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EVALUATION OF HEAVY METALS CONTAMINATION OF SOIL AND VEGETATION IN THE VICINITY OF DANGOTECEMENTFACTORY IN OBAJANA KOGI STATE NIGERIA

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ABSTRACT

In this work, soil and plant (Mango leaf) samples were collected in the Vicinity of Obajana Cement Factory in Kogi state Nigeria and analyzed for Fe, Zn and Pbusing Atomic Absorption Spectrometer. The results of the metal analysis in soil (534.80µg/gFe, 10.10µg/gZn and 1.50µg/gPb)andplant(25.90µg/gFe, 3.60µg/gZn and 0.40µg/gPb) samples exceeded their threshold values. The threshold values for Fe , Zn and Pb in soil are 145.16, 0.60 and0.006µg/g respectively and in plant they are 0.003, 0.001 and 0.001 µg/g for Fe, Zn and Pb respectively. The results further revealed that the metal distribution were in a fluctuating manner considering various distances and directions from the cement factory. However, it was observed that the mean metal levels in the soil and plant decrease as distance from the cement factory increased for most metals. This indicated that the factory which is the only industrial source in the area is the major cause of the pollutants contamination in its vicinity. It is recommended that further studies should be carried out on how to protect environment and human health of people living around cement and similar factory.

Keywords: Heavy metal, Contamination, Vegetation, Toxicity, Cement factory.

1. INTRODUCTION

Air pollution has long been recognized as a lethal form of pollution. Much of the problems of societal concern today are the heavy metals associated with air pollution. Heavy metal mobilization in the biy6osphere by human activities has become an important process in the geochemical cycling of these metals (Pandey *et al.,*2010). This is evident in industrial areas where stationery and mobile sources release large quantities of heavy metals into the atmosphere, soil and plants exceeding the natural emission levels (Cao *et al.,*2010). Pollution of the natural environment by heavy metal is a worldwide problem because these metals are indestructible and most of them have toxic effects on living organisms, when they exceed a certain concentration (EPA, 2010).

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Most heavy metals can be found generally at trace levels in soils and vegetation and in living organisms that need some of them as micro-elements (Abbas *et al.,*2010). Metal distribution between soil and vegetation, is a key issue in assessing environmental effect of metals in the environment (Orisakwe *et al.,*2012). Heavy metal toxicity has an inhibitory effect on plants growth, enzymatic activity, stomata functions, photosynthesis activity and accumulation of other nutrient elements, and also damage the root system (Usman and Abdus - Salam 2011). On the otherhand, soil is not only a medium for plant growth or pool to dispose of undesirable materials, but also a transmitter of many pollutants to surface water, groundwater, atmosphere and food (Mwegoha and Kihampa, 2010). Therefore, soil pollution may threaten human health not only through its effects on the hygiene quality of food and drinking water, but also through its effect on air quality especially in enriched trace metal content in airborne particles originating from soil.

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The determination of the metals in soils, dusts, plants and sediments are very important in monitoring environmental pollution. The contribution of metals to environmental pollution from industrial, agricultural and mining processes besides automobile emission, have been the main subject of many studies and research in recent years (Jawa, (2010, Dean *etal*;2014). Botanical materials such as fungi, lichens, tree barks, tree rings, leaves of higher plants and soil samples have been used to detect the deposition, accumulation and distribution of metal pollution (Yuanan, 2013). Abbas *etal*(2010) has observed that the most economical and reasonable method for monitoring heavy metals in the atmosphere is using soil and vegetation samples. Hence, soil and vegetation have been widely used as cumulative matrices of long and short term exposure respectively to environmental pollutants (Fotiadis and Lolas, 2011).

Atmospheric emissions from industrial establishments are one of the major sources of environmental pollution. One type of industry that causes particle pollution is the cement industry (ZHAO Hua- rong *et al.,*2012). The main inputs of cement activity on the environment are the broadcasts of dust and gases (Bilen, 2010). Cement dust spreads along large areas through wind, rain etc. and are accumulated in and on soils, plants and animals and can affect human health badly (ZHAO Hua- rong *et al.,*2012). Heavy metals are among the most relevant substances emitted during the process of cement manufacture (Semhi *et al.,*2010). The influence of cement dust as a major cause of heavy metal contamination in plants and soils has been observed by several researchers (Bilen,2010, Semhi et al; 2010).

