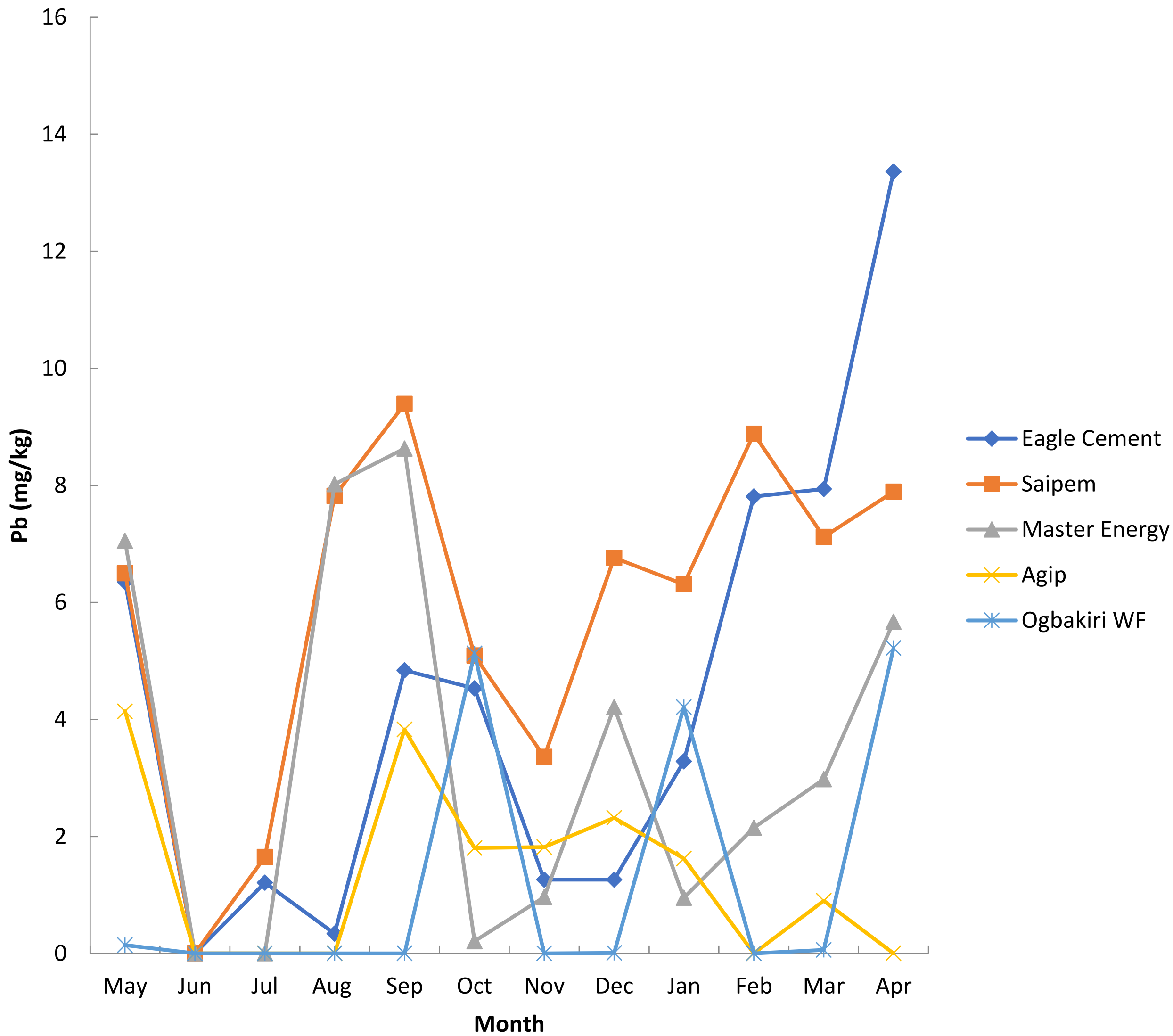

Fig. 6: Pb in Sediment in the Study Stations over the Study Period May, 2022 – April, 2023, in Elechi Creek

Cadmium Cd (mg/kg): The Cd concentration in the sediment samples of the study area ranged between 0.001 – 0.2 mg/kg, with a mean of 0.02 ± 0.006 mg/kg. The stations with the highest and lowest mean concentration of Cd were station 1 and station 5 with values 0.031 ± 0.02 mg/kg and 0.004 ± 0.002 mg/kg respectively. There was spatial variation; station 5 was different from the other stations. There was no pattern in the seasonal variations. The concentrations of Cd recorded from the sediment samples of the study stations over the study period are illustrated in Figure 7.

