In which regions is breast-feeding safer from the impact of toxic elements from the environment?

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Abstract

Owing to its unique nutritional and immunological characteristics, breast milk is the most important food source for infants. But, children are at greater risk for exposure to environmental toxicants from breast milk. The aim of this study was to evaluate the influence of environmental pollution on essential and toxic element contents of breast milk and determine the risky locations in our population. This study was conducted on women who were breastfeeding (*n*=90). Milk samples were collected at three locations in Marmara region, Turkey: highly industrialized region highly affected by pollution, urbanized region moderately and rural area that is affected little. Breast milk samples (5 mL) were collected at approximately one month postpartum (mature milk). The concentrations of cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn) in milk samples were compared to the milk samples coming from different locations. Lead, cadmium, nickel, chromium, iron and manganese levels in the breast milk are highest and engrossing especially in rural areas compared to the other regions but cobalt, copper, zinc levels are highest in highly industrial areas. The levels of essential and toxic elements in breast milk can vary in different regions. The levels presented in our study are above some countries' data albeit not at toxic levels. Because of global effects, environmental pollution is not the problem for industrializing regions only. Rural area also may not be safe for breastfeed babies.

KEY WORDS: breast milk, environment, milk elements, toxic elements

INTRODUCTION

Environmental factors increasingly gain importance in public health. Children are affected more than adults from environmental deterioration and harmful effects. Children's exposure to environmental hazards may cause permanent damage and will continue during adulthood. The presence of lead and mercury in human milk has been extensively studied [1]. Breast-feeding-mediated exposures to lead are extremely common. Very little attention has been given to breast milk as a source of exposure to other toxic elements [2]. The risk of excessive lead exposure for infants is higher and the effects much longer. Lead, cadmium and other potentially toxic metals that are dispersed throughout the environment also have bioaccumulative features [1]. Little is known about the mechanisms regulating the concentrations of iron, zinc, and copper in breast milk [3]. If the passage of iron, zinc, and copper from plasma to milk in the mammary gland were the passive diffusion, positive correlations would be expected between plasma mineral status (concentration) and milk mineral concentration. The consequences of this change in ratio are unknown [3]. Human breast milk provides all of the vitamins and essential minerals and trace elements (micronutrients) that are required for the normal development of infants [4]. Human milk contains many brain-protective substances, including selenium, glutathione, vitamin E, cysteine, tryptophan, choline, taurine [5, 6]. Nevertheless, the neurodevelopmental benefits of human milk tend to override the potential adverse effects of neurotoxicants [5]. The aim of this study was to determine the concentration of some minerals and toxic metals in the breast milk in different living spaces that may influence their concentrations.

MATERIALS AND METHODS

Sample collection

This study was conducted on women who were breastfeeding (*n*=90) to evaluate the influence of environmental pollution on essential and toxic element contents of breast milk. Milk samples were collected at three locations in Marmara region, Turkey. Highly industrialized region which population affected more, urbanized region affected medium and

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Submitted: 27 December 2010 / Accepted: 23 August 2011

TABLE 1. Concentrations of elements (mg/l) identified in breast milk according to regions

		Cd	Co	Cr	Cu	Fe	Ni	Pb	Zn	Mn
Industrial	N	26	25	26	26	26	26	20	26	26
	Average	0.022	0.074	0.099	0.501	1.064	0.000	0.282	3.723	0.080
	Std. Deviation	0.026	0.105	0.031	0.163	0.943	0.000	0.155	1.693	0.037
	Minimum	0.000	0.045	0.043	0.177	0.442	0.000	0.000	1.415	0.006
	Maximum	0.102	0.520	0.167	0.905	5.048	0.000	0.546	7.760	0.145
City Center	N	26	26	26	26	26	25	15	26	25
	Average	0.031	0.069	0.151	0.362	1.019	0.003	0.176	3.368	0.134
	Std. Deviation	0.055	0.053	0.113	0.222	0.798	0.018	0.151	2.271	0.147
	Minimum	0.000	0.043	0.044	0.104	0.378	0.000	0.000	1.024	0.053
	Maximum	0.203	0.251	0.467	0.822	4.296	0.090	0.450	12.000	0.631
Rural Area	N	23	20	23	23	23	23	21	23	23
	Average	0.044	0.055	0.176	0.480	1.142	0.028	0.303	3.250	0.164
	Std. Deviation	0.067	0.030	0.141	0.203	0.762	0.093	0.199	1.892	0.232
	Minimum	0.000	0.040	0.083	0.174	0.432	0.000	0.000	0.052	0.026
	Maximum	0.272	0.198	0.786	0.956	4.282	0.454	0.628	9.792	0.922

