HEAVY METAL CONCENTRATIONS IN SOIL, FLUTED PUMPKIN LEAF AND SURFACE WATER IN UMUEBULU COMMUNITY IN RIVERS STATE, NIGERIA

Orubite, K. O.
DEPARTMENT of PURE and INDUSTRIAL CHEMISTRY
University of Port Harcourt
Choba, Rivers State, **NIGERIA**

Ogunka-Nnoka, C. U.
Department of Biochemistry
University of Port Harcourt
Choba, Rivers State
NIGERIA

Okpokwu, K. K.
DEPARTMENT of PURE and INDUSTRIAL CHEMISTRY
University of Port Harcourt
Choba, Rivers State, **NIGERIA**

ABSTRACT

Concentrations of six heavy metals which include: Arsenic (As), cadmium (Cd), lead (Pb), mercury (Hg) and Zinc (Zn) in soil, fluted pumpkin leaf (*Telfaria occidentalis*) and surface water (Otamiri river) were estimated in three different locations in Umuebulu community in Etche Local Government Area of Rivers State, Nigeria (characterized by oil exploration and gas flaring). The soil and fluted pumpkin leaf samples were analyzed using x-ray fluorescence (XRF) and the surface water analyzed using Atomic Absorption Spectrophotometer (AAS). The pH of the soil (6.15-6.20) and surface water sample (6.50-6.95) range from acidic to near neutrality. The electrical conductivity for soil / surface water include 197.50/170.50,195.50/166.50 and 185.50/165.00(µS/cm) for locations 1,2 and 3 respectively. Values for location 1 differ significantly ($P \leq 0.05$) for both samples compared with locations 2 and 3. The results for heavy metals show that zinc had the highest concentration (ppm) in fluted pumpkin in all three locations. The zinc levels at locations 2 (59.80) and 3 (60.50) were significantly ($p \leq 0.05$) higher than those of location 1 (55.00). These values were not within the permissible limits of FAO/WHO. Apart from chromium (098-1.00ppm) the other heavy metals analyzed from pumpkin also had concentrations higher than FAO/WHO permissible limit. The concentrations of Zn (36.80-37.83ppm) were high for soil sample as well as for surface water (0.02-0.04ppm). These values were within the permissible limit of FAO/WHO. It is therefore evident that oil exploration and gas flaring has a negative impact in the health of people of this community following the presence of heavy metals in the pumpkin leaf.

Keywords: Heavy Metals, Soil, Fluted Pumpkin Leaf, Surface Water, Umuebulu.

INTRODUCION

The biological and toxic roles of heavy metals have been studied extensively in recent times. The result of which has contributed to various remedial actions taken up by government to improve the quality of the environment. Human exposures to these toxic metals are usually through the consumption of polluted plants grown on polluted soil as well as the consumption of polluted surface water. Oil exploration and gas flaring are possible causes of environmental hazard.

LITERATURE REVIEW

Heavy metals such as Cd, Zn,Pb,Cr,Fe and Cu are commonly found on contaminated sites (Oathman, 2001). Sources of heavy metal contamination to the environment have been identified by various researchers to include; exhaust pipes, waste water effluents and oil exploration activities. Specifically, in the Niger Delta region of Nigeria, oil exploration activities and its effects on the environment has been reported by some researchers (Olayinka, 2004; Idodo-Umeh, 2002). The implication of gas explosive on human health are all related to the exposure of those hazardous air pollutant emitted during incomplete combustion, acid rain effect and subsequent acidification of the soil (Akhionbare,2011). Bioaccumulation of these heavy metals has been identified mainly in surface water, soil and in plants (Akoto etal. 2008).

The supply of clean and uncontaminated water is a great challenge facing developing nations. In Nigeria, pollution is a major threat to both surface and underground water bodies (Oathman, 2001;Osabolien et al. 2013). Green vegetables such as pumpkin leaf from a substantial portion of the daily human diet of the southern part of Nigeria. These are grown on all types of available land such as banks of polluted rivers, alongside road and areas enclosing waste water ponds. These plants absorb some of these chemicals which are toxic to human health (Baranowska et al. 2002) Industrial emissions of contaminant to the atmosphere which is finally deposited on soil may cause some pollution problem. The contaminant concentration in soil mainly depends on the adsorption properties of soil matter (Deka and Sarma 2012). The high toxic and persistent nature of heavy metals in the environment has made them priority pollutants. These present study quantified the heavy metals; Zn, Pb, Cr, Cd, Hg and As in soil, fluted pumpkin leaf and surface water from different locations in Umuebulu community in Etche Local Government Area of Rivers State of Nigeria.

