

Original Research Article

# Heavy Metals Distribution in *Azadirachta indica* (Neem Tree) around the Neighbourhood of Ashaka Cement Factory in Gombe State Nigeria

Babayo A. U., Isyaka M.S. and A. A. Muazu

## Abstract

Department of Chemical Sciences,  
Faculty of Science, Federal University  
Kashere, Gombe State, Nigeria

\*Corresponding Author's E-mail:  
[babayo\\_umar72@yahoo.com](mailto:babayo_umar72@yahoo.com)

This study examines the effect of cement dusts which serves as a pollutant in *azadirachta indica* (Neem tree) around the neighbourhood of Ashaka Cement Factory site (within 5km radius of the factory) using Atomic Absorption Spectrophotometric technique. Chemical pools of the metals indicated that the metals were distributed into six fractions with most metals residing in the non-available fraction. From the result of analysis, Cd, Pb and Cr were found to be below the detectable limit of the instrument (A Pye Unicam Sp-C Atomic Absorption Spectrophotometer) in stem only. While the concentration of Fe, Mn, Cu, and Zn estimated, varied with locations. In stem, Fe had the lowest concentration of  $154.23 \pm 13.88$  in Jalingo settlement and the highest concentration of  $286.81 \pm 40.46$  in Jajami settlement. Zn had a lowest concentration of  $14.72 \pm 2.14$  in Jalingo settlement and highest concentration of  $503.13 \pm 10.50$  in Jajami settlement. Cu had the lowest concentration of  $10.50 \pm 1.65$  in the Housing Estate and highest concentration of  $51.90 \pm 10.41$  in Gongilla settlement. Mn had the lowest concentration of  $106.50 \pm 16.98$  in Jalingo and highest concentration of  $185.59 \pm 20.60$  in Jajami settlement. In the leaves, Fe, Zn, Cu, Mn and Pb had the lowest concentration in Jalingo settlement ( $161.70 \pm 32.71$ ), Ashaka settlement ( $131.25 \pm 13.85$ ), Housing estate ( $19.35 \pm 3.80$ ), Workers' village ( $108.85 \pm 14.78$ ) and Staff Housing ( $2.25 \pm 1.26$ ) and highest concentration in Juggol settlement ( $293.81 \pm 59.04$ ). Juggol settlement ( $755.01 \pm 88.50$ ), Jalingo settlement ( $38.93 \pm 7.80$ ), Jajami settlement ( $187.50 \pm 20.61$ ) and Jajami settlement ( $60.00 \pm 2.94$ ) respectively. All data were subjected to student's t-test. The computed value of t-tcal (0.864) is less than the critical value of t(2.179) for all metals which implies no significant differences in the concentration of all the metals in stem and leave.

**Keywords:** Atomic Absorption, *Azadirachta indica*, Cement dust, Heavy metals

## INTRODUCTION

The main environmental challenge faced by the cement industry is the emissions of particulate matter to the air. Large quantities of cement kiln dusts are produced during the manufacturing of cement clinker by dry process.

Measures to control the emission of these particles in the past to the environment have not been successful. The dust can have both physical and chemical impacts on sinks (plants, water, soil, sediment and animals).

Dust constitute a serious pollutants to man and the effect can be very devastating to the environment. It is emitted into the atmosphere from natural and artificial sources such as volcanic eruption, dusts, storms, road, traffic and industrial processes. (Hiranet. *Al.*, 1995). Dusts consist of solid matter in such a fine state of subdivision that the particles are small enough to be raised and carried by wind (Farmer, 1993). As a result of its fine particle size it travels over long distances and the total suspended particulate matter in the atmosphere is thus increased. Finer particles which contain various toxic elements (Fox, 1985) are deposited as the dust is transported away from emission source. Industrial processes produce particulate emission (Fennelly, 1975) and measures. The deposition of dust is accompanied with potential impacts caused to human and health, vegetation and soil.