As shown in the table, the highest region in terms of cadmium (Cd), chromium (Cr), iron (Fe), nickel (Ni), lead (Pb), manganese (Mn) is rural region. The highest level of cobalt (Co), copper (Cu), zinc (Zn) is in industrial area.

rural areas affected little. Women were consecutively invited to participate in the study and no other inclusion/exclusion criteria were defined except the individual consent to participate and the ability to supply at least 5 ml of milk. All samples were collected into special metal-free glass tubes. Breast milk samples were collected at approximately 4-week postpartum (mature milk) period. Using plastic disposable gloves, breast milk was extracted by hand directly into the tubes. All the samples were frozen at –20 °C until the date of analysis. Study was conducted according to the principles of the Declaration of Helsinki (1989) [7]. The study was approved by the Ethics Committee of the University of Kocaeli, Faculty of Medicine.

Analysis of the trace elements

The microwave assisted digestion method used in this work for the determination of minor and trace elements in breast milk was as follows. An aliquot (5 ml) of each sample was placed into a Teflon digestion vessel. Concentrated nitric acid (5 ml) and 30% hydrogen peroxide (1 ml) were added. The vessels were immediately closed after the addition of oxidants. The samples were mineralized in the microwave digestion system (MWS-3, DAP 60S, Berghof Products Inst. Germany). After digestion, the samples were quantitatively transferred to 25 ml volumetric flasks and brought up to the mark with ultra pure water. Blanks, consisting of ultra pure water and reagents were subjected to a similar sample preparation and analytical procedure. Working standard solutions for calibration purposes were prepared from spectroscopic grade stock standard solutions (100 mg/l) by serial dilution with 0.2% (v/v) HNO_3 prior to use. A Perkin-Elmer DV 2100 inductively coupled plasma–optical emission spectrophotometer (ICP–OES) was used to analyze the elements in digested samples. The metal content of each sample was obtained by four replicate determinations and the mean value was subjected to statistical analysis.

Statistical analysis

The data were analysed using a statistical packet programme (SPSS 16).

TABLE 2. Average and standard deviation values of the elements that detected in breast milk according to region

Element	Region	Average (mg/l)	Std. Deviation
Cadmium (Cd)	Industrial	0.022	0.026
	City Center	0.031	0.055
	Rural Area	0.044	0.067
Cobalt (Co)	Industrial	0.074	0.105
	City Center	0.069	0.053
	Rural Area	0.055	0.030
Chromium (Cr)	Industrial	0.099	0.031
	City Center	0.151	0.113
	Rural Area	0.176	0.141
Copper (Cu)	Industrial	0.501	0.163
	City Center	0.362	0.222
	Rural Area	0.480	0.203
Iron (Fe)	Industrial	1.064	0.943
	City Center	1.019	0.798
	Rural Area	1.142	0.762
Nickel (Ni)	Industrial	0.000	0.000
	City Center	0.003	0.018
	Rural Area	0.028	0.093
Lead (Pb)	Industrial	0.282	0.155
	City Center	0.176	0.151
	Rural Area	0.303	0.199
Zinc (Zn)	Industrial	3.723	1.693
	City Center	3.368	2.271
	Rural Area	3.250	1.892
Manganese (Mn)	Industrial	0.080	0.037
	City Center	0.134	0.147
	Rural Area	0.164	0.232

