



Evaluation of Heavy Metals in Soils around the Vicinity of Asbestos factory at Bauchi Industrial Layout, Northeastern, Nigeria

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ABSTRACT

This study was conducted to determine the heavy metals pollution in soils around the vicinity of asbestos factory in Bauchi Industrial layout, Bauchi State, Nigeria. Soils samples were collected from the soil at the depths of 0 – 15cm and 15 – 30cm representing top and sub- soils respectively and also from control site 100m away from the point of impact. Soil samples were taken to the laboratory for analysis of heavy metals such as Cd, Cr, Pb and Mn using Atomic Absorption Spectrophotometer (AAS) technique. The heavy metal levels had the mean values of (mgkg⁻¹) 1.49 mg/kg for Cd, 2.453 for Pb, 1.890 for Mn and 0.108 for Cr. The result of single pollution index indicated that soil in the vicinity of asbestos factory was practically un polluted with Mn, Cr but slightly polluted with cadmium. Pearson's correlation showed positive and significant associations between Cd and Mn ($r = 0.87$, $p < 0.05$), Pb and Mn ($r = 0.490$, $p < 0.05$) while negative and significant association existed between Pb and Cr ($r = -0.689^*$, $p < 0.05$). The result indicates that heavy metals such as Pb, Mn and Cr were in the class of unpolluted while Cd at asbestos factory was found at level of heavy polluted grading classification.

Keywords: Heavy metal, AAS, Asbestos factory, heavy metals pollution, Bauchi Industrial layout,

INTRODUCTION

Soil is composed of mineral constituents, organic matter (humus), living organisms, air and water, and it regulates the natural cycles of these components. It filters and purifies water and it degrades and stores materials. Heavy metals (Fe, Mn, Ni, Co, Zn, Cu, Cr, V, Ti, Cd, Hg, Mo and other trace metals) as well as As, Se and F occur naturally in soils, which are formed by geological processes, such as alteration and erosion of the geological underground materials. Besides the parent material, the sources of contamination in soils are multifarious, and include agricultural and industrial pollution (Tuchschnid *et al.*, 1995). Heavy metals occur naturally as chemical elements in the earth's crust and surface soils in varying concentrations (Iyaka and Kakulu, 2012), but of concern is their emissions through industrial, man's agricultural and urban activities into the environment and consequently into soils that serve as ultimate sink. Furthermore, the persistent accumulation of heavy metals in soils is of great concern because they constitute health threat and toxicity problems to human life and environment (Ngoc *et al.*, 2009). Heavy Metals are defined as elements in the periodic table having atomic number more than 20 or densities more than 5 gm⁻³ generally excluding alkali metals and alkaline earth metals (Sherene, 2010). The environmental problems with heavy metals are that they as elements are un destroyable and the most of them have toxic effects on living organisms when exceeding a certain concentration (Xilong *et al.*, 2005). Furthermore, some heavy metals are being subjected

to bioaccumulation and may pose a risk to human health when transferred to the food chain (Vijaya *et al.*, 2010). Soils, whether in urban or agricultural areas represent a major sink for metals released into the environment from a wide variety of anthropogenic sources (Sherene, 2010).

Asbestos has been identified as major sources of trace element which composed of silicate chains bonded with magnesium, aluminium, and sodium to form long, thin, separable fibrils. Asbestos fibres are classified by mineral structure as serpentine or amphibole (ASTDR, 2001). The use of asbestos fibers on a true industrial scale began in Italy early in the nineteenth century with the development of asbestos textiles (Skinner *et al.*, 1988; Alleman and Mossman, 1997). Also, in the production of fiber-reinforced cement products, many developing countries focused on readily available, low-cost cellulose fibers as an alternative to asbestos fibers. Since the 1980s, however, systematic research has been pursued in several industrialized countries to replace asbestos fibers in many current applications because of perceived health risks. There have been a number of studies which have investigated heavy metals pollution in soils of dumpsites, agriculture and mining area. However, as regards heavy metal pollution in the vicinity of Asbestos factory, little work has been done. This study aimed at assessing the heavy metals contents with a view to assess the level of pollution and analyses the correlation between the studied heavy metals in the vicinity of asbestos factory in Bauchi Industrial Layout.

