

Full Length Research Paper

Heavy metals in street soil dusts of industrial market in Enugu, South East, Nigeria

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Accepted 22 January, 2013

Analysis of some heavy metals present in soil dusts of Industrial Market in Enugu, South East Nigeria was carried out. Soil dust samples were collected from five different sections in the market and a control sample was collected 500 m away from the market. The samples were analyzed after aqua regia digestion with Flame Atomic Absorption Spectrophotometer for Lead, Iron, Nickel, Copper and Cadmium. The result showed a variation, which indicated that concentration of Fe > Cu > Pb > Cd > Ni. The levels of some of these metals were higher than the recommended allowable limit for such metals in soil by regulating agencies.

Key words: Soil dust, contamination, industrial market, pollution index, enrichment coefficient.

INTRODUCTION

The presence of high concentration of heavy metals in street dusts and soils have become a matter of serious concern of late. Street dust is derived from anthropogenic activities by interaction of natural elements with pollution sources (Turer et al., 2001; Al-Khashman, 2004; Bhattacharya et al., 2011). Reports (Archer and Barratt, 1976; Ayodele and Gaya, 1998; Jaradat and Momani, 1999; Shinggu et al., 2007; Osakwe, 2010) indicate increasing contamination of street dust and soils with heavy toxic metals poses serious threat to healthy living and environmental sustainability. For instance, human exposure to heavy metals has risen dramatically in the last 50 years as a result of an exponential increase in the use of heavy metals in industrial processes and products (Ano et al., 2007). Ultimately, they enter the food chain and affect human and animals. There is consensus among scientists that the increasing rate of heavy metals contamination of soil ecosystem is due to anthropogenic activities such as industrial and energy production, construction and fuel combustion (Murphy, 1981; Nasralla, 1984; Li et al., 2001; Li et al., 2006, 2007; Sharma et al., 2007; Nyangababo and Hamuya, 1986; Sutherland, 2000; White head, 1975). In humans, heavy metals are systemic toxins with specific neurotoxic,

nephrotoxic, fetotoxic and teratotoxic effects (Murphy, 1981). Heavy metal pollution can affect all environments but its effect is most long lasting in soils due to relatively strong adsorption of many metals on loamy and clay colloid of soil. Many reagents such as Calcium chloride, ammonium nitrate, and ammonium acetate have been employed to extract the mobile or bioavailable forms of heavy metals in single extraction method (Ahumada et al., 1999; He and Singh, 1995; Karczewska, 1996). Sequential extraction method has also been adopted (Narwal et al., 1996). However, acid digestion using aqua regia appears to be most common (Fazeli et al., 2009). Soil dusts may be analyzed for many reasons but this work was aimed at estimating the concentration of some heavy metals in soil dust of Ogbete Industrial market, Enugu.

MATERIALS AND METHODS

Enugu is the capital of Enugu State, South East Nigeria. It has a population of 722, 000 in 2006 (NPC, 2006) and is located between 6° 21'N and 6° 30' N and 7° 26' E 7° 30' E. Enugu urban has a humid tropical climate and the mean monthly temperature lies between 27 and 29°C with rainforest savanna ecotone vegetation. The industrial market covering a space of about 2 km² occupies the southern part of the city, popularly called coal camp because early coal miners settled in quarters which presently house some of the small and medium scale industries (SMEs). Found in the industrial market include foundry, motor parts fabrication, aluminum smelting and fabrication, woodworks and brickworks, automobile mechanics,

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Table 1. Concentration (mg/kg) of heavy metals in the soil dust.

Sample/Identification	Cu	Cd	Fe	Ni	Pb	EC* ($\mu\text{S/cm}$)	pH
Roadside I	64.0 \pm 3.0	2.8 \pm 0.2	690.0 \pm 0.2	0.4 \pm 0.1	31.0 \pm 0.1	0.45 \pm 0.0	7.9 \pm 0.1
Welding works II	23.0 \pm 1.1	2.2 \pm 0.3	281.1 \pm 0.0	0.8 \pm 0.2	35.0 \pm 0.1	0.32 \pm 0.1	8.4 \pm 0.0
Battery sales and Brick Cutting III	34.0 \pm 0.5	2.3 \pm 0.5	752.0 \pm 0.2	0.2 \pm 0.3	9.5 \pm 1.3	1.02 \pm 0.2	6.3 \pm 0.3
Motor Park IV	48.0 \pm 0.3	0.4 \pm 0.3	651.0 \pm 1.0	0.8 \pm 0.1	48.0 \pm 0.3	0.24 \pm 0.3	7.2 \pm 0.2
Automobile Mechanic V	63.0 \pm 1.2	0.8 \pm 0.1	613.5 \pm 2.0	0.5 \pm 0.2	87.0 \pm 0.1	0.51 \pm 0.1	8.1 \pm 0.3
Reference Station VI	2.8 \pm 0.1	0.2 \pm 0.1	125 \pm 1.0	0.1 \pm 0.0	4.8 \pm 0.0	0.21 \pm 0.0	6.9 \pm 0.0

