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Comparison of heavy metals (Pb, Cu, Ni, Zn and Al) in human scalp hair: A case study of Port Harcourt and Okigwe

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The proliferation of industries has led to increased presence of heavy metals in our environment and, humans are continually exposed to these heavy metals through their engagements in different industrial activities. The current study is designed to make a comparative assessment of the level of heavy metals (Pb, Cu, Ni, Zn, Al) in the hair scalp of humans living in industrialized and unindustrialized cities of Port Harcourt and Okigwe respectively. Male hair samples were randomly collected and analysed for their trace metals contents by atomic absorption spectrophotometry (AAS). Higher geometric mean values for Zn, Ni and Pb were obtained in hair samples of donors from Port Harcourt as compared to that of Okigwe which rather recorded high geometric mean values for Cu and Al. It was observed that there was a significant difference in the mean concentrations of Pb between Port Harcourt and Okigwe, with Port Harcourt having a very high concentration of 513.5 mg/kg while no significant differences were observed in the mean concentrations of the other metals between these two cities studied. For the general population studied, geometric mean values of 6.4, 118.9, 4.2, 35.9 and 45.7 mg/kg were obtained for the metals Cu, Zn, Ni, Pb and Al respectively. Results showed that the heavy metals found in human hair of the people living in the two cities were dependent mainly on environmental factors, occupation, lifestyle and feeding habits.

Key words: heavy metals, scalp hair, industrialized and unindustrialized area, environmental factors, occupation, lifestyle.

INTRODUCTION

Our bodies are gradually turning to dumping ground for thousands of toxic compounds that invade our air, water and even the soil in which our food grows. It is estimated that our bodies cannot metabolize over 20000 of these chemicals (Airey, 1983). Some metals are naturally found in the body and are essential to human health, though they normally occur at low concentrations and are known as trace metals (Ashraf et al., 1995). Heavy metal poisoning is the toxic accumulation of heavy metals in the soft tissues of the body. Hair analysis is one

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way of detecting heavy metal poisoning in humans. Studies indicate that levels of potentially toxic elements in human hair correlates with blood levels and body tissue deposition levels (Carson et al., 1987). Hair is a site of excretion of essential, nonessential and potentially toxic elements. Hair is also an excellent biopsy material. It is easy to sample, preserve and transport. Hair has the advantage of long term memory. It can keep a “permanent record like tree rings” (Daniel and Richard, 1981). Therefore, hair tissue mineral analysis (HTMA) is an analytical test which measures the presence of heavy metals, toxins, the nutritional content of hair and the balance between the nutrient level and heavy metal toxin (Daniel and Richard, 1981). In this study, a comparative assessment of heavy metals content in hair scalp of humans in two cities: Port Harcourt and Okigwe was made. The two cities were chosen so as to make a comparison of the concentration of these metals among two categories of people; those living in a densely populated industrialized city and those who live in an unindustrialized city.

MATERIALS AND METHODS

Sample collection, preservation and treatment

The class of people selected for this study was the male population from two localities viz; PortHarcourt and Okigwe and were of varying ages ranging from 10 to 40 years old. Male hair samples were chosen, since they maintain a low haircut, and do not treat their hair like women. A primary data was used, since data was directly gotten from donors through the assistance of barbers. A questionnaire was used as a research instrument, and information on age, occupation and residence were obtained from donors. 10 samples were randomly collected from youths and adults in Port Harcourt and the other 10 from youths and adults in Okigwe, so as to compare the extent of exposure in these geographical areas.

A minimum of 2 g per sample of hair was collected from each individual. This was gotten from the occipital region of the scalp. Sampling near the face was avoided due to increased likelihood of contamination from sebaceous secretions and facial hygiene products. Hairs that have been bleached or dyed were not collected.

The hairs were washed with acetone and afterward washed with deionized water. Acetone is an effective fat solvent and, partly a polar molecule, having the capacity to dissolve both fat soluble and water soluble elements attached to the hair strands following external contamination.

The hair samples were further cut into lengths of approximately 0.5 cm, soaked and washed in 2% nonionic surfactant (persil) and rinsed several times. The hair samples were then soaked and washed in acetone to remove oil and grease. Each washing lasted approximately 10 minwith continuous stirring. The samples were dried in electric oven at 60°C for 4 h. After drying, samples were left in a covered watch glass till all samples were ready for treatment.