METHODOLOGY

Sample Collection

A random composite sampling method was used in areas 350m east (L1), 500m west (L2) and 400m north (L3) of Shell Petroleum Development Company field operation center in the community. Sampling was done between June and September. Fluted pumpkin (*Telfaria occidentalis*) was plucked from the farm at different locations. Soil samples were collected at the root zone of the fluted pumpkin plant at a depth of about 8cm with a plastic cup. Both samples were placed in separate polythene bags. The water sample was collected from Otamiri River at points, 4km, 2km and 1.4km north of Shell field operation center with a plastic bottle.

Sample Preparation

Fluted pumpkin leaf were destalked, washed with deionized water and subsequently placed on a foil in an oven to dry at 60^{O}C for 18hrs. The sample was ground, sieved using a 60 micron mesh size to a obtain a fine powder**.** This was bagged in polythene bag for analysis. Soil sample was air dried for 3 days and further dried at 60^{O}C in an oven for 18hrs. Sample was bagged until ready for use. The water sample was filtered through whattmann No.1 filter paper previously rinsed with deionized water and bottled in plastic bottles. The sample was stored in a refrigerator until ready for use.

Experimental Procedure

pH / Electric conductivity determination: Soil and surface water sample were analyzed for pH according to standard methods (APHA, 1985) soil sample weight of 10g was measured into a 250ml conical flask containing 50ml deionized water. The flask was stoppered and placed in a shaker for one hour. Thereafter the sample was filtered into a beaker using a whattmann No.1 filter paper. The pH (MKV, pH meter) of the filtrate was measured after calibration. pH of the surface water was also measured using 40ml in a beaker. Electric conductivity measurement using weiber µ-process conductivity meter, followed the same procedure as in pH above.

Heavy Metal Determination

After the pretreatment of the fluted pumpkin and soil samples, the heavy metal contents were determined using X-ray florescence (model:xepose 03STD Gas). Whereas, the heavy metal contents of surface water after acidification were determined using a Perkin Elmer Model 2380 Atomic Absorption Spectroscopy (Perkinelmer, 1982).

Statistical Analysis

The results were statistically analyzed by analysis of variance and means were compared using least significant different (LSD) at 95% confidence level (Wahua, 1999).

RESULTS

Table 1 show the pH and electric conductivity of soil and surface water. The pH (6.15-6.20) for soil sample in all locations tend to be acidic; whereas the pH (6.50-6.95) of surface water in all locations varied from acidic to near neutrality. There is no significant ($P \geq 0.05$) difference observed in the various locations for any of the samples. However, there is a significant ($P \leq 0.05$) difference between the pH of the soil sample and that of the surface water.

Table 1: pH and Electrical Conductivity of the various samples

Sample Type /Location	pH	Electrical Conductivity (µS/cm)
Pumpkin leaf (L1)	ND	ND
Pumpkin leaf (L2)	ND	ND
Pumpkin leaf (L3)	ND	ND
Soil (L1)	6.15 ± 0.07^{a}	197.50 ± 0.7^{d}
Soil (L2)	6.20 ± 0.28^{a}	195.50 ± 0.3^{d}
Soil (L3)	6.20 ± 0.00^{a}	185.50 ± 1.23^{c}
Surface water (L1)	6.50 ± 0.57^{b}	170.50 ± 0.51^{b}
Surface water (L2)	6.70 ± 0.00^{b}	166.50 ± 0.24^{b}
Surface water (L3)	6.95 ± 0.21^{bc}	165.00 ± 1.4^{ab}

Values are means ± SD of triplicate determinations. Means on the same column not followed by same superscript differ significantly ($p \leq 0.005$).

The electrical conductivity as shown in Table 1 for soil/surface water samples include; 197.50/170.50,195.50/166.50 and 185.50/165.00 for locations 1,2 and 3 respectively. Values for soil and surface water from location 1 differ significantly ($P \leq 0.05$) from the other locations. The concentrations (ppm) of the heavy metal studied in pumpkin leaf are shown in Table 2. Values above the FAO/WHO permissible limit were recorded for Zn(56,93-60.21), Cd (2.80-3.56), Pb(2.39-3.22, As (0.49-0.50) and Cr(0.10-0.11) using fluted pumpkin sample. The concentration of Zn in location 3 (60.21) significantly differ from locations 1 and 2.

