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Assessmentof Haevy Metal Concentrationsin Waterand Sediments Of evbuarhue Riverin Ikpoba Okha Local Government Area Of Edo State,Nigeria.

Amodu O. A[*]., Imaji M[**] and Ichado A.S.P[**]

[*]Department of Mineral and Petroleum Resources Engineering, Kogi State Polytechnic, Lokoja Kogi State, Nigeria.

[**]Department of Science Laboratory Technology, Kogi State Polytechnic,
Lokoja, Kogi State, Nigeria.

Abstract: *This research work investigated the presence of heavy metal contamination in water and sediment of Evbuarhue River following the activities of agricultural and other minor industrial practices in the area. In this study, water and sediment samples were collected at three selected locations designated A, B and C. Two samples each were taken from each location at depths of 0 - 15cm and 15 – 30cm with the aids of pre-cleaned sterilized 1litre plastic bottle for water and a plastic hand towel for the sediment, and a GPS for geographic locations. The concentrations of 9 selected test parameters of Cu, Cr, Fe, Mg, Mn, Ni, Zn, Pb and Cd were determined by Aqua regia digestion and AAS method. The mean values and standard deviations of the various test parameters per location were obtained as follows; for water samples (Cu = 0.336±0.043, Cr = 0.030±0.009, Fe = 0.947±0.253, Mg = 0.570±0.119, Mn =0.082±0.019, Ni = 0.055±0.015, Zn = 0.471±0.082, Pb = 0.022±0.006 and Cd = 0.000±0.000) and for the sediment sample (Cu = 5.692±1.880, Cr = 1.706±0.750, Fe = 12.213± 0.658, Mg= 5.055±1.572, Mn = 3.605±0.778, Ni = 1.629±0.469, Zn=4.885±0.529, Pb=0.418±0.146 and Cd=0.080±0.015). The Mean values and standard deviation of temperature (27.7±0.23^{0}C) and pH (7.6±0.12) were within the of WHO/USEPA/EU guideline value for drinking water. The mean concentration values for heavy metals (Fe, Mn and Ni) were found to be a little above the WHO/FEPA limits while that of Cu, Mg, Zn and Cr, were little below the WHO/FEPA limits, Pb falls within the standard limit and Cd was not detected in the water sample but in sediment. However, the mean concentrations of Cu, Mg, Zn and Cr did not in any way indicate serious contamination treats since they were still below the WHO/FEPA limits for water consumption. The mean concentration values for the various test parameters in sediment samples were said to be above the WHO/FEPA guideline limits. The study revealed high concentrations of heavy metals in the sediment samples as compared to the water samples, because sediments are the major depository of metals. The findings are very useful as base line data especially for planners on water usage in the area. Activities of agricultural and industrial practices should be minimized or reduced drastically to avoid polluting the soil in the area.*

Keywords: Analysis, Concentration, Consumption, Parameter, Pollution, Sediments, Water.

1.0 INTRODUCTION

Water pollution occurs when a body of water is adversely affected due to addition of large amounts of materials to the water therefore, making unfit for intended purpose. Such water is considered polluted. Two forms of water pollution exist; point source and nonpoint source. Point sources of pollution water occur when harmful substances are emitted directly into a body of water. This includes effluent sewage treatment works or of waste from factory. While nonpoint source delivers pollution indirectly through environmental changes, for instance fertilizer and herbicide application is carried into the streams by rain in form of run-off which in turn affects aquatic life. Technology exist for point sources of pollution to be monitored and regulated although political factors may complicate matters. Nonpoint sources are much more difficult to control. Pollution arising from nonpoint sources account for majority of contaminants in streams and lakes.

However, by the definition given above almost everything produced by man can be considered as a potential pollutant. These can be toxic or non-toxic pollutants. Some of these may be acid or alkali, anions (e.gsulphides, cyanides, sulphites), detergents, domestic sewage and farm manures, food processing wastes, gases (e.g chlorine, ammonia), heat, metals, plant nutrients (phosphates and nitrates), organic toxic wastes (e.g formaldehyde and phenols), pathogens, pesticides, polychlorinated biphenyls, radionuclide and organic pollutants (Torrans and Clemens, 1982).

