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Detection of the Presence of Heavy Metal Pollutants in Eleme Industrial Area of Rivers State, Nigeria

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ABSTRACT

The presenceof some heavy metal pollutants which are deposited on soil in the Eleme environment due to the operational activities of some companies in the area have been studied. Some soil samples in areas situated around industrial installations were collected and analyzed using Atomic Absorption Spectrophotometer (AAS). Results obtained show the presence and concentration distributions of nine heavy metals. The metals are Iron (Fe), Manganese (Mn), Zinc (Zn), Lead (Pb), Copper (Cu), Chromium (Cr), Cobalt (Co) and Cadmium (Cd). It was observed that over 90% of each of the metals was located in communities hosting the industrial corporations while the remaining 10% is distributed to areas away from the source or host communities. This reveals that, a link exists between the pollutants and the activities of these industries.

Keywords: Pollutants, heavy metals, industrial, soil, environment

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I. INTRODUCTION

The negative impacts of industrialization on the environment and by implication, on the health and well-being of the inhabitants of the environment have posed some concern to scientists, the world over. In Nigeria, the oil industries, chemical industries and other industrial settings have also impacted so negatively on the environment that people now live in perpetual fear of what will happen the next minute. All these are due to the insensitivity of the operators of these corporations which in most cases result in very severe negative impact on the environment through oil spills, gas flaring, unguarded and uncontrolled emissions, siltation, and biodiversity depletion among others. (1) stated that oil exploration and exploitation has over the last four decades impacted disastrously on the socio-physical environment of the Niger Delta oil bearing communities so massively threatening the subsistence peasant economy and the environment, and hence, the entire livelihood and basic survival of the people. The rate at which the immediate environment (air/atmosphere, water/hydrosphere and land/lithosphere) of this oil rich region that defines wealth and poverty simultaneously is being affected is quite alarming. (2), revealed that since the exploration of oil in this region, about twenty trillion dollars have been realized as proceeds leaving several stresses on the environment due to large volume of crude oil that have been extracted. (3) also shows that over 95% of the volume of oil spilled on the environment in this region is not recovered. This means serious negative impact on both the environment and the economic resources of the people. All these are apart from the adverse effects of the reckless emissions and uncontrolled disposal of wastes and sludge's on the environment. Among the disturbing pollutants in the environment in this region that result from the reckless acts mentioned above are heavy metals and the increased level of hydrocarbon contents in the soil. The persistency and other harmful effects of these metals have attracted researcher's attention with a view to ascertaining their concentrations in the environment and their effects on the inhabitants. Hence, the motivating factor for this research.

II. EFFECT OF PETROLEUM HYDROCARBON AND HEAVY METAL POLLUTANTS ON THE ENVIROMENT

Petroleum hydrocarbons are complex mixtures of hydrocarbon compounds such as alkenes (from C_1 to C_{22}), fatty acid, naphthenic acid, ketones, ethers, lactones, anhydrides and petroleum waxes with C_{78}; in most instances, these exist together with large qualities of hydrocarbon natural gases such as methane (94%), ethane (1.5 to 4%) and propane (1-2%) and smaller amounts of other gases such as sulphide, nitrogen and carbon dioxide.

Another group of soluble organic pollutants arising from the hydrocarbon industry is the BTEX(Benzene, Toluene, Ethylene and Xylene) group that can pollute air, land and water, and are usually carcinogenic in nature (4).In addition to these, certain heavy metals such as lead (Pb), Iron (Fe), manganese (Mn), zinc(Zn), thallium (Ti), chromium (Cr), arsenic (As), cadmium (Cd), mercury (Hg), nickel (N_1), silver (Ag), copper (Cu), Boron (B), molybdenum (Mo), and many other occur together with hydrocarbons as natural components of the earth's crust.

These hydrocarbon and their components all affect and devastate (pollute) the environment in their own rights wherever there is oil spillage, lickage or discharge with concentrations up to 1,000ppm (5). Heavy metals in hydrocarbons occur in the form of organometals (compounds in which organic groups are linked directly to the metals through at least one carbon atom either through δ-bond or through a special π-bond (6). Most organometals are unstable and decompose easily because they are usually unstable in the presence of temperature, air and water.

