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Relationship between lead in drinking water and mothers' breast milk in the Volta region of Ghana

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ABSTRACT

The concentrations of lead in drinking water and breast milk samples from healthy lactating mothers who depended on the water for drinking were determined and relationship between them was established. Fifty four drinking water samples (Tap and borehole) and fifty four breast milk samples were collected in February 2009 from three districts in the Volta Region and analysed for their lead contents. Smoking habit was also taken into consideration. Drinking tap water showed higher lead levels (mean 0.018 mg/l= 1.80µg/dl) than drinking borehole water (mean 0.012 mg/l=1.20µg/dl)). Also, breast milk of mothers drinking tap water (mean 0.024mg/l =2.4µg/dl) showed higher lead levels compared to mothers drinking borehole water (mean 0.020mg/l=2.0 µg/dl). There was positive relationship between mean lead levels in drinking water and mothers' breast milk samples. The mean lead levels in breast milk of mothers drinking tap water and tap water samples were 0.024 mg/l and 0.018 mg/l respectively, while the mean lead levels were 0.020 mg/l and 0.012 mg/l in breast milk of mothers drinking borehole water and borehole water samples respectively. Exposure to smoking increased lead levels in breast milk samples analysed. The calculated daily intake of lead in breast milk was based on 840 ml breast milk for a 5.5 kg infant per day. Infant of mothers drinking borehole water would ingest 3.06 µg/kg/day; however infant of mothers drinking tap water would ingest 3.66µg/kg/day. These values were lower than the permissible value established by WHO which is 5 µg/ kg/day of breast milk.

Key words: Districts, Breast milk, Tap water, Borehole water, lead, Volta

INTRODUCTION

Lead contamination of water has occasionally arisen as a result of the use of bad pipes, lead – glazed tanks, metallic lead drinking water containers, atmospheric pollution or by addition of water purifying chemicals during water purification [1] Lead is a dangerous metal that has been linked to several serious health problems. Lead in drinking water is probably absorbed more completely than lead in food. Adults absorb 35%-50% of the lead they drink, and the absorption rate for children may be greater than 50% [2, 3, 4, 5, 6].

Human milk is usually the only source of food for infants during the first four to five months of their lives and is the ideal nutrient for the newborn, but unfortunately also a route of excretion for some toxic substances including lead. Lead reach into breast milk through passive transfer, this depending on three major characteristics; polarization of the chemical at body pH, lipid solubility and molecular weight [7, 8]. Exposing children to risk of contact with lead leads to impaired functioning of the nervous system which is manifested primarily in the disorder of motor functions and also in behaviour problems or physical hyperactivity [9] Lead has subtle effects on neurological functions, including learning, memory and attention span. Because the infant brain is developing rapidly both before birth and for several years after birth, lead exposures during this critical period are particularly detrimental to the future intellectual potential of children [10]. An excessive accumulation of lead in the organism leads to death [11]. The daily permissible intake estimated by WHO, 1972 for infant is 5 µg/kg/day of breast milk [12].

The aim of present study was to confirm the relationship between the lead levels in drinking water (Tap water and boreholes) from three districts and that of breast milk of lactating mothers living in these areas.

Preparation of Samples Solution for the Determination of Lead

All samples were collected directly into polyethylene bottles and were not filtered. Samples were analysed for pH immediately after the collection by glass electrode, preserved by acidification to pH < 2 with 18.6%w/w/ HNO_3, and stored in ice-packed coolers. The temperature of all stored samples was maintained at 0 to 4^0C until immediately before analysis.

Procedure for Pre-treating Water Sample for the Determination of Lead

Thirty-four tap water and twenty borehole water samples were initially pretreated before the final analysis. Beakers were thoroughly washed and dried in the oven and later cooled. The initial weights of empty clean beakers noted; 100ml aliquot of the water samples was poured into the beaker. The beaker was then placed on a hot plate and the water sample evaporated to dryness. The beaker was then cooled in a desiccators and the final weight of the beaker was recorded. The differences in weight recorded and the residue removed from the beaker, weighed and kept in desiccators for further analysis. 0.2g of the pretreated sediment that was kept in desiccators was taken into plastic beakers. 5ml of deionised water was then added to dampen the sample; 6ml of concentrated nitric acid (HNO_3) was also added followed by 1ml of perchloric acid. The mixture was heated on a water bath until there was appearance of white fumes then allowed to cool. After cooling 1ml of perchloric acid and 5ml hydrochloric acid were added and the mixture was heated on a steam bath until evaporated to dryness then cooled. 6ml of 6M HNO_3 was then added after the cooling and the resulting mixture boiled for ten minutes. The mixture was then filtered and made up to 100ml with deionised water in a 100ml volumetric flask. The samples were taken for analysis for lead.

