

Heavy Metals Concentrations of Water and Sediments in Oil Exploration Zone of Nigeria

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Abstract

Heavy metals concentrations of water and sediments in the oil exploration zone of the Qua Iboe river estuary in Nigeria was investigated by analysing the samples for their Cd, Ni, Pb and V concentrations using atomic absorption spectrophotometry. The results obtained indicated that the heavy metals concentrations of the samples were below the WHO pollution limits with maximum values of 0.003 mg/l for Cd, 0.143 mg/l for Ni, 0.040 mg/l for Pb and 0.102 mg/l for V in the water samples. Concentrations of the heavy metals in the sediment were significantly higher than the values in the water samples ($P < 0.05$), with positive correlation between the levels of the heavy metals in the water and the sediment, except for Pb. However, there is tendency of elevation in the concentrations of the studied heavy metals over a period of time, since oil exploration has the potential of increasing the concentrations of heavy metals in the estuary. The authors recommended the control of industrial activities within the coastal area.

Key words: Estuary, heavy metals, water, sediments, spectrophotometry

Introduction

Among the natural substances that man concentrates in his immediate environment, metals are the most ubiquitous. They can be neither degraded nor metabolised, which symbolises ultimate persistence in the environment (Sodhi, 2002).

Heavy metals are those metals whose density is greater than 5.00 g/cm³. Some heavy metals like Cu, Zn, Co, Mn and Mo are needed by biological systems because of their physiological roles (Eddy et al., 2006). Others such as Se, Cd, As, Hg Pb are toxic in all concentrations (Eddy et al., 2004). All heavy metals when present in the environment above a particular threshold have the capacity to endanger natural ecosystem and public health (Alegria et al., 1990). The most important feature that distinguishes heavy metals from other toxic pollutants is their non-biodegradability and the tendency to accumulate in global ecological circle, in which natural water serve as the main pathway (Alan, 1993; Adekola et al., 2000).

The common sources of heavy metal pollution in our environment are industrial and anthropogenic activities (Pip, 199; 1Davies et al., 2008). Studies have shown that, many of these heavy metals have contaminated the soil, plant systems and drink-

ing water, which can easily be transferred to the animals either through food chain or during drinking of water (Ekwumemgbo, 2005). According to Eddy and Udoh (2003) some heavy metals have their target organs in the body and the corresponding site effect is often accelerated towards this organ. For example, the target organ for Pb is the brain, the blood and the kidney.

Soil samples collected in vicinity of Tankers Park near Warri refinery in the Niger Delta Region of Nigeria had elevated metal concentrations for Cd, Cr, Pb and As when compared with the concentrations of iron, nickel and barium in the same study. It is established fact that a wide range of heavy metals is found in fossil fuels which are either emitted into the environment as particles during combustion or accumulated in ash which may itself be transported and contaminate soils (Ekwumemgbo, 2005). Qrszulik (1997) reported that the deposition of aerosols arising largely from fossil fuel combustion have given rise to concentrations of Pb, As, Zn and Se along the Southern coast of Norway.

Studies have shown that adsorption is the major pathway of metal partitioning in aquatic environment, resulting in metal ions accumulation in the bottom sediments

(Garcia- Magarraya and Sosa, 1994; Lee and Candy, 2001; Egila and Nimyel, 2002). Therefore, sediments serve as a very important tracer of metal pollution in aquatic systems and also a better reservoir of heavy metal than the water body (Elder, 1988).

From literature, it is indicative that heavy metals could bioaccumulate in biota over a period of time (Ekwumemgbo, and Audu 2006), therefore there is need for consistent monitoring of heavy metal levels in aquatic environment especially near industrial areas, such as oil exploration zone, where there lies tendency for oil spillage.

In Nigeria industrial pollution has been identified as a priority environmental problem which must be halted without delay before disastrous health and irreversible environmental problems occur. The national guidelines and standards for environmental pollution control have been established. This is another landmark in the history of environmental protection efforts in our country and indeed in Africa (FEPA, 1991).

The present study is aimed at investigating the concentration of some heavy metals in Qua Iboe river estuary in Nigeria. The concentrations of these heavy metals shall be compared with existing standards.

Materials and Methods

The studied site was the Qua Iboe river estuary located within the oil rich Niger Delta in the South-South geopolitical zone of Nigeria. Five sampling stations were established along the creek course with upper most study site at station 1 and downstream limit study site at station 5 creek mouth. The sampling stations were chosen based on ecological settings and human activities in the area.

Water samples were collected at various stations at a depth of 50.00 cm below the water surface. Collection of water samples was carried out manually using a 2.00 L plastic beaker tied on a long rope. Samples were scooped from the river and stored in 2.00 L plastic containers until analysed. The top 20.00 cm of the bottom sediment samples were collected from each sampling station using the Eckman bottom sampler (Topouoglu et al., 2002) and stored in glass bottle until analysed. Reference samples were collected at a station situated far from the sites of industrial and domestic activities (Ekwumemgbo, and Audu 2006).

