

Original Research Article

Detection of heavy metals in breast milk and drinking water in Damietta Governorate, Egypt.

ABSTRACT

Seven metals of (Manganese, Iron, Zinc, copper, Lead , Cadmium and Nickel) were determined in 20 samples of breast milk and drinking water samples collected from Damietta Governorate. Heavy metal residues in milk and water were analyzed using the Inductively Coupled Plasma-Mass Spectrometry (ICP-OES). The mean concentrations of Cd, Pb and Zn in milk samples were 1.68, 2.92 and 2.31 ppm, respectively. While Cu, Fe, Mn and Ni mean concentrations reached to 0.76, 2.65, .25 and 0.014 ppm, respectively. The mean concentrations of Cd, Pb, Zn, Cu, Fe, Mn, and Ni in water samples were 1.40, 1.80, 28.82, 0.90, 3.08, 0.17 and 0.024 ppm, respectively. This study concluded that some of heavy metal levels in the mother's milk and in the collected drinking water samples were higher than permissible levels and constitutes health hazard to citizens in these regions.

INTRODUCTION

Milk is considered a perfect natural food for consumers of all age groups due to its high nutritional value. It is high in protein and a valuable source of calcium, vitamins and antioxidants (**Zeluta et al., 2009**). Human milk is the best source of nutrition for infants. Breast milk contains the optimal balance of fats, carbohydrates, and proteins for developing babies, and it provides a range of benefits for growth, immunity, and development. Breast milk contains powerful immune factors that help infants fight infections and it contains growth factors that appear to influence brain development and increase resistance to chronic diseases such as asthma, allergies, and diabetes. Breast-feeding builds a powerful bond between a mother and her child, and this bond enhances health and well-being across the generations (**Landrigan et al., 2002**). Breast tissue is unique due to its complex hormonal influences and dramatic changes during various life events. Individual hormonal levels and metabolism were affected by environmental factors, and some frequently used chemical and metals have the ability to disrupt endocrine function, and thus mimic the effects of estrogen (**Martin et al., 2006**). Metals get into the body through air, food, water, or dermal exposure. Metals have to cross the plasma membrane to enter the cell in order to exert toxicity. If a metal is in a lipophilic form, such as methyl mercury and arsenic compounds, it readily penetrates the membrane (**Lakowicz and Anderson, 1980**). When bound to a protein, such as cadmium metallothionein, the metal is actively taken into the cell by endocytosis (**Antila et al., 1996**). Many different varieties of metals and metal compounds exist naturally around the world. Human exposure to metals occurred since pre-historic time in areas where the heavy metal content of water and food are naturally high. Other than exist as metal ores in the crust of the earth, metals can also be transported to different parts of the world by various natural cycles. For example, metals, which exist in soil or in ores, can be dissolved by rain. The dissolved metals can then enter river and ground water systems and later the oceans and deposit as sediments. Drinking water is obtained from a variety of sources like wells, tube wells, rivers, lakes, reservoirs and ponds. That poses the greatest risk to human health due to contamination of these sources. Water pollutants mainly consist of heavy metals, microorganisms, fertilizers and thousands of toxic organic compounds. Heavy metals in water occur only in trace levels but are more toxic to the human body (**Khan et al., 2011**). Metals may be carry up into the atmosphere along with water vapor and subsequently deposit elsewhere. The advancement of technology and industrialization had also contributed to the wider distribution of metals and