*EC = Electrical conductivity.

blacksmithing and a host of others. Also, dealers in assorted machines, spare parts, food, and household effects litter the industrial market. It has been established that the industrial market contribute significantly to the environmental degradation of the city especially the underground and surface waters in the area (Chima et al., 2009; Ekere, 2011).

Sampling site description

Samples were taken from coal camp Industrial market, Enugu, Nigeria at five different areas of industrial activities. These areas include (i) Automobile mechanic (ii) road side (iii) Battery and brick works (iv) Motor park and (v) welding works areas. Standard methods were applied for sample collection, preservation and analysis (Roger, 1994). Street soil dusts were sampled using plastic brush and a plastic scoop. The soil dust samples were passed through 62 μm sieve prior to analysis. Ten replicate samples were collected from each site during the study period, which covered four months (December-March). The samples were collected at this period (dry season) to avoid washing away the heavy metals by rain. Another sampling site was selected 500 m from the market to serve as a control.

Dust samples were collected and transferred to clean polyethene bags. Each of the samples was dried in an oven at 100-110°C to drive out moisture until a constant weight was obtained. The soil pH of each dust sample was determined in 1:5 dust: distilled water (w/v) suspension using a pH meter (Kent model) while the electrical conductivities (EC) was measured in a 1:2 dust: distilled water (w/v) suspension using a conductivity meter. Particular like slag stones were separated from the samples and the samples ground into a fine powder. The ground samples were sieved using a 250 μm sieve mesh diameter.

All experiments were performed with analar grade chemicals. One gramme of each sample was digested using aqua regia, 3:1 ratio of HCl to HNO₃ (Ayodele and Gaya, 1994; Xianagding et al., 2001) to incipient dryness. Then 5 ml HClO₄ was added and the mixture heated until a homogeneous solution was obtained. During the digestion, the samples were heated in a water bath at 100°C. Calibration standards were prepared from the stock solution of the metals. The digested samples were then analyzed for desired heavy metals using Buck Scientific Model 210 VGP Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

The concentrations of the assayed heavy metals are presented in Table 1. The pH of the soil dust suspension ranged from 6.3 to 8.6. The electrical conductivity (EC) of

the sample dusts was relatively high in all the stations indicative of presence of ionic species. The concentration of Iron had a range of 752.0 to 12.5 mg/kg soil dust, with a concentration trend in sampling sites of III > I > IV > V > 11 > VI. Iron had the highest concentration in soil dust from welding work section and lowest in the automobile mechanic section. Iron also had the highest concentration among all the metals in the reference station, some 500 m from the border of the industrial market. Earlier studies (Xianagding et al., 2001; Dara, 1993) found out that natural soils contain appreciable amount of Iron. The levels of iron observed in this study were higher than some reported elsewhere (Ahumada et al., 1999; He and Singh, 1995; Karezewska, 1996). Iron in industrial areas result from construction, filing and other metal works.

The levels of Copper in the samples studied ranged from 64.0 to 2.8 mg/kg. These were significantly higher than values reported elsewhere (Rashad and Shalaly, 2007; Dara, 1993). The presence of Cu in industrial street dust is attributable to smelting, battery, soldering works.

Lead levels in the soil dust studied ranged from 87.0 to 4.8 mg/kg, greatly higher than some earlier reported works (Rashad and Shalaly, 2007; Ayodele and Gaya, 2003). Lead enters dust through the actions of electrical smelting and soldering workers. Lead is noted as toxin and it has adverse effects on humans and animals (Murphy, 1981).

