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Analyses of lead and zinc levels in human scalp hair in occupationally exposed workers in Cape Coast, Ghana

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ABSTRACT

Chemical investigation was conducted into the concentrations of zinc and Lead in scalp hair samples of some selected workers who literally work at occupational settings which exposes them to metal contaminants. The measured concentrations of Zn and Pb were compared with the levels in workers who were unlikely to be occupationally exposed to the studied metal contaminants. Traces of Zinc and Lead were found in all the samples analyzed. However the concentrations of the studied metals were higher in occupationally exposed workers than those who were not likely to be occupationally exposed to the metals. The average concentration of lead and zinc obtained from the occupationally exposed individuals were found to be 0.219-2.201mg/L and 0.046-0.862mg/L respectively. The results of this study have revealed that the average concentration of lead and zinc in human scalp hair of occupationally exposed workers increases with increase number of years spent by an individual at the work place.

Key words: Human hair, scalp, Zinc, Lead, metal workshops, Cape Coast

INTRODUCTION

During the last three decades the investigation of trace element concentration in human scalp hair has become increasingly popular for monitoring environmental exposure [1], and evaluating systematic intoxication [2]. Studies have shown that human scalp hair can record the level and changes of many elements in the body over a long period of time [3]. Changes in the chemical composition of hair are believed to depend on alterations of external and internal media of the human body. The controversy of using hair to assess essential element is established, yet researchers have undoubtedly found many correlations of essential elements

to diseases (such as coma, anemia, convulsion, paralysis, hallucination, mascular tremor, headache et cetera), metabolic disorders, environmental exposures, and nutritional status [4]. It is considered that the hair of healthy individuals contain each element within a well defined range of concentration [3,5] and it can be considered as a potential indicator of both external and internal long term exposure to environmental pollutants. When these metals enter the body of living organisms even in trace amounts, they may not be metabolized but accumulate and attain levels which may be toxic to the organism.

The human hair, though lesser known as site for accumulation of metals, it accumulates more lead per unit weigh than any tissue in the body including even body fluids such as blood and urine [3].

Due to the nature of the environment and human activities, some people are exposed to trace amounts of lead through air, soil, household dust, food (fruit juice, soft drink etc), drinking water (lead levels in water increase as water stands in pipes) and various consumer products. Similarly, agricultural activities, heavy industrial activities, constructional works, industrial emissions, smelters, refineries, leaded gasoline and other technological advancements are other sources of zinc and lead pollutants. The hair may serve as important indicators for occupational exposure of heavy metals pollutant which to a large extent become toxic to human beings [6]. The element lead has been very widely studied in man due to its widespread occurrence and toxic effects. There is no known nutritional value of lead and it is stored in the bone by replacing calcium. In the pre-natal level, lead exposure may lead to an increase risk of prematurity and reduction of gestational age in humans. Lead-exposure causes adverse neuro-psychological effects among young children and numerous endocrinal disturbances among adults. It has shown that human scalp hair lead concentration can be used very successfully to document population exposure to this toxic element [4]. The idea of hair analysis is very inviting, because it is easily painlessly removed, normally discarded compared to blood. Also while urine and blood tend to show current or recent body status, hair represents a longer time frame potentially years, this gives more analytically accurate results because elements occur in hair at higher levels [4]. Trace element concentrations in hair are related to those in blood serum and urine but are usually at least ten times higher [7]. This makes hair an absolutely excellent choice in certain situations and as a screening tool [7]. In many instances the hair of human's especially that of males is cut and disposed off as waste materials. Apparently such unwanted hair could be analyzed and studied to learn of both external and internal exposure of the population to contamination. Therefore, the aim of this paper was to assess the concentrations of lead and zinc in workers who are exposed to metal hazards and those who are not likely to be exposed by means of the nature of their occupational settings in Cape Coast, Ghana.

EXPERIMENTAL SECTION

2.1 Sample collection

The samples were randomly selected from thirty workers who work at three metal workshops located in Cape Coast, Ghana. Ten samples were also collected from individuals who were virtually not occupationally exposed to Zn and Pb. Sampling was conducted once every month for three months period from January to March, 2009. The hair samples collected were stored in carefully labeled clean polythene bags and identified with the age of donors, sex and the sample location. The samples were then sent to the laboratory for preparation and chemical analysis.

