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Risk Assessment of Certain Heavy Metals and Trace Elements in Milk and Milk Products Consumed in Aswan Province.

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ABSTRACT

Considering that pollutants transformed to human body through food consumption, food safety is of great concern to consumers. Because consumption of milk contaminated with heavy metals poses serious threats to consumer's health. This study was conducted to evaluate the concentration of heavy metals and its risk with the consumption of milk and milk products in Aswan Province . A total of 20 samples of raw fresh buffalo, cow, sheep and goat milk and 16 samples of milk products of Kareish cheese, Domiati cheese, Mish and Samna were analyzed for the presence of heavy metals of Cadmium (Cd) and Lead (Pb) and trace elements of Copper (Cu) and Zinc (Zn) via Atomic Adsorption Spectrophotometer (AAS). The results showed that the concentration of total heavy metals differed between different areas, it was the highest in Edfu but the least in Toshka. With the analysis of metals concentration in milk of different species, the results showed higher concentration of total metals in sheep and goat milk combined with low content of Cd and high content of Zn and Cu than that of cow and buffalo milk. Comparing the Cd, Pb, Cu and Zn concentrations in locally manufactured milk products with the permissible upper limit of EOS (1993), the results are within the permissible limit. The health risk assessment of metals was assessed on the basis of determining of EDI and THQ for inhabitants through the consumption of contaminated milk and milk products. The EDI of Cd and Pb contributed to 59.7% and 20.48% of PTDI, while Zn contributed to 0.0345 to 2.582% and 0.0475 to 3.55% of RDA for male and female, respectively, but the Cu contributed to 0.0555 to 7.466 % of RDA. The results also showed that THQ of all metals under studies are less than one via the consumption of milk and milk products which means that inhabitants in Aswan Governorate will not exposed to health risk from the consumption of raw milk and milk product.

INTRODUCTION

In recent days, the rapid increase in industrial and agricultural activities has contributed to increased levels of heavy metals in the environment, for example in the air, soil and water (Pack *et al.,* 2014). Heavy metals like cadmium, lead, mercury, arsenic, chromium and some trace elements like zinc, copper are worldwide problem. The toxicity induced by excessive levels of these elements are well known, as it poses serious threats to con0sumer's health (Monika and Vlasta, 2005). Globally, there has been many reports on heavy metal intake by humans through food contamination (Muchuweti *et a*l., 2006). Heavy metals accumulate in tissues of dairy animals and ultimately excrete in milk because of their non-biodegradable and persistent nature (Burger and Elbin, 2015). Consumption of adulterated milk by consumers results in various health problems, and is a most important concern in the food industry (Singh *et al.,* 2010).

Studies on milk contamination with heavy metals in Aswan Governorate are very scarce, except a study accomplished since 25 years ago by Rashed (1992). As the level of environment contamination is directly correlated with the level of industrialization (Tubaro and Hungerford, 2007). At present, Aswan governorate have many industrial activities that cause excessive pollutions for the environment. Metal industry, mining industry, float-hotels transportation, can sugar industry and phosphate mining and other small industries are representing the major industrial activities at Aswan governorates. These activities are spread out of the most of the governorate and can cause pollution for the environment which expected to contaminate soil, water and more specifically agricultural lands. These pollutants transmitted directly or indirectly to food commodities.

So, due to the rapid increase in industrial and agricultural activities; the assessment of milk and dairy products for the contamination with toxic metals of cadmium, lead, copper and zinc being a big target. So, the objectives of this study are to determine the concentrations of some heavy and trace elements in milk and dairy products and to evaluate their potential health risks to humans.

MATERIALS AND METHODS

This research work was carried out to determine contamination of raw fresh milk and some milk products, like , kareish cheese, Domiati cheese, Mish cheese and Samna by toxic heavy metals (cadmium, Cd and lead, Pb) and trace metals (copper, Cu and zinc , Zn) at Aswan Province. A total of 20 raw milk samples of different species of cows, buffalos, goats and sheeps milk were obtained from the household lactating animals at different locations, namely, Edfu , Kom-Ombo and Toshka. As well as, 16 samples of different traditionally cheese types and Samna that manufactured locally (4 samples each) were collected from Aswan grocery shops and markets.

All samples were collected and stored in sterilized and washed with deionize-water bottles and immediately transferred to laboratory for analysis.

All samples were analyzed for the detection of cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) in milk, Kareish, Domiati, mish cheeses and Samna by ashing method described by James (1995). The obtained ash was dissolved in 5 ml HCL (36.6%) and the volume was completed to 50.0 ml by deionized water.

