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Investigation of heavy metal contents in Cow milk samples from area of Dhaka, Bangladesh

Md Iftakharul Muhib[1], Muhammed Alamgir Zaman Chowdhury[1,2], Nusrat Jakarin Easha[1], Md Mostafizur Rahman[1,4*], Mashura Shammi[1,5], Zeenath Fardous[2], Mohammad Latiful Bari[3], M. Khabir Uddin[1], Masaaki Kurasaki[4] and Md Khorshed Alam[2]

Abstract

Background: Cow milk is considered as one of the responsible food sources contaminated with heavy metals. The objectives of the study were to assess the content of selected metals in cow milk and its associated human health risks in the food chain of Bangladesh. A total of 90 cow milk samples of Branded, Dairy and Domestically produced milk were collected randomly from different sources of Savar Upazila in Dhaka area. Cadmium (Cd), chromium (Cr), lead (Pb), manganese (Mn), copper (Cu) and iron (Fe) contents in collected milk samples were determined using Flame Atomic Absorption Spectrometry (FAAS). To ensure quality control, one of the best quality control parameters i.e. recovery test; from eight various sample digestion methods were used. The Hazard Quotient (HQ) and Carcinogenic Risk (CR) values were also calculated.

Results: From the results, it was found that, the orders of heavy metal content in brand, dairy and domestic cow milk were Cr > Fe > Cu > Mn > Cd > Pb, Cr > Fe > Mn > Cu > Cd > Pb and Fe > Cr > Mn > Cu > Cd > Pb, respectively. Among the six metals, only Cr showed to exceed the highest Estimated Daily Intake (EDI) rate (for brand cow milk: 0.413 mg/day, dairy farm cow milk: 0.243 mg/day, domestic cow milk: 0.352 mg/day),and the comparison percentages of calculated values per permeable values were as follows; 206.5 % for brand cow milk,121.5 % for dairy farm cow milk and 176.0 % for domestic cow milk. Hazard Quotients (HQ) values and Carcinogenic Risk (CR) values were found within the acceptable level.

Conclusion: Although, the metal content in sampled cow milks were within the safe limit, the potential human health risks cannot be neglected for the regular/long time consumption of heavy metal contained cow milk.

Keywords: Cow milk, Heavy metals, Hazard quotients (HQ), Carcinogenic risk (CR), Estimated daily intake (EDI)

Background

Milk has a positive influence on human health. It is considered as nearly complete food since they are good source of proteins, fats, vitamin supplements and major minerals (Enb et al. 2009; Qin et al. 2009; Yuzbas et al. 2009; Salah and Ahmed 2012; Seyed and Ebrahim 2012). There are about 38 micro and trace elements reported to be found in raw milk from different regions around the world (Dobrzański et al. 2005; Nwankwoala et al. 2002). These minerals content in raw cow milk may vary depending on several factors i.e. lactation period of cows, health conditions, seasonal variations, climatic conditions, annual feed composition and environmental contamination (Licata et al. 2004; Yahaya et al. 2010). The milk processing conditions may also have effective influence on the contents and retains of minerals in total composition of milk (Lante et al. 2006; Salah et al. 2013). All of these minerals including the trace elements in cow milk occurred as inorganic ions and remain with

* Correspondence: mmrahman@ees.hokudai.ac.jp
[1]Department of Environmental Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh
[4]Faculty of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan
Full list of author information is available at the end of the article

proteins, peptides, carbohydrates and other molecules (Vegarud et al. 2000). Most of these trace elements have beneficial health importance. For example they act like enzymatic co-factors that can play vital roles in different physiological functions of human body and lack of these minerals may cause distribution and pathological problems mainly in vulnerable age (Enb et al. 2009). The essential elements become toxic when the concentration level exceeds 40 to 200 fold from their respective recommended threshold value (Rao 2005). Malhatet et al. (2012) found that the contamination in milk is considered as one of the main dangerous aspects within the last few years.

Increased environmental pollution has accelerated the problems of milk contamination and uncertainties about milk qualities (Farid and Baloch 2012). The worldwide milk contamination via environmental pollutants and xenobiotic compounds through cattle feeds like toxic metals, mycotoxin, dioxin and other pollutants are considered to have greater influence on public health (Seyed and Ebrahim 2012). Uptake of these contaminated milk acts like an additional source of heavy metal exposure (Ruqia et al. 2015). The main sources of metal contamination to humans are industrial or domestic effluents, combustion, bushfires, decomposition of chemical fertilizers, pesticides etc. (Degnon et al. 2012). Abdominal pain, hepatotoxicity, neurotoxicity, vomiting (Hussain et al. 2010), decreasing of intelligence quotient (IQ) level, Alzheimer's disease, behavioral disorders (Ahmad et al. 2011), tissue injury, irritation of lungs, cancer (Bushra et al. 2014) etc. could be generated due to over exposure of heavy metals. Besides heavy metals are non-biodegradable in nature and become accumulated in the food chains via bio-transformation, bio-accumulation and biomagnifications (Aslam et al. 2011). Complete elimination or prevention of chemical contaminants cannot be achieved from milk because the lipophilic contaminants will find its way into the persistent fat compounds from where heavy metals cannot be removed readily (Girma et al. 2014). Schematic diagram of heavy metals entering into food chain is given in the Fig. 1.

