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***Original Research Article***

# ANALYSIS OF ROADSIDE DUST FOR HEAVY METAL POLLUTANTS IN JIMETA/YOLA ADAMAWA STATE, NIGERIA

***ABSTRACT***

*A study of heavy metals in roadside soils is critical in assessing the potential environmental impacts of automobile emission on the soil. This study is aimed at analyzing the elemental concentrations of heavy metal pollutants that may be present in roadside dust samples in Jimeta/ 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 Unicam SP 969 was used for the elemental analysis. The variation in concentration of most of the heavy metals determined from different suites 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* 3460 ± 198 - 5800±50 *µg/g. A lower value was observed for Cd with respective range of 0.48 ± 0.05 - 1.74 ± 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 roadside dust samples of Jimeta /Yola did not originate from common anthropogenic sources. Probably automobile emission, welding of metal and exhaust from generators may have contributed as these are the major sources of these elements in the environment.*

**Key words:** ***Metal pollution, Dust, Roadside, automobile emission, atomic absorption spectrophotometer, concentration.***

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## INTRODUCTION

A study of heavy metals in roadside soils is critical in assessing the potential environmental impacts of automobile emission on the soil [1]. Heavy metal pollutant in urban street/roadside dust has become a growing concern in recent years [2]. Roads are important infrastructure that plays a major role in stimulating social and economic activities. However, road construction has also resulted in heavy environmental pollution [3].

Trace metals in roadside soils may come from various human activities, such as industrial and energy production, construction, vehicle exhaust, waste disposal, as well as coal and fuel combustion [4]. The contamination of the environment by heavy metals is a phenomenon of global importance today. This is because the accumulation of heavy metals in roadside 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 [5,6]. The 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 [7,8,9]. A range of metals and chemical compounds found in the roadside dust environment are harmful. Pollutants can attack specific sites or organs of the body and disease can develop as a consequence to such exposure[10,11]. Although there have been considerable number of studies on the concentration of heavy metals in roadside dust, the vast majority have been carried out in developed countries with long histories of industrialization [12]. Very few studies have been carried out in developing countries especially in northeast Nigeria. Little interest has been focused on the contamination of roadside dust by heavy metals in Nigeria and Africa in particular. Data on pollutant metal concentration of roadside dust in such areas are extremely scarce. In Jimeta/Yola roadside dust

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has become the major source of pollution in the metropolis due to bad roads and construction works in the State capital especially during dry season.

This paper therefore reports the level of heavy metals in Jimeta/Yola roadside dust at different locations that is places of high activities to places of low activities like mechanical workshops, motor parks, market areas roundabout and high-ways and residential areas. The health hazards of these heavy metals in roadside dust are also highlighted.

## MATERIALS AND METHODS

### Sampling Procedure

Roadside dust samples were taken from mechanical workshops, motor parks, market areas, roundabout and high ways and residential areas. The samples were sampled using brush and plastic scoop to collect the settled dust on polyethylene sheets placed along the roads in each of the study areas. Samples were collected from October, 2010 to April, 2011 to avoid rain-washing out the heavy metals.

### Sample preparation

Dust samples were collected and transferred to clean polyethylene bags and transported to the laboratory for onward analysis. All the samples were dried at 100 – 105$^{o}$C to drive out moisture. On cooling samples were sieved through a nylon sieve of 2mm diameter.

### Sample Digestion 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. Portions of two gram of each of each air-dried and sieved dust sample were ashed in a muffle furnace at 460$^{o}$C for 12 hours. The ash were digested in 10mL aqua regia in a digestion

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tube on heating blocks at different temperatures and times (2hours at 30$^{o}$C 2hours at 60$^{o}$C, 2hours at 105$^{o}$C, and 3 at 125$^{o}$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 [13]. The digested samples were then analyzed for heavy metal using Unicam SP 969 Atomic Absorption Spectrophotometer[14]. All the measurements were in replicate analysis. Data obtained were subjected to analysis of variance (ANOVA) by SPSS to determine the differences in the concentration of each metal between different sites.