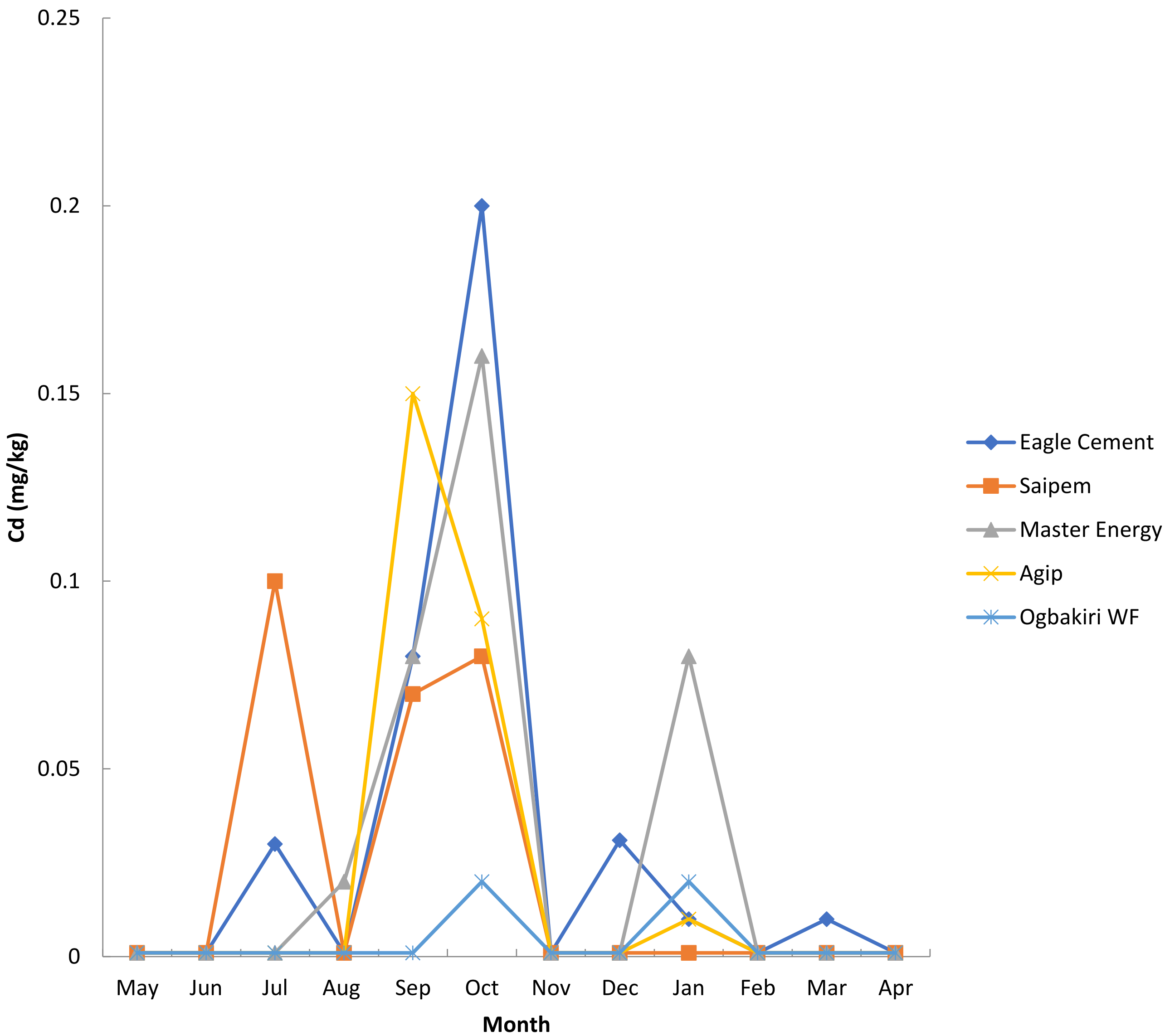

Fig. 7: Cd in Sediment in the Study Stations over the Study Period May, 2022 – April, 2023, in Elechi Creek

Nickel Ni (mg/kg): The Ni concentration in the sediment of the study area ranged between 0.001 – 11.8 mg/kg with a mean of 2.21 ± 0.33 mg/kg.

The stations with the highest and lowest mean concentration of Ni were stations 2 and 4 with values of 3.13 ± 0.76mg/kg & 0.89 ± 0.39 mg/kg respectively. There was spatial variation, stations 4 and 5 were similar but different from the other stations. There was also seasonal variation. The concentrations of Ni recorded from the sediment samples of the study stations over the study period are illustrated in Figure 8.

