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Full Length Research Paper

Multielement analyses of human scalp hair samples from three distant towns in southeastern Nigeria

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Hair samples were collected from three distant towns in Southeastern Nigeria and analyzed for their contents of the trace metals, Pb, Cd, Zn, Ni, Cu, and Cr by atomic absorption spectrometry. Higher geometric mean values for Pb, Zn, Ni, Cu, and Cr were obtained in hair samples of donors from the industrialized areas, Aba and Onitsha. Higher levels of Pb and Cr were observed in hair samples of male donors while higher levels of Zn and Cu were obtained in hair samples from the unindustrialized area, Isuochi. For the general population studied, geometric mean values of 65.4 µg/g (range 9.1 to 194.5 µg/g); 1.2 µg/g (0.4 to 6.6 µg/g); 146.2 µg/g (57.7 to 510 µg/g); 26.4 µg/g (5.0 to 143.2 µg/g); 117.2 µg/g (29.4 to 363.5 µg/g); 35.1 µg/g (19.5 to 60.6 µg/g) were obtained for the metals, Pb, Cd, Zn, Ni, Cu, and Cr, respectively. Our result indicates that ~ 89% of the population had Pb levels >30 µg/g, indicative of occupational exposure, while about 20% had levels >110µg/g which is considered dangerous.

Key words: Scalp hair, lead, trace metals, automobile exhaust.

INTRODUCTION

Hair analysis for trace elements is an area of increasing interest in the fields of medical, biological, forensic, and environmental sciences (Chittleborough and Steel, 1980; Bader et al., 1999; Ashraf et al., 1995a). Hair provides one of the most accurate records of the health and trace metal status of the human body. For long, blood and urine analysis were the main sources of information on the body's burden of trace metals. Studies of human exposure to Pb in Nigeria using human tissues have reported high levels of Pb in urine (Ogunfowokan et al, 2002), and blood samples (Nriagu et al., 1997; Omokhodion, 1994; Ogunsola et al., 1994; Adeniyi and Anetor, 1999).

Hair is an excellent indicator of past changes in metabolism and environmental exposure to metals (Ashraf et al., 1995b; Ajayi et al., 2001). The growth rate of human hair is approximately 1 cm per month (Wolfsperger et al., 1994). Hair analysis for trace elements is influenced by a number of factors including geographical location (Kaspereck et al., 1982; Rosborg et al., 2003; Ajayi et al., 2001) age and sex (Bertazzo et al., 1996; Ashraf et al., 1995b). Hair color ((Bertazzo et al, 1996; Sturaro et al., 1994) and treatment with various Chemicals and shampoos are also variables to consider (Rosborg et al., 2003).

Scalp hair consists of the protein keratin, which contains a high proportion of the sulphydryl groups(-SH) containing amino acid, cysteine (Denton et al., 1980; Fergusson et al., 1981; Ajayi et al., 2001). Hair samples treated with hair dye materials have been observed to contain very high levels of Pb after thorough washing to remove the dye. This suggests that Pb in its compounds when applied externally or deposited on the hair does enter the hair fiber (Fergusson et al., 1981). Thus trace metals initially as a surface contaminant may become incorporated into the hair structure, probably through attachment to the –SH groups in the hair. Lead as a trace metal in the human tissues have received the most attention and several studies have examined the physiological and behavioral effects of Pb especially with reference to hyperactivity in children (Wang et al., 2002; Koller et al., 2004)

The aim of the present study was to determine the concentration of Pb, Cd, Zn, Ni, Cu, and Cr in scalp hair samples of selected groups in three distant towns in Southeastern Nigeria.

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MATERIALS AND METHOD

Sampling

Hair samples (scalp hair) were obtained with the assistance of barbers and hair dressers. Information on age, sex and occupation

Table 1. Trace metal contents (µg/g dry weight) of scalp hair samples from Aba, Onitsha and Isuochi in Southeastern Nigeria.

