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Presence of Heavy Metals in Vegetables Collected from Jashore, Bangladesh: Human Health Risk Assessment

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KEYWORDS

Heavy metal;
Transfer factor;
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ABSTRACT: This research was carried out to estimate the concentrations of heavy metals (Fe, Mn, Cu, Zn, Pb and Cd) and to assess the human health risk. Estimated Daily Intake (EDI), Target Hazard Quotient (THQ), Hazard Index (HI) and Target Cancer Risk (TCR) were measured and the carcinogenic and non-carcinogenic health risks were calculated. The concentrations of Mn, Fe, Cu and Zn except Cd and Pb were below the permission limit proposed by the joint FAO/WHO. Transfer factor of heavy metals from soil to vegetables was calculated and the decreasing order was Cu (0.786) > Cd (0.759) > Zn (0.569) > Pb (0.432) > Mn (0.167) > Fe (0.050). Assessment of non-carcinogenic health hazards by THQ indicated no concern for individual Mn, Fe, Cu and Zn except Cd and Pb. But the combined impact of all metals (HI = 8.64775) was very high than the acceptable limit of 1.0 for all vegetables. So, the consumption of these vegetables were the prime concern for non-carcinogenic health effects and all metals together may affect the human health as revealed by HI. The probability of developing cancer from the consumption of studied vegetable was greater than USEPA threshold risk limit ($>10^{-5}$) for Mn ($2.8E^{-3}$), Pb ($1.17E^{-4}$) and Cu ($9.5E^{-4}$); ($> 10^{-3}$) for Zn ($2.15E^{-2}$) and Fe ($1.45E^{-1}$). These values indicated moderate cancer risk for Mn, Cu and Pb, high cancer risk for Fe and Zn whereas Cd showed low cancer risk from this study area.

INTRODUCTION

Vegetables are known as common diet among populations throughout the world due to essential sources of minerals, adequate vitamins, fibers, nutrients, antioxidants and metabolites. Besides, they also function as buffering agents for acid substance that are obtained during the digestion process [1]. Leafy, root and fruit vegetables have acquired a significant position in the human diet. For this reason, people all over the world have been concerned about the higher intake of fresh vegetables instead of red meat. Vegetables play a significant role to reduce the chronic diseases like cancer, diabetics, cardiovascular and other aged related diseases [2, 3]. Unfortunately, vegetables are being contaminated with heavy metals in different ways. It is an alarming issue not only for developing countries like Bangladesh but also all over the world [4]. Generally, heavy metals are found in the earth crust and they can exist in the environment for long time without any biodegradation. Vegetables cultivated in contaminated soil are polluted with heavy metals. These metals deposit on the surface of roots, transport them upwards to their shoots and finally accumulate them inside their tissues [5–7]. Other factors like change of climate, atmospheric deposition of heavy metals, application of excessive amount of inorganic fertilizers and organic manures in the agricultural field are responsible for increasing level of heavy metals in the

