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Comparative study of the age and location dependence of some heavy metals in hair of residents from two cities in Nigeria

F. A. Adekola, O. O. Dosumu and G. A. Olaleye

Department of Chemistry, University of Ilorin, P. M. B. 1515, Ilorin, Nigeria

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ABSTRACT: The concentration of some heavy metals (lead, cadmium, zinc and copper) were determined in the scalp hair of children (aged between 1 and 15 years) and active adults (aged between 16 and 40 years) in two different cities in Nigeria. The levels of zinc were found to be higher in children than in adults population. There was a significant difference ($P < 0.05$) between the two age groups. The levels of copper were all within the same range for the two age groups and irrespective of location. The levels of lead and cadmium were generally higher in adult than in children. However, there was no significant difference ($P > 0.05$) in the average concentrations of lead and cadmium between the children and adult populations of the two cities. The regression analysis indicated a strong correlation ($r=0.86$) between zinc and copper. Lead and cadmium were correlated at $r=0.19$.

Introduction

The use of human hair for the study of environmental and occupational exposure has largely been explored by a good number of researchers from different parts of the world. Information in the literature in this area is quite extensive. Valkovic *et al*. (1975) have been able to associate the level of lead in human hair with vehicular emissions and automobile traffic. Ahmed and Mubarak (1990) found the levels of trace elements in hair of Saudi Arabian adult male population to correlate with the level of urbanization.

Takeuchi *et al*. (1982), in a study carried out on a Japanese population, reported that the levels of trace elements depended on the age, sex and hair treatment, Ashraf *et al*. (1995) also observed an age and sex dependence for trace metals in a Pakistani population. In some recent studies in this area, Nowak (1998) observed that heavy metals content of hair depended on age, sex and colour of a Polish population. Cherniaeva *et al*. (1997) have linked the accumulation of lead in children's hair to the pollution level of some Russian cities. Specifically, some workers have been able to establish a direct link between the heavy metal contents in scalp hair and the nature of profession of the population under investigation (Ramakrishna *et al*., 1996; Man *et al*., 1996). Many workers have equally demonstrated the dependency of heavy metal level on several factors such as geographical location of urban population (Ashraf *et al*., 1995; Feng *et al*., 1997), age and sex (Nowak, 1988; Ashraf *et al*., 1995) and colour of the hair (Nowak, 1998).

A systematic study undertaken by Zakgyuska *et al*. (1998) revealed that lead accumulated with age and that copper and cobalt of youth seemed to give way to a predominance of Zn in maturity. Furthermore, the levels of copper in human hair have been reported by some authors to be independent of sex and location (Ashraf *et al*. 1995; Shoichiro, 1985). Some of these studies have therefore revealed that trace metals in hair could serve as useful indicators for the assessment of the extent of exposure of individual to heavy metal atmospheric pollution. The origin of these metals in hair could be from metabolic irregularities associated with the ageing process, sweat deposits and the environment (Ashraf *et al*., 1995).

The most important environmental sources of trace elements in hair include cosmetics, water supply (bathing, washing and swimming pool) and air pollution (Barker *et al*., 1976). Heavy metals such as cadmium and lead tend to accumulate in hair at concentrations well above those present in some biological fluids such as blood and urine. The metals have been found to correlate with the amount of these metals in internal organs (Valkovic *et al*., 1975; Chatt and Katz, 1988). Nutritional habits and atmospheric exposure could explain the reason for the variations of heavy metal levels with the geographical location as well as with age group (Foo and Tan, 1998). The levels of heavy metals in scalp hair could therefore provide information on the extent of atmospheric pollution of a particular urban population.

Relatively, very little study has been carried out in this area with respect to African population, at least to the best of our knowledge. Those reported in the literature include Machakos district population in Kenya (Othman and Spyrou, 1980) and Sudanese population (Eltayeb and Grieken, 1990). In this study, we have attempted to compare the level of some heavy metals among two different age groups (young and active age groups with ages ranging from 1 to 15 years and 16 to 40 years respectively) in two cities in Nigeria. The two cities are Ibadan, the largest city in Black Africa, located in the South West, and Ilorin, a medium-sized city located in the Middle Belt of Nigeria. Ibadan City is predominantly Yoruba ethnic group, while Ilorin has a cultural resemblance with the northern tribes (Hausa/Fulani) of Nigeria. This is particularly reflected in the dietary habits of Ilorin population.