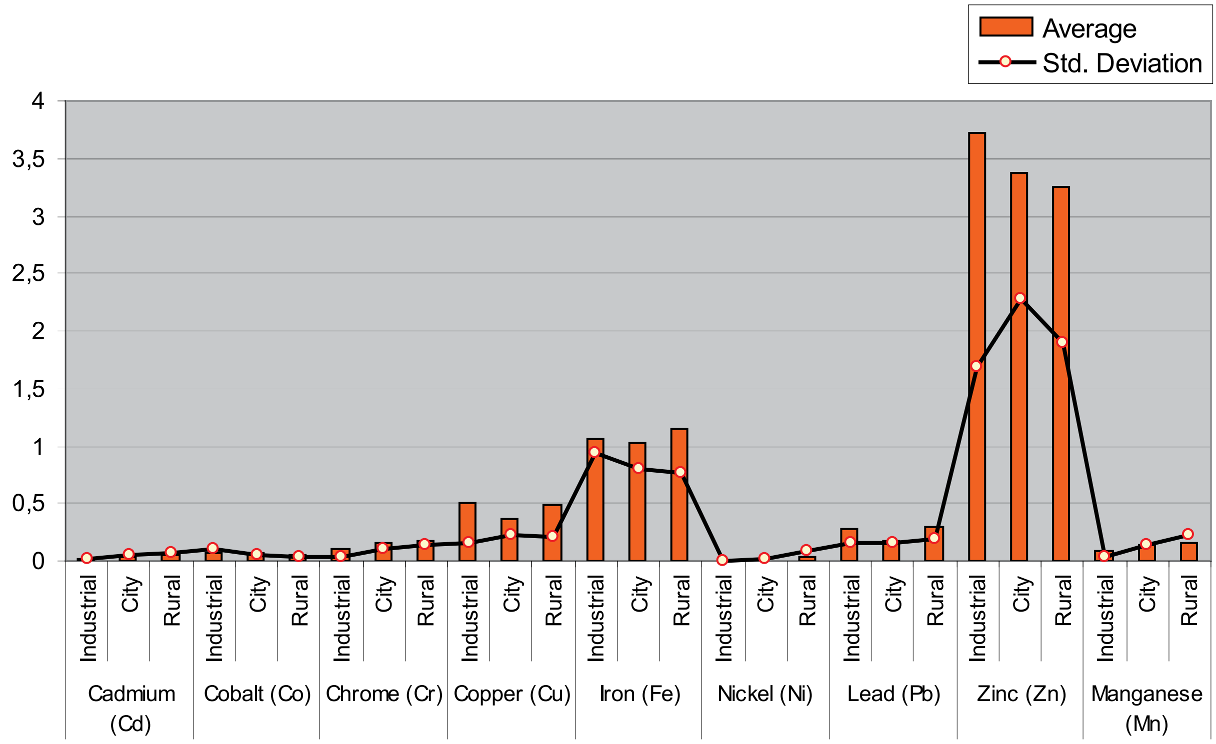

FIGURE 1. Average values of the elements in breast milk according to regions

The descriptive statistics that include the minimum, maximum, means and standard deviations of the data were computed (Table 1). The concentrations of cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), nickel (Ni), lead (Pb) and zinc (Zn) in milk samples were compared through Kruskal Wallis Test analysis at 5% level of significance.

RESULTS

As shown in Table 2 and Figure 1 the region with the highest Cd, Cr, Fe, Ni, Pb, Mn is rural region. The highest level of Co, Cu, Zn is in highly industrial area. As shown in Table 3, statistically significant difference exists in breast milk in terms of the levels of chromium, copper, nickel and lead according to regions (p <0.05). Cu in industrial zone, Cr, Ni and Pb in rural areas were highest.

TABLE 3. Comparison of the elements in breast milk according to regions

Element	χ^2	P* Value
Cadmium (Cd)	1.707	0.426
Cobalt (Co)	1.182	0.554
Chromium (Cr)	12.805	**0.002**
Copper (Cu)	7.898	**0.019**
Iron (Fe)	1.536	0.464
Nickel (Ni)	9.248	**0.010**
Lead (Pb)	6.221	**0.045**
Zinc (Zn)	1.794	0.408
Manganese (Mn)	1.249	0.536
Kruskal Wallis Test (df=2)		

DISCUSSION

The macro and micronutrients in breast milk present an extensive distribution. Breastfeeding is essential to complete infant development. Breast milk is the ideal nutrient for the newborn, but unfortunately also a route of excretion for some toxic substances from the body. Children are at greater risk for exposure to environmental toxicants, but very little data exist on these exposures [8]. In our study, when measuring the concentrations of the essential and toxic elements in milk samples from different regions, the levels of Co, Cu and Zn were higher in industrial field than city center and rural area. Also the levels of Pb, Cr, Ni, Cd, Fe and Mn were higher in rural region than other regions statistically. As shown in Table 4, the level of toxic elements in breast milk may vary in different countries and regions [9-20]. The values adopted in our study are above the some countries' data in spite of they were not on toxic level. Environmental pollution sensitivity has varied in different countries. Environmental pollution in different country or regions, even in rural areas may adversely affect to human life. Air currents, mixing of water sources with metals, the use of leaded gasoline, lead pipes in drinking water transport, traditional methods of food storage copper containers in rural sector can make the world more risky in terms of environmental pollution. It is speculated that highly industrialized regions are affected more in this pollutıons. But according to our results, rural areas having less industrial complexes can have the highest level of some toxic elements in breast milk sam-

