ISSN: 2141 – 3290
www.wojast.com

HEAVY METAL LEVELS IN ULTISOLS FROM AN ABANDONED BATTERY INDUSTRY ENVIRONMENT IN AKWA IBOM STATE, NIGERIA

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ABSTRACT: Inter-seasonal concentrations of six heavy metals (Pb, Ni, Cr, Cd, Sb and V) in soils collected from abandoned battery industry environment were determined using atomic absorption spectrophotometer. The mean concentrations obtained ranged between 0.022 - 0.814 ugg^{-1}, and 0.004 – 32.844 ugg^{-1} during wet and dry seasons respectively. The coefficients of variation of these metals were 42.130% and 93.094% for Pb; 20.754% and 29.930 for Ni; 11.425% and 33.434% for Cr; 37.333% and 50.00% for Cd; 129.170% and 150.00% for Sb and 18.502% and 29.930% for V during wet and dry seasons respectively. The results obtained showed higher levels of heavy metals in the soils during dry season than in wet season. The environmental and health implications of the presence of these non essential metals in the soil, uptake and bioaccumulation by crops and subsequent ingestion by man have been highlighted based on national and international permissible limits.

INTRODUCTION

The potential for environmental pollution started during the industrial revolution and since then attempt to control pollution continued since 1820 (Steinborn and Breen, 1999). Pollutants are often introduced into the atmosphere, water bodies and soils as a result of anthropogenic and natural activities and these subsequently affect the ecosystem as well as human health (Alegria et al, 1991 and Udosen, et al 2007). Moreover, the soil serves as sink for pollutants, and while acting as a buffer, it controls the movement of heavy metals to other components of the environment, namely: surface water, ground water, plant and animal food chains (Udosen, et al 2010).

In Nigeria two basic seasons exist: the rainy or wet season which often occur between April and October or November and the dry season which usually occurs between October or November and March. The soil temperature is usually higher during dry season (30 – 45^{o}C) while the soil temperature during the wet season usually ranges between 20^{o}C and 30^{o}C (Essien and Udpsen 2000). The soils of the Niger Delta region in Nigeria are generally acid soil with pH ranging from 3.0 to 5.1 (Kamalu and Isirimah, 1992). According to the author, lower pH values have been reported in the histosols (which comprised mainly of acid sulphate and organic salts of the mangrove deposits) and mineral soils (ultisols, entisols and inceptisols) of the coastal plain of the Niger Delta. Characteristically, heavy metals are non-biodegradable and therefore, are very stable and persistent in the environment.

Heavy metals discharged into our environment including their distribution and reactions in the ecosystem and subsequent uptake and bioaccumulation in plants and subsequent ingestion by man is of great concern. Therefore, conscious efforts should be made to reduce the quantity of heavy metals that might be detrimental to human, plant and animals' health which interact within this environment.

MATERIAL AND METHOD

Sampling of soils was carried out within the sunshine battery industry environment where battery waste which were stored in open drums and exposed to the atmosphere were abandoned for over twelve years. Sampling was carried out randomly at five designated points close to the drums (S_1) and at four other points about 200 metres away from each drum (S_2 to S_5). Control samples were also collected 10 kilometres away from the industry (S_6). The sample locations are shown in Figure 1.

