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Full Length Research Paper

Assessment of Heavy Metals Concentrations in Soils and Edible Vegetables Grown in Core Crude Oil Producing Communities of Ibeno, Akwa Ibom State, Nigeria

Etim, A. O[1]. Ekpo, F. E[2*]. Okeke, A. I[1].

[1]Department of Forestry and Environmental Management, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria.
[2]Department of Biological Sciences, Akwa Ibom State University, Ikot Akpaden, Mkpat Enin, P. M. B. 1167, Uyo, Akwa Ibom State, Nigeria.

Abstract

Studies of heavy metals concentrations in soil samples and edible vegetables (*Telfaiferia occientalis* and *Vernonia amygdalina)* were investigated in three core crude oil producing communities (Mkpanak, Ukpenekang and Inuayet Ikot) of Ibeno Local Government Area in Akwa Ibom State during the rainy and dry seasons and the control sites at Etinan L G. Area. Each sample was replicated three times. The levels of heavy metals in the samples collected were determined using Atomic Absorption Spectrophotometer (AAS) Unicam 919 model. The concentrations of heavy metals in soil samples during dry season were higher than those recorded in the rainy season in all the sample locations. The concentrations of heavy metals observed in soil depth (0-15 cm) were significantly higher than those recorded in (16-30cm) soil depth. The concentrations of heavy metals in edible vegetables (*Telfaiferia occientalis* and *Vernonia amygdalina)* collected from the three core crude oil producing communities of Ibeno exceeded the maximum permissible limits values of heavy metals for edible vegetable as prescribed by FEPA and WHO. The soils and edible vegetables in the core oil producing communities of Ibeno are contaminated and may pose serious adverse effect to humans and the environment.

Keywords: Heavy Metals, Soils, Edible Vegetables, Core Oil Communities.

INTRODUCTION

Heavy metals are present in the environment and most of them are essential for animals and plants. They are natural constituents of rocks and sediments. Heavy metals contamination of the environment is of major concern because of their toxicity and threat to human life and the environment (Anthwange *et al.,* 2012). Heavy metal pollution can affect all facets of the environment but their effects are most long lasting in soils and plants due to the relatively strong absorption of many metals onto humic and clay colloids in soil and bioaccumulation in plants (Alloway and Arye*,* 1994). The role of heavy metals in the ecosystem is increasingly becoming an issue of global concern, especially as it constitutes a crucial component of human life (Purves, 1990; Adekola and Mitchell, 2011). Soil contamination with heavy metals through the repeated use of untreated or poorly treated waste from industries and oil exploration and exploitation activities is one of the most severe ecological problems in the core crude oil producing communities in Akwa Ibom State. Heavy metals constitute a main group of soil pollutants that their contamination in environment affects all ecosystem components (Edem *et al*., 2008). Although heavy metals are present as natural components of soils, toxic contamination may frequently occurs at industrial and mining sites (Das, 1999; Kuo*et al*., 2011). Heavy metals such as Cu, Zn, Mn and Fe are essential for plant

*Corresponding Author Email: aoetim@yahoo.com

growth; many of them do not have any significant role in the plant physiology. The uptake of these heavy metals by plants is an avenue of their entry into the human food chain with harmful effects on health (Abbas *et al*., 2010; Basta *et al*., 2010). Crude oil contained various types of hazardous wastes that are being discharged during oil exploration, exploitation, storage and transportation processes (Iwegbue et al., 2009, Clevenger et al., 2001). Consequently the wastes from crude oil exploration and refining processes are disposed into drains, canals and rivers without treatment and the wastes are dumped into surrounding land or water bodies which contaminate the soil or water with highly toxic inorganic or organic pollutants. The continuous receiving of crude oil waste especially by land poses a great threat to the soil and plant in the core oil producing community (Wassay et al., 2001). The harmful inorganic and organic substances in the crude oil wastes degrade the soil and changing the composition of existing heavy metals and other organic constituents. As a result the plants and animals that depend directly or indirectly on the polluted soil are affected. When these plants are eaten by man, the heavy metals become bioaccumulated and eventually result in several ailments which may subsequently end up in death (Odiette, 1999; Adriano, 2003). Plants can accumulate some of these metals which are not injurious to them, but may be poisonous to animals grazing on the plants (Raven and Evert, 2006). Thus, this research work aims at investigating the influence of heavy metals in soils and edible crops grown within core crude oil producing communities of Ibeno in Akwa Ibom State, Nigeria.