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environment [1]. Besides, rapid growth of industrialization and urbanization increases the level of heavy metals in the environment [3]. Moreover, anthropogenic activities like mining industries, electroplating, paint or chemical laboratories discharge waste water that contain high amount of heavy metals such as Cadmium (Cd), Copper (Cu), Lead (Pb) etc. [7]. Vehicles are also responsible for the deposition of heavy metals on the vegetables during their transport, marketing etc. [8]. Electronic waste processing sites that are usually located in fields adjacent to land used for agricultural purposes can contribute for the increasing level of heavy metals. Heavy metals released from salvaging useful materials and from the uncontrolled open burning of electronic waste could penetrate the soil where vegetables and crops are grown by contaminating irrigation water and through direct deposition by air. It is reported that almost half of the Lead, Copper and Chromium are transferred through food due to fruit and vegetables [9]. The consumption of these vegetables is one of the most important routes for the entrance of heavy metals in the food chain. The contaminated leafy vegetables pose a significant health risk to humans. The nature of effects can be toxic, neuro-toxic, carcinogenic and becomes apparent only after several years of exposure, as there is no good mechanism for their elimination from the human body [10]. Some heavy metals such as Mn, Zn, Cu, and Fe are essential nutrient in small amount for biological functions of human body but high level of them may cause problem to human. On the other hand, Pb and Cd are not essential for biological functions in human body so, they are considered as toxic heavy metals [1]. It has been reported that Cd is responsible for kidney, bone diseases, lung and prostate cancers. Pb causes the diseases of hematological, cardiovascular neurological systems and carcinogen [11, 12]. The accumulation of certain heavy metals in soil decrease the nutrients, for instance Cu, Mn, Fe inhibit plant uptake of Zn, decrease the level of microbial community and N_2 fixation. Thus, these toxic metals inhibit root growth and hamper physiological processes including uptake of nutrients [13]. In some developed and developing countries have carried out the estimation and assessment of carcinogenic and non-carcinogenic effect of heavy metals. But still now there are many regions of Bangladesh where the monitoring has not been yet done and nutritional data of vegetables are not available. Numerous literatures reported that heavy metals are entering in the food chain through consumption of vegetables hence regular monitoring of the soil and crops quality cultivated around the industrial are necessary. Because of geographical location, huge cultivation, industrialization and household works, vegetables in this study area may be contaminated. Considering the effects of heavy metals on human health this research was carried out. This study therefore, aimed to examine the concentrations of heavy metals (Mn, Fe, Cu, Zn, Pb and Cd) and to assess the health risks exposure via consumption of vegetables from this region as well as to apprise the inhabitants and government about the current status of contamination level in Jashore, Bangladesh.

MATERIALS AND METHODS

Study Area

The study area Jashore district is located at 21.45°–23.34° north latitudes and 89.15°–89.55° east longitude in south-western region of Bangladesh (Figure 1). It has an area of 2606.98 km² with population of 2,764,547. This district is surrounded by Khulna and Satkhira districts at the south, Magura and Jhenaidah districts at the north, Narail and Khulna districts at the east, and West Bengal of India at the west [14]. There are several industrial unit is being established day by day and most of the industries discharging industrial effluents without proper treatment. Due to rapid growth of population local farmers are using excessive fertilizers, agrochemicals and pesticides in the field to cultivate more crops. Industrial effluents, municipal and domestic sewage sludge, agrochemicals and waste materials are tremendously polluting the air, water and soil. As a result, vegetables, crops, cereals and fruits are being contaminated by toxic heavy metals.

