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Evaluation of concentrations and contamination factors of potentially toxic elements in sediments of Egi communities, Rivers State, Nigeria

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Abstract

Potential toxic elements in sediments and water are harmful to humans and other organisms even at low concentration. Therefore, the objective of this paper was employed to evaluate the concentrations and contamination factors of potential toxic elements (PTE) in sediments of selected areas in Egi communities (Obagi, Oboburu and Ogbogu) in Ogba/Egbema/Ndoni LGA of Rivers State, Nigeria using AAS (GBC XplorAA) after mixed-acid wet digestion of the sediment. The result of the levels of PTEs reveals that the highest mean were iron (6983±123 mg/Kg), manganese (19.42±6.87 mg/Kg), zinc (11.73±2.10 mg/Kg) copper (7.057±1.08 mg/Kg), and lead (5.871±2.76 mg/Kg). The result also showed that the most toxic metals had values as follows: cadmium: Obagi (1.244±0.01 mg/Kg), Oboburu (0.411±0.01 mg/Kg) and (0.051±0.01 mg/Kg); arsenic; Ogbogu (2.481±0.31 mg/Kg), Obagi (1.452±0.02 mg/Kg), and Oboburu (0.991±0.02 mg/Kg), copper Oboburu (5.333±0.010 mg/Kg), Obagi (6.800±0.07 mg/Kg), and Ogbogu (9.037±0.12 mg/Kg). The geo-accumulation (*I*geo) values indicated uncontaminated for all the PTEs. The contamination factor shows that all samples had low contamination. The enrichment factor for Obagi; Pb (1.011), As (0.675), Cr (0.467), Cu (1.052), Zn (0.650), Ni (0.493), and Co (0.767) were of biogenic, while Cd (45.42) was of anthropogenic origin. For Oboburu; biogenic origin were As (0.321), Cr (0.188), Mn (0.003), Cu (0.574), Zn (0.709), Ni (0.313), and Co (0.454) while Pb (2.100), Cd (5.756) were of anthropogenic origin. Ogbogu; Cr (0.845) and Mn (0.807) were of biogenic while Pb (5.079), Cd (4.241), As (4.770), Cu (5.780), Zn (2.339), Ni (2.135) and Co (5.586) were of anthropogenic sources. The order of toxicity was Fe>Mn>Zn>Cu>Cr>Pb>Ni>Co>Cd>As>Hg. The order of impact were Ogbogu>Obagi>Oboburu.

Keywords: Potentially Toxic Elements; Sediment contamination; Enrichment factor; Heavy metals

1. Introduction

Heavy metals (PTEs) are conventionally defined as elements with metallic properties and an atomic number >20. The most common heavy metal contaminants are Cd, Cr, Cu, Hg, Pb, and Zn. Metals are natural components in soil (Lasat *et al*., 2000, Horsfall *et al.,* 1994, Horsfall and Spiff 2002). Some of these metals are micronutrients necessary for plant growth, such as Zn, Cu, Mn, Ni, and Co, while others have unknown biological function, such as Cd, Pb, and Hg (Gaur and Adholeya, 2004). Metal pollution has harmful effect on biological systems and does not undergo biodegradation (Owhoeke *et al.,* 2023). Toxic heavy metals such as Pb, Co, Cd can be differentiated from other pollutants, since they cannot be biodegraded but can be accumulated in living organisms, thus causing various diseases and disorders even in relatively lower concentrations (Pang *et al*., 2015). Heavy metals, with soil residence times of thousands of years, pose numerous health dangers to higher organisms. They are also known to have effect on plant growth, ground cover and have a negative impact on soil microflora (Pan and Wang, 2012). It is well known that heavy metals cannot be chemically degraded and need to be physically removed or be transformed into nontoxic compounds (El-Sorogy *et al* 2016).

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Major indicators of pollution in aquatic environments are contaminated sediments that can be defined as soils, sand, organic matter, or minerals accumulated at the bottom of a water body (USEPA, 1998). Under certain conditions, contaminants found in sediments can be released to waters and thus, sediments can be important sources of the contaminants in waters. Metals have the potential to be toxic to living organisms if present at availability above a threshold level. This threshold varies between taxa and metal speciation. Most urban and industrial runoff contains a component of trace and heavy metals in the dissolved or particulate form.