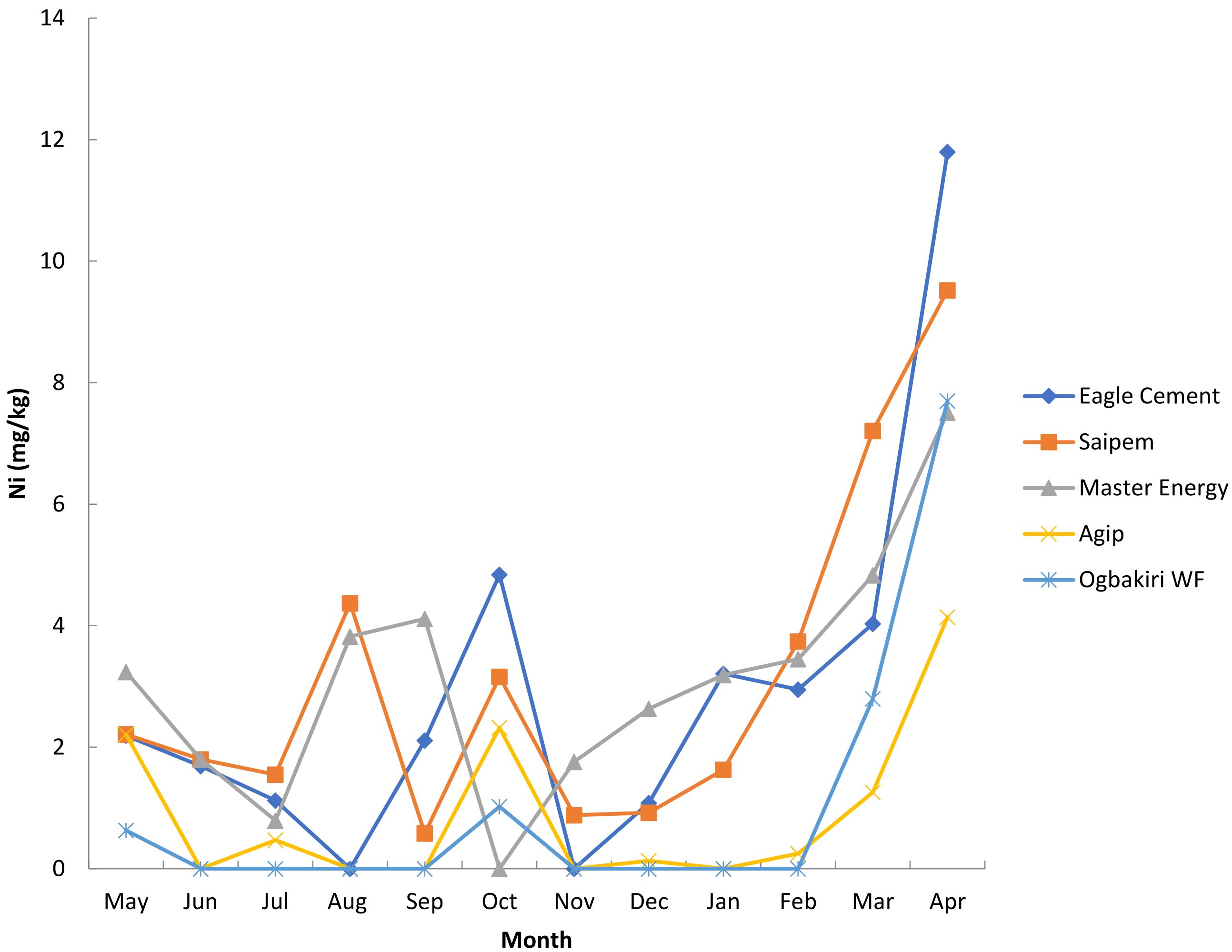

Fig. 8: Ni in Sediment in the Study Stations over the Study Period, May, 2022 – April, 2023, in Elechi Creek

Vanadium in Sediment, V (mg/kg): The concentration of V in the sediment of the study area ranged between 0.001 – 0.77 mg/kg, with a mean of 0.13 ± 0.02 mg/kg. s

The stations that recorded the highest and lowest mean concentration of V in the sediment were stations 3 and 5 with values of 0.18 ± 0.029mg/kg & 0.07 ± 0.04 mg/kg respectively. There was spatial variation; station 5 was different from other stations. There was no pattern in the seasonal variation. The concentrations of V recorded from the sediment samples of the study stations over the study period are illustrated in Figure 9.