2.2 Sample preparation and metal determination

Each hair sample was immersed in a 65ml mixture of n-hexane, ethyl alcohol (ethanol), and acetone (4:2:1; v/v) twice in a 250mL volumetric flask. Each immersion lasted for about 1.5 hours. The samples were then decanted and were rinsed with deionized water four times and then immersed in 65mL acetone for 15 minutes. The samples were given a final rinse with deionized water three times, filtered and transferred into a carefully labeled, cleaned ceramics. These samples were dried at ambient temperature conditions, and prepared for ashing and digestion. Hair samples were weighted (0.200- 0.100g) and placed in an acid wash carefully labeled porcelain crucibles. The samples were ashed in a muffle furnace at a temperature of 450^0C for a period of 4 hours. The samples were removed from the oven after the 4 hours period and allow tocool for an hour.

Five drops of "Suprapur" HNO_3, was added to each sample in the porcelain crucibles and was heated using the Clifton hot plate at a temperature of 300^0 C for I hour. After the 1 hour, the samples were removed from the Clifton hot plate and allowed to cool for 1 hour. 1m1 of "Suprapur" HNO_3, in 4ml of distilled water was added to each sample in the porcelain crucibles. After 30 minutes, each sample was decanted into a carefully labeled acid wash 25-ml volumetric flask and was then topped with distilled water to the mark. A blank solution was also prepared by transferring 5 drops of "Suprapur" HNO_3 into a clean porcelain crucible and then was heated for an hour. About 1ml of "Suprapur" HNO_3, in 4ml of distilled water was then added to each porcelain crucibles and acid digestion was done in a similar manner as the hair samples. The solutions were then taken for chemical analysis using Atomic absorption spectrophotometer analysis (Varian 240 series). The absorbances of the samples were measured and the concentrations of the Zn and Pb in each prepared sample quantified from the generated calibration curves.

RESULTS AND DISCUSSION

3.1. Zinc and Lead in human scalp hair

The result of the measurement of the concentrations of Zinc and Lead in human scalp hair of twenty occupationally-exposed and ten occupationally-unexposed workers from designated sampling sites in Cape Coast, Ghana, is presented by Figure 1 and Table 1. The highest average Zn (1.3904mg/L) and Pb (0.1122mg/L) concentration in hair was recorded in workers recruited from sampling point 1 of University of Cape Coast. However, as expected, the least average Zn concentration was reported in hair samples from sampling point 4, where the workers were not expected to be exposed to the metal due to the nature of their occupational settings. In general, relatively high Zn and Pb concentrations were observed in hair samples collected from workers who were literally exposed to the metals due to the nature of their work settings. This is not surprising, since workers in sampling points 1, 2 and 3 are exposed to metal particles including smokes, fumes and particulate matter.

Figure 2 shows the box and whisker diagrams of the levels of Zn and Pb in occupationally exposed and unexposed workers. The diagram reveals the high variation nature of the metals levels in hairs of workers who are exposed and little variation in unexposed workers (Figure 5). As depicted by Figure 3 and Figure 4, the variations in the concentrations may be due to the variations in the number of years spent by the workers at the work environment.