Contamination caused by trace metals affects the ocean waters, the continental shelf and the coastal zone, where besides having a longer residence time; metal concentrations are higher due to the input and transport by river runoff and the proximity of industrial and urban zones. The impact of anthropogenic perturbation is most strongly felt by estuarine and coastal environments adjacent to urban areas (Howard *et al.,* 2006 and Horsfall and Spiff, 2005).

Heavy metals from incoming tidal water and fresh water sources are rapidly removed from the water body and are deposited onto the sediments. Since heavy metals cannot be degraded biologically, they are transferred and concentrated into plant tissues from soils and pose long-term damaging effects on plants. Nevertheless, different plants react differently to wastewater irrigation; some are more resistant to heavy metals. The ability of mangrove plants to tolerate heavy metals in wastewater is not clear and the impact of wastewater on plant growth must be understood before the system can be employed for removing heavy metal from wastewater. Heavy metals that accumulate in soils not only exert deleterious effects on plant growth, but also affect the soil microbial communities and soil fertility (Spiff and Horsfall, 2004). The potential hazard to the marine environment of pollutants depends mostly on their concentration and persistence. Persistence pollutants, such as heavy metals, can remain in the environment unchanged for years and thus may pose a threat to man and other organisms. The pollution levels and wide distribution reported here suggest that heavy metals must be considered a serious regional threat. Inadequate or no sewage treatment, increasing waste from industrial and particularly agricultural activities, oil spill and soil erosion are just a few of the chronic problems that Central American countries have faced over the last two decades.

All the problems associated with heavy metal pollution will increase considerably in the years to come if measures for control and management are not created. Metal accumulation in agricultural soils together with associated natural metal erosion will remain a chronic pollution problem in the future. A major regional problem is associated with deforestation, increasing soil erosion from agricultural activities, consequent run-off of both natural and anthropogenic metals and long-distance transport of pollutants from industrial areas. Therefore, the problem extends beyond any local or national borders and must be managed at regional levels (Horsfall *et al*., 2005)

Marine sediments constitute part of the contaminants in aquatic environments. The bottom sediment serves as a reservoir for heavy metals, and therefore, deserves special consideration in the planning and design of aquatic pollution research studies. Heavy metals such as cadmium, mercury, lead, copper, and zinc, are regarded as serious marine pollutants because of their toxicity, tendency to be incorporated into food chains, and ability to remain in an environment for a long time (Iwuoha *et al*., 2012).

Sediments are known to act as the main sink for heavy metals in coastal ecosystems that are impacted by anthropogenic activities. The concentration of heavy metals in sediments can be influenced by variation in their texture, composition, reduction/oxidation reactions, adsorption/desorption, and physical transport or sorting in addition to anthropogenic input. Potentially, toxic compounds, especially heavy metals, are adsorbed on mineral or organic particles either in their organic or inorganic forms. Studies on the distribution of trace metals in sediments and other media are of great importance in the context of environmental pollution.

Sediments of rivers, lakes and estuaries in a large number of locations have been contaminated by inorganic and organic materials. Among the inorganic materials metals are frequent and important contaminants in aquatic sediments. They are involved in a number of reactions in the system including sorption and precipitation, and they are greatly influenced by redox conditions in the sediments. Heavy metals are transported as either dissolved species in water or an integral part of suspended solids. They may be volatilized to the atmosphere or stored in riverbed sediments. They can remain in solution or suspension and precipitate on the bottom or can be taken up by organisms. Several studies on potential toxic metals in sediments are available in some of the areas in the Niger Delta region. They include Iwuoha *et al*., 2012; Osakwe *et al*., 2014a Osakwe *et al*., 2014b; Leizou *et al*., 2015 and Horsfall and Spiff, 2005, however, information on potential toxic metals in Sediments of Egi Communities, Ahoada are rare. Hence, the objective of this paper employed the use of concentrations and concentration factors to evaluate potential toxic elements (PTE) in sediments of selected areas in Egi communities (Obagi, Oboburu and Ogbogu) in Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria.

