ECOLOGICAL AND HEAVY METALS CONTAMINATION IN SOILS AROUND IBESE CEMENT FACTORY OGUN STATE

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Abstract

Soil pollution is generated by the presence of manmade chemicals or other changes in the natural soil environment which can be caused by industrial activity, agricultural chemicals, or inappropriate disposal of waste. This study investigated the ecological and heavy metal contamination in soils around ibese cement factory. Samples were collected from twelve sampling points at distances from the factory i.e (Abule Oke, Abule Maria, Afami, Ajibawo, Factory Gate and Ibese). Physicochemical parameters and assessment of soil contamination such as pH, electrical conductivity (EC), Organic Matter, Organic Carbon, contamination factor, geoaccumulation index were determine using standard methods. Heavy metal (Zn, Cd, Cr, Ni and Pb) were analyzed in the samples using Microwave Plasma Atomic Emission Spectroscopy (MP-AES). The level of contamination of the study area was determined using 3 indices which are Geo-accumulation factor, Contamination factor and Pollution Load Index. The average mean value for all the heavy metals determined were within the permissible limit of WHO and USEPA except Cadmium at Abule Oke subsoil (1.01), Abule Maria top soil and subsoil (1.06 and 1.02) respectively and Factory Gate topsoil (1.03) which exceeded the permissible limit of 0.8mg/kg. it was observed that the heavy metal determined in the soil samples decrease gradually away from the cement factory.

Keywords: Heavy metal, Soil pollution, Contamination indices and Pollution index.

Introduction

Soil is a natural resource which consists of the mixture of organic matter, minerals, liquids and gases which the existence of human and animals relies on directly or indirectly. Soil support plant life and a medium for water storage and organisms that take part in decomposition of organic matter and the creation of a habitat for new organisms. Apart from agricultural uses, soil serves as contaminant from industries. (Olatunde et al 2020)

One of the leading soil pollutants in Nigeria is cement production creating the spread of contaminated dust across large area through rain, wind and other dispersal process (Olatunde et al 2020). Despite multiple adverse effect and impacts of cement production in the environment, it still remains the most important material for building, construction and infrastructure growth in Nigeria (Olatunde et al 2020).
Availability of cement dust into the environment is increasing due to increase in cement production and increases in domestic demand of cement across the country. (Anudu and Faminu, 2019).
Spread of alkaline dust and gases are major direct impact of cement production in the environment which enters into the water bodies, surrounding soil and vegetation.Overwhelming metals in soils are of incredible worry to the earth, because of the severe and bio-collective possibility, biodegradability. Some metals are essential for life, playing important role as sources of nutrients and minerals for human organs to work. Every single living life form requires differing measures of metals; however, at higher fixations, they end up poisonous (Adesuyi *et al*., 2015). Due to the indiscriminate spread of cement dust that releases heavy metals, there has been an increase of these heavy metals which poses serious threat to soil causing serious damage to human life, thereby reducing the life span of humans

living in that vicinity. There is a necessity to determine the concentration of these heavy metals in the soil around Ibese cement factory soil and also to evaluate the ecological and health risk assessment.

MATERIALS AND METHODS

Study Area

Ibese is located at Egbado North of Ogun State southwestern Nigeria. Ibese plant has four cement lines with a total capacity of 12Mta. Its first two lines opened in February 2012 and were designed to use gas and low pour fuel oil (LPFO) but abandoned (LPFO) at Ibese in favour of coal, which can be used to run all four kilns if needed.

Below is the map of the study area located at Ibese, Egbado North of Ogun State southwestern Nigeria.