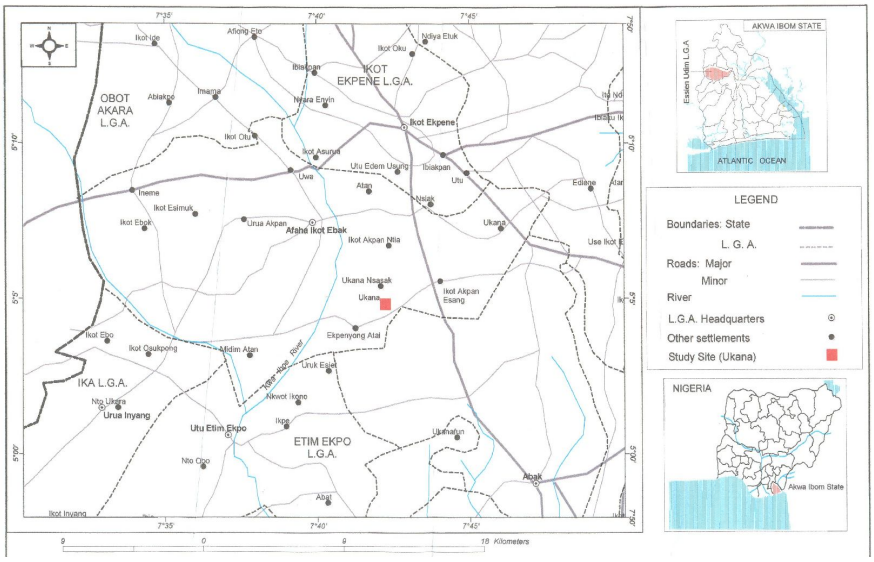

Fig. 1: Essien Udim Local Government Area showing sample locations

Soil samples were collected using soil auger and put into metal - free calico bags. The bags containing the samples were labeled and taken to the laboratory for pre-treatment prior to analysis. In the laboratory the samples were air dried, crushed and sieved using 0.2mm sieves. After sieving, they were immediately put into calico bags and kept until digestion. Each soil sample (2.0g) was placed in a teflon beaker and digestion was carried out with analar grade concentrated HNO_3-HCl solution (10ml) in a ratio of 2:1. Digested samples were filtered and made up to $10cm^3$ mark. The solutions obtained were analysed for six heavy metals (Pb, Ni, Cr, Cd, Sb and V) using Pye Unicam 939/959 Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The mean concentrations of six heavy metals (Pb, Ni, Cr, Cd, Sb and V) in soil samples from five stations within abandoned battery industry environment (S_1 to S_5) and a background site (S_6) as well as correlation coefficients in the wet and dry seasons are presented in Tables 1 – 3.

Table 1: Concentration of heavy metals in soil samples in wet season (μgg^1)

Sample ID	Pb	Ni	Cr	Cd	Sb	V
S_1	0.131	0.086	0.722	0.090	0.078	0.179
S_2	0.122	0.084	0.899	0.122	0.028	0.193
S_3	0.128	0.103	0.706	0.155	0.002	0.284
S_4	0.327	0.128	0.861	0.242	0.001	0.229
S_5	0.285	0.128	0.885	0.144	0.001	0.250
S_6	0.016	0.050	0.025	0.005	BDL	0.062
$\bar{x}$	0.216	0.106	0.814	0.150	0.022	0.227
SD	0.091	0.022	0.093	0.056	0.033	0.042
CV (%)	42.130	20.754	11.425	37.33	150.00	18.502

Table 2: Concentration of heavy metals in soil samples in dry season (μgg^{1})

Sample ID	Pb	Ni	Cr	Cd	Sb	V
S_1	78.425	0.536	0.588	0.006	0.144	0.225
S_2	42.778	0.540	0.750	0.006	0.079	0.179
S_3	4.431	0.672	0.236	0.006	0.002	0.406
S_4	33.234	0.772	0.836	BDL	0.007	0.424
S_5	5.352	0.318	0.906	0.005	0.006	0.300
S_6	0.001	0.060	0.205	BDL	BDL	0.004
$\bar{x}$	32.844	0.568	0.664	0.004	0.048	0.306
SD	30.576	0.170	0.222	0.002	0.062	0.170
CV (%)	93.094	29.930	33.434	50.00	129.170	29.930

Table 3: Correlation matrix between the heavy metals concentrations in soil samples for both wet and dry seasons