2. Materials and Methods

2.1. Description of the Area of Study

Egi is a clan in Ogba–Egbema–Ndoni Local Government Area of Rivers State, Nigeria and is comprised of sixteen communities namely; Akabuka, Akabuta, Ede, Egita, Erema, Ibewa, Obagi, Obigbo, Obiyebe, Obiosimini, Obite, Oboburu, Obukegi, Ogbogu, Ohali-elu and Itu. The Ogba–Egbema–Ndoni (also spelled Ogba/Egbema/Ndoni) is a Local Government Area of Rivers state, Nigeria (Old Ahoada LGA) under Rivers West Senatorial District, with its capital at Omoku. With about 258,700 People according to 2006 Census, It is bounded by Imo, Delta, Bayelsa, Abia and Akwa Ibom states and also by Ahoada West, Ahoada East and Emohua Local Government Areas of Rivers State. Ogba being the dominant tribe with 12 legislative wards and the Egbema and Ndoni Tribes with 2&3 legislative wards respectively. It is majorly upland and home to the highest upstream Oil and Gas exploration/exploitation activity in the State since early 1960's with about 12 mining/producing fields operated by Agip, Total and Shell/NPDC with many other reserve/untapped fields.

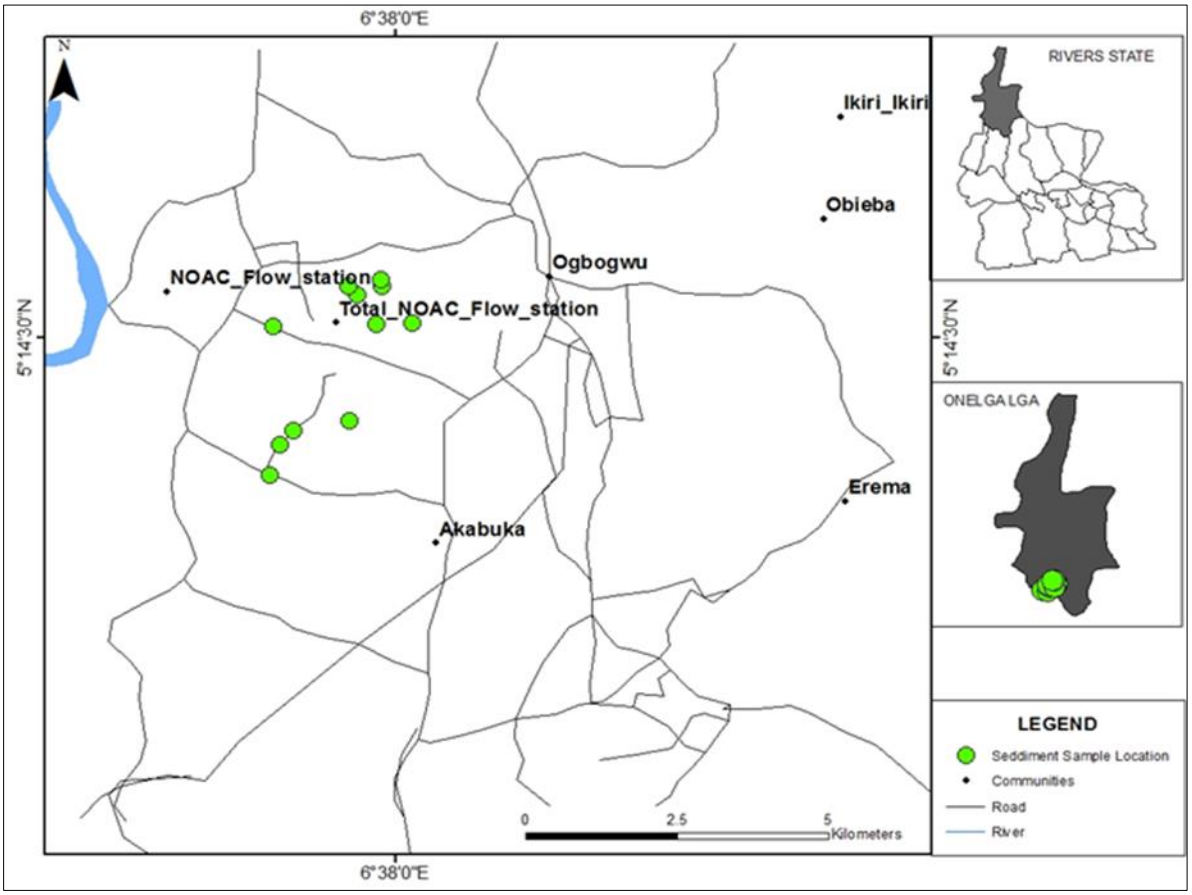

Figure 1 The selected sample locations of the study

2.1.1. Sample and Sampling Techniques

Sediment samples were collected from three (3) streams in three communities within Egi clan of Ogba-Egbema-Ndoni, namely; Obagi, Oboburu, and Ogbogu. Three sampling station each from the communities to assess the level of heavy metals in sediment and the contamination status. Sampling locations were selected based on locational interest, such as industrial sewage outlets and municipality sewage outlets, old chemical dumpsites.

2.1.2. Methods of Data Collection

Sediment samples were collected using the Ekman grab, which was lowered gradually into the water. At the bottom of the water, the messenger is released. Sediment is collected in the grab. It is repeated three or more times from different point and time within the same sampling area. The samples are combined and stored in a clean-labeled polythene bag. Specific labels are firmly attached and finally the sample is transported in an ice chest to the laboratory.

2.2. Sample preparation and Analysis

1 g of air-dried sediment passed through 2 mm sieve was accurately Weigh with foil paper and transfer into a 250 ml conical flask. A measured volume of well-mixed acid, Perchloric acid nitric acid and sulphuric acid in the ratio 1:2:2 was transferred into the flasks containing the sediment samples in the fume hood. Heat was applied for about (15-20 min) in the hot plate until a white fume was observed. The digestion process was stopped and the mixtures cooled. After cooling, 20 ml of distilled water was added and boiled again to bring the metals into solution. The digested mixtures were allowed to further cool and filtered through Whatman 42 filter paper in a 100 ml volumetric flask and made to mark with distilled water, tthen transferred to 100 ml plastic can for analysis.

