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Full Length Research Paper

Determination of heavy metal pollutants in street dust of Yola, Adamawa State, Nigeria

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Contamination of the environment by heavy metals is a phenomenon of global importance today. When present in high concentrations in the environment, heavy metals may enter the food chain from soils and result in health hazards. This study is aimed at determining the elemental concentrations of heavy metal pollutants that may be present in street dust samples in Yola, Adamawa State, Nigeria. Dust samples were collected in mechanical workshops (MWK), motor parks (MPK), market areas (MKA), roundabouts/highways (RHW) and residential areas (RDA). The dust samples were digested using aqua regia digestion method and Atomic Absorption Spectrophotometer was used for the elemental analysis. The variation in concentration of most of the heavy metals determined from different sites decreases in an order represented as MWK>MPK>MKA>RHW>RDA. The heavy metals showed a variation that indicated that Fe>>Zn>Pb>As>Cu>Ni>Cr>Cd. Iron had the highest concentration in all the sampling areas with range of 6460.00 ± 198 - 40500.00 ± 500 µg/g. The lowest value was observed for Cd with respective range of 0.43 ± 0.05 - 1.54 ± 0.0 6 µg/g. Cobalt and selenium were not detected in all the samples. Statistical analyses by ANOVA showed a significant difference (P < 0.05) between the elements determined. This suggested that, the heavy metal pollutants in the street dust samples of Yola did not originate from common anthropogenic sources. Probably automobile emission, welding of metal and exhaust from generators may have contributed as one of the major sources of these elements.

Key words: Metal pollution, dust, sampling sites, automobile emission, atomic absorption spectrophotometer, toxic substances, concentration.

INTRODUCTION

Heavy metal pollutant in urban street dust has become a growing concern in recent years (Shinggu, et al, 2007). The contamination of the environment by heavy metals is a phenomenon of global importance today. This is because the accumulation of heavy metals in street dust is one major way through which heavy metals may find their way into soils and subsequently living tissues of plants, animals and human beings. Heavy metals can impair important biochemical processes posing a threat to human health, plant growth and animal life (Ward et al., 1977; Jarup, 2003 and Michalke 2003). The heavy metals can impair important biochemical processes posing a threat to human health, plant growth and animal life (Silva et al, 2005 and Mashi, et al, 2005).In monitoring urban pollution, chemical and biological indicators are of interest since they provide information on the concentration and accumulation of heavy metals in the ecosystem (Campbell, 1976, Ramlan and Badri, 1989 and Alter,1989)). A range of metals and chemical compounds found in the street dust environment are harmful. Pollutants can attack specific sites or organs of the body and disease can develop as a consequence to such exposure (Archer and Barrett, 1976; Ayodele and Gaya, 1998).

Although there have been considerable number of studies on the concentration of heavy metals in street dust, the vast majority have been carried out in developed countries with long histories of industrialization (Jaradat and Momani,1999). Very few studies have been