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MATERIALS AND METHODS

Study Area

Bauchi Metropolis is a residential area in the Eastern part of Nigeria (Figure 1). It is the capital of Bauchi State; it is located at the North edge of Jos Plateau at an elevation of

616m (Anonymous). The State lies between longitudes 8.50° and 11° East of the Greenwich Meridian which gives it a mixed climatic zone. The State is one of the few states in Northern Nigeria that has two distinctive ecological zones; namely, the Sudan savannah and the Sahel savanna

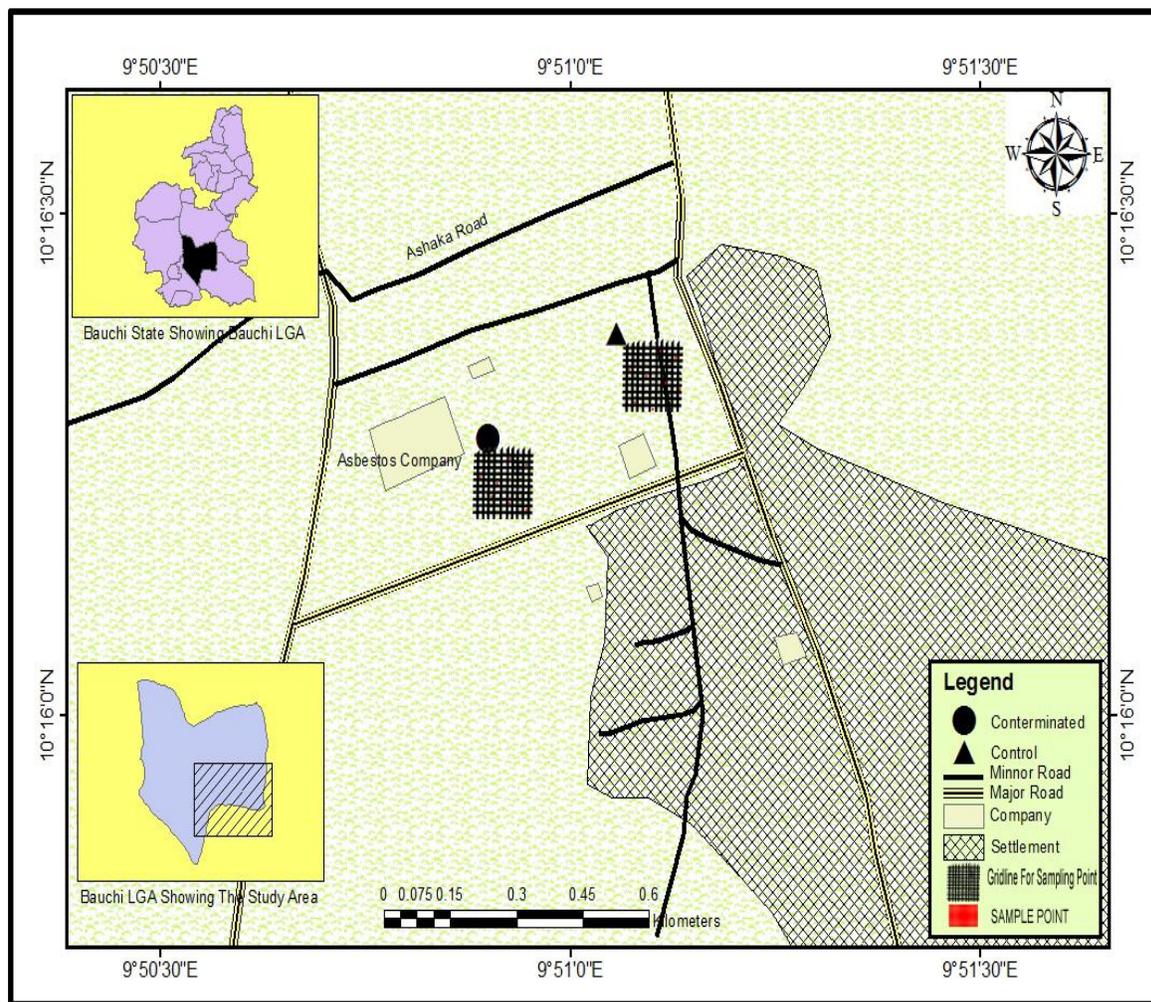


Figure 1: Map of the study area (Sources: BUK Cartography Laboratory)

Soil Collection

Soil samples were collected from seven different points in the vicinity of Asbestos factory (contaminated site). The locations of the seven sampling sites were determined using a hand-held global positioning system. At each sampling site, the surface soil layer at depth 0 – 15 cm (top soil) and the second represented the subsurface soil layer at depth 15– 30 cm (sub soil) were taken from seven points, distributed as an 'S', and then the samples were fully mixed to form one sample. A control sample was also collected from a distance of 100 m were neither industrial nor commercial activities.

