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SPIDER WEBS AS INDICATORS OF COBALT AND LEAD POLLUTION IN KANO MUNICIPALITY

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ABSTRACT

Spider webs were collected from the indoor and outdoor of 120 sampling sites of 10 zones of Kano Municipality. The samples were analysed for cobalt and lead by the use of ALPHA-4 model of Atomic Absorption Spectrophotometer (AAS). The analysis of the webs showed different levels of the metals in the indoor and outdoor samples with means and standard deviations of 19.68±12.00 and 27.09±13.71µg/g for cobalt indoor and outdoor respectively and 503.34±139.60µg/g and 662.50±145.22µg/g for lead indoor and outdoor respectively. These variations in concentrations have been attributed to emissions from dust particles, motor vehicle/industrial emissions and other activities in the metropolis. Analysis of the webs also showed large differences between the sites which could be attributed to the geology and activities in each locality. Spider webs analysis has thus proved a useful indicator and accumulator of the pollutants of the environment from which they were collected.

Keywords: spider, indicator, cobalt, lead, pollution, Kano

INTRODUCTION

Cobalt is required for blood formation in the specific form of vitamin B_{12} by higher animals (Schmidt-Nielsen, 1995). Deficiency of cobalt in form of vitamin B_{12} leads to severe anemia. In ruminants vitamin B_{12} is formed in the rumen by the microbial flora, provided a sufficient amount of cobalt is present in their diet. Where there is insufficient amount of the metal in the animalsô diet, cobalt containing ceramic is administered into them and slowly releasing cobalt over several years (Schmidt-Nielsen, 1995). Cobalt has been used as a treatment for aneamia, because it stimulates red blood cell production (ATSDR, 1992). However, acute exposure to high levels of cobalt in humans and animals results in respiratory effects, such as decrease in ventilatory function, congestion, edema, and hemorrhage of the lung. On the skin, cobalt dust can cause rashes and irritation (Rank, 2010). Chronic cobalt poisoning may produce polycythemia and hyperplasia of the bone marrow (NLM, 1995). Lead is poisonous (Tong, 1998). World Health Organization (WHO) has recommended its maximum intake of 5mg/week (Tebbut, 1983). Although lead absorption is slow, its excretion is slower. It accumulates in the body, concentrating in the liver, kidneys, bones, teeth and brain (Tong, 1998). Its effects range from loss of appetite, weakness and headache to brain and central nervous system damages, paralysis, kidney failure, foetal deformity and ultimate death (WHO, 1996). Females occupationally exposed to lead may encounter reproductive dysfunction (Jan *et al*., 1985). Lead is associated with mental impairment, learning disabilities and increase in hearing threshold; a defect in psychometric intelligence and other cognitive and behavioral consequences in young children (Tong, 1998). Important sources of environmental lead relate to the manufacture of batteries, sheet and pipe, cable sheathing, solder shot and paint (Ayodele and Gaya, 1994). Other sources include lead arsenate insecticides, pottery glazes, plastics and application of sewage sludge as fertilizer (Tong, 1998). The combustion of alkyl lead additives in motor fuels accounts for the major part of all lead emissions into the atmosphere (WHO, 1987); 80-90% of lead in ambient air is derived from the combustion of leaded petrol. A total of 330,000 tonnes of lead is discharged directly into the atmosphere each year (Nriagu and Pacyna, 1988).

The house spider is detested by house wives because it sometimes spins a web near the ceiling in a corner of some rooms or closet. They frequent dark less-used places such as attics, cellars barns, sheds, or under porches and are useful as destroyers of flies, mosquitoes and moths (George and Roland, 1980). A typical web, usually built at night, has a central sheet of densely woven silk which serves as a hiding place and is anchored by numerous guy lines that are long and strong. These spiders are beneficial as they catch and eat nuisance insects such as flies, ants, aphids- plant-feeding, cockroaches, small grasshoppers and crickets, thrips, leafhoppers, white flies and mosquitoes. They are excellent indicators of carpenter ant infestations as their webs are commonly near the house where ants forage and become truant. While elimination of some spiders is acceptable when they are an annoyance, wholesale elimination is ecologically unsafe and results in more nuisance pests (Lanier, 1999).