Table 2: Heavy Metal Contents present in the various samples

Sample type /Location	Heavy metals					
	Arsenic	Cadmium	Lead	Mercury	Chromium	Zinc
Pumpkin leaf (L1)	0.05±0.01[b]	3.25±0.21[c]	2.39±0.03[b]	0.10±0.01[b]	1.001±0.01[b]	56.93±0.01[d]
Pumpkin leaf (L2)	0.50±0.01[b]	2.80±0.03[ab]	2.82±0.12[b]	0.11±0.02[b]	0.98±0.04[b]	59.79±0.01[e]
Pumpkin leaf (L3)	0.49±0.01[b]	3.56±0.08[c]	3.22±0.14[b]	0.11±0.00[b]	1.00±0.04[b]	60.21±0.42[e]
FAO/WHO	(0.1)*	(0.2)*	(0.3)*	(0.03)*	(2.3)*	(55)*
Soil (L1)	0.80±0.01[c]	0.10±0.00[a]	12.93±1.18[d]	0.10±0.01[b]	12.61±0.01[c]	36.52±0.04[b]
Soil (L2)	0.50±0.001[b]	0.10±0.00a	13.35±0.64[d]	0.103±0.004[b]	14.36±0.07[d]	36.83±0.02[b]
Soil (L3)	0.51±0.00[b]	0.10±0.00[a]	11.87±0.04[c]	0.10±0.03[b]	16.75±0.07[e]	37.73±0.00[c]
FAO/WHO	(30)*	(2.5)*	(300)*	(2)*	(175)*	(260)*
Surface water (L1)	0.002±.003[a]	1.50±2.12a[b]	0.01±0.01[a]	0.00±0.00[a]	0.01±.01[a]	0.04±0.01[a]
Surface water (L2)	0.001±0.01	0.00±0.00[a]	0.003±0.01[a]	0.002±0.02[a]	0.003±0.01[a]	0.02±0.01[a]
Surface water (L3)	0.00±0.00[a]	0.002±0.00[a]	0.00±0.00[a]	0.001±0.00[a]	0.003±0.00[a]	0.04±0.02[a]
FAO/WHO	(0.1)*	(0.01)*	(0.1)*	(0.05)*	(1.0)*	(15.0)*

Values are means ± SD of triplicate determinations. Means on the same column not followed by same superscript differ significantly ($p \leq 0.005$).
()*= values are EPA and FAO/WHO standard for the corresponding samples.

Soil samples (Table 2) recorded higher significant ($p \leq 0.05$) values for chromium (12.61-16.75) lead (11.87-13.35) and zinc (36.52-37.73). However, Zn is significantly ($p \leq 0.05$) higher in location 3 followed by chromium and lead in locations 3 and 2 respectively. Heavy metal concentrations in the surface water (Table 3) are so minimal ranging from 0.00-1.50ppm for all locations. Although cadmium in location 1 (1.50ppm) had a value above the recommended level. Based on the various locations for the samples studied, some of the heavy metal concentrations are not location dependent. The values obtained were below the FAO/WHO permissible limit. Figure 1. Compared the heavy metals concentrations in location 1 for all the samples with zinc having the highest value (0.04-56.93ppm) and mercury having the least value (0.00-0.10).

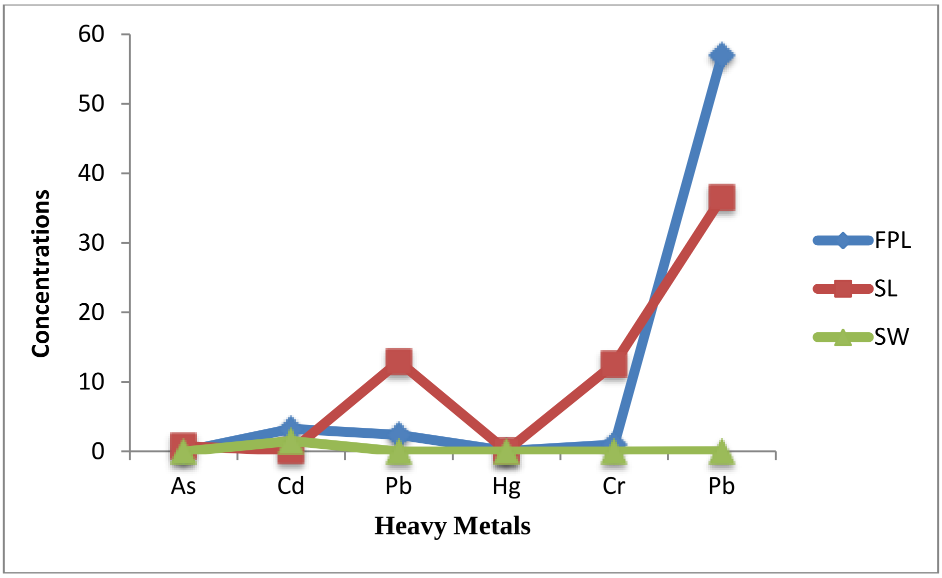

Figure 1: Heavy Metal concentrations present in the various samples in location 1