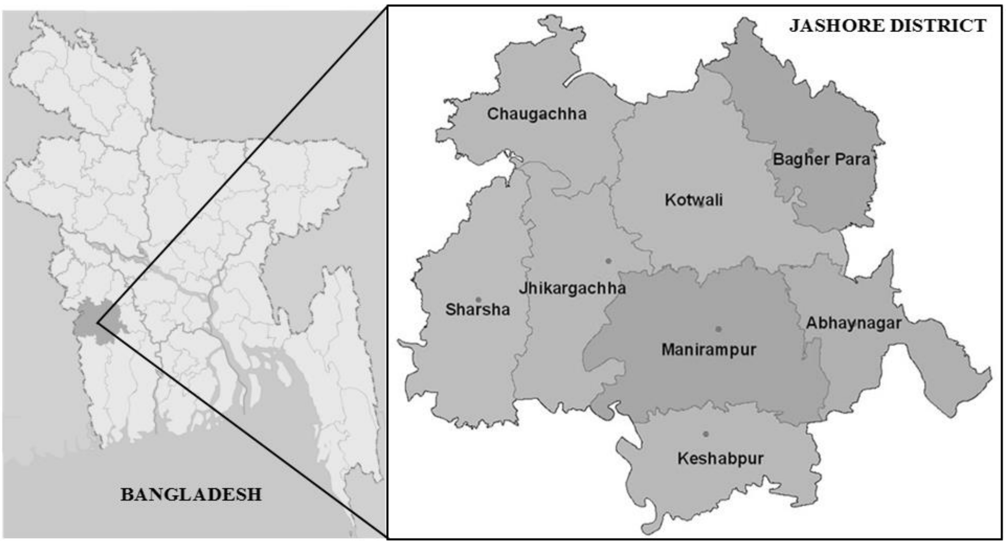

Figure 1. The study area Jashore, Bangladesh

Sample Collection and Preparation

Collection of samples was carried out from January to March 2018. Six different species of leafy, root and fruit vegetables, *Amaranthus gangeticus* (Red Spinach), *Spinacia oleracea* (Spinach), *Brassica oleracea* (Kholrabi), *Raphanus raphanistrum* (Radish), *Solanum lycopersicum* (Tomato) and *Cukurbita pepo* (Sweet Gourd), which are cultivated in these areas for the consumption of local people. All studied vegetables and its growing soil were collected from five relevant sites namely Keshabpur (S-01), Sharsha (S-02), Chaugachha (S-03), Kotwali (S-04) and Abhaynagar (S-05) of Jashore, Bangladesh. During sampling the study areas were split into many sampling units, selected by planting mode and pollution background. Each vegetable sample was washed thoroughly with tap water followed by distilled water to remove dust. The edible part of the samples were cut in small piece, air dried for 2 days and kept in hot air oven at 100 ± 1 °C for 4 h to attain constant weight. Soil samples were collected from the surface soil to a depth of 15 cm around each plant root zone and were air dried at room temperature, finely powdered, and sieved through a 2-mm nylon mesh to remove large debris, stones, and pebbles. Then the soil samples (500 g) were dried at 105 °C for 2 h to remove all the moisture content and ground to pass through 60 mesh sieves and homogenized for analysis. After drying the samples were grinded into a fine powder using a commercial blender and stored in polyethylene bags until used for wet digestion. 15 mL of 5:1:1 tri-acid mixture (70% HNO_3, 70% H_2SO_4 and 65% $HClO_4$) was added to the each beaker containing 1 g dry sample [15, 16]. The mixture was subjected to digest at 80 °C until the transparent solution appeared. After cooling, the digested samples were filtered using Whatman No. 42 filter paper and poured into teflon bottle and finally the filtrate was diluted to 50 mL with deionized water for heavy metal analysis [15].

Sample Analysis

The concentrations of heavy metals (Mn, Fe, Cu, Zn, Pb and Cd) in the digested soil and vegetable samples were analyzed by using atomic absorption spectrophotometer (Shimadzu model AA-7000, made by Japan) with deuterium lamp (D2-lamp) background correction and hollow cathode lamp. The overall analyses process was carried out according to the method described by Nazah et al. [16]. Air-acetylene flame (BOC, Jashore, Bangladesh) was used for the determination of all elements. Series of reference standard solutions (0.0 to 5.0 ppm) were prepared and standard calibration curves were constructed at 279.5, 248.3, 213.9, 324.8, 217.0 and 228.8 nm wave lengths for detecting Mn, Fe, Cu, Zn, Pb and Cd metals respectively in ppm level. Analytical grade (Wako, Japan and Merck, Germany) reagents were purchased from the local market and used for all purpose without any further purification. The working solutions were prepared immediately by using high purity deionized water before the analysis. The determined values of heavy metal in vegetables and its growing soil were used to assess the health implications of this study areas people. Statistical analysis was performed by using Statistical Package for Social Sciences (SPSS) version 16.0 and Microsoft Excel 2010.

Transfer Factor (TF)

Plant transfer factor may be defined as the uptake of elements by plants from the soil. It is calculated from the ratio of the heavy metal concentrations in the plant to soil using the following equation [17].

$$\text{PTF} = \frac{\text{Heavy metal content (mgKg-1), dry weight in plant tissue}}{\text{Heavy metal content (mgKg-1), dry weight in corresponding soil}} \quad (1)$$

Estimated Daily Intake (EDI)

Studies have shown that ingestion of contaminated food is exposure pathway of heavy metals to human [18]. EDI of heavy metals examined in this study determined using the equation:

$$\text{EDI} = \frac{C_m \times I_g}{W_b} \quad (2)$$

Where,

- C_m: Metal concentration in vegetables (mg kg^{-1} dry weight)
- I_g: Ingestion rate, which is taken as 0.126 kg day^{-1} for vegetables [19, 20]
- W_b: Average body weight of Bangladeshi people which is taken as 49.5 kg [17]

Target Hazard Quotient (THQ)

THQ value was determined using the equation [18]:

$$\text{THQ} = \frac{C_m \times I_g \times E_f \times D_e}{D_f \times W_b \times T_{avncar}} \quad (3)$$