Higher plants are used as indicators in air pollution monitoring, in highly polluted area where lichens and mosses are often absent. Higher plants act as bio-monitors in the assessment of heavy metal contamination by their bio-accumulative properties. Metal aerosols pollute soil and plants. Higher plants not only intercept pollutants from the atmosphere deposition but also accumulate metals from the soil. Heavy metal deposited are taken up from the soil by plants through their root system and translocated to other regions of the plants, (Lintalen and Tuba, 1992). Particle deposition on the leaf surface may be affected by a variety of factors including particle size and mass, wind velocity, leaf orientation, size, moisture level and surface characteristics (Bache, 1991). The deposited particles maybe washed by rain into the soil, re-suspended or retained on the plant foliage. The degree of retention is influenced by the wealth of conditions, nature of pollutants, plant surface characteristics and particle size (Harrison and Chirgaw, 1989). Harrison and Chirgawi (1989) demonstrated the significance of foliar accumulation and translocation of air derived metal pollutants and reported that the foliar route was also important to soil root path way.

### Absorption of heavy metals by plants

Heavy metal absorption is governed by soil character such as  $p^H$  and organic matter Content (Machlin, 1992). Thus, high level of heavy metals in the soil does not always indicate similar high concentration in plants. The extent of accumulation and toxic level depend on plant and heavy metal species concentration under observation. In an investigation of Cd, Cu, Ni and pb uptake from air and soil by *AchilleaMillefolium* (Milfoil) and *HordeumVulgare* (barley).

Pilegard and Johnson (1984) observed that the concentration of Cu and pb in plant correlated with aerial deposition but not with soil concentration. In contrast, Ni and Cd content in plants correlated with deposition and

soil content. The distribution patterns and budgets of heavy metals within forest trees growing at contaminated sites in Germany were investigated by Truby (1995). Plants have also demonstrated morphological physiological responses to heavy metal pollution, some of which may be utilized in bio-indication, Truby, (1995). Therefore the main aim of this research work is to estimate the concentration of cement dust as a pollutant around the neighbourhood of Ashaka Cement Company (i.e. within 5km radius of the cement factory).

### Area of study

Ashaka Cement Company was established in 1976 in Jalingo Village of Bajoga, Funakaye Local Government Area of Gombe State, Nigeria. The company was established to meet the needs of construction works in the North Eastern part of Nigeria. It has an installed capacity of 500,000 MT per annum NSE (2004). It is located in the northern part of Gombe and lies between latitudes  $10^{\circ}45'N$  and  $11^{\circ}00'N$  and longitudes  $11^{\circ}15'E$  -  $11^{\circ}30'E$ .

### Experimental

In the preparation of solutions, chemical of analytical reagents grade, purity and distilled water used. All glasses and plastic wares were washed with detergent solution and rinsed with water before immersion in 10% Nitric acid solution and was again rinsed with water and finally dried in oven at  $105^{\circ}C$ . All weighing were carried out on mettler shumad20 Libro-E3-B3OH analytical balance.

### Sampling period/collection

Sampling was taken at the same time of the year to reduce variability. All plants samples (leaves and stems) were collected randomly in different location. In polythene bags during the month of August 2005 and August, 2010, an interval of 5 years each. Throughout the sampling period, leaf samples were collected five times at the top of different branches of each tree to give a gross sample. The stem barks of trees from which leaves samples were collected to stimulate the method reported by (Kovacs, 19920). All samples were oven dried at  $110^{\circ}C$  for 24hrs. They were crushed in a mortar and ground into powder form. This was quartered go give a reasonable sample size of about 100g each (stem and leaves). This was stored in sample bottles for analysis.

### METHODOLOGY

The oven dried ground powder sample was digested by

weighing 0.5g in a 50cm<sup>3</sup> beaker. Then 5.0cm<sup>3</sup> of concentrated nitric acid was added. The beaker was then covered with watch glass and heated on a hot plate in flume cupboard until the brown fume ceased. Then 5.0cm<sup>3</sup> of perchloric acid was added to the content and then boiled again for few minutes. 15cm<sup>3</sup> of deionised water was added and allowed to cool to room temperature. Then content was quantitatively transferred into 100cm<sup>3</sup> volumetric flask and was made up to the marked with deionised water. The resultant solution was stored in clean plastic container and labeled. The procedure was repeated for all the samples and kept for AAS analysis (AOAC, 1990).

### Preparation of standard solution for atomic absorption

#### Spectrophotometry

10.0cm<sup>3</sup> of concentration nitric acid (5g 1.42 70% ww) was diluted with water in beaker and on cooling the solution was transferred into a liter volumetric flask and was diluted to mark with deionised water.

