

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 heavy metal pollutants that may be present in roadside dust samples in Jimeta/ Yola, Adamawa State, Nigeria. Dust samples were collected ~~in~~ around 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 heavy metal analysis. The change in concentration of most of the heavy metals determined from different sites decreases in the following order MWK>MPK>MKA>RHW>RDA. The heavy metals reveal a variation which indicates ~~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 ± 0.06 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 due to traffic density, welding of metal and exhaust from power generators may have contributed to the presence of these elements in the roadside dust environment.

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

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27 INTRODUCTION

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

33 Trace metals in roadside soils may come from various human activities, such as industrial and
34 energy production, construction, vehicle exhaust, waste disposal, as well as coal and fuel
35 combustion [4]. The contamination of the environment by heavy metals is a phenomenon of
36 global importance today. This is because the accumulation of heavy metals in roadside dust is
37 one major way through which heavy metals may find their way into soils and subsequently living
38 tissues of plants, animals and human beings [5,6]. In monitoring urban pollution, chemical and
39 biological indicators are of interest since they provide information on the concentration and
40 accumulation of heavy metals in the ecosystem [7,8,9]. A range of metals and chemical

41 compounds such as lead dioxide and lead sulfate found in the roadside dust environment are
42 harmful. Pollutants can attack specific sites or organs of the body and disease can develop as a
43 consequence to such exposure [10,11]. Although there have been considerable number of studies
44 on the concentration of heavy metals in roadside dust, the vast majority have been carried out in
45 developed countries with long histories of industrialization [12]. A very few studies have been
46 carried out in developing countries especially in northeast Nigeria. Little interest has been
47 focused on the contamination of roadside dust by heavy metals in Nigeria and Africa in
48 particular. Data on pollutant metal concentration of roadside dust in such areas are extremely
49 scarce. In Jimeta/Yola roadside dust has become the major source of pollution in the metropolis

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50 due to bad roads, construction works and heavy vehicular traffic volume of about 1100 vehicles
51 per day along the major roads entering the state capital. The increase traffic volume is due to
52 security checkpoints and banned of commercial motor cycles in the State capital especially
53 during dry season.

54 This paper therefore reports the level of heavy metals in Jimeta/Yola roadside dust at different
55 locations.-

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57 MATERIALS AND METHODS

58 Study Area

59 Jimeta/Yola capital of Adamawa State, is located in the central part of the state and is located
60 on latitude 09°18'11" N and longitude 12°25'36" E. It record a lot of transportation activities due
61 to high population density and traffic in the town. Consequently, gaseous pollutants from exhaust
62 of cars, and tucks are emitted into the atmosphere. The lack of power supply in the state capital
63 has compelled industries and small scale business activities to rely on power generators as an
64 alternatives power supply. Welding and metal construction works by the roadside are common
65 phenomena in the state capital. Through these activities, heavy metal pollutants are also emitted
66 into the atmosphere or deposited in the roadside soil/dust.

Comment [S6]: If possible, provide the schematic map of the study area and samplings

67 Sampling Procedure

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

73 **Sample preparation**

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

76 ~~On cooling samples were sieved through a nylon sieve of 2mm diameter.~~

Comment [S7]: No need to sieve since they are already dust particles.

77 **Sample Digestion Procedure:**

78 All experiments were performed with analytical reagent grade chemicals. The digestions of the
79 dust samples were done using aqua regia that is 3:1 ratio of hydrochloric acid to trioxonitrate (V)
80 acid. Portions of two gram of each of each air-dried ~~and sieved~~ dust sample were ashed in a
81 muffle furnace at 460°C for 12 hours. The ash were digested in 10mL aqua regia in a digestion
82 tube on heating blocks. After the digestion, the digests were first centrifuged and were acid
83 washed to pass through whatman 540 filter paper and then filtered into 100ml volumetric flask
84 then made up to the volume with distilled water. Calibration standards were prepared from the
85 stock solution of the elements to be determined by serial dilution and were matrix matched with
86 the acid concentration of the digested samples [13]. The digested samples were then analyzed
87 for heavy metal using ~~Unicam SP 969~~ Atomic Absorption Spectrophotometer (Unicam SP 969)
88 [14]. All the measurements were in replicate ~~analysis~~analyses. Data obtained were subjected to
89 analysis of variance (ANOVA) by SPSS to determine the differences in the concentration of each
90 metal between different sites.

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Table1: Mean $\pm$ SD of ~~Elemental-elemental Concentrations-concentrations~~ of some heavy metals ($\mu\text{g/g}$) in ~~Roadside~~ 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	$364.26 \pm 26.30^{d,b}$	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	$9.50 \pm 1.00^{c,b}$	5800 ± 50^b	$448.74 \pm 43.40^{d,b}$	30.30 ± 8.83^c	ND	824.40 ± 198.20^c

All values represent ~~Mean-mean~~ $\pm$ SD (Standard Deviation). Comparison was done within the column and values with different ~~Superscripts~~ 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.