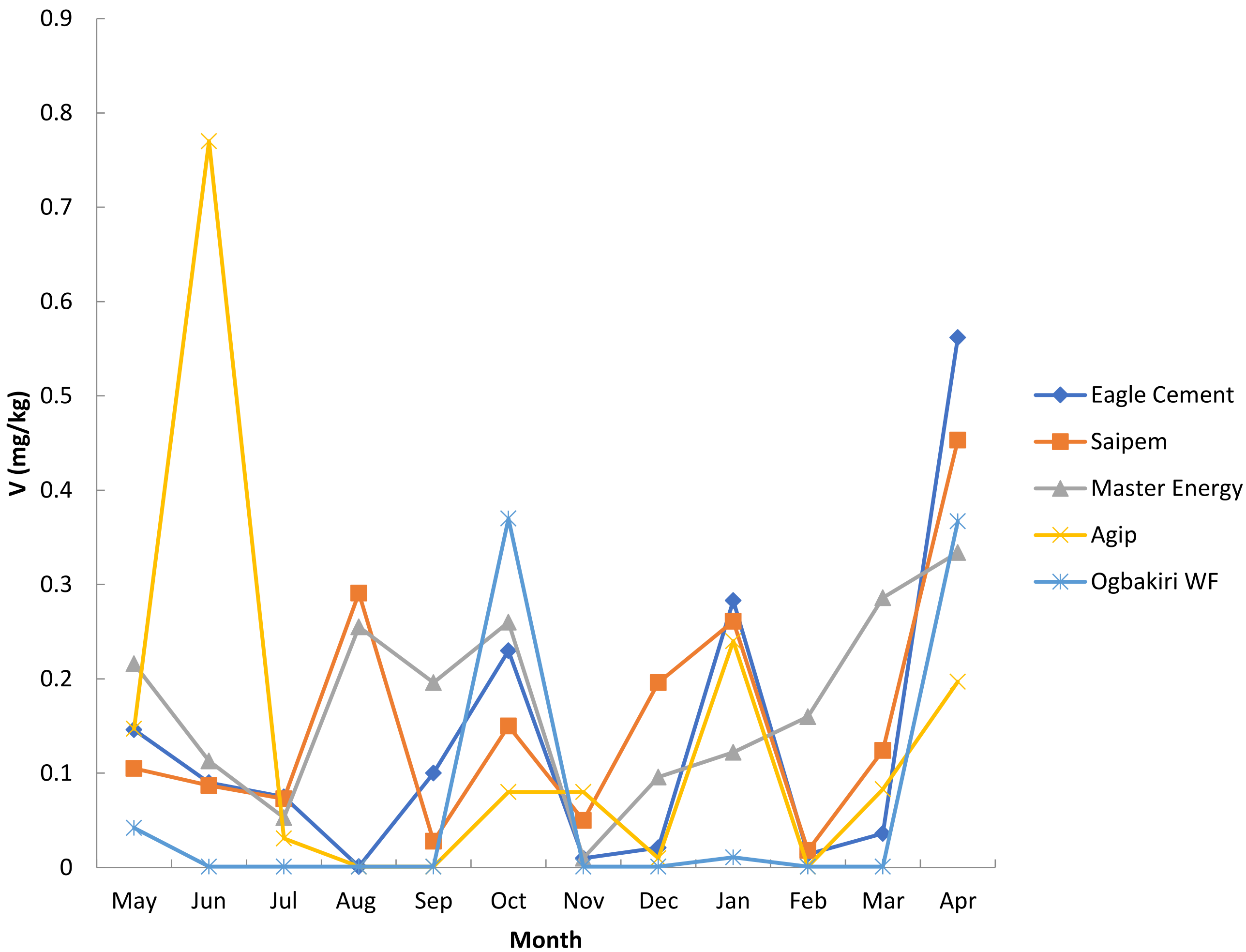

Fig. 9: V in Sediment in the Study Stations over the Study Period, May, 2022 – April, 2023, in Elechi Creek

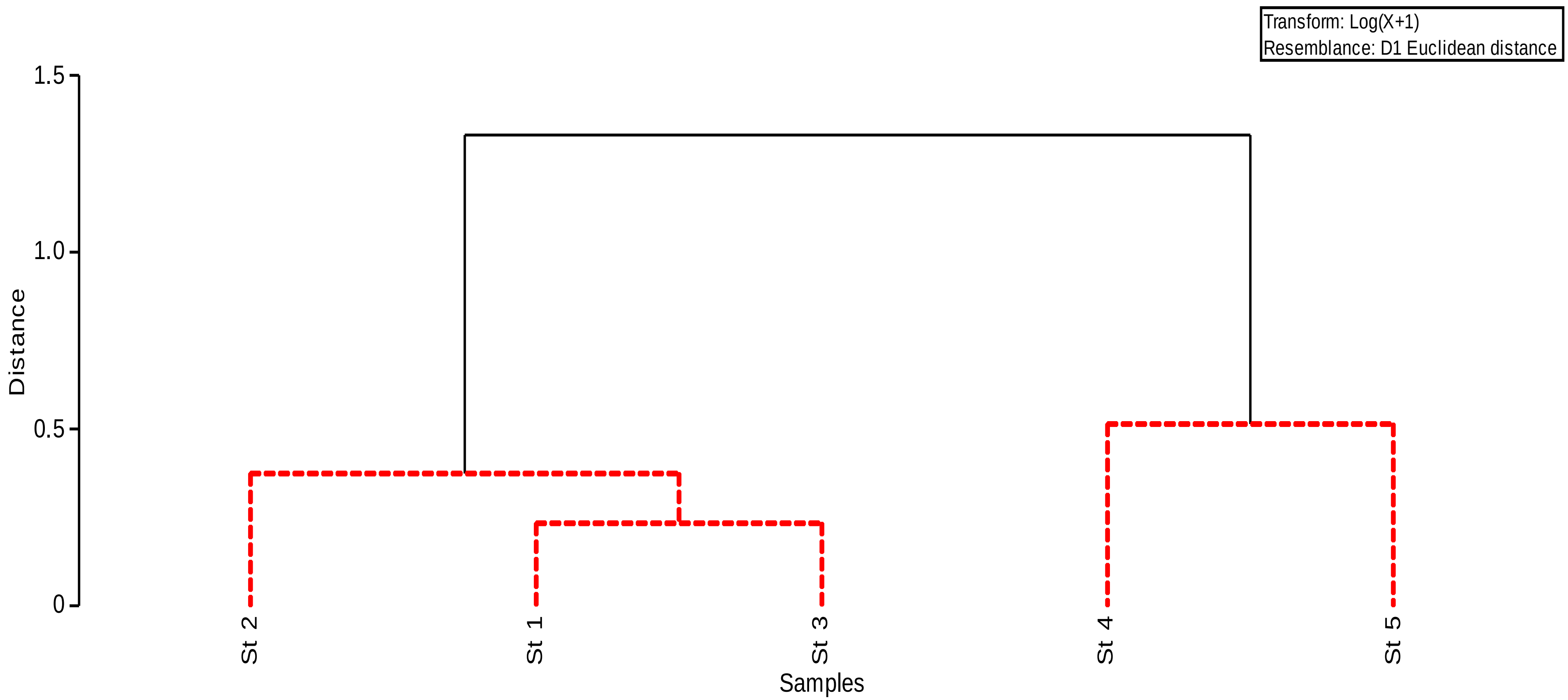

Fig. 10: Hierarchical Cluster Analysis of Sediment Samples based on the Concentrations of the Heavy Metals