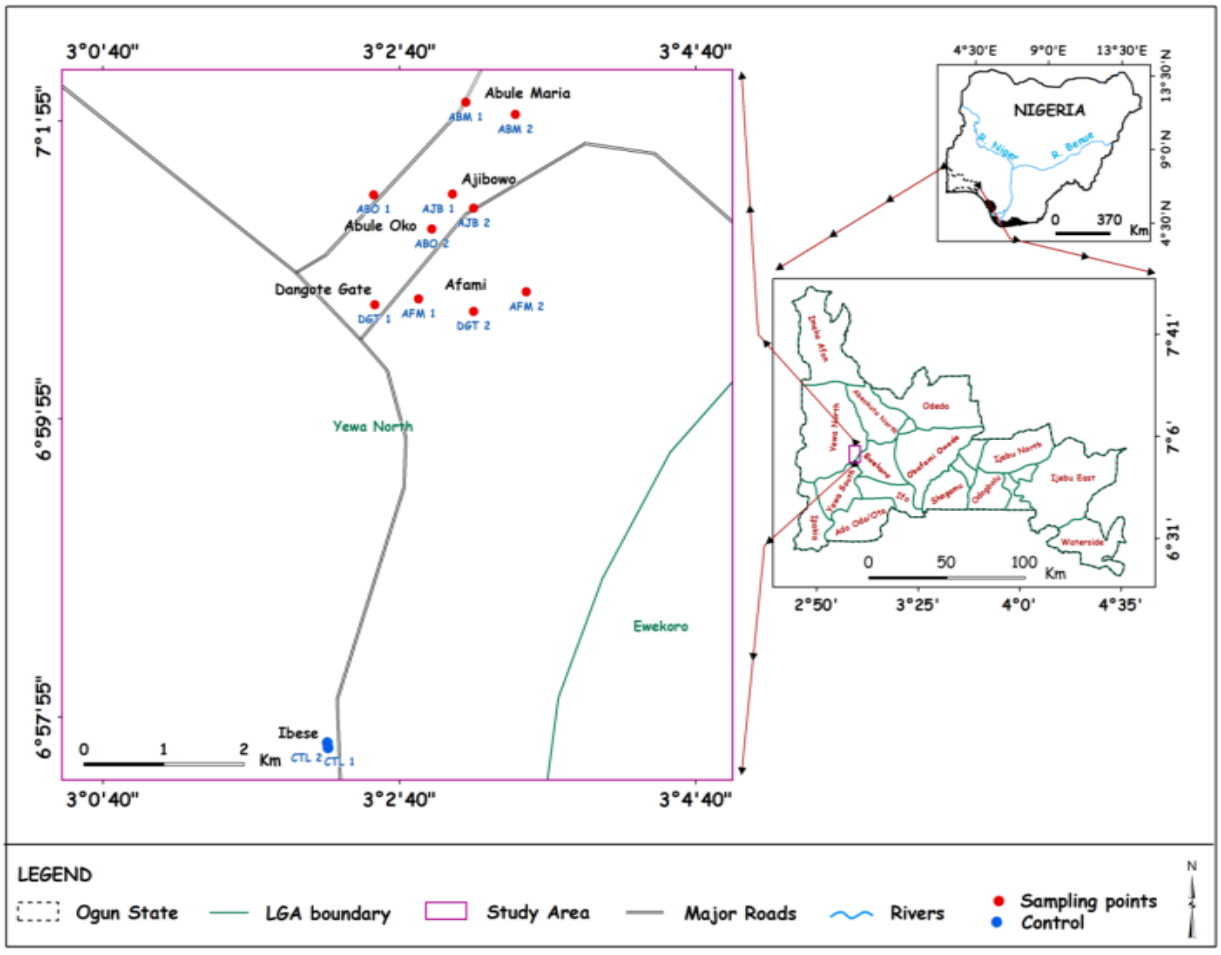


Figure 1: Map showing the study area

Sampling Collection and Analysis

Top and subsoil were collected from twelve sampling points at different distances from the kiln: Abule Oke, Afami, Ajibawo, Abule Maria, Factory Gate and Ibese. Control samples were taken from Ibese. At each sampling point, soil was collected 0-15 cm in depth using a stainless-steel soil auger for the topsoil and 15 – 30 cm for the subsoil. The soil samples were air dry for three days and then homogenized and was sieved with 1.8 mm mesh sieves and stored in a labeled polythene bags for analysis.

