Toxic Metal Concentration In Street Dust A Case Study Of Arakale, Ondo State, Nigeria

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ABSTRACT

Dust is a form of pollution which have shown undaunted effect on the health and wellbeing of human and other forms of life. Looking in-depth into the component of dust have shown to consist of heavy metals which when inhaled by human, it has caused stunted growth, cancer and certain ill- state of health. Therefore, this research study the concentration of certain toxic metals in street dust along road construction site and relate the finding to the standard control measure to determine the extent to which environmental uncontrolled process can pollute the environment. This study therefore investigates the Physicochemical parameters of street dust and concentration of three toxic metals; Nickel (Ni), Copper (Cu) and Cadmium (Cd) in Arakale – NEPA Road in Akure City of Ondo State. A total number of thirty-six (36) dust samples were collected from the study area and the sample were in two quadrants; Left and Right. Samples were analyzed using Atomic Absorption Spectroscopy and standard analytical procedure were follow to ensure accuracy. Data were subjected to descriptive statistics. Results showed that street dust samples contained significant levels of the metals. The variation in concentration of most of the heavy metals determined decreased in the order Cu > Cd > Ni for both quadrants. 'Research findings indicate significant environmental effect in the study area.' Hence, there is need to prioritize action to minimize or combat the current impacts from street dust.

INTRODUCTION

Roads are the second largest non-point source of pollution in urban environment (Fakayode and Olu-Owolabi 2003). Dust is a very important category of air pollution. Road dust represents a significant source contributing to the generation and release of particulate matter into the atmosphere (Shi *et al*. 2008), and consists of particles in the atmosphere which emanate from various sources such as soil dust lifted by weather (*via* an Aeolian process), volcanic eruptions, etc. Street dust receives heavy metals emissions from stationary and mobile sources such as soil erosion by wind and rainfall, road traffic, industrial activities, power plants combustions, residential combustion, waste incineration, corrosion of construction materials, corrosion of asphalt, concrete and paint. Dust kicked by vehicles traveling on roads may make up 33% of air pollution (Sezgin *et al.* 2003).

Street dust is one of the major mediums through which toxic metals may en route into soil surface and underground water through rains and subsequently into living tissues of plants, animals and human beings (Chirenje *et al*. 2006 and Inyang *et al*. 2006). Humans can become exposed to toxic metals in dust through several routes which include ingestion, inhalation, and dermal absorption. In dusty environments, it has been estimated that adults could ingest up to 100mg dust/day (Hawley 1985). Children are usually exposed to greater amounts of dust than adults as a result of pica and play behavior (Murgueytio *et al*. 1998).

In recent years, there is a growing concern for the potential contribution of ingested dust to metal toxicity in humans (Chirenje *et al*. 2006; Inyang *et al*. 2006). Young children are more likely to ingest significant quantities of dust than adults because of the behavior of mouthing non-food objects and repetitive hand/finger sucking (Bargagli 1998). Besides, children have a much higher absorption rate of toxic metals from digestion system and higher hemoglobin sensitivity to toxic metals than adults (Hammond 1982). Both domestic dust and atmospheric dust pose some serious health and safety risks to those who are exposed to them, especially if the exposure is consistent over a period of time. One of the greatest dangers of domestic dust is related to so-called house dust mites. House dust mites, or simply dust mites, are tiny creatures that feed on dust, especially on dead cells of humans and animals, and they excrete certain compounds that can often cause an allergic reaction, particularly in the very young and the elderly. Exposure to high level of toxic metals can result in acute and chronic toxicity, such as damage to central and peripheral nervous systems, blood composition, lungs, kidneys, liver, and even death.

Heavy metal pollution in roadside/street dust has caused concerns in the past years throughout the world (Ract et al. 2003). Such pollutant exists everywhere and poses potential threats to a person's daily life because heavy metals cannot be degraded or decomposed in the environment and can accumulate in the human body (Imperato et al. 2003).

Various studies state that one of the most important sources of heavy metals in the urban environment is represented by road traffic emissions (Charlesworth et al. 2003; Tositti et al. 2014). Emissions from major highways contain different kinds of contaminants such as metals, polycyclic aromatic hydrocarbons and are caused mainly by tire wear off break lining, wear of individual vehicular components such as the car body, clutch or motor parts and exhaust (Lindgren 1996). In particular, metals are of great concern because they cannot be decomposed by microorganisms and have a long term toxicity for plants, animal and human.