#### 1000mg/litre copper solution

1g of copper dust was dissolved in 5cm<sup>3</sup> concentrated HNO<sub>3</sub> acid and the resultant solution was diluted to the mark in a litre volumetric flask. A 1000mg/litre copper solution was prepared by diluting 10cm<sup>3</sup> of the stock solution with water in a 1000cm<sup>3</sup> volumetric flask. 20cm<sup>3</sup> of this solution was further diluted with 50cm<sup>3</sup> of water to give a 40mg/litre. Stock solution from which 0, 3, 6, 9, 12, 15 and 18mg standard were prepared in 50cm<sup>3</sup> volumetric flask through appropriate dilution this were repeated for iron (Fe), Zinc (Zn), Manganese (Mn), Lead (pb), Cadmium (cd) and chromium (Cr).

#### Instrumentation

A Pye Unicem Sp-9 atomic absorption spectrometer equipped with digital read out and deuterium arc background correction system was used as a fuel. A hollow cathode lamp for each element was employed. The instrument was switched on and allowed to stabilize for 30 minutes. The current and resonance line wavelength were selected. The gas control system was adjusted to give rich fuel flame. Blank and standard solutions were aspirated and absorbance read were recorded. These separated absorbance readings were taken for each sample and average computed. The elements were Cu, Fe, Zn, Mn, Pb, Cr and Cd. Their

respective wavelengths were 324.8, 248.3, 213.9, 279.5, 217.0, 233.5 and 228.8nm. Absorbance readings for both standard and samples were corrected using the readings for the blank. A calibration curve was used to interpolate the concentration of each metal in each of the samples. The values were then corrected for background and dilution effect.

### DISCUSSION OF RESULT

Table 1 and 2 show the mean concentration of Heavy metals in (Mg/kg) in *Azadirachta indica* (stem and leaves). The concentration of the heavy metals in the settlement within 2km Radius of cement factory is less polluted than the corresponding concentration in *Azadirachta indica* (stem and leaves) settlement between 3-5km radiuses away from the factory. This is likely due to height of chimney through which the dust is disposed into the atmosphere. The high concentration of heavy metals from the site as a result of the influence of wind or terrain and turbulence on the dispersion of smoke plumes or dust from the factory. In the case of stem, the mean concentration of Fe ranged from 152.35±16.01 at Jalingo settlement to 283.79±34.70 at Jajami settlement Cu ranged from 10.38±2.02 at Housing Estate to 51.90±11.97 at Gongolia settlement Zn ranged from 14.56±2.36 at Jalingo settlement 503.14±11.69 at Jajami settlement. Mn ranged from 106.69±8.01 at Jalingo settlement to 185.52±23.74 at Jajami settlement. Lead ranged from 2.25±1.26 at staff housing to 60.00±2.84 at Jajami settlement. This shows that there exist more pollution by lead at Jajami than other settlements. Hence the concentration of metals in stem are above the values reported by Ayodele and Ahmed, (1996). While in leaves Fe concentration ranged from 160.91±38.69 at Jalingo settlement to 293.76±68.08 at Juggol settlement. Cu ranged from 19.31±15.94 at Estate Housing to 38.91±8.97 at Jalingo settlement. Mn ranged from 100.41±18.82 at Workers' Village to 185.51±23.74 at Jajami settlement. Zn ranged from 131.26±13.48 at Ashaka settlement to 590.75±55.50 at Juggol settlement. The concentration of lead in the leaves of the plant samples from the settlement is below detectable limit of the instrument used. Comparing the results obtained in this study with the values presented in table 3 below. The results indicate that the concentration of the metals in leaves is above maximum limits. However, the concentration of Cd and Cr in the stems and leaves of plant samples were below the detectable limit of the instrument used. Analysis of the concentration of these metals in the leaves and stems by student's t-test, as presented in table 4 which revealed that there is no significant differences in concentration of Fe in stems and leaves of the plant samples collected from all locations considered. The computed value of t-cal (0.864) is less than the critical values of t(2.179). So the same trend is