the increased variety of metal compounds (Hasballah, 2010). Together with essential nutrients, plants and animals also take up small amounts of contaminant heavy metal compounds and can concentrate them. As certain heavy metals such as lead, cadmium, and mercury, arsenic (arsenic is usually regard as a hazardous heavy metal even though it is actually a semi-metal) have been recognized to be potentially toxic within specific limiting values, a considerable potential hazard exists for human. Those metals described as "heavy metals" which, in their standard state, have a specific gravity of more than about 5 g/cm³. Some of them, such as copper, nickel, manganese, chromium and iron, for example, are essential in very low concentration for the survival of all forms of life (Watson, 2001). Only when they are presented in greater quantities, can these, like the heavy metals lead, cadmium are already toxic in very low concentrations, causes metabolic anomalies, (Hasballah, 2010). The interest on trace metals in various milk and dairy products has recently gained a remarkable importance because; their presence can represent a qualitative parameter. For example, a content of production procedures, environmental pollution, sanitary conditions, and quality of animal feeding that can affect Milk characteristics, cheese properties, and storage and health aspect. For this reason, some trace elements are the actual importance because of their correlation to environmental pollution, and others release from packaging and alloys of material and tools utilized for milking to dairy productions (Bakircioglu, 2011). Industry is an important source of heavy metals. Industrial air pollution releases a number of heavy metals into the atmosphere, which become potential sources of water pollution after dry or wet deposition. Agriculture soils are rich in heavy metals because of the use of various phosphate fertilizers, organic matters, and pesticides as well as the presence of decaying plant and animal residue. The use of wastewater in irrigation and sewage sludge has further increased the quantity of heavy metals in agriculture soils. The agricultural run-off together with soil erosion are considered as the potential source of water pollution (Salem *et al.*, 2000).

This study seek to investigate and confirm a correlation between the levels of heavy metals (Manganese, Iron, Zinc, Copper, Lead , Cadmium and Nickel) in breast milk and drinking water in Damietta Governorate community.

MATERIALS AND METHODS

Sampling

breast milk and drinking water samples were collected from different regions in Damietta Governorate. Milk samples (11 sample) collected by manual expression into 10-ml acid-washed test tubes while, drinking water samples (11 sample) were collected into a 1000-ml acid-washed polyethylene (PE) bottle. All of the samples transported to the laboratory where they were stored at -4°C until analysis.

Methods

I. In human breast milk

Heavy metals concentration in milk was according to method of (AOAC, 2000a), 1 ml of milk sample into a clean silica dish dry on hot plate. When the samples were thoroughly dry, heat the contents of the dish with a soft flame (such as that of a Bunsen burner) until all volatile or readily combustible matter has been removing. Transfer the dish to a furnace set at 250 °C. Slowly raise temperature to 550 °C for about 6 to 8 hours. Remove the dish and cool. Ash should now be white or brownish red and essentially be carbon free. When clean ash is obtaining, remove the dish from furnace, cool and add 1ml HNO₃ and 10 ml of water. Heat on hot plate until sample ash is dissolving. Cool, and add gently 1 to 2ml of nitric acid and water to dissolve the salts. Filter into a 25 ml volumetric flask using Whatman No. 44 filter paper. Wash the residue and basin twice using water. Make up to volume with water. Prepare

sample blank solution by following the same procedure as described for sample. Use same quantities of reagents including water for both sample and blank. Subject both sample and sample blank to identical treatment (even the length of time kept in furnace etc.).

II. In drinking water sample

Heavy metals concentration in drinking water was **according to method of (AOAC, 2000b)**. Measure a volume 100 ml of sample into a beaker and add 5 ml concentrated HNO_3 . Boil slowly on a hot plate or a steam bath. Evaporate down to about 20 ml. Add a further 5 mL concentrated HNO_3 , cover with, a watch glass and heat. Continue adding concentrated HNO_3 and heating until the solution appears light colored and clear. Add 1-2 ml, concentrated HNO_3 and heat slightly to dissolve any remaining residue. Wash down the beaker walls and watch glass with water. Transfer to a 50 mL volumetric flask, cool and make up to the mark with water. The Inductively Coupled Plasma-Mass Spectrometry (ICP-OES) were used for Heavy metal analysis.