These sources of water supply are susceptible to pollution due to heavy human dependency on these river waters. Notably there is indiscriminate dumping of waste and agricultural practices taking place in area. Waste disposal in the area is through open dump for solid wastes, pit latrines, septic tank for human wastes. Liquid wastes are admitted through the major drainage networks and emptied into the river Evbuarhue. Hence, the need to monitor the pollution level of the river water body in this area.

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Pollution of streams and rivers flowing through agricultural areas where pesticides, fungicides and herbicides might have been applied and industrial districts where there may have been organic and inorganic waste deposits, all these present varied and difficult problems due to drainage into different water bodies. Effluents discharged into a river, which may affect aquatic life, may do so either directly or indirectly (Ademoroti, 1996). However, it must be mentioned that some heavy metals are naturally present in some natural water sources. Some of them are essential for health of living organisms, but when their concentrations are very high, beyond acceptable limits, they become toxic.

Among environmental pollutants, metals are of most concerned, due to their potential toxic effects and ability to bio accumulate in aquatic ecosystem (Ozturk et al, 2009). Unlike many organic contaminants that lose toxicity with biodegradation, metals cannot be degraded further and their toxic effects can be long lasting, more so, their concentration can be increased via bioaccumulation. Heavy metals are known to have deleterious effects at low concentrations; for instance, lead (Pb) (Akporhonor et al, 2007). Heavy metal in aquatic ecosystem are usually monitored by measuring their concentrations in water sediments and biota. The generally exist in low levels in water and high in sediments and biota. Heavy metals including both essential and non-essential elements have a particular significance in ecotoxicology since they are highly persistent and all have the potential to be toxic to living organisms (Akporhonor et al, 2007). The mercury group is generally toxic at low levels which include lead, cadmium, plutonium, and others. Some marine algae may contain heavy metals at concentrations of up to 100 times that of water in which they are living. In most natural settings, heavy metal accumulations in organisms are not very serious because the natural concentrations of these metals are low in waters and soils to begin with the problems developed when human activities locally upset the natural cycle. These essential metals can also produce toxic effect when the metal intake is excessively elevated (Ozturk et al, 2009). In Nigeria, the growing rate of industrialization is gradually leading to contamination and deterioration of the environment. Thus, industrialization and heavy metal pollution are positively correlated (Oboh et al, 2007). The wide spread contamination of surface water by heavy metals is of increasing concern to scientists. The contamination of various elements in the air water and land may be increased beyond their natural levels due to agricultural, domestic and industrial effluents. When the effluent substances discharged in the environment are very little or in minute or low concentration, which are not toxic to both plants and animals and also have short residence time in the environment, they are described as “contamination” (Oboh et al, 2007). Studies have showed that many water bodies in Nigeria contains various levels of heavy metals pollutants (Kakulu et al, 1987). The major source of heavy metal pollution to Evbuarhue river are likely agricultural and are being washed away by rain along with heavy metals from weathered rocks. The industrial effluents from factories in Edo state are believed to be one of the major sources of heavy metal pollution to Evbuarhue River.

; Ogugbuaja and Kinjir (2001) in their studies of some portions of river Benue and Gongola found that rivers Benue/Gongola confluence shows high concentration levels for some of the trace metals due mainly to increased river load deposition. High human activities at the abattoir rear the shores of river Benue probably led to an increase organic indicator levels obtained with a high negative COD/DO correlation coefficient (r – 0.98) was recorded. Low mineralization ratio (range 0.007 to 0.043) was attributable to sourcing of determined metals from a poorly mineralized area.

Musa, et al (2004) in their study of lead concentration in well and borehole water in Zaria, found out that the Pb concentration ranged from 0.00786 to 0.0595mg/l with 91% of the samples above the 0.01mg/l WHO drinking water guideline level.

Studies has shown that water bodies in Nigeria contain various levels of heavy metal pollutants. (Akporhonor et al, 2007) in their studies on heavy metals in rivers, lakes, fish and sediments have proven that sediments are contributor of various pollutants like pesticides and heavy metals and also play major role in the remobilization of contaminants in aquatic systems under favorable conditions and interactions between water and sediments (Ozturk et al, 2009).

2.1 GEOLOGY OF THE AREA

The study area is within the Benin Region which is underlain by sedimentary formation of the south sedimentary basin known as Niger Delta Basin. This basin has three main lithostratigraphic units within the subsurface, they are the Akata formation which is the oldest, followed by Agbada formation and Benin formation which is the youngest of the three formation. The geology of the area is generally characterized or marked by top reddish earth, composed of ferroginized or literalized clay sand. It consists of over 90% sandstone with shale intercalations. The formation was further established by well logging of Etete 1, well drilled on shore east of River Niger by Shell Nigeria February 23, 2016.