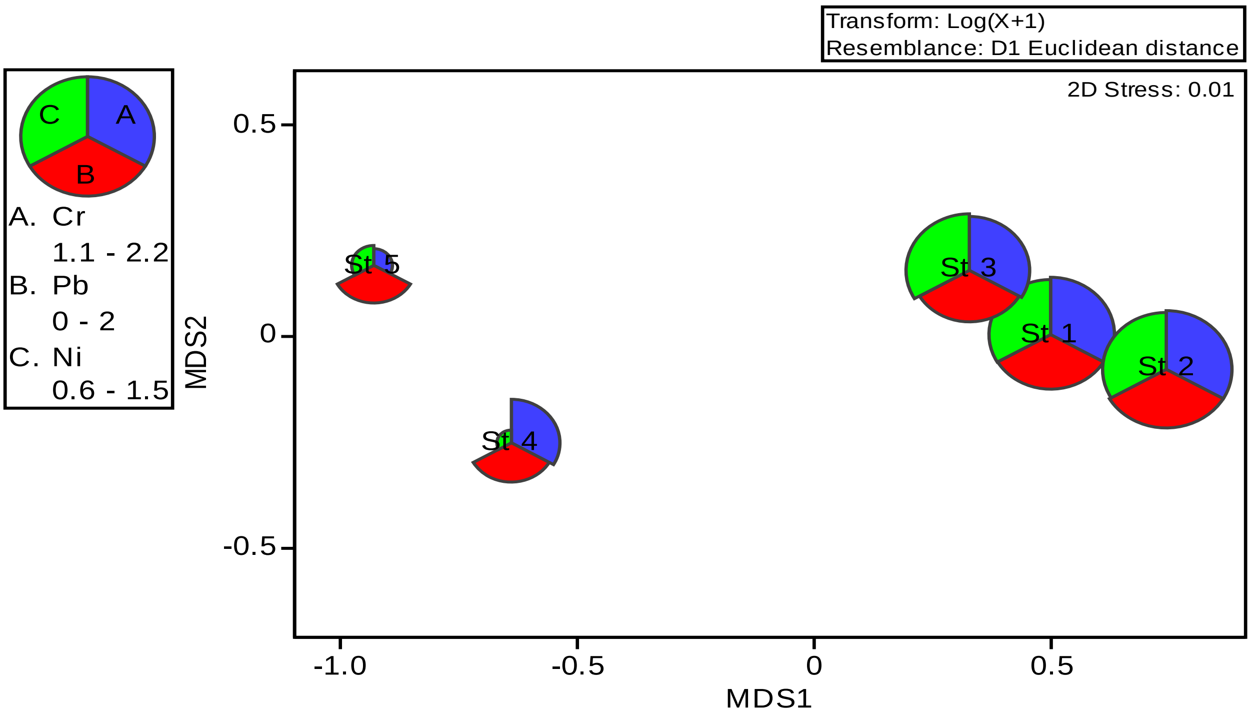

Fig. 11: Metric Multidimensional Scaling of Sediment Samples based on Concentration of the Heavy Metals Tested, using Bubble Plots to show Differences in Concentration of Ni and Pb

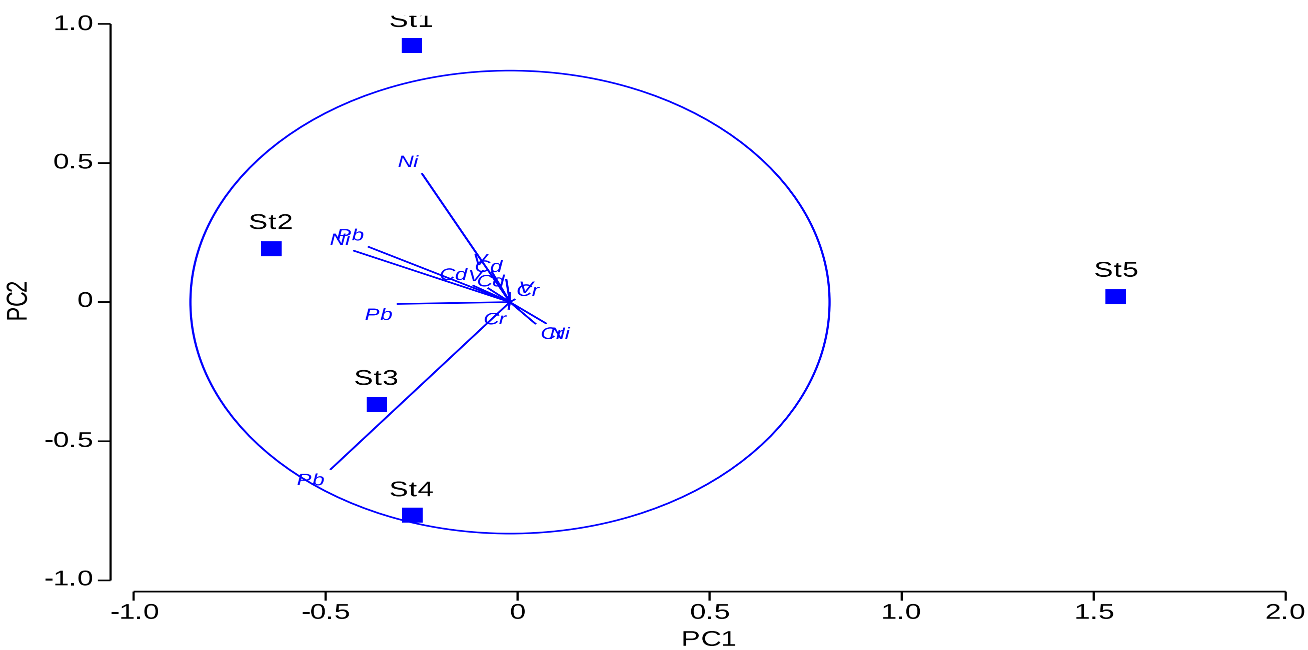

Fig. 12: PCA of Heavy Metal Concentrations in Sediment Samples.

