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Full Length Research Article

Study of Correlation Between Heavy Metal Concentration, Street Dust and Level of Traffic in Major Roads of Kano Metropolis, Nigeria

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ABSTRACT: This study was aimed at evaluating heavy metal contents in street dust of five major roads within the trunk of Kano metropolis. The dust were collected from heavy traffic roads of the city which include Zaria road (ZR), Maiduguri road (MR), Katsina road (KR), Hadejia road (HR) and Bayero University Kano road (BR). Triplicates samples were collected and the number of vehicles that pass through each road was recorded for one hour. The metal concentration of the dust was determined using atomic absorption spectroscopy (AAS). Strong positive correlation exist between the amount of dust collected and the number of vehicles that passed in all the roads except for Hadejia road with $r^2 = 0.32$ which is less positive. The metal contents in dust of the five streets were higher than the WHO reference value. The positive correlation between the number of vehicles and metal type was significant ($P<0.05$) for Zn, Fe, and Mg in ZR, Pb and Fe in HR; Fe and Mn in BR, while between street dust and metal type was significant ($p<0.05$) for Zn and Fe in ZR; Fe and Cu in KR; Ca in HR and Fe in BR. The high positive correlation observed in this study may mean that the metals in the street dust originate from common anthropogenic sources. Higher than reference values of the heavy metals in street dust, indicate hazard associated with residing or conducting business along the major street in the city. The finding is in support of government effort in protecting its citizenries by prohibiting road site business.

Keywords: Street dust, Vehicle, Heavy metals, Atomic absorption Spectroscopy, Pollution.

INTRODUCTION

Pollution is the alteration of the natural properties as to create hazard to health, safety or welfare of any living specie. Component and quality of street dusts are indicators of environmental pollution especially in big cities (Fenniran and Areola, 1985). Street dusts are generally composed of automobile exhausts particles and particles transported by wind. Heavy metals found in street dust are significant environmental pollutants of growing concern in recent years. The use of leaded fuels gives a boost to the lead level especially in street dust even at the start of 21st century. These metals are bio-accumulative and the possibilities that these metals reach a critical value and threatening human health increase the importance of this issue**.** Street dust is rich in soil particles, according to Fenniran and Areola (1985). The sources are varied and include natural sources and all human activities, which have the possibility of polluting the environment. Control of smoke from fires used for cooking and fossils fuels in poorly ventilated residences are major source of exposure to pollutant (ATSDR, 1993). Duffus (1986) was consistent that high concentration of heavy metals in the atmosphere is not only undesirable but also harmful to plants, animal and humans as identified by Bounce and Megown (1989). Traffic congestion has a number of negative effects, exhaust from all combustion engines combine to produce local adverse effects on the health of car users and all innocent by standers. Cities have become islands of toxic chemicals from the unrestrained use of fossil fuels in vehicle. Urban people are most affected and the worst sufferers are traffic policemen, who are particularly close to the fumes of automobile exhaust. Studies indicate that there is a high rate of occurrence of respiratory, digestion and skin problems among the traffic policemen and a significant number of them become victims of lungs disorder (Pirkle *et al.,* 1994), okader riders may be included. According to Pirkle *et al* (1994) traffic fumes from individual vehicles are decreasing every year as engine become cleaner in advanced countries, but there are more vehicles on the road and the number continues to grow. The long term effects of living in urban areas and breathing in traffic fumes is widely studied, particularly in cities, where there is a lot of sunlight and not much air movement, resulting in photochemical smog from traffic fumes and industrial gases hanging in the air (Pirkle *et al.,* 1994). These effects may be clearly seen in developing countries such as Nigeria and most of the diseases evident now (diabetes, renal failure, hypertension, skin diseases etc.) may be connected with exposure to heavy metals. In addition to the facts by Tamasi and Cini (2004) that emphasized the needs to evaluate heavy metal content of water and food, the metal content of street has to be evaluated also. Exposure to heavy metals by inhalation may be considered direct and devoid of gastrointestinal absorption regulatory mechanism. Despite vast majority of studies on metal contents of street dust done in developed countries with long histories of industrialization (Jaradat and Momani, 1999), relatively very few of such studies were done in developing countries like Nigeria. Little interest has been focused on metal contamination of street dust despite its direct contact with greater part of every population. This study is to evaluate relationship between traffic, rate of sedimentation of road side particles and its metal contents alone some major roads of Kano metropolis.

MATERIAL AND METHODS

Sample collection

Street dust of five major highways in Kano metropolitan, (Zaria road, Katsina road, Maiduguri road, Hadejia road and BUK road) were collected by applying a plastic mat (6 cm length and 37.5 cm width) along the road site at interval of one hour and the numbers of vehicles passed within that period were recorded. The samples (dust) were transferred to clean labeled polyethylene bags and were directly taken to the laboratory for analysis.