TABLE 4. Comparison of elements in breast milk samples of different countries

Reference	Country	Lactation Stage	Lead (Pb)	Cadmium (Cd)	Manganese (Mn)	Chromium (Cr)	Cobalt (Co)	Iron (Fe)	Copper (Cu)	Nickel (Ni)	Zinc (Zn)
Leotsinidis et al. (9)	Greece	Colostrum	0.00048± 0.0006 mg/l	0.00019± 0.00015 mg/l	0.00479 ± 0.00323 mg/l	-	-	0.544 ± 0.348 mg/l	0.381 ± 0.132 mg/l	-	4.905 ± 1.725 mg/l
Turan et al. (10)	Turkey	Colostrum	0.0146 mg/l	0.0028 mg/l	0.0432 mg/l	0.0086 mg/l	-	3.5 mg/l	0.278 mg/l	0.0278 mg/l	12.9 mg/l
Elmastas et al. (11)	Turkey	Mature milk		0.000097 ± 0.000007 mg/l					0.162 ± 0.045 mg/l	0.48 ± 0.005 mg/l	1.2 ± 0.009 mg/l
Rahimi et al. (12)	Iran	Mature milk	0.01039 ± 0.00472 mg/l	0.00244 ± 0.00147 mg/l							
Halen et al. (13) smelter area control area	Swedish	Mature milk	0.0009 mg/l 0.0005 mg/l	0.00005 mg/l 0.00007 mg/l							
Koyashiki (14)	Brazil	Mature milk	0.0029 ± 0.0011 mg/l								
Ettinger et al. (15)	Mexico	Mature milk	0.0003± 0.008 mg/l								
Sharma and Pervez (16)	India	Colostrum	0.0006 ± 0.0002 mg/l								
Anastacio et al. (17)	Brazil	Mature milk	0.0028 ± 0.0025 mg/l								
Khaghani et al. (18)	Iran	Mature milk							0.36 ± 0.11 mg/l		2.95 ± 0.77mg/l
Sowers et al. (19)	USA	Mature milk	0.0061 ± 0.001 mg/l								
WHO (20)	A multi-centric study (six countries)	Mature milk	0.002-0.005 mg/l	< 0.001 mg/l	0.003-0.004 mg/l	0.0008-0.0015 mg/l	0.00015-0.00035 mg/l	0.35-0.72 mg/l	0.18-0.31 mg/l	0.011-0.016 mg/l	0.7-2.0mg/l
This study Industrial City Center Rural Area	Turkey	Mature milk	0.282 mg/l 0.176 mg/l 0.303 mg/l	0.022 mg/l 0.031 mg/l 0.044 mg/l	0.080 mg/l 0.134 mg/l 0.164 mg/l	0.099 mg/l 0.151 mg/l 0.176 mg/l	0.074 mg/l 0.069 mg/l 0.055 mg/l	1.064 mg/l 1.019 mg/l 1.142 mg/l	0.501 mg/l 0.362 mg/l 0.480 mg/l	0.000 mg/l 0.003 mg/l 0.028 mg/l	3.723 mg/l 3.368 mg/l 3.250 mg/l