The concentrations of Cadmium ranged from 2.3 to 0.2 mg/kg. Cadmium presence in the soil dusts results from industrial works such as battery and other electrical works. Nickel levels ranged from 0.8 to 0.1 mg/kg. The element has the lowest concentration of all the metals analyzed. The levels of the metals found in the industrial market soil dust are appreciably higher than those found in the reference station, an indication of pollution of the market soils. The result of this work has far reaching implications to the environment. Heavy metals are widely distributed from the pollution sources into various components of the environment ranging from the humans to air, vegetation and water. For instance, in a study of heavy metal pollution of ground water in the same market (Ekere, 2011), many heavy metals were found to be in excess of the maximum allowable limit. Health risks associated with Cd, Pb, Cu, Ni, and Fe have been

Table 2. C/P index of some metals in the soil dusts.

Sample	Fe	Cu	Pb
I	0.14	1.78	0.37
II	0.06	0.61	0.41
III	0.15	0.94	1.12
IV	0.13	1.33	0.57
V	0.12	1.75	1.02

extensively reviewed and hardly need further stress (JECFA, 1989; Oldiges et al., 1989; Nriagu, 1996; Eaton and Robertson, 1994; Glover-KerKvilet, 1995; Imeggbue et al., 2006; Jkrup, 2003). The contamination/pollution index (C/P) of the three most abundant metals in the soil dusts was calculated as recommended by Lacatusu (2000) thus:

$$C/P = \frac{\text{Conc. of the metal in the soil}}{\text{Target value}}$$

where the target value was obtained by using the standard formulated by the Department of Petroleum Resources (Osakwe, 2010) in Nigeria as cluster abundant values for maximum allowable concentration of heavy metals in soil in mg/kg {5000 for Fe; 85 for Pb; 36 for Cu}. The C/P index values for the dust samples are shown in Table 2.

A C/P value greater than 1 is an indication that the soil is polluted while values less than 1 indicates contamination. Based on the classification, it can be easily seen that the dust samples from the industrial market in locations I, IV and V were polluted with respect to Cu and Pb while sections III and V are polluted with respect to Pb.

In order to evaluate the anthropogenic environmental status of the elements examined, the Enrichment Coefficient was used (Assah et al., 2003; Egbareuba and Odjada, 2002). The Enrichment Coefficient {EC} is given as:

$$EC = \frac{C_1Me/C_1n}{C_2Me/C_2n}$$

Where C_1Me and C_2Me are examined metal content in the examined environment and reference environment respectively while C_1n and C_2n are reference element in the examined environment and reference environment respectively.

Iron was used as the reference element as it in the most naturally abundant element in the soil dust. Five contamination categories are recognized on the basis of EC (Egbareuba and Odjada, 2002) as follows:

Table 3. Enrichment Coefficient (EC) of the metals studied.

Sample	Fe	Cu	Pb	Cd	Ni
I	5.52	4.1	1.16	1.62	0.72
II	2.25	3.61	0.87	4.84	3.52
III	6.01	2.02	0.34	1.96	0.34
IV	5.21	3.26	1.90	0.38	1.52
V	4.90	4.50	3.69	0.80	1.00

- i. Deficiency to minimal enrichment for values below 2,
- ii. Moderate enrichment for values from 2 to 5,
- iii. Significant enrichment for values from 5 to 20,
- iv. Very high enrichment for values from 20 to 40,
- v. Extremely high enrichment for values above 40.

The result of the analysis is shown in Table 3. Enrichment coefficient is a very veritable tool in assessment of anthropogenic contribution to environmental pollution with heavy metal in literature (WHO, 1989). The EC values obtained for Iron have a range of 2.25 to 6.01 placing the element in the category of moderate enrichment to significant enrichment. Copper with a range of 2.02 to 4.50 has moderate enrichment while lead had minimal enrichment in all samples except V (automobile mechanic) which was moderately enriched. Cadmium and Nickel fall within deficiency to minimal enrichment category. Some of these values were above the range reported in some similar studies but definitely the contributions of anthropogenic activities is evident (Assah et al., 2003; Egbareuba and Odjada, 2002; Akoto et al., 2008; Ogundiran et al., 2012; Amusan et al., 2005).

Conclusion

The soil dusts from the industrial market studied indicated pollution of the soil environment by heavy metals. The values obtained from the contamination/pollution index corroborated this view. Further more, analysis of the enrichment coefficient indicated a range of minimal to significant enrichment for the metal contents studied.

