

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 from 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 $3460 \pm 198 - 5800 \pm 50 \mu g/g$. A lower value was observed for Cd with respective range of $0.48 \pm 0.05 - 1.74 \pm 0.06 \mu g/g$. 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.

28 INTRODUCTION

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

34 Trace metals in roadside soils may come from various human activities, such as industrial and
35 energy production, construction, vehicle exhaust, waste disposal, as well as coal and fuel
36 combustion [4]. The contamination of the environment by heavy metals is a phenomenon of
37 global importance today. This is because the accumulation of heavy metals in roadside dust is
38 one major way through which heavy metals may find their way into soils and subsequently living
39 tissues of plants, animals and human beings [5,6]. Through monitoring urban pollution, chemical and
40 biological indicators are of interest since they provide information on the concentration and
41 accumulation of heavy metals in the ecosystem [7,8,9]. A range of metals and chemical
42 compounds found in the roadside dust environment are harmful. Pollutants can attack specific
43 sites or organs of the body and disease can develop as a consequence to such exposure[10,11].
44 Although there have been considerable number of studies on the concentration of heavy metals
45 in roadside dust, the vast majority have been carried out in developed countries with long
46 histories of industrialization [12]. Very few studies have been carried out in developing
47 countries especially in northeast Nigeria. Little interest has been focused on the contamination
48 of roadside dust by heavy metals in Nigeria and Africa in particular. Data on ~~pollutant~~ metal
49 concentration of roadside dust in such areas are extremely scarce. In Jimeta/Yola roadside dust

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

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

56

57 MATERIALS AND METHODS

58 Sampling Procedure

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

64 Sample preparation

65 Dust samples were collected and transferred to clean polyethylene  bags and transported to the
66 laboratory for onward analysis. All the samples were dried at 100 – 105°C to drive out moisture.

67 On cooling samples were sieved through a nylon sieve of 2mm diameter 

68 Sample Digestion Procedure:

69 All experiments were performed with analytical reagent grade chemicals. The digestions of the
70 dust samples were done using aqua regia that is 3:1 ratio of hydrochloric acid to trioxonitrate (V)
71 acid. Portions of two gram of each of each air-dried and sieved dust sample were ashed in a
72 muffle furnace at 460°C for 12 hours. The ash were digested in 10mL aqua regia in a digestion

73 tube on heating blocks at different temperatures and times (2hours at 30°C 2hours at 60°C,
 74 2hours at 105°C, and 3 at 125°C), spreading over a total of nine hours. After the digestion, the
 75 digests were first centrifuged and were acid washed to pass through whatman 540 filter paper
 76 and then filtered into 100ml volumetric flask then made up to the volume with distilled water.
 77 Calibration standards were prepared from the stock solution of the elements to be determined by
 78 serial dilution and were matrix matched with the acid concentration of the digested samples [13].
 79 The digested samples were then analyzed for heavy metal using Unicam SP 969 Atomic
 80 Absorption Spectrophotometer[14]. All the measurements were in replicate analysis. Data
 81 obtained were subjected to analysis of variance (ANOVA) by SPSS to determine the differences
 82 in the concentration of each metal between different sites.



Table1: Mean $\pm$ SD of Elemental Concentrations of some heavy metals ($\mu\text{g/g}$) 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 $\pm$ 0.06 ^a	28.97 $\pm$ 0.74 ^a	ND	2.07 $\pm$ 0.15 ^a	3460 $\pm$ 198 ^a	47.50 $\pm$ 8.56 ^a	ND	ND	125.74 $\pm$ 3.07 ^a
RHW	ND	0.66 $\pm$ 0.03 ^a	90.08 $\pm$ 1.63 ^b	ND	3.15 $\pm$ 0.12 ^a	4500 $\pm$ 103 ^b	340.13 $\pm$ 26.30 ^b	10.05 $\pm$ 1.80 ^a	ND	506.76 $\pm$ 30.40 ^b
MKA	199.94 $\pm$ 48.50 ^a	0.70 $\pm$ 0.10 ^a	62.51 $\pm$ 1.38 ^c	ND	6.56 $\pm$ 0.20 ^b	5400 $\pm$ 250 ^b	307.41 $\pm$ 9.80 ^c	16.10 $\pm$ 3.43 ^a	ND	452.88 $\pm$ 36.00 ^b
MPK	105.48 $\pm$ 11.00 ^b	0.90 $\pm$ 0.24 ^a	62.7 $\pm$ 4.36 ^c	ND	5.90 $\pm$ 0.40 ^a	5600 $\pm$ 498 ^b	364.26 $\pm$ 26.30 ^{d,b}	20.08 $\pm$ 2.00 ^b	ND	613.46 $\pm$ 19.90 ^c
MWK	70.36 $\pm$ 9.80 ^c	1.74 $\pm$ 0.06 ^b	106.04 $\pm$ 5.23 ^b	ND	9.50 $\pm$ 1.00 ^{c,b}	5800 $\pm$ 50 ^b	448.74 $\pm$ 43.40 ^{d,b}	30.30 $\pm$ 8.83 ^c	ND	824.40 $\pm$ 198.20 ^c