Physicochemical Properties

Electrical conductivity and pH were determined using the D-6 Dialysate meter. Total Organic carbon was determined by weighing 1g of soil sample into a conical flask and 5 ml of potassium dichromate ($K_2Cr_2O_7$) was added and was titrated with ferrous sulphate (Anderson and Ingram 1989). Soil organic matter was determined using Anderson and Ingram 1989 method.

Heavy Metals Analysis

Exactly 5gofthedriedsievedsoilwere weighed using electronic weighing balance and freshly Aqua-Regia was prepared at ratio 1:3 (HNO_3: HCL) and was added into the Kjeldahl flask, the samples were digested accordingtoEPAmethod3050B. The filtrate was analyzed using (MP-AES 4200).

Pollution Indices

The geo-accumulation index (I-geo) and pollution load index (PLI) were utilized to assess the pollution of metals in the soil samples from the market.

Geo-accumulation index (I-geo): Geo-accumulation index was determined by the following equation according to Müller (1979) which was described by Rabee, Al-Fatlawy, Najim, and Nameer, (2011).

$$I - geo = \log 2 \left({}^{C_n}/_{1.5B_n} \right) \quad (1)$$

Where;

Cn is the measured concentration of heavy metal in the soil sample.

Bn is the geochemical background value in average soil (Rabee, et al 2011) of element n.

The factor 1.5 is used for the possible variations of the background data due to lithological variations (Rabee, et al, 2011).

I-geo was classified into seven levels:

I-geo ≤ 0 (level 0), unpolluted;

0< I-geo ≤1 (level 1) slightly polluted;

1 < Igeo ≤ 2 (level 2), moderately polluted;

2< Igeo ≤3 (level 3), moderately severely polluted;

3< I-geo ≤4 (level 4), severely polluted;

4< I-geo ≤5 (level 5), severely extremely polluted;

I-geo > 5 (level 6), extremely polluted (Rabee, et al, 2011).

The Pollution Load Index (PLI)

PLI was determined using Tomlinson, Wilson, Harris, and Jeffney (1980), which is as follows:

$$CF = {}^{C_{metal}}/_{C_{background\ value}} \quad (2)$$

$$PLI = \sqrt[n]{(CF_1\ x\ CF_2\ x\ CF_3\ x \dots \dots \dots x\ CF_n)} \quad (3)$$

Where;

CF is the contamination factor,

n is the number of metals

C metal is the metal concentration in soil samples

C Background value is the background value of that metal.

Cf ≤ 1 designates low pollution; 1 < Cf ≤ 3 is moderate pollution; 3 < Cf ≤ 6 is considerable pollution; and Cf > 6 is very high pollution.

PI< 1 Low contamination factor indicating low contamination or not polluted

1< PI < 3 Moderate contamination factor

3< PI <6 Considerable contamination factor

6 < PI Very high contamination factor. (Hakanson, 1980)

All samples recorded were subjected to Statistical Package for the Social Science (SPSS) to determine the mean and standard deviation.

RESULTS AND DISCUSSION

Physicochemical Parameters

The characteristics of soil samples: pH, electrical conductivity (EC), organic carbon, organic matter and calcium carbonate ($CaCO_3$) of soil samples are shown in Table 1 and Table 2 for both top soil and subsoil. Soil pH was slightly basic for topsoil in Afami and subsoil in Abule Oke (7.50 and 7.62) respectively and lowest in Factory Gate 6.30 which is slightly acidic. Electrical conductivity values ranged between 70.21±0.04 to 8.10±0.13 as shown in Table 1, which are within the permissible limit of 300 μScm^{-1} (WHO 2015). However, Afami have the highest electrical conductivity of 70.21 μScm^{-1} around the location.