RESULTS AND DISCUSSION

Heavy metals have the same pathway of exposure, emissions from industry and traffic exhaust contains considerable air contaminants, which reach the food chain and then animals to finally deposit in human body (**ATSDR, 1988**). **In human breast milk**, Concentrations of heavy metals in breast milk samples as shown in **Table 1 and Figure 1**, followed the order as $\text{Pb} > \text{Fe} > \text{Zn} > \text{Cd} > \text{Mn} > \text{Cu} > \text{Ni}$. Lead and iron had the highest concentrations in all the sampling regions with mean concentrations of 2.921 ± 4.406 and 2.655 ± 4.166 mg/l breast milk samples, while Ni with mean concentration of 0.014 ± 0.041 mg/l recorded the lowest concentration. The toxic metal Pb achieved high concentration, which considered high risk for humans. **In drinking water**, concentrations of heavy metals in drinking water samples as shown in **Table 2 and Figure 2**, followed the order as $\text{Zn} > \text{Fe} > \text{Pb} > \text{Cd} > \text{Cu} > \text{Mn} > \text{Ni}$. Zinc and iron had the highest concentrations in all the sampling regions with mean concentrations of 28.824 ± 39.375 and 3.083 ± 4.808 mg/l, respectively. In contrast, a lower value was observed for Ni with mean concentration of 0.024 ± 1.046 mg/l milk sample. Iron and Zinc had the highest concentrations in all the sampling regions. As in **Figure 3**, breast milk samples recorded higher concentrations of Cd, Pb and Mn than drinking water samples, while concentrations of Zn, Cu, Fe and Ni in drinking water samples recorded the higher concentrations in drinking water than breast mother milk samples. High levels of zinc through study samples and regions may be contributed to increasing use of zinc substances which contact with galvanized copper or plastic pipes (**Bakircioglu et al., 2011**). Also the discharges of industrial wastes such as a municipal solid waste (MSW) compost which increased Cu, Pb and Zn in soil (**Carbonell et al., 2011**). commercial area with high population and traffic sources where Zinc in accumulators of motor vehicles or in carburetors, zinc may come from lubricating oils and tires of motor vehicles, in addition to Organo-zinc compounds are used as fungicides, topical antibiotics (**Arslan, 2001**) and the basic metal pesticides (**Watson, 2001**). Finally, Zinc released to water (**US. EPA, 1980**) then to soil for irrigation reaching to crops then to animal which consumed on contaminated plants with Zn. High concentration of iron

due to that iron is natural whereas the sources for other heavy metals were due to soil pollution, vehicular and industrial emissions and crust re-suspension. Iron is originated mainly from the soil type and construction work materials. It is also clear that auto-exhaust Fe particulates were added to the natural Fe, which is a major constituent of earth crust (El-Zeiny, 2010). This is in agreement with Habibi (1973) who found that the major source of Fe in the city centre was the auto-exhaust where Fe constituents ranged from 30 to 53 % of emitted particles. Balachandran *et al.* (2000) had stated also that the high concentration of Fe can be attributed to the open and rocky terrain of the area which is more susceptible to the condition of re-suspension of soil dust. Finally, heavy metals are extremely persistent in the environment; they are non-biodegradable and non-thermo degradable and thus readily accumulate to toxic levels. Heavy metals can accumulate in the soil at toxic levels due to the long-term application of wastewater. The primary natural source of nickel in drinking water is leaching from ultramafic rocks and the soil derived from these rocks. It is found primarily combined with oxygen (oxides) or sulfide Nickel compounds are also used for nickel plating, to color ceramics, to make some batteries and as catalyst in different chemical processes. These may be the possible means for water contamination. Nickel is required to maintain health in animals. A small amount of nickel may be essential for human, although a lack of nickel has not been found to effect peoples' health (Khan, 2011). One important dietary uptake pathway could be through crops irrigated with contaminated wastewater. Soils irrigated by wastewater accumulate heavy metals such as Cd, Zn, Cr, Ni, Pb, and Mn in surface soil. When the capacity of the soil to retain heavy metals is reduced due to repeated use of wastewater, soil can release heavy metals into ground water or soil solution available for plant uptake (Sharma *et al.*, 2006). According to data in Table (3), the concentrations of Cd, Pb and Zn in drinking water samples were above safe limits of WHO regulation, while Mn and Ni concentration below safe limits (WHO, 1993, 2003). In addition, concentrations of Cd, Pb and Mn in breast milk samples were above safe limits (WHO, 1993, 2003).