MATERIALS & METHODS

Study Area

Akure lies about 70°15' north of the equator and 50°15' east of the Meridian. It is about 700 km Southwest of Abuja and 311 km north of Lagos State. Residential districts are of varying density, some area such as Arakale, Ayedun Quarters, Ijoka, and Oja-Oba consist of over 200 persons per hectare, while areas such as Ijapo Estate, Alagbaka Estate, Avenue and Idofin have between 60-100 people per hectare. (Dorcas, 2016) The town is situated in the tropic rainforest zone in Nigeria and bounded with a geographical coordinates of 7°15′0″N 5°11′42″E.

The selected site for this study was an area in which road construction work was ongoing and with high vehicular traffic and commercial activities characterized by parked and dump vehicles, motorcycles, petroleum dispensing station, mechanical workshops, groundnut oil sales points, bus-stop, business centres, boutiques, shops, restaurants, pavements and road side plant.

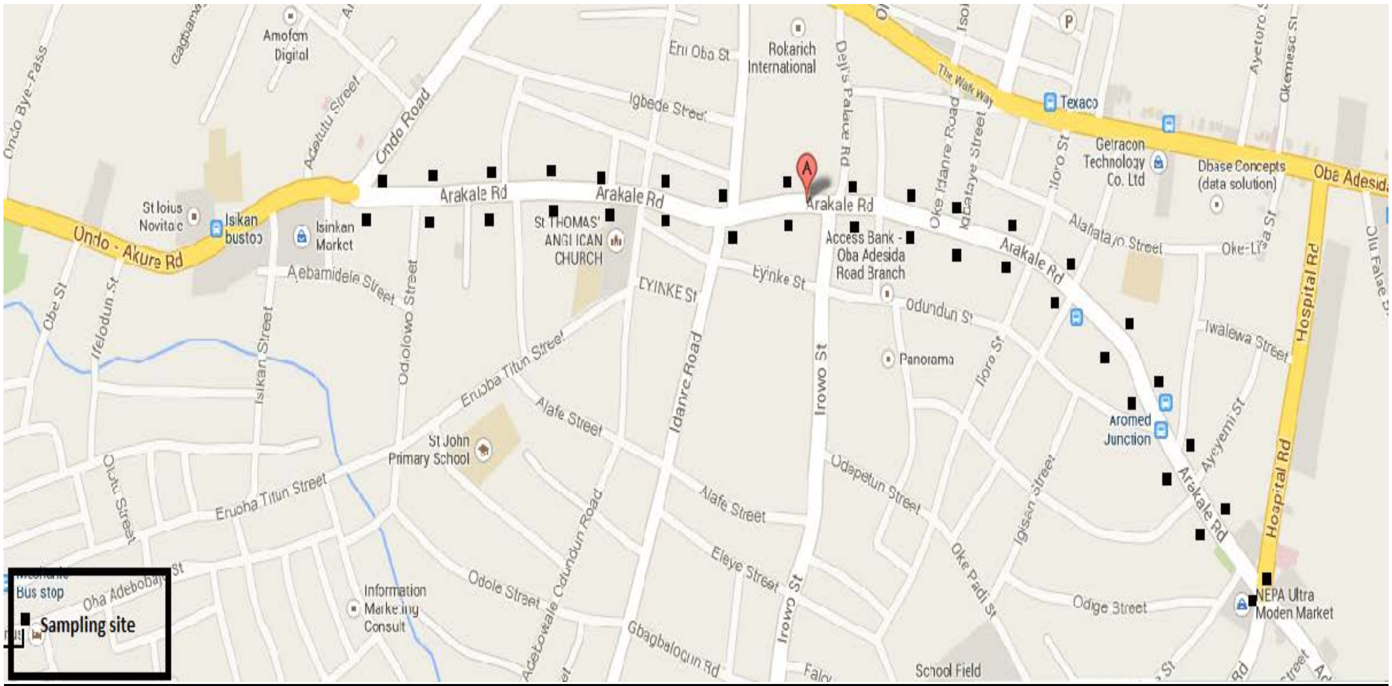

Fig. 1 Google map of Arakale Road showing the sampling locations and site

Sample collection and processing

Road dust samples were collected from the study area of urban environment in the Arakale metropolis (Fig. 1). Samples of road dust were collected by using soft touch brush and Aluminium foil and stored in a polythene bag. A representative composite bulk sample for every sampling location was obtained by taking subsamples from three points of the road at each location and then mixing thoroughly. The study area was divided into two quadrant; Right (R) and Left (L) which are 100m apart from each other. A total number of thirty-six (36) samples were collected which comprises of eighteen samples from the first section (R_1 - R_{18}) and eighteen samples from the second section (L_1 - L_{18}) within a period of two days starting from Arakale road in the South towards NEPA ultramodern market road junction in the North. Precaution was observe to reduce the disturbance of the fine particles which were readily lost by re-suspension and to avoid contamination during sampling, drying and storage.