DISCUSSION

The results of this research are comparable to those of other researchers in similar environments. The range of temperature in this study is normal for tropical water considering the intensity of the sun at some months. The observed high peak of temperature coincided with the dry season period, while the observed low peak coincided with the wet season. The study showed a spatial variation in the surface water mean temperature that was not significant. The findings of this study for water temperature were in close similarity with the works of Otene (2014) for Amadiama creek (27.42 – 31.22^{o}C), Erondu and Chindah (1991) in New Calabar River (25.5 – 32^{o}C), Ansa (2005) (25.9 – 32.4^{o}C) in the Andoni River.

DO in this study was above the FMENV (1999) 5mg/L especially in station 4 (Table 1) which could also be attributed to continuous speed boat movement, which increases the surface aeration. The DO of 7.0 mg/L recorded by Ekeh and Sikoki (2003) in Amadi Creek, is in agreement with the findings in this work. However, it was contrary to the reduced DO observed by Ekeh (2008) in Nwaja Creek, Rivers State, which was attributed to the presence of oily and greasy pollutant around the Creek resulting in insufficient surface aeration.

The pH in this study was slightly acidic (Table 1) but within the limit that will support aquatic life. There was no spatial variation in the surface water pH which was similar to Amuche (2012), and Makinde *et al*. (2015) in Buguma and Ekerekana Creeks, Niger Delta. The pH range was lower than the range of 6 – 9 of FEPA (1991), and according to Wetzel and Liken (2000), pH values outside 6.5 – 8.5 range suggest pollution. The low pH range of the surface water could be the reason for the higher concentration of heavy metals in the sediment.

There was spatial variation in Cr concentration in the sediment, the observed difference between Station 5 and the other stations could be attributed to less industrial activities in station 5 as Cr and its compounds have several Industrial uses.Table.4.6. The concentrations of sediment Cr in this study was different from that of Ideriah *et al.*,(2006) who reported sediment Cr concentration of 0.007 mg/kg in the same Creek and 0.44 mg/kg in Sombreiro River in 2010 and Ibanga (2015) reported concentrations of 34.79±39.4 for sediment Cr in Woji Creek. The work of Usese (2015) in Lagos Lagoon had similar concentration with the present study. However, the mean sediment concentration of Cr in this study was less than the International Sediment quality guidelines of USEPA (2010) and ISQG of Canada (2002) which are 43.4 and 37.3 mg/kg respectively.

There was spatial variation in the mean values of Pb for stations 1, 2 and 3 from that of stations 4 and 5, The mean values of stations 1, 2, &3 were greater than those of stations 4&5.(table 2, fig 11); The reason for this variation could also be attributed to concentrated industrial activities, accidental spills from loading or discharging vessels and frequent burning of illegal crude recovered by some oil regulating agencies, on stations 1, 2 and 3. The surroundings of stations 4 and 5 have close proximity to residential areas so these activities are reduced.

The findings in the mean concentration of Pb was close to that of Usese (2015) who reported 2.90mg/kg in Lagos Lagoon while Ibiba *et al*. (2014) reported 1.81 and 2.07 mg/kg of Pb in sediment in two states in the Niger Delta, Ibanga (2015) has also reported a higher concentration of Pb 11.58±7.54 mg/kg in Woji Creek. Pb is toxic to aquatic organisms even at trace levels, this concentration in the sediment can poise a threat to benthic dwellers and also magnify across the food chain. However the Pb concentration in the sediment was lower when compared with the USEPA (2010) and Canadian ISQG (2002) of 35.8 and 35 mg/kg respectively.

There was spatial variation observed in the mean value of Cd concentration, the variation observed in station 5 and the other stations(Table 2, fig 13) could be because of less industrial activities as Cd has wide industrial use in anti corrosion (coating and electroplating). The findings of this study was in agreement with the previous workers: Ideriah *et al*. (2006), Ibiba (2014), Ibanga (2015), Usese (2015). (Usese, 2015). Cadmium concentration in this study was lower than the 0.99 and 0.6 mg/kg of USEPA 2010 and Canadian ISQG (2002) respectively.

There was spatial variation in Ni concentration in the sediment though not significant, the observed spatial variation, was between stations 4 and 5 which seem similar, but different from stations 1, 2 and 3. The mean value of stations 4&5 were less than the mean value of station 1, 2, & 3 (see Table 2). The reason could be attributed to the reasons aforementioned for Pb, reduced industrial activities on stations 4 and 5. The findings were similar to the work of Oyekunle *et al*. (2011) in Ajawere River. The difference in seasonal variation could be because of the menace of this black soot that befalls Port Harcourt, and Ni is a component of black soot (IPS, 2022).