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

PLACE	Cu	Cd	Co	Pb	Zn	Fe	REFERENCE
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	“

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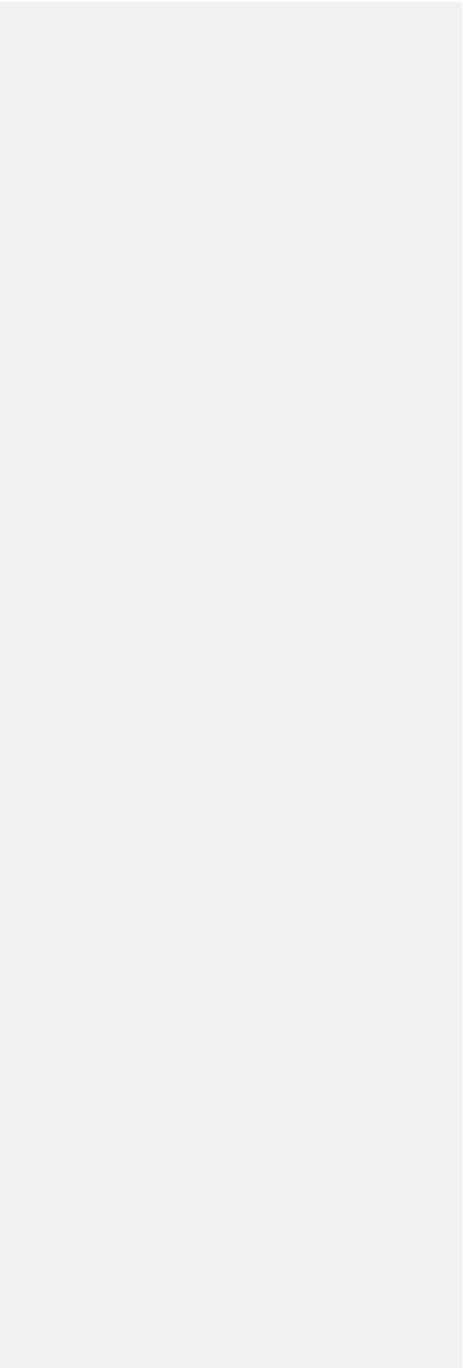
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ND: Not Detected



127 **RESULT AND DISCUSSION**

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

132 The high concentration of iron and zinc in the roadside dust samples may be attributed to metal
133 construction works, iron bending and welding of metals, which is a common practice along the
134 major roads and mechanical workshops in Jimeta/Yola. The heavy metals in urban roadside dust
135 take their origin from sources such as vehicles, road wear, activities of roadside artisans (battery
136 charging, vehicle repairs, iron-bending, vehicle painting and panel beating) and emissions and or
137 discharges from industries [1]. Zn, Pb, Cr and Ni come mainly from vehicular activities such as
138 tyre wear, wear of brake linings and studded tyres may be the sources for Ni, Cr, and Pb [15] and
139 Fe, Ni, Mo, Cr Co, Cd, Ti and Cu respectively [16]. These statement agrees with the result
140 obtained in tables 1&2. Corrosion of bushings, brake wires and radiators and the various types of
141 deicing chemicals and friction materials used on road surfaces for slipperiness control could
142 expose metals such Cu, Fe, Ni, Cr, and Co [16] and others into the environment.

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

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151 and lead are three of the most common heavy metals released from road travel, accounting for
152 most of the heavy metals in road runoff [17,18]. Lead concentrations, however, consistently have
153 been decreasing since leaded gasoline was discontinued. Smaller amounts of many other metals,
154 such as nickel and cadmium, are also found in road runoff and exhaust. About half of the zinc
155 and copper contribution to the environment from urbanization is from automobiles. Brake
156 linings release copper, while tyre wears releases zinc as shown in ~~tables~~ Tables 1&2.

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

165 Statistical analysis showed significant differences ($P < 0.05$) between the elements as indicated
166 in Table 1. This suggests that, the indicated heavy metal pollutants in street dust of Jimeta/Yola
167 did not originate from common anthropogenic sources, probably automobile and the welding of
168 metals as well as bad roads and construction works are the major sources of these metals.

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

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

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

192 **CONCLUSION**

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

196 This decrease might indicate aerial deposition of metal particulates in the roadside dust
 197 environment from extraneous sources and not only a function of soil type. Automobile and
 198 metal construction works could be responsible for the build up of the heavy metals in the
 199 roadside dust along the high ways and mechanical workshops through the emission of metal
 200 particulates. The roadside dust environment had a significantly high content of heavy metals,
 201 especially, Fe, Zn, Pb and Cu, and generally their levels increased with increasing traffic volume
 202 and welding of metals in urban areas. Hence, possible accumulation in the soil and transfer to
 203 plants growing along the edge of the highway could occur as a result continual usage of the road
 204 by automobile. This can also lead to accumulation of the metal in the tissues of organisms that
 205 feed on the plant and other plants growing along the highway.

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