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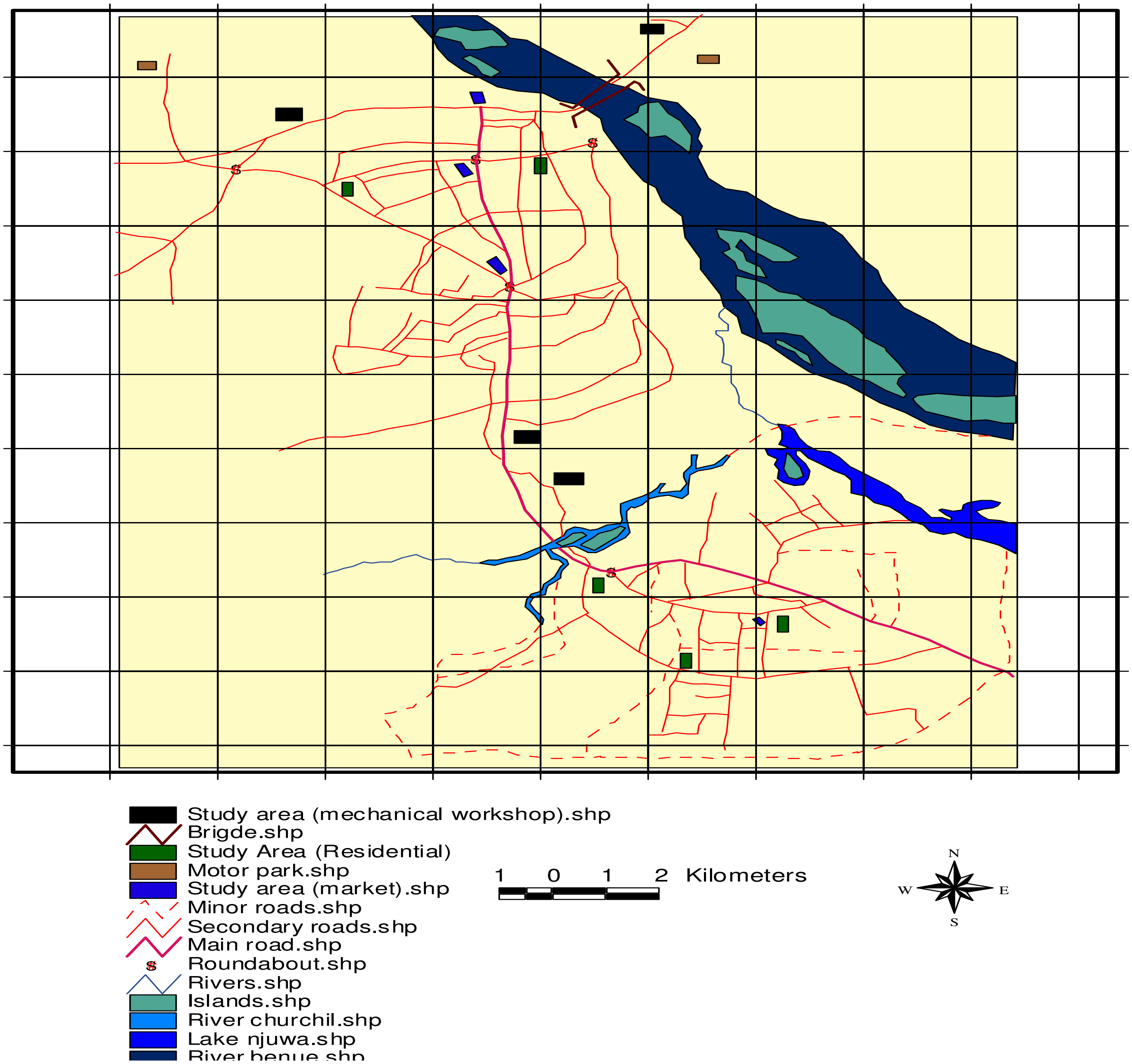

Figure 1. Map of Jimeta Yola showing the major roads and the sampling areas.

carried out in developing countries like Nigeria. Little interest has been focused on the contamination of street dust by other heavy metals in Nigeria and Africa in particular. Such data on heavy metal concentration of street dust in these areas are extremely scarce. In Yola, street dust has become the major source of pollution in the metropolis due to bad roads and construction works in the State capital.

This paper therefore reports the concentration of heavy metals in Yola street dust at different sites. From places of high activities to places of low activities that is mechanical workshops, motor parks, market areas round-about and high-ways and residential areas. The health hazards of these heavy metals in street dust are highlighted.

MATERIALS AND METHODS

Sampling map

Five sites were selected for the study along the major roads in Yola metropolis. Five replicate samples were collected from each sampling sites as shown in Figure1. It shows the major roads and sampling areas in Yola metropolis. Street dust samples were taken from mechanical workshops, motor parks, market areas, round-

Table 1. Mean ± SD of Elemental Concentrations of some heavy metals (µg/g) in street dust samples between October, 2006 to April, 2007 in Yola, Adamawa State, Nigeria.

	Sample	Cd	Cu	Co	Cr	Fe	Pb	Ni	Se	Zn
RDA	ND	0.42 ± 0.05^{a}	28.97 ± 0.74^{a}	ND	2.07 ± 0.15^{a}	6460 ± 198^{a}	47.50 ± 8.56^{a}	ND	ND	225.74 ± 3.07^{a}
RHW	ND	0.66 ± 0.03^{a}	90.08 ± 1.63^{b}	ND	4.15 ± 0.12^{a}	24500 ± 103^{b}	630.13 ± 26.30^{b}	12.05 ± 1.80^{a}	ND	1006.76 ± 30.40^{b}
MKA	599.94±48.50^{a}	0.70 ± 0.10^{a}	62.51 ± 1.38^{c}	ND	7.56 ± 0.20^{b}	30500 ± 250^{b}	307.41 ± 9.80^{c}	18.10 ± 3.43^{a}	ND	952.88 ± 36.00^{b}
MPK	105.48 ± 11.00^{b}	0.90 ± 0.24^{a}	62.7 ± 4.36^{c}	ND	5.90 ± 0.40^{a}	16600 ± 498^{c}	664.26 ± 26.30^{d,b}	23.08 ± 2.00^{b}	ND	613.46 ± 19.90^{c}
MWK	70.36 ± 9.80^{c}	1.54 ± 0.06^{b}	196.04 ± 5.23^{b}	ND	10.50 ± 1.00^{c,b}	405500 ± 50^{d}	648.74 ± 43.40^{d,b}	50.30 ± 8.83^{c}	ND	2424.40 ± 198.20^{d}

All values represent mean±SD (Standard deviation). Comparison was done within the column and values with different superscripts are statistically different ($p < 0.05$).ND: Not detected; RDA = Residential areas; RHW = Roundabouts and high ways; MKA = Market areas; MPK = Motor park; MWK = Mechanical workshops.

about and high ways and residential areas.