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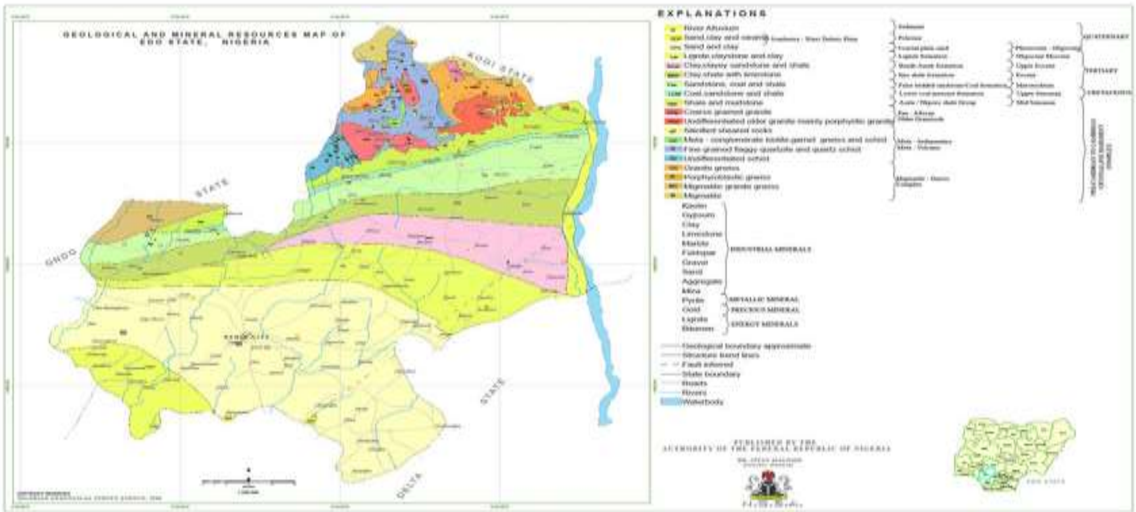

Figure 1: geological and Mineral Resources Map of Edo State. (source: Google map)

2.2 HYDROGEOLOGY OF THE AREA

The study area lies within the Tropical rain forest and has two distinct seasons (wet, April to October, and dry, November to March). The study area lies within the Benin formation which extends from the west across the whole of the Niger delta areas and southward beyond the present coastline. The aquifer found within the study area developed within the boundaries of the deposit and in areas adjoining it, is fissures; water filled pores and fractures in the weathered crust as well as the fractures in un-weathered crystalline rocks. In the crust of weathering, the rocks have been weathered to various degrees and sometimes into sand and clay. The depth of weathering is between 9m – 54m. The weathering of rocks makes it very possible for atmospheric precipitation to infiltrate into the rocks.
Depth of water table at the study area varies from 3.4m to 64.3m depending on the elevation of ground surface at the point of measurement.

2.3 RIVER EVBUARHUE

The study area is located within latitude $5^0 213^1 67^{11}$ N to $5^0 211^1 69^{11}$ N and longitude $4^0 52^1 13^{11}$ E to $4^0 54^1 20^{11}$ E and covers an area of about 205km^2. The Evbuarhue River constitutes the major drainage system in the area. It has an elevation of 186m above the mean sea level.
River Evbuarhue is the principal tributary of the Ikpoba River. The major economic activities in this area is agriculture, this includes fishing and crops such as groundnuts, maize, cassava, plantain and palm tree cultivations. There also some quarry activities around the area.
This source of water supply is susceptible to pollution due to heavy human dependency on these river water. Notably here is indiscriminate dumping of waste and agricultural practices taking place in the area. Waste disposal in the area is through open dump for solid waste, pit latrines, septic tank for human wastes. Liquid wastes are admitted through the major drainage networks and emptied into the river Evbuarhue. Hence, the necessity of monitoring the pollution level of the river water bodies in this area.

3.0 MATERIALS AND METHODS:

The assessment of surface water and aqueous sediment samples in river Evbuarhue in IkpobaOkha local government of Edo state is the focus of this research. It is meant to assess and evaluate the water environment. This is aimed at ascertaining the quality, quantity and the causes of physical and chemical pollutions in the water bodies and their effects on human, animal and aquatic organisms.