Examples of thermal and oxidation decompositions of organometals are shown below, respectively.

Thermal: $Me_4Pb_{(s)}\,Pb_{(s)} + 2C_2H_6(g)$: $\Delta H = -360$ K J / mole

Oxidation: $Zn(CH_3)_2\,(g) + 4O_2(g) \longrightarrow ZnO(_s) + 2CO_2(g) + 3H_2O(l)$

These instabilities can lead to the deposition of metal contents of the compound in the environment on exposure to unstable conditions like sunlight after spill. This further complicates and aggravates the negative impacts of the heavy metals.

Under natural conditions, oreganometalloids tend to move from one location to another either by purely physiochemical (abiotic) or through the inter mediations of organisms (biotic) and reduction processes. Higher concentrations of organometallics in the environment are possible due to their usage as biocides or as gasoline additives. This makes it imperative to focus attention on their toxicity not just in the immediate environment but at other farther points. Hence it will also be necessary to study the transport of the decomposed products which tend to persist for considerable length of time under natural conditions and which can also form new organnometallics by alkylation in the environments.

III. MONITORING AND TRACKING OF HEAVY METALS IN THE ENVIRONMENT

The monitoring and tracking of heavy metal pollutants in the immediate environment and at farther points is normally carried out either experimentally or theoretically. Many researchers have used these methods to study and determine the presence, types and quality of contamination in the environment they studied. Some experimental studies that have been carried out to determine the types and concentrations of heavy metals contaminations of various environments are as follows:

(7) used the denaturing gradient gel electrophoresis to study the impact of heavy – metals contaminant of Archean communities. The study revealed that there are differences in the soil structure with increasing heavy metals contamination. (8) did a spectrophotometric determination of some trace metals in Aquatic fauna from Bonny terminal in Rivers state, and found that the level of contamination was on the average. (9) and (10)used Atomic absorption spectrophotometric technique to determine trace metals concentration in shell fish dog whelk (thais haemostoma) from Brass River in Bayelsa state, and on paved roads in Ilorin and Lagos Areas, respectively. The results show more than average level of contamination. Also, (11) used flame atomic absorption spectrophotometry technique to study the distribution of heavy metals in water and sediments of the lower Ikpoba River, Benin City. Result shows higher concentration of metals during the dry session than the raining session.

In this study, the authors have used spectrometric analysis technique to study the types and concentration of metal pollutants in various sites in the Eleme Industrial Area.

The Study Area

The study area is located in Rivers State (Niger Delta) between longitude 7^o 10' and 7^o 30'E and latitude 4^o 30' and 4^o 50'N. The area is bounded in the North by Obio/Akpor LGAs, in the South by Opobo/Nkoro, Andoni and Bonny LGAs, in the East by AkwaIbom State and in the West by Ogu/Bolo and Okrika LGAs.

The area of study comprise of the Eleme Petrochemicals Company Limited (EPCL), Port Harcourt Refining Company (PHRC), and national fertilizer Company of Nigeria Limited (NAFCON). These industries are targeted because they could be the primary sources of these metals. Nine heavy metals that could pose serious negative impact on the environment within their host communities will be investigated. These are Zinc (Zn), Iron (Fe), Copper (Cu), Lead (Pb), Nickel (Ni), Cadmium (Dc), Cobalt (Co), Manganese (Mn) and Chromium (Cr).