Ideriah *et al*. (2010) reported values <1 mg/kg in all his stations in Sombreiro River. However, Ni concentration was lower than the USEPA 2010 and the Canadian 2002 values of 22.7 and 16 mg/kg respectively.

There was spatial variation in V concentrations. Station 5 mean varied from the other stations. The reason could be reduced oil activities. Vanadium is associated with crude oil and its presence indicates contact with crude oil. The findings of this study had sharp contrast with the work of Oyekunle *et al*. (2010) in Ajaware River who reported 10.75±2.04 mg/kg. Previous workers (Ugbomeh, 2013) did not find V in sediment. The presence of illegal refineries at Elechi Creek in recent times has increasd the presence of V. There was no sediment quality standards found for V in the literatures soughted.

Simprof test defined two statistical groups A and B for sediment heavy metals in stations. Group A has stations 1,2 and 3 while group B has stations 4 and 5 (Fig 10). Simper was used to show contribution of specie to the observed differences and similarities. Pb contributed 85.95%, Cr 12.60%, Ni 1.29% the other metals contributed less than 1% of the similarities of group A. For the group B Cr contributed 95.24%, V contributed 1.98%, Pb Contributed 1.40% and Ni contributed 1.26% to the similarities of group B. Metric multi-dimensional scale (m-MDS) (see Fig.11) and Principal component analysis (PCA) (fig 12) was used to illustrate the contribution of the variables.

The hierarchical cluster analysis of sediment samples based on the concentration of heavy metals (Fig. 10) showed that stations 1, 2 and 3 fit into one cluster and stations 4 and 5 fit into another cluster.

The cluster is not very different from the bubble plots of the metric multi-dimensional scaling of sediment samples based on the concentration of the heavy metals tested (Fig 11).

pH has no significant spatial variation and is within the range of (6.09 - 6.37) The effect could be attributed to be general rather than specific- it agrees with Li etal's work pH (7-9) who acclaimed that pH has no significant effect on heavy metal release in the sediment.

CONCLUSION AND RECOMMENDATIONS

The mean spatial variation of temperature in the study was not significant. It was observed that from the cluster analysis, stations 1, 2 and 3 had higher metal absorption in sediment and the mean temperatures of the above stations were slightly higher than the mean temperature values of stations 4 and 5. This could be a mere coincidence because the difference in the mean values of temperature were not significant to cause such variation, it could be attributed to higher industrial activity.

There was spatial variation, but this spatial variation which is not attributed to difference in heavy metal accumulation for this situation, reason being that station 4 with the highest mean value of DO has the least concentration of heavy metals in the sediments after station 4. These assertions were in line with the work of Li *et al*. (2013) who acclaimed that temperature, DO and pH do not contribute to heavy metal accumulation.

In conclusion, this study established that anthropogenic activities influence heavy metal absorption in sediment rather than physicochemical activities.

All metals studied in this study (Cr, Pb, Cd, Ni and V) were industrial and oil based and their increased concentrations were as a result of anthropogenic activities rather than lithogenic activities.

REFERENCES

Bacini, P& Suter,U. (2009). MELIMEX, An Experimental Heavy Metal Pollution Study,Chemical Speciation and Biological Availability of Copper in Lake Water. *Schweiz Journal of Hydrology*.41:291-301.

Stickney, A. & Robert, R. (1999). *Principles of warm water Aquaculture*. Oxford University Press, USA.

Boyd, C.E. (2002).Water Quality Management for Pond Fish Culture.*ScienceDirect* 11(6) 110-117.

Ademoroti, L.M.A.(2006). *Environmental chemistry and Toxicology*. Folulex Press Ltd, Ibadan.

United State Environmental Protection Agency(USEPA) (2002). Methods for evaluating wetland conditions: using algae to assess environmental conditions in wetlands. Office of water, U.S. Envir onmental Protection Agency, Washington D.C EPA – 822 – R – 02 – 021.

Douterelo, I., Joby, B. B., Peter, D., Raju, S., Katherine, E. F., and Catherine, A. B., (2004): Methodological approaches for studying the Microbial Ecology of Drinking Water Distribution Systems. Elsevier Ltd. *Science Direct Journal*. 36 (3);26-31

Obire, O., Tamuno, D.C. & Wemedo, S.A.(2003). Physicochemical Quality of Elechi Creek in Port Harcourt, Nigeria. *Journal of Applied Science and Environmental Management*, 3: 11-22.

Hakanson, L. (2000). The quantitative impact of pH, bioproduction and Hg-contamination on the Hg – content of fish (pike). *Environmental Pollution,18:285-304.*

Bacini, P& Suter,U. (2009). MELIMEX, An Experimental Heavy Metal Pollution Study,Chemical Speciation and

Biological Availability of Copper in Lake Water. *Schweiz Journal of Hydrology*.41:291-301.

Yilmaz, A.B. & Tilmaz, Y. (2004). Comparism of Heavy Metal Levels of grey mullet (mugilcephalus) and Sea Bream (Sparus durata L.) Caught in Iskenderum Bay (Turkey). *Turkish Journal of Veterinary and Animal Sciences* 29: 257 – 262

Murray, C.V. & Murray, L. (2003) Absorption-desorption equilibria of some radionucleotides in sediment freshwater and sediment-seawater systems. pp. 105-124. In*: Proceedings of the Symposium on Interaction of Radioactive Contaminants with the Constituents of the Marine Environment. International Atomic Energy Commission*.