The organic carbon content ranged from 1.20 to 5.70% as presented in Table 1 which agreed with Griffin *et al*., 2013 that organic carbon of soil around 5% is averagely good for upper soil layers and diminishes with depth. Soil organic carbon can be greater than 10%, while in poor soil can range below 1% (Griffin *et al*., 2013).
Organic matter content (5.00% to 9.80%) recorded in this study which agreed with FAO 2015 standard of most soils contains 2 to10 percent organic matter. $CaCO_3$ contents of the analyzed soil vary from 4.40 to 9.40%, indicating Afami community to have the highest $CaCO_3$ for both the topsoil and subsoil (9.40 and 9.10%) respectively.

Table 1: Mean value of pH, Organic Carbon%, Organic Matter, Electrical conductivity, $CaCO_3$ Top soil

Parameter	Sampling locations (Top Soil) (ppm)					
	Abule Oke	Afami	Ajibawo	Factory Gate	Abule Maria	Ibese
pH	7.48±0.03	7.50±0.01	6.90±0.05	6.30±0.12	6.77±0.13	7.30±0.06

Organic Carbon %	2.90	5.40	3.30	1.20	3.15	3.25
Organic Matter %	5.00	9.31	5.69	2.07	5.43	5.60
Electrical Conductivity μScm^{-1}	17.12±0.03	17.75±0.01	17.35±0.05	70.21±0.04	28.36±0.12	8.10±0.13
($CaCO_3$) %	4.90	9.10	5.60	5.80	4.60	4.40

Table 2: Mean value of pH, Organic Carbon%, Organic Matter, Electrical conductivity, $CaCO_3$ for Sub soil

Parameter	Sampling locations (Sub Soil) (ppm)				
	Abule Oke	Afami	Ajibawo	Abule Maria	Ibese
pH	7.62±0.02	6.85±0.12	6.92±0.05	6.98±0.03	7.00±0.09
Organic Carbon %	3.10	5.70	3.10	2.90	3.20
Organic Matter %	5.34	9.83	5.34	5.00	5.52
Electrical Conductivity μScm^{-1}	18.96±0.21	11.07±0.07	17.62±0.24	9.37±0.06	9.42±0.04`
($CaCO_3$)	5.30	9.40	5.30	4.90	4.60

Heavy Metals in the Soil

Cadmium

The mean concentration of Cadmium for Afami and Ajibawo were within the permissible limit of 0.8 mg/kg. Cadmium concentration for the following location are above the permissible limit of WHO 2015, Abule Oke subsoil (1.01±0.02), Abule Maria top soil and subsoil (1.06±0.04 and 1.02±014) respectively and Factory Gate topsoil (1.03±0.02). Transportation can distribute cement dust with the aid of wind velocity which can be accounted for the high concentration of some heavy metals in soil samples.

The mean concentrations for Chromium are presented in Figure 2. The mean concentrations are within the permissible limit of 100mg/kg (WHO 1996, 2015). The mean concentration of Cr ranges between 4.54±0.03 to 12.70±0.01 for subsoil and 5.53±3.44 to 12.78±0.05 for topsoil.

Nickel is a plant micronutrient and it is important for bacteria and fungi which are important for good plant growth. (Harasim and Filipek, 2015). The mean concentrations of Nickel as presented in Figure 3 are within the permissible limit of 35 mg/kg (WHO 2015).

The mean concentrations of Lead as shown in Figure 4 are within the permissible limit of 85 mg/kg (WHO 2015). The mean concentration of lead ranged between 0.41±0.01 to 1.71±2.35 for topsoil and 0.24±0.01 to 0.74±0.11.

Concentration of lead in the soils could be as a result of automobile exhaust fumes as well as dry cell batteries, sewage effluents.