MATERIALS AND METHODS

Description of Study Site

The study area was on the pollution impact of crude oil in core crude oil producing communities of Ibeno Local Government Area of Akwa Ibom state. Ibeno, lies within latitude 5° and 6° N and longitude 4° and 5° E. Ibeno occupies the South- South part of Akwa Ibom State. It is bounded on the North by Esit Eket Local Government Area, on the West by Eket local government area and on the South by Atlantic Ocean. The area experiences the normal Niger Delta climatic conditions. The climate of the area is basically that of the equatorial tropical rainfall occurring almost through the year except in December, January and February, which are not completely free from rainfall in some years. The annual rainfall of the area is about 2, 500mm (Bisong, 2011). Annual mean air temperature is 31.3°C; the highest monthly mean temperature was 29.7°C in (August), and the lowest monthly mean temperature is 27.5°C in (January). The major occupation of the people includes fishing and agricultural activities in the area. The four major oil companies operating in the area include Ashiland Nigeria Limited, Mobil Producing Nigeria, Shell development Company Nigeria and Nigeria Agip Oil Producing Company.

Samples Collection

Soil and plant samples were collected during rainy and dry seasons from the core oil producing communities of Ibeno (Mkpanak, Ukpenekang and Inuayet Ikot) Akwa Ibom State. The soil samples were collected using a soil auger from 0-15cm and 16-30cm soil depths. The samples were put into polyethylene bags, labeled and taken to the laboratory for pre-treatment and analysis. Similarly, the leaf samples of pumpkin (*Telfaiferia occientalis)* and bitter leaf *(Vernonia amygdalina)* commonly used in making vegetable soup in the area were obtained from the core oil producing communities of Ibeno Akwa Ibom State and put into polyethylene bags, labeled and taken to the laboratory for further treatment and analysis. Samples of both soils and edible vegetables were collected in triplicate. Control samples were also collected at Etinan Local Government Area where there is no oil processing activity.

Sample Treatment and Analysis

Soil samples were air-dried at ambient laboratory temperature. The soil samples were ground using mortar and pestle and sieved to pass through 2 mm sieve and stored for chemical analysis. Each soil sample (5g) was placed in a Teflon beaker and digestion was carried out using concentrated nitric (10 cm^3) and concentrated perchloric (5cm^3) acids in the ratio of 2:1 (Gokoglu and Yerlikaya, 2003). This was allowed to cool before leaching the residue with 5 cm^3 of 20% HNO_3. Digested samples were filtered and made up to 50 cm^3 with deionized water. A blank determination was treated in the same method but without sample. Solution of samples were then taken and aspirated into Atomic Adsorption Spectrophotometer (Unicam Solaar A.A.S 969 model). Each plant sample was oven-dried at 50˚C - 60˚C. The dry sample was ground into powder and stored. The powdered plant sample (2g) was weighed into a crucible and ashed in a furnace at 500˚C-700˚C for 4 hours. It was removed after ashing from the furnace and cooled. The sample (ash) was leached with 5 cm^3 of 6 MHCl and was made to 50 cm^3 of volume of deionized water. Blank determination was also carried out as in a similar way as described above except for the omission of the sample (AOAC, 1990). The solutions were analyzed for metals using A. A. S (Unicam Solaar A.A.S 969 model).