The heavy metal contamination of milk is less explored in less developed countries like Bangladesh (Islam et al. 2015; Shahriar et al. 2014). Islam et al. (2015) found that food chain around the nearby areas of Dhaka city in Bangladesh was contaminated by elements namely Cr, Ni, Cu, As, Cd and Pb through milk consumption in the study period of 2012–13. Besides the milk consumption rate in Bangladesh is very low (39.2 ml/day) while the recommended allowance is 250 ml/ day (Islam et al. 2015). According to previous survey, the annual milk production was 1.74 million tons during the year of 2001 and 2.28 million ton in 2007 (HIES 2011; BER 2007). Jamal and Fuad (2013),calculated that the milk production would be increased up to 4.55 million ton during the year of 2015–16. Moreover, with this increasing scenario in milk production, it is assumed that the consumer population of the country would face significant health threat in the long run from consuming contaminated milk and milk products. Thus the daily intake rate of heavy metal hazard quotients (HQ) and carcinogenic risk (CR) might be considered as exponentially increasing trend with the increasing rate of milk production.

The contamination of food stuffs due to metals and other toxins is one of the most important issues in developing countries. There are a lot of studies which have been conducted around the world associated with health risks for example; arsenic in cultivated rice in Srilanka (Channa et al. 2015), trace metal and alfatoxin in cassava flour in west Africa (Hayford et al. 2016),metals contaminated mushroom in Ethiopia (Medhanye et al. 2016), also health risk for contamination of foods and soils in China (Khan et al. 2008) and India (Sridhara Chary et al. 2008). However, it is observed that continuous long term exposures of consumers to heavy metal by consumption of cow milks get less emphasis in developing countries particularly in Bangladesh. Considering the aforementioned issues the study provides a significant importance in terms of public health hazard of Bangladesh. Therefore, the present study was designed to investigate concentration of selected heavy metals contaminating cow milks in Bangladesh particularly in city areas.

Methods

Study area and sample collection

The study was conducted in the period from December 2014 to October 2015. A total of 90 cow milk samples were collected from different areas of SavarUpazila, Dhaka, Bangladesh (Fig. 2). The milk samples were classified according to their collection sources as (i) the popular packaged cow milk was considered as Brand milk (33 samples), (ii) the dairy farm milk (30 samples) collected from the available dairy farms and (iii) the milk samples collected from the small household farmers as domestic cow milk (27 samples). All the samples were collected in a sterile glass bottle following standard methods and stored at 4 °C until analysis.

Instrumental analysis

Flame Atomic Absorption Spectroscopy (FAAS) (Model: AA-6300, Atomic Absorption Spectrophotometer, SHIMADZU, Japan) was used for heavy metal analysisfor-cadmium(Cd), chromium (Cr), copper (Cu), manganese (Mn), lead (Pb), and iron (Fe). Standard solution of each metal wasprepared at four different concentrations of 0.01, 0.1, 1.0, 5.0 ppm from Sigma-Aldrich (St. Louis,

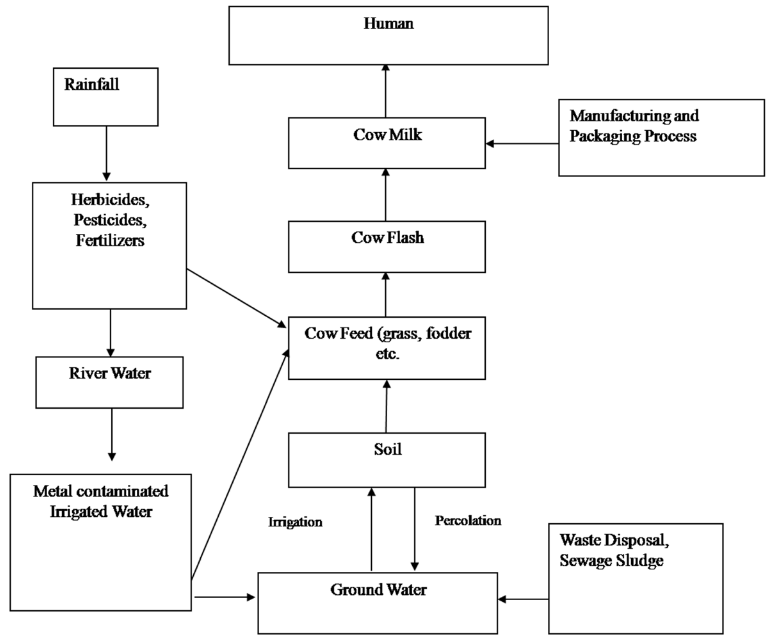

Fig. 1 Possible food chain pathways through which humans may be exposed to trace metals (Modified after Islam et al. 2015)