Zinc is an essential micronutrient for plant growth; zinc deficiency can result in stunted growth. The means concentrations of zinc (figure 5) are within the permissible limit of 50 mg/kg (WHO 2015). The mean values ranged from 1.65±0.04 to 2.37± 0.05 for the topsoil and 1.39±0.02 to 2.22±0.14 for the subsoil.

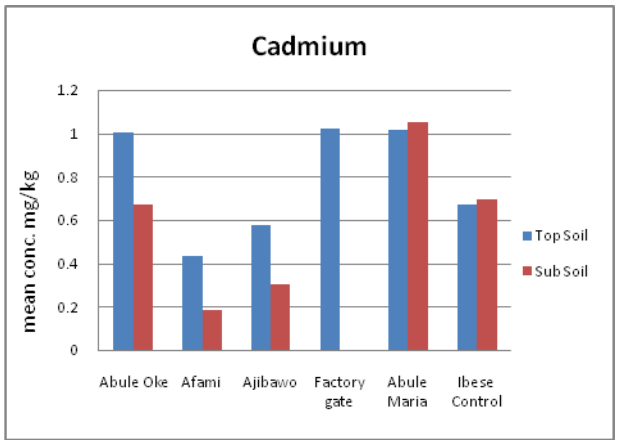


Figure 2: Cadmium in soil samples for the various locations

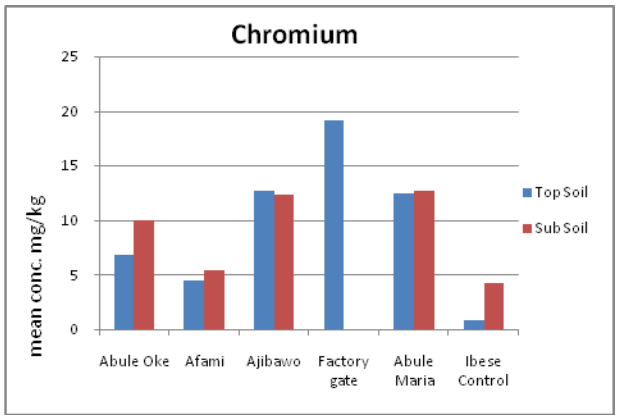


Figure 3: Chromium in soil samples for the various locations

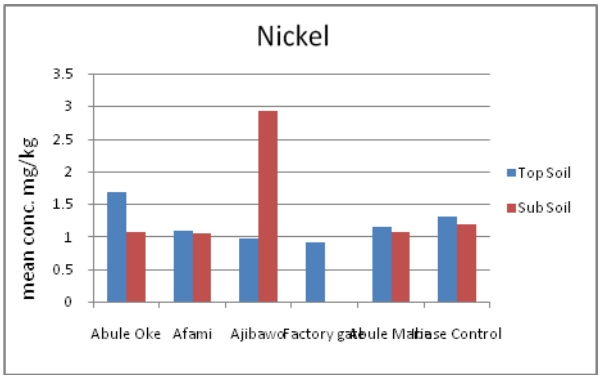


Figure 4: Nickel in soil samples for the various locations

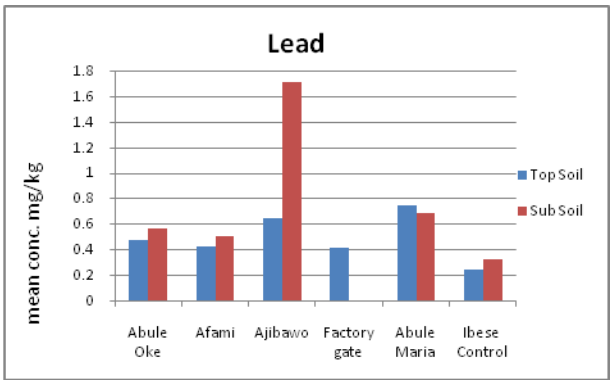


Figure 5: Lead in soil samples for the various locations

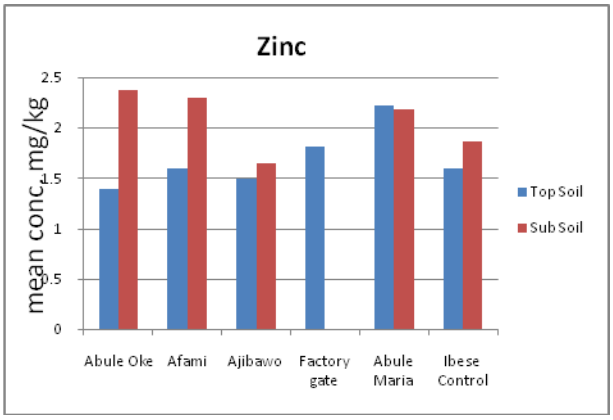


Figure 6: Zinc in soil samples for the various locations

Pollution Index

Cadmium has the highest Pollution Index of 4.67 which is considerable contamination factor. Cr, Ni, Pb and Zn have 0.05, 0.02, 0.03 and 0.02 respectively, which are low contamination factor indicating low contamination.

Geo-accumulation index

Geo-accumulation indices (Igeo) of heavy metals in the soil are illustrated in Table 5. Soil were unpolluted < 0 but was moderately polluted with Cd at Abule Maria and factory gate with 1.42 and 1.38 respectively.

Table 5: Illustration of pollution index

Heavy Metals	Pollution index value	Pollution Index	Category
Chromium	0.05	PI<1	Low contamination factor indicating low Contamination
Nickel	0.02	PI<1	Low contamination factor
Cadmium	4.67	3<PI<6	Considerable contamination factor
Lead	0.03	PI<1	Low contamination factor
Zinc	0.02	PI<1	Low contamination factor