**Table1: Mean ± SD of Elemental Concentrations of some heavy metals (µg/g) in Roadside dust samples between October, 2010 to April, 2011 in Jimeta/Yola, Adamawa State, Nigeria**

| SAMPLE | As | Cd | Cu | Co | Cr | Fe | Pb | Ni | Se | Zn |
|---|---|---|---|---|---|---|---|---|---|---|
| RDA | ND | 0.48±0.05[a] | 28.97± 0.74[a] | ND | 2.07±0.15[a] | 3460 ± 198[a] | 47.50 ± 8.56[a] | ND | ND | 125.74± 3.07[a] |
| RHW | ND | 0.66±0.03[a] | 90.08±1.63[b] | ND | 3.15 ± 0.12[a] | 4500±103[b] | 340.13± 26.30[b] | 10.05±1.80[a] | ND | 506.76±30.40[b] |
| MKA | 199.94±48.50[a] | 0.70± 0.10[a] | 62.51±1.38[c] | ND | 6.56 ± 0.20[b] | 5400±250[b] | 307.41 ± 9.80[c] | 16.10 ±3.43[a] | ND | 452.88±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] | 5600± 498[b] | 364.26±26.30[d,b] | 20.08 ± 2.00[b] | ND | 613.46±19.90[c] |
| MWK | 70.36 ± 9.80[c] | 1.74± 0.06[b] | 106.04±5.23[b] | ND | 9.50±1.00[c,b] | 5800±50[b] | 448.74± 43.40[d,b] | 30.30±8.83[c] | ND | 824.40±198.20[c] |

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.

**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 | REFERECE |
|---|---|---|---|---|---|---|---|
| Yola | 28.97 - 106.04 | 0.48 -1.74 | ND | 47.50 – 448.74 | 125.74 – 824.40 | 3460 – 5800 | 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) |
| Jos | 1.01- 2.19 | 5.15 - 5.79 | - | 1.59- 12.10 | 5.67 - 12.88 | 141.80 - 159.00 | Abechi *et al.,* 2010) |
| 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

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## RESULT AND DISCUSSION

Table 1 presents the concentrations of some heavy metal pollutants determined in the roadside dust samples in Jimeta/Yola from October, 2010 to April, 2011. High elemental concentration was observed in Fe, followed by Zn, Pb, As, Cu, Ni, Cr and Cd in all the five different sampling areas.

The high concentration of iron and zinc in the roadside dust samples may be attributed to metal construction works, iron bending and welding of metals, which is a common practice alone the major roads and mechanical workshops in Jimeta/Yola. The heavy metals in urban roadside 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[1].

These metals, Zn, Pb, Cr and Ni come mainly from vehicular activities such as tyre wear ,wear of brake linings and studded tyres may be the sources for Ni, Cr, and Pb [15](Muschack,1990) and Fe, Ni, Mo,Cr Co, Cd, Ti and Cu respectively [16](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 [16](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,

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and lead are three of the most common heavy metals released from road travel, accounting for most of the heavy metals in road runoff [17,18. Lead concentrations, however, consistently have been decreasing since leaded gasoline was discontinued. Smaller amounts of many other metals, 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 tyre wears 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 [2,6,12] 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 [19,20]. Chromium, cadmium and nickel are among the toxic listed elements by the International Agency for Research on Cancer (IARC) as carcinogenic [21].

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. Roadside dust with its high heavy metal contents has a high vulnerability of causing cough/breathing in both children and adults during inhalation. Leke [22], reported that the inhalation of siliceous dust causes

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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 [23, 24]. This response of lungs to mineral dust with attendant formation of fibrotic tissue is commonly referred to as pneumonomosis[24]. In addition to these toxic effects, it ahs also been suggested that cadmium may play a role in the development of hypertension and heart disease[25,23].

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 [26]. 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 roads of Jimeta/ Yola. Dust also settles on building, walls, roofs, windowpanes and doors causing mechanical abrasion and aesthetic blight. This can also lead to accumulation of the metal in the tissues of organisms that feed on the plant and other plants growing along the highway. This can be transferred to other consumers in the food chain [27]

**CONCLUSION**

This study has shown that the roadside dust in Jimeta Yola is relatively contaminated with heavy metals. The heavy metal contaminations in roadside dust show a considerable decrease from place of high activities to a place of low activities (mechanical workshops to residential areas).

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This decrease might indicate aerial deposition of metal particulates in the roadside 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 roadside dust along the high ways and mechanical workshops through the emission of metal particulates. The roadside dust environment had a significantly high content of heavy metals, especially, Fe, Zn, Pb and Cu, and generally their levels increased with increasing traffic volume and welding of metals in urban areas. Hence, possible accumulation in the soil and transfer to plants growing along the edge of the highway could occur as a result continual usage of the road by automobile. This can also lead to accumulation of the metal in the tissues of organisms that feed on the plant and other plants growing along the highway.

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