PRINT ISSN 1119-8362
Electronic ISSN 2659-1499

Full-text Available Online at
https://www.ajol.info/index.php/jasem
https://www.bioline.org.br/ja

J. Appl. Sci. Environ. Manage.
Vol. 29 (1) 305-311 Jan. 2025

Assessment Of Heavy Metals Concentration and Pollution Indices Of Surface Water In Enerhen River, Warri South LGA, Delta State, Nigeria

***EGAI, AO: PAARU, M**

Department of Geology, Niger Delta University, Amassoma, P.M.B 071, Yenagoa, Bayelsa State, Nigeria

**Corresponding Author Email: ayibawariegai@ndu.edu.ng, aegai19@yahoo.com*
**ORCID: Http//orcid.org/0019-0009-2516-3002*
**Tel: +2347037665963; +2348088477267*

Co-author Email Address: paarumoses@ndu.edu.ng

ABSTRACT: The objective of this paper is to assess heavy metal concentrations and pollution indices of surface water in Enerhen River, Warri South, Delta State, Nigeria using appropriate standard method. Data obtained show that the result indicated the concentration of Zinc 0.065mg/l - 0.190mg/l, Pb (0.003mg/l - 0.142mg/l), Cu (0.081mg/l - 0.213mg/l), Cd (0.02mg/l - 0.282mg/l, Cr (0.041mg/l - 0.171mg/l), Fe (0.162mg/l - 0.278mg/l) and Ni (0.104mg/l - 0.762mg/l) comparison with WHO 2012 permissible limit the probed water sample falls within the allowable concentration of the standard except the concentration of lead (Pb) in SW1, SW2, SW4 and SW5 which is a concern because it exceeded the allowable limit, lead is considered toxic to human at higher concentrations . The computed indices for the maximum admissible concentration upper permissible values buttress as follows Zn 0.3MAC, Pb 0.01MAC, Cu 2MAC, Cd 0.01MAC, Cr 0.05MAC, Fe, 0.3MAC and Ni 0.02MAC. Also, the interpretation of the assessment of pollution indices with connotations as heavy metal pollution indices (HPI), Heavy metal evaluation index (HEI) and Degree of contamination as CD. The values from the analysed sample locations are as follows SS1 for HPI value gives (3869.928), HEI (103.0056) and CD (96.00583). For SS2 HPI value gives as (6157.674), HEI (100.4356) and CD (93.4353). SS3 HPI (5394.674), HEI (102.2192) and CD (95.21933), SS4 HPI (507.0053), HEI (20.39265), CD (13.39267) and SS5 HPI (568.5303), HEI (25.9153) and CD (18.9154) .The HPI indicated values >150 which expresses high concentration of heavy metal pollution. Similarly the HEI also indicated values > 20 which again buttress high heavy metal evaluation index and the degree of contamination also gives values > 3 which indicate a higher level of contamination in the samples. The River water is recommended for treatment before use due to the higher concentration of Nickel, Pb and Cadmium especially lead (Pb) which is deleterious to human health.

DOI: https://dx.doi.org/10.4314/jasem.v29i1.37

Cite this Article as: EGAI, A. O: PAARU, M. (2025). Assessment Of Heavy Metals Concentration and Pollution Indices Of Surface Water In Enerhen River, Warri South LGA, Delta State, Nigeria. *J. Appl. Sci. Environ. Manage.* 29 (1) 305-311

Dates: Received: 22 October 2024; Revised: 20 November 2024; Accepted: 08 December 2024; Published: 31 January 2024

Keywords: Heavy metals, Contamination, Surface water, Atomic Absorption Spectrophotometer

Heavy metals in our environment especially in coastal waters have been on the increase over the years, the rapid surge may due to increase in population growth, industrialization and possible technological advancements. Environmental challenges arising from heavy metals have become a great concern because at higher concentrations this metals are poisonous and also at times at lower concentrations respectively, heavy metals are becoming a burden to human health system and the human environment thus creating an environmental challenge to human habitation. The Public awareness of the environment

**Corresponding Author Email: ayibawariegai@ndu.edu.ng, aegai19@yahoo.com*
**ORCID: Http//orcid.org/0019-0009-2516-3002*
**Tel: +2347037665963; +2348088477267*

on the possible vicissitude of heavy metals has not been fully reported in Enerhen River, hence, it is very crucial for Communities to be on the watch to release toxic substances into our river system, the adherence can also reduce the pool of waste in our river system thus publishing the dangers and the concomitant effects on the environment will be helpful in reducing harmful effect. Water is an essential resource for humanity and the alteration of water by industrially and anthropogenic ally remains a global concerns, (Yongabi, 2012) highlighted coastal waters pollution by heavy metals due to higher concentration of trace elements occasioned by careless release of burning of fossil fuels.