Table 6: Metal concentrations (mg kg^{-1}), geoaccumulation factor (Igeo) of heavy metals in soil

Heavy Metals	Parameter	Site					
		Abule Oke	Afami	Ajibawo	Factory Gate	Abule Maria	Ibese (Control)
Cadmium	Conc	0.68	0.19	0.31	1.03	1.06	0.70
	I_{geo}	0.91	0.25	0.41	1.38	1.42	0.94
Chromium	Conc	10.00	5.53	12.35	19.13	12.78	4.29
	I_{geo}	0.01	5.89E-03	0.01	0.02	0.01	4.56E-03
Nickel	Conc	1.08	1.07	2.93	0.92	1.08	1.19
	I_{geo}	2.58E-03	2.56E-03	7.00E-03	2.20E-03	2.58E-03	2.84E-03
Lead	Conc	0.56	0.50	1.71	0.41	0.68	0.32
	I_{geo}	5.06E-03	4.52E-03	0.02	3.70E-03	6.12E-03	2.89E-03
Zinc	Conc	2.37	2.30	1.65	1.81	2.18	1.87
	I_{geo}	4.87E-03	4.73E-03	3.40E-03	3.72E-03	4.49E-03	3.84E-03

CONCLUSION AND RECOMMENDATIONS

This present study evaluated the risk of heavy metals contamination in soil around Dangote Cement Factory, Ibese Ogun State, Nigeria. The concentration of the metals, Zn, Pb, Ni and Cr were below the permissible limit set by FAO and WHO 2015 but only Cd exceeded the permissible limit which could be because of other activities expunge around the factory such as, use of fertilizer, dry cell batteries of long vehicle, sewage effluents, plastics and pigments. However, high level of heavy metal is harmful to the environment and can reduce plant growth, most especially the Ibese community, which is a rural area where most farmers are engaged in farming business especially cassava plantation which implies that high level of heavy metals can reduce farm yield Based on the results obtained, it showed that the soil from the sampling point were not polluted by difference pollutants from the industry and not harmful for recreational and agricultural purposes.

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