Where,

- THQ: Non-carcinogenic risk
- E_f: Exposure frequency (365 days year^{-1})
- D_e: Exposure duration (71.8 years)
- D_f Reference dose of Fe, Mn, Cu, Zn, Pb and Cd are 0.7, 0.14, 0.037, 0.30, 0.0036 and 0.0005 (mg kg^{-1} day^{-1}) respectively [21–23]
- T_{avncar}: Averaging time for non-carcinogens [22] (365 days year^{-1} × D_e)

Hazardous Index (HI) and Target Cancer Risk (TCR)

Estimation of the risk of more than one heavy metal to human health, the HI was developed which is the sum of the hazard quotients for all metals and calculated by the equation [21, 24].

$$\text{HI} = \sum \text{HQ} = \text{THQ}_{Mn} + \text{THQ}_{Fe} + \text{THQ}_{Cu} + \text{THQ}_{Zn} + \text{THQ}_{Pb} + \text{THQ}_{Cd} \quad (4)$$

TCR was evaluated using the formula [22]:

$$\text{THQ} = \frac{C_m \times I_g \times E_f \times D_e \times S_{cpo}}{D_f \times W_b \times T_{avncar}} \quad (5)$$

Where,

- S_{cpo}: Carcinogenic potency slope of Mn, Fe, Cu, Zn, Pb and Cd (0.003, 0.3, 0.04, 0.3, 0.004 and 0.001) in mg kg^{-1} body weight day^{-1}

RESULTS AND DISCUSSION

The average concentrations of different heavy metals (Fe, Mn, Cu, Zn, Pb and Cd) in vegetables cultivated around different locations of Jashore, Bangladesh have been represented in Table 1. The observed concentrations of metals were compared with the recommended limit as established by the joint FAO/WHO to assess the level of food contamination [25–27]. These concentrations were also used to calculate average daily intake for non-carcinogenic and carcinogenic risk. According to the estimated data the decreasing order of the level of heavy metals obtained from different kinds of vegetables were Fe > Mn > Zn > Cu > Pb > Cd respectively. By comparing with permissible level of food standard recommended by FAO/WHO, the mean concentrations of Fe, Mn, Cu and Zn were within the permissible limit but other two heavy metals Cd and Pb were higher than the recommended guideline [25–27]. The results of present study were compared with other similar studies in Bangladesh and other countries (Table 2). Few exceptions were observed in Dhaka (Fe 1160 mg kg^{-1}) and Chittagong (Pb 1.54 mg kg^{-1}) in Bangladesh; Misurata, Libya (Pb 0.25; Cd 0.14 mg kg^{-1}); Changxing, China (Pb 0.039; Cd 0.035 mg kg^{-1}) and Varanasi, India (Pb 1.15 mg kg^{-1}).

Table 1. Concentration of heavy metals (mg kg^{-1}) in vegetables and its growing soil collected from Jashore, Bangladesh

Name of the Vegetables	Sampling Stations	Mn	Fe	Cu	Zn	Pb	Cd
Red Spinach	S-01	32.48	77.43	9.27	43.53	8.54	0.65
	S-02	20.12	69.52	30.80	37.06	5.08	0.66
	S-03	41.27	313.12	10.26	31.28	4.10	0.63
	S-04	45.52	145.20	8.33	19.27	2.61	0.40
	S-05	29.34	95.45	19.34	19.29	5.08	0.57
Spinach	S-01	34.29	255.57	7.62	35.68	7.53	0.74
	S-02	16.48	232.11	7.34	45.52	8.47	0.57
	S-03	12.10	159.28	5.73	12.52	12.21	0.25
	S-04	14.17	123.11	11.12	30.77	4.88	0.38
	S-05	23.49	288.23	17.39	18.19	8.95	0.58
Kholrabi	S-01	41.11	364.67	5.90	20.23	5.08	0.58
	S-02	27.14	168.54	11.21	21.69	4.41	0.54
	S-03	25.29	104.29	4.11	17.19	5.47	0.30
	S-04	11.33	139.23	4.07	34.59	3.86	0.41
	S-05	23.34	97.92	3.49	21.28	3.25	0.77
Radish	S-01	46.79	349.22	1.12	47.76	8.75	0.54
	S-02	28.37	126.21	3.22	23.24	1.60	0.58
	S-03	29.11	377.44	3.50	25.07	0.62	0.57
	S-04	11.40	131.87	12.19	35.27	2.81	0.24
	S-05	40.55	194.07	3.57	30.49	4.07	0.58
Tomato	S-01	25.07	302.18	8.56	37.17	14.79	0.60
	S-02	130.18	446.68	5.13	26.49	7.73	048
	S-03	38.29	125.03	8.17	26.05	3.42	0.41
	S-04	21.93	198.98	13.37	35.68	5.25	0.48
	S-05	13.64	247.09	6.89	32.78	1.63	0.43
Sweet Gourd	S-01	32.28	73.35	6.59	14.89	6.51	0.71
	S-02	16.60	105.77	7.69	22.81	7.92	0.55
	S-03	127.22	186.59	16.22	32.44	2.83	0.43
	S-04	24.23	106.08	19.5	19.43	3.46	0.52
	S-05	15.78	105.37	7.58	29.29	2.61	0.28
Mean		33.297	190.32	9.31	28.23	5.45	0.514
Range		11.33–130.318	69.52–446.68	1.12–30.80	12.52–47.76	0.61–14.79	0.24–0.77
Standard Values		30-300[a]	-	5-30[a]	27-150[a]	-	-
		-	450[b]	40[b]	60[b]	5[b]	0.3[b]
		500[c]	425[c]	73[c]	100[c]	-	-