Global researchers points out that human influences can deteriorates our river system thus, changing the geochemical composition, the architecture of the surrounding landscape, the association of bacteria composition and faecal wastes are few instances of change in water composition the river system (Ukiwe, and Egereonu, 2012). Some authors also reported harmful consequences of the bio-indicators; in order to identify the causes of contamination on river system which is considered to be threatening from anthropogenic sources to alter biodiversity in our coastal waters. Heavy metals contamination and their sources vary in diverse composition these includes faecal waste, hydrocarbon wastes which is considered poisonous to aquatic life , causing a foul poisonous composition in the marine system as well as affects the sustainability of humanity (Ukiwe, 2013). However, in some instances heavy metals are introduced to the water system due to wastes generated from animals which are discharged into the aquatic system, these can also alter the composition. There is a central market in Enerhen and the people depend on the river water for domestic and for industrial purposes, hence, the objective of this paper is to assess the Heavy Metals Concentration and Pollution Indices of Surface Water in Enerhen River, Warri South LGA, Delta State, Nigeria

MATERIALS AND METHOD

Brief Description of Study Area: Enerhen is situated in Warri South LGA of Delta State; the geology of the area is mostly sedimentary with coastal landforms. It is accessible by both water and road means of transportation. It is located with latitude 5'31^{o}N to 5'37^{o}N and between longitudes 5'47^{o}E to 5'48^{o}E.

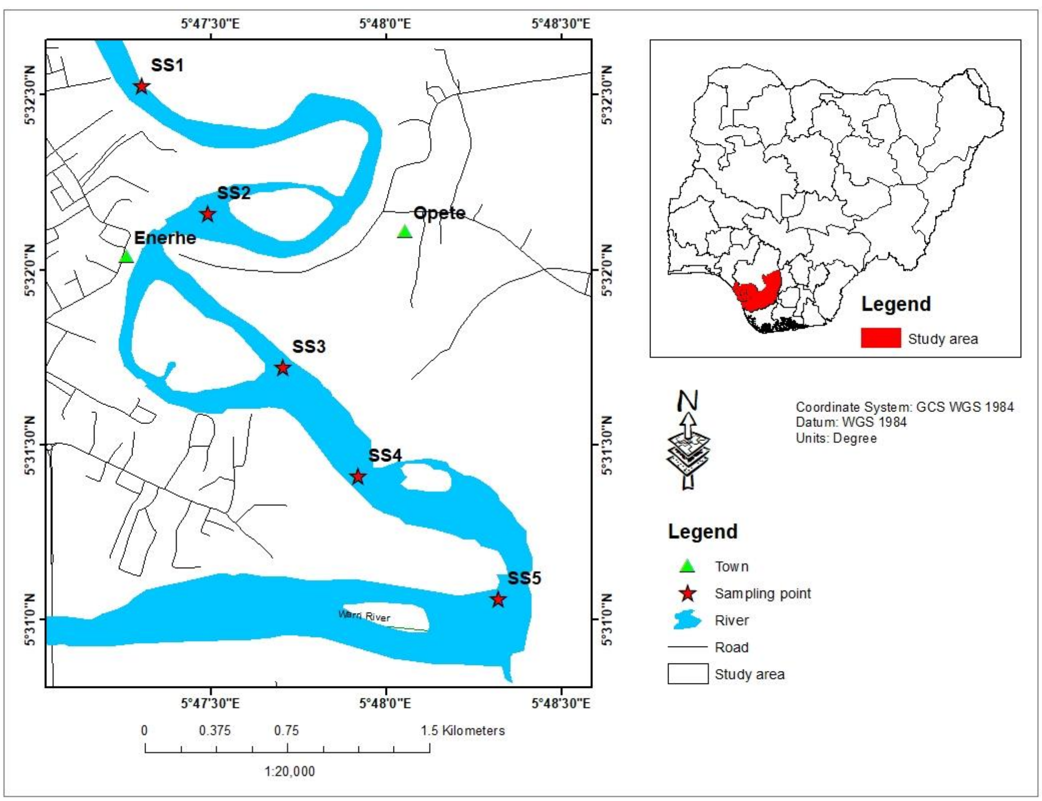

Fig 1: Study Location Map
Source: (generated from the current study)