The filtrates obtained from the digestion process were subsequently analyzed for PTEs (Pb, Cd, Cr, As, Fe, Ni, Mn, Co, Cu and Zn) using atomic absorption spectrophotometer (GBC XplorAA) (Flame Atomic Absorption spectrophotometer). Direct Air-Acetylene Flame Method was used for the analysis of PTEs in sediment samples by using the Flame Atomic Absorption as the instrumentation.

2.3. Contamination Indices

The contamination level was estimated using certain models set aside to address that; geochemical index, contamination factor and enrichment factor. They are used to identify the degree of pollution based on the detected concentration for each sample. These indexes recognize, numerically, pollution height in such particular media and normally they are calculated on the soil exchangeable fraction because it represents the real bio-available fraction. This background concentration is often shared into naturally occurring background and anthropogenic background as defined by the world health organization (USEPA, 2002).

2.3.1. Geoaccumulation index (Igeo)

The PTEs contamination level based on baseline concentrations data were estimated by the model or method suggested by Looi *et al*, (2019), which is called geo-accumulation index (Igeo) (Table 1). This technique measures the elemental pollution in terms of seven (0 to 6) enrichment classes ranging from background level to very heavily polluted, as follows:

$$\text{Igeo} = \log_2 \frac{\mathbf{Cn}}{\mathbf{1.5Bn}} \ldots\ldots(1)$$

Cn is HMs concentration in the sample, Bn is the geochemical background value in average shale of the element (Wang *et al,* 2019, the shale value was 1.5 of the background matrix correction in factor due to lithogenic consequences.

Table 1 Contamination degree for geo-accumulation index

Class	Value	Soil quality level
0	Igeo<0	Uncontaminated
1	0<Igeo<1	Uncontaminated to moderately
2	1<Igeo<2	Moderately Contaminated
3	2<Igeo<3	Moderately to heavily contaminated
4	3<Igeo<4	Heavily Contaminated
5	4<Igeo<5	Heavily contaminated to Extremely Contaminated
6	Igeo>5	Extremely Contaminated

2.3.2. Contamination Factor

The contamination factor shows the extent of contamination by the contaminant on the environmental samples. This was valued by taken an average concentration of a particular element in a media divided by the background concentration (Håkanson, 1980).

$$CF = \frac{\mathbf{Cm}}{\mathbf{Bn}} \ldots(2)$$

Where, Cm is concentration of HMs in soil; Bn is the background concentration of the HMs.