Renfro, W.C. (2003). Transfer of 65mg Zn from sediments by marine polycheate worm. *Marine Biology*, 21: 305- 316.

Hall, A., M.I. Valente & B. Davis,(2007). The Zambesi River in Mozambique: The physicochemical status of the middle and lower Zambezi prior to the closure of the Cabora Bassa Dam. *Freshwater Biology*, 7: 187-206.

Gachter, R. & Davis, J.S. (2008). Regulation of copper availability to phytoplankton by macromolecules in lake water. *Environment, Science and Technology,*12:1416-1421.

Irion, G. (2001) Minerals in rivers. In: Degens E., Kempe F., Richey J. (eds) Biogeochemistry of major world rivers, SCOPE 42. Wiley, New York, pp 356.

Wang, F., Cheng, J.,& Forsling, W. (2007) Modeling sorption of trace metals onnatural sediments by surface complexation model. *Environment, Science and Technology*, 31:448–453.

Bryan, G.W. & W.J. Langston (1998). Bioavailability, Accumulation and Effects of Heavy Metals in Sediments with special reference to United Kingdom Estuaries. *A Review of Environment and Pollution* ; 76 (2): 89-131.

Kinkade, M.L & Erdman, H.E. (2005). The influence of hardness components (Ca2+and Mg2+) in water on the uptake and concentration of cadmium in a simulated freshwater ecosystem. *Environmental Resources,*10:308-313.

Bell, A.V. (2006). Waste Controls at Base Metal Mines. *Environent, Science and Technology*, 10:130-135.

McCarthy, C. S., Henry, J.A.C & Houston, A.H. (2008).Toxicity of cadmium to goldfish (*Carassius auratus*), in hard and soft water. *Journal of Fisheries Resources,* 35:35-42.

Calamari, D., Marchetti, R & Vailatie, G. (2010). Influence of water hardness on Cadmium toxicity to *Salmo gairdneri.International Journal of Water Resources*.,14: 1421-1426.

Somero, G.N., Chow, T.J; Tancy, P.H., & Snyder, C.B. (2007). Lead accumulation Rates in Tissues of the Estuaries Telecost Fish. Gillichthys Mirabilis Salinity and Temperature effects, *Archives of Environment Contamination & Toxicology.* 6:337-348….

Hirose, K. & Sugimura, Y. (2005).Role of metal-organic complexes in the marine environment. *Marine Chemistry*,16:239-247.

Benhard, M & George, S.G. (2006).Importance of Chemical Species in Uptake, Loss and Toxicity of Elements for Marine OrganisminTheImportance of Chemical Speciation in Environmental Processes.*Springer, Berlin Heidelberg New York*, pp. 275-299.

Gachter, R. & Davis, J.S. (2008). Regulation of copper availability to phytoplankton by macromolecules in lake water. *Environment, Science and Technology,*12:1416-1421.

Kargin, F., Donnes, A. and Cogun, H.Y. (2001). Distribution of heavy metals in Different tissues of the Shrimp,*Penaeus semiculatus* an *Metapenaeus monoceros* from the Iskenderum Gulf, Turkey, Seasonal variations. *Bulletin of Environmental Contamination and Toxicology*, 66:102-109.

Soegianto, A., Charmantier-Davies M. Trilles, J.P. & G Charametar (2009). Impact of Cadmium on the Structure of Gills and Epipodites of the Spring (Penaecies Japondis Crustacca: Decapoda). *Aquatic living Resources*, 12:57-70.

Soegianto, A., Charmantier-Daures, M., Trilles, J.F. and G. Charmatier (2007). Impact of Copper on the Structure of

Gills and Epipodites of the Shrimp Penaeus Japonicus (Decapoda). *Journal of Crustacean Biology*, 19: 209 -223.

Mackevičiene, G., Štriupkuviene, N. & Berlinskas, G. (2002). Accumulation of Heavy Metals and Radionuclides in Bottom Sediments of Monitoring Streams in Lithuania. *Ecological Vilnius press*. 2.15-23

Forstner,U.&Witlmann, G.T.W. (2009). Metal pollution in the aquatic environment. Berlin, Springer-Verlag publishers.

American Public Health Association (APHA) (1998). *Standard methods for the examination of water and waste water*.20th(Ed), American Public Health Association,Washington D.C.

Dambo, W. B. and Ekweozor, I. K. E. (2000). The Determination of Lead in Mangrove Oyster, *Crassostrea gasar* from the Lower Bonny Estuary, Nigeria. *Journal of Applied Science and Environmental Management.* 4(2):101-108.

Ekweozor, I.K.K. (1985). A Baseline Survey for the Motoring of Oil in the Bonny Estuary, Nigeria. M. Phil. Thesis, Rivers State University of Science and Technology, Port Harcourt, Nigeria. pp. 212

Cite This Article: Anyiamuka-Chinedu Osisioma K. and Amuzie Chidinma C. Correlation of Physiochemical Parameters and Heavy Metal Accumulation in The Sediment of Elechi Creek, Port Harcourt, Nigeria