All samples were dried in the oven at 110^{o}C for 48 hrs and sieved through 200 mesh sieve. The sieved dust samples were analyzed for metal content according to standard methods (US-EPA 1996). Measurement of metal concentrations was carried out using atomic absorption spectroscopy. Calibration standards were prepared through serial dilution of standard stock solution of multielements concentrations of 1000mg/L. Standard solutions were used to validate the analytical method. All extractions and analysis were in triplicate and the mean values were reported.

Determination of physicochemical parameters

The physiochemical properties of the dust samples were determined using routine methods as described by (Allison 1960 and Ibitoye 2006) and presented in Table 1.

Analysis and determination of heavy metals

2.0 g of the dust sample was weighed into extraction cup (length 33cm; width 23.4cm; depth, 14cm) and 10ml of 0.5M $HNO_{3(aq)}$ (Lob Chemie Pvt. Ltd, India) was added to the sample. The soil-extractant solution was shaken for 24 hrs at 5 hrs interval using stirrer and then filtered into 50 ml volumetric flask using Whatman filter paper № 42and marked up to the level with distilled water. The filtrate was poured into the sample bottle and stored for elemental analysis. A blank sample was also prepared. Zn, Ni and Cd content of the filtrate were determined by Atomic Absorption Spectrophotometry. The distribution characteristics of heavy metals in the study area are shown in Table 1.

Toxic metals extraction using 1M $NaNO_{3\,(aq)}$ extractant

2.0 grams of the dust sample was weighed into an extraction cup (length 33cm; width 23.4cm; depth, 14cm) and 5 ml of 1M $NaNO_{3(aq)}$ (Lob Chemie Pvt. Ltd, India) was added to the sample. The soil-extractant solution was shaken for 24 hrs at 5 hrs interval using stirrer and then filtered into 50 ml volumetric flask using Whatman filter paper № 42 and marked up to the level with distilled water. The filtrate was poured into the sample bottle and stored for elemental analysis. A blank sample was also prepared. Zn, Ni and Cd were determined by Atomic Absorption Spectrophotometry. The distribution characteristics of toxic metals in the study area are shown in Table 1

Data Analysis

All statistical analyses and data processing of this study were performed on an IBM-PC computer using Microsoft Excel 2010 (www.microsoft.com). Descriptive statistics (mean, range, standard deviation) were performed

RESULTS DISCUSSION

Physicochemical analysis and toxic metals results

The concentration of metals (mean, ranges and standard deviation) and the physicochemical parameters in street dust samples of this research are presented in Table 1. The concentration of the heavy metals determined decrease in an order Cu > Cd > Ni for both quadrants. Results indicate that the metal pollutants in street dusts could significantly contribute to deteriorate the environmental status of the city of Akure metropolis.

Table 1: Descriptive Statistical data obtained from the physicochemical analysis and toxic metals concentration at the study site

Parameters		Sampling Locations	Mean (mg/kg)	Standard Error	Median	Mode	Standard Deviation	Sample Variance	Range
*p*H		R	8.64	0.25	9.38	9.43	1.07	1.15	2.80
		L	9.03	0.23	9.51	9.54	0.98	0.95	2.69
Electrical conductivity		R	659.61	80.75	592.50	0.00	342.60	117372.96	1220
		L	794.00	67.26	754.50	1125.00	285.37	81434.59	875.00
Total organic carbon		R	0.81	0.19	0.45	0.17	0.79	0.63	2.69
		L	0.86	0.13	0.80	0.89	0.53	0.28	1.80
Cl^-		R	0.55	0.05	0.49	0.28	0.23	0.05	0.69
		L	0.58	0.05	0.59	0.36	0.20	0.04	0.55
Cd	HNO_3	R	2.35	0.17	2.24	2.70	0.71	0.50	2.54
		L	2.06	0.17	1.98	3.51	0.72	0.53	2.79
	$NaNO_3$	R	0.03	0.01	0.02	0.00	0.06	0.00	0.23
		L	0.02	0.00	0.01	0.01	0.03	0.00	0.12
Ni	HNO_3	R	1.10	0.28	0.79	0.02	1.19	1.41	3.87
		L	0.23	0.06	0.10	0.02	0.27	0.07	1.05
	$NaNO_3$	R	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		L	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cu	HNO_3	R	12.44	0.45	12.79	14.10	1.89	3.59	5.82
		L	7.31	1.05	6.23	0.00	4.44	19.73	15.10
	$NaNO_3$	R	0.13	0.04	0.08	0.14	0.15	0.02	0.60
		L	0.05	0.02	0.03	0.02	0.07	0.01	0.29