Industries, street dust and motor vehicle emissions are sources of airborne particulates in urban environments (Kowalczyk *et al*.,1982; Gertler *et al.*,2000).The presence of these particles, either airborne or as precipitated dusts poses a significant human and environmental health risk. The particles emitted by motor vehicles carry or contain heavy metals that may be toxic when present in excess of natural background levels. In general, the toxic properties of the air borne particulates are due to the biochemical activities of metals attached to them (Lighty *et al*., 2000).

Spider webs act as efficient traps of airborne particulates providing a useful indicator for monitoring environmental pollutants because they are inexpensive, easy to collect and are widespread in the environment (Hose *et al.*,2002).They are found near and around buildings and thus capture particulates to which humans may be exposed to. Spider webs have been demonstrated as effective indicators of heavy metals attributed to particulate emissions (Hose *et al.*, 2002).

In an attempt to use spider web as bioindicator of pollution, several webs were analyzed for their cobalt and lead contents in both indoors and outdoor urban areas of Kano metropolis. This paper reports the levels of cobalt and lead in indoor /outdoor spider webs collected from a number of sites in the urban area of Kano. The use of the spider webs can serve as a substitute for the usage of sophisticated samplers used in monitoring environmental pollution and hence give light on the extent of the environmental pollution by these heavy metals.

MATERIALS AND METHODS

Spider webs were collected from different districts in urban Kano. The climatic and geologic characteristics of these areas are generally the same, but the areas are different in their proximities to highways and industries. Spider webs of species native to Sudan savanna eco-climatic zones (*Achaearanea tepidariorum*) were collected and analyzed for their trace metal levels. Webs were collected between October and April of each year; during the dry season. The samples were collected from 120 sampling sites in 10 sampling zones of Kano municipality. Each sampling zone had 12 sampling sites. Existing webs were removed while leaving the spider intact to rebuild the webs; spiders have the ability to quickly replace their webs when removed or damaged once they are not disturbed (Zhao, 1993; Pestproducts, 2008). The sites were marked and documented for referencing. To ensure uniform and comparable age of the webs for each site, a week old webs were harvested (Xia-Li *et al*.; 2006). Once collected they were each dried and packed in clean plastic containers prior to analysis.

0.2g of each sample was digested in 70%: 30% mixture of concentrated HNO_3 and hydrogen peroxide (Xiao-li *et al.*, 2006). The digestion was completed by heating the mixture on a sand bath for about 30 minutes. The resulting solution was evaporated to almost dryness (Ruya *et al*., 2006) and redissolved in 0.1M nitric acid, transferred into $50cm^3$ volumetric flask and made to the mark with deionised water. The cobalt and lead concentrations were determined by ALPA-4 model of Atomic Absorption Spectrophotometer (AAS). The result of the absorbance of each sample was the average of three sequential readings.

STATISTICAL ANALYSIS

The statistical analysis of the data obtained for the average indoor and outdoor cobalt and lead concentrations obtained at the various sites in the municipality was carried out by using the SPSS Version 16.0 statistical software.

RESULTS AND DISCUSSION

The frequency distribution pattern for cobalt in the municipality is as shown in Fig. 1. Both distribution patterns are skewed towards high frequencies of low concentrations, which is an indication of the general low value of the metal in most of the areas, and both indoor and outdoor. Hence, the mean values of 19.68±12.00 and 27.09±13.71µg/g respectively were obtained. Cobalt is present in vehicular exhausts (De Miguel *at al.*, 1997; Yeung *et al.*, 2003), therefore its concentration found to be higher in high traffic areas. The outdoor concentration is higher than those obtained from street dusts in London (Fergusson and Ryan, 1984), New Zealand (Fergusson *et al.*, 1986), Madrid (De Miguel *et al.,* 1997), Ottawa (Rasmussen *et al.,* 2001) and Hong Kong (Yeung *et al.*, (2003). However, the indoor concentration is comparable to that reported for street dust of Oslo (De Miguel *et al.*, 1997). The differences could be attributed to the difference in the period of the determinations, as there is increase in the number of automobiles within Kano municipality in the recent years and geological differences of the regions (Yeung *et al.*, 2003) or the webs might accumulate more of the pollutants as collection is continuous even over night than the conventional devices that only provide a snapshot of conditions and possibly nature of the fuels used.