The concentration of Cd, Pb, Cu and Zn metals was assessed by Atomic Absorption Spectrophotometer (AAS) Model: A SP 1900 Pie Unicom Flame Atomic Absorption Spectrophotometer, at Unit of the Environmental Studies and Development, Faculty of science- Aswan University.

RESULTS AND DISCUSSION

The concentration of heavy and trace metals in milk and milk products depend on many circumstances, which are related to geographical locations and intensity of the industrial activity in these locations. The intensity of heavy metals contamination of milk and milk products at different sites in Aswan governorate, namely, Edfu, Kom-Ombo and Toshka is determined and the results are shown in Tables (1 and 2). The results in Table (1) indicated to the concentration of cadmium (Cd), lead (Pb), copper (Cu) and zinc (Zn) in milk at these locations. There is a wide variations between metals contents at these locations. The concentrations of total heavy metals is higher in Edfu cit e, compared with other locations. The range of total heav y metal concentrations are: 0.630–2.453; 0.970–1.916 an d 0.940–1.667 mg/kg in milk of Edfu, Kom-Ombo and T oshka, respectively. These differences are related to the in tensity of industrial activity which is higher in Edfu cites, compared with Toshka, which considered unindustrialize d area. Tubaro and Hungerford (2007) attributed the diffe rence in metal contaminations between different cites due to environment pollutions which is directly correlated wi th the level of industrialization.

The difference in rate of heavy metals contamina tion between different regions is a matter of concern of different studies. In Egypt, many studies mentioned the differences in heavy metals contaminations in different cites (Abou-Arab, 1991; Rashed, 1992; Enb *et al.,* 2009; Sayed *et al.,* 2012, Malhat *et al.,* 2012; Abd-El-Aal *et a l.,* 2012; Meshref *et al.,* 2014 and El-Ansary, 2017).

Table 1. Concentration range of metals in milk of dif ferent locations

Metal mg/kg	Locations		
	Edfu	Kom-Ombo	Toshka
Cadmium (Cd)	0.013 - 0.060	0.002 - 0.036	0.000 – 0.016
Lead (Pb)	0.159 - 0.737	0.173 - 0.430	0.143 - 0.183
Copper (Cu)	0.041 - 0.336	0.058 - 0.315	0.148 - 0.295
Zinc (Zn)	0.417 - 1.420	0.737 - 1.135	0.649 - 1.173
Total	0.630 - 2.4 5 3	0.970 - 1.916	0.940 - 1.667

The concentration of heavy metals in milk of diff erent species households at these locations are evaluated . Results in Table (2) show the interspecies differences o f heavy metals concentration between milk of different s pecies. The total heavy metals concentration was higher in Goat and Sheep milk than that in cow's or buffalo's m ilk. The total metals concentration of sheep and goat mil k are: 0.948 to 2.501, 1.364 to 1.988 mg / kg, compared with 1.030 to 1.727 and 0.630 to 1.833 mg / kg for cow' s and buffalo's milk, respectively. The sheep and goat m ilks are characterized by higher content of Zn and Cu. T he maximum Zn content in sheep and goat milk are 1.42 0 and 1.368, compared with 1.128 and 0.961 in cow and buffalo milk respectively. These findings are in line wit h Ijas *et al.,* (2009) who found higher in total metals con tent in goat milk than cattle milk (63.445 vs 42.407 mg/ L), while Ismail *et al.,* (2017) found the opposite trend, as goat milk is the lowest.

Table 2. heavy metals content of different types of milk

Metal mg/kg	Type of milk							
	Buffalo		Cow		Goat		Sheep	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Cd	0.013	0.060	0.027	0.036	000	0.030	0.004	0.029
Pb	0.159	0.733	0.209	0.430	0.143	0.254	0.147	0.737
Cu	0.041	0.079	0.111	0.133	0.254	0.336	0.148	0.315
Zn	0.417	0.961	0.683	1.128	0.967	1.368	0.649	1.420
Total	0.630	1.833	1.030	1.727	1.364	1.988	0.948	2.501