Geology and Stratigraphy: The local geology of the study area is within the Niger Delta Sedimentary basin. The sedimentation of the basin began in the cretaceous, marginal pull-apart who contained host and graben, roll-over anticline, growth fault, point bars, barrier island arc are some of the diagnostic features of the basin.

Plastic water bottles were used to collect the five water samples and it was carefully labelled as (SW1, SW2, SW3, SW4 and SW5) the empty plastic bottles were washed to deter contamination, refrigerator was used to store and control the temperature before it was sent out within twenty hours of sample collection.

Trace/Heavy Metal Analysis (APHA 3110): A representative portion of the water sample was transferred into a 250ml beaker and 5.0ml conc. HNO_3 was added. The solution was evaporated to a near dryness on a hot plate, making sure that the sample did not boil. The beaker was then allowed to cool and another 5.0mL conc. HNO_3 was added. The beaker was covered with a glass and returned to the hot plate. A gentle refluxing action of the solution was set as a result of increase in the temperature of the hot plate. Heating continued with subsequent addition of acid as necessary until digestion was completed (light- coloured residue obtained).

About 1-2.0ml conc. $HNO_{3,}$ was added to dissolve the residue. The residue was washed with distilled water and filtered to remove silicate and other insoluble materials. The volume of the solution was then adjusted to 100mL in a volumetric flask. The absorbance of the metal was determined by aspiration of the sample digest into an Atomic Absorption Spectrophotometer (AAS) PE-3100 while its corresponding concentration (in mg/l) was read off the linear calibration curve

HPI, HEI and concentration index analysis was employed to provide comprehensive report of the status of contamination.

This index was initiated by Mohan *et al.,* 1996; the expression of value is weighted arithmetic quality mean method with two basic steps. Rating scale was provided for each of the parameters that were selected and a weight (Wi) was also assigned to it. The selection of the pollution parameter is the second step in which the index was utilized. The arbitrary rating value between zero and one which is dependent upon the importance of the individual quality consideration.

These can be assessed by making the value inversely proportional to the recommended standard (Si) for corresponding parameter (Kwaya et al., 2017 and Mohan et al., 1996).

The HPI computation model is usually done using the equations:

$$\frac{\sum_{i=1}^{n} W_i Q_i}{\sum_{i=1}^{n} W_i} \quad (1)$$

Where Q_i is the sub-index of i^{th} parameter. $W_i$is the unit weightage of the i^{th} parameter and n is the number of parameters considered The Q_i sub-index is calculated using the equation below

$$Q_1 = \sum_{t=1}^{n} \frac{\{M_i(-)l_i\}}{(s_i - l_i)} \times 100 \quad (2)$$

Where $M_i I_i$ and S_i are the Heavy metals i^{th} parameter monitored, ideal and standard values respectively. The negative sign (-) is the numerical difference of the two value, the algebraic sign is ignored. For this index, the intended use is for drinking hence the critical pollution index value is 100. In this study the W_i andS_i are taken as the inverse of MAC and WHO (2011) /standard.

The evaluation of Heavy metal index (HEI), HEI method gives the overall quality of the water with respect to heavy metals WHO (2011); Edet, and Offiong, (2002), HEI is calculated from the following equation.

$$\text{HPI} = \sum_{i=1}^{n} {}^{Hc}/_{Hmac} \quad (3)$$

Where: $Hc$is the monitored value of the parameters and Hmac is the minimum admissible concentration of the parameter

The degree of contamination (Cd) describes both the number of parameters that exceed the upper permissible limit or guide values of potentially harmful elements and also exemplifies the concentration exceeding these limit values (Backman et al., 1997). To evaluate the degree of contamination (Cd) it can also be computed separately for each sample of water analysed as the sum of water contaminant factor of the individual components exceeding the upper permissible values. Generally, the Cd is a summary of the combined effects of the several quality parameters which is considered harmful to household water. In this study all detected values were used in computing the contaminant index, it is computed using the following:

$$C_d \sum_{t=1}^{n} C_{f_i} \quad (4)$$

C_{f_i} = represent the contaminant factor for the i-th component and is calculated from the equation

$$C_{f_i} = \frac{C_{A_i}}{C_{N_i}} - 1 \quad (5)$$

Where C_{A_i} = analytical value of the i-th component and C_{N_i} = upper permissible concentration of the i-th component (N denotes the normative value).