Sample digestion and chemical analysis

Exactly 0.5 g of the sample was weighed out for digestion. Wet digestion was used and the sample was digested in a digestion beaker with 10 ml concentrated HNO_3 (AnalaR grade) and 5 ml of 80% (v/v) H_2O_2 at room temperature to prevent foaming. The beaker was then heated up to 120°C till the content became amber as the hair decomposed. Heating was continued for some time to allow the content of the beaker to evaporate to dryness. The content was 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. This whole process was done in a fume cupboard with the aid of a hot plate and a magnetic stirrer. The content of the beaker was taken up in a prepared 1 M HNO_3 and the solution filtered through a pre-acid washed filter paper , collected in a 10 ml volumetric flask, and the filtrate made up to volume with the 1 M HNO_3. The filtrate was then analyzed using flame atomic absorption spectrophotometer. The same procedure was followed for the entire sample. Chemical analysis was done for the heavy metals Cu, Al, Zn, Pb and Ni using flame atomic absorption spectrophotometer (unicam 966 model).

Data analysis technique

The statistical parameter for comparison of the heavy metal concentrations between both cities was the student's t-distribution test, at 0.05 confidence level (that is level of significance). T-test was used because it tries to confirm if there is a significant difference in the level of heavy metal concentrations in both areas. Kari Pearson's product moment of coefficient of correlation r was also used. The geometric mean values of the five metals were determined. This is because it is more appropriate to report results of studies such as this using geometric mean value, as the results are usually positively skewed and close to the normal log (Peltersson and Rasmassen, 1999).

RESULTS AND DISCUSSION

From the results, it was observed that a distinct pattern of distribution was observed for Pb and Al (Tables 2 to 5) in Okigwe area. The order of increasing level for Pb and Al are the same that is 10 to 20 years > 21 to 30 Years > 31 to 40 years while that for Cu follows the trend 10 to 20 years > 31 to 40 years > 21 to 30 years as seen in Table 1. The highest geometric mean values obtained for heavy metals in hair samples of those in age limit 10 to 20 years could be attributed to feeding habits, lifestyle and environmental exposure. The highest geometric mean values were gotten for Cu, Zn, Ni and Pb (Tables 6 to 9) in age limit 21 to 30 years while the highest geometric mean value was obtained for Al in age limit 31 to 40 years (Table 10). The factors outlined above, could also be the reasons for the high geometric mean values obtained in the different age limits.

A total hair concentration of Cu is seen to be higher in Okigwe than in Port Harcourt (Table 11) with a total concentration of 70.8 mg/kg and a geometric mean of 6.9 mg/kg against 67.1 and 6.0 mg/kg respectively.

However, from the t-test conducted (Table 16), it is observed that there was no significant difference in the mean concentrations of copper between both cities. But the high concentration of copper in Okigwe may be attributed to the consumption of contaminated food or drinking water and also due to contamination of hair. In a similar study in Sweden (Petering et al., 1973), a large proportion of young children obtained their daily

Table 1. Cu Content in hair samples from Okigwe

Age Limit	Number	Range (mg/kg)	Mean (mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10– 20	3	6.6 – 7.7	7.2	7.2	7.1
21 – 30	4	4.8 – 8.7	7.0	6.8	1.5
31 – 40	3	5.2 – 9.8	7.1	6.8	2.3

Table 2. Zn Content in hair samples from Okigwe.

Age limit	Number	Range(mg/kg)	Mean(mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	113.9 – 116.2	115.3	115.3	3.6
21 – 30	4	112.7 – 140.5	123.3	122.8	11.3
31 – 40	3	106.8 – 125.5	116.9	116.7	10.0

Table 3. Ni Content in hair samples from Okigwe.

Age limit	Number	Range(mg/kg)	Mean(mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	3.1 – 4.7	3.8	3.7	0.6
21 – 30	4	1.3 – 19.8	7.0	4.2	8.6
31 – 40	3	2.5 – 3.0	2.8	2.8	0.6

Table 4. Pb Content in hair samples from Okigwe.

Age limit	Number	Range(mg/kg)	Mean(mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	16.7 – 70.4	39.5	33.3	27.7
21 – 30	4	23.5 – 36.3	29.6	29.0	7.0
31 – 40	3	11.4 – 35.9	20.0	17.4	13.8

Table 5. Al Content in hair samples from Okigwe.

