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Elevation of Heavy Metals in the Environment of Aragba and Uvwiamughe in the Niger Delta Region of Nigeria after an Oil Spillage

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Abstract

Atomic absorption spectrometry method was used to measure the elemental concentrations of lead, mercury and arsenic from the uncontaminated and contaminated soils after the oil spill in Aragba and Uvwiamughe communities. Both the contaminated and uncontaminated soil samples from Aragba community exhibited higher mean concentration values than the corresponding concentrations recorded for Uvwiamughe community. For the contaminated soil samples, the mean elemental concentrations of 0.08mg/kg, 0.04mg/kg and 1.04mg/kg were recorded for mercury, arsenic and lead respectively in aragba community while 0.06mg/kg, 0.02mg/kg and 0.25mg/kg were recorded for mercury, arsenic and lead respectively in Uvwiamughe community. The results also showed that the levels of the heavy metals in the contaminated soil samples are higher than the levels in the uncontaminated soil samples. This signifies elevated values of elemental concentration of the heavy metals in the soil samples from the oil spill field. The results obtained are comparable to the values of 18.77mg/kg for Lead in the sediments of Okrika river; nil for arsenic in the preliminary assessment of heavy metal levels in soils of an oil field in Niger Delta, Nigeria and nil for Mercury in the characteristic levels of heavy metals in soil profile of automobile mechanic waste dump in Nigeria. The levels of concentration for water in the present study are also comparable to the International values recommended by WHO for portable and drinkable water which are 0.01mg/L, 0.01mg/L and 0.001mg/L for lead, arsenic and mercury respectively. The WHO values are much smaller than the corresponding mean values of 0.12mg/L, and 0.005mg/L for Lead and Mercury respectively in the present study while the values for Arsenic are the same.

Keywords: Elevation, Niger delta, oil spillage, concentration, heavy metals and community.

Introduction

Every part of the world is endowed with different natural resources, such as diamond, lime stone, petroleum, gold, copper etc. Nigeria is abundantly blessed with many of these natural resources, the prime of which is petroleum that the nation's economy depends. Owing to the increase in the world demand for energy, the Nigerian crude oil is exported in exchange for foreign currencies. The monies accrued from the crude oil exportation are used for industrialization, technological development and economic growth of the nation. Oil exploration and exploitation in Nigeria started in Oloibiri, presently in Bayelsa state, in 1956. Since then more potential petroleum locations had been explored in other parts of the nation, particularly Niger Delta see figure 1. In recent time the nation's oil reserves are estimated at about twenty-seven (27) billion barrels and the daily production (exploitation) of the hydrocarbon is about 2.5 million barrels[1].

Oil spillage is encountered during the process of production, transportation and storage of crude oil, Over 550 cases of crude oil spillages with the release of over 2.8 million barrels of crude oil into the environment since 1976 was reported in Niger Delta region alone[2] see figure 1. In the past, metals dispersed in soil and sediments, dissolved in ground and surface water, suspended as particles in surface water and in pore fluid in sediments had the major concern of Geoscientists[3]. But today heavy metals and petroleum hydrocarbons have great ecological significance due to their toxicity, and contrary to most environmental pollutants, heavy metals are not biodegradable and undergo a global exobiological cycle[4]. Consequently, unexpected rapid mobilization of heavy metals could result in environmental catastrophe, menacing human health, and welfare by poisoning water and food[5]. The activities of the oil companies are so devastating as they posed substantial environmental degradation and social crises that threaten the sustainable development in the affected communities. Meanwhile oil exploration is one of the sources of elevated concentration of heavy metals in soils[6]. Besides, petroleum industry activity is one of the major anthropogenic sources of heavy metal contamination in the environment[7]. Contamination due to heavy metals resulting from oil spills is a threat to human life and the environment[8]. In addition, the oil spill inadvertently cause pollution in the environment leading to the destruction of wildlife and biodiversity, loss of fertility of the soil, damage to vegetables, livestock; farmland degradation, damage to aquatic ecosystem and contamination of soil and water bodies. The major route of heavy metal uptake by man is attributed to food, water and air. Aquatic fauna especially fishes that are greatly consumed by man are the most sources of mercury and arsenic pathway to human body[2].