Concerning the pattern of individual heavy metals c oncentration in different milks, the results are shown in Ta ble (2). The cadmium concentration varied greatly between different milks, as it was absent in some goat milk samples and recorded 0.060 mg/kg in buffalo milk. In general, goa t and sheep milk showed the least Cd content compared wit h the content of buffalo or cow milk. With comparison of Cd concentration in milk of this study with literature . Com paring the Cd concentration in milk of different species in t he current study with the results mentioned in the literature, lower values than were found by Enb *et al.,* (2009); Ogabi ela *et al.,* (2011) and Malhat *et al.,* (2012) who found 0.068 , 0.163 and 0.200 to 0.288 µg/g, respectively. Also, Abd-El Aal *et al.,* (2012) and El-Ansary, (2017) reported 0.355 an d 0.416 ppm of Cd in raw and sterilized milk in El-Dakahli a Governorate and 0.3067 to 0.3084 mg/kg for cow and bu ffalo milk in Alexandria, respectively. Nnadozi *et al.,* (201 4) found 0.420 and 0.103 mg/kg for goat and sheep milk, r espectively. However, our results are higher than Sola-Larr añaga and Navarro-Blasco, (2009); Bilandžić *et al.,* (2011); Pilarczyk *et al.,* (2013) and Khan *et al.,* (2014) who report ed lower values of Cd than our study as they reported: 0.00 04, 0.003, 0.004 and 0.002 µg/g, respectively. The presenc e of Cd with high concentration in milk might be due to the consumption of contaminated feeding stuffs and water wh ere it comes from industrial emissions and fertilizers (phos phate rocks, which form the basis of commercial fertilizers and sludge), which may contaminate soil and crops. Also, i nhalation of fumes and dusts from the industrial activities, and cadmium lined metal equipment used in commercial fo od processing, kitchenware enamel, pottery glazes and plas tics containing cadmium (Abd-El-Aal *et al.,* 2012). Compa ring of Cd concentration in this study with the maximum al lowed limit for Cd in milk as reported by Codex Alimentar ius Commission (2014) of 0.0026 mg/kg, the results in Ta ble (3) indicated that all milk samples are exceeded this lim it. But according to the Egyptian Organization Standard (E OS) (1993) which reported 0.05 mg/kg as a permissible li mit for cadmium (Cd) in milk, which means that the Cd co ncentration in all milks under study at all locations is in per missible limit.

Concerning the lead (Pb) concentrations in differe nt milk samples, a wide range was found. The range is 0. 143 mg/kg to 0.737 mg/kg (Table 2). The least values are found in milk of Toshka (0.183 mg/kg) while the highest values are found in Edfu and Kom-Ombo (0.430–0.733 mg/kg). These results confirmed the last conclusion of th e higher contamination in milk of Edfu cite than others. C oncerning the interspecies differences, sheep milk recorde d the highest Pb concentration (0.737 mg/kg), compared with the least in goat milk samples (0.143 mg/kg). While, the lead concentration in buffalo and cow milk are 0.159- 0.733 and 0.209- 0.430 mg/kg, respectively.

Comparing the Pb concentration in milk of diffe rent species, the results indicated that there are variation s in different locations in Egypt. El Sayed *et al*., (2011); Meshref *et al*., (2014) and El-Bassiony *et al.,* (2016) fou nd Pb values in line with our study (0.327, 0.4086 and 0 .2016 mg / kg, respectively). While, Enb *et al.,* (2009) a nd El-Ansary, (2017) found lower values (0.066 and 0.0 84; and 0.0934 and 0.05878 mg/L) for cow's and buffal o's milk, respectively, but, Malhat *et al.,* (2012) found hi gher values (1.850 to 4.404 µg/g).

By evaluation the milk safety against Pb concent ration, the results are compared with the permissible ma ximum limit for Pb of 0.02 mg/kg as reported by Interna tional Dairy Fedration (1979) The results in Table (3) in dicated that milk of all species at all locations are higher in Pb than the permissible maximum limit of 0.02 mg/kg. The high concentration of Pb in milk might be explained by the Pollution of the environment with this metal. Lead alkyl additives into petrol are combusted and emitted into the atmosphere and can be responsible for high concentration of lead in some vegetation, roadside, soil, air, water and plant (Tunegova *et al*., 2016).