The samples were later digested following standard methods (ASTM 1990). Stock solutions of the metals were prepared and calibration standards prepared from the stock solution by dilution (Chong, 1986). Absorbance measurements of both the standards and sample solutions were read at appropriate wavelengths using a single element hollow cathode lamp on a Basic Pye Unicam model 192 Atomic Absorption Spectrometer (AAS), equipped with automatic background correction. The result of each sample was the average of ten sequential readings (Ayodele and Abubakar, 1998). The quality assurance for the analyses was conducted through the spiking method.

Results and Discussion

The results of the experiment show that the water and sediment samples collected from the various sampling stations contain measurable levels of Cd, Ni, Pb, and V as presented in Table 1. The quality assurance for the analyses conducted showed that the mean % recovery for the analyses ranged from 83.4 ± 0.15 to 95.5 ± 0.30 .

From Table 1, it can be depicted that the concentration of Pb ranged from 0.024 to 0.040 mg/l, Cd ranged from 0.002 to 0.003 mg/l, Ni ranged from 0.123 to 0.143 mg/l while V ranged from 0.030 to 0.102 mg/l in the water samples. However, the levels of all the metals in the sediments were higher than that in the water samples of the each site studied. The ranking of the mean concentrations of metal ions in the water samples was $Cd < Pb < V < Ni$. The order in the sediment samples was $Cd < Pb < Ni < V$. There was no significant difference between the amount of Pb measured in the water and sediment, while strong significant difference existed between the amounts of Cd, Ni and V ions present in the sediment samples compared to that in water. The correlation coefficient for the relationships in the metal levels of the sediments and water samples indicated high correlate, except for Cd which had a slight correlate ($r = 0.5223$).

The amounts of Cd, Ni, Pb, V in water were slightly higher than the control values, while Pb in sediment was two-fold as in the control samples, Cd in sediment was five-fold, Ni forty-fold and V two-fold the level in the control sediment samples. It is significant to note that the mean concentrations of heavy metals in the control station were lower than those obtained from stations 1 to

4 indicating that industrial and anthropogenic activities might have been responsible for the slight increase in the concentration of heavy metal in the water and sediment in estuary.

The highest concentration of Pb in both sediment and water were recorded in station 1 and least at station 4. Similar trends were observed for water and sediment concentrations of Cd, Ni and V indicating that station 4 is less exposed to heavy metals. The results further indicate that the concentrations of the studied heavy metals in the water are within the WHO permissible limit.

These finding is consistent with those reported by Ajayi and Osibanjo (1981). Sediments have been reported to form the major repository of heavy metal in aquatic system while both allochthonous and autochthonous influences could make a concentration of heavy metals in the water high enough to be of ecological significance (Allison, 1997). Several studies conducted on heavy metal retentive capacity of sediment and water have revealed that there is a constant exchange of heavy metals between sediment and water and that the concentration of heavy metals in sediment is often higher because sediment acts as a sink for heavy metals.

Highest correlation coefficient (r) was calculated for lead while least value of r was calculated for Cd. The positive correlations

obtained, indicate that the increase in the concentration of heavy metal in the sediment results to elevation of metal ion level in the water sample in this estuary.

Generally, the concentrations of the metals studied in all sampling sites indicate pollution of the system, which consequently will result in the build up of high levels in the water body of estuary in the nearest future, which may pose human environmental problems if not urgently checked.

Conclusion

Concentrations of Pb, Cd, Ni and V in the Qua Iboe river water is within permissible limits. However, there is a danger in continuous discharge of heavy metal containing waste into the estuary. Authors recommend that processes such as oil exploration, industrial discharge of waste and even discharge of domestic waste should be controlled.

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Table 1. Concentration of heavy metals in water (mg/l) and sediment (mg/kg) in oil exploitation zone of Nigeria

Station	Pb		Cd		Ni		V	
	Water	Sediment	water	sediment	water	sediment	water	Sediment
1	0.04	0.063	0.003	0.006	0.143	0.24	0.04	2.3
2	0.034	0.045	0.002	0.006	0.132	0.234	0.03	1.23
3	0.036	0.043	0.002	0.005	0.14	0.24	0.03	1.023
4	0.024	0.027	0.002	0.004	0.123	0.23	0.102	0.124
Mean	0.034	0.045	0.002	0.005	0.135	0.236	0.051	1.169
S.D.	0.0068	0.0147	0.0005	0.0010	0.0090	0.0049	0.0347	0.894
Control	0.004	0.002	0.002	0.001	0.1	0.054	0.043	0.5
R	0.9408		0.5223		0.7136		0.8605	

* r - Spearman correlation coefficient

Each concentration value represents the mean +/- standard deviation of three replicates

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