3.1 MATERIALS:

The materials used for the purpose of this analysis are; one-liter plastic bottles, global positioning system (GPS), thermometer, pH meter, ice box, sterilized polythene bags, concentrated HNO_3, aqua-regia (3ml of conc. HNO_3 + 9ml of conc. HCl, i.e. ratio 1:3) filter paper, 25ml standard flask, deionized distilled water, pestle and mortar, Atomic Absorption Spectrophotometer (unicam 969) and DR/2010 spectrophotometer.

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3.2 METHOD

3.2.1 WATER SAMPLE COLLECTION AND TREATMENT:

Samples which are representatives of the water bodies were collected and examined. Two surface water samples were collected from three different sampling points or locations along the river Evbuarhue and the sampling points are approximately 100m away from each other. This was done by lowering pre-cleaned 1L plastic bottles into the bottom of the water body at a depth 0 - 15cm and 15 – 30cm and allowed to over flow before withdrawing. A total of six samples were analyzed. The physico-chemical parameters determined insitu at the collection points includes temperature, pH elevation and location. For analysis of heavy metals, acidification with 10ml of concentrated HNO_3 was done because this tends to keep the required species of cations in solution and slow down or stop biological changes. The samples were placed in an ice box at 4^0C and then transported to the laboratory for analysis.

3.2.2: STORAGE AND PRESERVATION

Since changes occur frequently in water samples, analysis was done immediately after collection. Where analysis could not commence immediately, samples were stored at 4^0C or relevant preservatives were added depending on the parameter to be determined and duration of the preservation as described by APHA (1985).

3.2.3: SEDIMENT SAMPLES COLLECTION AND TREATMENT:

The aquatic sediments were collected by scooping with sterilized plastic hand trowel at a depth of 0 – 15cm and 15 – 30cm and these were immediately put in sterilized polythene bags, closed and labeled accordingly. They were immediately taken to the laboratory, air-dried, and were powdered using pestle and mortar to produce a homogenate sample and passed through 160Nm sieve and stored at 40^0C in an oven, prior to analysis.

3.2.4 ANALYSIS OF WATER SAMPLES:

The water samples were transported in an ice box at 4^0C to Benin-Owena River Basin/University of Benin Joint Analytical Research Laboratory in Ugbowo Campus University of Benin Edo State for analysis. Atomic Absorption Spectrophotometer (unicam 969) was used in the determinations of heavy metals (Cu, Cr, Fe, Mn, Ni, Zn, Pb, and Cd) and Mg using DR/2010 spectrophotometer.

3.2.5 DIGESTION OF SEDIMENT SAMPLES:

The digestion of sediment samples was done by dissolving one gramme of the dried powdered sediment samples in a clean 100ml beaker. This was followed by the addition of 20ml concentrated HCl in small portions, 5ml of concentrated HNO_3 and 2ml of HF. The mixture was covered with watch glasses and heated to near boiling for one hour. It was filtered hot using a whatman No 42 filter paper and made up to mark with distilled water in 100ml volumetric flask and stored for further chemical analysis.

4.0 RESULTS AND DISCUSSION

4.1 RESULTS:

The results of physico – chemical analysis of the sampled Evbuarhue River and sediments are presented in tables 1 to 9 respectively in the order of their locations. Table 10 shows the World Health Organization (WHO) / Fepa guideline values.

Table 1: Temperature and pH measured insitu in Evbuarhue River at the sampling sites.

SAMPLING POINTS	TEMPERATURE (^{0}C)	pH
LOCATION A	28.0	7.7
LOCATION B	27.6	7.5
LOCATION C	27.6	7.5
MEAN	27.7	7.6
STD	0.23	0.12

Note: STD = Standard Deviation

The temperature in location A (28^0C) varies slightly with that of locations B and C (27.6^0C) respectively. In similar manner the pH in location A (7.7) also varies with that locations B and C (7.5) respectively.

Table 2.0: WHO, EU and USEPA limit for Ph

	WHO	EU	USEPA
pH	6.5 – 9.5	6.5 – 8.5	6.5 – 8.5

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Table 3.0: The total Mean values of Heavy metal concentration of Evbuarhue River in Locations A, B and C respectively.