Sampling procedure

Street dust samples were sampled using brush and plastic scoop to collect the settled dust on polyethylene sheets placed along the streets in each of the study areas. Samples were collected from October, 2006 to April, 2007 to avoid rain-washing out the heavy metals.

Sample preparation

Dust samples were collected and transferred to clean polyethylene bags. All the samples were dried at 100 – 110°C to drive out moisture. On cooling, samples were sieved through a nylon sieve of 2 mm diameter.

Procedure

All experiments were performed with analytical reagent grade chemicals.

The digestions of the dust samples were done using aqua regia that is 3:1 ratio of hydrochloric acid to trioxonitrate (V) acid. A portion of one gram of each of each air-dried and sieved dust sample was ashed in a muffle furnace at 460°C for 12 h. The ash was digested in 10mL aqua regia in a digestion tube on heating blocks at different temperatures and times (2h at 30°C 2h at 60°C, 2h at 105°C, and 3h at 125°C), spreading over a total of nine hours. After the digestion, the digests were first centrifuged and were acid washed to pass through Whatman 540 filter paper and then filtered into 100ml volumetric flask then made up to the volume with distilled water. Calibration standards were prepared from the stock solution of the elements to be determined by serial dilution and were matrix matched with the acid concentration of the digested samples (Whitehead, 1975). The digested samples were then analyzed for heavy metal using Unicam SP 969 Atomic Absorption Spectrophotometer (Al-shayeb, et al, 1995). All the measurements were in triplicates. Data were subjected to analysis of variance (ANOVA) by SPSS to determine the differences in the concentration of each metal between different sites.

RESULTS AND DISCUSSION

Table 1 presents the concentrations of some heavy metal pollutants determined in the street dust samples in Yola from October, 2006 to April, 2007. High elemental concentration was observed in Fe followed by Zn, Pb, As, Cu, Ni, Cr and Cd in all the five different sampling sites.

The high concentration of iron and zinc in the street dust samples may be attributed to metal construction works, iron bending and welding of metals, which is a common practice along the major streets and mechanical workshops in Yola. The heavy metals in urban street dust take their origin from sources such as vehicles, road wear, activities of roadside artisans (battery charging, vehicle repairs, iron-bending, vehicle painting and panel beating) and emissions and or discharges from industries. The metals such as Zn, Pb, Cr and Ni come mainly from vehicular activities such as tyre wear, wear of break linings and studded tyres may be the sources for Ni, Cr, and Pb (Muschack, 1990) and Fe, Ni, Mo, Co, Cd, Ti and Cu respectively (Viklander, 1998). Corrosion of bushings, brake wires and radiators and the various types of deicing chemicals and friction materials used on road surfaces for slipperiness control could expose metals such Cu, Fe, Ni, Cr, and Co (Viklander, 1998) and others into the environment.

In every mechanical workshop there are various sections that deal with either filling or welding of these metals and paveling of vehicle bodies. Iron fillings from this metal works, exhaust emissions from vehicles, oil spillage of gasoline, diesel, wastes from car batteries, engine oil and lubricating oils, coupled with rusting of non-coated metals have all collectively contributed to the presence of these elements Fe, Zn, Pb, Cu, Cr, As, Cd and Ni as shown in Table 1. Heavy metal pollution is a problem associated with areas of intensive industry, however, roadways and automobiles now are considered to be one of the largest sources of heavy metals. Zinc, copper, and lead are three of the most common heavy metals released from road travel, accounting for most of

Table 2. Mean concentration of some heavy metals (µg/g) in Roadside / Street dust compared with other studies world wide