The frequency distribution patterns for lead in the Kano municipality are as shown in Fig. 2. The indoor distribution pattern is skewed towards low frequency of low concentration with a mean of 503.34±139.60µg/g, while the outdoor follows almost a normal distribution with a mean of 662.50±145.22µg/g. All the indoor and the outdoor concentrations in the municipality are significantly correlated ($P<0.01$). The indoor pattern is an indication of the general high level of the metal in the municipality. Normal distribution of the metal in the outdoor shows regular changes in the concentration of the metal from one location to the other within the municipality. The lead mean outdoor concentration obtained in this work is in line with those determined in street dusts in London (Fergusson and Ryan, 1984); New Zealand (Fergusson *et al.*, 1986); Kano (Ayodele and Gaya, 1994); Riyadh (Ismail *et al.*, 1994); Oslo and Madrid (De Miguel *et al.*, 1997); Cincinnati (Tong, 1998); Ottawa (Rasmussen *et al.*, 2001) and Hong Kong (Li *et al.*, 2001). It is also in agreement with what was obtained in spider webs by Xiao-li *et al.*, (2006).

The multivariate analysis technique, analysis of variance through ANOVA, t-test and Pearson Correlation analysis were applied. The considered variables were the normalised concentrations of Co and Pb determined in indoor and outdoor concentrations (Tables1 and 2).

When comparing the indoor and the outdoor distribution the latter appeared superior in accumulating higher amounts of the metals because of its ready availability to trap the dust particles laden with the metals since most of the sources are outdoor ones.

African countries have the worst record for suspended particulate matter in rural homes, while Latin America, India and China are the worst for suspended particulate matter in urban interiors (Bascom, 1996; Albalak *et al*., 1999; Naeher *et al.*, 2000). Although most monitoring is being carried out on ambient (outdoor) air, whereas many health problems potentially linked to indoor air pollution still go unrecognized .For example several studies have shown that coal smoke has a strong risk factor for lung cancer among non-smoking women, while another study has related lung cancer to the past use of bio-fuels in cooking (Ellegard, 1996; Zhang and Smith, 1996). In Gambia, children fewer than five carried on their motherós back during cooking (in smoky cooking huts) had six times higher risk of Acute Respiratory Infections (ARI), a substantially high risk factor than if their parents smoked. A shift of focus is needed to estimate the health hazards from indoor air pollution and making sure they were accorded the importance they deserve (Armstrong and Campbell, 1991; OóDempsey *et al.*, 1996).

