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Contamination of Cows Milk by Heavy Metal in Egypt

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Abstract The present investigation was carried out to assess the residues levels of five metals (Cadmium, Copper, Lead, Iron and Zinc) in cow milk collected from different sites in El-Qaliubiya governorate, Egypt. A total of 100 cow milk samples were collected from twenty cows in each location sites during the morning milking in the period from March to April, 2011. The highest average concentration are those of iron (16.38 µg/g) followed by zinc (10.75 µg/g) and lead (4.404 µg/g), while the lowest mean concentration are 2.836 and 0.288 µg/g for copper and cadmium, respectively. The results showed that most of the milk samples from the different sites containing all the studied metals with concentration higher than those recommended for milk by international dairy federation standard and Codex.

Keywords Metals · Milk · Contamination

Milk is known as an excellent source of Ca, and it can supply smaller amount of Zn and very small contents of Fe and Cu (Pennigton et al. 1995). In the last few years, the contamination of milk is considered as one of the main dangerous aspects (Abou Ayana et al. 2011). Trace metals are a general collective term applying to the group of metals and metalloids with an atomic density greater than 6 g/cm. This term is widely recognized and usually applied to the elements such as Cd, Cu, Fe, Pb and Zn which is commonly associated with pollution and toxicity problems (Alloway and Ayres 1993). Unlike most organic pollutants, trace metals occur naturally in rock forming and are minerals. Pollution gives rise to high concentrations of the metals relative to the normal background levels; therefore, the presence of the metal is insufficient evidence of pollution. Although metals differ widely in their chemical properties they are used widely in electronics machines and the artifacts of everyday life. Agriculture constitutes one of the very important non-point sources of metals pollutants. The main sources are impurities in fertilizers, pesticides and sewage sludge. Increased industrialization and agricultural activities has been accompanied throughout the world by the extraction and distribution of mineral substances from their natural deposits (Wahlberg et al. 2001). Metal contamination raises environmental concerns, such as influences on the food chain, which can be potentially harmful to humans. Inorganic compounds such as trace metal are shown to have a multitude of toxic effects such as acute syndrome and neurotoxic effects (that ultimately cause disease in brain, kidney, skin cancer, etc.). Cd and Pb are two of the more toxic food chain contaminants. Cd damages the lungs and causes the painful Itai–Itai disease. Pb affects the blood, numerous organs, and the nervous system. Children are especially susceptible to toxic metal effects because the incipient development in the digestive tract produces high absorption (Jeng et al. 1994). The consumption of cow milk is very popular in Egypt because of its medicinal and dietary properties. Consumption of cow milk in particular is associated with beneficial health effects beyond its pure nutritional value. In spite of heightened concern and pollution programs, very little is currently known about the distribution, behavior, and effects of trace metals in the cow milk in Egypt. Particularly, this study was designed to investigate the levels of some metals in cow milk collected from different sites in El-Qaliubiya governorate, Egypt.

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Materials and Methods

One hundred fresh milk samples (about 500 mLeach) were collected from twenty cows in each location sites during the morning milking directly into sterile screw-topped bottle to avoid any potential contamination due to metallic container. The samples were collected during the period from March to April 2011. Samples were taken from different five location sites in El-Qaliubiya governorate namely Benha, Kaha, Shebin El-Kanater, Tokh and Kafr Shokr. They were transported to the laboratory and immediately analysed for the heavy metals. Nitric acid (HNO_3) (density at 20°C: 1.4 g/mL) (95% purity) was obtained from SDS, Peypin, France. Stock Standard solution of Pb, Cd, Zn, Cu and Fe were obtained from Merck in concentration of 1,000 mg/l (Merck, Darmstadt, Germany). Before use all, the glassware had been soaked in detergent, rinsed with tap water, soaked in 15% nitric acid, rinsed with distill water and kept in the oven at 110°C till need. 0.5 g of each milk samples was taken in 50 mL Pyrex digestion flak and digested with 5 mL of concentrated nitric acid and the content of flask was heated on electric hot plate at 80°C, for 2–3 h, till the clear transparent digest was obtain. Then, the excess acid was evaporated to semidried mass on a heating plate. After cooling at room temperature, the final solution was dilute to 25 mL with 0.2 mol/L nitric acid and filtered through 0.45 µm Whatman filter paper in polyethylene flask for end determination. Quantitative determination of Pb, Cd, Zn, Cu and Fe were conducted by using atomic absorption spectrometer. Thermo atomic absorption spectrometer with hallow cathode lamp and a deuterium background corrector, at respective resonance line using an air-acetylene flame. Recoveries were carried out by the addition of the standards of each element at different levels (Table 1). All data were corrected according to the recovery percentage values. Calibration standards were regularly performed to evaluate the accuracy of the analytical method. Working calibration standards of Pb, Cd, Zn, Cu and Fe were prepared by serial dilution of concentrated stock solution of 1,000 mg/l. These and blank solutions were also analyzed in the same way as for the digested samples. Concentrations were expressed as mean ± standard deviation, minimum and maximum values. Data were statistically evaluated by one-way analysis of variance (ANOVA). All statistical analyses were done using the statistical package for social sciences (SPSS 16.0) program.