Contamination factor value of CF < 1 refers to low contamination; 1 ≤ CF < 3 means moderate contamination; 3 ≤ CF ≤ 6 indicates high contamination and CF > 6 indicates very high contamination.

2.3.3. Enrichment Factor

It is a measure of the metallic concentration to the reference metal (iron) in the sample compared to the world average shale values, as shown below (Reimann *et al*., 2017).

$$EF = (M/Fe)_{sample} / (M/Fe)_{background} \ldots\ldots\ldots (3)$$

M = metal ion concentration in both the sample and background while Fe = iron concentration in both the sample and the background. Zhang *et al*., 2009), stated that EF values from ½ to 1.5 shows the metal is of biogenic or natural processes, while values more than 1.5 is of anthropogenic or man-made sources.

3. Results and Discussions

3.1. Levels of potential toxic elements (PTEs) in samples from the study area

The concentration of the PTEs in the sediment samples and its mean is displayed in tables 2 and 3. The mean of lead (pb) was 5.871±2.76 mg/Kg for samples from the study area and the most contaminated sites was Oboburu (10.00±1.41 mg/Kg), other sites like Ogbogu (4.027±1.00 mg/Kg) and Obagi (3.387±0.04 mg/Kg) had lower heavy metal detected concentrations. These values were lower than the WHO and DPR guideline limits for lead soil and sediment samples. The concentrations of Pb in this report were lower than that reported by Nwachukwu *et al*. (2010), (1162 mg/kg) in top-soils from South East Nigeria and below works by Fosu-Mensah *et al*. (2017) on lead concentration and distribution in soils and vegetation at Korle Lagoon region in Accra, Ghana (72.000 $mgkg^{-1}$). This can be attributed to the availability of lead containing effluents that could have been discharged to the water-bodies around the study area which might have settled in the sediments of the said streams. The lead presence in the sediments of the streams especially Oboburu could also be as a result of mining, combustion, waste incineration, disposal of contaminated sewage and others. The likely consequence is transfer to fishes and consumption by humans which when accumulated could lead to anemia, weakness, kidney and brain damage, death, damage to human reproductive system. The effect could also be on visible in aquatic species and most time can lead to their death. The study reveal that cadmium had highest detection levels in streams of Obagi (1.244±0.01 mg/Kg) followed by Oboburu (0.411±0.01 mg/Kg) and the least was for Ogbogu (0.051±0.01 mg/Kg). The presence of Cd in the sediments could be attributed to oil and gas activities, manufacturing, fossil fuel combustion, cement production, and municipal and sewage waste. The exposure to cadmium leads to numerous illnesses like kidney damage, birth defect, fragile bone and lung damage. The result clearly indicated that activities within Obagi had effect on the amount of the contaminants in the sediments which could be reduced by proper check and continuous monitoring of the media. .The table 3 also display the amount of arsenic in samples from the study with at 1.642±0.25 mg/Kg and highest detection was for samples from Ogbogu (2.481±0.31 mg/Kg), Obagi (1.452±0.02 mg/Kg), and Oboburu (0.991±0.02 mg/Kg). These are lower than the WHO limit. The presence of As at a substantial amount always have negative effect on the immediate consumers of such products. The level of As from this study shows that anthropogenic activities had greater impact on the contamination of the sediment as arsenic background concentration is normally low. The major consequences of As in the body include cancer an skin lesions, impaired infant development and interference with respiratory system. The amount of iron were significantly high for all the samples but highest was for Oboburu (11234±12.3 mg/Kg) and others were lower like Obagi (7824±70.4 mg/Kg), and Ogbogu (1892±10.05 mg/Kg), the mean of the samples was 6983±233 mg/Kg. These values are below the WHO guideline level for iron in sediment.