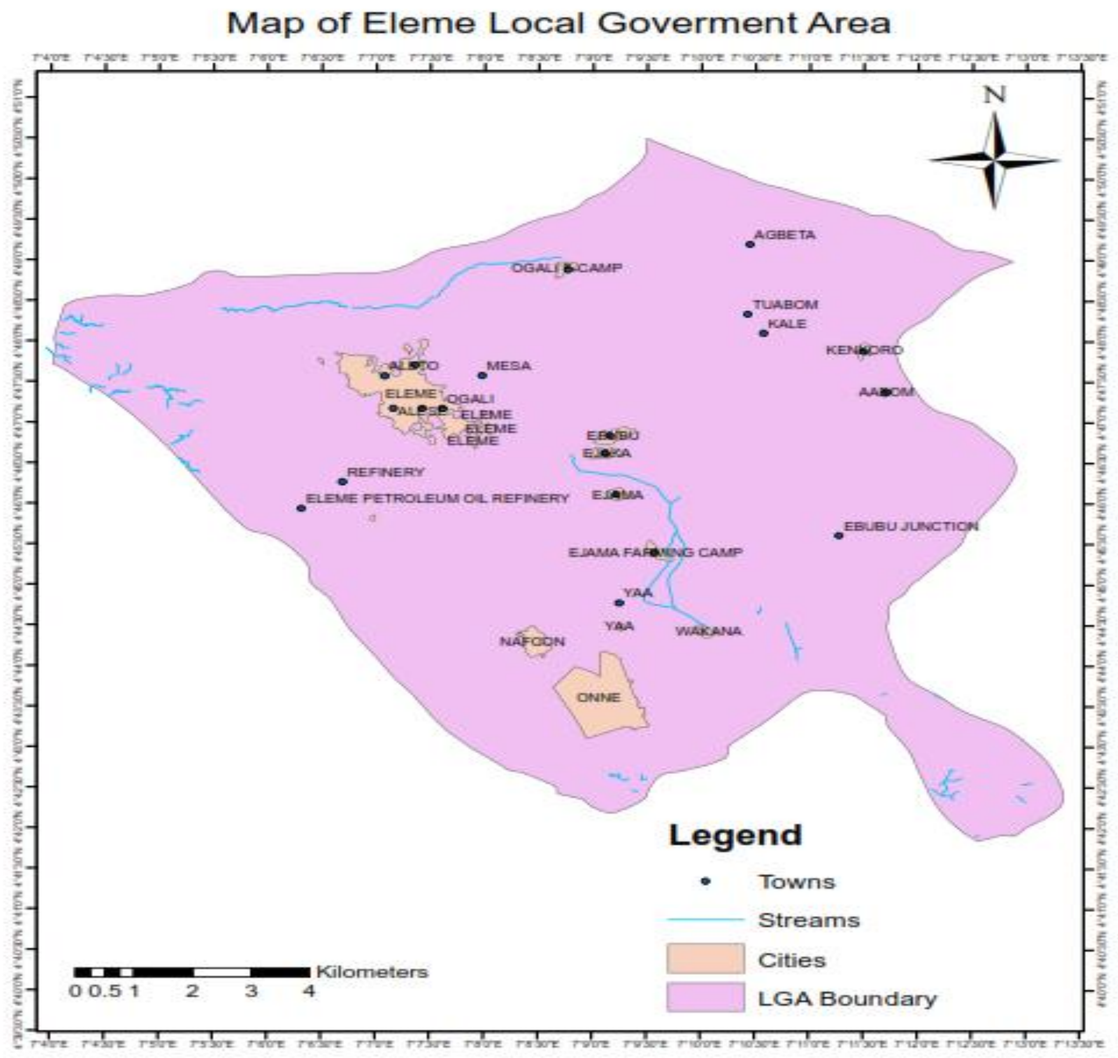

Fig. 1: Map of the Study Area.

IV. METHODOLOGY

The study area has three potential sources of heavy metals pollutants, namely; the Eleme Petrochemical Company limited (EPCL), Port Harcourt Refining Company (PHRC) and the defunct National Fertilizer Company of Nigeria limited (NAFCON). The sites (communities) were characterized and delineated according to their nearness to the companies as follows:

- EPCL : Akpajo, Agbonchia and Aleto communities
- PHRC: Alese, Alode and Ogale communities
- NAFCON: Onne, Ebubu, Eteo and Ekporo communities.

Samples were carefully collected from the study sites by taking about three auger boring at random around the area with a 9cm Dutch auger (12) to give representative soil samples (0 – 30cm) of each industrial site. Samples collected were placed in well labeled plastic bags and taken to the laboratory for the acid digestion analysis with hydrochloric acid and concentrated nitric acid. After the digestion, the sample was filtered through a No. 44 filter paper and trace metal, extraction were performed using the powder pillows supplied by HACH company for the DR/2000 spectrophotometric procedure manual (13). The final determination of the trace elements from the digest was performed using the DR/2000 spectrophotometer.