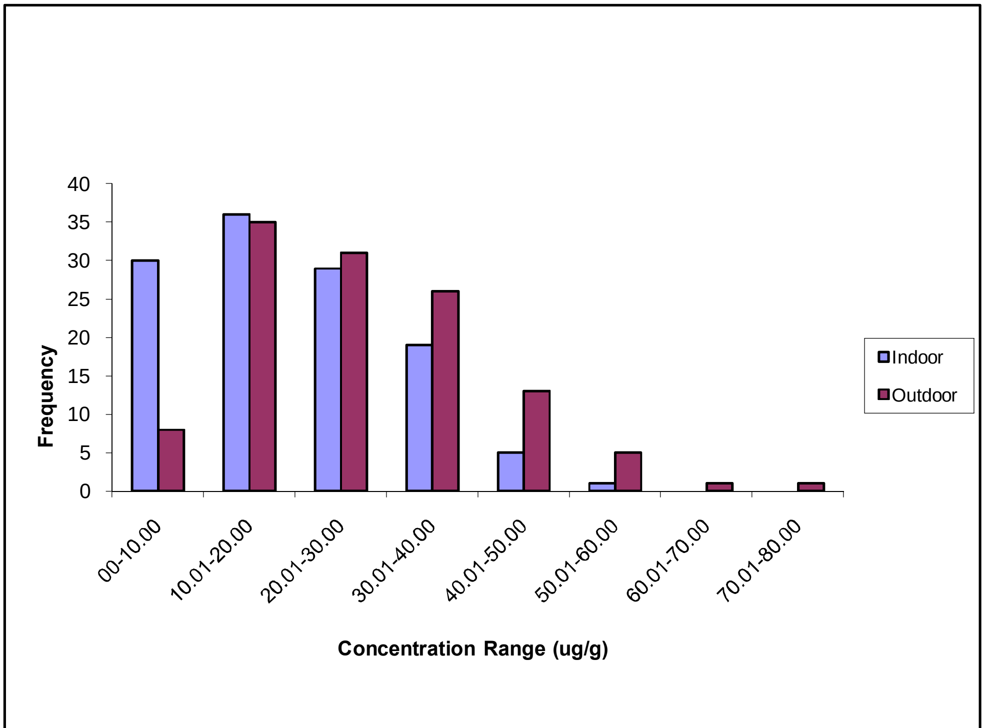

Fig. 1 Frequency Distribution Pattern for Cobalt in Spider Webs

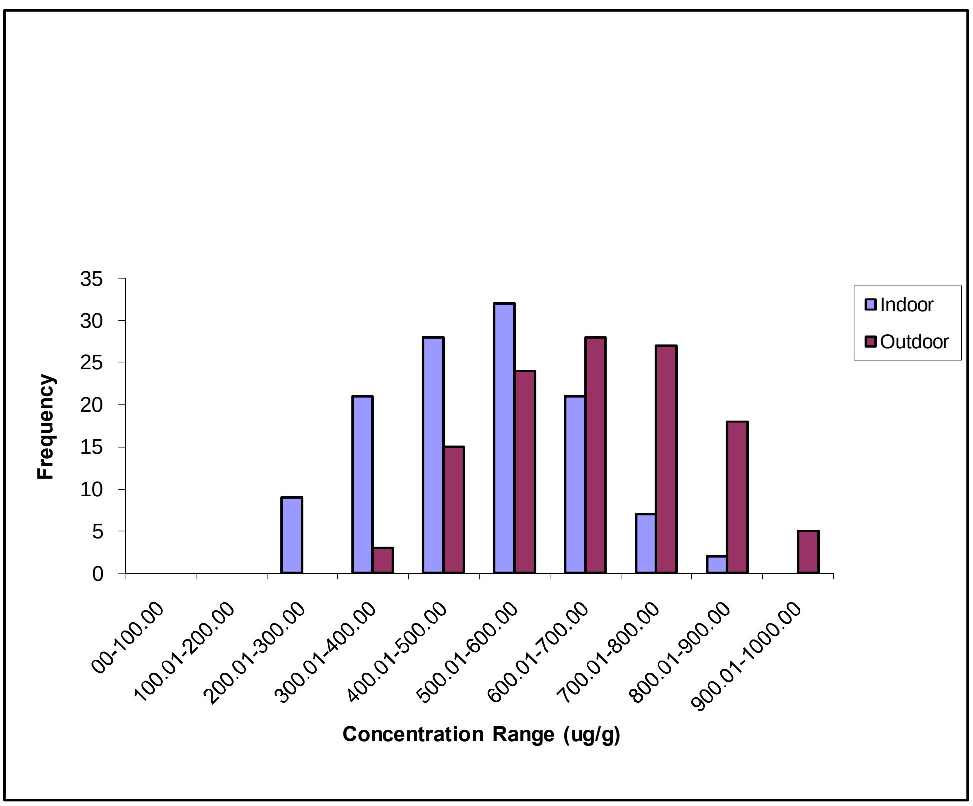

Fig. 2. Frequency Distribution Pattern for Lead in Spider Webs

Table 1: Parametric Correlations

		Co Indoor	Co Outdoor	Pb Indoor	Pb Outdoor
CoIndoor	Pearson Correlation	1	.977**	.971**	.964**
	Sig. (1-tailed)		.000	.000	.000
	N	120	120	120	120
CoOutdoor	Pearson Correlation	.977**	1	.967**	.963**
	Sig. (1-tailed)	.000		.000	.000
	N	120	120	120	120
PbIndoor	Pearson Correlation	.971**	.967**	1	.990**
	Sig. (1-tailed)	.000	.000		.000
	N	120	120	120	120
PbOutdoor	Pearson Correlation	.964**	.963**	.990**	1
	Sig. (1-tailed)	.000	.000	.000	
	N	120	120	120	120

**. Correlation is significant at the 0.01 level (1-tailed).

Table 2: Nonparametric Correlations

			CoIndoor	CoOutdoor	PbIndoor	PbOutdoor
Kendall's tau_b	CoIndoor	Correlation Coefficient	1.000	.952**	.961**	.955**
		Sig. (1-tailed)	.	.000	.000	.000
		N	120	120	120	120
	CoOutdoor	Correlation Coefficient	.952**	1.000	.970**	.970**
		Sig. (1-tailed)	.000	.	.000	.000
		N	120	120	120	120
	PbIndoor	Correlation Coefficient	.961**	.970**	1.000	.973**
		Sig. (1-tailed)	.000	.000	.	.000
		N	120	120	120	120
	PbOutdoor	Correlation Coefficient	.955**	.970**	.973**	1.000
		Sig. (1-tailed)	.000	.000	.000	.
		N	120	120	120	120
Spearman's rho	CoIndoor	Correlation Coefficient	1.000	.988**	.990**	.988**
		Sig. (1-tailed)	.	.000	.000	.000
		N	120	120	120	120
	CoOutdoor	Correlation Coefficient	.988**	1.000	.994**	.994**
		Sig. (1-tailed)	.000	.	.000	.000
		N	120	120	120	120
	PbIndoor	Correlation Coefficient	.990**	.994**	1.000	.995**
		Sig. (1-tailed)	.000	.000	.	.000
		N	120	120	120	120
	PbOutdoor	Correlation Coefficient	.988**	.994**	.995**	1.000
		Sig. (1-tailed)	.000	.000	.000	.
		N	120	120	120	120

