Standard Scientific Research and Essays Vol 4(7): 236-243, July 2016 (ISSN: 2310-7502)
http://www.standardresearchjournals.org/journals/SSRE

Research Article

The impact of gas flaring on heavy metal concentration in Okpai soil, Ndukwa East Local Government Area, Delta State, Nigeria

***Otunkor Oliver Olisemauchei and Ohwovorione Peter Avwerosuoghene**

School of General Studies, Delta State Polytechnic, Ogwashi-Uku, Nigeria

*Corresponding Author E- mail: oliseoliver4real@yahoo.com, **ohwopet1@gmail.com**

Accepted 1 July 2016

Abstract

The work examines the impact of gas flaring on heavy metal concentration in soil of Okpai, Ndukwa East Local Government Area, Delta State, Nigeria. To achieve this, the study employed a systematic sampling technique in collection of soil samples on a linear transit at distances away from the flare site at two different depths of 0-15cm and 15-30cm. A total of 10 samples were collected. Soil samples collected were analyzed in the laboratory for heavy metal concentration in soil. Result from the laboratory analysis shows that gas flaring contributes to the enrichment of heavy metal concentration in soil of the study area with some above the toxic threshold and others within the toxicity threshold. This is with exception of lead that is below the toxic level. Result also shows that heavy metal concentration in soil of Okpai is not a function of distance and depth from the flare site. This is due to the fact that these heavy metal elements are carried by wind and are deposited at different distances.

Keywords: Impact, Gas Flaring, Heavy Metal Concentration, Soil

INTRODUCTION

Due to oil and gas exploration, exploitation and production in Okpai and its environs, the environment is being degraded, deteriorated and destroyed as in other parts of Niger Delta. This fragile environment is being polluted by the introduction into it of substances and energy that are liable to cause hazards to human health, harmful to living organisms, resources and ecological systems as well as interference with legitimate uses of the environment. Oil production activities are detrimental to man and its environment through gas flaring and oil spillage. In Okpai, oil exploration and exploitation activities have seriously affected the environment such as soil, water bodies, vegetation, wild life and the atmosphere (Turner, et al 1990). Gas flaring results in heating up of the environment known as thermal pollution. Thermal pollution results from the use of fire (burning) directly on the environment. In Okpai, gas flaring is the major source of thermal pollution. This goes on for 24 hours every day, for more than three decades. Thermal pollution causes a distinct micro-climate around the vicinity of operation (Alakpodia, 1989).

These activities release harmful and poisonous elements/substances such as heavy metals to the air which end up in the soil and water bodies. Soil being one of the components of the eco-system which support flora and fauna as well as man is most affected by these substances. This component of the environment is in danger due to oil pollution in Niger Delta especially in oil bearing communities.

Degradation and deterioration of soil and the destruction of vegetation also characterize the area. This affects soil fertility, agricultural potentials, other related activities and practices in Okpai and its environs. Vegetation and the health of the people are not spared from the detrimental effects of gas burning (gas flaring). There is also enrichment of heavy metals in soil and its consequent effect on crops, vegetation, man and animals since they ultimately find their way into the food chain, albeit in small doses. These accumulate overtime and across trophic levels to pose serious health hazards to man (Pickering and Owen, 1997). This study is therefore set out to examine the impact of gas flaring on heavy metal concentration in Okpai soil, Ndukwa East Local Government Area, Delta State, Nigeria. It is to make information available on the effects of gas flaring on heavy metal concentration on Okpai soil where there is dearth of information presently.

The effects of gas flaring on heavy metals concentration in the soil

Heavy metals are metals having densities greater than $5gcm^3$. They constitute non-biodegradable pollutants and include mercury (Hg), lead (Pb), cadmium (Cd), chronium (Cr), vanadium (vi), iron (Fe), cupper (Cu) nickel (Ni) (Maclaren and Cameron, 1990). These metals are toxic to man and animals when they are at sufficiently high levels or dosages.