V. RESULTS

The result of the experimental tests from the ten locations is shown in table (1) below. This table presents the result in milligram per milliliter (mg/m1). This is because; it is the result of the liquid digests of the various samples.

Table 1: Metal Test Result in (mg/m1)

Location			Metal concentrations (mg/m1)								
Industrial Area	Host communities	Distance from Source	Zn	Fe	Cu	Pb	Ni	Cd	Co	Mn	Cr
NAFCON	Onne	1.1km	3.27	477	0.54	0.47	0.61	0.05	0.26	7.17	0.40
	Ebubu	3.2km	1.43	204	0.10	0.08	0.66	0.02	0.21	7.89	0.07
	Eteo	3.5km	0.59	147	<0.01	0.05	0.10	<0.02	0.10	0.34	0.07
	Ekporo	4.1km	0.37	36	<0.01	<0.10	0.10	0.01	<0.01	0.23	<0.01
PHRC	Alesa	<1km	3.70	519	0.58	0.95	0.76	0.09	0.32	10.35	0.50
	Alode	1.5km	2.60	486	0.14	0.59	0.30	0.03	0.16	0.65	0.40
	Ogale	2.2km	1.24	171	0.18	0.05	0.51	0.02	0.01	0.35	0.10
EPCL	Akpajo	<1km	2.10	390	0.21	0.11	0.56	0.03	0.21	5.02	0.10
	Agbonchia	1km	2,43	420	0.21	0.11	0.56	0.05	0.21	5.38	0.13
	Aleto	1.1km	0.79	300	0.32	0.11	0.61	0.04	0.21	6.20	0.30

The results of the metal tests in table (1) were also converted to milligrams per Kilograms (mg/kg) for convenience, suitability and for the fact that our samples were actually soil samples and not water. Table (2) below, however presents the results of the metal experimental tests in mg per kg. This table and its preparation are based on the fact that one gram (1g) of soil from the samples was used to prepare twenty five (25) milligrams of the digest for high sensitivity.

Table 2: Metal Test Result in (mg/kg)

Location			Metal concentrations (mg/kg)								
Industrial Area	Industry/Host communities	Distance from Source	Zn	Fe	Cu	Pb	Ni	Cd	Co	Mn	Cr
NAFCON	Onne	1.1km	81.8	11925	13.5	118	15.3	1.30	6.5	179.3	10
	Ebubu	3.2km	35.8	5100	2.2	2.00	16.5	0.50	5.3	197.3	1.80
	Eteo	3.5km	14.8	3675	0.25	1.25	2.5	0.50	2.5	0.5	1.80
	Ekporo	4.1km	9.25	900	0.25	0.25	2.5	0.30	0.25	5.8	0.25
PHRC	Alesa	<1km	92.5	12975	1.45	23.8	19.00	2.3	8.0	258.8	12.5
	Alode	1.5km	65.0	12150	3.5	14.8	7.50	0.80	4.0	16.30	10
	Ogale	2.2km	31.0	4275	4.5	1.30	12.80	0.50	2.5	8.80	2.5
EPCL	Akpajo	<1km	50.3	9750	5.30	2.80	14.0	0.80	5.3	125.5	2.50
	Agbonchia	1km	60.8	10500	5.30	2.80	14.0	1.30	5.3	134.5	3.30
	Aleto	1.1km	18.5	7500	8.0	2.80	15.3	1.00	5.3	155	7.5

VI. DISCUSSION

The dispersion trends observed in this study are shown in the categories below.

Category 1

For most of the metals, there was a decrease in concentration with increasing distances from the host communities from the source.

Category 2

Some of the metals tested for, showed a reversal of the observed trend in category 1. This means that there was an increase in the concentration as the distances of the host communities' increase from the source of the pollutant.

Category 3

Few of the metals were also found to show no change in the concentration distribution irrespective of the increase/decrease in the distances of the host communities form the source of the pollutant.