Materials and Methods

Scalp hair samples were collected from two barbers' shops each located at different parts of Ilorin and Ibadan in Nigeria. Ibadan is located in the South west of Nigeria and is the largest city in the whole of Black Asfrica, while Ilorin is a medium-sized town with a very low level of industrialization and is located in the Middle Belt of Nigeria. In each city, two different locations were chosen based on the intensity of human activities. Three composite samples were collected from each location and per age group. A composite sample was obtained by pooling together an average of 150 hair samples from different donors within the same age group and for each location. Samples were collected in plastic bag containers, well labeled and carrying different colour tags for each age group in order to prevent a mix-up. Samples were taken immediately after collection to the laboratory for analysis. Each composite hair sample was first washed with acetone for about 10 minutes with continuous stirring, followed by rinsing with a large quantity of distilled water and then again with acetone (Ashraf *et al*., 1995). The samples were later air-dried in the laboratory during a period of about 24 hours.

A known quantity of the pre-treated hair sample, about 500 mg, was put in a 50 ml Erlenmeyer flask. 5 ml of conc. nitric acid (69%) was added at room temperature. The whole lot was later heated to boiling, followed by the addition of 1.0 ml of perchloric acid (70%). The whole content was then heated until dense white fumes appeared. The content of the flask was later transferred into a 50 ml volumetric flask and made up to the mark with 2% nitric acid. A reagent blank was subjected to the same treatment as for the samples in order to check for possible reagent contamination. Samples and the blank were analysed for Cu, Cd, Zn and Pb with the aid of a Perkin-Elmer 550 Model Atomic Absorption Spectrophotometer. The standard procedure provided in the operting manual of the analytical equipment was strictly followed. The spectrophotometer was calibrated using a range of concentrations prepared from the stock atomic absorption standards (Aldrich Chemicals, USA). Doubly-distilled water was used throughout for the preparation of samples and for the dilution of stock solutions. All samples were analysed in triplicate and the mean metal concentrations were all within ± 2%. The analytical equipment was subjected to both interlaboratory and intralaboratory control test before use.

Statistical analysis was carried out using SAS statistical software system mounted on a personal computer (PC). The data were subjected to Analysis of Variance (ANOVA) and means were further ranked using Duncan's multiple range test when the F-test was significant. Correlation analysis was also carried out among the possible pairs of heavy metals in order to associate the metals based on their common origins.

Results and Discussion

The results obtained in respect of the average concentrations for copper, cadmium, lead and zinc are summarized in Table 1. The concentration seems to be highest in zinc, followed by lead, cadmium and copper, in that order. Copper has relatively the lowest concentration values. Application of Duncan's multiple range test for the analysis of variance indicates that in each of the two locations in the cities, only zinc is significantly different at 0.05 probability level from the other metals. This is evidenced from the higher levels of zinc compared to other metals. The levels of zinc range from about 511.3 ± 15.1 to 1047.2 ± 430.2 mg/kg.

Table 1:Average levels of Pb, Cd, Zn and Cu in hair samples.

City	Location	Age (Years)	Pb (mg/kg)	Cd (mg/kg)	Zn (mg/kg)	Cu (mg/kg)
Ibadan	Agodi	1 – 15	57.2 ± 14.2	30.6 ± 10.2	914.4 ± 170.0	19.1 ± 3.3
		16 – 40	66.7 ± 33.2	29.9 ± 9.4	531.5 ± 26.7	18.3 ± 2.8
	Irefin	1 – 15	42.9 ± 18.6	12.2 ± 5.4	1047.2 ± 430.2	28.0 ± 8.7
		16 – 40	64.3 ± 25.8	24.5 ± 5.4	599.4 ± 105.6	14.2 ± 6.6
Ilorin	Oja-Oba	1 – 15	78.8 ± 28.4	26.5 ± 10.2	563.5 ± 14.6	16.3 ± 1.7
		16 – 40	32.1 ± 25.0	31.3 ± 5.9	461.5 ± 24.2	13.7 ± 1.5
	Tanke	1 – 15	35.7 ± 20.6	25.2 ± 6.2	525.1 ± 79.7	12.2 ± 4.1
		16 – 40	60.7 ± 23.6	29.9 ± 8.5	511.3 ± 15.1	10.7 ± 4.0

In respect of the two locations in Ibadan, the levels of zinc are higher in children (aged between 1 and 15 years) than in active adult population (16 – 40 years). There is also a significant difference at 0.05 probability level between the levels of zinc in the two age groups. The levels of zinc are equally found to be higher in children at the two locations investigated in Ilorin town. There is, however, no significant difference in the levels of zinc between the two age groups in Ilorin. The higher levels obtained for children could be attributed to the specific metabolic cycle incorporating the uptake and retention of this essential metal in the body of the children, and the reduction in the level of zinc in the adult hair could be due to the use of zinc for the production of melanin pigment in hair (Ashraf *et al*., 1995). The levels of copper generally fall between 10 and 28 mg/kg and is independent of age and geographical location.