**Table 1.** Concentration (Mg/kg) of Heavy metal in stems

Location	Fe	Cu	Zn	Mn	Pb
EH1	281.25	11.25	215.25	120.00	4.01
EH2	206.25	9.25	360.00	116.25	2.02
EH3	225.00	8.25	244.38	117.75	2.00
EH4	112.50	12.75	151.88	112.50	1.01
Mean	206.25	10.38	367.88	116.63	2.25
±	±	±	±	±	±
Std	60.75	2.02	231.76	31.05	1.71
Location	Fe	Cu	Zn	Mn	Pb
WV1	168.75	12.04	115.25	90.01	6.02
WV2	140.63	10.88	260.00	79.13	4.00
WV3	112.50	9.02	144.38	116.25	2.01
WV4	271.88	7.50	151.88	116.25	bd
Mean	173.44	9.86	167.54	100.25	3.00
S±	±	±	±	±	±
Std	69.53	2.01	231.76	16.50	2.58
Location	Fe	Cu	Zn	Mn	Pb
AS1	225.01	24.02	121.88	116.25	3.02
AS2	252.75	21.01	132.75	108.75	4.02
AS3	328.13	25.50	61.50	103.75	3.01
AS4	178.13	16.50	78.75	106.50	5.00
Mean	246.02	21.75	98.87	113.81	3.75
±	±	±	±	±	±
Std	62.81	3.99	34.05	7.83	0.96
Location	Fe	Cu	Zn	Mn	Pb
JS1	168.75	18.25	16.75	106.25	5.02
JS2	150.01	5.75	14.75	101.25	3.01
JS3	131.25	11.25	10.25	100.25	2.02
JS4	159.38	16.50	15.56	99.25	bd
s					
Mean	152.35	15.44	14.56	106.69	2.50
±	±	±	±	±	±
Std	16.01	2.98	2.36	8.01	2.05
Location	Fe	Cu	Zn	Mn	Pb
JUS1	150.01	10.00	215.25	120.00	6.02
JUS2	187.51	14.50	660.00	116.25	4.01
JUS3	225.01	12.00	444.38	117.75	2.02
JUS4	362.50	16.00	151.88	112.50	3.00
Mean	231.26	13.13	376.88	116.63	3.75
±	±	±	±	±	±
Std	92.70	2.66	231.76	3.15	0.96
Location	Fe	Cu	Zn	Mn	Pb
JJS1	255.01	11.02	400.03	155.01	18.00
JJS2	255.13	14.01	437.51	181.02	15.00
JJS3	300.02	21.02	512.50	195.03	16.00
JJS4	325.01	51.04	662.53	211.01	11.00
Mean	283.79	25.80	503.14	185.52	15.00
±	±	±	±	±	±
Std	34.70	21.26	116.09	23.74	2.94

Location	Fe	Cu	Zn	Mn	Pb
GS1	175.01	37.51	75.02	147.01	4.02
GS2	187.50	47.50	300.01	165.01	2.01
GS3	212.52	57.50	312.50	168.02	3.00
GS4	287.51	65.01	575.01	175.01	1.02
<b>Mean</b>	215.64	51.90	315.64	163.80	2.50
<b>±</b>	±	±	±	±	±
<b>Std</b>	50.39	11.97	204.47	11.93	1.29

Table 2. Concentration (Mg/kg) of Heavy metal in Leaves

Location	Fe	Cu	Zn	Mn
EH1	168.75	8.25	300.01	116.25
EH2	168.75	10.50	328.13	135.75
EH3	225.01	15.75	384.38	146.25
EH4	243.75	42.75	496.88	158.25
<b>Mean</b>	201.57	19.35	377.35	139.13
<b>±</b>	±	±	±	±
<b>Std</b>	38.66	15.95	87.07	17.81

Location	Fe	Cu	Zn	Mn
WV1	159.38	16.50	106.88	90.01
WV2	206.25	18.75	547.50	79.13
WV3	234.38	27.75	791.51	116.25
WV4	281.25	33.75	815.63	116.25
<b>Mean</b>	220.32	24.19	387.38	100.41
<b>±</b>	±	±	±	±
<b>Std</b>	51.06	8.02	157.01	18.82

Location	Fe	Cu	Zn	Mn
AS1	131.25	33.75	9.38	110.25
AS2	150.01	33.75	46.88	131.25
AS3	187.50	37.50	168.75	138.75
AS4	290.63	40.51	6300.01	140.25
<b>Mean</b>	189.85	36.38	131.25	130.13
<b>±</b>	±	±	±	±
<b>Std</b>	71.14	3.27	31.48	13.82

Location	Fe	Cu	Zn	Mn
<b>JS1</b>	128.01	28.13	56.25	110.25
<b>JS2</b>	140.63	35.63	225.01	123.75
<b>JS3</b>	159.38	43.13	234.38	128.01
<b>JS4</b>	215.63	48.75	431.25	131.25
<b>Mean</b>	460.91	38.91	236.72	123.32
<b>± Std</b>	± 38.69	± 8.97	± 153.36	± 9.24