[a] Source= World Average Value [28], [b] Source=FAO/WHO standard [29], [c] Source= Joint FAO/WHO food standard programme 2001 [30]

Table 2. Comparison of mean heavy metal concentrations (mg kg^{-1} dry weight) in vegetables collected from Jashore, Bangladesh with other studies

District (Country)	Mn	Fe	Cu	Zn	Pb	Cd	Ref.
Dhaka (Bangladesh)	--	1160	17.63	--	11.48	0.32	[31]
	--	1126-1209	10.27-29.1	--	7.32-17.0	0.216-0.40	
Rajshahi (Bangladesh)	4.54	--	--	--	5.10	1.05	[20]
	1.36-8.11	--	--	--	0.43-1.37	0.15-1.75	
Chittagong (Bangladesh)	--	--	9.21	--	1.54	--	[9]
	--		1.89-25.04	--	0.67-2.99	--	
Patuakhali (Bangladesh)	--	--	42.35	--	8.35	2.0	[32]
			4.12-529.42	--	0.47-103.53	0.011-25.88	
Narayanganj (Bangladesh)	--	--	9.37	19.76	3.69	0.168	[33]
	--		3.45-14.35	12.79-27.22	2.16-5.50	0.095-0.283	
Misurata (Libya)	--	--	3.36	8.15	0.25	0.14	[34]
	--		0.75-5.75	0.042-16.83	0.02-0.511	0.02-0.27	
Changxing (China)	--	--	--	--	0.039	0.035	[35]
	--	--	--	--	0.003-0.178	0.003-0.230	
Varanasi (India)	--	--	22.38	48.62	1.15	1.51	[36]
	---	--	9.50-56.30	25.20-94.30	0.20-2.56	0.10-4.30	
Jashore (Bangladesh)	**33.297**	**190.32**	**9.31**	**28.23**	**5.45**	**0.514**	**Present Study**
	11.33-130.18	**69.52-446.68**	**1.12-30.80**	**12.52-47.76**	**0.61-14.79**	**0.24-0.77**	

The mean concentrations of heavy metals (mg kg^{-1}) in soil were estimated Mn (199.38), Fe (3773.29), Cu (11.85), Zn (49.58), Pb (12.61) and Cd (0.68) respectively. The decreasing trend of the heavy metal contents according to the mean concentration observed in the studied soil having order of Fe > Mn > Zn > Pb > Cu > Cd (Table 3). The toxicity of heavy metals in soil was compared to the reference values provided by Mahfuza et al. [17]. The concentrations of most of the heavy metals were in the safe limit except Mn in S-01 and S-02. The mean concentration of heavy metals observed in soil samples have been compared with other similar studies in Bangladesh and other countries (Table 4). The present study showed that the average concentrations of Mn, Fe, Cu and Zn in soils were lower compared with several areas in Bangladesh and other countries whereas Pb and Cd showed few exceptions.