Three quantitative methods were used in assessing the risk level of heavy metal concentrations contamination in the samples: Contamination Index, Heavy metal pollution index (HPI) and Heavy Metal Evaluation Index (HEI).

RESULTS AND DISCUSSION

Results of the various analysed values are presented below; there are three tables and eight figures. Table 1 shows the concentration of the analysed seven heavy metals their concentration with respect to the sampled locations, table 2 and table 3 shows the computed values of the heavy metals using the pollution indices to characterize their strength with respect to low, medium and high based on the corresponding assigned values. Figures 1-8 are plotted using the analysed values of the heavy metals with their respective sample number and the standard used. The vertical section of the figure shows the concentration of the analysed value , whereas, the horizontal sections which is marked figure 1-figure 5 shows the five samples numbers and figure 6 indicating the standard .

Table .1: Surface water heavy metal in the study area

Sample code	Zn	Pb	Cu	Cd	Cr	Fe	Ni
SW1	0.065	0.018	0.207	0.166	0.171	0.278	0.762
SW2	0.151	0.003	0.081	0.282	0.041	0.152	0.104
SW3	0.165	0.015	0.107	0.243	0.106	0.216	0.320
SW4	0.190	0.033	0.273	0.02	0.043	0.162	0.170
SW5	0.170	0.142	0.101	0.012	0.025	0.240	0.115
WHO (2011)	5	0.01	2	0.003	0.05	0.3	0.02

Table 2: Adopted Standard for computed indices

Heavy metal	Wi	S	I	MAC
Zinc	0.2	5	0.3	0.3
Lead (Pb2+)	100	0.01	0.01	0.01
Copper (Cu2+)	0.5	2	2	2
Cadmium	333.33	0.003	0.01	0.01
Chromium	20	0.05	0.05	0.05
Iron	3.33	0.3	0.3	0.3
Nickel	50	0.02	0.02	0.02

Key: MAC = maximum admissible concentration/upper permissible; Wi = Weightage (1/MAC); S = Standard permissible; I= Highest permissible

Table 3: Assessment of Pollution indices in surface water

Sample Code	**HPI**	**HEI**	**Cd**
SS1	3869.928	103.0056	96.00583
SS2	6157.674	100.4356	93.4353
SS3	5394.945	102.2192	95.21933
SS4	507.0053	20.39265	13.39267
SS5	568.5303	25.9153	18.9154
Mini	507.0051	20.39265	13.39265
Max	6157.672	103.0056	96.00585
Mean	3308.961	67.90965	60.90964
Low	<100	<5	<1
Medium	100-150	5-20	1-3
High	>150	>20	>3

Table 3 clearly shows the values of computed HPI, HEI and CD, the HPI values indicated in the five samples gives >150 which buttress heavy metal pollution. Similarly the HEI values >20 also expresses high heavy metal evaluation index The Cd (degree of contamination) for the 5 samples are high (>3) which also indicates a high level of contamination in the samples, SW1 > SW3>SW2>SW5>SW4 respectively

From figure 2-8 is showing their various concentration of the analysed parameters such as shown below in figure 2, this also implies to figure 3-8 – but with their corresponding sample values for Pb, Cu, Cd, Fe, and Ni respectively

The concentration of Zinc (Figure 2) range from SW1 0.076mg/L to SW4 0.19mg/L when compared with WHO (2011)which is marked with green colouration, all the five (5) samples of the study area falls within the WHO permissible limit, Hence, the sampled waters surrounding Enerhen Community will not constitute environmental burden of Zinc at this concentration