DISCUSSION

The pH of the soil and surface water in all locations ranged from the acidic region to near neutrality. pH variation in the surface water, significantly influenced the dynamics of heavy metal concentrations present in the surface water. Ahikionbare (2011) reported that higher metal concentration was observed during the early rain in April which correspond to low pH; higher pH which corresponds with those of low metal concentrations showing a significant correlation between them. The present study however, is in line with this observations. The electrical conductivity which is a measure of how well a material accommodates the movement of an electric charge indicates non salanity of the soil (Zhangreen et al. 2002). Deko and Sarma, (2012) reported that the solubility of heavy metal ions in soil is mainly influenced by pH and conductivity. Soil electric conductivity can serve as a proxy for soil physical properties such as organic matter and cation exchange capacity (Khattak and Page, 1992). Cation Exchange Capacity (CEC) are largely determined by the concentration of negatively changed group (OH^-). As pH increases, the negative charge on such surfaces is increased. These negatively charged sites may increase the probability of absorption of positively charged ions (metal ion) in the surrounding soil by increasing CEC (Khattak and Page, 1992; Wegglerr et al. 2004).

The heavy metal concentration in surface water for all locations reported in this study, showed that they were all within permissible limit except for cadmium in location 1. Zureru et al. (1989), reported that when water pH declines (during acidic rain or other acidic episode), heavy metals can be mobilized and leached into the water column. Also, heavy metals may be affected by various surface water components (e.g carbonate, sulphates, organic compounds etc) and form insoluble salts or complexes. Akhionbare and Akhionbare, (2004) reported a higher concentration of heavy metals in sediments than in surface water in Otamiri rivers during rainy season. The concentrations of these heavy metals present in the soil were all low compared with FAO/WHO permissible limit. Dekor and Sarma, (2012) reported that the contaminant concentration in the soil which arise from industrial emission depends on the adsorption properties of soil matter. The adsorption properties are largely determined by organic matter such as phenolic group with -OH. Such as -OH group may extract heavy metals in the soil forming organic complexes. Dekor and Sarma, 2012; Basta and Tabatabai 1992; Xu and Yang 1982; also reported that environmental factors such as

Anthropogenic activities, land use, lithogenic contribution via run off erosion, deposition of eroded materials, temperature etc can artificially change organic matter content as well as heavy metal concentration in the soil. The heavy metals studied in fluted pumpkin with the exception of chromium had values higher than FAO/WHO recommended permissible levels. The bioaccumulation of these metals into the pumpkin leaf may be due to non formation of complexes with the organic matters in the soil thereby making it possible for these metals to leach from the soil into the plant. (Deko and Sarma, 2012;Kabatta and Henryk 1984). Akhionbare and Akhionbare, (2004) reported that increase in total zinc content of the soil could lower fluted pumpkin lead accumulation. Zhangreen et al. 2002, also reported that the soil, root and stem play a role in the process of heavy metal transport. These The level of Pb,Cr and Zn reported in the pumpkin leaf from these locations also corresponds to the study of Oshman, (2001) for pumpkin and Amaranths leaf. Comparing the average heavy metal contents obtained in vegetable to the maximum levels permitted by FAO/WHO, we observed that people eating vegetable grown at these locations, were consuming it at concentration levels that are potentially hazardous to their health.

CONCLUSION

Concentrations of metals present in some of the samples were not location dependent although in others there was significant difference in terms of location. Zinc and cadmium were more in location 3 for pumpkin leaf whereas, soil samples had more Zn, Cr followed by Pb in location 2. The concentrations of these metals in soil and surface water were within the permissible limit. However, heavy metal concentrations in fluted pumpkin leaf are above FAO/WHO permissible limit. Due to the high heavy metal concentrations generated through gas flaring activities, fluted pumpkin leaf from this area may appear unsafe for human consumption.

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