Sex/City	Age group	N	Pb	Cd	Zn	Ni	Cu	Cr
Female	1 - 9	3	49.3	1.2	145.4	43.1	-	-
	10-19	6	82.7	1.0	135.1	16.2	121.0	36.3
	20-30	24	59.2	1.4	159.9	33.0	116.9	30.8
Male	1-9	2	31.1	1.0	110.1	20.6	-	-
	10-19	3	92.4	0.9	125.9	13.4	104.5	40.9
	20-30	8	68.2	1.1	134.8	22.1	107.4	38.8
Female overall		3	61.9	1.0	128.6	19.5	116.3	38.0
Male overall		13	64.8	1.0	128.6	19.5	116.3	38.0
Industrialized areas								
Onitsha	Male	5	90.8	0.9	105.9	13.2	95.5	45.6
	Female	8	132.0	1.1	198.0	23.8	62.9	36.9
Aba	Male	5	102.2	1.5	150.2	34.9	197.0	27.0
	Female	14	47.9	1.9	128.7	47.2	-	-
Male	Total	10	96.3	1.2	126.2	21.5	117.4	39.3
Female	Total	22	69.3	1.5	150.6	36.8	62.9	36.9
Unindustrialized area Isuochi								
	Male	3	31.9	0.6	137.2	14.0	113.7	35.2
	Female	11	49.9	0.9	160.3	19.5	260.3	28.4
General Population		46						
Geometric mean		46	65.4	1.2	146.2	26.4	117.2	35.1
Median		46	64.5	1.2	137.9	29.4	123.9	30.2
Range		46	9.1 to 194.5	0.4 to 6.6	57.7 to 510	5.0 to 143.2	29.4 to 363.5	19.5 to 60.6

and residence were obtained from donors. Aba and Onitsha, two industrialized and densely populated cities and Isuochi, a rural small un-industrialized town (all in Southeastern Nigeria) were selected to study the effect of industrialization and automobile exhaust pollution on trace metal levels of human hair. Hair sample were collected from males and females of different age groups ranging from 3-30 years old.

The hair samples were stored in poly-ethylene bags immediately after collection. Hairs that have been bleached or dyed were not collected. The samples were soaked and washed in 2% nonionic surfactant (Persil) and rinsed several times (Fergusson et al., 1981). The hair samples were then soaked and washed in acetone to remove oil and grease (Rosborg et al., 2003). Each washing lasted approximately 10 min with continuous stirring (Ashraf et al., 1995) . The samples were then dried at 60ºC for 4 h in an electric oven.

Chemical analysis

0.5 g of the sample was digested in a 50 mL Erlenmeyer flask with 10 mL AnalaR concentrated HNO_3 and 5 mL of 80% (v/v) of H_2O_2 at room temperature to prevent foaming. The flask was then heated up to 120ºC and then evaporated to near dryness, and further treated with two portions of the HNO_3 /H_2O_2 and evaporated to near dryness. This was necessary in order to oxidize the hair completely to give an almost clear to faint amber solution. The content of the flask was taken up in 1 M HNO_3, filtered through a pre-acid washed filter paper, collected in a 10 mL volumetric flask, and made up to volume with the 1 M HNO_3 . This was subsequently analyzed for Pb, Cd, Zn, Ni, Cu, and Cr by the standard calibration technique using flame atomic absorption spectrophotometer (UNICAM, 969). Batch precision and accuracy was successfully monitored with a 10% insertion rate of sample duplicates, blanks and spikes.

