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Analysis of Lead and Cadmium in Human Milk in the Greater Accra Region of Ghana

J.K. Koka[1]* J.E. Koranteng-Addo[1], J.K.Bentum[1], D.M. Koka[2], G.Kamoah[3]

[1]*Department of Chemistry, University of Cape Coast, Ghana*
[2]*Department of Science Education, University of Education, Winneba, Ghana*
[3]*Department of Laboratory and Technology, University of Cape Coast, Ghana*

ABSTRACT

The cadmium and lead concentrations were determined by atomic absorption spectrometry in forty eight breast milk samples collected between January to March 2007 from healthy lactating women who were engaged in commercial activities in Accra and Tema for at least five years. The mean cadmium concentrations in human milk were 0.0246±0.0116µg/L (range 0.0085-0.0500µg/L) and 0.0329 ±0.1263µg/L (range 0.0122-0.0644µg/L) in Accra and Tema respectively while the mean for lead levels was 2.476 ± 1.097µg/L (range 0.0456 - 5.224µg/L) and 3.367 ±1.131µg/L (range1.375 -5.890µg/L) in Accra and Tema respectively. Averagely, levels of the metal observed were higher in Tema than in Accra. There was a positive significant correlation between lead and cadmium levels in mothers' breast milk samples in both metropolis (P < 0.05). Also, there was a significant increase in the levels of both metals in breast milk of women passively exposed to smoking compared to non exposed ones (p< 0.05. None of the women was exposed occupationally.

Keywords: Lead; cadmium; Tema, Accra, human breast, atomic absorption spectrometry.

INTRODUCTION

Due to high urbanization and industrial growth Accra and Tema have become the most densely populated cities in Ghana. Studies over the last 25 years have proved that as pollutants have built up in the environment, they have even invaded the most natural of all sources of nourishment; mother's milk.[1] Ghana is not an exception of this built-up pollution. Research shows that the concentration of heavy metals in affected people is proportional to their exposure rate to the metals.[2] Uncontrolled emissions from industries, release of toxic wastes from industrial and domestic activities coupled with emissions of toxic chemicals from the exhaust of vehicles have increased the levels of pollutants in most metropolis. Emissions from vehicles contain a variety

of toxic chemicals such as lead from the burning fuel from cars that run on leaded petrol and cadmium from vehicular tyres. These toxic chemicals accumulate in the nearby soils, in the surface of leaves of plants grown along the highways, on surface of waters, foodstuffs sold along the highways and in the hairs of individuals who are actively engaged in commercial activities. Lead and Cadmium may form chemical complexes and get mobilized into ground water and finally into the food chain, eventually into the human system [2]. When metals enter the body of living organism, even in trace amounts, they may be metabolized and may accumulate if not excreted. During the process of accumulation they may attain levels which may be toxic to the organism [3]. These metals are able to bind well with fats in human bodies building up measurable concentrations and eventually working their ways into the mother's breast milk when the body calls on fat supplies during lactation [4].

Owing to its unique nutritional and immunological characteristics human breast milk is the most important food source for infants. Breast milk can, however, also be a pathway to maternal excretion of toxic elements such as lead and cadmium [5]. Infants and little children do not have effective functioning regulatory mechanisms and the absorption of mineral elements including toxic ones is higher in infants than older children and adults [6]. These toxic substances impact most severely on the newly born at a time of rapid development of the central nervous system.

Cadmium is regarded as an indicator of carcinogenic processes. It also impairs kidney functions [7]. Moreover, a relationship between the presence of cadmium in food, calcium and iron metabolism disturbances was demonstrated. Cadmium is a metal to which babies are exposed continuously, since its source may be water, air, food and cigarette smoke [6]. Studies proved that this element accumulates in babies' organism during their foetal lives to much higher degree than in their mother's organisms [8]. Cadmium's half life in the human organism is *ca* 30 years which explains why exposing children to this element is particularly hazardous [6].

A drafted report by UNICEF/ UNEP states that '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]. It is toxic to the developing brain, and at high levels results in numerous poisoning symptoms. In addition, at the low doses common today in many countries, 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 [6].

The objectives of this study were to determine cadmium and lead concentrations in the breast milk of healthy lactating women who were living in Accra and Tema, an industrial area of Ghana and to investigate the effect of smoking habits in families living in the vicinity of areas contaminated with heavy metals.