REFERENCES

- Ahumada I, Mendoza J, Asear L (1999). Sequential Extraction of heavy metals in soils irrigated with waste water. *Commun. Soil Sci. Plant Anal.* 30:1507-1519.
- Akoto O, Ephraim JH, Dako G (2008). Heavy metals pollution in surface soils in the vicinity of Abundant Railway Servicing workshop in Kumasi, Ghana. *Int. J. Environ. Res.* 2(4):359-364.
- Al-Khashman OA (2004). Heavy metal distribution in dust street dust and soils from work place in Karak Industrial Estate, Jordan. *Atmos. Environ.* 38:6803-6812.
- Amusan AA, Ige DU, Olawales R (2005). Characteristics of Soils and Crop uptake of metals in Municipal waste dumpsites in Nigeria. *J. Hum. Ecol.* 17(3):167-171.

- Ano AO, Odoemela SA, Ekwueme PO (2007). Lead and Cadmium levels in soils and cassava. (*Manihot Esculenta* Grantz) along Enugu-Port Harcourt Expressway in Nigeria. *Electronic J. Environ. Agric. Food Chem.* 6(5):2024-2031.
- National Population Commission of Nigeria (NPC) (2006). Population and Housing Census Result. NPC, Lagos. P. 26.
- Archer A, Barratt RS (1976). Lead in the Environment. *Monitoring for Lead. Sci. Total Environ.* 96:173-176.
- Assah VA, Abimbola AF, Such CE (2003). Heavy metal concentration and distribution on surface soils of the Rassa Industrial Zone I Dounal Cameroon. *Arabia J. Sci. Eng.* 31(24):147-158.
- Ayodele JT, Gaya UM (1998). Zinc and Manganese in Kano municipality street Dust. *J. Chem. Soc. Nig.* 23:24-31.
- Ayodele JT, Gaya UM (2003). Nickel in Municipal street dust. *J. Chem. Soc. Nig.* 25(1):15-20.
- Ayodele JT, Gaya UM (1994). Determination of lead in street dust to index its pollution in Kano municipal. *Spectrum J.* 1:92-97.
- Bhattacharya T, Chakraborty S, Fadadu B, Bhattacharya P (2011). Heavy Metal concentrations in street and Leaf Deposited Dust in Anand City, India. *Res. J. Chem. Sci.* 1(5):61-66.
- Chima GN, Ogbonna CE, Nwankwo IU (2009). Effects of urban wastes on the quality of Asata River in Enugu, South Eastern Nigeria. *Global J. Environ. Sci.* 8(1):31-39.
- Dara SS (1993). *A Textbook of Environmental Chemistry and Pollution Control.* S. Chand and Company Ltd. Ran Nagar. New Delhi 110055.
- Eaton DL, Robertson WO (1994). Toxicology' in Rosenstick L and Cullen MR eds. *Textbook of Clinical Occupational and Environmental Medicine.* WB Saunders Company. Philadelphia pp. 116-117.
- Egbareuba F, Odjaja V (2002). The Pollution Potential and Chemical Interaction Parameter of some agro and industrial wastes on soil. *Nig. J. Basic Appl. Sci.* 11:177-188.
- Ekere NR (2011). Heavy metals contamination of Ground water in Industrial areas of Enugu Nigeria *J. Appl. Sci.* 14(1):9535-9542.
- Fazeli MS, Moosavi MH, Pournia M, Jassemi ZZ (2009). Metals Distribution in Top soils around Industrial Town of Ahwaz II. Ahwaz, Iran. *J. Appl. Sci.* 9(6):1121-1127.
- Glover-Kerkvilet J (1995). Environmental Assault on Immunity. *Environ. Health Perspect.* 103(3):236-237.
- He QB, Singh BR (1995). Calcium Availability to Plants as Affected by Repeated Applications of Phosphorous Fertilizers. *Acta. Agric. Scand. B.* 45:22-31.
- Imegbue CMA, Isirimah NO, Igwe C, William ES (2006). Characteristic, levels of heavy metals in soil profile is automobile Mechanic waste dumps in Nigeria. *Environmentalist* 26:131-137.
- Jaradat OM, Momani AK (1999). Contamination of road side soil, plants and air with Heavy metals in Jordan. A Comparative study. *Turk. J. Chem.* 23:209-220.
- JECFA (1989). Toxicological evaluation of certain food additives and contaminants. World Health Organization. Joint FAO/WHO Expert Committee on food Additives Cambridge, Cambridge Univ. Press (WHO Food Additives series No. 24) pp. 163-219.