The category of metals that have atomic masses ranging from 63.55 to 200.59 and specific gravity greater than 4 are referred to as heavy metals[9]. Among these metals are Mercury (Hg), Lead (Pb) and Arsenic (As) that are considered in the present study. These heavy metals can have serious implication in all environments but the effects are most long lasting in soils due to the relatively strong absorption of many metals onto humic and clay colloids in the soils[10]. Unlike organic pollutants that are easily decomposed, the heavy metals can be retained in the soil for hundreds or thousands of years depending on the type of the soil and physicochemical parameters of the soil.

Interest in heavy metal pollution has been of great interest recently probably as a consequence of high levels of contamination measured in number of cities and the potential health risks associated with them particularly considerable loading of heavy metals to receiving waters and water bodies[11].

This however, motivated the present study to determine the level of contamination by elevation of heavy metals in the environment of Aragba and Uvwiamughe in the Niger Delta region of Nigeria after an oil spillage. It is also aimed at educating the various Environmental Agencies on the possible sources of these metals by providing a database so as to proffer effective management practice to reduce risk of exposure and possible health effects.

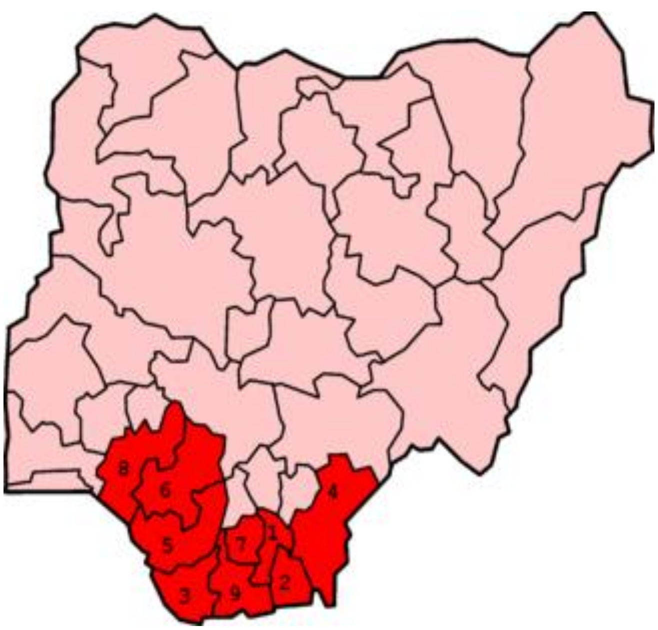

Figure-1
Map of Nigeria numerically showing states typically considered part of the Niger Delta region comprising the following namely: i. Abia, ii. Akwa Ibom iii. Bayelsa iv. Cross Rivers, v. Delta, vi. Edo, vii. Imo, viii. Ondo, and ix. Rivers

Material and Methods

Study area: The study area involves Aragba and Uvwiamughe communities in the Ughelli South Local Government Council of Delta State that is among Niger Delta oil producing region of Nigeria. The main occupation of the Niger Delta people are fishing and farming. Besides the major industrial activity in the area is that of oil exploration and exploitation. The area is characterized with geological setting sequentially arranged from Akata to Agbada to Benin formation. The oldest formation, Akata formation which is the source rock consists of under-compacted and over-pressured shale. This allows the flow of hydrocarbons into the Agbada formation that predominantly consists of sandstone. Because of the porosity and interconnectivity of the Agbada formation, it serves as a reservoir for oil and gas in the Niger Delta. These formations make the Niger Delta the most prolific for the production of hydrocarbons in Nigeria, making the region the greatest producer of oil and gas. About 80% of the Federation income or revenue collected in Nigeria comes from Niger Delta[12].

Sample collection: Soil samples were collected from the land contaminated with oil spill in the two communities of Aragba and Uvwiamughe. Soil samples were also collected from the areas that are unaffected by the oil spill in the two communities for control purpose. Water samples were only collected at the upstream and down stream of River Agbarho in Aragba community. The soil samples were collected within a constructed 500mx500m quadrant in each community. The quadrant was further divided into five cells of 200mx200m with each cell representing a sampling station. About four samples were randomly collected at a depth of 0-15cm with hand auger. These samples were then mixed thoroughly to give a composite sample of the cell.