The concentration of lead (Figure 3) in the study area shows values from SW2 0.002mg/L to SW5 0.144mg/L, when compared with the WHO (2011) stipulated value of 0.01mg/L, SW1, SW3 SW4 and SW5 were above the threshold. Lead is a poisonous heavy metal at higher concentration even some times at lower concentrations. Its inferred causative effects includes depletion of central nervous system of humans, diminishes the mental IQ of infant babies and other abnormal bio-accumulative tendencies in the human metabolic system

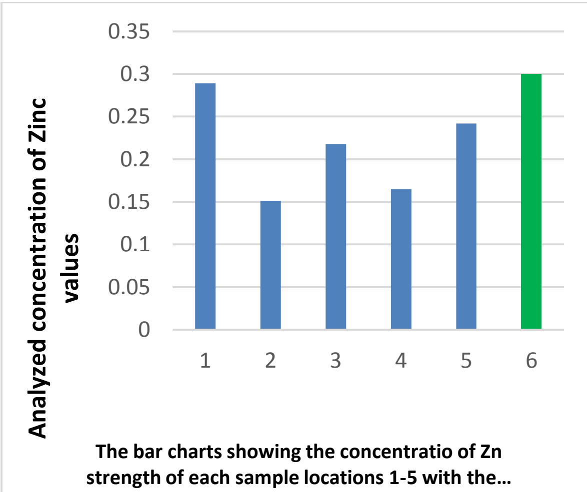

Fig 2: Concentration of Zn in surface water

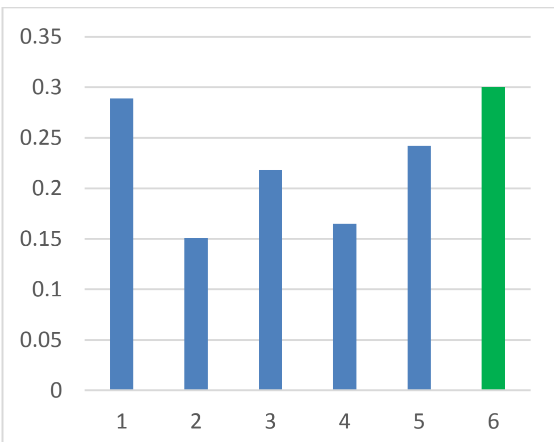

Fig 3: Concentration of Pb in surface water

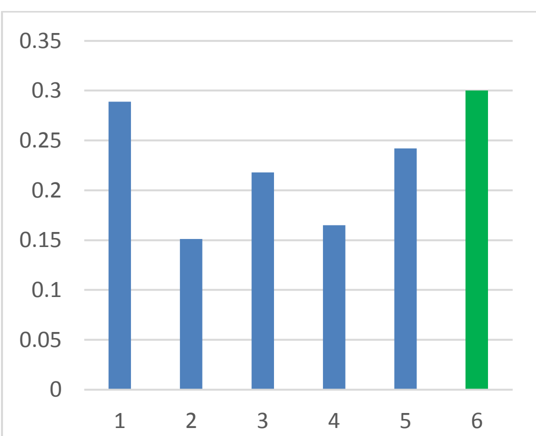

Fig 4: concentration of Cu in surface water

The analysed vales of copper (Figure 4) in the study area shows from SW2 0.091mg/L to SW4 0.276mg/L when compared with the permissible limit of WHO (2011) value of 2mg/L. All the analysed samples fall within the acceptable limit of the standard. Hence, copper concentration is considered normal and do not contribute any harmful effect to the environment at this concentration.