- Jkrup L (2003). Hazards of heavy metals contamination. Great Britain. British Council Publication. pp. 18-22.
- Karezweska A (1996). Metal Species Distribution in Top and Subsoil in Area Affected by Copper Smelter Emissions. *Appl. Geo. Chem.* 11:35-42.
- Li XD, Poon CS, Liu PS (2001). Heavy metal contamination of urban soils and street dusts in Hong Kong. *Appl. Geo. Chem.* 16:136-1368.
- Lacatusu R (2000). Appraising levels of soil contamination and pollution with heavy metals European Soil Bureau Research Report. 4:393-402.
- Li MS, Lou YP, Su ZY (2007). Heavy metal concentrations in soils and plant accumulation in a restored manganese mine land in Guangxi. South China. *Environ. Pollut.* 147:168-175.
- Li Y, Wang X, Gou X, Isu YB, Wang B (2006). Risk assessment of heavy metals in soils and Vegetables around non-ferrous metals mining and smelling sites, Baiyin, China. *J. Environ. Sci.* 18:1124-1134.
- Nasralla MM (1984). Lead in Jaddah urabn dust. *Environ. Pollut. (series B)* 8:133-141.
- Murphy CB (1981). Bioaccumulation and toxicity of heavy metals and related trace elements. *J. Wat. Pollut. Contr. Fed.* 53(6):993-999.
- Narwal RP, Singh BR, Salbu B (1996). Association of Cadmium, Zinc, Copper and Nicked with Components in Natural Heavy Metal Rich Soils Studied by Parallel and Sequential Extractions. *Com. Soil Sci. Plant. Anal.* 30:1209-1230.
- Nriagu JO (1996). History of Global metal pollution. *Science* 272:223-224.
- Nyangababo JT, Hamuya JN (1986). The deposition of lead, Cadmium, Zinc and Copper from motor traffic on Bombay road in Kampala city. *Inter. J. Environ. Stud.* 28:115-119.
- Ogundiran MB, Ogundela DT, Afolayan P, Osibanjo O (2012). Heavy metals levels in forage Grasses, Leachate and Lactating Cows Reared around lead Slag Dumpsites in Nigeria *Int. J. Environ. Res.* 6(3):695-702.
- Oldiges H, Hochrainer T, Glaser U (1989). Long term Inhalation Study with Wistar rats and four Cadmium Compounds. *Toxicol. Environ. Chem.* 19: 217-222.
- Osakwe SA (2010). Distribution of Heavy metals in soils around automobile dumpsites in Agbo and Environs, Delta State, Nigeria. *J. Chem. Soc. Nig.* 35(1):53-60.
- Rashad M, Shalaly EA (2007). Dispersion of heavy metals around Municipal solid waste (MSW) dumpsites, Alexandria, Egypt. *Am. Eurasian J. Agric Environ. Sci.* 2(3):204-212.
- Roger NR (1994). *Environmental Analysis.* 13th edition. John Wiley & Sons. New York. pp. 25-40.
- Sharma RK, Agrawal M, Marshal F (2007). Heavy metal contamination of soils and vegetables in sub urban areas of Varansi, India. *Ecotoxicol. Environ. Safety* 66:258-266.
- Shinggu DY, Ogugbuaja VO, Barminas JT, Toma I (2007). Analysis of street dust for heavy metal pollutants in Mubi, Adamawa State Nigeria. *Int. J. Phy. Sci.* 2(11):290-293.
- Sutherland RA (2000). Bed Sediment associated trace metals in the urban stream. Oahu Hawaii. *Environ. Geol.* 39:611-627.
- Turer D, Maynard JB, Sansalone JJ (2001). Heavy metal contamination in soils of urban highways. Comparison between runoff and soil concentration at Cincimmati, Ohio. 132:293-314.
- White head PJ (1975). *Pye Unicam Atomic Absorption Data Book.* 1st ed. Pye Unicorn Ltd. England; Cambridge.
- WHO (1989). *Environmental Health Criteria 3 and 5* CPCB (1997). CPCB News letter 4(iii).
- Xianagding Li, Chi-sum P, Pui-sumliu S (2001). Heavy metal contamination of urban soils and street dust in Hong Kong. *Appl. Geo. Chem.* 16:1361-1368.