Table 1 Recovery percentage, relative standard deviation and method detection limits of metals in milk

Name	Recovery	RSD (%)	LOD (ng g^{-1})
Pb	93	5.7	12
Cd	98	9.3	2
Zn	87	5.4	25
Cu	95	6.2	5
Fe	100	4.6	15

Results and Discussion

One of the main problems with metals is their ability to bio-accumulate. Metals residues in milk are of particular concern because milk is largely consumed by infants and children (Tripathi et al. 1999). The concentration of Pb, Cd, Zn, Cu and Fe in milk samples from the studying area are shown in Table 2. Mean metal content in the milk samples in all location sites followed the profile: Fe > Zn > Pb > Cu > Cd. Fe level was the highest in milk samples analyzed in this study. The mean Fe concentration in the milk samples varied from 10.95 to 16.38 µg/g. The highest average values of Fe were found in milk samples collected from Benha region. Fe can represent a problem in dairy technology because of its catalytic effect on oxidation of lipids with development of unpleasant smell, bounding preferably proteins and membrane lipoproteins of milk fatty globule (Lant et al. 2006). The mean concentrations of Zn ranged from 4.770 to 10.75 µg/g. The highest pollution level of Zn in milk samples was found in Shebin El-Kanate (Table 2). These values were higher than those reported by Abou-Arab (1991), who recorded the variation in Zn content in milk samples collected from great Cairo over on year ranged from 4.1 to 5.45 µg/g with an average 4.25 µg/g. The average Pb content ranged from 1.850 to 4.404 µg/g. The highest and lowest mean concentration of Pb were found in milk samples collected from Tokh and Benha, respectively. The high of Pb in milk may result from industrial air pollution in this area. The highest mean concentration of Cu was found in Benha region (2.836 µg/g), while the lowest average concentration was found in milk samples collected from Tokh region. A possible source of contamination of Cu in milk can occur from animal feed, high Cu content of water also from Cu bearing and Cu alloys used in equipment (Mitchell 1981).

Table 2 shows the Cd level ranged from 0.200 to 0.288 µg/g. These results were disagreed with Lante et al. (2006), who found that Cd was absent in milk samples. The maximum permissible levels of metals recommended by international dairy federation standard (IDF Standard 1979) are 0.037 µg/g for Fe, 0.328 µg/g for Zn, 0.02 µg/g for Pb, 0.01 µg/g for Cu and 0.0026 µg/g for Cd. According to Codex Alimentarius Commission (2007) the maximum residues limit for Pb in milk is 0.02 µg/g. The concentration of the studied metals for each sample of each site was compared with the maximum permissible limits. The results showed that most of the milk samples from the

Table 2 Concentration ranges (μg/g) of metal in milk samples (n = 20 for each sampling site)

Metal	Benha	Kaha	Shebin El-Kanater	Tokh	Kafr Shokr
Zn					
Min.	1.740	1.621	2.300	2.690	2.650
Max.	7.414	15.84	31.60	14.30	14.04
Mean ± SD	4.770 ± 1.524	6.796 ± 3.740	10.75 ± 6.749	8.178 ± 4.108	5.520 ± 2.492
Cu					
Min.	1.437	0.091	0.722	0.235	0.016
Max.	5.002	2.439	2.592	2.037	1.640
Mean ± SD	2.836 ± 1.094	1.505 ± 0.703	1.379 ± 0.447	0.899 ± 0.451	0.623 ± 0.420
Pb					
Min.	0.018	0.742	0.298	1.600	0.270
Max.	6.754	5.805	5.416	7.015	5.400
Mean ± SD	1.850 ± 1.557	3.500 ± 1.517	2.900 ± 1.287	4.404 ± 1.607	3.053 ± 1.305
Fe					
Min.	5.234	0.399	1.879	2.780	1.841
Max.	35.95	63.61	31.910	50.00	18.30
Mean ± SD	16.38 ± 8.402	12.67 ± 17.68	10.95 ± 9.253	15.02 ± 10.27	12.43 ± 4.377
Cd					
Min.	0.004	0.034	0.052	0.085	0.110
Max.	0.516	0.672	0.618	0.290	0.598
Mean ± SD	0.288 ± 0.161	0.278 ± 0.186	0.200 ± 0.137	0.223 ± 0.056	0.239 ± 0.102

n = number of samples

different sites containing metals with concentration higher than those recommended for milk by IDF standard and Codex.

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