RESULTS

Table 1 shows the concentrations of heavy metals

Table 1. Concentrations ($mgkg^{-1}$) of heavy metals in soils (dry and rainy season) in core crude oil producing communities in Ibeno L. G Area, Akwa Ibom State

		Mkpanak		Ukpeneikang		Inua eyet Ikot		Etinan (Control)	
		Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
Fe	0 - 15cm	135.17	229.30	157.60	245.20	145.16	230.25	57.55	65.50
($mgkg^{-1}$)	16- 30 cm	78.10	85.12	71.25	101.15	88.90	120.75	35.22	39.14
Pb	0-15cm	31.58	54.40	31.75	45.65	1.60	29.80	0.54	1.05
($mgkg^{-1}$)	16-30cm	1.25	1.75	1.15	1.36	1.24	1.30	0.15	0.20
Cu	0-15cm	3.35	3.10	3.05	3.20	2.95	3.45	1.05	1.08
($mgkg^{-1}$)	16-30cm	2.20	2.65	2.05	2.25	1.50	1.65	0.65	0.75
Cd	0-15cm	0.15	0.22	0.12	0.25	0.11	0.27	0.01	0.01
($mgkg^{-1}$)	16-30cm	0.05	0.10	0.02	0.09	0.05	0.11	0.00	0.01
Zn	0-15cm	10.30	18.50	13.45	27.15	15.13	22.50	3.50	3.14
($mgkg^{-1}$)	16-30cm	5.17	9.50	7.90	11.28	7.10	12.90	2.15	1.75
Mn	0-15cm	32.20	40.23	34.18	45.12	30.29	42.25	9.45	12.50
($mgkg^{-1}$)	16-30cm	23.29	27.10	19.00	25.90	22.30	30.14	7.55	8.00

obtained from soil samples from core crude oil producing communities (Mkpanak, Ukpenekang and Inuayet Ikot) in Ibeno Local government Area of Akwa Ibom State in the dry and rainy seasons. The concentrations of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) in soils during dry season were (229.30 $mgkg^{-1}$, 54.40 $mgkg^{-1}$, 3.10 $mgkg^{-1}$, 0.22 $mgkg^{-1}$, 18.50 $mgkg^{-1}$ and 40.23 $mgkg^{-1}$) in Mkpanak community respectively. While the concentrations of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) in soils during rainy season were (135.17 $mgkg^{-1}$,31.58 $mgkg^{-1}$, 3.35 $mgkg^{-1}$, 0.15 $mgkg^{-1}$, 10.30 $mgkg^{-1}$ and 32.20 $mgkg^{-1}$) in Mkpanak community respectively. At Ukpeneikang community the concentrations of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) in the soils during dry season were (245.20 $mgkg^{-1}$, 45.30$mgkg^{-1}$, 3.30$mgkg^{-1}$, 0.25$mgkg^{-1}$, 27.12$mgkg^{-1}$ and 45.17$mgkg^{-1}$) respectively.. While the concentrations of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) recorded in soil obtained from Ukpeneikang community during rainy season were (157.58$mgkg^{-1}$, 31.25$mgkg^{-1}$, 3.05$mgkg^{-1}$, 0.12$mgkg^{-1}$, 13.45$mgkg^{-1}$ and 34.18$mgkg^{-1}$) respectively. Similar variations were observed at the Inuaeyet Ikot community. At Etinan L. G. Area (control site) the concentration of heavy metals (Fe, Pb, Cu, Cd, Zn and Mn) in soil during dry control season were (65.50 $mgkg^{-1}$, 1.05$mgkg^{-1}$, 1.08$mgkg^{-1}$, 0.01$mgkg^{-1}$, 3.14$mgkg^{-1}$ and 8.00$mgkg^{-1}$) respectively. The concentration of heavy metals (Fe, Pb, Cu, Cd, Zn and Mn) in soils during rainy season were (57.55$mgkg^{-1}$, 0.54$mgkg^{-1}$, 1.05$mgkg^{-1}$, 0.01$mgkg^{-1}$, 3.50$mgkg^{-1}$ and 7.55$mgkg^{-1}$) respectively at the control site. The concentrations of heavy metals recorded in topsoil (0-15cm) soil depth were higher than those recorded in subsoil (15-30cm) depth in all the studied communities.