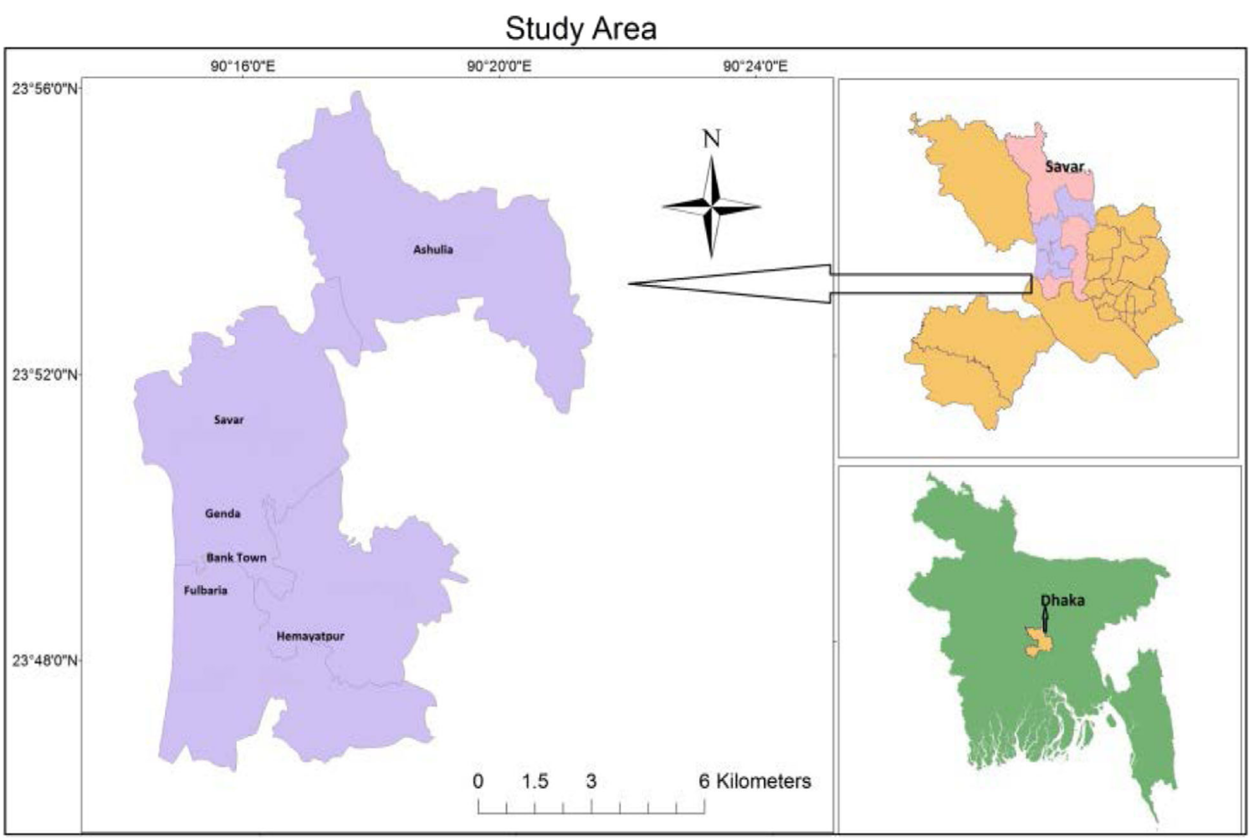

Fig. 2 Location of the Sampling Areas in Dhaka, Bangladesh

USA). Spectral lines were set to 228.67, 357.65, 324.57, 279.43, 217.35 and 248.30 nm for Cd, Cr, Cu, Mn, Pb and Fe, respectively. The minimum detection limit (MDL) for Cd, Fe and Cu was 0.001 mg/kg; MDL for Mn and Pb was 0.002 mg/kg and for Cr MDL was 0.005 mg/kg. For ensuring the quality control we used the certified reference materials (CRM) for metal analysis and also performed the recovery test with the best digestion method for each metals (Table 2). The CRM for metal was purchased; Cd, Cr, Pb and Fe from Fluka, Sigma Aldrich (St. Louis, USA) and Mn and Cu from Kanto chemicals co. Inc. (Tokyo, Japan).