MATERIALS AND METHODS

Sampling of Breast milk.

Forty eight breast milk samples were collected from healthy lactating mothers from Accra and Tema. 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.

Sample Treatment

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 [12]. 2ml each of the aqueous fraction of milk samples were treated with drops of $Mg(NO_3)_2$ solution [11] and then ashed in porcelain crucibles (previously washed with dilute HNO_3 to eliminate any possible lead and cadmium content). 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. The samples were taken for analysis for lead and cadmium using Schimadzu AAS model No. 6401F (oxy-acetylene flame AAS)

To determine the suitability of the sample preparation and analysis method, samples of human breast milk were spiked with 1µg g $^{-1}$ sample of Cd and 3 µg g $^{-1}$ sample of Pb. All the spiked samples were quadruplicated and subjected to the same preparation and analysis procedures as the unspiked samples.

Lactating mothers were made to fill out questionnaire indicating their area of residence, how long they have stayed in that area, smoking habit, occupation.

RESULT AND DISCUSSION

Recovery and reproducibility studies

Reproducibility and recovery studies were conducted. The average recoveries (%) of Cd and Pb were 98% and 100% respectively. Similar results were obtained for the reproducibility studies. The percentage of cadmium and lead recovered in the reproducibility studies ranged from 97.3% to 99.6% (standard error ± 0.005–0.560). The standard error is less than 1, suggesting that the method employed to analyse cadmium and lead is reproducible.

Table 2 Mean concentrations of metals in mothers' breast milk (µg/L)

Element	Pb	Cd	T- test
Accra	2.476 ±1.097	0.0246±0.0116	t = 10.945
Range	0.0456-5.224	0.0085-0.0500	P<0.05
Tema	3.367 ±1.131	0.0329±0.1263	t =14.446
Range	1.375-5.890	0.0122-0.0644	P<0.05

Table 1: Lead and Cadmium Concentrations in Breast Milk Samples.

Human Milk	ACCRA		Human Milk	TEMA	
	Pb (µg/L)	Cd(µg/L)		Pb(µg/L)	Cd(µg/L)
H_1	1.350	0.0148	H_{25}	1.375	0.0220
H_2	1.245	0.0235	H_{26}	4.550	0.0345
H_3	1.955	0.0455	H_{27}	3.155	0.0400
H_4	2.000	0.0258	H_{28}	2.630	0.0345
H_5	1.700	0.0140	H_{29}	3.150	0.0455
H_6	2.665	0.0500	H_{30}	3.445	0.0345
H_7	2.845	0.0325	H_{31}	3.450	0.0280
H_8	2.450	0.0215	H_{32}	3.200	0.0434
H_9	1.545	0.0124	H_{33}	3.235	0.0275
H_{10}	3.564	0.0154	H_{34}	3.300	0.0235
H_{11}	3.900	0.0200	H_{35}	3.654	0.0332
H_{12}	2.875	0.0085	H_{36}	2.375	0.0420
H_{13}	0.456	0.0252	H_{37}	4.565	0.0122
H_{14}	1.998	0.0166	H_{38}	3.542	0.0322
H_{15}	3.220	0.0264	H_{39}	2.345	0.0234
H_{16}	4.320	0.0334	H_{40}	2.359	0.0245
H_{17}	1.200	0.0156	H_{41}	5.890	0.0424
H_{18}	2.346	0.0216	H_{42}	4.234	0.0432
H_{19}	5.224	0.0458	H_{43}	1.456	0.0644
H_{20}	1.580	0.0442	H_{44}	5.865	0.0246
H_{21}	2.450	0.0214	H_{45}	3.234	0.0144
H_{22}	3.425	0.0148	H_{46}	2.840	0.0128
H_{23}	2.225	0.0184	H_{47}	2.642	0.0345
H_{24}	2.885	0.0225	H_{48}	4.323	0.0530

Table 3: Mean levels of metals in mothers' breast milk (µg/L) as regard passive exposure to smoking

Mothers' Breast milk	Mean ±SD		T test
	Women exposed passively to smoking (n=18)	None exposed women(n=30)	
Lead levels	4.082±0.8686	2.247±0.7497	t = 19.779 P<0.05
Range	3.150- 5.890	0.456- 3.300	
Cadmium	0.0322±0.1172	0.0259±0.019	t= 16.225 P<0.05
Range	0.0148-0.0530	0.0085-0.0455	