The levels of lead are generally higher in adults than in children. This is true for the two locations in Ibadan and for one of the two locations investigated in Ilorin. This agrees with some of the literture values which suggested the accumulation of lead with age (Zakrgyuska *et al*., 1998). As for lead, the levels of cadmium are also relatively higher in adult than in children. The reason for the higher levels of lead and cadmium in adults than in children could be due to atmospheric pollution coupled with the level of occupational exposure (Nowak, 1998). Similar results had earlier been reported by Ashraf and co-workers (Ashraf *et al*., 1995) in respect of two urban populations in Pakistan, and also by Eltayeb and Grieken, 1990 in respect of Sudanese populations.

Comparison between the two cities for the same age group reveals that for the levels of zinc are higher in urban population of Ibadan than that of Ilorin. This is true for both age groups. There is also a significant difference at 0.05 probability level between the levels of zinc in the two populations. These higher levels of zinc observed in Ibadan City population could be attributed to the nutritional characterization of the two populations.

The levels of lead are also generally higher in the adult population of Ibadan than that of Ilorin. There is, however, no significant difference between the levels of lead in the two urban populations. The higher levels of lead observed in Ibadan could be associated with the high level of urbanization and industrialization of Ibadan. The higher level of lead obtained in the case of one of the locations in Ilorin (Oja-oba area) is not surprising, especially if one considers the fact that Oja-oba area of Ilorin is almost at the heart of the town and equally a highly traditional area. Engagement of children in hawking of goods on the roadside is a common practice in this area. The literacy level is also very low in this particular area.

The results of the regression analysis carried out on the results for different possible pairs of the heavy metals are given in Table 2. Only zinc/copper and lead/cadmium exhibit positive correlation out of all the possible combinations of the heavy metals. A strong correlation (r=0.8624) appears to exist between zinc and copper. Correlation also exists between lead and cadmium (r=0.1924) even though to a lesser extent. There is no positive correlation between lead and any other metal, except cadmium. These findings quite agree with those reported by previous workers (Nowak, 1998; Ashraf *et al*., 1995). Zinc and copper could therefore be traced to the same origin which is likely to be physiological or metabolic as suggested by some people (Ashraf *et al*., 1995; Man *et al*., 1996). Zinc has been particularly related to the production of melanin pigment in hair. Lead and cadmium would most probably be of environmental origin. The results of some previous investigators have lent support to this (Valkovic *et al*., 1975; Ashraf *et al*., 1995).

Table 2: Metal to metal regression equation and correlation coefficients.

S/No.	Regression Equation	Correlation coefficient (r)
1.	[Pb] = 0.504 [Cd] +41.56	0.1924
2.	[Pb] = – 0.0069[Zn] + 59.23	– 0.0900
3.	[Pb] = – 0.117 [Cu] +56.75	– 0.0390
4.	[Cd] = – 0.019 [Zn] + 38.52	– 0.654
5.	[Cd] = – 0.822 [Cu] + 39.87	– 0.7168
6.	[Zn] = – 33.96 [Cu] + 81.74	0.8624

Comparison between the present data and the literature values for male populations (Table 3) indicates that the levels of zinc and lead are much higher than those reported. The high level of lead could be attributed to a relatively higher level of atmospheric pollution in the two Nigerian cities, compared to other countries cited in the literature, while the high level of zinc could be as a result of the Nigerian characteristic dietary habits. The levels of copper are in the same range with those of other countries.

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Table 3: Comparison between the present data and the literature values.

Age Group (Years)	Metal	Present Work	Literature values (References)
1 – 15	Zn	914 ± 170	113.8 ± 17.7 (Ashraf *et al*. 1993)
			141.5 ± 40.5 (Shoichiro, 1985)
16 – 40	Zn	531.5 ± 26.7	208.8 ± 15.4 (Ashraf *et al*., 1993)
			160.0 ± 35.0 (Shoichiro, 1985)
			126.0 ± 23.0 (Eltayeb and Grieken, 1990)
			165.0 ± 27.7 (Barker *et al*., 1976)
			124.0 ± 3.0 (Othman and Spyrou, 1980)
1 – 15	Cu	19.1 ± 3.3	13.4 ± 3.6 (Ashraf *et al*., 1993)
			11.5 ± 1.6 (Shoichiro, 1985)
16 – 40	Cu	18.3 ± 2.8	18.9 ± 5.1 (Ashraf *et al*., 1993)
			11.7 ± 1.5 (Shoichiro, 1985)
			10.0 ± 3.0 (Eltayeb and Gricken, 1990)
1 – 15	Pb	57.2 ± 14.2	
16 – 40	Pb	66.7 ± 43.2	7.0 ± 4.0 (Eltayeb and Gricken, 1990)
			10.6 (Ashraf *et al*., 1993)
			5.1 ± 4.3 (Barker *et al*., 1976)

Note: The results concerning one of the locations in Nigeria are cited here. All the values are expressed as mg/kg of hair.

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