Data calculation

Recovery test

Eight various methods for milk samples digestion were selected from previous related works to perform recovery test. Acid mixing ratios$HNO_3 + HCLO_4$ (10 ml + 5 ml) were considered as M-1, $HNO_3 + H_2O_2$ (10 ml + 3 ml) as M-2, Sample + HNO_3 (1 gm + 5 ml) as M-3, $HNO_3 + HCLO_4$ (7 ml + 4 ml) as M-4, Supernatant Sample + HNO_3 (15 ml + 5 ml) as M-5, HNO_3 + HNO_3 $_+HCLO_4 + H_2O_2$ (15 ml + 5 ml + 5 ml + drop wise) as M-6, HNO_3+ H_2O_2 (6 ml + 1 ml) as M-7 and HNO_3 + HCl + HF (2 ml + 6 ml + 2 ml) were set as M-8 for digestion of selected cow milk (Seyed and Ebrahim 2012; Nnadozie et al. 2014; Elatrash and Atoweir 2014; Rubina et al. 2013; Dawd et al. 2012; Jolanta et al. 1996; Tassew et al. 2014; European Committee for Standardization 2002). All of the reagents were from Merck (Darmstadt,Germany). The recovery percentages were calculated by the following equation:

$$RecoveryPercentages = \frac{CE}{CM} \times 100 \quad (1)$$

Where, CE = Experimental concentration (ppm) and CM = Spiked Concentration (ppm)

Estimated daily intake (EDI) of metals due to milk consumption

The estimated daily intake (EDI) of trace metals inmilk depends on metal concentrations (for dry weight basis), and daily milk consumption rate as well as the average body weight.

$$EDI\,f\,or\,each\,metal\,(mg/kg) = (Ci \times 39.2)/60 \quad (2)$$

Here, 39.2 mg/day = Daily milk consumption rate for Bangladesh (HIES 2011) and 60 kg = average body weight of an adult resident.

Ci = metal concentrations in milk (mg/l) (Islam et al. 2014).

Hazard quotients (HQs)

In the present study, the human health risks associated with the consumption of cow milk by the local community inhabitants were evaluated based on the hazard quotients (HQs). The method of estimating health risk using HQs was described in the USEPA Region III risk-based concentration table (USEPA 2000). The equation for HQ:

$$HQ = \frac{EDI}{RfD} \times 10^{-3} \quad (3)$$

Here, EDI = estimated daily intake of metal (mg/day),

RfD = Oral Reference Dose (mg/kg/day). For Cr, Cd, Cu and Pb it is0.003, 0.001, 0.04 and 0.004, respectively (Islam et al. 2014; USEPA 2010). HQs indicate potential health risk when it is equal or higher than 1 (Islam et al. 2014).

Carcinogenic risk (CR)

The target carcinogenic risks (CR) were also calculated by using the equation provided in USEPA Region III Risk-Based Concentration Table (USEPA 2006):

$$CR = \frac{\mathrm{EF}r \times \mathrm{ED} \times EDI \times \mathrm{CSFo}}{AT} \times 10^{-3} \quad (4)$$

Here, EFr = exposure frequency (350 days/year), ED = exposure duration (30 years) (USEPA 2006). AT = averaging time for carcinogens (365 days/year × 70 years). CSFo stands for oral carcinogenic slope factor (USEPA 2010).

Results and discussion

Method validation and quality control

To determine recovery as one of the most important method validation parameters, eight various milk sample digestion methods (M-1 to M-8) were performed and results presented in Table 1. It is obvious that the highest recovery value was obtained for M-7 digestion method where HNO3 and H2O2 acids used were in the 6:1 ratio.(Tassew et al. 2014).

To ensure the quality control, the certified reference material (CRM) valuefor metal analysis with percentage of recovery for respective metalsarelisted in Table 2.

Heavy metal concentration incow milk

Concentrations of Cadmium (Cd), Chromium (Cr), Lead (Pb), Manganese (Mn), Copper (Cu) and Iron (Fe) were determined in 90 cow milk samples (brand, dairy farm and domestic) using the most efficient digestion method (M-7) and results are summarized in Table 3

Average concentrations of trace metals among the branded cow milk samples had shown a descending order of Cr>Fe>Cu>Mn>Cd>Pb (Fig. 3). On the other hand, the dairy farm cow milk samples had shown