Copper has been greatly known in the whole world as a good source of biological significance in milk, whereby excess copper content in milk contribute towards fast lipid oxidation and contribute towards acceleration of many diseases (Nazir *et al.,* 2015).The possible contamination of milk with copper can occur from animal feed, higher copper content in water and also from copper bearing and copper alloys used in equipment (Mitchel, 1981 and Temiz and Soylu, 2012). The Cu Content was 0.041 mg/kg to 0.336 mg/kg (Table 2). Goat's and sheep's milk are higher in Cu content than of cow's and buffalo's milk. The Cu concentrations are: 0.041– 0.079, 0.111 – 0.133, 0.148 – 0.315 and 0.254 – 0.336 mg/kg in buffalo, cow, sheep and goat milk, respectively. Comparing the Cu concentration in milk of this studied area with the Cu concentration in milks of other parts of Egypt, the results in Tables (1 and 2) indicated lower values of Cu than that reported at other locations of Egypt, i.e. Assiut, Beni-Suif, Giza, Great Cairo and El-Qaliubia (Kamel *et al*., 2012; Sayed *et al.,* 2012; Meshref *et al.,* 2014; Enb *et al.,* 2009; and Abou Arab, 1991). Also, the study showed that the Cu concentration is lower than that reported by Nnadozi *et al*., (2014) who found higher values of 0.143 and 0.721 mg/kg in cow milk and sheep milk, respectively. In all milk samples at different location, the concentration of copper was above the maximum residual limit (Table 3) of 0.01 mg/L as recorded by WHO and Joint Expert Committee on Food and Agriculture (Bushra *et al*., (2014).

Zinc is an essential element for human health, it is important for normal growth and development in the human body. Results in Table (2) indicated that the range of Zn content in examined milk samples is 0.417 to 1.420 mg/kg. Zn concentration in sheep and goats milk showed higher concentration values than that of buffalo and cow milk 1.420 and 1.368 mg/kg vs 0.961 and 1.128 mg/kg, respectively. Literature revealed wide variations in Zn concentration between studies, (Licata *et al.,* 2004; Park 2000; Levkov *et al.,* 2017; Nnadozi *et al.,* 2014; Güle 2007; Park *et al.,* 2007 and Zodape *et al.,* 2012).

Zinc concentrations in all milk samples at different location of this study are higher than the permissible limit of 0.328 mg/kg as reported by International Dairy Federation (1977) standard. Results in Table (3) are 100 % over the permissible limit of Zn. The high level of Zn in concentration in milk is a result of soil contamination with zinc which it contributes to increased concentration in the vegetation that serves as fodder for the sheep (Balabanova *et al*., 2015.

Table 3. Frequency distribution of heavy metals in milk of different species

Metal	Permissible Limit	Samples within permissible limit			Samples exceeded permissible limit		
		Milk sample	No.	%	Milk sample	No.	%
Cadmium	0.0026 mg/kg [a]	Buffalo	0	0	Buffalo	5	100
		Cow	0	0	Cow	5	100
		Goat	1	20	Goat	4	80
		Sheep	0	0	Sheep	5	100
Lead	0.02 mg/kg [b]	Buffalo	0	0	Buffalo	5	100
		Cow	0	0	Cow	5	100
		Goat	0	0	Goat	5	100
		Sheep	0	0	Sheep	5	100
Copper	0.01 mg/l [b]	Buffalo	0	0	Buffalo	5	100
		Cow	0	0	Cow	5	100
		Goat	0	0	Goat	5	100
		Sheep	0	0	Sheep	5	100
Zinc	0.328 mg/kg [c]	Buffalo	0	0	Buffalo	5	100
		Cow	0	0	Cow	5	100
		Goat	0	0	Goat	5	100
		Sheep	0	0	Sheep	5	100

a: Codex Alimentarius Commission (2014)
b: IDF Standard (1979) c: IDF Standard (1977)

Heavy metal concentrations in some traditionally milk products:

The heavy metals concentration in different milk products is shown in Table (4) The results indicated that the concentration of total heavy metals in milk products are in the order of: Kareish cheese > Domiatli cheese > Mish > Samna. The total heavy metals in Kareish cheese is 2702 – 4181 µg/kg while it is 277 – 911 µg/kg in samna. Although the results indicated to high differences in the concentration of total heavy metal between milk products, the differences between individual heavy metals, exactly in Cd and Pb, are negligible. Cadmium concentration varied between 8 to 21 µg/kg with highest concentration of 21 µg/kg in Domiati cheese and the least of 8 µg/kg in Kareish. The Cd concentration differed widely between studies as mentioned in literature. Concerning our results, the Cd concentration is lower than Abdulkhaliq *et al.,* (2012) for white cheese (29.28 µg/kg), Meshref *et al.,* (2014); and Al-Ashmawy *et al.,* (2011) for Kareish cheese (90 and 87 µg/kg) respectively. As well as with Ibrahim (2004) in Kareish cheese and Domiati cheese. This range of Cd concentration in examined milk products is in the permissible limit of 0.05 mg / kg as recommended by Egyptian Organization Standard (EOS, 1993).