SAMPLES	Cu	Cr	Fe	Mg	Mn	Ni	Zn	Pb	0.000
Location A, Mean Values	0.368	0.023	1.234	0.589	0.090	0.042	0.440	0.022	0.000
Location B, Mean Values	0.288	0.040	0.854	0.443	0.061	0.071	0.564	0.016	0.000
Location C, Mean Values	0.353	0.026	0.754	0.679	0.096	0.052	0.410	0.028	0.000
Mean Values	0.336	0.030	0.947	0.570	0.082	0.055	0.471	0.022	0.000
Standard Deviation	0.043	0.009	0.253	0.119	0.019	0.015	0.082	0.006	0.000

Table 4.0: The total Mean values of Heavy metal concentration of Evbuarhue Sediment in Locations A, B and C respectively.

SAMPLES	Cu	Cr	Fe	Mg	Mn	Ni	Zn	Pb	Cd
Location A, Mean Values	7.463	1.475	12.970	4.288	2.717	1.632	4.647	0.534	0.095
Location B, Mean Values	3.719	2.544	11.776	4.013	3.930	2.096	5.492	0.468	0.080
Location C, Mean Values	5.894	1.099	11.894	6.863	4.168	1.159	4.517	0.254	0.065
Mean Values	5.692	1.706	12.213	5.055	3.605	1.629	4.885	0.418	0.080
Standard Deviation	1.880	0.750	0.658	1.572	0.778	0.469	0.529	0.146	0.015

Table 5.0: Mean Concentration and Standard Deviation of Heavy Metal in Evbuarhue River and Sediment.

	WATER	SEDIMENT
Heavy Metals	Mean (±STD)	Mean (±STD)
Cu	0.336 ± 0.043	5.692 ± 1.880
Cr	0.030 ± 0.009	1.706 ± 0.750
Fe	0.947 ± 0.253	12.213 ± 0.658
Mg	0.570 ± 0,119	5.055 ± 1.572
Mn	0.082 ± 0.019	3.605 ± 0.778
Ni	0.055 ± 0.015	1.629 ± 0.469
Zn	0.471 ± 0.082	4.885 ± 0.529
Pb	0.022 ± 0.006	0.418 ± 0.146
Cd	± 0.0	0.080 ± 0.015

Table 6.0: WHO/FEPA Guideline Values

	WATER	SEDIMENT
Heavy metals	Maximum limit (WHO/FEPA) mg/l	Maximum limit (WHO/FEPA) mg/l
Cu	1.00	0.025
Cr	0.05	_
Fe	0.30	0.0
Mg	20-50	_
Mn	0.05	_
Ni	0.02	-
Zn	3,00-5.00	0.0123
Pb	0.01 – 0.1	0.04
Cd	0.003	0.006

4.2: DATA ANALYSIS:

The results were presented as mean ± SD. Analysis of variance (ANOVA) with bar chart were used for the statistical analysis of results obtained at 96% confidence level using Microsoft Excel 2013 package.

4.3: Determination of Heavy Metals:

Heavy metals or trace elements also includes those elements that occur at very low levels of few parts per million in a given system. They are among the most harmful of the elemental pollutants. Some of them like Pb, Sn, Hg, Zn and Cu can be very toxic to the system (Bhatia, 2006). Heavy metals include essential elements like iron as well as toxic metals like Cd and Hg. Most of them have strong affinity for sulphur and disrupt enzyme function by forming bonds with sulphur groups in enzyme. Heavy metals are highly persistent and can easily enter a food chain and accumulate until the reach toxic levels. These may eventually kill fishes, birds and mammals (USEPA, 1999). Water sediments and biota are generally metal reservoirs in aquatic environment. Researches has shown that nearly all metal content in aquatic environment reside in water sediments (Ademoroti, 1996). Bower, (1979) found that sediments are the major depository of metals, in some cases holding up to 99% of the total amount of metals present in the system. The concentration of harmful and toxic substances is of many orders of magnitude higher in water sediments and biological tissues than in water itself. These concentrations may vary considerably depending on annual seasonal fluctuation

4.4 DISCUSSION:

Some of the factors controlling the chemistry and quality of groundwater includes, the geological environment in which the water passes through, the rate of groundwater flow, the source of the groundwater and anthropogenic activities.