Public attention has been drawn in recent years to environmental contamination by these inorganic compounds. The prime target in environmental research today is to determine the concentration levels of these heavy metals as well as to elucidate the chemical forms in which they appear (Onuoha, 1996). The burning of fossil fuels, smelting and other processing techniques release into the atmosphere tones of these elements which can adversely affect surrounding vegetation and soil component. These “aerosol” dust particles may be carried far and later deposited on the vegetation and soil. These elements enter into the life cycle and become harmful to living organisms especially when they accumulate in animal and human body tissues to toxic levels.

Studies carried out by Kakulu and Osibanjo (1988) and Osibanjo and Kakulu (1992) revealed elevated levels of Pb, Cr, Ni, and Zn in Port Harcourt and Warri sediments which suggest that effluents from petroleum refineries located in these cities have contributed significantly to the heavy metal pollution of the respective aquatic ecosystems.

Okoye et al. (1991) reported anthropogenic heavy metals enrichment of Cd, Co, Cu, Cr, Fe, Mn, Ni, Pb and Zn in the Lagos lagoon and implicated land based urban and industrial wastes sources as responsible.

Ndiokwere and Guinn (1983) determined As, Cd, Cr, Hg, Mn, Mo, Ni, Se and Pb in two Nigerian rivers and two harbours and attributed high metal concentrations to local pollution sources. In their study of streams and lakes around Ibadan, Mombeshora et al. (1983) reported much higher levels of lead in sediments than in water. The highest levels of lead coincided with areas of high traffic density. A study carried out by Hart et al. (2005) on concentrations of trace metals (lead, iron, copper and zinc) in crops harvested in some oil prospecting locations in Rivers State, Nigeria shows a high level concentration of heavy metals in crops analysed especially zinc and lead.

Sridhar (1988) analyzed the aquatic plant *Pistia stratiotes* and showed that the shoot system accumulated more K, Ca and Mg, whereas the roots accumulated significantly more Cd, Cr, Co, Fe, Pb, Hg, Ni and Zn. Also, Deekor (2002) worked on the impact of gas flaring on wetland soils of the Niger Delta using Ebocha and Obigbo. He observed that heavy metal concentrations in the soils of these areas were low. He however noted that industrial processes which include burning of crude oil in oil wells and flow stations release significant amounts of heavy metals into the atmosphere, which in turn contaminate vegetation and soil in the Niger Delta region.

Pelig Ba (1991) examined the level of contamination of drinkable ground-water from the Accra plains and upper regions of Ghana and found that in some areas Pb, Cr, and Fe concentration exceeded the WHO guideline limits for drinkable water. Also, Achebe and Epstein (2000) reported that arsenic is introduced into the groundwater from erosion and dissolution of arsenic containing mineral ores. In addition, the combustion of fossil fuels is a significant source of arsenic in the environment. Arsenic has been found in the wells dug for drinking water in the River Niger Delta and long term exposure has been linked to a variety of illness including hypertension, diabetes, cardiovascular disease, infertility, cancers of the skin, lungs, urinary bladder and kidney.

MATERIALS AND METHODS

Study Area

Okpai is one of the communities in Niger Delta region of Nigeria. It is rich in oil and gas. Okpai is under the local jurisdiction of Ndokwa East Local Government Council Area of Delta State. Okpai lies within latitudes 5.5^0 17^1N and 5.2^0 14^1N of the Equator and longitudes 4^0 40^1E and 4^0 45^1E of the Greenwich Meridian. It is located in the lower Niger floodplain of the Central Delta Socio – Economic Zone (EIA of Okpai, 2003). It is bounded in the East by the River Niger, in the West by the Ase River, on the South by Onuabo community and on the North by Umuagboma and Benuku communities.

Okpai people are mainly subsistence farmers with few traders. The crops that are usually grown are cassava, yam, vegetables, plantain and coco-yams. They practice mixed cropping with these crops in combination. Plantation agriculture is carried out in this area with plantain and pineapple dominating (EIA of Okpai, 2003). The Okpai people are of the Ukwani ethnic group with a population of about 2,038 (NPC, 1991) which was projected to 2,324 (NPC, 1996).