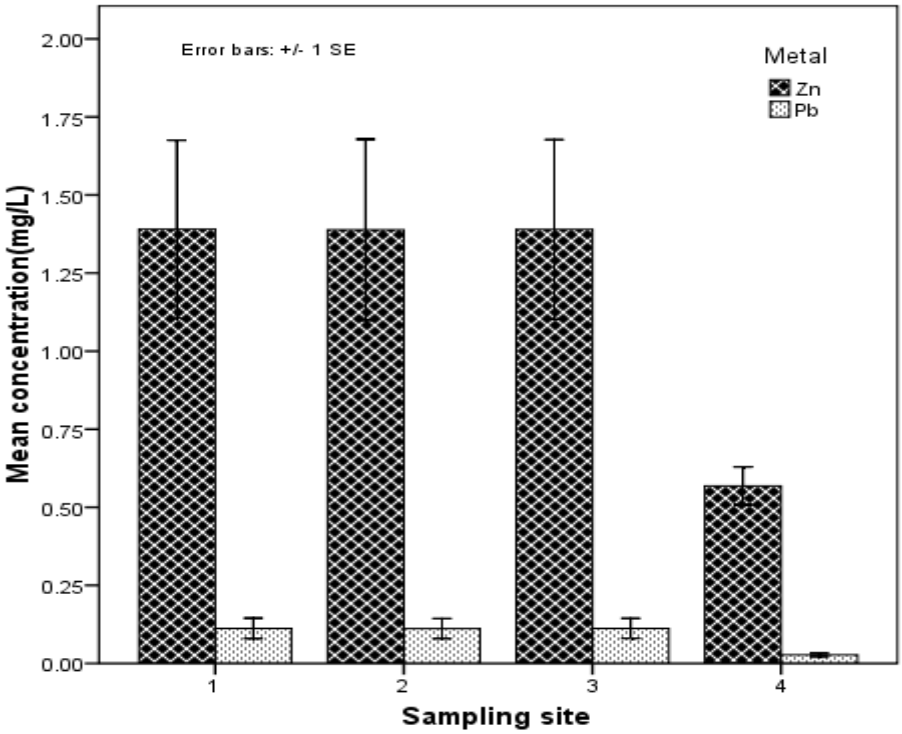

Figure 1. Comparison of concentrations of Zn and Pb in hair scalp from four sampling sites

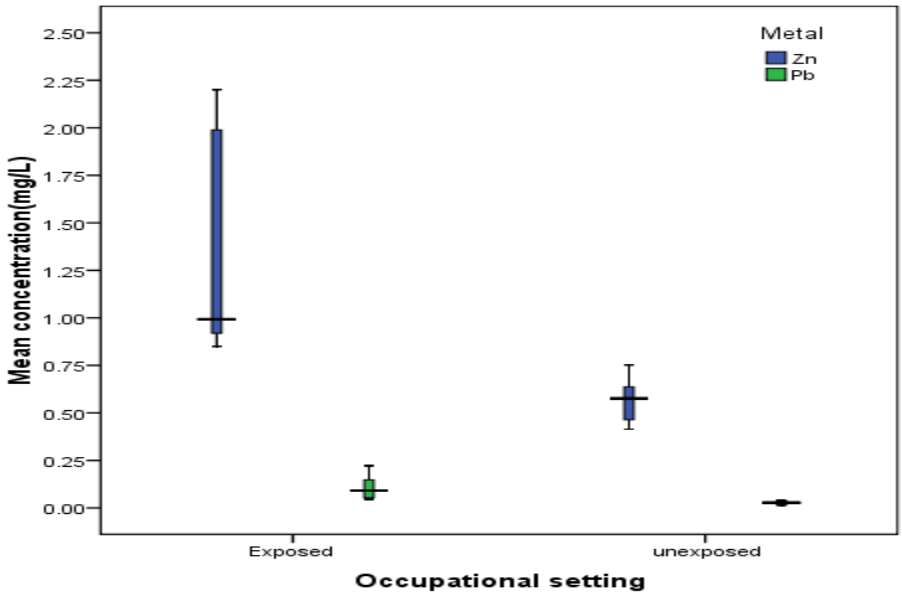

Table 1. The mean levels of Zn and Pb in scalp hair of occupationally exposed workers

Metal	Years of working	Mean(±SD) concentration (mg/L)
Zinc	1-11months	0.901±0.08
	1-2years	0.927±0.02
	2-5 years	1.393±0.69
	5-10 years	1.979±0.02
	10-15 years	1.748±0.77
Lead	1-11months	0.063±0.02
	1-2years	0.054±0.001
	2-5 years	0.134±0.07
	5-10 years	0.147±0.001
	10-15 years	0.163±0.09

SD: Standard deviation

Figure 2. Box plot of Zn and Pb concentrations in hairs of occupationally exposed and unexposed workers