Table 4. Heavy metal concentration of some milk products (µg / kg)

Product	Cd		Pb		Cu		Zn		Total	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Kareish	8	14	174	178	155	193	2365	3796	2702	4181
Domiati	14	21	111	174	48	206	1026	2598	1199	2999
Mish	14	16	164	173	61	183	842	1057	1081	1429
Samna	11	15	163	179	10	83	93	634	277	911

(Metals µg/kg)

The results of examined Pb concentration in milk products of this study are shown in Table (4). The range of Pb concentrations in different milk products is 111 to 179 µg/kg. Slight differences are found between milk products wit h optional value of 111µg was found in Domiati cheese. In the examined milk products (Table, 4), a low Pb concentration was observed compared with other studies (Ibrahim, 2004; Meshref *et al.,* 2014; Anastasio *et al.,* 2006 and Ayar *et al.,* 2009). The lead (Pb) concentration in Samna (Table 4) ranged between 163 to 179 µg/kg which is lower than that mentioned by Enb *et al*., (2009) who found 269 and 414 µg/kg of lead in Samna of cow and Buffalo milk, respectively; and higher than Shahriar *et al.,* (2014) who found 15 µg/kg of lead in ghee.

Lead concentrations in this study exceeding the maximum limit of 0.02 mg/Kg w.w. (EU Regulation 2001/466) for bovine milk, while it is within the maximum permissible limit of max. 0.3 mg/kg according to EOS (1993).

The results of Cu concentrations in milk products as shown in Table (4) ranged between 10 to 206 µg/kg. The lowest concentration was found in samna (83 µg/ kg), compared with 0.183 to 0.206 µg/ kg for other milk products. The Cu level in Kareish cheese is much lower than those reported in other studies in Egypt as reported by Ibrahim, (2004); Deeb, (2010); Meshref *et al.,* (2014); Sayed *et al.,* (2012); Ghafari and Sobhanardakani, (2017); and AbdulKhaliq *et al.,* (2012). Guideline value of EOS (1993) for permissible limit of copper in cheese (Max. 0.3 mg /kg) means that Cu concentrations in all examined milk products are in permissible limit.

Results in Table (4) revealed that the range of Zn concentration in milk products is 93 µg in Samna to 3796 µg/kg in Kareish cheese. The increase in Zn concentration in cheese products (Kareish, Domiati and Mish) than in Samna may be explained on the basis that 97% of Zn in milk is bound in casein. In the literature, higher values of Zn are mentioned for Kareish cheese by Meshref *et al.,* (2014); Deeb (2010); Maas *et al.,* (2011) and Ghafari and Sobhanardakani (2017).

From the foregoing results, it could be concluded that the heavy metals concentrations in milk products manufactured at Aswan vicinity are in permissible limit according to EOS, (1993).

Estimated Daily Intake (EDI) of Metals and Their Respective Human Health Risks:

The human health risk assessment is determined not only by pollutant concentrations in milk products, but also by milk consumption rates. So it is necessary to calculate health risk assessments according to the daily intake of metals.

A- Estimated daily intake of heavy metals and trace elements in milk at different locations:

The estimated daily intake (EDI) of metals depends on metal concentration, body weight of human and daily food consumption. The EDI of metals was determined by the following equation, as described by (Meshref *et al*., (2014).

$$EDI = \frac{C\ metal \times w\ food}{BW}\ mg/kg\ b.w/day$$

Where C_{metal} (mg/kg, on fresh weight basis) is the concentration of heavy metals in contaminated foods, W food represents the daily average consumption of food and BW represents the body weight. The average daily consumption of milk per adult person (60 kg BW) was considered to be 200 mL

Table 5. Estimation of Daily Intake (EDI) of metals (mg /$kg_{b.w}$/ day) via consumption of milk by adult (BW=60 k gm) at different locations:

Metal (µg/kg/day)	Location		
	Edfu	Kom-Ombo	Toshka
Cd	0.2	0.12	0.053
Pb	2.46	1.43	0.61
Cu	1.12	1.05	0.983
Zn	4.73	3.78	3.91