Table 1: Localities of drinking water samples in Volta Region

District	No of Tap water	No of Borehole Water
Kpando (KP)	10	9
Hohoe (HH)	13	6
South Dayi (SD)	11	5
Total	34	20

Sampling of Breast milk

Fifty-four Breast milk samples were collected from lactating mothers from the three districts indicted (Table 2). 5 ml of each breast milk sample was collected manually in labelled sterile polyethylene lead free tube. The nipple areas were cleaned with water before expressing the milk; the first few drops were discarded and only the midstream flow was collected. The tubes were sealed immediately and kept at 4 ºC. A history was taken from the mothers through answering a questionnaire, which included; age, source of drinking water, nature of occupation, and smoking (active or passive exposure).

Table 2: Localities of lactating mothers

Location	Kpando	Hohoe	South Dayi	Total
Samples	23	16	15	54

Pre-treating Human Breast Sample for the Determination of Lead

Proteins were precipitated by the addition of few drops of 0.1M trichloroacetic acid to 10ml milk samples and the aqueous fraction of the milk was separated by centrifugation at 1000 revolution per second for 10 minutes. 2ml each of the aqueous fraction of milk samples were treated with drops of $Mg(NO_3)_2$ solution and then ashed in porcelain crucibles (previously washed with dilute HNO_3 to eliminate any possible lead). A muffle furnace was used for ashing the samples, where the temperature was gradually increased to 500^oC (at this temperature, ashing was completed after one hour). Samples were then cooled, dissolved with 3ml of 0.5M HNO_3 and filtered through a pre-washed filter paper into a 10ml volumetric flasks and then made to the mark by adding 0.5M HNO_3. All samples; drinking water and breast milk were analyzed for lead levels using Schimadzu AAS model No. 6401F (oxy-acetylene flame AAS)

Statistical analysis

Both statistical analysis and tabulation were carried out. Data were summarized as means and standard deviation (SD). Differences were analyzed using SPSS/16 statistical software; SPSS, t-student test for comparison between the two groups and differences were considered significant at values of $P < 0.05$

RESULTS

Table (4) showed that Lead levels in Tap drinking water samples ranged from 0.014 to 0.022 mg/l with mean of 0.018 ±0.002 mg/l. Also, lead levels of borehole drinking water samples ranged from 0.009-0.014 mg/l with mean of 0.0115 ± 0.0014 mg/l. Statistically; there was significant increase in lead levels in tap drinking water compared to borehole drinking water, for the *t*-test for equality of means the *p*-value was found to be 0.000 which is lower than an α-value of 0.05 hence ($p< 0.05$).

Table 3: Lead levels (mg/l) in water samples

Tap Water						Borehole water			
KP	Pb mg/l	**HH**	Pb mg/l	**SD**	Pb mg/l	**KP**	Pb mg/l	**HH**	Pb mg/l
W_{1}	0.018	W_{16}	0.017	W_{29}	0.015	W_{35}	0.011	W_{47}	0.014
W_{2}	0.022	W_{17}	0.018	W_{30}	0.015	W_{36}	0.012	W_{48}	0.012
W_{3}	0.020	W_{18}	0.015	W_{31}	0.014	W_{37}	0.010	W_{49}	0.013
W_{4}	0.018	W_{19}	0.016	W_{32}	0.014	W_{38}	0.014	**SD**	
W_{5}	0.022	W_{20}	0.015	W_{33}	0.016	W_{39}	0.011	W_{50}	0.014
W_{6}	0.020	W_{21}	0.016	W_{34}	0.015	W_{40}	0.012	W51	0.012
W_{7}	0.022	W_{22}	0.018			W_{41}	0.011	W_{52}	0.010
W_{8}	0.019	W_{23}	0.019			W_{42}	0.010	W_{53}	0.010
W_{9}	0.021	**SD**				W_{43}	0.012	W_{54}	0.012
W_{10}	0.020	W_{24}	0.020						
HH		W_{25}	0.018			**HH**			
W_{11}	0.017	W_{26}	0.018			W_{44}	0.010		
W_{12}	0.018	W_{27}	0.018			W_{45}	0.011		
W_{13}	0.020	W_{28}	0.017			W_{46}	0.009		
W_{14}	0.019								
W_{15}	0.021								

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Table 4: Mean lead levels in drinking water samples

Lead levels (mg/l)	Tap drinking water		Borehole drinking water		t = 11.114
	n=34	Mean ±SD mg/l	n=20	Mean ±SD mg/l	
		0.0180 ±0.002		0.0115 ± 0.0014	P<0.05
Range	0.014-0.022		0.009-0.014		

Table 5: Age of the studied groups

Age(years)	Mothers drinking Tap water (n=34)	Mothers drinking Borehole water (n=20)	t = 1.40
Mean ±SD	27.3 ± 6.4	26.2 ±5.6	P>0.05
Range	20-39	18 -38	

The mean age of mothers drinking tap water was 27.3± 6.4 years, while the mean age of mothers drinking borehole water was 26.2±6.2 years, with statistically non significant difference ($p > 0.050$) as shown in (Table 5).

Table 6 Mean lead levels of mothers' breast milk in drinking water Sample

Lead levels (mg/l)	Tap water (n=34)	Borehole water (n=20)	t = 5.46
Mothers' Breast milk Mean ±SD	0.024 ± 0.005	0.020 ±0.006	
Range	0.022— 0.032	0.016— 0.022	P<0.05

Table (6) showed that there was statistically significant increase in lead levels in breast milk of mothers drinking tap water compared to mothers drinking borehole water ($p< 0.05$).