CONCLUSION

In conclusion, the concentrations of Cd and Pb in the breast milk and drinking water samples collected from Damietta Governorate were higher than international permissible limits. Cd and Pb contaminations in the breast milk and drinking water samples had potential for human health risk. Therefore, it is recommending that drinking water should be regularly monitoring for heavy metals in order to prevent excessive buildup of these heavy metals in the human food chain.

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 242 **Table (1): Concentration of heavy metals in mother breast milk in different sites from Damietta .**

Sites	Heavy Metals (mg/l)						
	Pb	Zn	Mn	Cu	Fe	Ni	Cd
1	4.889	17.27	0.243	0.401	1.141	0.001	4.6
2	14.93	3.268	1.449	0.353	14.04	0.132	10.17
3	1.584	0.003	0.048	0.001	0.763	0.001	0.668
5	0.655	0.003	0.163	0.001	0.973	0.001	0.001
6	0.845	0.003	0.048	0.001	0.364	0.001	0.263
7	0.32	0.855	0.132	0.001	4.38	0.001	0.67
8	2.045	1.697	0.153	0.001	2.241	0.001	0.04
9	1.226	0.003	0.109	0.001	1.032	0.001	0.02
10	1.105	0.003	0.136	0.001	0.779	0.001	0.177
11	1.612	0.003	0.055	0.001	0.84	0.001	0.218
*Mean±SE	2.921±4.40	2.311±5.36	0.254±0.42	0.076±0.15	2.655±4.16	0.014±0.04	1.683±5.36

Table (2): Concentration of heavy metals in drinking water in different sites from Damietta

Sites	Concentration of Heavy Metals (mg/l)						
	Pb	Zn	Mn	Cu	Fe	Ni	Cd
1	8.333	32.35	0.174	1.227	1.469	0.103	4.022
2	0.8	0.003	0.098	0.21	1.726	0.001	2.298
3	0.8	0.003	0.098	0.21	1.726	0.001	2.298
6	0.544	107.5	0.353	0.333	15.76	0.107	2.445
7	0.495	46.67	0.003	6.117	1.343	0.001	0.049
8	1.672	0.048	0.136	0.001	0.699	0.001	0.115
9	2.18	71.4	0.286	0.001	0.206	0.001	0.414
10	0.003	0.003	0.073	0.001	2.241	0.001	0.801
11	1.378	1.44	0.389	0.001	2.576	0.001	0.156
*Mean±SE	1.801±2.538	28.824±39.375	0.179±0.134	0.900±1.995	3.083±4.808	0.024±1.046	1.400±1.411

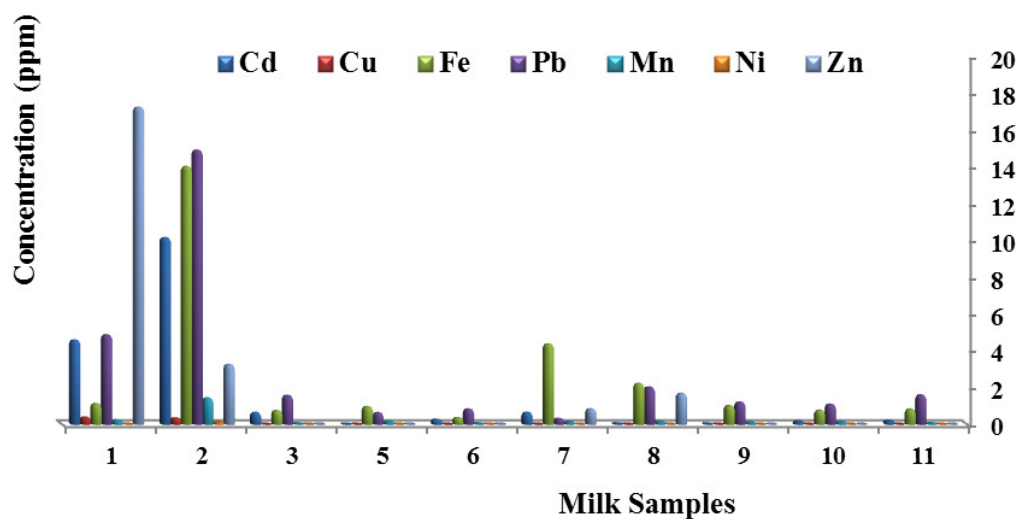
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Table (3). Permissible Limits for heavy metals of drinking water and breast milk