Among the metals especially known to have toxic effect in environmental studies are lead, arsenic, cadmium, mercury and thallium (Yahia[1,2*] and Almgrabi[2], 2013).Zinc, Aluminum, beryllium, chromium, copper, manganese, and nickel, among others, have been identified in the emission from cement plants (Fotiadis and Lolas, 2011). The main purpose of the present study was to evaluate the environmental impact caused by dust emissions from a Dangote cement factory in Obajana. Specifically, the study focuses on the dispersion of heavy metals on soils and vegetation around the cement factory.

2. EXPERIMENTAL

2.1. Study Area

The study area was at Dangotecementcompany, Obajana Kogi State, Nigeria. It is located in Oworo district of Lokoja Local Government Area of Kogi State.The company lies within longitudes 6°24'E and 6°27'E and latitudes 7°54'N and 7°56'N (Fig.1). It covers an area of approximately 696.81 Km^2 and has an undulating surface and slopes gently downward in a southwest – northeast trend. The area is characterized by wet and dry seasons. The wet season starts in April and last until November. The wet season on the average lasts for about 217 days while the dry season starts from November-March and lasts for about 151 days (Elueze *et al.,* 2015).The vegetation is guinea savannah consisting of tall grasses, low trees and shrubs. In the wet season, this vegetation grows to become thick and impenetrable in some parts. In the dry season however, the grasses become dry and are burnt annually. The cement factory is about 50minutes drive from Lokoja (Fig 1). There are no other industrial developments within the area. The cement factory plays a significant role in the local building industry in theeconomy of Nigeria. The Dangote-owned factory was established in 1992 and was a major employer in the area. The factory's surrounding area is essentially rural with minor agricultural activities. Settlements are scattered houses at varying distances with the nearest settlement of about 250m (Elueze *et al.,* 2015).

2.2. Sample Collection and Preparation

Random sampling was carried out on the entire study area to provide a satisfactory environmental representation of the study area, the entire factory environment was divided in to four sitesnamely North, South,West and East, with the factory at the centre surface. Soil and plant (Mango leaf) samples were collected at each of the designated sites. The Mango leaf was selected as an important representative species of the annual vegetation of the area and was collected simultaneously with the soil at the same point where the plant grows.

Soil samples were taken with a small plastic shovel from 0 – 10 cm below the soil surface and scrapped into labeled polythene containers of approximately 90 cm^3. Any large stones or foreign objects were removed. In the laboratory,the soil samples were mixed together and sun-dried in plastic bowl for five consecutive days and were screened through a 110μm mesh sieve to obtain a more homogeneous distribution. The screening process further enabled the removal of small stones, roots and large organic residues. These oversized materials were discarded and were not included in the analysis.

The plant samples were obtained by cutting healthy mature Mango leaves from each designated sites. The plant sample was mixed together and immediately packed in aluminum foil and labeled accordingly as the soil samples. Subsequently, it was dried in an oven at a temperature of 60°C for two days after which they were pulverized in a wooden mortar and kept in similar plastic containers as the soil until analysis