NAFCON

Category 1: The trend observed around NAFCON, showed that the metals Fe, Zn, Cu, Pb, Cd, Cr, had uniformity in their dispersion pattern with increased distance from the source. This implies that from the location of the industrial area to other communities, heavy metal concentration decreased significantly, with the industrial area having the highest concentration.

Category 2: The only reversal in the concentration order with increased distance was seen in the concentration levels between Onne and Ebubu community for Ni. Thus, Ebubu community, a distance of 3.2k from the source has a concentration of Ni (16.5mg/kg as against Ni (15.3omg/kg) for the Onne community itself, a distance of 1.1km from the source. This could be attributed to the presence of other sources of the metal within the Edubu community, such as the various flow stations within the community.

Category 3: Partial uniformities in the concentration of metals like Cu, Ni, Cd and Cr between Ebubu and Eteo communities as well as between Eteo and Ekporo communities were observed. For instance, the concentrations of Cd (5.3mg/kg) and Cr (1.80mg/kg) were uniform between the Ebubu and Alode communities. Those of Cu (0.25mg/kg) and Ni (2.5mg/kg) were also observed to be uniform between Eteo and Ekporo communities. This observational trend may be due to the preserve of other minor sources of Cd and Cr in the Eteo community as well as of Cu and Ni in the Ekporo community.

PHRC

Category 1: Around the PHRC, most of the metals show uniformity in their dispersion pattern. This is because they have decreased level of concentration with increased distance of the host communities. These may be due to wind and water as a result of topographical effects of the host communities. Thus, the metals Zn, Fe, Pb, Cd, Co, Mn and Cr decreased from the highest levels in the concentration trend of Fe (12975mg/kg) >Mn (258.8mg/kg) > Co (8.0mg/kg)> Cd (2.3mg/kg) to values as low as Fe (4275mg/kg), Zn (31.omg/kg), Pb (1.30mg/kg), Cr (2.5mg/kg(, Mn (8.80mg/kg), Co (2.5mg/kg) and Cd (0.50mg/kg). This observational trend shows that this source (PHRC) could be the major contributor to the levels of concentrations of these metals for Cu and Ni. The observation also shows a partial dispersion in the levels of concentrations of these metals between the Alesa and Alode communities as well as Alesa and Ogale communities. This observation shows that there could be other activities or establishments within the Ogale community that contributed to the increased concentration of these two metals in Ogale community as against the concentration in Alode community.

Category 2: While the situation in and around the PHRC show majorly that category 1 is predominant, two cases were observed in the concentrations of Cu and Ni that support category 2 especially, as seen between Alode and Ogale communities. Evidently, the concentrations of these two metals between Alode and Ogale communities show an increase of the concentration of these metals with increased distance from the source. This could be attributed to the preserve of other possible source of the metal within Ogale community or an overlap of the concentrations from other primary source due to the effect of the topography.

EPCL

Generally, categories 1, 2 and 3 trends which were well established for NAFCON and PHRC did not seem to apply exactly to the EPCL. Thus, disruption in trend around the EPCL was observed as against those of PHRC and NAFCON. This anomaly could be due to the decentralization of the plants. The variations in the concentrations of these metals at the different areas of the three host communities could be reflections of the type of operations and materials inputs that take place at the different parts of plants bordering on the lands of each of these communities of the EPCL. For instance, within this source, the olefins plant is at the Akpajo axis, Ethylene plant is at the Agbonchia axis while the polypropylene plant is sited towards the Aleto axis of the complex. Thus the observed anomaly may be due to the operation and material inputs of each of the plants. That is the concentrations observed in the metals Zn, Fe and Cd show that the operations around the polypropylene plant may produce more of metals like Cu, Ni, Mn and Cr, while the concentration of Pb and Co show a balancing of material inputs to the three plants.

VII. CONCLUSION

This study has in the foregoing detected the presence and quantity of nine (9) heavy metals which comprise of zinc (Zn), Iron (Fe), Lead (Pb), Nickel (Ni), Cadmium (Cd), Cobalt (Co), Manganese (Mn) and Chromium (Cr). These metals are found to have higher concentrations around industrial installation and its neighborhood as compared to concentrations in areas farther away. This revealed that, there is a link between the operations and/or material inputs to these industries and the concentration of the pollutants (metals) around these areas.

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