Assuming that a value of 200 (ml/day) of raw bovine milk consumption in Egypt. The estimated daily intake (EDI) of Cadmium, Lead, Copper and Zinc at different locations were determined and recorded in Table 5. The EDI of total metals is highest in Edfu cite, 8.51 and lowest in Toshka, 5.556 mg/kg/day. The high EDI of heavy metals in Edfu is coincided with the result of Table (1) which mentioned high total metals concentrations, compared with other locations. Zinc (Zn) is the highest EDI metal (4.73mg /kg/da) at Edfu, while the least EDI metal is Cd (0.053 µg/kg/day) at Toshka. The risks to health from certain elements in food can be assessed by comparing estimates of daily intake with the Provisional Tolerable Daily Intake (PTDI) as mentioned by (Tripathi et al., 1999). It is worth to mention that the Joint FAO/WHO Expert Committee on Food Additives [2012] withdrew the previous provisory tolerable weekly intake (PTWI) and considered it no longer health protective. As the tolerable upper intake level of toxic heavy metals of Pb and Cd are 3.57 and 0.8-1.0 µg/kg/day, respectively (Tripathi *et al.,* 1999). The calculated values of EDI of Cd and Pb at all locations are lower than the upper limits as it represented 20-25 % and 17.08 to 68.9 of tolerable upper intake, respectively. So, we concluded that milk consumption at these locations is safe concerning the concentration of Cd and Pb.

B- Estimated daily intake of heavy metals in consequence of consumption of milk of different species and milk products:

The EDI values of Cd, Pb, Cu and Zn for adult (60 kg body weight) via the consumption milk of different species (200 ml) and milk products (22 g cheese, Kareish, Domiati and Mish and 6 g samna) (FAO, 2009) are calculated and presented in Table (6). The Results indicated that the people consumed goat milk intake high amount of heavy metals compared with the consumption of milk of other species, as total metals estimated daily intake (TEDI) for cow milk is 5.76 E-03 compared with 8.30 E-03, 6.06 E-03 and 6.67 E-03 mg/kg/day for sheep, buffalo and goat milk, respectively.

By comparing the EDI of individual metals, the EDI of Cd is highest with the consumption of buffalo milk, the EDI of Pb and Zn are highest with sheep milk consumption while the consumption of goat milk gave highest EDI of Cu. These differences in the patterns of EDI for different metals with the consumption of milk of different species are due to of the differences in the concentration of these heavy metals in milks (Table 2).

Concerning the TEDI of milk products, the consumption of Kareish cheese is the highest followed by Domiati cheese, Mish and Samna. The TEDI of heavy metals for these products are: 1.53 E-03, 1.1 E-03, 5.24 E-04 and 9.11 E-05 mg/kg/day for Kareish cheese, Domiati cheese, Mish cheese and Samna, respectively. The least EDI of samna is due to the low retention level of fat for heavy metals during manufacturing process (El Sayed *et al.,* 2011). By taken in to account the EDI of individual elements (Table 6), the results showed variations between EDI of the different metals according to following trend: Zn > Pb > Cu > Cd. This behavior of the EDI for different metals is the same in different studies, as Yu *et al.,* (2015); and Ghafari and Sobhanardakani (2017) found the same order. Yu *et al.,* (2015) found the EDI of Zn, Pb, Cu and Cd with the consumption of fermented milk and sterilized milk are 2.11 E-03 and 1.65 E-03; 5.08 E-06 and 3.54 E-06; 3.54 E-05 and 2.5 E-05 and 1.94 E-06 and 1.07 E-06 mg/kg/day, respectively.

Taken in concern, the EDI of heavy metals in different milk products. Ismail *et al.,* (2017) and Ghafari and Sobhanardakani (2017) found lower values of EDI in butter and cheese for Cd, Cu, Pb and Zn than our results. Also, Meshref *et al.,* (2014) found lower values of EDI of Cd. Also, in the current study, higher values of EDI are found for Cd and Pb and Cu than that EDI reported by Meshref *et al.,* (2014) who found 0.33, 1.27 and 1.1 µg/kg/day compared with 5.37, 7.313 and 3.092 µg/kg/day in our study, respectively.

The EDI of Cd through consumption of milk and dairy products was calculated to be 0.537 µg/kg/day, which corresponds to 59.7 % of PTDI. The EDI of Pb was calculated to be 0.731 µg/kg bw/day, which corresponds to 20.48 % of the PTDI.