Permissible Limits	Metals (mg/l)						
	Cd	Cu	Ni	Mn	Pb	Fe	Zn
(WHO, 1993) in drinking water	0.003	-	-	0.5	0.01	-	3
(WHO, 2003) in drinking water	0.003	-	0.02	-	-	0.3	3
(WHO, 1993) in breast milk	0.0001			0.018	0.005		

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Figure 1: Heavy metal concentrations in breast milk samples.

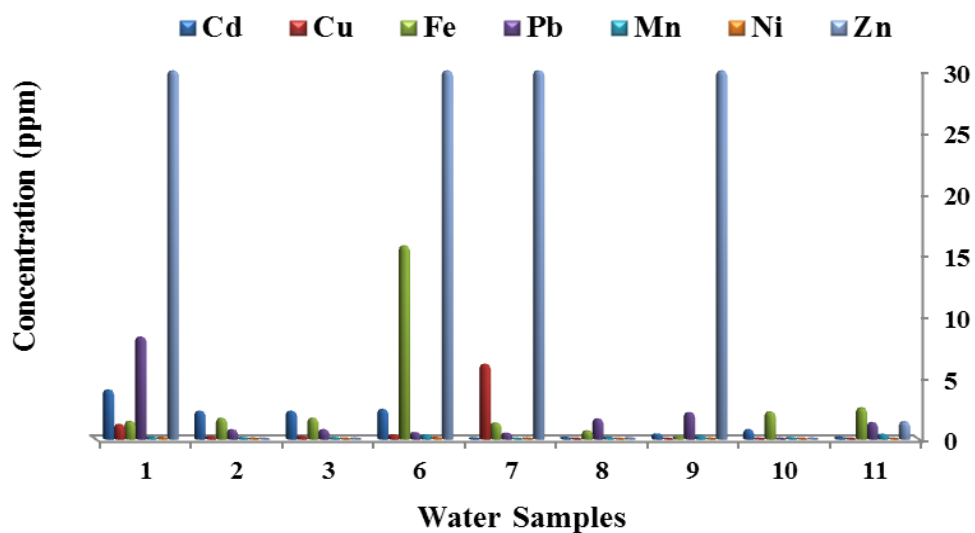


Figure 2: Heavy metal concentrations in drinking water samples.

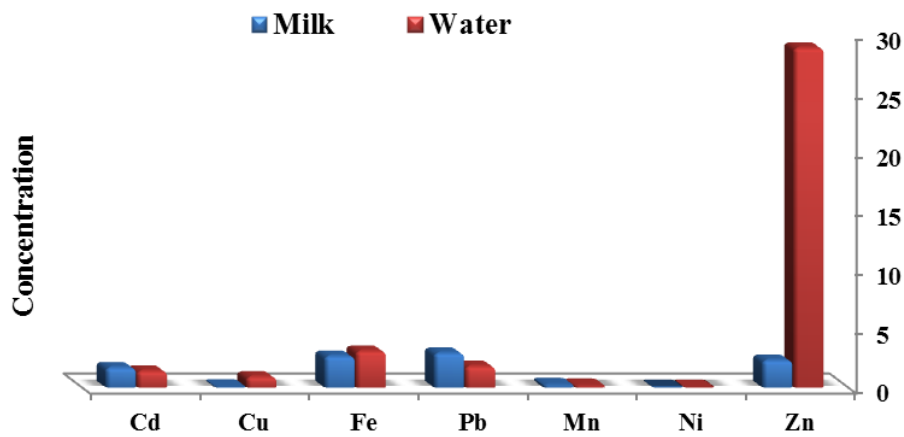


Figure 3: Comparison between heavy metal concentrations in drinking water and breast milk samples.