Table 2 shows the concentrations of heavy metals in edible vegetables ((*Telfaiferia occientalis* and *Vernonia amygdalina)* in each of the studied communities during dry and rainy season. The concentration of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) recorded in the leaves of ((*Telfaiferia occientalis) during* rainy season were (152.00 $mgkg^{-1}$, 0.98$mgkg^{-1}$, 1.16$mgkg^{-1}$, 0.75$mgkg^{-1}$, 55.00$mgkg^{-1}$ and 20.43$mgkg^{-1}$) respectively in Mkpanak oil producing community. While the concentrations of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) recorded in the leaves of ((*Telfaiferia occientalis)* during dry season were (*140.90*$mgkg^{-1}$, 0.75 $mgkg^{-1}$, 1.05 $mgkg^{-1}$, 0.65 $mgkg^{-1}$, 4.20 $mgkg^{-1}$ and 18.25$mgkg^{-1}$) respectively in Mkpanak community. The concentration of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) in bitter leaf (*Vernonia amygdalina*) recorded during rainy season were (143.55 $mgkg^{-1}$, 1.00 $mgkg^{-1}$, 1.10 $mgkg^{-1}$, 0.68 $mgkg^{-1}$, 54.20 $mgkg^{-1}$ and 18.20 $mgkg^{-1}$) respectively in Mkpanak community. While the concentration of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) in bitter leaf (*Vernonia amygdalina*) observed during dry season were (137.15 00 $mgkg^{-1}$, 0.76 00 $mgkg^{-1}$, 0.95 00 $mgkg^{-1}$, 0.5900 $mgkg^{-1}$, 51.0100 $mgkg^{-1}$ and 17.00 00 $mgkg^{-1}$) respectively in Mkpanak community. Similar trend of heavy metals concentration were observed in Ukpeneikang and Inua eyet Ikot oil producing communities. The concentrations of heavy metals analyzed in the edible vegetables (fluted pumpkin and bitter leaf) were higher during rainy season than the dry season. At Etinan L. G. area (control site), the concentrations of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) recorded in ((*Telfaiferia occientalis)* during rainy season were (64.40 $mgkg^{-1}$, 0.01 $mgkg^{-1}$, 0.12 $mgkg^{-1}$, 0.02$mgkg^{-1}$, 25.60 $mgkg^{-1}$, 10.20$mgkg^{-1}$) respectively. While the concentration of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) observed during dry season in pumpkin leaves were (54.75 $mgkg^{-1}$, 0.01 $mgkg^{-1}$, 0.01 $mgkg^{-1}$, 0.01 $mgkg^{-1}$, 22.12$mgkg^{-1}$ and 7.00$mgkg^{-1}$) respectively in control site. The concentration of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) recorded in bitter leaf (*Vernonia amygdalina)* during rainy season were (60.10 $mgkg^{-1}$, 0.02$mgkg^{-1}$, 0.10$mgkg^{-1}$, 0.01$mgkg^{-1}$, 24.75$mgkg^{-1}$ and

Table 2. Concentrations ($mgkg^{-1}$) of heavy metals in edible vegetables (dry and rainy season) in core crude oil producing communities in Ibeno, Akwa Ibom State

		Fe ($mgkg^{-1}$)		Pb ($mgkg^{-1}$)		Cu($mgkg^{-1}$)		Cd ($mgkg^{-1}$)		Mn ($mgkg^{-1}$)		Zn ($mgkg^{-1}$)	
		Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
Mkpanak	Fluted Pumpkin	152.10	140.90	0.98	0.75	1.16	1.05	0.75	0.65	55.10	45.20	20.43	18.24
	Bitter leaf	143.55	137.15	1.00	0. 76	1.10	0.95	0.68	0.59	54.20	51.01	19.20	17.00
Ukpeneikang	Fluted Pumpkin	155.60	135.65	0.95	0.80	0.97	1.02	0.50	0.70	57.40	50.75	22.50	20.00
	Bitter leaf	160.20	145.40	0.78	0.64	1.00	0.87	0.85	0.71	59.15	49.35	21.35	22.50
Inuaeyet Ikot	Fluted Pumpkin	147.10	142.30	1.05	0.90	0.85	1.00	0.70	0.60	52.55	53.90	19.50	16.90
	Bitter leaf	150.20	130.70	0.80	1.00	0.90	0.82	0.68	0.55	50.30	47.35	21.75	18.65
Etinan (Control)	Fluted Pumpkin	65.40	54.75	0.01	0.01	0.12	0.01	0.02	0.01	25.60	22.12	10.20	7.00
	Bitter leaf	60.10	55.00	0.02	0.01	0.10	0.05	0.01	0.01	24.75	20.16	10.40	8.55