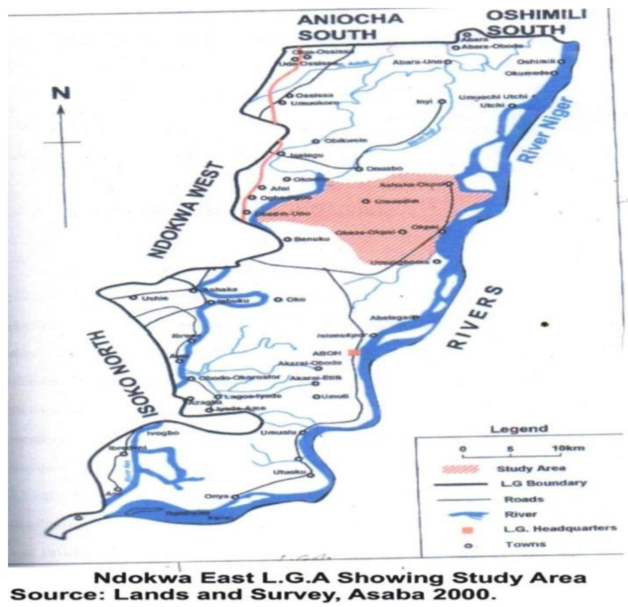

Figure 1. Geographical map of the study Area

Sample Collection

Systematic sampling method was used in the collection of soil samples. The soil samples were collected on a linear transect in the direction of the wind. This is because wind is known to influence the direction or orientation of a burning flame and hence its associated gases and particles. The wind direction was determined during the reconnaissance survey using a wind vane. The soil samples were collected at a determined interval of 50 meters from the embankment or bond wall (barrier built to confine the flaring site). From the bond wall, soil samples were collected from five points, which were labeled A, B, C, D and E, with E being the most distant point. A total of 10 soil samples were collected at depths of 0–15cm and 15–30cm which were referred to as topsoil and subsoil respectively. At each point, four soil samples were collected around the point to form a composite sample. The linear transect method was chosen for this study so as to ensure that the relationship between distance from flare site and changes in heavy metal concentration of the soil are properly represented and to further facilitate a proper data analysis. However, the control site was located at Aboh where flaring is not taking place.

The instruments employed for the work and laboratory test are soil, tape, meter rule, cutlass, soil auger, polythene bags, centigrade thermometers, recording book, soil testing kit and chemicals.

Data analysis

The soil samples collected were analysed in the laboratory for heavy metal concentration. Heavy metals were determined, using the Atomic Absorption Spectrophotometer (American Standard Testing On Spectrophotometer (AMST) 1982). The heavy metals that were analysed are lead (Pb), cadmium (Cd), iron (Fe), copper (Cu) and nickel (Ni). These were chosen because some are trace elements to plants and toxic at low level concentration.

RESULTS AND DISCUSSION

Analysis of Heavy Metal Concentrations in Okpai Soil

The data on heavy metal concentration is shown on Tables 1, 2 and 3. Table 1 shows the values of heavy metals analysed for both the top-soil and sub-soil. On the other hand, Table 2 shows the range and mean values of heavy metal concentration in the soil. While Table 3 shows the mean values of heavy metal concentration in distances away from the flare site.

Table 1. Photochemical Properties of Heavy Metals in Soil of Okpai and Control Site