ples. Although production of lead dye is limited in our region, their use is common in rural areas for economic reasons. Our study covers the three different regions in the same city. In all three regions, levels of some toxic elements in breast milk in one area are found higher than others and it is clear that industries negatively effect not only on cities but also villages. Lead is a toxic element which threatens the health of children but it is common in nature. The risk of exposure to lead is complex [5]. Industrialised societies, increasing urbanization and industrialization have been major factors for the overdose of lead threatening the health of the people. Environmental pollution based on the industry and dense traffic is causing the overdose of toxic metals such as lead and cadmium [2, 21]. Lead has some concerns about public health due to toxic effects on vulnerable fetuses, persistence in the blood of pregnant and breastfeeding mothers, and widespread occurrence in the world. Exposure to Pb may result in neurotoxic and nephrotoxic effects and anemia [22]. Exposure to Pb in-utero and in infancy has been associated with cognitive risk, even at low blood level. Prenatal and postnatal Pb exposure may induce neurodevelopmental disabilities in children. Fortunately, the Pb levels in breast milk can be up to about one tenth of the maternal blood level of Pb [23]. To diminish maternal and infant exposure to Pb, it is necessary to establish guidelines based on an understanding of the global occurrence of this metal. WHO recommends to targeting 0.5-1 μg/m3 urban air Pb concentrations and preventing to exceed 1 μg/ml blood Pb concentration. Adverse effects are not observed in human at these levels [23]. In a study of Gundacker et al. [24], the factors significantly related to toxic levels of Pb in breast milk were related to living spaces, consumption of fish and smoking. The values presented in our study are above the some countries' data albeit not in toxic level. Fortunately, Pb concentrations did not exceed critical levels (Pb: 1.63 ± 1.66 6g/l). In our country, both leaded and unleaded petrol are allowed to sell. We found that Pb levels in industrial zone were not higher than other regions despite it was at the edge of the highway and it had intensive factory waste. However, the levels of toxic elements Cu and Co were higher in this area than the others. In our study, Pb, Cr, Ni, Cd and Mn levels in breast milk are found higher in rural areas. It is pleasing that toxic levels have not exceeded. Nevertheless, the risks of these levels on health of babies and their future life are unknown. Cd and Pb levels in the breast milk of 158 women lactating and living in eight environmentally different polluted locations presented that only the active/passive smoking of the mother at home has significantly increased Pb levels in breast milk [25]. Cd exposure routes are mainly via food, environmental tobacco smoke and house dust. Although transfer to the neonate through breast milk is limited, teratogenic and developmental effects were observed in animals experimentally [26]. Cd that features cumulative toxic substance are among the priority pollutants in report prepared by the "Environmental Protection Agency". In the "Clean Air Act" lists, Cd, Co, Cr, Pb, Mn and Ni were included in 187 hazardous air pollutants [27]. Cd particles which suspend in the air may take very long distances before falling on ground or water. As shown in our study, Cadmium is determined higher in rural region, also. But the effects of this toxic element are not regional. It has been advised by WHO that the concentration of air Cd should not exceed 1-5 ng/m3 in rural areas, 10-20 ng/m3 in urban and industrial areas where agricultural activities are taken into account [23]. In a study measured the levels of Pb, Cd, Cu and Zn in different types of breast milk it was determined that the concentration of Cd was found to be very low (0.1 μg/l) and fairly constant in all types of milk [28]. Deng et al [29] did not detect the heavy metal Cd in 60 human breast milk samples, also. Koppen et al. [30] measured Cd and Pb in cord blood samples from 1196 mother-child pairs. In their study, Cd was detected in only 64% of the samples. But Pb was detected in all samples [30]. In our study, the Pb and Cd values were found under the toxic levels in all samples. Cu is taken about 150 μg in a day from drinking waters. Infants under one year are more sensitive to Cu. Some of the compounds used in agriculture as a fungicide and tank cleaning algicid contain Cu. In addition, Cu has threatened the environmental health mixing to water resources from water pipes or mining fields. The amount of Cu may be high in waters close to places of mine and factories extracted Cu, but contamination rarely exist [31]. However, Cu is found higher in industrial region in our study in spite of the fact there are not any mines in our region. It is mentioned that Cu has threatened the health in highly industrial region. Zn, Fe, Mn, Cu, Cd, Pb levels in breast milk samples were checked out by Leotsinidis et al in different times [9]. All metals but Cu were found in lower concentrations in transitory breast milk samples. They pointed out that Pb concentration were higher in the samples coming urban areas [9]. In our study Cd, Ni, Cr, Pb and Mn levels were found higher than expected even in a rural area but below the toxic levels. Cobalt exposure is usual at some places where it is worked with heavy metal processes. Co is known to produce cough, dyspnea, wheezing, asthma or interstitial fibrosis, called as "hard metal disease" [32]. Nickel compounds are considered to be the main cause of the cancer. The epidemiological studies demonstrate a strong association between water-soluble nickel compounds and risks of lung cancer and nasal cancer. Ni compounds have been classified being carcinogenic in humans by international scientific groups [33]. In our study, Co is determined in the highest level in industrialized region. As known, the people living in this area have more risk of cancer showing the most dramatic adverse effect of toxic elements. Zn concentrations in breast milk are quite high in the early weeks of postpartum period, averaging 3 mg/l at 2 weeks, but then decline sharply in the early weeks of lactation [34]. Fe and Zn are desired substances found out in abundant in breast milk. As the good news of our study, Fe levels in rural areas, Zn levels in the industrial zone were higher in breast milk in our study.

CONCLUSION

The level of toxic elements in breast milk can vary in different countries and regions. The values adopted in our study are above the some countries' data albeit not on a toxic level. Environmental pollution is not only a problem in industrialized region but also affects the regions globally. These results demonstrate the need for more extensive work about this subject.

LIMITATIONS

In this study it was aimed to show the effect of environmental pollution on breast milk. However children's physical and mental health was affected by environmental pollution has not been studied. Also the causes of environment problems were out of our purposes. Very good follow-up studies that require long-term longitudinal and multidisciplinary studies are required.

ACKNOWLEDGMENTS

This study was supported by Sakarya University, Research Fund.

DECLARATION OF INTEREST

There is no conflict of interest for this study.

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