Table 3. Physico- chemical properties of soils (dry and rainy season) from core crude oil producing communities in Ibeno L. G Area, Akwa Ibom State

		Mkpanak		Ukpeneikang		Inua eyet Ikot		Etinan (Control)	
		Rainy	Dry	Rainy	Dry	Rainy	Dry	Rainy	Dry
Sand (%)	0-15cm	80.30	82.21	80.50	81.16	83.20	85.19	76.15	78.90
	16-30cm	76.5	76.7	76.4	76.8	73.13	79.25	71.30	77.18
Silk (%)	0-15cm	5.27	6.50	5.37	6.55	5.50	6.90	5.10	5.95
	16-30cm	3.75	4.67	3.67	4.30	4.65	4.19	3.23	4.56
Clay (%)	0-15cm	13.1	11.5	12.54	13.50	11.50	12.19	13.00	13.11
	16-30cm	19.6	20.7	11.42	13.20	11.76	12.55	11.65	12.75
pH	0-15cm	4.90	6.50	5.20	6.55	5.25	6.75	6.45	6.50
	16-30cm	4.70	6.40	5.15	6.20	5.90	6.00	5.50	5.75
Organic matter (mg/l)	0-15cm	1.34	1.65	1.75	2.15	1.10	1.70	1.87	2.35
	16-30cm	0.95	1.05	0.75	1.00	1.05	0.85	1.20	1.50
Organic carbon	0-15cm	1.28	1.15	1.94	2.05	1.45	1.89	2.10	1.99
(mg/l)	16-30cm	0.45	0.75	1.10	1.22	1.04	0.86	1.00	1.40
N (%)	0-15cm	1.10	1.45	1.30	1.49	1.40	1.61	1.24	1.53
	16-30cm	1.05	1.01	0.98	1.20	1.20	1.41	1.11	1.33
P (mg/l)	0-15cm	0.45	0.76	1.00	1.10	1.02	1.15	1.16	1.09
	16-30cm	0.15	0.12	0.25	0.75	0.54	0.67	0.50	0.85
K (mg/l)	0-15cm	0.35	0.65	0.74	0.95	0.92	1.00	1.00	0.90
	16-30cm	0.25	0.27	0.45	0.35	0.50	0.78	0.55	0.75
Ca (mg/l)	0-15cm	4.43	5.52	3.55	5.97	5.10	6.00	5.10	5.55
	16-30cm	3.05	3.12	2.90	4.52	4.00	5.15	3.90	4.55
Mg (mg/l)	0-15cm	4.15	4.45	4.10	5.11	4.00	4.75	4.65	5.00
	16-30cm	2.54	3.10	3.85	4.25	3.30	3.55	4.20	4.30

10.45mgkg^{-1}) respectively in the control site. while the concentration of heavy metals (Fe, Pb, Cu, Cd, Mn and Zn) observed in bitter leaf (*Vernonia amygdalina)* during dry season were (55.00mgkg^{-1}, 0.01mgkg^{-1}, 0.05mgkg^{-1}, 0.01mgkg^{-1}, 20.16 mgkg^{-1}and 8.88mgkg^{-1}) respectively in the control site. The physico chemical properties measured in the soil showed ranges of pH, 4.70 -6.70, Organic matter, 0.79 - 1.93%, Silt, 2.64 – 12.0%, Clay, 3.76 – 20.40%, Sand, 73.5 – 93.6% and textural class of predominantly loamy sand at the spilled site and sand at the control sites (Table 3).