No of points	Sample Depth (cm)	Dist. From Flare site(m)	Lead(Pb) (ppm)	Nickel(Ni) Ppm)	Cadmium(Cd) (ppm)	Iron(Fe) (ppm)	Copper(Cu) (ppm)
	0 - 15	50	20.00	6.00	2.00	3750	0.005
A	15-30	,,	20.00	4.00	2.00	4520	0.005
	0-15	100	10.00	7.00	5.00	4550	5.00
B	15-30	,,	20.00	6.00	0.00	3890	5.00
	0-15	150	10.00	0.05	3.00	1150	3.00
C	15-30	,,	2O.00	0.05	3.00	3460	4.00
	0-15	200	10.00	6.00	3.00	4230	7.00
D	15 -30	,,	20.00	6.00	9.00	4330	2.00
	0-15	250	0.08	3.00	6.00	4280	0.005
E	15-30	,,	10.00	2.00	11.00	4530	5.00
CONTROL	0-15		6.71	0.26	0.27	3390	0.64
SITE	15-30		3.45	0.04	0.15	3984	0.25

Table 2. Range and Mean Values of Photochemical Properties of Heavy Metals In Soil of Okpai and Control Site

	Affected Area		Control site	
Heavy Metals	**Range**	**Mean**	**Range**	**Mean**
Lead (ppm)	0.08-20.00	14.01	3.45-6.71	5.08
Nickel (ppm)	0.05-7.00	4.01	0.04-0.26	0.15
Cadmium (ppm)	0.00 – 11.00	4.40	0.15 – 0.27	0.21
Iron (ppm)	1150 – 4550	3869	3390 – 3984	3687
Copper (ppm)	0.005 – 7.00	3.102	0.25- 0.64	0.45

Table 3. Mean Values of Heavy Metals Concentration in Distances Away from the Flare Site

No of Points	Dist. From Flare Site(m)	Lead (ppm)	Nickel (ppm)	Cadmium (ppm)	Iron (ppm)	Copper (ppm)
A	50	20	5.0	2.0	4135	0.005
B	100	15	6.5	2.5	4220	5.00
C	150	15	0.05	3.0	2305	3.50
D	200	15	6.0	6.0	4280	4.50
E	250	5.04	2.5	8.5	4405	2.50

LEAD (Pb)

The data in Table 1 show enrichment in concentration of lead in soil of Okpai. The values range from 0.08 to 20.0ppm with a mean value of 14.01ppm as shown in Table2. These figures show considerably high level of lead concentration in the area. The control site shows low level of lead in soil which ranges between 3.45 to 6.71ppm with mean value of 5.08 ppm.

NICKEL (Ni)

Nickel from the analysis of result is high. The range is from 0.05 to 7.00ppm and a mean value of 4.01ppm (Table 2). The values obtained from the control site are low which range from 0.04 to 0.26 ppm with mean value of 0.15 ppm.

CADMIUM (Cd)

The data in Table 1 indicate the concentration level of cadmium in soil of Okpai. Table 2 shows the concentration of cadmium as ranging from 0.00 to 11.00 ppm and having a mean value of 4.40 ppm. This value shows significant enrichment of cadmium in soil of Okpai. This value is far higher than 0.21 ppm which is the mean value for control site.

IRON (Fe)

Results from Tables 1 and 2 show a very high level of iron in soil. The values range from 1150 to 4550 ppm with a mean value of 3869 ppm (see Table 2). The control site shows a high level of iron in soil ranging between 3390 to 3984 ppm with mean value of 3687 ppm.

COPPER (Cu)

The copper content of soil in Okpai as shown in Table 1 is moderate. The concentration level ranges between 0.005 – 7.00 ppm. This has a mean value of 3.102 ppm. This is considered moderate. For the control site, the value of copper ranges between 0.25 to 0.64 ppm with mean value of 0.45 ppm.

Considering the analysis of heavy metals, lead was found to be considerably low in soil of Okpai. Lead is insoluble in soil especially if the soil is not very acidic. Gas flaring contributes to lead concentration in soil of this area. The mean value obtained (14.01 ppm) is far below 300 to 1,200 ppm toxic threshold stated by United States Environmental Protection Agency. The soil is not therefore contaminated by lead.

From the analysis of result, nickel is seen to be low at 150 m point and considerably high on others. On the average, nickel is observed to be high with mean value of 4.01 ppm. This figure is higher than 0.5 – 2.0 ppm for heavy metals toxic thresholds to plant growth recorded by Bowen (1979) and with-in the toxic thresholds level (7.0 – 10.0 ppm) recorded by Baker and Eldershaw (1993). Although nickel is considered a trace element for most plants, it is very toxic to plant at high concentration. At this level of concentration in soil of Okpai, nickel could be said to be at a toxic level.