  

Location	Fe	Cu	Zn	Mn
<b>JUS1</b>	212.52	22.04	142.50	114.02
<b>JUS2</b>	275.01	25.01	730.01	122.01
<b>JUS3</b>	312.50	37.03	1060.00	142.01
<b>JUS4</b>	375.01	45.01	1087.50	135.01
<b>Mean</b>	293.76	32.27	590.75	135.76
<b>± Std</b>	± 59.04	± 9.31	± 558.55	± 22.78

  

Location	Fe	Cu	Zn	Mn
<b>JJS1</b>	255.03	11.02	400.01	155.01
<b>JJS2</b>	255.01	14.01	437.51	181.01
<b>JJS3</b>	300.02	21.01	512.51	195.02
<b>JJS4</b>	325.01	57.02	662.50	211.01
<b>Mean</b>	268.77	25.77	503.13	185.51
<b>± Std</b>	± 51.54	± 21.25	± 116.08	± 23.74

  

Location	Fe	Cu	Zn	Mn
<b>GS1</b>	175.01	15.00	82.50	132.03
<b>GS2</b>	200.02	21.00	105.01	135.02
<b>GS3</b>	212.50	22.00	165.51	147.02
<b>GS4</b>	225.01	25.00	177.01	155.01
<b>Mean</b>	203.14	20.75	131.76	142.27
<b>± Std</b>	± 21.35	± 4.16	± 45.22	± 10.68

EH – Estate Housing: WV – Worker's Village  
 AS – AshakaGari Settlement: JS – Jalingo Settlement  
 JUS – Juggol Settlement: JJ – Jaja

**Table 3.** Concentrations of metals in plants (mg/kg)

Metals	Concentration mg/kg
As	1.00
Cd	0.05-0.30
Cu	2.5-25.0
Pb	0.0-10.0
Cr	0.03-14.0
Zn	10.0-100
Mn	20.0-100

Source: (Ayodele and Ahmed, 1996)

**Table 4a.** Summary of the analysis of the concentration of Iron (Fe) in plants samples

	Leaves	Stem
Mean	219.76	215.53
Variance	2140.554	1947.55
Observation	7	7
df	12	
$t_{cal}$	0.864106	
$t_{critical}$	2.178813	

**Table 4b.** Summary of the analysis of the concentration of Copper (Cu) in plants samples

	Leaves	Stem
Mean	28.23143	21.18
Variance	58.99741	217.9867
Observation	7	7
df	12	
$t_{cal}$	0.291314	
$t_{critical}$	2.262159	

**Table 4c.** Summary of the analysis of the concentration of Zinc (Zn) in plant samples

	Leaves	Stem
Mean	336.9014	292.1214
Variance	31775.3	29688.53
Observation	7	7
df	12	
$t_{cal}$	0.641319	
$t_{critical}$	2.178813	

**Table 4d.** Summary of the analysis of the concentration of Manganese (Mn) in plant samples

	Leaves	Stem
Mean	136.6417	137.6543
Variance	659.8939	984.6716
Observation	7	7
df	12	
$t_{cal}$	0.948693	
$t_{critical}$	2.178813	

observed for Cu, Mn and Zn with  $t_{cal}$  values of 0.291, 0.949 and 0.641 respectively and the same critical value of  $t(2.179)$ .

## CONCLUSION

From the analysis of the results, the study revealed that the concentration of heavy metals in plants within 2km radius is less than what was observed in plants 3-5km radius away from cement factory. This implies that plants that are 3-5km away from the factory were more polluted. This may be as a result of wind direction and height of

the chimney. The results indicated that the level of contamination in these plants is above the normal range. Hence, the results show no significant difference in concentration of heavy metals monitored in the leaves and stems of plants used in the study.

## RECOMMENDATIONS

Consequently, most industries especially the modern ones are usually designed to make adequate provision for the effective handling and disposal of their wastes. Every responsible government is expected to provide

adequate legislation to regulate environmental pollution. Such legislation if retrospective should give enough time for factories, which had got the facilities for effective control and compliance. Government should also monitor blue prints for new factories to ensure that they meet modern standards with respect to pollution control. Indeed, government's effort at controlling industrial pollution should commence from the initial state of the approval design, construction and location of new industries. Farms locations should be standardized in relation to industrial site and sitting to avoid production of polluted vegetables/fruits.

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