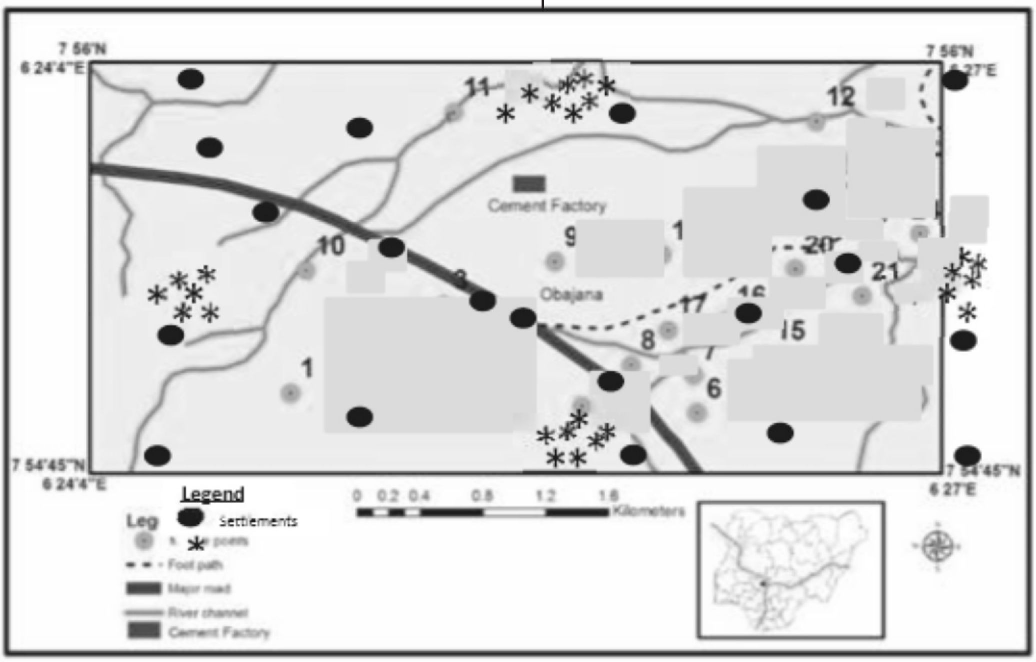

Figure 1:Location map of the study area showing sampling points around the cement Factory

2.3.SampleAnalysis

A. Soil

One gram of the soil sample was weighed into a 125 ml beaker and digested with a mixture of 4 ml, 25 ml and 2 ml each of concentrated $HClO_4$, HNO_3 and H_2SO_4 respectively on a hot plate in a fume cupboard, On completion of digestion, the samples were cooled and 50 ml of de- ionized distilled water was added and then the samples were filtered. The samples were made up to 100 ml with de- ionized distilled water and concentrations of the Iron (Fe), Zinc (Zn) and Lead (Pb) determined using Atomic Absorption Spectrophotometer Model No.AA280FSat Multipurpose Users Laboratory, Ahmadu Bello University Zaria Kaduna state, Nigeria().

B. Mango leaf

A 2.0g of the plant sample (in duplicate) was weighed out into Kjedah flasks, mixed with 20 ml of a mixture of sulphuric acid, perchloric acid and nitric acid in the ratio 1 : 4 : 40 by volume respectively, and left to stand overnight (to prevent excessive foaming). Thereafter, the flasks were heated moderately at 70^0C for about 40 minutes and then gradually increased to 120^0C. The mixture turned black after a while and the digestion was complete when the solutions became clear and white fumes appeared (Mizuguchi *et al.,*2011). The digests were diluted with about 20 ml of de- ionized distilled water and boiled for another 15 minutes. These were then cooled and transferred into a 100 ml volumetric flask and diluted to the mark with de – ionized distilled water. The sample solutions were then filtered into screw capped polyethylene bottles, and used for analysis of the Fe, Zn and Pb using

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Atomic Absorption Spectrophotometer Model No.AA280FS at Multipurpose Users Laboratory, Ahmadu Bello University Zaria Kaduna state, Nigeria (Mizuguchi *et al.,*2011).

C. Instrumental Analysis

An Atomic Absorption Spectrophotometer Model No.AA280FS equipped with a digital read- out system was used for the determination of the element concentrations. Working standards were prepared by further dilution of 1000ppm stock solution of each of the elements. A calibration curve was constructed by plotting absorbance versus concentration. By interpolation, the concentrations of the elements in the sample digests were determined using Atomic Absorption Spectrophotometer Model No.AA280FS at Multipurpose Users Laboratory, Ahmadu Bello University Zaria Kaduna state, Nigeria (Mizuguchi *et al.,*2011).
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3. RESULTS AND DISCUSSION

Table 1 shows the mean levels of Fe, Zn and Pb in soil sampled in the vicinity ofObajana cement factory. As it can be seen Fe recorded the highest level (534.80µg/g) followed by Zn (10.10µg/g) and the least is Pb (1.50µg/g).These results are much higher than that obtained by (Addo *etal*., 2012) who carried out similar study in the vicinity of a full fledge cement factory in Spain which has operated for over 40 years as against the sixteen years period of Obajana cement factory. This result is quite high when compared with (WHO/FAO, 2011) permissible limits of Fe, Zn and Pb in soil which are 145.16, 0.60 and 0.006µg/g respectively. According to the present study the level of Pb is alarming suggesting thatPb pollution is criticalin the investigated area. Generally the levels of these metals understudy are higher than their average abundance in the continental crust (Maleki and Zarasvand, 2010). The elemental concentration of these metals in the soil are in the order Fe> Zn >Pb.