The concentration level of cadmium in soil of the study area is high. The high level of cadmium in soil of Okpai indicates that this metal contaminates the soil. The mean value obtained (4.40 ppm) is higher than the toxic threshold of 1.5 ppm recorded by Baker and Eldershaw (1993). This value also falls within 0.2 to 9.0 ppm toxic threshold to plant growth obtained by Bowen (1979). However, the uptake of cadmium is usually high in acid soils like that of Okpai.

Iron from the analysis has a very high level of concentration in soil of the area both at the flaring area and the control site. Thus, the concentration of iron can be said to be generally high and not caused by gas flaring. When compared with the toxic threshold concentration in soil, it was found out that there is no agreeable toxic threshold for iron in the soil especially in the tropics because tropic soils are high in iron concentration.

The concentration of copper in soil was found to be moderate. However, the mean value obtained falls within the toxic thresholds levels to plant growth recorded by Bowen (1979). The toxic threshold is 0.5 – 8.0 ppm. Though copper is a micro nutrient for plant, it is however highly toxic to plant at higher levels in the soil. Therefore, at this level of concentration of copper in soil of the study area, copper could be said to be toxic to plants depending on the tolerant capacity of the plant(s).

The concentration levels of these heavy metals considered are illustrated in the graphs shown in figures 2 to 6. The graphs give a clear view of the concentration and distribution pattern of these heavy metals in soil with in the study area. A critical look at the graphs reveals that soil in the area is significantly enriched with these heavy metals. Cadmium shows increasing pattern away from flare site.