Sample Treatment

The sample was digested to break down organic matter and dissolved minerals for analysis as described by Allen *et al.* (1974) using perchloric acid (ACS, ALDRICH), nitric acid (GR) and sulphuric acid (BDH). The digests were used for elemental analysis as described by John and Van (1980) using Alpha 4 – model Atomic Absorption Spectrophotometer.

RESULTS AND DISCUSSION

Table 1 shows the number of vehicles and amount of road side dust for the Zaria, Katsina, Maiduguri, Hadejia and BUK roads in Kano metropolis. The amount of the dust varies with traffic density.

The levels of Zn, Fe, Cu, Pb, and Mn in the street dust show similar distribution in all the major highways although some differences were seen in Zaria and Katsina roads (Table 2). Tables 3 – 7 show the r^2 for correlations between; number of vehicle vs road side dust, number of vehicle vs each metal, road side dust vs each metal and metal vs metal for each of the major road.

Table 1: Number of vehicles and street dust at various studied roads

	Roads				
	Zaria	**Maiduguri**	**Katsina**	**Hadejia**	**BUK**
No. Vehicle/h					
10 am-11 am	1320	1092	1279	834	980
11am – 12noon	1138	885	1072	951	1026
12noon -1pm	1066	937	754	898	978
Amount of Street dust (g)					
10 am-11 am	9.35	5.24	8.55	6.11	4.11
11am – 12noon	7.10	3.63	8.21	8.02	6.20
12noon -1pm	7.01	5.16	6.5	5.11	3.56

Table 2: Mean metals concentration (μg/g) of the roads

Element	Zaria road	Maiduguri road	Katsina road	Hadejia road	BUK road	Ref. Value$^{\Phi}$
Pb	8.73 ± 1.94	7.90 ± 2.37	8.20 ± 2.22	2.97 ± 1.21	6.10 ± 1.48	2.50
Zn	243.9 ± 1.82	160.5 ± 2.67	195.23 ± 1.89	167.53 ± 3.07	270.13± 2.03	25.00
Fe	224.73 ± 1.53	224.76 ± 2.45	242.16 ± 3.04	75.46 ± 2.00	217.46 ± 2.77	37.50
Mn	4.64 ± 1.18	3.88 ± 1.28	6.80 ± 2.12	4.96 ± 6.19	4.96 ± 5.23	1.25
Mg	5.00 ± 2.10	5.13 ± 1.82	5.81 ± 2.65	5.44 ± 1.62	9.82 ± 2.02	
Ca	113.96 ± 1.70	202.90 ± 2.77	119.2 ± 1.58	104.33 ± 1.99	154.46 ± 4.47	
Cu	189.50 ± 1.99	93.63 ± 2.13	106.93 ± 2.94	2.94 ± 0.94	2.75 ± 0.93	37.5
Cr	2.52 ± 0.66	1.75 ± 0.74	2.70 ± 0.53	62.53 ± 2.02	52.83 ± 2.59	12.5

Values are mean ± standardard deviation for the metals and values in the same row bearing similar superscript are significanlty different at $p < 0.05$

$^{\Phi}$**Source:** WHO, 1983

Table 3: Correlation coefficient for the relationship between number of vehicles, road side dust metals along Zaria road

	No. of vehicle	street dust	Pb	Fe	Zn	Mn	Mg	Ca	Cu	Cr
No. of vehicle	1									
street dust	0.94	1								
Pb	0.80	0.95	1							
Fe	0.98*	0.99**	0.90	1						
Zn	0.99**	0.95	0.81	0.98*	1					
Mn	0.92	0.99**	0.97	0.98*	0.93	1				
Mg	0.98*	0.36	0.89	1.00***	0.99**	0.98*	1			
Ca	0.81	0.58	0.37	0.68	0.80	0.55	0.69	1		
Cu	0.86	0.66	0.44	0.75	0.85	0.63	0.76	0.99**	1	
Cr	0.38	0.17	0.04	0.25	0.37	0.14	0.26	0.81	0.75	1

***, ** and * Indicates significant correlation P< 0.001, 0.01 and 0.05 respectively

Table 4: Correlation coefficient for the relationship between number of vehicles, road side dust metals along Maiduguri road