Table 7: Comparison between mean lead levels (mg /l) in drinking water and mothers' breast milk as regard the type of drinking water

Lead levels	Tap Water		Borehole Water	
	No of Samples	Mean ± SD mg/l	No of Samples	Mean ± SD mg/l
Water Samples	34	0.0180 ±0.002	20	0.0115 ± 0.0014
Mothers' Breast milk	34	0.024 ± 0.005	20	0.020 ±0.006
	t = 8.53		t =9.85	
	P < 0.5		P< 0.05	

Table (7) showed a positive correlation between lead levels in drinking water and mothers' breast milk , however there was statistically significant increase in the lead levels in breast milk compared to its levels in drinking water in both groups ($p< 0.05$).

Table 8: Mean lead levels of mothers' breast milk (mg/ l) as regard passive exposure to smoking

Lead levels	Mean ±SD		t =8.42
	Women exposed passively to smoking (n=16)	None exposed women (n=38)	
Mothers' Breast milk	0.026 ±0.003	0.020±0.002	P<0.05
Range	0.024- 0.032	0.016-0.024	

Table (8) showed a significant increase of lead levels in breast milk of women passively exposed to smoking compared to non exposed one ($p< 0.05$).

DISCUSSION

On average, it is estimated that lead in drinking water contributes between 10 and 20 percent of total lead exposure in young children. Breast milk can, however, also be a pathway to maternal excretion of toxic elements such as lead [13]. It is a known fact that intoxication of newborn may be caused by breast feeding with milk containing heavy metals [14, 15].

In this study, lead concentrations in fifty four randomly collected water samples from three districts in the Volta Region of Ghana were investigated. From the results it was observed that the mean lead concentration in Tap and Borehole water samples exceeded 0.01mg/l World Health Organisation (WHO) drinking water guideline value by 80% and 15%, respectively. This indicates they have completely failed the limit test for lead and such water samples are not fit for drinking or for human and animals consumption, the fact that if such water samples are continuously consumed, they may produce lead toxicity after some time as lead accumulation may occur in the body leading to lead poisoning and may be fatal. Lead has a possible carcinogenic effect in human that is ability to cause cancer this is from inconclusive evidence of human and sufficient evidence of animal carcinogenicity [16]. In addition, lead also causes many non-carcinogenic disorders in humans such as headache, joint pains, abdominal colic and paralysis [17]. Hence drinking water that contains high concentration of lead should always be avoided.

Overall mean lead level in tap drinking water showed higher levels than in borehole drinking water (Table 4). Levels of lead in tap drinking water sampled at the source were within the WHO guideline value of 0.01mg/l. However, water taken from taps in homes where lead is present in the plumbing can contain levels up to 1 mg/l [18].

An elevation of lead concentrations in breast milk of mothers drinking tap water was noticed when compared with that of mothers drinking borehole water (Table 6). The higher levels of lead in drinking water and mothers' breast milk of tap water origin observed in the present work were from peri urban towns in the districts studied and could be attributed to welding shops, the potential exposure to automobile exhaust, lead lined storage tanks are common in houses in addition to the use of lead water pipes lines. The comparison between mean lead levels (mg/l) in drinking water and mothers' breast milk samples showed positive correlation (Table 7). In this study, all women were non-occupationally exposed to lead. They had no special habits but, sixteen women (29.7%) were exposed passively to smoking i.e. passive smokers. These women showed higher lead contents in their breast milk compared to non exposed women (Table 8).

The permissible lead limit established by WHO 5 µg/kg/day based on 840 ml breast milk for a 5.5 kg infant per day [19]. In this study, calculated daily lead intake in breast milk according to its values was presented, infant of mothers drinking borehole water would ingest [3.06 µg/kg/day], however infant of mothers drinking tap water would ingest (3.66 µg/kg/day). These values were lower than the permissible value established by WHO.

CONCLUSION

This investigation/study revealed the presence of excessive amount of lead as impurity in drinking samples in some areas of Volta Region of Ghana. The highest concentration of lead was found in tap water in Kpando district. The high lead concentrations in borehole indicate that the areas have high concentration of lead in the soil; this might be due to fitting and welding shops sited close to these boreholes. Lead excretion via breast milk reached high levels among women living in polluted areas and those exposed to passive smoking compared to non exposed women hence suckling infants were getting more lead. Prolonged contact with lead plumbing also increased the lead content in tap water with subsequent increase of lead burden in infant fed formula and infant blood [20**]**.

Recommendations

The Ghana Water company should expand the programme of replacing the old metal pipelines with PVC (poly vinyl chloride) pipes to all parts of the country. Mechanic garages should be sited away from human settlement area. Chemical analyses must be carried-out periodically for the water samples in various homes to ensure the water suitability for drinking purposes. Drinking water with safe levels of lead could be supplied to the people, by the integrated use of borehole water monitoring, and appropriate water treatment systems. Mitigation efforts should also be employed to improve the health of the people in the area.

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