Water samples were collected from five different points at the upstream and downstream of the Agbarho in Aragba community. This river serves as the source of water for domestic use in the Aragba and Uvwiamughe. The upstream was the source of the river that was not affected by the oil spill. The water samples were collected in polythene containers that were previously washed in non-ionic detergent, rinsed with tap water and later soaked in 10% HNO_3 for 72 hours before finally rinsed with de-ionized water prior to chemical analysis[13].

Sample preparation and analysis: Each soil sample was properly dried in an oven at a temperature of 65^0C, grinded in order to reduce the particle size, thereby increasing the surface area of contact on addition of acid. 5.0 gm of the sieved soil sample was mineralized with the mixture of nitric-perchloric hydrofluoric acid at 120^0C for 2hours. The digest was filtered and diluted to 100ml using ultra pure water. The filtrate sample was subsequently analysed for lead (Pb), arsenic (As) and mercury (Hg) using Atomic Absorption Spectrometer, AAS Model Analyst 100, produced by Perkin Elmer from England.

The digestion of the water sample was carried out as explained by Carrondo[14] in the open beaker digestion method using nitric-perchloric hydrofluoric acid. 10ml of the water sample was taken for analysis in a beaker (Teflon beaker previously soaked in 10% nitric acid for 72hours and rinsed with de-ionized water) and 30ml of concentrated HNO_3 was added and the sample was evaporated to dryness on a hot plate in a fume cupboard. The resulting solution was allowed to cool and 5ml of the concentrated HNO_3, 2ml of 60% perchloric acid, $HClO_4$ and 6ml of 40% of HF were added.

The digested water sample was filtered into a 20ml standard flask, made up to the mark with distil water and stored in a bottle (polythene bottle soaked in 10% nitric acid for 72 hours and rinsed with de-ionized water) prior to the chemical analysis. The water extract was similarly analyzed for lead (Pb) arsenic (As) and mercury (Hg) using atomic absorption spectrometer.

Results and Discussion

The elemental concentration of mercury (Hg), arsenic (As) and lead (Pb) in the soil of Aragba and Uvwiamughe in the Niger Delta region of Nigeria are shown in tables 1 and 2 respectively.

In Nigeria there had been no official baseline for concentrations of metals in the soil[1,15] but the result obtained in the present study can be compared with the other relevant and available previous works in Nigeria. The concentrations of heavy metals in the soil of Aragba and Uvwimuaghe communities indicated elevated values after the occurrence of oil spillage in the two communities (tables 1 and 2).

Lead exhibited the highest mean concentration of 1.04mg/kg in the contaminated soil of Aragba while the mean concentration in the uncontaminated soil was 0.62 mg/kg. Meanwhile lead exhibited a mean concentration of 0.84mg/kg in the contaminated soil and the uncontaminated soil showed a concentration of 0.25mg/kg at Uvwiamughe.

The concentration of lead either in the contaminated or uncontaminated soil in the study area is far below a concentration of 10.0mg/kg recorded in the vicinity of Uwelu motor spare part market in Benin, Nigeria[16]. Other Scientists reported a mean lead concentration of 18.77 mg/kg in the sediments of Okrika river system in River State[17]. This value is also greater than the value recorded for concentration of Lead in the study area. The European Union (EU) environmental quality criterion on the elemental concentration of Lead in the soil is about 300mg/kg[18]. This value is significantly higher than the value recorded for Lead in the present study.

Arsenic (As) exhibited a concentration of 0.04mg/kg in the contaminated soil of Aragba and the uncontaminated soil showed a concentration of 0.02mg/kg. These values are more significant when compared with the nil value reported by other researchers[1] in the preliminary assessment of heavy metal levels of soils of an oil field in Niger Delta, Nigeria.

Mercury (Hg) exhibited a concentration of 0.08mg/kg in the contaminated soil and the uncontaminated soil showed a concentration of 0.05mg/kg. These values are significantly high when compared to the nil value also reported by some researchers[15].