From the table above, the mean value of the electrical conductivity were quite high for the left side of the road with value of 794 µs/cm and lower for the right side with the mean value of 659.61 µs/cm These values are in the same range with the values reported by (Osakwe and Otuya 2008), but comparatively lower than the values reported by (Tukura *et al*. 2007). This may be due to the increase in the concentration of some soluble salts in the soil which increases metal pollutant in the area reported by (Pechacek 1994). Also the pH value also show higher alkalinity on the left side compare to that of the right side with mean value of 9.03 and 8.64 respectively which is within value 8.89 reported by (Abechi et al. 2006). The pH serves as a useful index for availability of nutrients, the potency of toxic substances present in the soil and the physical properties of the soil. Several studies have shown that availability of heavy metals is pH dependent (Iwegbue *et al*. 2006). The pH values of the study area indicated tendency for availability of these toxic metals. Furthermore, the mean value of total organic carbon for left and right side of the study is almost the same with value 0.86 mg/kg and 0.81mg/kg respectively. The different in the total organic carbon (TOC) within these sites could be due to the sales activities such as sales of groundnut oil and petroleum products which release hydrocarbon waste.

From the result table above, it is evident that Cd, Ni and Cu are present in the area analyze with different concentration. In most of the site analyzed, it was observed that the mean concentration of toxic metals extracted with HNO_3 and $NaNO_3$ extractant were in the sequence Cu > Cd > Ni which also conform to the standard deviation value obtain in the statistical data. However, it was studied that the mean concentration of Cu in the right side is high (12.44 mg/kg) compared to that of the left side dust (7.31mg/kg) which is higher compared to than the value (0.014 mg/kg) reported by (Heitland and Koster 2006). Cu is a primitive metal that contribute to environmental process and a good indicator of contamination in street dust, since it appears in gasoline, car components, oil lubricants, industrial and incinerator emissions. The mean values, 2.35 mg/kg (Right side) and 2.06 mg/kg (Left side) for Cd indicate that the road dust in the Arakale – NEPA road is lowly contaminated by Cd but higher than the mean value 0.00027 mg/kg reported by (Heitland and Koster 2006). Cd consider an indicator for long-term exposure reported by (Seifert *et al*., 2000). While, the Ni concentration is higher on the right side than left side with value 1.10 mg/kg and 0.23 mg/kg respectively. Ni indicate that the road dust in the study site is lowly contaminated by Ni. The high disparity in metal concentrations in the dust is clear, indicating that human activities, populations, etc. determines the metal concentration in dust samples

From the results table revealed that $HNO_{3(aq)}$ is more suitable than $NaNO_{3(aq)}$ for the extraction of the aforementioned toxic metals from road side dust.

Lower standard deviations (S.D) were found in Cd and Ni compared to that of Cu. It is evident that the automobile exhaust emission and vehicle tire wear contributed significantly to the toxic metals accumulation in the road dust taken from the ample site (Arakale - NEPA Road).

Possible Environmental Impacts Due To the Heavy Metals

Release of heavy metals is one of the most significant environmental problems caused by the anthropogenic activities. Recently, there has been an increased concern regarding the occurrence of the heavy metals because of their toxicity. Exposure to the metal ions in sufficient quantities can have serious impacts on human health (Roy et al. 1993). Nickel is one of the metals, which are essential at very low concentrations for life because they have important roles in metabolic processes taking place in living cells. This involves blocking essential functional groups, displacing essential metal ions, or modifying the active confirmation of biological molecules resulting in the inhibition of a variety of metabolic as well as enzyme activities in living organisms. The metal toxicity has a direct effect on various physiological and biochemical processes such as photosynthesis, chlorophyll content and reduction in plant growth (Reddy et al. 1990). Large quantities of cadmium can be found in soils. the metal ions bind strongly to soil particles and some of these dissolve in water causing metal pollution. Hence, they accumulate in the bodies of water and soil organisms. They can interrupt the activity in soils, as they negatively influence the activity of soil microorganisms and earthworms.

CONCLUSION

This research work has revealed that roads dust pollution is a serious concern in the world especially in urban and developing country like ours where science and technological advancement is on the rapid scale. The major happenings and activities that escalate the concentration of toxic metals in the environment are unguarded construction work, uncontrolled population growth rate, increasing number of vehicular activities and industries in a region of poor governmental regulations and sanctions. It can be concluded that significant contamination of street dust was observed in the city of Arakale in Akure metropolis. The distribution of the metal concentration of the dust in the study is an indicated that automobile and metal construction works could be responsible for the build-up of the heavy metals in the street dust along the major streets and mechanical workshop through the emission of particulates.

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