Table 6. Estimated daily intake of milk and milk products:

Milk and milk products	Estimated Daily Intake (mg/kg/day)				TEDI
	Cd	Pb	Cu	Zn	
B. milk	2 E-04	2.4 E-03	2.6 E-04	3.2 E-03	6.06 E-03
C. milk	1.2 E-04	1.4 E-03	4.4 E-04	3.8 E-03	5.76 E-03
G. milk	1 E-04	8.5 E-04	1.12 E-03	4.6 E-03	6.67 E-03
S. milk	9.66 E-05	2.456 E-03	1.05 E-03	4.7 E-03	8.30 E-03
Kareish	5.133 E-06	6.23 E-05	7.077 E-05	1.39 E-03	1.53 E-03
Domiati	7.7 E-06	6.38 E-05	7.553 E-05	9.5 E-04	1.1 E-03
Mish	5.87 E-06	6.34 E-05	6.71 E-05	3.9 E-04	5.24 E-04
Samna	1.5 E-06	1.79 E-05	8.3 E-06	6.34 E-05	9.11 E-05
Total	5.37 E-04	7.313 E-03	3.092 E-03	1.91 E-02	

From the foregoing results, although the EDI values for Pb and Cd in milk and milk products of studied area are lower than the upper limits of tolerable daily intake level for Pb and Cd (3.57 and 0.8 – 1.0 µg/kg/day, respectively) Tripathi *et al.,* (1999) but still they have the potential to result in serious problems as other dietary and non-dietary factors also contribute in the calculation for total daily intake of heavy metals. Though, it cannot be concluded that there was no risk for human health. It is seemly necessary to warn about the hazardous effects of these toxic elements on both child and adult.

The daily intake of trace elements of Zn and Cu (mg/day) was compared with the recommended dietary allowances (RDAs) values expressed for females and males established by Institute of Medicine [2001], with the assumption that the average adult woman and the average adult man consumed the same diet. The results shown in Table (7) indicated that daily intake (mg/day) for Zn in the milk and dairy products ranged from 0.0038 to 0.284 mg/day, The results showed that EDI values of Zn contributed from 0.0345 to 2.582 and 0.0475 to 3.55% of RDA of Zinc for males and females, respectively. These results are very low compared with Meshref *et al.,* 2014 who found that EDI of Zn contributed to 0.33–11.44 and 0.45–15.73 % of the RDA values of 11 mg/day for adult males and 8 mg/day for adult females respectively. The low EDI of Zn in Dairy products may be attributed to the fact that only 1–3 % of Zn in milk is related to the lipid fraction, while the remaining part (97 % of Zn is bound to casein fraction) can be found in the skim milk fraction and consequently shift mostly to the curd during dairying. On the other hand, the EDI of Cu in this study ranged between 0.0005 to 0.0672 mg/kg/day, which contributed to 0.0555 to 7.466 % of RDA. In comparison with the results of Meshref *et al.,* (2014), the EDI of Cu in this study is higher for most of studied samples except for buffalo and Samna samples, which contributed 1.755 and 0.0555 % of RDA respectively. Therefore, Milk and dairy products are considered a very poor source of copper; however, copper deficiency is uncommon except in conditions with severe malnutrition.

Table 7. Trace metals daily intake (mg/day) through the consumption of milk and milk products in comparison to RDA_s values

Milk and milk products	Trace metals				
	Zn			Cu	
	DI (mg /day)	Contribution of DI to RDA %		DI (mg /day)	Contribution of Di to RDA %
		Male	Female		
Buffalo milk	0.1922	1.747	2.403	0.0158	1.755
Cow milk	0.2256	2.051	2.82	0.0266	2.955
Goat milk	0.2736	2.487	3.42	0.0672	7.466
Sheep milk	0.284	2.582	3.55	0.063	7.00
Kareish cheese	0.0835	0.759	1.044	0.0042	0.467
Domiati cheese	0.0572	0.52	0.715	0.0045	0.5
Mish cheese	0.0232	0.211	0.29	0.004	0.4444
Samna	0.0038	0.0345	0.0475	0.0005	0.0555

RDA (Recommended Dietary Allowances) for female (F) and male (): Zn 11 mg/day (M), 8 mg/day (F); Cu 0.9 mg/day (M), 0.9 mg/day (F

Target hazard quotient (THQ)

The THQ has been recognized as a useful parameter for evaluation of risks associated with the consumption of metal contaminated food (Zhuang, *et al.,* 2009). The THQ for the local inhabitants through the consumption of contaminated milk and dairy products were assessed based on a ratio of determined dose of a pollutant to a reference oral dose (RFD_o) for that substances and can be calculated according to the following question:

$$THQ= EDI/ RFD_o$$

The RFD_o values of Cd, Pb, Cu and Zn are set to be 0.001,0.0035, , 0.04, and 0.3 mg/kg bw/day respectively (US EPA,2008). The THQ <1 means that the exposed population is assumed to be safe. The THQ of all metals (Pb, Cd, Cu and Zn) via milk and dairy products consumption are shown in Table 8. The THQ of all metals (Cd, Pb, Cu and Zn) via milk and dairy products consumption were less than one. These values suggesting that the inhabitants in Aswan governorate will not be exposed to a potential health risk from consumption of milk and dairy products.