Soil preparation and Analysis

The samples were transferred to the laboratory, air-dried at room temperature for 10 days, and then sieved through a 2 mm mesh. The soil samples were then stored in glass bottles at 4°C until they were analyzed. 25 ml of extractant (0.5 M HCl and 0.0125 M H_2SO_4) were added to the sample in the plastic container and shake for about 15 minutes in a reciprocating shaker and the suspension was filtered through Whatman filter paper. The filtrates were analyzed for heavy metals (Pb, Cr, Mn and Cd) using Oluwafofor *et al.* (1990) method.

Table 1: The coordinates of the soil samples collected from seven different locations at Asbestos factory

S/N	Sample points	Latitude	Longitude
1	A1	10 ⁰ . 27 15' 76"	9 ⁰ . 84 61' 24"
2	A2	10 ⁰ . 27 15' 46"	9 ⁰ . 84 62' 73"
3	A3	10 ⁰ .71 60' 90"	9 ⁰ . 84 64' 68
4	A4	10 ⁰ . 27 13' 75"	9 ⁰ . 86 31' 70"
5	A5	10 ⁰ . 27 14' 37"	9 ⁰ . 84 65' 12"
6	A6	10 ⁰ . 27 15' 21"	9 ⁰ . 84 66' 40"
7	A7	10 ⁰ . 27 15' 78"	9 ⁰ . 84 67' 81"

Sources: Field work, 2017

Statistical Analysis

The statistical analysis was performed using Excel Microsoft 2010 and SPSS version 17 programs. Data were also subjected to pollution index (Pi) which is calculated as calculated as the ratio of heavy metal concentration at each sampling point to metal reference values provided by WHO threshold limit. The correlation was used to test for the relationship and association of the heavy metals under investigation in the asbestos.

calculated as the ratio between the metal concentration (Ci) in a soil sample and its reference value (Si) and interpreted using Table 2 as presented by Deng *et al.* (2012). The equation is as follows: $Pi = Ci/Si$ where Pi is an environmental quality pollution index for a special heavy metals, Ci is the heavy metals content in a soil sample (mg kg-1); and Si is the reference values of the same metals (mg kg-1). In order to unify the assessment results, reference values as provided by WHO (2008) were used as background values (Cr = 180, Cd = 3.0, Mn = 850, Pb= 300

Pollution Assessment Index

The pollution level by a given heavy metal (i), was evaluated with the single pollution index (Pii), and

Table 2: Terminologies used to describe pollution Index

S/NO	Sub Index	Quality grade
1	Pii <1	Clean
2	1 ≥ Pii >2	Potential pollution
3	2 ≥ Pii >3	Slight pollution
4	2 ≥ Pii ≥3	Heavily Polluted

Adopted by Deng *et al.* (2012).

RESULT AND DISCUSSION

Table 3 shows the mean concentration of heavy metals (Cd, Pb, Cr and Mn) in contaminated and control sites. Maximum permitted threshold concentrations of potentially toxic metals prescribed by WHO (2008) are given in Table 3. The lowest value of studied heavy metals (Cd, Cr, Mn and Pb) was observed in both in both contamination and control sites (Table 3). The results showed variations in the concentrations of the elements, which possibly indicate the effects of the soil type, type of the parent rocks and

anthropogenesis and industrial activities. The results regarding Cd and Cr contents are in agreement with those of Hill and Patrucci (1999) and Mansur (2018) who reported that metals like cadmium and chromium are known to be rare in nature and therefore the result of this analysis further confirm that they are always low in concentration. However, the value of Cr (0.10 mg/kg) in the present study was comparatively lower with the work reported by Nashmeel and Idrees (2018) in soils at a Steel factory and the Surrounding Area in Erbil City, Jordan.