Table 1. Mean Heavy metal concentration in soil sample collected in the neighbourhood of ObajanaCement factory (µg/g)

Metals	Min	Max	Mean	SD
Fe	0.47	691	534.80	± 17.07
Zn	0.00	12.10	10.10	±1.04
Pb	0.00	2.17	1.50	±0.12

SD – Standard Deviation

Mean Levels of these metals in the plant sample (Mango leaves) obtained in the neighbourhood of the cement factory are shown in Table 2. The highest level corresponded to Fe (25.90µg/g) followed Zn (3.60µg/g). Here again the lowest level was recorded in Pb (0.40µg/g). The result indicates that the plant sample has greater tendency for selective accumulationof Fe and Zn than Pb. The result also shows that the plant sample could serve as an important pathway for transfer of Fe and Zn to animals and humans faster than Pb. Although heavy metal accumulation in some plants such as Mango may provide an important link in the transfer of chemicals to its predators, their hazardous effect on human health, plants and animals require serious attention (Karanja *etal.*, 2010). Some trace metals are significant in nutrition, either for their essential or their toxicity. Metal such as Pb is non essential with toxic effects while Fe and Zn are essential with known biochemical functions (Majolagbe *et al.,*2013).The levels of the metals in the plant sample were again much higher than what(Addo *etal.,*2012) obtained for herbage plant samples in the vicinity of the same cement factory ten years later after the previous study. A close look at Table 2 shows that when the different levels of all the metals distribution in the plant sample are compared with their permissible levels in plants (Fe 0.003 µg/g, Zn 0.001µg/g and Pb 0.001 µg/g) all the metals exceed their critical value in the plant sample (WHO/FAO 2011). For example the critical level of Pbis (0.001µg/g) indicating that the result (0.4µg/g) in the investigated area runs a risk of Pb pollution in the plant sample (Abdulrasoul *eta*l., 2011 Usman,2012-2013). As it can be seen that the metal levels in the plant sample have exceeded their critical levels the results in the investigated area runs a risk of metal pollution in the plant sample. The order of the metal level in the plant sample is Fe > Zn >Pb.

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Table 2. Mean Heavy metal concentration in plant sample collected in the neighbourhood of ObajanaCement factory (µg/g)

Metal	Min	Max	Mean	SD
Fe	0.68	9.78	25.90	± 1.23
Zn	0.09	0.75	3.60	± 0.22
Pb	0.00	0.20	0.40	± 0.05

SD– Standard Deviation

The heavy metal analysis in the cement product implicates cement dust originating from the cement factory for being partly or wholly responsible for metal contamination in soil and plant in the neighbourhood of the factory. The decreasing order in the quantitative trend of the metal content in both the plant and soil samples indicates a certain measure of similarity between the plant and soil samples. This similarity is expected since heavy metals from soil enter plant primarily through the root system. This similarity in the trend suggests some level of relationship in the plant uptake of metal from the soil. In general plant roots are the most important sites for uptake of chemicals from the soil (Al- Qud *et al.,*2011). In an attempt to understand this relationship, the Pearson Correlation Co-efficient, r, was used to establish the relationship between the levels of the corresponding metals evaluated from the soil and plant samples.

Table 3 (a, b and c) shows Correlation coefficients between the soil and plant for Fe, Zn and Pbrespectively.Unlike when we have positive correlation between soil and plant for all metals, that shows that plant take nutritional elements from soil through their roots, in this study there are negative correlation between soil and plant for all the metals in the investigated area. As a result of this, the metals give a strong suspicion to the fact that the elements might be assimilated through other organs of the plant other than the roots or the plant have high affinity of assimilation of the elements directly from atmospheric deposition (Yaylali – Abanuz, 2011). Another good reason may be linked to the fact that only the upper layer(A soil horizon) of soil wassampled. Generallythe mean concentrations levels in soil are higher than that of plant sample (Tables 1 and 2).