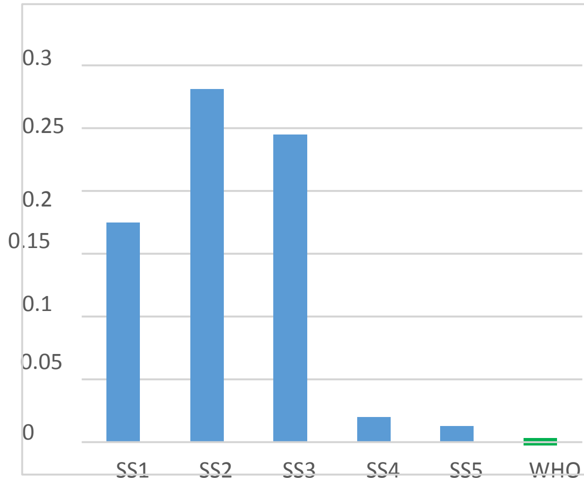

Fig 5: concentration of Cd in surface water

The values indicated from cadmium (Figure 5) at the study location range from SW5 0.013mg/L to SW2 0.281mg/L when compared with the limit of WHO (2011) of 0.003mg/L. Cadmium concentration was higher than the stipulated limits in all the sampled locations. Cadmium is a heavy metal in which it is dispersed to the environment anthropogenically via plastic wastes. The higher concentration of cadmium recorded in this study is from the dispersal of the wastes generated from the Enerhen central market. At higher concentrations cadmium causes numbness of the human bones and also induces weakness of human bones thus deteriorating to bone brittleness.

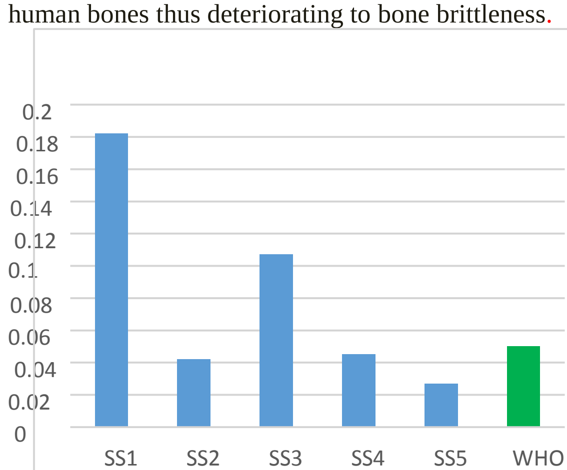

Fig 6: Concentration of Cr in surface water

The concentration of chromium Figure 6) range from SW5 0.027mg/L to SW1 0.182mg/L in the study locations when compared with the standard of WHO (2011) value of 0.05mg/L. SW1 and SW3 locations were above the threshold value. Hence, the surrounding water recorded higher concentration of chromium. At higher concentration chromium affects the gums of the human tooth and also alters the human metabolic system. The source of chromium to the human environment is through dispersal of hydrocarbon and gasoline. Consequently, the higher concentration of chromium is traceable to the frequent transportation of engines boats in this environment due to the commercial market. .

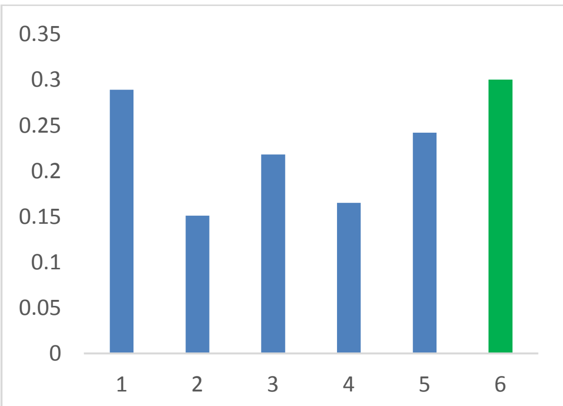

Fig 7: Concentration of Fe in surface water

The concentration of Iron (Figure 7) indicated from the study area shows from SW2 0.15mg/L to SW1 0.289mg/L when compared with the threshold value of 0.3mg/L. All the samples in the area were within the standard. Higher iron concentration does not contribute or degenerate toxic effects on humans rather it induces rusting and scales in boiler feeds, higher iron concentration also introduces bluish colouration which depict an offensive odour, eye irritation and dirtiness of the storage tanks.

.