All values represent Mean $\pm$ 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, <i>et al</i> , (2007)
Jos	1.01- 2.19	5.15 - 5.79	-	1.59- 12.10	5.67 - 12.88	141.80 - 159.00	Abechi <i>et al.</i> , 2010)
Gwagwalada Abuja	97.00	3.40	-	210.00	79.00	120.00	Mashi, <i>et al</i> , (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

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 along 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 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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143 and lead are three of the most common heavy metals released from road travel, accounting for
 144 most of the heavy metals in road runoff [17,18]. Lead concentrations, however, consistently have
 145 been decreasing since leaded gasoline was discontinued. Smaller amounts of many other metals,
 146 such as nickel and cadmium, are also found in road runoff and exhaust. About half of the zinc
 147 and copper contribution to the environment from urbanization is from automobiles. Brake
 148 linings release copper, while tyre wears releases zinc.

149 Motor oil also tends to accumulate metals as it comes into contact with surrounding parts as the
 150 engine runs, so oil leaks become another pathway by which metals enter the environment. Iron,
 151 lead and zinc in this study area are higher compared to other studies in Mubi, Abuja, Amman,
 152 Hong Kong, Madrid [2,6,12] respectively as shown in Table 2. Studies have shown that,
 153 stainless steel and alloy steel contain Fe, Cr, Co, Al and/or Cu and that exhaust emission from
 154 both gasoline and diesel fueled vehicles contain variable quantities of these elements [19,20].
 155 Chromium, cadmium and nickel are among the toxic listed elements by the International Agency
 156 for Research on Cancer (IARC) as carcinogenic [21].

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

161

162 The health implication of these heavy metals in street is quite obvious. Roadside dust with its
 163 high heavy metal contents has a high vulnerability of causing cough/breathing in both children
 164 and adults during inhalation. Leke [22], reported that the inhalation of siliceous dust causes

165 siliceous disease of the lungs. It has been observed that inhalation of some mineral particles can
 166 produce diseases in persons working in quarry sites, road construction, mines and welders.
 167 These mainly affect the lungs and the major pathogenic effect is the formation of fibrotic tissues
 168 in the lungs. The degree of incapacitation or loss of operational capacity of the lungs is
 169 dependent on the amount and type of mineral dust inhaled [23, 24]. This response of lungs to
 170 mineral dust with attendant formation of fibrotic tissue is commonly referred to as
 171 pneumonosis[24]. In addition to these toxic effects, it has also been suggested that cadmium
 172 may play a role in the development of hypertension and heart disease[25,23].

173 Chromium and its compounds are known to cause cancer of the lungs, nasal cavity and para
 174 nasal sinus and suspected to cause cancer of the stomach and larynx [26]. Apart from these
 175 direct effects of the dust on man, its effects are also felt indirectly. It settles on dried foodstuff
 176 such as rice, groundnut, maize, yam flour and dried cassava when the moisture contents of these
 177 foods are high. The dust dissolves in this moisture and become absorbed and thereby
 178 contaminates the foodstuff. Other foods such as sugar cane, roasted meat, beans cake, sugar, salt
 179 and vegetables may be contaminated by this dust, since most of the food items listed above are
 180 commonly sold along the roads of Jimeta/ Yola. Dust also settles on building, walls, roofs,
 181 windowpanes and doors causing mechanical abrasion and aesthetic blight. This can also lead to
 182 accumulation of the metal in the tissues of organisms that feed on the plant and other plants
 183 growing along the highway. This can be transferred to other consumers in the food chain [27]

184 CONCLUSION

185 This study has shown that the roadside dust in Jimeta Yola is relatively contaminated with heavy
 186 metals. The heavy metal contaminations in roadside dust show a considerable decrease from
 187 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 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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