Table 1 Metal recovery values for different milk sample digestion methods

Method Id	Spiked Concentration	Metal concentration (ppm)					
		Cr	Cd	Pb	Mn	Cu	Fe
M-1	10 (ppm)	5.5010±0.03	6.4110±0.026	6.421±0.001	4.8312±0.001	5.5128±0.040	5.5301±0.040
	Recovery percentage	55 %	64 %	64 %	48 %	55 %	55 %
M-2	10 (ppm)	7.5020±0.025	5.6133±0.001	7.5113±0.102	6.7014±0.030	7.2105±0.050	7.2311±0.003
	Recovery percentage	75 %	56 %	75 %	67 %	72 %	72 %
M-3	10 (ppm)	8.0010±0.075	8.1201±0.002	7.9012±0.120	7.9111±0.030	7.4127±0.001	8.1020±0.030
	Recovery percentage	80 %	81 %	79 %	79 %	74 %	81 %
M-4	10 (ppm)	8.6012±0.010	8.1101±0.002	7.7010±0.030	6.8013±0.013	5.028±0.040	9.2033±0.102
	Recovery percentage	86 %	81 %	77 %	68 %	50 %	92 %
M-5	10 (ppm)	4.5413±0.275	3.8014±0.001	3.6103±0.102	7.5103±0.030	4.1031±0.031	6.8102±0.050
	Recovery percentage	45 %	38 %	36 %	75 %	41 %	68 %
M-6	10 (ppm)	5.0322±0.085	5.1300±0.001	5.087±0.014	8.1078±0.130	4.1002±0.027	4.2341±0.050
	Recovery percentage	50 %	51 %	50 %	81 %	41 %	42 %
M-7	10 (ppm)	9.8621±0.002	9.8801±0.002	9.7805±0.006	10.1400±0.001	9.9320±0.008	9.7300±0.017
	Recovery percentage	98 %	98 %	97 %	101.4 %	99 %	97 %
M-8	10 (ppm)	7.8147±0.010	7.3101±0.220	7.7103±0.104	5.8310±0.027	5.1901±0.002	7.1713±0.050
	Recovery percentage	78 %	73 %	77 %	58 %	51 %	71 %

the descending order of Cr>Fe>Mn>Cu>Cd>Pb while the average concentrations of trace metals among the domestic cow milk samples had shown the descending order of Fe>Cr>Mn>Cu>Cd>Pb (Fig. 3). It is clear from the figure that chromium possessed the highest concentration of metal content for both branded milk (0.672±0.010) and dairy cow milk (0.373±.008), while iron had shown the highest concentration (0.631 ±0.101) for the domestic cow milk. Lead had shown the least concentration for all types of sampled milk including 0.033±0.006 ppm for branded cow milk, 0.015±0.002 ppm for dairy farm cow milk and 0.012 ±0.001 ppm for domestic cow milk, respectively. Heavy metal contaminations in milk samples are found different countries all over the world in both brand milk and non-brand milk. A comparative scenario among previous studies around the world is illustrated in Table 4

Concentration of Cd was found extremely higher in one report from Pakistan (Mohammed et al. 2013) for both branded and non-brand milk samples (USEPA 2010) compared to the present study. In case of chromium both previous study from Bangladesh (Islam et al. 2015) and the present study had shown higher concentration compared to the other countries (USEPA 2006; Zodape et al. 2012). Similar results of higher concentration were also reported from branded milk of Indian study (Islam et al. 2014). Concentration of manganese was not reported previously from any type of cow milk. Lead samples had been reported higher in India (Islam et al. 2014) and Egypt (USEPA 2010) followed by Pakistan (Mohammed et al. 2013), Palestine (Abdul et al. 2012) and Nigeria (Ali et al. 2011) compared to the other reported countries (Seyed and Ebrahim 2012; Elatrash and Atoweir 2014; Khalil and Seliem 2013) including present study and previous study from Bangladesh (Islam et al. 2015). Concentration of cupper and iron had been found lower compared to the previous reports (Table 4).

Table 2 Metal concentration and recovery values for CRM milk samples digested by M-7 method

Metal	CRM value (mg/l)	Measured con.(mg/l)	Recovery (%) with M-7[a]	Minimum detection limit
Cd	1000 mg/l ± 4 mg/l	9.8801±0.002	98.8	0.001 mg/kg
Cr	1000 mg/l ± 4 mg/l	9.8621±0.002	98.6	0.005 mg/kg
Pb	1000 mg/l ± 4 mg/l	9.7805±0.006	97.8	0.002 mg/kg
Fe	1000 mg/l ± 4 mg/l	9.7300±0.017	97.3	0.001 mg/kg
Mn	1005 mg/l	10.1400±0.001	101.4	0.002 mg/kg
Cu	1001 mg/l	9.9320±0.008	99.3	0.001 mg/kg

[a]M-7: HNO_3+ H_2O_2 (6 ml + 1 ml) for digestion of milk

Table 3 Concentration of Cd, Cr, Pb, Mn, Cu and Fe in Milk samples

Metal	Brand Cow Milk (ppm)			Dairy Cow Milk (ppm)			Domestic Cow Milk (ppm)		
	Min	Max	Mean ± SD	Min	Max	Mean ± SD	Min	Max	Mean ± SD
Cd	BDL[a]	0.075	0.053±0.022	BDL	0.073	0.024±.009	BDL	0.081	0.047±0.026
Cr	0.165	1.099	0.672±0.010	BDL	1.233	0.373±.008	0.081	1.533	0.539±0.013
Pb	BDL	0.200	0.033±0.006	BDL	0.200	0.015±0.002	BDL	0.204	0.012±0.001
Mn	0.032	0.167	0.092±0.02	0.069	0.173	0.126±0.02	0.042	0.198	0.130±0.023
Cu	0.042	1.778	0.163±0.031	0.008	0.224	0.064±0.013	0.040	0.184	0.127±0.029
Fe	0.250	0.861	0.486±0.077	0.196	0.624	0.333±0.054	0.355	0.949	0.631±0.101