Though lower than the WHO limit but still high enough to cause harm. The high level of iron could be due to the dumping of drill chemicals in these zones over a long time ago. Ekmekyapar *et al*. (2012), studied PTEs in samples from Corlu-Cerkezkoy highway in Thrace region, Turkey, they had Fe in higher amount than the result from this work. The concentration of Fe implies high amount which may not be of effect especially when it bioaccumulates in fishes. This concentration of the Fe may have emanated from indiscriminate dumping of drill chemicals, vehicular emission/chemicals, oil and gas, transportation of oil equipment and other may cause increase in their concentration if adequate measures are not taken to curb the continuous influx of the metal to the aquatic media.

Table 2 Result of the levels of PTEs (mg/kg) I sediments from the area

PTEs	Obagi	Oboburu	Ogbogu
Pb	3.587 ± 0.04	10.00 ± 1.41	4.027 ± 1.00
Cd	1.244 ± 0.01	0.411 ± 0.01	0.051 ± 0.01
As	1.452 ± 0.02	0.991± 0.02	2.482 ± 0.31
Fe	7824±70.4	11234 ± 12.3	1892 ± 10.05
Cr	7.020 ± 0.07	4.032 ± 0.07	3.054 ± 0.11
Mn	28.45 ± 2.85	0.660 ± 0.03	29.15 ± 1.28
Cu	6.800 ± 0.07	5.333 ± 0.10	9.037 ± 0.12
Zn	10.24 ± 1.85	16.03 ± 1.02	8.908 ± 0.97
Ni	3.013 ± 0.07	5.064 ± 0.08	5.822 ± 0.09
Co	2.211 ± 0.05	1.945 ± 0.04	4.031 ± 0.06
Hg	0.114 ± 0.01	0.082 ± 0.01	0.202 ± 0.02

Table 3 Mean of contaminants level against the permissible limits of the agencies

PTEs	Mean	WHO Permissible limits	DPR
Pb	5.871±2.76	35.8	85
Cd	0.569±0.45	0.8	0.8
As	1.642±0.25	9.8	29
Fe	6983±123	20000	N.A
Cr	4.702±1.13	100	100
Mn	19.42±6.87	460	N.A
Cu	7.057±1.08	31.6	36
Zn	11.73±2.10	121	140
Ni	4.633±0.56	22.7	35
Co	2.729±1.31	20	20
Hg	0.133±0.05	0.3	0.3

Chromium was present in substantial amount, as it had the highest mean concentration for sediment samples from Obagi at 7.020±0.07 mg/Kg, followed by Oboburu at 4.032±0.07 mg/kg, while the least was 3.054±0.11 mg/Kg for Ogbogu community. The mean was 4.702±1.13 mg/Kg. The values were lower than the standard limit of the world health organization for Cr in sediments and soil samples. The presence of chromium in the body system causes general body defect which could get to the body via eating of aquatic organisms that have acquired the metal from the environment. The world health organization maximum allowable concentration of 0.05 mg per litre in drinking water. Cr can easily get to the body through oral route, inhalation and dermal contact. Manganese had values that ranged from 0.660 to 29.15 mg/Kg for all the stations sampled. The highest detection was for Obagi and Ogbogu at 28.45±2.85 mg/Kg and 29.15±1.28 mg/Kg respectively. The high level of mining activities in the area may have influenced the high amount of Mn in the sediment. These sources include majorly dumping of used chemicals in old borrow pits later overtaken by water. Though there were other sources like bush burning, municipal/industrial wastewater, combustion of fossil fuel, and emission from combustion of fuel additives. Though manganese support a lot of biological activities like stimulation of enzymes for metabolic actions, other chemical processes that goes on within the body system but its state, amount matters when found in a living system. High level of manganese in the system can cause impaired growth, reproductive system damage, skeletal abnormalities, poisoning, hallucination, forgetfulness, and nerve damages. The level of copper

was relatively lower than the permissible limit of 31.6 mg/Kg but the values were high enough to cause alarm. The mean was 7.057±1.08 mgKg for the study area while the least mean was for Oboburu (5.333±0.010 mg/Kg), Obagi (6.800±0.07 mg/Kg), and Ogbogu (9.037±0.12 mg/Kg) had a higher value. The major sources of Cu are manure input, sewage, sludge, mineral fertilizers, and pesticides. The result from this work is far above works by Khaled et al (2021), on Cu contaminants on samples of Cu-W mine area of Korea. The excessive use of chemicals could lead to elevated level of copper in the environment. Reports by WHO suggest that ingestion more than 1g of copper sulfate result in symptoms of toxicity such as metabolic defect, brain damage, liver failure and death.