Table 8. THQ for daily intake of metals through consumption of milk and dairy products.

Milk and milk products	Metals			
	Cd	Pb	Cu	Zn
RFD_o	0.001	0.0035	0.04	0.3
Buffalo	0.2	0.686	0.0065	0.0106
Cow	0.12	0.400	0.011	0.0126
Goat	0.10	0.2428	0.028	0.0153
Sheep	0.097	0.7017	0.0262	0.0156
Kareish	0.005	0.0178	0.0018	0.0046
Domiati	0.008	0.0182	0.0019	0.0032
Mish	0.006	0.0181	0.0017	0.0013
Samna	0.002	0.0051	0.0002	0.0002

CONCLUSION

From the foregoing results, we conclude that the heavy metals concentrations in milk products manufactured at Aswan vicinity are in permissible limit according to EOS (1993). The THQ of all metals (Cd, Pb, Cu and Zn) via milk and dairy products consumption were less than one. These values suggesting that the inhabitants in Aswan governorate will not be exposed to a potential health risk from consumption of milk and dairy products, but still they have the potential to result in serious problems as other dietary and non-dietary factors also contribute in the calculation for total daily intake of heavy metals. Though, it cannot be concluded that there was no risk for human health. It is seemly necessary to warn about the hazardous effects of these toxic elements on both child and adult.

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تقييم مخاطر بعض المعادن الثقيلة والعناصر النادرة في الألبان ومنتجات الألبان المستهلكة في محافظة أسوان

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يمكن للملوثات أن تدخل جسم الانسان من خلال استهلاك الغذاء ، وسلامة الغذاء تمثل مصدر قلق كبير للمستهلكين. لأن استهلاك اللبن الملوث بالمعادن الثقيلة يشكل تهديدات خطيرة لصحة المستهلك ، وأجريت هذه الدراسة بهدف تقييم تركيز المعادن الثقيلة وخطرها مع استهلاك اللبن ومنتجاتة في محافظة اسوان . وتم تحليل المعادن الثقيلة من الكادميوم والرصاص والعناصر النادرة من النحاس والزنك فى20 عينة من اللبن الخام الجاموسي والبقري والأغنام والماعز ، 16 عينة من منتجات الألبان (جبن قريش ، جبن دمياطي ، مش وسم) وذلك عبر جهاز الامتصاص الطيفي (AAS) وأظهرت النتائج أن إجمالي تركيز المعادن الثقيلة يختلف بين المناطق المختلفة ، وكان الأعلى في إدفو ، والأقل في توشكي. وبتحليل تركيز المعادن في الأنواع المختلفة من الالبان ، أظهرت النتائج تركيزاً أعلى من إجمالي المعادن في لبن الأغنام والماعز مع محتوى منخفض من الكادميوم ومحتوى عالى من الزنك والنحاس مقارنة مع لبن البقر والجاموس. وبمقارنة تركيزات الكادميوم والنحاس والزنك في منتجات الألبان المصنعة محلياً بالحد الأعلى المسموح به من قبل المواصفة القياسية المصرية 1993 ، فإن النتائج كانت ضمن الحدود المسموح بها . تم تقييم المخاطر الصحية للمعادن على أساس تقدير الاستهلاك اليومى للسكان من اللبن ومنتجاتة. ساهم الاستهلاك اليومى للبن ومنتجاته بنسبة 59,7% ، 20,48 % من كمية الكادميوم والرصاص المستهلكة يومياً على التوالي بينما ساهم الزنك بقيم تتراوح من 0,0345 إلى 2,582 % ، ومن 0,0475 الى 3,55 % من الإحتياجات اليومية المطلوبة (RDAs) بالنسبة للذكر والأنثى على الترتيب ، وساهم النحاس بقيم تتراوح بين 0,555 إلى 7,466 % من الإحتياجات اليومية المطلوبة. و توضح النتائج ايضاً ان مدى المخاطر لكل المعادن تحت الدراسة تكون أقل من واحدعن طريق استهلاك اللبن ومنتجاتة مما يعنى ان سكان محافظة أسوان لن يتعرضوا لمخاطر صحية من استهلاك اللبن الخام ومنتجاتة .