[a]*BDL* bellow detection limit

Health risk assessment

The estimated daily intake (EDI) of metals from cow milk consumption had been investigated for selected metals. EDI and Permissible Values (PV) for metals studied, together with the contribution of EDI to PV (%), for adult consumers of cow milk (brand, dairy farm and domestic) are listed in Table 5.

To evaluate the daily intake, mean concentrations of metals in each cow milk category were multiplied by the milk consumption rate and divided by the body weight

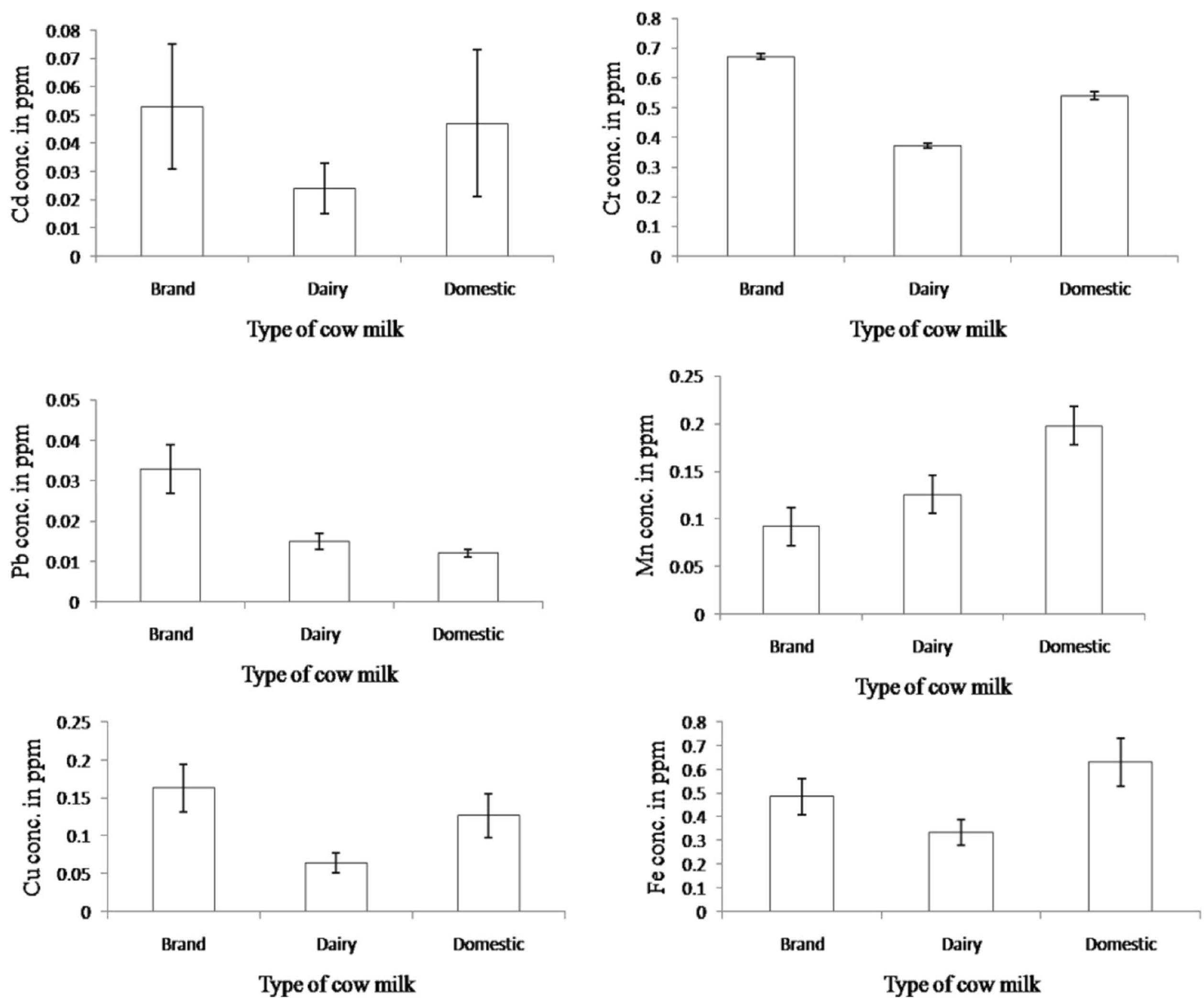

Fig. 3 Bar diagram of metal (Cd, Cr, Pb, Mn, Cu and Fe) concentrations versus type of cow milk, error bars indicating mean ± SD (n (number of samples) = 33, 30 and 27 for brand, dairy and domestic, respectively)