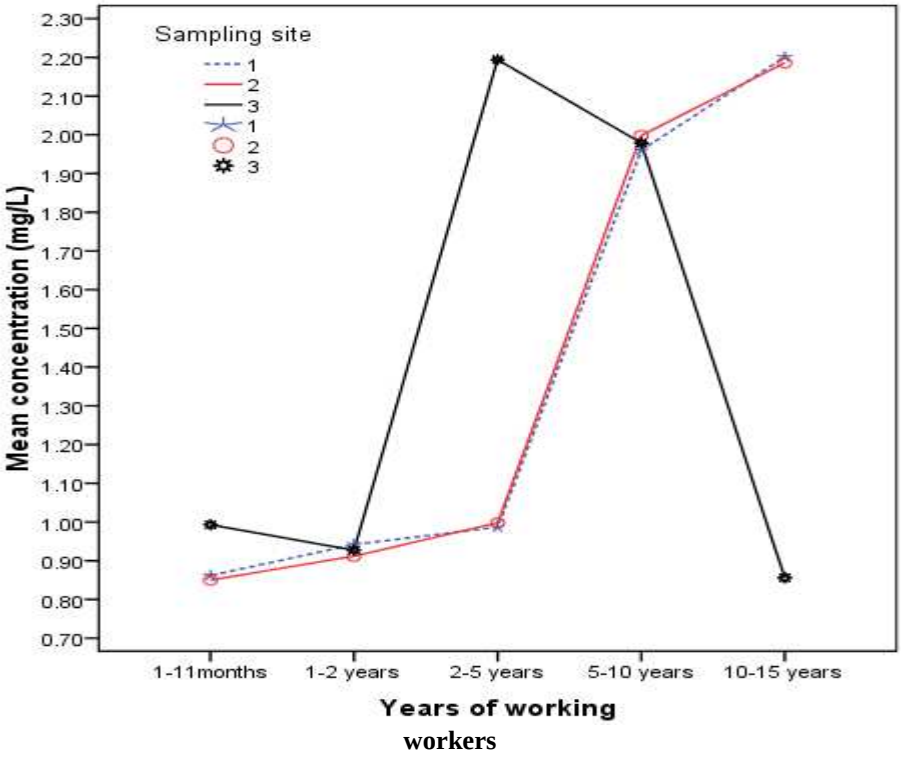

Figure 3. Variation of Zn in scalp hairs of occupationally exposed workers

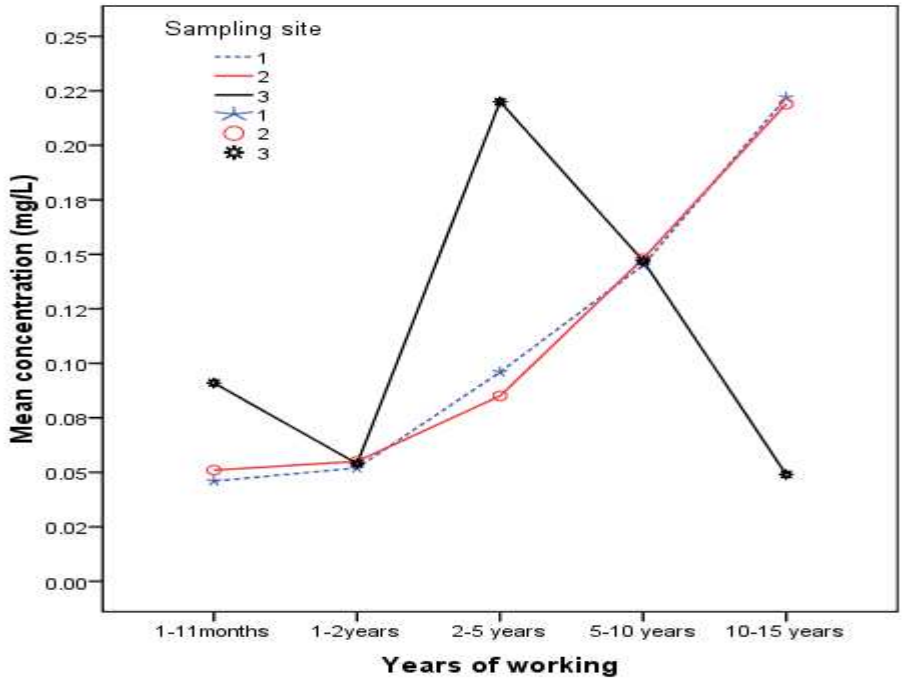

Figure 4. Variation of Pb in scalp hairs of occupationally exposed workers

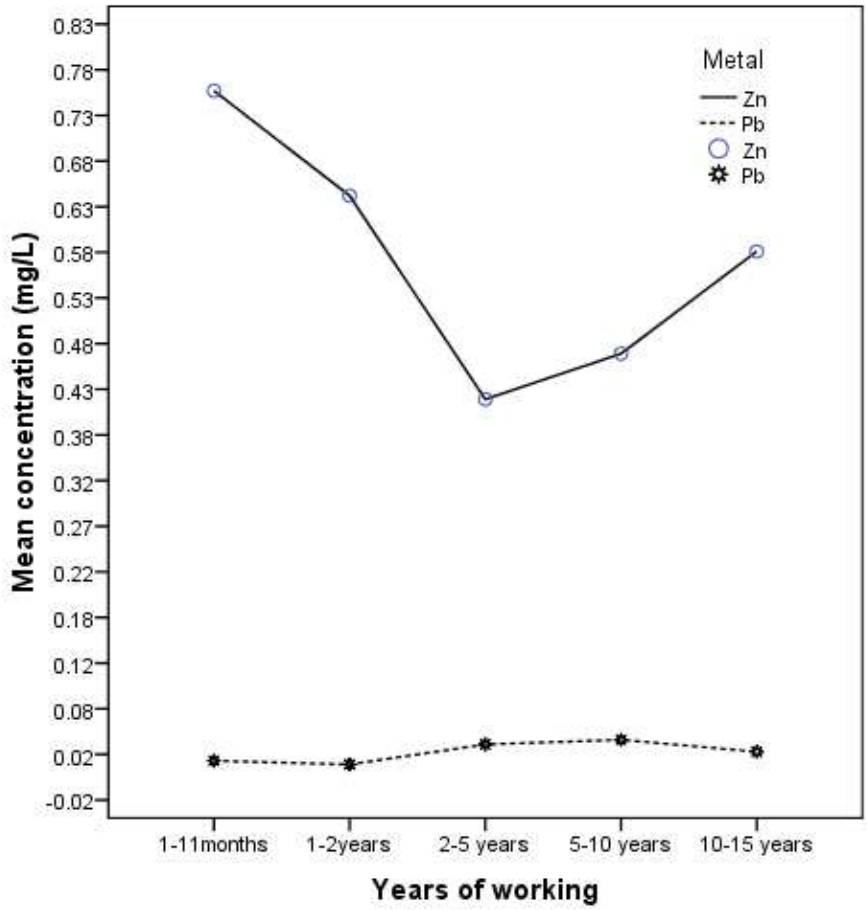

Figure 5. Variation of Zn and Pb in scalp hairs of occupationally unexposed workers

Table 2. Multiple comparison of Zn levels in scalp hair using Games Howell

(I) Years of working	(J) Years of working	Mean Difference (I-J)	Sig.
1-11months	1-2years	-0.025	0.973
	2-5 years	-0.491	0.754
	5-10 years	**-1.077**	**0.004**
	10-15 years	-0.846	0.507
1-2years	1-11months	0.025	0.973
	2-5 years	-0.466	0.777
	5-10 years	**-1.052**	**0.000**
	10-15 years	-0.821	0.524
2-5 years	1-11months	0.491	0.754
	1-2years	0.466	0.777
	5-10 years	-0.586	0.658
	10-15 years	-0.355	0.969
5-10 years	**1-11months**	**1.077**	**0.004**
	1-2years	**1.052**	**0.000**
	2-5 years	0.586	0.658
	10-15 years	0.231	0.977
10-15 years	1-11months	0.846	0.507
	1-2years	0.821	0.524
	2-5 years	0.355	0.969
	5-10 years	-0.231	0.977