Table4: Cd and Pb concentrations in human milk reported internationally

Country	Cd	Pb	Reference
Croatia	2.54	7.3 ± 8.3	Frkovic *et al*.1997 (15)
Sweden	0.05 ± 0.04	0.9 ± 0.4	Palminger Hallen et al.1995(16)
Turkey	2.8	14.6	Turan *et al*.2001
Iran	2.44 ± 1.47	10.39 ± 4.72	E. Rahimi *et al* 2009 (17)
Saudi Arabia	1.73	31.67l	Al Saleh and Shinwari, 2003(18)
Ghana	0.0246 ± 0.0116^{A}	2.476 ± 1.097^{A}	This study
	0.0329 ± 0.1263^{T}	3.367 ± 1.131^{T}	

A=Accra; T=Tema

Milk is the fundamental food for infants and with the recent introduction of the policy of exclusive breast feeding of infants in Ghana, the most accepted and best source of milk is from breast feeding and this is greatly encouraged for the first 6 months of life after birth and should be sustained for as long as 2 years.

The results of the study of the levels of lead and cadmium in human milk are represented in Table1. The result revealed that lead levels in Accra and Tema ranged from 0.0456 to 5.224µg/L with mean concentration of 2.476µg/L and 1.375 to 5.890µg/L with mean concentration of 3.367µg/L respectively. Assuming 0.78 L/day breast milk is consumed; infants in Accra are likely to ingest about 1.93 µg of lead daily. For infants of age 7-12 months and 1-3 years of average weight 9 and 13 kg respectively [22-24], the daily intake are respectively 0.21 and 0.15 µg/kg/day in Accra while infants in Tema are likely to ingest about 2.63 µg of lead daily. For infants of age 7-12 months and 1-3 years of average weight 9 and 13 kg respectively the daily intake are respectively 0.29 and 0.20 µg/kg/day. All of which are lower than the world health organization daily permissible intake (DPI) of 5 µg/kg/day [20].

Cadmium concentration in Accra and Tema ranged from 0.0085 to 0.0500µg/L with mean concentration of 0.0246 µg /L and 0.0122 to 0.0644µg/L with mean concentration 0.0329µg/L respectively. An infant in Accra would therefore ingest 0.019µg or 0.002 and 0.0015µg/kg/day for average weight of 9 and 13 kg respectively while infants in Tema would ingest 0.026µg or 0.003 and 0.0020µg/kg/day for average weight of 9 and 13kg respectively. The levels are by far less than DPI for adult, 1µg/kg/day [21]. Cadmium has no constructive purpose in human body. Cadmium is extremely toxic even in low concentrations and will bioaccumulate in organisms and ecosystems [19]. The body absorbs and holds cadmium and is not able to expel it at a rate fast enough to be safe hence its presence in a minute concentration should be of high concern.

On the average the mean values of the two metals were higher in Tema than Accra. This could be associated with the high industrial and commercial activities in Tema compare to Accra. A positive correlation ($p< 0.05$) existed between lead and cadmium levels in mothers' breast milk in both Accra and Tema (Table 2) however; there was statistically significant increase in the levels of lead in breast milk in both cities than levels of cadmium. A significant increase ($p< 0.05$) of levels of both metals in the breast milk of women passively exposed to smoking compared to non exposed one (Table 3). None of the women sampled was occupationally exposed.

CONCLUSION

The results of this study revealed the presence of cadmium and lead in all the milk samples obtained from healthy women in Accra and Tema. An indication that infants are likely to be exposed to high levels before birth and during breast feeding period. Cadmium and lead in milk are better absorbed into the body than other dietary components, therefore high cadmium and lead concentration in breast milk is the first source of poisoning with these heavy metals in neonates [15]

Infants of mothers exposed passively to smoking are receiving about 30% more of lead and 12% more of cadmium levels than infants of non- exposed mothers.

Comparatively, the values observed in this study were lower than some values obtained internationally (Table 4).

In view of all potential consequences of advanced lead and cadmium intoxication, it is necessary to point out the importance of an early diagnosis before morphological changes have been developed [17].

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