Table 4 Heavy metal concentrations (ppm) in different countries around the world

Country	Cd	Cr	Pb	Mn	Cu	Fe	Milk Type	References
Nigeria	-	-	0.63 ± 0.24	-	0.59±0.01–0.56±0.02	-	Non-Brand	Ali et al. 2011
Iran	-	-	0.013±0.006	-	-	-	Non-Brand	Seyed and Ebrahim 2012
Palestine	0.054	-	0.93	-	0.66	12.91	Brand	Abdul et al. 2012
	0.036	-	0.20	-	0.62	8.23	Non-Brand	
Philippines	0.003 to 0.01	0.0008 to 0.001	-	-	-	-	Brand	Solidum et al. 2012
Egypt	0.288	-	4.404	-	2.836	16.38	Non-Brand	Farag et al. 2012
India	-	0.175 to 0.013	5.904 to 0.139	-	37.290 to 0.039	-	Brand	Zodape et al. 2012
Pakistan	1.97±0.40	-	0.68±0.15	-	-	-	Non-Brand	Mohammed et al. 2013
	4.06±1.9		3.32±1.66				Brand	
Saudi Arabia	-	-	0.01 to 0.02	-	0.16 to 0.42	1.13	Brand	Khalil and Seliem 2013
Libia	0.001	-	0.003	-	-	-	Non-Brand	Elatrash and Atoweir 2014
Ethiopia	-	0.064± 0.010	-	-	0.206±0.024	-	Non-Brand	Alem et al. 2015
Bangladesh	0.029±0.026	1.6± 0.41	0.20±0.23	-	2.3±1.2	-	Non-Brand	Islam et al. 2015
Bangladesh	0.053±0.022	0.672±0.010	0.033±0.006	0.092±0.02	0.163±0.031	0.486±0.077	Brand	Present study
Bangladesh	0.024±.009	0.373±.008	0.015±0.002	0.126±0.02	0.064±0.013	0.064±0.013	Dairy Cow Milk	Present study
Bangladesh	0.047±0.026	0.539±0.013	0.012±0.001	0.130±0.023	0.127±0.029	0.631±0.101	Domestic Cow Milk	Present study

of the adult resident consumer. Metal specific EDIs revealed that EDI of Cr (for brand cow milk: 0.413 mg/day, for dairy farm cow milk: 0.243 mg/day and for domestic cow milk 0.352 mg/day) exceeded the permissible value (0.2 mg/day) and possess the highest concentration percentages to permissible value. EDIs of Cd, Pb, Mn, Cu and Fe were found below the permissible limits and also agreed with previous reports (Islam et al. 2015; Ademola 2014; Salah et al. 2012; Anita et al. 2010). Based on these data, this can be concluded that Cr was the major components contributing to the potential health risk via the consumption of all milk samples collected from Savar Upazila.

Hazard quotients (HQ) and carcinogenic risk (CR)

By definition, risk assessment is the evaluation process of the potential health effects from doses to human of one contaminant received through one or more exposure pathways. So, the potential health effects from doses to humans can be evaluated from risk assessment. By evaluating the hazard quotients (HQ), non-carcinogenic risks from consumption of foodstuffs by the adult inhabitants can be assessed. Based on the HQ we evaluated the non-carcinogenic risks due to consumption of cow milk for the adult resident and the estimated HQ values of metals are given in Table 6. From the results (Table 6) all the metals showed the HQ value below the threshold value of 1 suggested that there are no obvious health

Table 5 PV for metals studied in cow milk samples, mean EDI values and their contributions to PV for adult consumers

Metal	Permissible Value (PV) (mg/day)	References	Brand Milk		Dairy Farm Milk		Domestic Milk	
			EDI (mg/day)	Contribution to PV	EDI (mg/day)	Contribution to PV	EDI (mg/day)	Contribution to PV
Cd	0.046	(JECFA 2003)	0.043	73.91 %	0.016	34.78 %	0.030	65.21 %
Cr	0.2	(Oliver 1997)	0.413	206.5 %	0.243	121.5 %	0.352	176.0 %
Pb	0.21	[JECFA 2003]	0.021	10 %	0.10	4.76 %	0.003	1.42 %
Mn	5	(Ogabiela et al. 2011)	0.068	1.36 %	0.082	1.64 %	0.082	1.64 %
Cu	30	(JECFA 2003)	0.106	0.35 %	0.045	0.15 %	0.082	0.27 %
Fe	40	(FAO/WHO 2002)	0.317	0.79 %	0.215	0.53 %	0.412	1.03 %