Significant level is 0.05

3.2. Number of years at work place and levels of Zn in scalp hair

The result of Shapiro-Wilk normality test showed that the data was normally distributed (Statistic=0.733, df=15, p-value=0.01). Hence the the One-Way ANOVA post-hoc test using Games-Howell method was used, the multiple comparison of the Zn concentrations in exposed workers with respect to the number of years spent at the work settings. The outcome of the analysis is presented by Table 2. The differences in the concentrations of the Zn with respect to the number of years spent by the sampled workers which are regarded as statistically significant ($p<0.05$) are displayed in bold faced. As shown by Table 2, the difference in the concentration of Zn in hairs of workers who have spent 5-10years working in their various occupational settings and those who have spent 1-11months and 1-2years in the same work places is statistically significant with p-values of 0.004 and 0.000 respectively. As shown by Table 3, similar result was obtained for the Pb concentrations in hairs of sampled workers.

Table 3. Multiple comparison of Pb levels in scalp hair using Games Howell

(I) Years of working	(J) Years of working	Mean Difference (I-J)	Sig.
1-11months	1-2years	0.009	0.956
	2-5 years	-0.071	0.610
	5-10 years	-0.084	0.082
	10-15 years	-0.101	0.558
1-2years	1-11months	-0.009	0.956
	2-5 years	-0.080	0.522
	5-10 years	**-0.093**	**0.000**
	10-15 years	-0.110	0.500
2-5 years	1-11months	0.071	0.610
	1-2years	0.080	0.522
	5-10 years	-0.013	0.997
	10-15 years	-0.030	0.991
5-10 years	1-11months	0.084	0.082
	1-2years	**0.093**	**0.000**
	2-5 years	0.013	0.997
	10-15 years	-0.017	0.997
10-15 years	1-11months	0.101	0.558
	1-2years	0.110	0.500
	2-5 years	0.030	0.991
	5-10 years	0.017	0.997

Significant at the 0.05 level.

3.3. Exposed workers versus unexposed workers

The One-Way ANOVA results comparing the means of the concentrations of Zn (F=9.055, df=1, p-value=0.008) and Pb (F=7.664, df=1, p-value=0.013) were found to be statistically significant at the 0.05 level. This result suggests that Zn and Pb concentration levels in human scalp hair are dependent on the work settings and risks factors. The correlation analysis (Table 4) of Zn and Pb in human scalp hair in exposed workers showed a strong positive association between the metals. This may suggest that the two studied metals come from a common source in the occupational settings within the three high exposure risk sampling sites (Sampling points 1, 2 and 3). On the contrary, negative correlation was

observed between Zn and Pb in unexposed workers. However this was not significant statistically (P>0.05)

Table 4. Pearson' correlation coefficients for Zn and Pb association

Sampling site	R	P-value
1	0.945*	0.015
2	0.960**	0.009
3	0.955*	0.012
4	-0.867	0.057

CONCLUSION

The concentrations of zinc and lead obtained in occupationally exposed workers increased with increasing duration of employment. This study has showed that human scalp hair may serve as important indicators for occupational exposure of metal pollutant. It is envisaged that the results of this study will enrich the understanding of occupational hazards and human safety.

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REFERENCES

[1] P Grandjean. *Int Arch Occup. Environ Health*, **1978**, 15, 42(2), 69-81.
[2] L Kopito, RK Byers; H Shwachman. *New Engl J Med*, **1967**, 276, 949-952.
[3] JM McKenzie. American Journal of clinical nutrition, **1979**, 32, 570-579.
[4] JH Le clair; DW Quig. *J orthomolecular Med*, **2001**; 6,13-32.
[5] JM McKenzie. *Journal of clinical nutrition*, **1978**, 31, 470-476
[6]. LM Klevay. *Arch, Environ Health*, **1973**,26(4),169-953.
[7] JM McKenzie. *American Journal of clinical nutrition*,**1978**, 31, 470-476.