	No. of vehicle	street dust	Pb	Fe	Zn	Mn	Mg	Ca	Cu	Cr
No. of vehicle	1									
street dust	0.71	1								
Pb	0.36	0.88	1							
Fe	0.18	0.00	0.14	1						
Zn	0.26	0.86	0.95	0.34	1					
Mn	0.92	0.44	0.13	0.54	0.01	1				
Mg	0.00	0.28	0.64	0.73	0.84	0.08	1			
Ca	0.87	0.36	0.76	0.62	0.00	0.99**	0.13	1		
Cu	0.91	0.41	0.11	0.57	0.01	1.00***	0.10	1.00***	1	
Cr	0.23	0.01	0.19	0.99**	0.40	0.47	0.80	0.55	0.49	1

***, ** and * Indicates significant correlation P< 0.001, 0.01 and 0.05 respectively

Table 5: Correlation coefficient for the relationship between number of vehicles, road side dust metals along Katsina road

	No. of vehicle	street dust	Pb	Fe	Zn	Mn	Mg	Ca	Cu	Cr
No. of vehicle	1									
street dust	0.94	1								
Pb	0.99**	0.98*	1							
Fe	0.85	0.98*	0.92	1						
Zn	0.96	0.82	0.90	0.68	1					
Mn	0.53	0.77	0.65	0.88	0.34	1				
Mg	0.53	0.77	0.65	0.88	0.34	1.00***	1			
Ca	0.15	0.02	0.08	0.00	0.32	0.12	0.12	1		
Cu	0.88	0.99**	0.95	1.00***	0.73	0.85	0.85	0.03	1	
Cr	0.97	0.84	0.92	0.71	0.99**	0.37	0.37	0.29	0.76	1

***, ** and * Indicates significant correlation P< 0.001, 0.01 and 0.05 respectively

Table 6: Correlation coefficient for the relationship between number of vehicles, road side dust metals along Hadeja road

	No. of vehicle	street dust	Pb	Fe	Zn	Mn	Mg	Ca	Cu	Cr
No. of vehicle	1									
street dust	0.36	1								
Pb	0.98*	0.24	1							
Fe	0.99**	0.41	0.97	1						
Zn	0.39	0.06	0.52	0.43	1					
Mn	0.67	0.91	0.54	0.72	0.00	1				
Mg	0.78	0.36	0.17	0.05	0.85	0.10	1			
Ca	0.43	1.00***	0.30	0.48	0.03	0.94	0.29	1		
Cu	0.27	0.14	0.40	0.22	0.98*	0.01	0.93	0.09	1	
Cr	0.55	0.96	0.42	0.60	0.00	0.99**	0.19	0.99**	0.04	1

***, ** and * Indicates significant correlation P< 0.001, 0.01 and 0.05 respectively

Table 7: Correlation coefficient for the relationship between number of vehicles, road side dust metals along BUK Road

	No. of vehicle	street dust	Pb	Fe	Zn	Mn	Mg	Ca	Cu	Cr
No. of vehicle	1									
street dust	0.97	1								
Pb	0.96	0.87	1							
Fe	0.99**	0.98*	0.95	1						
Zn	0.80	0.91	0.61	0.82	1					
Mn	1.00***	0.97	0.96	0.99**	0.79	1				
Mg	0.01	0.00	0.11	0.01	0.11	0.02	1			
Ca	0.90	0.79	0.99**	0.89	0.50	0.90	0.19	1		
Cu	0.75	0.88	0.56	0.78	0.99**	0.75	0.14	0.45	1	
Cr	0.61	0.46	0.80	0.59	0.18	0.62	0.51	0.88	0.10	1

***, ** and * Indicates significant correlation P< 0.001, 0.01 and 0.05 respectively

DISCUSSION

The spatial distribution of the metals along the major roads studied around Kano metropolis shows positive correlation to both number of vehicle and the quantity of street dust collected per hour and the result indicates the existence of positive correlation between the number of vehicles per hour and the street dust collected per hour. However the r^2 value for the correlation between the number of vehicles and the amount of street dust, though not significant ($P > 0.05$), is highly positive except for Hadejia road ($r^2 = 0.36$) which is low positive.