Table 3 Correlation coefficients between the soil and plant for Fe, Zn and Pb

(a)

		Amount of Iron in Soil	Amount of Iron in Plant
Amount of Iron in Soil	Pearson Correlation	1	-.147
	Sig. (2-tailed)		.289
	N	54	54
Amount of Iron in Plant	Pearson Correlation	-.147	1
	Sig. (2-tailed)	.289	
	N	54	54

* Correlation is significant at the 0.05 level (2-tailed)

(b)

		Amount of Zinc in Soil	Amount of Zinc in Plant
Amount of Zinc in Soil	Pearson Correlation	1	-.277*
	Sig. (2-tailed)		.042
	N	54	54
Amount of Zinc in Plant	Pearson Correlation	-.277*	1
	Sig. (2-tailed)	.042	
	N	54	54

* Correlation is significant at the 0.05 level (2-tailed)

(c)

		Amount of Lead in Soil	Amount of Lead in Plant
Amount of Lead in Soil	Pearson Correlation	1	-.200
	Sig. (2-tailed)		.146
	N	54	54

Amount of Lead in Plant	Pearson Correlation	-.200	1
	Sig. (2-tailed)	.146	
	N	54	54

* Correlation is significant at the 0.05 level (2-tailed)

To assess the influence of the cement factory on the area directly within the vicinity, various radii distances (150, 500 and 1000m) as well as different directions (north, south, west and east) with the factory at the centre were considered.

Table 4 summarizes the mean elemental concentrations of both soil and plants and their distribution with respect to distance and direction from the cement factory. A close observation from the available data reveals a number of irregular distributions in metal concentration in the samples in respect of distance and direction. At one point, the highest level of a metal occurs closer at varying direction from the factory. In another instance, the peak level of a metal was observed further away in varying direction. For instance, for the soil sample: the highest level (900.50µg/g) of Fe is observed at a radius distance (rd) of 150m at the East direction; Zn (15.00µg/g) (rd=1000m at South direction); Pb (2.4µg/g) (rd=500m at North direction). However. The mean concentration of the soil and plant samples decrease as the distance from the factory increased for most metals. The situation can be linked to the cement factory as a major source responsible for this metal distribution pattern.

Table 4. Concentration of heavy metals (µg/g) in soil and plant samples at varying directions from the cement factory

Metals	Geographical directions from cement factory			
	North	South	West	East
Fe	534.80 (20.60)	202.40 (22.50)	701.50 (40.50)	900.50 (20.00)
Zn	10.10 (2.20)	15.00 (3.20)	10.00 (4.00)	5.30 (5.00)
Pb	2.40 (1.10)	0.50 (3.20)	1.60 (0.10)	1.50 (0.20)

4. CONCLUSION

In this study, soil and plants (representing the annual vegetation of the study area) have been analyzed by Atomic absorption Spectrometer for heavy metals (Fe, Zn and Pb)

Sampling points were chosen in such a manner as to cover the entire vicinity of the Cement factory in Obajana. The sampling points represent three radii distances (150m, 500m and 1000m) and the four geographical directions (North, South, West and East). The results indicated that levels of the metals are above background and critical limits in soil and plant respectively.

Correlation analysis of the corresponding metal levels in soil and plants suggested a negative correlation between the soil and plant samples. The level of metal distribution considering distance and direction from the cement factory were of a complex pattern and many factors were suggested to account for that. One of the major suggestions was that other pollution sources might be in display. Majority of the sampling points were enriched or contaminated with heavy metals and that the source of pollution was anthropogenic. The cement factory together with the attendant vehicular traffic and emissions might be responsible for metal pollution in the area, as in general the highest metal level were found close to the cement factory.

From the results of the current investigation, we recommend that future cement production factory must be set away from settlements and that our environmental regulations must be strengthened so as to prompt current industrial operators to take precautions and new techniques to protect the environment from hazardous pollutants. The reason being that the human body is of a complex structure, therefore, the accumulation of metals can cause many toxic effects, which can influence different mechanisms on the body (ACDC, 2010).

By way of monitoring the operational influence of the cement factory on the environment, this study underlines the need for replicating periodic studies (two years duration) on the effect the factory on the environment in addition to the evaluation of effects of hazardous pollutants from the factory on human health.

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