**. Correlation is significant at the 0.01 level (1-tailed).

Unfortunately, while the health problems are all too clear, the solutions are as many as grains of sand in the desert. The issues involved are culturally diverse since they relate to such basic traditional patterns as how people live, cook and eat. With the designs of silencers with special filters that remove the pollutants and simple smokeless stoves or elementary chimneys, hood and smoke removing appliances, and persuading the people to build, install, maintain and use such devices, the problems can be highly minimized. Indeed, the first step is probably to persuade the millions exposed to biomass exhausts that they do actually pose health hazards

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CONCLUSION

Monitoring trace metals in street dust has provided a tool for estimating the degree of contamination, sources, habit etc of residential, commercial and industrial areas. The concentration of the various metals in street dusts is a function of their proximity to major highways, industrial areas and types of activities in the immediate surroundings. The results obtained exhibit a range of concentrations between the industrial, residential and commercial areas thus suggesting strong sporadic influence from anthropogenic sources. Therefore the primary sources of these metals in street dust are resuspention of soil derived dust, vehicle induced turbulence, geochemical processes, and windblown dusts. In urban cities, people are exposed to a variety of potentially toxic chemicals. Of particular concern is the inhalation of fine-grained atmospheric particles with high concentrations of heavy metals. From geochemical data obtained by sampling dust samples in the urban areas of Kano, significant anomalies were detected and some conclusions could be drawn that in urban cities, people are exposed to a variety of potentially toxic chemicals. This analysis has also proved that spider webs can be used as indicators of the pollutants of the environment from which they were collected and that spider webs being natural device for sample collection can even be more efficient than many other devices as collection is continuous 24 hours a day and they are very common and chief.

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