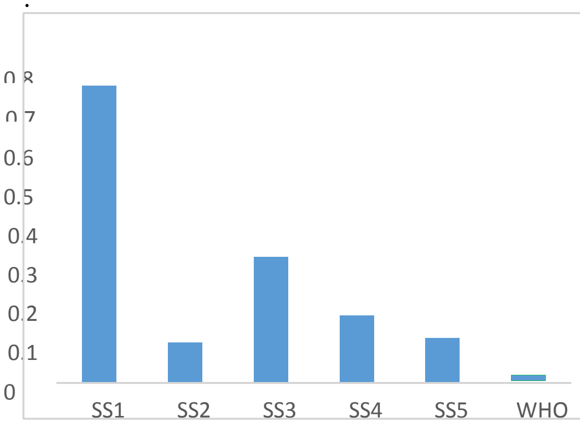

Fig 8: concentration of Ni in surface water

The concentration of Nickel (Figure 8) range from 0.115mg/L to 0.76mg/L when compared with the WHO (2011) value of 0.02mg/L, all the sampled locations were above the stipulated value of 0.02mg/L. The environment recorded higher concentration of Nickel. The accelerated values of Nickel is due to dispersal from the wastes generated from the activities of transportation of flying boats, engine boats etc in the river surrounding Enerhen. The anthropogenic source of Nickel to the environment is through waste released from hydrocarbon and this is linked to the commercial activities going on in the Enerhen and its environs.

Conclusion: The heavy metal concentration elaborates higher concentration of Cadmium, Nickel and Lead and two locations in chromium whereas, the other parameters were within the threshold of WHO (2011) standard.. The heavy metal evaluation index of the five samples highlighted values >20 which expresses as higher evaluation of heavy metals index. The degree of contamination for the five samples were above (>3). This also buttress a higher contamination level, SW1 > SW3>SW2>SW5>SW4. Recommendation is raise for environmental bodies to have assessment of the surroundings to ensure safety to adhere or avast threat. Hence, periodic regulation of the environment will be helpful for environmental sustainability.

Declaration of Conflict of Interest: The authors declare no conflict of interest

Data Availability Statement: Data are available upon request from the first author or corresponding author or any of the other authors

REFERENCES

Balkis, N. (Ed.). (2012). Water Pollution. BoD–Books on Demand, Eaton.

Burford, N; Eelman, MD; Groom, K. (2005). Identification of complexes containing glutathione with As (III), Sb (III), Cd (II), Hg (II), Tl (I), Pb (II) or Bi (III) by electrospray ionization mass spectrometry. *J. Inorg Biochem.* 99(10), 1992-1997

Burki, TK. (2012). Nigeria's lead poisoning crisis could leave a long legacy. *The Lancet.* 379(9818), 792

Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y; Zhang, L. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The lancet*, 395(10223), 507-513\\)

Chilton, J; Chilton, K. (1992). A critique of risk modeling and risk assessment of municipal landfills based on US Environmental Protection Agency techniques. *Waste Manage. Res.* 10(6), 505-516

De Flora, S., D'Agostini, F., Balansky, R., Micale, R., Baluce, B., & Izzotti, A. (2008). Lack of genotoxic effects in hematopoietic and gastrointestinal cells of mice receiving chromium (VI) with the drinking water. Mutation *Res. Rev. in Mut. Res.* 659(1-2), 60-67

Eaton, AD; Franson, MAH; Clesceri, LS; Rice, EW; Greenberg, AE. (2005). Standard methods for the examination of water & wastewater. In Standard methods for the examination of water & wastewater (pp. 1-v).

Edet, A. E., & Offiong, O. E. (2002). Evaluation of water quality pollution indices for heavy metal contamination monitoring. A study case from Akpabuyo-Odukpani area, Lower Cross River Basin (southeastern Nigeria). *Geo J.* l, 57, 295-304

Egereonu, U. U. (2003). Groundwater investigation of Orlu and Onitsha and their environs in eastern Nigeria to ascertain encrustation and corrosion characteristics. Jour. l of Assoc Adve Model and Simul Techn Enterprises, 64, 33-45

El-Masry, MH; El-Bestawy, E; El-Adl, NI. (2004). Bioremediation of vegetable oil and grease from polluted wastewater using a sand biofilm system. World Jour. l of Microbiology and Biotechnology, 20, 551-557

Fomina, M; Gadd, GM. (2014). Biosorption: current perspectives on concept, definition and application. Bioresource technology, 160, 3-14

Garbarino, JR; Hayes, H; Roth, D; Antweider, R; Brinton, TI; Taylor, H. (1995). Contaminants in the Mississippi river. US geological survey circular, 1133

Giri S, Singh AK. (2014) Risk assessment, statistical source identification and seasonal fluctuation of dissolved metals in the Subarnarekha River, India. *J. Hazardous Mat.* 265:305-314

Goolsby, DA; Battaglin, WA. (2001). Long-term changes in concentrations and flux of nitrogen in the Mississippi River Basin, USA. *Hydrological Processes.* 15(7), 1209-1226