The accumulation of copper on the aquatic animals will be a danger to those who will consume such fishes. The highest mean for zinc was detected in samples from Oboburu (16.03±1.02 mg/Kg), Obagi (10.24±1.85 mg/Kg) and Ogbogu (8.908±0.97 mg/Kg) had lower values and the mean for the entire area was 11.73±2.10 mg/Kg. These concentrations are below the WHO standard at121.0 mg/Kg. The natural sources of zinc are igneous rocks, mineral sources, zinc containing debris found dumpsites within the study area. Zinc is useful in plant growth for the formation chlorophyll and is apparently linked with iron and manganese. Zinc is a potential nutrient for plant uptake and is essential in many processes and its deficiency causes hair loss, lack of alertness; reduce sense of taste and smell. The presence of zinc in the sediment can cause bioaccumulation which could be transferred to man. Health wise presence of zinc in sediment is not good at the wrong quantity.

Nickel was most in sediments of Ogbogu (5.822±0.09 mg/Kg), and second was Oboburu (5.064±0.08 mg/Kg) and the least was detected in Obagi (3.013±0.07 mg/Kg). The average value of nickel was 4.633±0.56 mg/Kg. The value was lower than the standard of the WHO. The sources of Ni in the water-bodies include corrosion from drill sites etc. The rate of high corrosion and wear from old vehicle (as a result of high patronage in imported used cars) plying the roads could have accounted to the significant levels of anthropogenic contributions of Ni in roadside dust and are easily washed to the water-bodies and formal deposition in sediments. The major effect of nickel includes greenhouse emission, habitat destruction, contamination of air, soil and water, and leads to numerous diseases. Cobalt had the average of 2.729±1.31 mg/Kg, with highest value discovered in Ogbogu (4.031±0.06 mg/kg).

These results obtained are within same range as obtained by Oladeji and Saeed, (2015) in soil from Kubanni stream channel (0.63 – 3.57 mg/kg), same as industrial areas along Jos road (2.50 mg/kg, 2.28 mg/kg) during harmattan season at *Tudun Wada*, 2.23 mg/kg at Ungwar Fulani during dry season. The high concentration could be attributed to the kind of activities that goes within the area of study which might have waste items with high amount of chromium which could lead to waste washing such to the soil environment. The level of mercury was very low though mercury is a very toxic metal. The mean is 0.133±0.05 mg/Kg. The major sources of mercury to the environment include geologic deposit, combustion process waste incineration and mining. The presence of mercury is not a good one due to its harmful effect on the ecosystem. The test results for the PTEs in the sediment samples showed that the concentration of metals in the sampled water bodies all occurred within the known range of values for WHO permissible limits and Department of Petroleum Resources target values for micro pollutants for a standard sediment. With regard to mean values the metals occur in the ranking order of: Fe>Mn >Zn>Cr>Cu>Ni >Co>Pb> As > Cd >Hg.

3.1.1. Geo-accumulation Index

The geoaccumulation index (I_{geo}) was used to assess the level of heavy metal and metalloid elements in the sediment by comparing the status of the current concentration with the pre-industrial level. In this paper, the values of the estimated geo-accumulation index of potential toxic elements (PTE) in sediments of selected areas in Egi communities (Obagi, Oboburu and Ogbogu) in Ogba/Egbema/Ndoni Local Government Area of Rivers State, Nigeria are presented in Table 4.

The calculated geo-accumulation (*I*geo) values indicated that the values for PTEs in sediments around from Obagi, Oboburu and Ogbogu were within uncontaminated level.