Place	Cu	Cd	Co	Pb	Zn	Fe	Reference
Yola	28.97 - 196.00	0.42 - 1.54	ND	47.50 - 664.00	225 - 1006.00	6461 - 40500	This study
Mubi	11.63 - 52.35	0.59 - 1.33	ND	20.37 - 241.34	102.22 - 705.80	5331 - 24100.00	Shinggu et al. (2007)
Gwagwalada Abuja	97.00	3.40	-	210.00	79.00	120.00	Mashi et al. (2005)
Honkong	110.00	ND	ND	120.00	3840.00	14100.00	Jaradat and Momani (1999)
Madrid	188.00	ND	ND	247.00	476.00	ND	“
Auckland	27.00	0.40	6.41	1650.00	180.00	20900.00	“
London	-	4.20	73.00	1354.00	513.00	22800.00	“
Birmingham	ND	0.70	180.00	ND	205.00	ND	“
USA Different es	ND	0.89	ND	444.00	ND	ND	“
Ecuador	ND	0.36	ND	293.00	509.00	ND	“
Lancaster	199.00	5.20	ND	ND	530.00	ND	“
North Wales	24.00	6.90	ND	1779.00	1143.00	ND	“
Amman	29.70	0.75	ND	188.80	121.70	ND	“

ND: Not detected.

most of the heavy metals in road runoff (Hutton and Symon, 1986; Rasmussen, et al, 2001).

Lead concentrations, however, consistently have been decreasing since leaded gasoline was discontinued. Smaller amounts of many other me-tals, such as nickel and cadmium, are also found in road runoff and exhaust. About half of the zinc and copper contribution to the environment from urbanization is from automobiles.

Brake linings release copper, while tyres wear releases zinc. Motor oil also tends to accumulate metals as it comes into contact with surrounding parts as the engine runs, so oil leaks become another pathway by which metals enter the environment. Iron, lead and zinc in this study area are higher compared to other studies in Mubi, Abuja, Amman, Hong Kong, Madrid (Shinggu et al, 2007, Mashi, et al, 2005 and Jaradat and Momani, 1999) respectively as shown in Table 2. Studies have shown that, stainless steel and alloy steel contain Fe, Cr, Co, Al and/or Cu and that exhaust emission from both gasoline and diesel fueled vehicles contain variable quantities of these elements (Chong, 1986 and Yu, et al, 2003). Chromium, cadmium and nickel are among the toxic listed elements by the International Agency for Research on Cancer (IARC) as carcinogenic (IARC, 1998).

Statistical analysis showed significant differences ($P < 0.05$) between the elements as indicated in Table 1. This suggests that, the indicated heavy metal pollutants in street dust of Mubi did not originated from common anthropogenic sources with probably automobile and the welding of metals as the major sources.

The health implication of these heavy metals in street is quite obvious. Street dust with its high heavy metal contents has a high vulnerability of causing cough/ breathing in both children and adults during inhalation. Leke (1999), reported that the inhalation of siliceous dust causes siliceous disease of the lungs. It has been observed that inhalation of some mineral particles can produce diseases in persons working in quarry sites, road construction, mines and welders. These mainly affect the lungs and the major pathogenic effect is the formation of fibrotic tissues in the lungs. The degree of incapacitation or loss of operational capacity of the lungs is dependent on the amount and type of mineral dust inhaled (Elinder and Jarup, 1996; Nsi and Shallsuku, 2002). This response of lungs to mineral dust with attendant formation of fibrotic tissue is commonly referred to as pneumonomosis (Nsi and Shallsuku, 2002). In addition to these toxic effects, it has also been suggested that cadmium may play a role in the development of hypertension and heart disease (Radojevice and Bashkin, 1999, Elinder and Jarup, 1996).

Chromium and its compounds are known to cause cancer of the lungs, nasal cavity and para nasal sinus and suspected to cause cancer of the stomach and larynx (ATSDR, 2000). Apart from these direct effects of the dust on man, its effects are also felt indirectly. It settles on dried foodstuff such as rice, groundnut, maize, yam flour and dried cassava when the moisture contents of these foods are high. The dust dissolves in this moisture and become absorbed and thereby contaminates the foodstuff. Other foods such as sugar cane, roasted meat, beans cake, sugar, salt and vegetables may be contaminated by this dust, since must of the food items listed above are commonly sold along the streets of Yola. Dust also settles on building, walls, roofs, windowpanes and doors causing mechanical abrasion and aesthetic blight.

Conclusion

This study has shown that the street dust in Yola is relatively contaminated with heavy metals. The heavy metal contaminations in street dust show a considerable decrease from place of high activities to a place of low activities (mechanical workshops to residential areas). This decrease might indicate aerial deposition of metal particulates in the street dust environment from extraneous sources and not only a function of soil type. Automobile and metal construction works could be responsible for the build up of the heavy metals in the street dust along the high ways and mechanical work-shops through the emission of metal particulates. The street dust environment had a significantly high content of heavy metals, especially, Fe, Zn, Pb, Cu, and As and generally their levels increased with increasing traffic volume and welding of metals in urban areas. Finally, results obtained from this research work would now provide significant reference value for future studies of these areas and other regions in Adamawa State and North eastern region of Nigeria.

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