High concentration of Fe was observed in the major roads around Kano metropolis, this may not be unconnected to the fact that the rocks around Kano are igneous in nature in addition to other sources, like vehicle and industrial activities. The level of Fe ranges from 157.1μg/g in Hadejia road to as high as 244.9μg/g in Zaria road. This shows that, all the roads were polluted by Fe as it exceed the maximum permissible limit of 37.5μg/g (WHO, 1983). This may expose the population to iron and possible negative health effect. The result of this study shows positive correlation between the number of vehicles and levels of iron in street dust and is statistically significant ($P < 0.05$) except for Maiduguri and Katsina roads. This could be due to nature of traffic (mostly long vehicles) and proximity of houses (relatively far away) to these streets. Positive correlation also exist between street dust collected per hour and the level of iron and the coefficient correlation is significant ($P<0.05$) except for Hadejia and Maiduguri roads. This is probably due to their comparative rate of traffic. Iron levels show strong correlation with levels of metals studied in the streets except for Ca in Katsina road, Mn, Ca, Cu and Cr of Maiduguri road, Mg in BUK road and Mg, Ca and Cu in Hadeja road and the coefficient correlation is significant ($P< 0.05$) for Zn, Mn and Mg in Zaria road and Cu in Katsina road. These positive correlations especially with toxic metals such as Pb are alarming for the fact that Pb is known for its toxic effect in the body. The spatial distribution of lead correlates positively with both number of vehicles and street dust per hour in all the roads studied except for number of vehicle and street dust of Maiduguri and Hadejia roads and the correlation coefficient is significant ($P< 0.05$) for vehicles of Katsina road and Hadejia road, and street dust of Katsina road. This positive correlation of a toxic metal like Pb with essential needs of transportation means may pose a serious threat in life in the trend should continuous in that pattern. The distribution of Pb shows low positive correlation with Ca distribution in all the streets except in Hadejia road where the coefficient correlation is significant ($P< 0.05$). This may probably be due to mimicking/ displacement ability of Pb over Ca. The distribution of Zn and Mn shows high positive correlation with Pb distribution in the roads studied. Distribution of Pb show high positive correlation with the distribution of; Mg, Cu and Cr in Katsina road, Cu and Cr in BUK road, Mg in Zaria and Maiduguri roads. Zn and Pb had the highest concentration in street dust particularly along the main trunk roads that is Zaria and Katsina roads. The main concentration of Pb ranges from 2.81 µg/g in Hadejia road to higher mean value in Zaria road of 9.5µg/g. In all the study areas Zn and Pb were found in levels higher than maximum permissible limit of 25 µg/g for Zn and 2.5µg/g for Pb (WHO, 1983). The high Zn content in Zaria road may be the results of traffic density especially vehicle types and high level of Pb content in Zaria road and other roads may be due to use of leaded gasoline, lubricating oil, motor oil, grease, tyre wears and brake emission of vehicle and other human activities are additional factors.

The mean concentration of Cu ranges from 42.5µg/g in Hadejia and BUK roads 93.6µg/g in Maiduguri road, 106.9 µg/g in Katsina road and 107.9µg/g in Zaria road and each is more than the permissible limit of 37.5µg/g. High level of Cu in these roads may be due to break emission and the comparatively higher value in Zaria road could be due to high traffic. Mn concentration has shown mean value higher than maximum permissible limit of 1.25µg/g (WHO, 1983) in all roads and ranges from 3.0µg/g to 5.1µg/g. Low level of Cr has been obtained in all the study areas, the mean concentration of Cr range from 0.43µg/g in Zaria road to 0.94 in Hadejia road and are all found to be below the reference value standard of 12.2µg/g. However, possible Cr poisoning may not ruled out by this finding because it was not shown whether the little amount of Cr detected is none toxic form of Cr or not.

High levels of these metals have been observed mostly from 10am-11am in Zaria road and Katsina road, due to the high number of truck observed within the period, compared to 11am-12noon and 12noon-1pm. However with regard to BUK and Maiduguri roads high level of these metals were seen from 11am-12noon compared to other periods of sampling. The positive correlation detected between the metals, number of vehicles and amount of street dust is an indicator that these metals were introduced to the environment from the same source. The highly significant ($P <0.05$) inter – relationship between some metals, some metals and vehicle along the roads indicates strong dependence of concentration of the metal on the traffic density vis - a - vis the level of street dust. The finding of this research work may confirm the work of Alhassan *et al* (2008) that reported significant level of heavy metals in sachet water sold around Kano metropolis and report by Adam *et al* (2011) that also reported elevated levels of heavy metals in ground water around Tarauni Local Government of Kano State.

It was reported by Agbo (1997) that the main source of lead in Nigeria are gasoline combustion, because vehicles commonly used leaded gasoline mostly emitted as fine lead particle. In addition the use of old vehicles with poorly functioning carburetors has added to this emission (Adeyemi, 1998). The finding of this research confirms the findings of these scientists and is also in conformity with the finding of Koning de (1987), who established that high level of lead are found in urban areas due to industrial activities such as smelting and combustion of leaded gasoline. The findings also concur with conclusion that the environmental consequences of metal – related industrial processes include air, soil and water pollution (Ward, 1989).