3.1.2. Contamination factor

Most contaminants enter the environment from industrial and commercial facilities; oil and chemical spills; non-point sources such as roads, parking lots, and storm drains; and wastewater treatment plants and sewage systems. In the study area there has been series of oil and gas activities which has subsequently lead to pollution through spillages. Hence, the contamination factors of in sediment samples from the study area was evaluated. The result of the assessment of the contamination factor of the PTEs in the study area is depicted in Table 5

Table 4 Geo-accumulation Index of PTEs in sediments of the study area

PTEs	Obagi	Oboburu	Ogbogu
Pb	-3.904	-2.331	-3.737
Cd	-0.391	-0.198	-0.953
As	-1.764	-2.340	-1.984
Fe	-0.828	-1.316	-1.461
Cr	-3.593	-3.780	-3.533
Mn	-3.049	-3.36	-3.204
Cu	-1.918	-2.056	-1.991
Zn	-2.582	-2.647	-2.961
Ni	-1.884	-2.749	-2.195
Co	-2.069	-1.823	-2.559
Hg	-1.981	-2.456	-1.156

Table 5 Contamination factor of PTEs in sediments from streams around the study area

PTEs	Obagi	Oboburu	Ogbogu
Pb	0.100	0.298	0.112
Cd	1.144	1.308	0.775
As	0.442	0.296	0.379
Fe	0.845	0.603	0.545
Cr	0.124	0.109	0.130
Mn	0.181	0.150	0.163
Cu	0.397	0.361	0.377
Zn	0.251	0.240	0.193
Ni	0.406	0.223	0.328
Co	0.357	0.424	0.255
Hg	0.380	0.273	0.673

The contaminator factor shows that all sediment samples from the study area had low contamination. It can be categorically stated that, the contamination factor estimation shows that the streams within Obagi, Oboburu and Ogbogu are not of serious threat from the PTEs studied based on the estimation but synergistic effect may also play a key role on the effect of these metals.

3.1.3. Enrichment factor

The enrichment factor (EF) is a widely used metric for determining how much the presence of an element in a sampling media has increased relative to average natural abundance because of human activity. The result of the estimated enrichment factor of the PTEs in sediments from the study area is shown in table 6. The table 6 indicates that the calculation of the enrichment factor showed that majority of the PTEs where of biogenic origin indicating that soil geology had most effect on the pollution status of the sediments obtained from the streams. The assessment shows that for Obagi community, the following PTEs; Pb (1.011), As (0.675), Cr (0.467), Cu (1.052), Zn (0.650), Ni (0.493), and Co (0.767) were of biogenic or natural origin, while Cd (45.42) was of anthropogenic origin. In Oboburu the metals of biogenic origin were As (0.321), Cr (0.188), Mn (0.003), Cu (0.574), Zn (0.709), Ni (0.313), and Co (0.454) while Pb (2.100), Cd (5.756) were of anthropogenic origin. The estimation of Ogbogu revealed that Cr (0.845) and Mn (0.807)

were of biogenic origin while Pb (5.079), Cd (4.241), As (4.770), Cu (5.780), Zn (2.339), Ni (2.135) and Co (5.586) were of anthropogenic sources. The entire assessment reveals that majority of the PTEs in Obagi and Oboburu were of biogenic origin, while Ogbogu had majority were of human activities. It is pertinent to note that the age of the streams and the period of human activities within these borrow pits that later turn stream affected the sources of the contaminants.

Table 6 Enrichment factor of PTEs in sediments from streams around the study area

PTEs	Obagi	Oboburu	Ogbogu
Pb	1.011	2.100	5.079
Cd	45.42	5.756	4.241
As	0.675	0.321	4.770
Cr	0.467	0.188	0.845
Mn	0.190	0.003	0.807
Cu	1.052	0.574	5.780
Zn	0.650	0.709	2.339
Ni	0.493	0.313	2.135
Co	0.767	0.454	5.586

4. Conclusion

The study revealed that the amount of PTEs in the sediments of the three communities varied significantly. The amounts of PTEs were however lower than the WHO permissible limit for all the samples in the three communities is used as study locations. The order of toxicity was Fe>Mn>Zn>Cu>Cr>Pb>Ni>Co>Cd>As>Hg. The most impacted community was Ogbogu followed by Obagi and then the least was Oboburu. The entire assessment reveals that majority of the PTEs in Obagi and Oboburu were of biogenic origin, while Ogbogu had majority were of human activities. It is pertinent to note that the age of the streams and the period of human activities within these borrow pits that later turn stream affected the sources of the contaminants.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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