Table 3 shows the concentrations obtained for the three elements (lead, arsenic and mercury) at the upstream and downstream of the Agbarho River in Aragba community. The mean concentrations of Pb, As and Hg at the upstream recorded were 0.12mg/L, 0.01mg/L and 0.005mg/L respectively. These values are lower than the corresponding concentrations, recorded as 1.02mg/L, 0.04mg/L and 0.05mg/L for Pb, As and Hg respectively at the downstream. The values of lead concentration recorded in this study at the upstream and downstream are higher than the values of 0.023mg/L and 0.14mg/L for the upstream and downstream respectively reported for Alaro River in Ibadan, Nigeria[19]. The quality criteria for drinking water that contains Pb, As and Hg was recommended by World Health Organization (WHO, 1984) are 0.01mg/L, 0.01mg/L and 0.001mg/L respectively[20]. These World Health Organization (WHO) values are much lower than the corresponding mean values recorded at the downstream in the Agbarho River. This indicates that the water from the downstream is unhygienic for human drinking. It is observed that the level of Hg at the upstream is about five times the limit recommended by WHO, hence the water at the upstream is also unsafe for human drinking.

Table-1

Elemental concentrations of Hg, As and Pb (mg/kg) in the soil samples from Aragba community

Soil Sample	Hg		As		Pb	
	Contaminated	Uncontaminated	Contaminated	Uncontaminated	Contaminated	Uncontaminated
1	0.09	0.06	0.03	0.02	1.07	0.62
2	0.07	0.04	0.04	0.03	1.02	0.61
3	0.08	0.05	0.04	0.01	1.04	0.63
4	0.10		0.06	-	106	-
5	0.06	-	0.03	-	1.01	-
Mean	0.08	0.05	0.04	0.02	1.04	0.62

Table-2
Elemental concentrations of Hg, As and Pb (mg/kg) in the soil of Uviamughe Community

Soil Sample	Hg		As		Pb	
	Contaminated	Uncontaminated	Contaminated	Uncontaminated	Contaminated	Uncontaminated
1	0.06	0.04	0.02	0.02	0.84	0.25
2	0.07	0.05	0.03	0.03	0.76	0.26
3	0.08	0.03	0.02	0.01	0.89	0.24
4	0.04	-	0.01	-	0.88	-
5	0.05	-	0.02	-	0.83	-
Mean	0.06	0.04	0.02	0.02	0.84	0.25

Table-3
Elemental concentrations of Hg, As and Pb (mg/L) in the water from Agbarho River in Aragba community

Soil Sample	Hg		As		Pb	
	Downstream	Upstream	Downstream	Upstream	Downstream	Upstream
1	0.08	0.005	0.04	0.01	1.04	0.12
2	0.09	0.004	0.03	0.01	1.03	0.11
3	0.08	0.005	0.03	0.01	1.06	0.13
4	0.07	0.006	0.06	0.01	1.05	0.12
5	0.08	0.005	0.04	0.01	1.02	0.12
Mean	0.08	0.005	0.04	0.01	1.04	0.12

Conclusion

Although the levels of the elemental concentrations of Pb, As and Hg in the environment of Aragba and Uvwiamughe communities are very low compared with the values obtained from other studies from other parts of the country, but it is clear that the values showed elevated concentration levels of Pb, As and Hg after the oil spillage had occurred in the two communities. However, no matter how small, all levels of elemental contamination are hazardous to human health, it is therefore pertinent that the Nigeria Environmental Protection Agency and other environmental bodies at both Local and State levels should take appropriate steps to enforce environmental laws and regulations that would make the oil companies and allied organizations clean up the spills from the environment to a satisfactory extent when there is oil spillage in the environment. In addition the government and the multinational oil companies must educate the inhabitants of the rural communities affected by oil spillage to use simple fractionalization or chromatography method, that is, use of fibre or cotton wool to separate the oil from the water collected from the brooks or rivers in the affected areas before boiling. Addition of alum for further purification is another added advantage before consumption. The ability of activated carbon produced from coconut shell to remove Hg, Pb, and Cu from dye effluent has been reported by Onyeli and Abaie[21]. Their method could be adopted and improved upon by the governments (Local and States) for water treatment in the affected areas.

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