Age limit	Number	Range(mg/kg)	Mean(mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	53.5 – 81.1	63.0	61.8	15.9
21 – 30	4	35.1-66.4	50.4	49.1	12.9
31 – 40	3	21.8 – 58.0	42.4	39.1	18.5

requirements of copper solely from drinking water due to copper in water pipes. According to age range, 21 to 30 years of age had the highest copper concentration, which could be due to accumulation of the metal from similar sources. And the order of increasing level is 21 to 30 years > 31 to 40 years > 10 to 20 years.

Zinc concentration was the highest in all hair samples (Table 12). This could be due to the type of treatment given to hair, or due to feeding habit. This is because zinc being an essential element tends to be high in concentration in the human body. For the general population studied, the overall geometric mean value of 118.9 mg/kg obtained for zinc is similar to that obtained from a similar study in south-eastern Nigeria (146.2 mg/kg). Very high total zinc concentration in Port Harcourt (1202.80 mg/kg) is slightly higher than that in Okigwe (1189.9 mg/kg). The Zinc ratio between geometric mean values in both cities is 1.02. From the t-test conducted (Table 17), no significant difference was seen in the mean concentrations of Zn between Port Harcourt and Okigwe. Male population ranging from 21 to 30 years had the highest mean concentration of Zinc in their hair compared to other age limits.

The hair concentration of nickel was observed to be higher in Port Harcourt than in Okigwe (Table 13), with a total concentration of 105.0 mg/kg and a geometric mean of 3.6 mg/kg. Those within the range of ages 21 to 30, showed the highest geometric mean of 9.3 mg/kg

Table 6. Cu Content in hair samples from Port Harcourt.

Age limit	Number	Range(mg/kg)	Mean(mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	1.9 – 8.4	5.7	5.0	2.7
21 – 30	4	4.3 – 11.7	8.9	8.1	4.0
31 – 40	3	4.9 – 7.0	6.0	5.9	1.0

Table 7. Zn Content in hair samples from Port Harcourt.

Age limit	Number	Range (mg/kg)	Mean (mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	94.8 – 152.8	119.6	118.2	21.4
21 – 30	4	116.2 – 148.2	128.7	128.0	17.5
31 – 40	3	100.52– 117.4	109.0	108.6	11.0

Table 8. Ni Content in hair samples from Port Harcourt.

Age limit	Number	Range (mg/kg)	Mean (mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	1.4 – 22.2	6.2	3.4	9.0
21 – 30	4	2.9 – 30.1	12.3	7.0	15.4
31 – 40	3	1.3 – 35.6	18.5	6.8	24.2

Table 9. Pb Content in hair samples from Port Harcourt.

Age limit	Number	Range (mg/kg)	Mean (mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	44.5 – 57.0	47.8	47.6	5.0
21 – 30	4	41.0 – 91.4	63.1	58.7	25.7
31 – 40	3	34.7 – 50.7	42.7	41.9	11.3

Table 10 . Al Content in hair samples from Port Harcourt.

Age limit	Number	Range (mg/kg)	Mean (mg/kg)	Geometric Mean (mg/kg)	Std. Dev
10 – 20	3	29.7 – 60.4	42.1	41.0	11.2
21 – 30	4	39.1 – 57.5	43.3	41.9	13.4
31 – 40	3	37.7 – 60.0	48.9	47.6	15.5

compared to other age ranges for Ni. The high concentration of nickel observed from Port Harcourt could be attributed to the consumption of food cooked with vegetable oil and margarine. These cooked or fried food items are usually prepared with vegetable oil manufactured through the hydrogenation of palm kernel oil (PKO) using Ni catalyst. A similar study in Pakistan made a similar observation (Thatcher, and Lester, 1982). The ease of affordability of the hydrogenated oil in the industrialized area (Port Harcourt) could also be a cause. Most families in Okigwe may prefer the readily available palm oil or palm kernel oil. Therefore, a difference in cooking and eating habits could explain the Ni content in the hair samples from both cities studied. Other reasons could be attributable to the consumption of chocolate, or food grown near industrialized areas, or even those residing close to solid waste incinerators. However, the t-test in Table 18 shows no significant difference in the mean concentrations of Ni between Port Harcourt and Okigwe.

From Table 14, a higher Pb concentration of 513.5 mg/kg was obtained for hair samples from Port Harcourt compared to 296.9 mg/kg for samples from Okigwe. A distinct pattern of distribution was observed for Pb for the age groups. The order of increasing level of Pb in the hair samples in Port Harcourt and Okigwe is 10 to 20 > 21 to 30 > 31 to 40. From Table 19, the t-test conducted showed a significant difference in the mean

Table 11. Total Copper Content in hair for the two cities.