RESULTS AND DISCUSSION

The geometric mean values of the six metals determined in human scalp hair is shown in Table 1. It is more appropriate to report results of studies such as this using geometric mean values rather than the arithmetic mean as the results are usually positively skewed and close to log normal (Fergusson et al., 1981; Ajayi et al., 2001). Higher levels of Pb and Cr were observed in hairs of male donors while higher levels of Cd, Zn, Ni, and Cu were observed in the hair samples of female donors. The Pb, Zn, Ni, Cu, and Cr values from male donors from the industrialized areas (Aba and Onitsha) were observed to be higher compared to the values for their counterparts from the rural area, Isuochi. However, comparative amounts of Cu were obtained in the hair samples of the two groups. Female donors of Aba and Onitsha had higher levels of Pb, Cd Ni, and Cr than the female donors of Isuochi. On the other hand, higher levels of Zn (160.3

µg/g) and Cu (260.3 µg/g) were, however, obtained in the female hair samples from Isuochi. Our result indicates higher geometric mean values for Pb, Cd, Ni, and Cr for hair samples from Aba and Onitsha.

The observation of approximately two times higher levels of Ni in the hair samples of females compared to males in the three localities studied may be attributed to the preference of food cooked with vegetable oil by the females. These cooked or fried food items are usually prepared with vegetable oil manufactured through the hydrogenation of palm oil and palm kernel oil (PKO) using nickel catalyst. A similar study in Pakistan made a similar observation (Ashraf et al., 1995b). The observed higher level of Ni in the female hair sample from Aba and Onitsha compared to Isuochi may be attributed to the ease of affordability of the hydrogenated oil in these areas. Most families in Isuochi may prefer the readily available palm oil. Thus a difference in cooking and eating habits could explain the content of Ni in the hair of the three localities studied.

A distinct pattern of distribution was observed for Pb and Cd for the age groups in both sexes. The order of increasing levels of Pb in the hair samples of both males and females is 10 to 19 years > 20 to 30 years > 1 to 9 years. Similarly, the order for Cd in both sexes is 20 to 30 years >1 to 9 years > 10 to 19 years. However no defined order was observed for Ni, Cu, Zn and Cr.

Strong positive correlation was observed for Cd and Ni (r = 0.7), Pb and Ni (r = 0.6), and between Pb and Cd (r = 0.6) in the male population. A similar observation was made for Cd with Pb, Ni, and Zn in the hair of females of the 20 to 30 years age range, the corresponding r values were 0.8, 0.8, and 0.7, respectively. The linear correlation study also revealed that Cd was strongly correlated with Pb and Ni (r = 0.7) in the male hair of donors from the industrialized areas. Also a similar observation was made for Pb and Zn (r = 0.6); Pb and Cd (r =0.5) and Zn and Ni (r = 0.6) in the hair samples of females from the industrialized areas. No significant positive correlation was observed for hair of donors from the unindustrialized area.

Our median Zn result is 137.9 µg/g, while a similar study from Sweden found 163 µg/g in an acid region and 174 µg/g in an alkaline region (Rosborg et al., 2003). The highest mean Zn value of198 µg/g observed for female hair samples from Onitsha compares with the 180.5 µg/g reported for females in Lahore, Pakistan (Ashraf et al., 1995b). The very high lead levels of our result may be attributed to the deposition of Pb particulates from exhaust fumes on human hair. This with time gets incorporated into the hair fiber. Other authors have also observed widespread nature of lead poisoning in Nigeria (Dioka et al., 2004). The level of lead in Nigerian petrol has been estimated as 0.7 g/L (0.6 to 0.8 g/L) (Osibanjo and Ajayi, 1989; Awofolu, 2004). At present the daily consumption of petrol is about 30 million liters.

Attempts have been made at specifying hair Pb levels to be considered high and dangerous; >30 µg/g indicating an excessive level and >110 µg/g as dangerous level (El-Dakhakhny and El- Sadik, 1972; Fergusson et al., 1981; Ajayi et al., 2001). Our result indicates that 20% have lead levels >110µg/g. Ajayi et al. (2001) also reported a similar percentage (18%) for levels >110µg/g in hair samples collected from Ibadan, Abeokuta, and Lagos states in Nigeria.

In conclusion, these data indicates the level of human exposure to heavy metals in Nigeria. These observations suggest Pb poisoning of a high magnitude arising from environmental factors probably largely due to high gasoline lead. There is an urgent need to initiate a gradual phase out of the use of leaded gasoline in Nigeria.

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