Table 3: Mean value of heavy metals in studies site and EU regulatory limit

Heavy metals	Contaminated site	Control site	WHO (2008) value
Cd	1.49	0.035	3.0
Pb	2.45	0.26	100
Cr	0.10	0.30	150
Mn	1.89	1.05	850

SOURCE: LAB, 2017 and WHO (2008)

The result of Pb concentrations across different sites showed the presence of Pb in samples from all the sites. Pb was highest at contamination sites (2.49 mg/kg) and the lowest at control sites (0.22 mg/kg). The concentration of Pb obtained in both contamination and control are within

the WHO threshold value of (100 mg/kg). The values obtained in the present study was lower with that of Musa *et al.* (2018) who reported the means concentration of Pb (14.7 mg/kg) and Mn (70 mg/kg) in soils around the industrial effluents at Bompai Industrial area, Kano,

Nigeria. The results of Mn in Table 3 revealed that Mn was highest in concentration at contamination sites (1.74 mg/kg) and the lowest at control site (1.36 mg/kg). Mn in soil across the study area ranged from 30 – 112.5 mg/kg with mean value of 78 mg/kg. However, this value was different with the work reported by Iwegbue *et al.* (2013) for Mn in soil around cassava processing industries in Delta State, Nigeria. The result in Table 3 indicates that heavy metals in soil across the study area are within the permissible limit

The mean concentration of Cd, Pb and Mn in contaminated site (Figure 2) were significantly greater than the control

sites which is attributed to the fact that these metals were found in location 1 which is closer to the asbestos factory (supercor) than the control site (location 2) which is 100 m away from the factory. Moreover, gaseous emissions from the heavy machineries as well as dust particle emission from the factory is believed to be highly concentrated in location 1 (contaminated) than in control site (location 2). This is in agreement of Mc lean and Bledsoe (1992) who reported that some heavy metals like Cr, Cd and Pb were added to the soils pre-dominantly through gaseous emissions from industries, combustion of petroleum from automobile or using heavy duty machineries that are diesel powered as their major sources in the soils