DISCUSSIONS

The concentrations of the heavy metals during dry season were higher than the concentrations of heavy metals during the rainy season in all the soil samples. Similarly, the topsoil (0-15cm) concentrations of the heavy metals were higher than the subsoil (15-30cm) concentrations. These observations are attributed to the washing effect of rainfall during the rainy season which reduces the concentrations of metals in the soil samples. The higher concentrations of heavy metals recorded in (0-15cm) soil depth may be attributed to oil exploration and exploitation activities and other human activities in the core oil producing communities of Akwa Ibom State. The result was in line with the work of Ideria et al., (2013) who reported the higher concentration of heavy metals in the top soil obtained from Niger Delta region of Nigeria. The dry and rainy seasons soil samples showed a significant difference ($p<0.05$) for all the metals analyzed. Statistical analysis also showed that the difference between the soil depths (0-15cm and 16-30cm) concentrations of the heavy metals were significant ($p<0.05$). The concentrations of heavy metals recorded from the soil samples obtained from the core oil producing communities in Ibeno Local Government Area of Akwa Ibom State where higher than those from the control sites. The higher concentration of heavy metals recorded in all the soils collected from core oil producing communities may be attributed to the various activities of oil companies in the communities. Also responsible for the high concentration of heavy metals in the soil samples obtained from core crude oil producing communities may be due to frequent oil spills as a result of oil exploration, exploitation and oil processing activities. However, the lower values of heavy metals observed at the control site (Etinan Local Government Area) in the soil samples may also be due to the fact that there is no activity of crude oil exploration and exploitation actives going on in the area.

The higher concentration of heavy metals observed in top sol is attributed to tiling of the soil during cultivation and abandoned metal parts buried in the soil. The concentrations of the heavy metals in the soil samples obtained from the core crude oil producing communities were higher than the FEPA (1991) and WHO (2001) permissible limits. While the concentrations of heavy metals recorded in the soil samples obtained from the control site were within the permissible limits. This implies that the soil samples obtained from core crude oil producing communities in Ibeno L. G. Area of Akwa Ibom State are contaminated with metals and pose serious environmental and health concern.

The edible vegetables ((*Telfaiferia occientalis* and *Vernonia amygdalina)* obtained from core oil producing communities of Ibeno Local Government Area recorded the highest concentrations of heavy metals during rainy season. The concentrations of the metals in edible vegetables obtained during rainy season were significantly higher ($p<0.05$) than those obtained during dry season in all the plant samples. The result was in line with the work of Ekpo *et al.,* (2014) who reported the bioavailability of metals during rainy season. The bioavailability of heavy metals in the core crude oil producing communities may be attributed to the frequent oil spills and improper disposal of wastes in the community. The concentrations of heavy metals recorded from the plant samples obtained from the core oil producing communities where higher than those from the control sites. The higher concentration of heavy metals in plant samples collected from core oil producing communities may be due to the incessant crude oil spillage arising from the oil production activity in the community. The situation is increasingly becoming a concern to the people of the area as oil companies are expanding and waste treatment facilities are either inadequate or not available.

The results obtained from laboratory analysis indicate that soils and edible vegetables obtained from core oil producing communities of Ibeno Local Government Area are contaminated with heavy metals. Although, a number of heavy metals are essential for biological systems, it deficiency symptoms are noted with depletion or removal which disappear when the elements are returned to the biological system. However, essentials heavy metals become toxic when their concentration level exceeds those required for correct nutrition. According to Walter et al. (2005) metals toxicity occurs when an organisms is unable to cope with additional metal concentration by direct usage, storage and excretion.

CONCLUSION

The concentrations of heavy metals recorded in soil and edible vegetable samples obtained from core crude oil producing communities of Ibeno Local Government Area, Nigeria were higher than the FEPA and WHO permissible limits. Therefore, edible vegetables grown in core crude oil producing communities in Ibeno Local Government Area pose health hazards for consumers.

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