Metal	Pb	Ni	V	Cd	Cr	Sb
Pb	- 0.603	0.176	0.806	- 0.770	0.343	- 0.815
Ni	- 0.622	- 0.005	0.706	- 0.691	0.435	- 0.793
V	- 0.918*	0.106	0.762	- 0.079	- 0.391	- 0.874
Cd	- 0.425	0.605	0.802	- 0.914*	0.237	- 0.728
Cr	- 0.195	- 0.296	- 0.225	0.360	0.865	- 0.263
Sb	- 0.919*	- 0.135	- 0.669	0.422	- 0.109	0.982*

Critical r = 0.878

* Significant correlation ($p<0.05$, n=5)

During wet season, the least concentration of Pb recorded was $0.122\mu gg^{-1}$ at S_2, while in the dry season the least concentration for Pb was $4.431\mu gg^{-1}$at S_3. The highest concentration of Pb ($0.327\mu gg^{-1}$) in wet season and ($78.452\mu gg^{-1}$) in dry season occurred at S_4 and S_1 respectively. The mean levels of Pb in both seasons were $0.216\mu gg^{-1}$ and $32.844\mu gg^{-1}$ respectively. The mean Ni levels in both wet and dry seasons were $0.106\mu gg^{-1}$ and $0.568\mu gg^{-1}$respectively.

The mean concentrations of V in wet and dry seasons were $0.227\mu gg^{-1}$ and $0.306\mu gg^{-1}$ respectively. Similarly, mean concentrations of Cd in both wet and dry seasons were $0.150\mu gg^{-1}$ and $0.004\mu gg^{-1}$ respectively while levels of Cr obtained for both seasons were $0.814\mu gg^{-1}$ and $0.664\mu gg^{-1}$ for wet and dry seasons respectively and that for Sb during for wet and dry seasons were $0.022ugg^{-1}$ and $0.048ugg^{-1}$. The mean concentrations for all the metal during wet season therefore followed the trend: Cr>Pb>V>Cd>Ni>Sb while for dry season, the trend was Pb>Cr>Ni>V>Sb>Cd. From the observed trends, the high levels of Pb in both seasons could be attributable to Pb being a major raw material that was used in the production of the batteries. Contrarily, the high level of Cr during both seasons may have resulted from anthropogenic activities (Dara, 1993). The coefficients of variation for all the metals in both wet and dry seasons ranged between 11.425% and 150.0% and 29.930 and 129.170% respectively.

The concentrations of heavy metals determined were remarkably higher in dry season than in wet season indicating that these metals were immobile in the clay fractions of the soil compared to their mobility during wet season (Kersten and Forstner 1995). Pb levels were above the permissible limit of 10ppm in soil, indicating that the soil was heavily polluted with lead through bioaccumulation. The consumption of Pb in high concentration could result in the deadening of nerves receptor, decline in intelligence in children, impairment of hair, general weakness and a lot of other human diseases. The high concentration of Cr during both seasons is not a healthy development as accumulation of this metal in the environment could lead to such health effects as liver necrosis, nephritis, irritation of the gastrointestinal mucosa, digestive tract cancer, lung cancer and in very high doses death (Udosen, 1991).Antimony was about the least concentrated presumably because it was present in a very proportion in antimonial lead used in the production of battery plates. This low level notwithstanding the

presence of antimony for a prolonged period of time could pose a serious health problem as it could produce heart toxicity and sudden death in high doses. Nickel in some forms is likely to be carcinogenic in human even though clinical or epidemiological studies were not available on the defect of oral ingestion of Ni.

CONCLUSION

Results from analysis of soils from the abandoned Sunshine Battery Industry environment revealed that the concentration of Pb and other metals (except Cd) at different stations during dry season were higher than those obtained during wet season. This may be attributable to the fact that more acidic conditions during wet season produces desorption of these metals into solution making them available for plants.

It is therefore more likely that most of the Pb leached during wet season were retained in the soil during dry season due to bioaccumulation and bioconcentration. Since Pb and virtually all the other metals studied are potentially carcinogenic and have mutagenic characteristics, periodic monitoring of their levels by all concerned is absolutely necessary

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