The physic-chemical and biological parameters of water determine the quality of every water. Surface water temperature is one of the common factors that affects the aquatic environments. Firstly, temperature affects nearly all other water parameters and secondly aquatic organisms are adapted to certain temperature range (Prosil, 1989). It exerts an important effect on metal specification because most chemical reaction rates are highly sensitive to temperature change. This metal specification (dissolved or particulate) could be well determined by the temperature regime at a particular season. The means of the in-situ temperature of water sample during the course of this study is found to be 27.7 ± 0.23^0C. pH also has impact on solubility hence specification and bioavailability of metals in natural water. The lower the pH, the higher the solubility of heavy metals and thus increase in metal bioavailability (Waite and Moral, 1984). This research shows that Evbuarhue River is non-acidic with the mean value of 7.6 ± 0.12 see table 1.0 above. Both the temperature and pH values of Evbuarhue River fall within the range of WHO, EU and USEPA guideline values for drinking water see table 2.0 above.

4.5 HEAVY METAL CONCENTRATION IN WATER:

The concentration of heavy metals in Evbuarhue River is given in table 3.0 above. The concentrations were seen to be decreasing in this order: Fe > Mg > Zn > Cu > Mn > Ni > Cr > Pb > Cd. Similarly figure 4 is the bar chart of the mean concentration of metals in water in Evbuarhue River. In water, iron (Fe) have higher concentration which ranged between 1.234, 0.854 and 0.754 mg/l for locations A, B and C respectively with overall mean value concentration of 0.947mg/l compared to other trace metals. The WHO recommendation for iron content in drinking water should not be greater than 0.3mg/l, because iron in water stains plumbing fixtures, stains cloths during laundering, incrusts well screens and clogs pipes. The other metals have the following concentrations, Mg ranged between 0.589, 0.443 and 0.679mg/l for locations A, B and C with the overall mean concentration of 0.570mg/l, WHO allowable limit of 20 – 50mg/l for domestic consumption. The low level could be due to the absence of mineral related magnesium ions in the area. Zn ranged between 0.440, 0.564 and 0.410mg/l for locations A, B and C with the overall mean concentration of 0.471mg/l, water containing zinc at concentrations in excess of 3 – 5mg/l may appear opalescent and develop a greasy film on boiling. Although, drinking water seldom contains zinc at concentration of above 0.1mg/l. Cu ranged between 0.368, 0.288 and 0.353mg/l for locations A, B and C with the overall mean value concentration of 0.336mg/l, Copper in drinking water may increase the corrosion of galvanized iron and steel fittings. Staining of laundry and sanitary wares occurs at copper concentrations above 1mg/l. at levels above 1.5mg/l, copper also impact a colour and an undesirable bitter taste to water. Mn ranged between 0.090, 0.061 and 0.096mg/l for locations A, B and C with the overall mean concentration of 0.082mg/l. The presence of manganese in drinking water may leads to accumulation of deposits in distribution system. Concentration below 0.1mg/l, preferably 0.05mg/l are usually acceptable to consumers. Even at a concentration of 0.2mg/l manganese will often form a coating on pipes, which may slough off as a black precipitate. Ni ranged between 0.042, 0.071 and 0.052mg/l for locations A, B and C with the overall mean concentration of 0.055mg/l, Cr ranged between 0.023, 0.040 and 0.026mg/l for locations A, B and C with the overall mean value of 0.030mg/l, this values fall within the WHO recommendation for chromium in drinking water of 0.05mg/l. Excess of chromium causes lung cancer. Pb ranged between 0.022, 0.016 and 0.028mg/l for locations A, B and C with the overall mean concentration of 0.022mg/l. However, cadmium (Cd) was totally absent in sampled water.

The water chemistry of the system controls the rate of absorption and desorption of metals to and from sediment. Absorption removes the metals from the water and stores them in the sediment and suspended solids. Desorption returns the metals to the water column, where recirculation and bio assimilation may take place. Metals may be desorbed from sediment and suspended solid if the water experiences increase in salinity decrease in redox potential, or decrease in pH. Decrease in pH may also dissolve metals-carbonate complexes, releasing metal ions into the water column (Osmond et al, 1995). From the research study, it was observed that the value of heavy metals for water was higher than the recommended values by WHO and FEPA for Fe, Mn and Ni but was found to be lower for Cu, Mg, Zn, and Cr. However, Pb is within the permissible level and Cd was not detected at all. Based on the above analysis, Evbuarhue River could say to be unfit for human consumption but does not pose any threat to both aquatic and human lives when consumed all the parameters were not far above and below the WHO standard for water consumption. Figure 5 below is the bar chart showing the mean concentration of heavy metals in water of Evbuarhue River in mg/l.