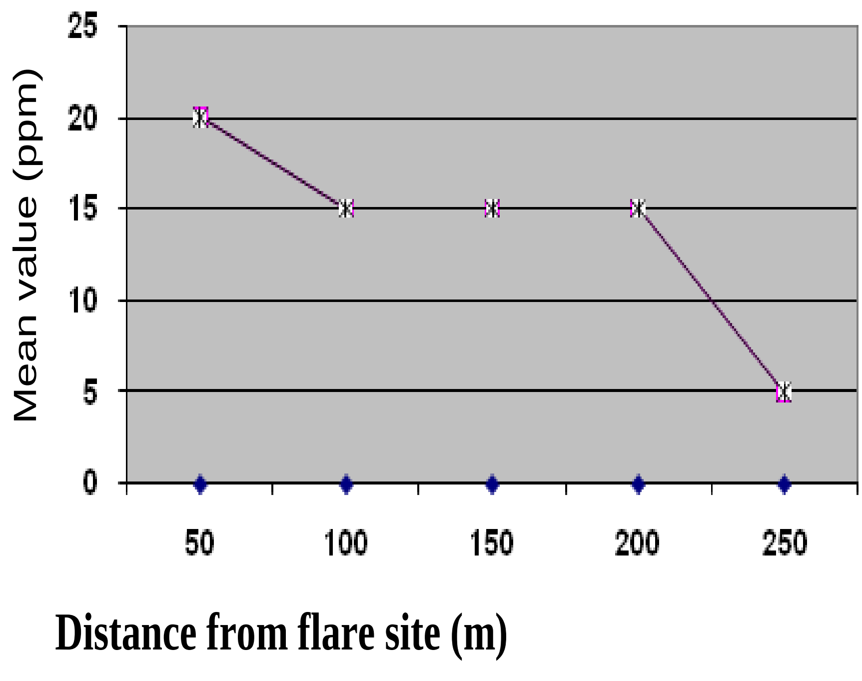

Figure 2. Concentration and Distribution of Lead

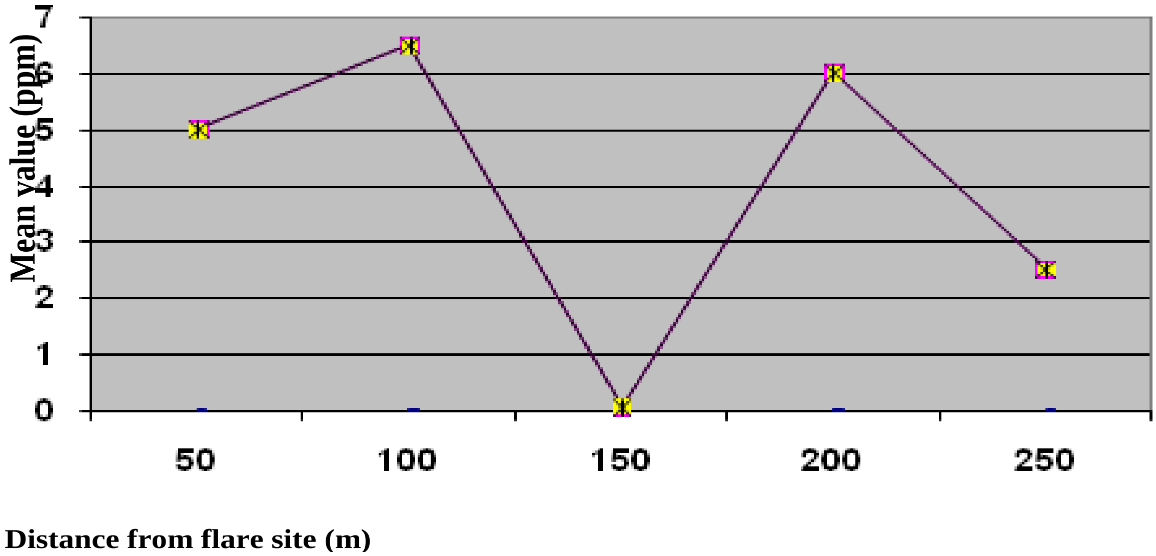

Figure 3. Concentration and Distribution of Nickel

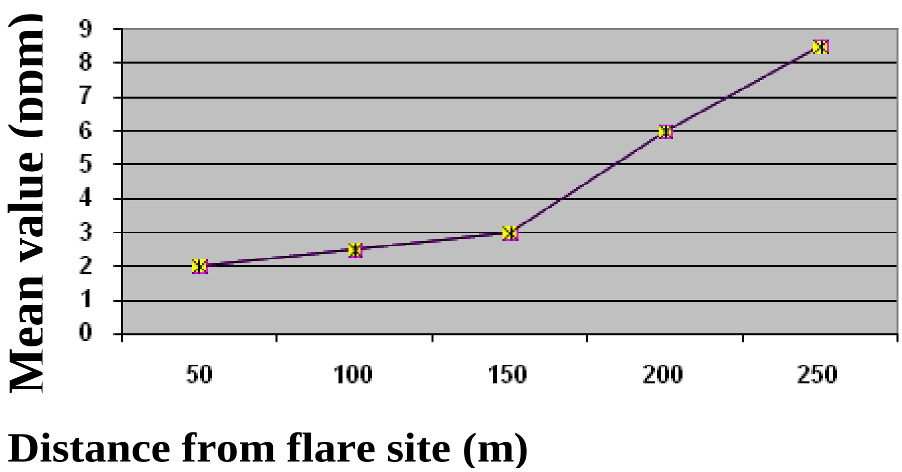

Figure 4. Concentration and Distribution of Cadmium

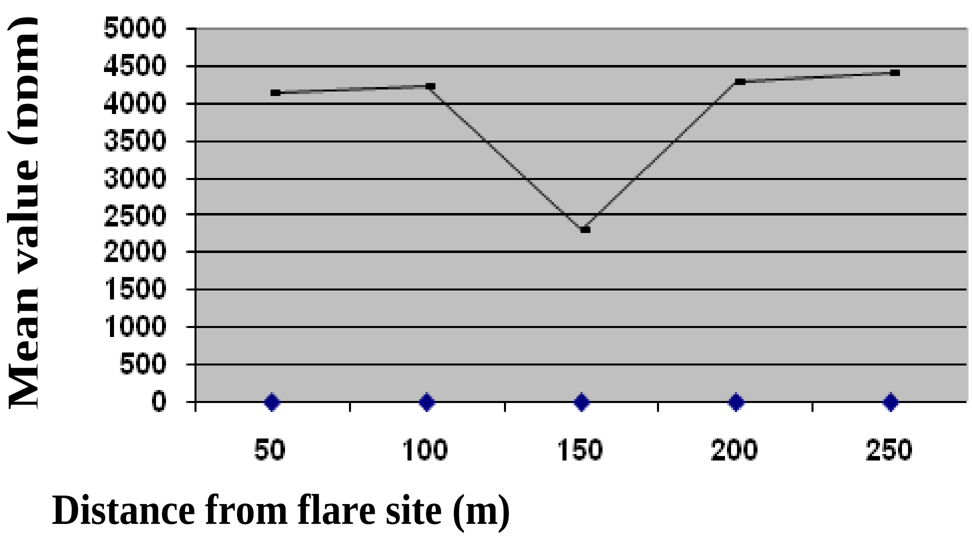

Figure 5. Concentration and Distribution of Iron

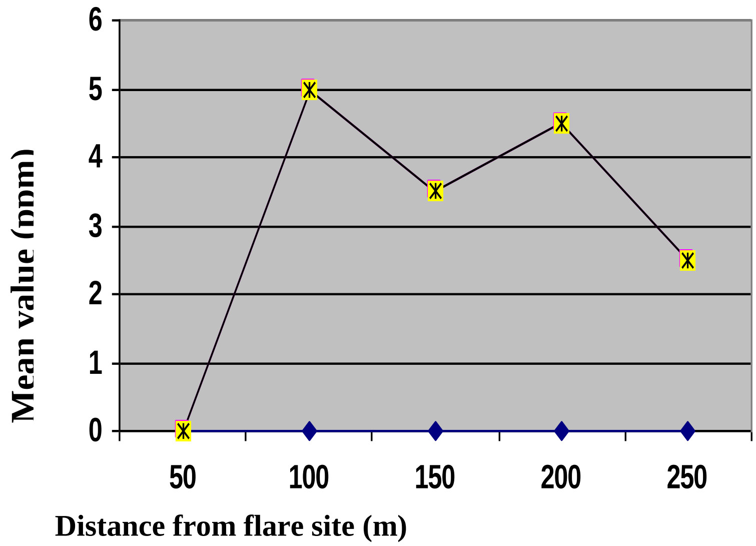

Figure 6. Concentration and Distribution of Copper

This enrichment of heavy metals in Okpai soil could be traced to industrial processes of NAOC through gas flaring and oil spillage. This is because it is the only industrial activity going on in the area that could contaminate the soil as well as the whole environment. Thus, gas flaring contributes mainly to the enrichment or high level of heavy metals concentration in soils of Okpai. This affects plants growth by interfering with enzyme activities and preventing the absorption of essential nutrients. However, the effect of heavy metals on crops/plants depends on the tolerance level of such crops/plants.

CONCLUSION

In conclusion, the study reveals a high concentration or enrichment of heavy metals in the soil of Okpai in comparison with the control site. However, lead was seen to be lower than the threshold level. Apart from lead, other metals considered are at toxic and above toxic levels. Thus, the high concentration or enrichment of heavy metals in Okpai soil is due to the activities of the oil company operating in the area through gas flaring and oil spillage. Though, these elements are essential for plant growth but detrimental to plants, crops and man at toxic levels especially when they found their way to consumables like vegetables, root crops and other food crops.

The activities of oil companies pollute the environment, their economic benefits notwithstanding. Therefore, these activities should be well regulated legislations and their detrimental impacts properly compensated for to mitigate its effects on the people's health, livelihood and the environment.

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