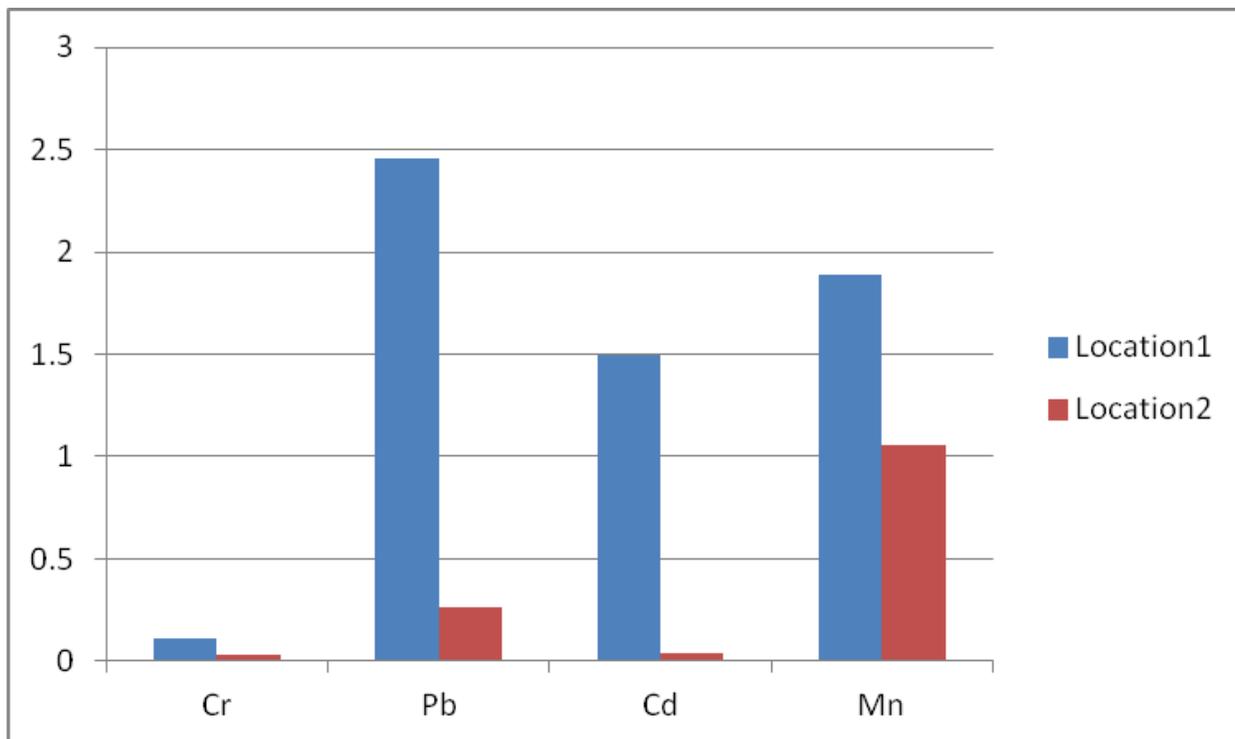


Figure 2: Mean concentration of Cr, Pb, Cd, and Mn in the two studied sites

Pollution level of Heavy Metal

The results of single pollution index for the soils around asbestos factory were presented in Table 3. The result indicates that heavy metals such as Pb, Mn and Cr were in the class of un polluted while Cd at asbestos factory were found at the level of heavily polluted according to Deng *et*

al (2012) grading classification. The increasing trend of metals pollution level in the studied asbestos factory environment on the basis of average single pollution index per metal is in the order of Cr < Mn < Pb with Cd having the highest pollution level.

Table 3: Pollution level of studied Heavy Metals

Heavy Metals	Cij	Sij	Pij		Remark
Cd		1.492	3.0	2.0	slightly polluted
Pb		2.453	100	0.002	Non polluted
Cr		0.108	180	0.0005	Non polluted
Mn		1.054	850	0.001	Non polluted

Cij-, Concentration of metals; Sij-, Reference value WHO (2008) Standard; Pij,- pollution

The results presented in the Table 3 also indicate that the soils in the study sites were not polluted with Pb, Cr and Mn in according to Deng *et al* (2012) classification index. This observation deviates with the finding of Olayinka *et al* (2017) who reported that all anthropogenic sites were moderately polluted and severely contaminated with the studied heavy metals. The value of pollution index r in the present study was in agreement with the work of Musa *et al.* (2018) who reported low contamination for Pb, Mn and Cr in soils around the industrial effluents at Bompai Industrial area, Kano, Nigeria. However, the result was inconsistent with the work of Nashmeel and Idrees (2018) which showed considerable to very high contamination of

soils at a Steel factory and the Surrounding Area in Erbil City, Jordan.

Relationship between the studied heavy metals

In order to establish inter-element relationships between studied heavy Metal, Pearson's correlation coefficient was calculated and results were presented in Table 5. Rakesh and Raju (2013) reported that high correlation coefficient (near +1 or -1) means a good relation between two variables, and its concentration around zero means no relationship between them at a significant level of 0.05% level, it can be strongly correlated, if $r > 0.7$, whereas r values between 0.5 and 0.7 shows moderate correlation between two different parameters.

Table 4: Relationship between the studied heavy metals in soils sample

Heavy Metals	Cd	Pb	Cr	Mn
Cd	1			
Pb	0.12*	1		
Cr	0.3	-0.69*	1	
Mn	0.22	0.21*	0.17	1

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed).

From Table 4, the results of the correlation coefficients showed strong positive correlation between Cd with Mn ($r = 0.837$), and Cr and Pb that negatively correlated with Cd ($r = -0.689^*$). The strong association of Cd and Mn indicates common sources, and that these metals may have been derived from anthropogenic sources, especially the industries (Rahman *et al.*, 2012). The negative correlation exhibited mainly by Cr and Pb at certain sampling distances/points suggests input of these metals from a non-point source.

This study concludes that the concentrations of Cd, Pb, Mn and Cr around the soil of asbestos of Bauchi Industrial layout were below European Union (2002) threshold limit. Pollution indices by heavy metals of Cd, Pb, Cr and Mn in the vicinity of soils around asbestos were calculated using single pollution index. Results indicate that soil qualities in the study were heavily polluted with cadmium while Cr, Pb were in the state of low polluted according to Deng *et al.* (2012). The result of Pearson's correlation revealed positive and significant associations between Cd and Mn ($r = 0.87$, $p < 0.05$), Pb and Mn ($r = 0.490$, $p < 0.05$) while negative and significant association existed between Pb and Cr ($r = -0.689^*$, $p < 0.05$).

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