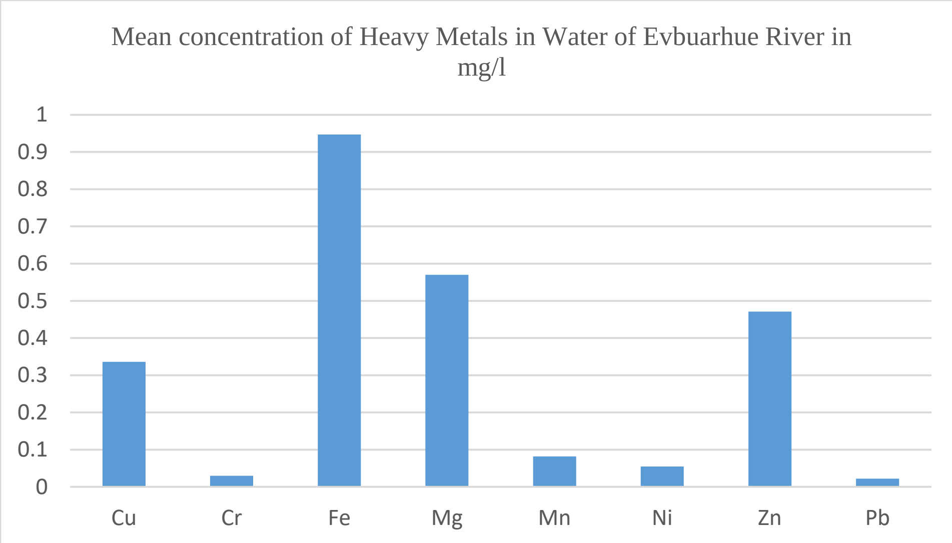

Figure 5: Mean concentration of heavy metals in water of Evbuarhue River.

4.6 HEAVY METAL CONCENTRATION IN SEDIMENT

The total heavy metal concentration in sediment sample is shown in table 4.0 above. The concentrations were seen to be decreasing in this order: Fe > Cu > Mg > Zn > Mn > Cr > Ni > Pb > Cd. Similarly figure 5 is the bar chart of the mean concentration of metals in sediment of Evbuarhue River. In sediment, iron (Fe) have higher concentration which ranged between 12.970, 11.776 and 11.894mg/l for mean locations A, B and C respectively with overall mean value concentration of 12.213mg/l compared to other trace metals. The other metals have the following concentrations, Cu ranged between 7.463, 3.719 and 5.894mg/l for mean locations A, B and C with the overall mean concentration of 5.692mg/l, Mg ranged between 4.288, 4.013 and 6.863mg/l for mean locations A, B and C with the overall mean concentration of 5.055mg/l, Zn ranged between 4.647, 5.492 and 4.517mg/l for mean locations A, B and C with the overall mean value concentration of 4,885mg/l, Mn ranged between 2,717, 3.930 and 4.168mg/l for mean locations A, B and C with the overall mean concentration of 3.605mg/l, Cr ranged between 1.475, 2.544 and 1.099mg/l for mean locations A, B and C with the overall mean concentration of 1.706mg/l, Ni ranged between 1.632, 2.096 and 1.159mg/l for mean locations A, B and C with the overall mean value of 1.629mg/l, Pb ranged between 0.534, 0.468 and 0.254mg/l for mean locations A, B and C with the overall mean concentration of 0.418mg/l and cadmium (Cd) was found to be present in the river sediment and ranged between 0.095, 0.080 and 0.065mg/l for mean locations A, B and C respectively with the overall mean value of 0.080mg/l.
The research shows that values of heavy metals for sediment samples were found to be higher than that of water and the recommended values by WHO and FEPA (see table 6.0). This is because sediment is said to be the major depository of metals.