Sample	Number	Range (mg/kg)	Mean (mg/kg)	Geometric mean (mg/kg)	Std. Dev
Overall result	20	1.9 – 11.7	6.9	6.4	2.3
PortHarcourt	10	1.9 – 11.7	6.7	6.0	3.1
Okigwe	10	4.8 - 9.8	7.1	6.9	1.4
Age 10 – 20	8	1.9 – 8.4	6.2	5.8	2.4
Age 21 – 30	7	4.3 – 11.7	7.8	7.4	2.8
Age 31 – 40	5	4.9 – 9.8	6.8	6.4	2.5

Table 12. Total zinc Content in hair for the two cities.

Sample	Number	Range (mg/kg)	Mean (mg/kg)	Geometric mean (mg/kg)	Std. Dev
Overall result	20	94.8 – 152.8	119.6	118.9	14.0
Port Harcourt	10	94.8 - 152.8	120.2	119.0	18.4
Okigwe	10	106.8 – 140.5	119.0	118.7	8.8
Age 10 – 20	8	94.8 – 152.8	118.0	117.1	16.3
Age 21 – 30	7	112.7 – 148.2	125.6	125.0	13.3
Age 31 – 40	5	100.5 – 125.5	113.7	113.4	10.5

Table 13. Total nickel content in hair for the two cities.

Sample	Number	Range (mg/kg)	Mean (mg/kg)	Geometric mean (mg/kg)	Std. Dev
Overall result	20	1.3 – 35.6	7.6	4.2	10.4
P.H	10	1.3 – 35.6	10.5	4.9	13.4
Okigwe	10	1.3 – 19.8	4.8	3.6	5.3
Age 10 – 20	8	1.4 – 22.2	5.3	3.5	6.9
Age 21 – 30	7	1.3 – 35.6	9.3	5.2	11.1
Age 31 – 40	5	1.3 – 35.6	9.1	4.0	14.8

Table 14. Total lead content in hair for the two cities.

Sample	Number	Range (mg/kg)	Mean (mg/kg)	Geometric mean (mg/kg)	Std. Dev
Overall result	20	11.4 – 91.4	40.5	35.9	19.5
P.H	10	34.7 – 91.4	51.4	49.7	15.4
Okigwe	10	11.4 – 70.4	29.7	25.9	17.1
Age 10 – 20	8	16.7 – 70.4	44.6	41.6	16.1
Age 21 – 30	7	23.5 – 91.4	44.0	39.5	23.7
Age 31 – 40	5	11.4 – 50.7	19.4	24.7	29.5

concentration of Pb between both areas. High level of Pb observed in the hair samples from Port Harcourt being an industrialized area may be primarily due to the deposition of Pb particulates from automobile exhaust fumes on human hair. Occupational exposure and contaminated drinking water could also be other causes. This is because acid and soft water may dissolve Pb from lead pipes or lead soldered copper tubes, thereby contaminating the drinking water.

Aluminium hair concentration was observed to be

Table 15. Total Aluminium Content in hair for the two cities.

Sample	Number	Range(mg/kg)	Mean(mg/kg)	Geometric Mean (mg/kg)	Std. Dev
Overall result	20	21.8 – 81.1	47.8	45.7	14.2
P.H	10	29.7 – 60.4	43.8	42.5	11.5
Okigwe	10	21.8 – 81.1	51.8	49.2	16.1
Age 10 – 20	8	29.7 – 81.1	49.9	47.8	16.3
Age 21 – 30	7	35.1 – 66.4	47.4	45.9	12.4
Age 31 – 40	5	21.8 – 6.0	45.0	42.3	15.6

Table 16. T- test Comparison of mean concentrations of Cu between Port Harcourt and Okigwe.

Parameter	Number	∑x	X	S.D	Cal. T-value	Decision at PL.05
Zn Conc. in samples from PH	10	67.1	6.7	3.1	-0.37	No significant difference
Cu conc. in samples from Okigwe	10	70.8	7.1	1.4		

Table 17. T-test Comparison of mean Concentrations of Zn between Port Harcourt and Okigwe.

Parameter	Number	∑x	X	S.D	Cal. T-value	Decision at PL.05
Zn Conc. in samples from PH	10	1202	120.2	18.4	0.185	No significant difference
Cu conc. in samples from Okigwe	10	1190	119.0	8.8		

Table 18 T- test Comparison of mean Concentrations of Ni between Port Harcourt and Okigwe.