Table 6 Non-carcinogenic human healthrisk of trace metalsdue to consumption of cow milk in area of Dhaka city, Bangladesh

Metals	Hazard quotients (HQs)			Carcinogenic Risk (CR)	
	Brand Milk	Dairy Milk	Domestic Milk	Milk type	Pb
Cd	0.043	0.016	0.030	Brand milk	7.33×10^{-7}
Cr	0.137	0.081	0.117		
Pb	0.005	0.025	0.0007	Dairy milk	3.5×10^{-7}
Mn	0.004	0.005	0.005		
Cu	0.002	0.001	0.002	Domestic milk	1.0×10^{-7}
Fe	0.0004	0.0003	0.0005		
Total ΣHQ	1.9×10^{-1}	1.28×10^{-1}	1.55×10^{-1}		

risks related to these metals associated with the consumption of cow milk in the study area. This finding agrees with Anita et al. 2010 and Islam et al. 2015. However the HQ value for each metal due to consumption of cow milk in the study area decreased in the order of: for brand milk; Cr>Cd>Pb>Mn>Cu>Fe, for dairy milk; Cr>Pb>Cd>Mn>Cu>Fe and for domestic cow milk; Cr>Cd>Mn>Cu>Fe>Pb. The data in the Table 6 also show the cumulative HQ (HQs) did not exceed the suggested threshold valueof 1 but the HQs value had decreased in the order of brand milk>domestic milk>dairy milk. This had revealedthat the brand milk hadhigher vulnerability to reach at the threshold for human health risks than the domestic and dairy cow milk. The carcinogenic risk (CR) of Pb due to consumption of cow milk by adult inhabitants in the study area was assessed using the target carcinogenic risk (CR). The result from the Table 6 showed the CR of Pb (Brand; 7.33×10^{-7}, Dairy; 3.5×10^{-7} and Domestic; 1.0×10^{-7}) due to consumption of cow milk was below 10^{-6} and considered as negligible. Due to the unavailability of carcinogenic slope factor values in USEPA 2010, most of the studied metals were not considered for direct CR assessment except for Pb. Therefore, the potential of CR for the inhabitants of the study area is within the safe limit, but the cumulative hazard quotients are nearing the threshold. Therefore, the non-carcinogenic health risk of the inhabitants due to consumption of cow milk should not be neglected.

Conclusion

To evaluate the safety of cow milk samples from Dhaka city area, selected heavy metal contents were analyzed by the most validated methods. Among the metals analyzed, Cr concentration along with their daily intake rate was found to be dominant percentages for both branded and non-branded cow milk samples. The current cumulative risks of studied metals due to consumption of cow milk remained below unity (HQ<1), indicating that people would not experience significant risk due to cow milk consumption. The studied direct carcinogenic risk of Pb is also below the recommended level ($CR<10^{-6}$). But the cumulative HQs value is nearing the to the threshold, meaning due to regular consumption of cow milk along with its potential risk of contamination could lead to human health risks in the near future. It can be recommended that proper monitoring of cattle feed quality as well as the techniques of milk processing should be carefully considered for the public health safety in Bangladesh.

Abbreviations

AT: Averaging time for carcinogens; BDL: Below detection limit; CR: Carcinogenic risk; CRM: Certified reference materials; CSFo: stands for oral carcinogenic slope factor; ED: Exposure duration; EDI: Estimated daily intake; EFr: Exposure frequency; FAAS: Flame atomic absorption spectrometry; HQ: Hazard quotient; MDL: Minimum detection limit; PV: Permissible value; RfD: Oral reference dose

Author's contribution

MIM contributed to study design, sampling, instrumental analysis and writing; MAZC, NJE, ZF, MLB and MKA contributed to carry out instrumental analysis and sampling; MMR, MS, MKU, MK contributed to study design, manuscript preparing, data analysis, paper review. All authors read and approved the final manuscript.

Competing interests

This is an original manuscript that has not been submitted elsewhere for publication. All authors have read the manuscript and agreed that the work is ready for submission to the journal with no conflict of interests. The author Md. Mostafizur Rahman will represent for all correspondence.

Author details

[1]Department of Environmental Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh. [2]Agrochemicals and Environmental Research Division, Institute of Food & Radiation Biology, Atomic Energy Research Establishment, G.P.O. Box 3787, Savar 1349, Bangladesh. [3]Food Analysis Research Laboratory, Center for Advanced Research in Sciences, University of Dhaka, Dhaka 1000, Bangladesh. [4]Faculty of Environmental Earth Science, Hokkaido University, Sapporo 060-0810, Japan. [5]Department of Environmental Pollution and Process Control, Xinjiang Institute of Ecology and Geography, ChineseAcademy of Sciences, Urumqi 830011, Xinjiang, People's Republic of China.

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