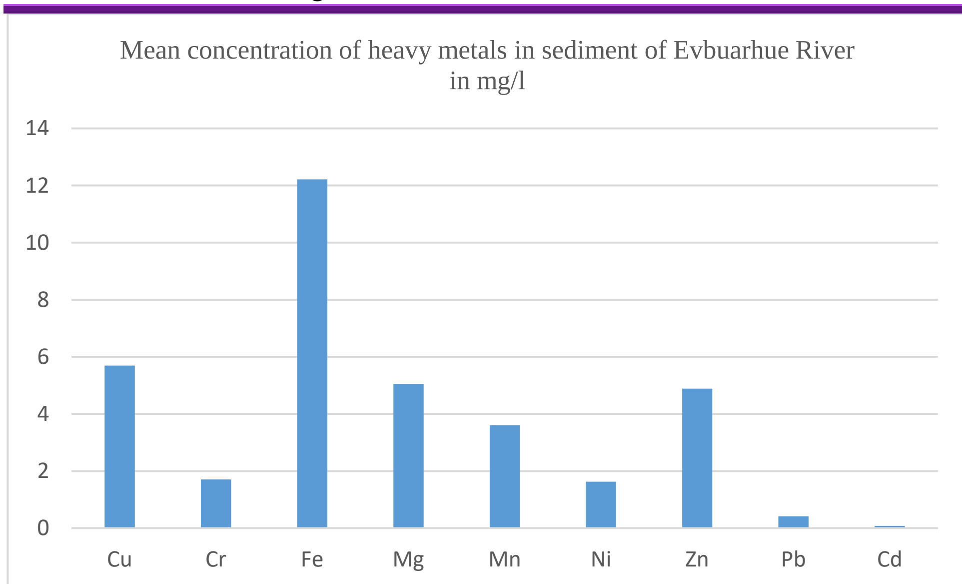

Figure 6: Mean concentration of heavy metals in sediment of Evbuarhue River.

5.1 CONCLUTION:

Water quality parameter in the river and sediment of Evbuarhue River were assessed to evaluate the level of heavy metal concentrations in the river water and its sediment. This study shows the baseline values of temperature and pH of Evbuarhue River water and both are within the range of recommended limit of EU, WHO and USEPA (see table 2.0). The pH shows that the river water was alkaline and has no effect on the availability of dissolved heavy metals in water they were all detected in all the sampled sites. Generally, the heavy metal concentration was high in the sediment than in water samples of Evbuarhue River. From the results, in the sampled water, only Pb falls within the acceptable limit of the WHO (2006). Fe, Mn and Ni were found to be little above the acceptable limit and Cu, Mg, Zn and Cr were also found to be little below the acceptable limit of the WHO (2006) and Cd not detected. The concentration of heavy metals in water samples were seen to be in this decreasing order: Fe > Mg > Zn > Cu > Mn > Ni > Cr > Pb All the test parameters for heavy metal concentrations were detected in the sediment samples, the values fall above the acceptable limit of the WHO (2006) and were said to be in this decreasing order: Fe > Cu > Mg > Zn > Mn > Cr > Ni > Pb > Cd. The heavy metal concentrations in the sediment samples were higher compared to those of the water samples. This is because water sediments are metal reservoirs. Research has revealed that nearly all metal content in aquatic environment reside in water sediments (Ademoroti, 1996).

5.2 RECOMMENDATIONS:

In view of the above findings, the following recommendations were made to help curtail or minimize the discharge of heavy metal concentrations into Evbuarhue River. Parameters such as temperature and pH should be regularly monitored to ensure the sustainable use of Evbuarhue River for domestic and other purposes. Since agricultural practices are said to be the potential source of these heavy metals to the river, chemical applications such as fertilizer, pesticides, herbicides etc. should be reduced drastically to avoid infiltration into the sediments and river water, since the river serves as an aquifer recharge within the adjoined environs.
Solid waste handling, controlling and monitoring technique in the area must be geared towards achieving quality environmental condition for man to live in. this will go a long way to protecting natural resources such as water that are degraded by these solid wastes. From this framework, it is possible to articulate a position on thorough environmental management procedure to protect the river in the area.
Solid waste should be recycled instead of dumping them by the river side. Ministry of Environment and Waste Management Board should be properly reorganized. There is need for environmental awareness through enlightening campaigns to know the side effects of refuse dumps by or in rivers before it is consumed, the principal resources management should be adopted and applied at all times. People should be forced to use waste bins and other facilities provided by waste managers for proper disposing of their wastes.

Industrial activities in the area should be properly regulated to avoid unnecessary emission of poisonous gaseous substance into the air and land which in turn pollutes these natural resources thereby making them unfit for the inhabitants of the area.

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