Parameter	Number	∑x	X	S.D	Cal. T-value	Decision at PL.05
Zn Conc. in samples from PH	10	105.0	10.5	13.4	1.524	No significant difference
Cu conc. in samples from Okigwe	10	47.8	4.8	5.3		

Table 19. T-test Comparison of mean Concentrations of Pb between Port Harcourt and Okigwe.

Parameter	Number	∑x	X	S.D	Cal. T-value	Decision at PL.05
Zn Conc. in samples from PH	10	514	51.4	15.4	2.958	No significant difference
Cu conc. in samples from Okigwe	10	297	29.7	17.1		

higher in Okigwe (Table 15) with a total concentration of 517.9 mg/kg and geometric mean of 49.2 mg/kg in Okigwe compared to 438.1 mg/kg and geometric mean of 42.5 mg/kg in samples from Port Harcourt. A similar distinct pattern observed in the age range for Pb was also observed in Al, where the order of increasing levels of Al in hair samples from Port Harcourt and Okigwe was 10 to 20 > 21 to 30 >31 to 40 . Table 20 shows from the t-test that there is no significant difference in the mean concentration of Al between Port Harcourt and Okigwe. However, the high concentration of Al may be attributed mainly to drinking water, intake of Al-containing drugs, and the application of Al-containing deodorants, increased Al intake through juices and soft drinks has also been reported in Spain (Tuthill, 1996). An overall range of 21.8 to 81.1 mg/kg was obtained compared to 0.2 to 21.4 µg/g of that obtained from a similar study in Sweden (Petering et al., 1973).

Table 20. T-test Comparison of mean Concentrations of Al between Port Harcourt and Okigwe.

Parameter	Number	∑x	X	S.D	Cal. T-value	Decision at PL.05
Zn Conc. in samples from PH	10	438	43.8	11.5	-1.270	No significant difference
Cu conc. in samples from Okigwe	10	518	51.8	16.1		

For the whole sampling material, strong positive correlations were observed for Cu to Zn.

Conclusion

This study was primarily intended to compare the level of heavy metal concentrations in human scalp hair between Port Harcourt and Okigwe. Five metals were studied which included; Cu, Zn, Ni, Al, and Pb. Hair samples were randomly collected from the male population from both cities under study. There was no significant difference in the mean concentration of Cu, Zn, Ni, and Al between Port Harcourt and Okigwe, when tested at 0.05 level of significance. A significant difference was observed in the mean concentration of Pb between Port Harcourt and Okigwe. Higher concentrations and geometric mean values for Zn, Ni, and Pb were observed in the hair samples from Port Harcourt, while higher concentrations and geometric mean values for Cu and Al were obtained for hair samples from Okigwe.

It was also observed that the level of these heavy metals found in these two cities could result from feeding habits, occupational exposure, environmental factors and lifestyle. For instance, the high concentration of Pb could be probably due to high gasoline lead discharge from exhaust fumes. Results clearly show that there were some heavy metals in the hair samples of donors. This indicates that one is constantly exposed to heavy metal contamination throughout one's life but the fact remains that heavy metals may be found in low concentrations when adequate precautions are taken.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Airey D (1983). Nickel in Human Hair due to Environment and Diet: A review", Environmental Health Perspective 52:503-516.

Ashraf W, Jaffer M, Anwer K, Ehsan U (1995). Age-and-Sex-Based Comparative Distribution of Selected Metals in Scalp Hair of an Urban Population from Two Cities in Pakistan, Environmental pollution 87:61-64.

Carson RL, Eliss HU, McCann JL(1987). Toxicology and Biological Monitoring of Metals in Humans, Lewis Publishers, Chelsea MI. pp. 27-33.

Daniel L, Richard A (1981). Sample Collection and Analysis, Environmental Research, New York 87:61-66.

Peltersson R, Rasmassen F (1999). Daily Intake of Copper from Drinking Water among Young Children in Sweden, Environmental health perspectives 107:441-446.

Petering H, Yeager D,. Witherup S (1973). Trace metal content of hair: II. Cadmium and lead of human hair in relation to age and sex." Environmental Health: An International Journal 27:327-333.

Thatcher R, Lester M (1982). Effects of Low Levels of Cd and Pb on Cognitive Function in Children, Environmental Health 37:159-166.

TuthillB R (1996). Hair Pb Levels Related to Children's Classroom Attention Deficit Behavior, Environmental Health 51:214-216.