The present or future population may suffer many health consequences due to exposure to these metals. Since acute or chronic exposure to the metals is associated with the etiology of many diseases. For example; lead is implicated in anxiety, arthritis (rheumatoid and osteophorosis) attention deficit disorder, blindness cardiovascular disease, cartilage destruction, constipation, depression, epilepsy, gout, immune repression, infertility, kidney disorder, liver dysfunction, menstrual problems, muscle weakness, spinal cord pathology, peripheral neuropathies, psychomotor dysfunction infant, death syndrome, e.t.c. (ASTDR, 1993; Hu, 1991; Amdur *et al.,* 1991, Moiz, *et al.,* 2010). Most of these lead associated diseases may be common among the population. The etiology of increasing rate of hypertension, diabetes, renal failure, liver disease, frequents abdominal and menstrual pains among women and the aggressive attitude people especially the commercial motorcyclist (okada riders) in the population may be traced to lead exposure, among others. In general human exposure to lead can result in a wide range of biological effects depending on the level and duration of exposure. Various effects occur over a broad range of doses with the developing foetus and infant being more sensitive than the adult. High level of exposure may result in toxic biochemical effects in humans, which in turn cause problems in the synthesis of haemoglobin, effect on kidneys, gastrointestinal tract, joints and reproductive system and acute or chronic damage to the nervous system (Amdur *et al.,* 1991).

Copper, though essential to human life, at high dose can cause anemia, liver and kidney damage, stomach and intestinal irritation (Lenntech, 2005). High level of copper in this study may be associated with some of possible sources of copper such as; birth control pills, copper cooking wares, copper pipes, dental alloys, fungicides, industrial emission, insecticides, water (city/well), welding etc as outlined previously (Yap *et al.,* 2005). The strong positive correlation indicates that the element for all the study roads is of the same source. Effects of human exposure to copper include adrenal inefficiency, allergies, anorexic, anxiety, arthritis, diabetes, digestive disorder, eastrogen dominance, fractures, heart attack, high cholesterol, libido decrease, urinary track infection, e.t.c. (Yap *et al.,* 2003). Most of health effects associated with copper may be among the common diseases affecting present population or that may affect future population.

Small amount of nickel is needed for erythroposis, however, in excessive amount, can cause mild toxicity but long term exposure can cause decreased body weight, heart and liver damages and skin irritation (Lobel and Wright, 1982). Sources are industrial waste, nuclear devices, stainless steel cookware, tea, tobacco smoke. Effects include anorexia, kidney dysfunction apathy, disruption of hormone and lipid metabolisms, fever, hemorrhage, headaches, heart attack, intestinal cancer, low blood pressure, muscle tremours, nausea, oral cancer and vomiting (Wong and Chu, 2001).

Cadmium is also present as impurity in several product including phosphate fertilizers, detergents and refined petroleum products. In general, for non smoking population the major exposure pathway is through food, the addition of cadmium to agricultural soil from, various sources (atmospheric deposition and fertilizer application) and up - take by food and fodder crops. Additional exposure to humans arises through cadmium in ambient air and drinking water (Steassen *et al.,* 1999). Cadmium derives its toxicological properties from its chemical similarity to zinc an essential macronutrient for plant, animals and human. Cadmium once absorbed by an organization remains resident for many years (over decades for humans), although it is eventually excreted. In humans long-term exposure is associated with renal dysfunction. High exposure can lead to obstructive lung disease and has been linked to lung cancer, although data concerning the latter are difficult to interpret. Cadmium may also produce bone defects (osteomalacia, osteoporosis) in humans and animals. In addition the metal can be linked to increase blood pressure and effects on the myocardium in animals, although most human data do not support these findings (Iscam *et al.,* 1993).

Hexavalent chromium (Cr^{6+}) has been used extensively in the industrial and government sectors and however, is present in soil and ground water and presents a considerable heath risk as a toxic mutagenic and carcinogenic pollutant. Chromium (Cr) is used in many alloys especially stainless steel. Welding, grinding and polishing of stainless steel in a major means of introducing Cr into the environment. Other ways of Cr exposure in the environment is introduction through include the burning of fossils fuels and waste incineration (WHO, 1998). Hexavalant chromium compounds readily penetrate cell membranes via anion transport system in to the cell, the compounds are readily reduced to trivalent chromium e.g. by thiol such as GSH and cystein and cytochrome P_{450} dependant monooxygenaze (P_{450mo}) (Gerhardsons and Skerfund, 1996). Interpretational administration of hexavalent to rats resulted in atrophy and reduction in epidermal sperm, whereas treatment with trivalent chromium has no effect (Ernst, 1990). We may conclude that the population is prone to heavy metal exposure authorities should therefore take immediate measure.

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