Table 3. Mean concentration of heavy metals in soil collected from Jashore, Bangladesh (mg kg^{-1})

Sampling Station	Mn	Fe	Cu	Zn	Pb	Cd
S-01	317.46	3653.52	9.56	72.33	13.38	0.89
S-02	381.29	3653.36	12.78	44.03	23.81	0.65
S-03	191.54	3803.58	11.52	46.76	9.765	0.67
S-04	52.89	3952.79	11.49	39.34	11.39	0.44
S-05	53.72	3803.22	13.89	45.45	4.68	0.74
Mean	199.38	3773.29	11.85	49.58	12.61	0.68
Reference values[d]	270	40000	30	100	50	1

[d] Source= Mahfuza et al., 2014 [17]

Table 4. Comparison of mean heavy metal concentrations (mg kg^{-1}) in soil with other studies

Study Area	Mn	Fe	Cu	Zn	Pb	Cd	Ref.
Entire Bangladesh	669.56	37247.15	54.29	202.81	9.4	1.26	[17]
Iswardi, Bangladesh	283.50	15684.70	21.43	123.283	68.84	0.538	[31]
Chittagong, Bangladesh	160.79	--	32.63	139.30	7.33	2.43	[37]
Mymensingh, Bangladesh	182.33	24683.33	49.10	123.19	59.39	--	[38]
Bogra, Bangladesh	--	--	131.87	28.46	9.60	6.95	[39]
Gazipur, Bangladesh	--	--	36.18	176.66	75.00	0.20	[40]
Dhaka, Bangladesh	--	--	75.04	103.34	3.84	0.52	[41]
Dhaka, Bangladesh	--	21216	37.57	--	50.32	0.45	[42]
Dhaka, Bangladesh	1715.80	--	39.14	115.43	49.71	11.42	[43]
Manila, Philippines	1999.00	--	98.70	440.00	213.60	0.57	[44]
Bangkok, Thailand	340.00	--	41.70	118.00	47.80	0.29	[45]
Palermo, Italy	519.00	--	63.00	138.00	202.00	0.68	[46]
Sialkot, Pakistan	17991.62	--	26.85	94.2	121.4	36.80	[47]
Uttar Pradesh, India	--	--	42.90	159.90	38.30	--	[48]
Fuyang, China	--	--	40.77	159.85	40.59	0.37	[49]
Present Study	**199.38**	**3773.29**	**11.85**	**49.58**	**12.61**	**0.68**	**--**

The TF of heavy metal is a vital component for describing human exposure to metal via food chain. This conversion of heavy metals from soil to vegetables were calculated and represented in Table 5. TF of heavy metals for all vegetables cultivated in studied soil was observed as: Mn (0.167), Fe (0.050), Cu (0.786), Zn (0.569), Pb (0.432) and Cd (0.759) respectively. Generally, higher values of TF indicate more translocation in plants and poor retention of metals in soil. A TF of > 0.2 represents the greater chances of metal contamination of vegetables by anthropogenic activities [50]. These values suggested that the TF was at very high level for Cu, Cd, Zn and Pb, at a moderate high level Mn and at a lower level for Fe. Similar findings were also observed by Khan et al. [4], Rattan et al. [51] and Ratul et al. [32]. EDI, THQ, HI and TCR values of heavy metals via consumption of vegetables has been shown in Table 5.

Table 5. Transfer factor (TF) of heavy metals from soil to vegetables, estimated daily intake (EDI), hazardous Index (HI mg kg^{-1} body weight day^{-1}) and target cancer risk (TCR) assessment

Parameters		Mn	Fe	Cu	Zn	Pb	Cd
Transfer Factor (TF)	Red Spinach	0.169	0.037	1.317	0.607	0.403	0.858
	Spinach	0.101	0.056	0.831	0.576	0.667	0.743
	Kholrabi	0.129	0.046	0.486	0.464	0.350	0.767
	Radish	0.157	0.062	0.398	0.653	0.283	0.740
	Tomato	0.230	0.070	0.711	0.638	0.521	0.708
	Sweet gourd	0.217	0.031	0.972	0.479	0.370	0.735
Mean TF		0.167	0.050	0.786	0.569	0.432	0.759
EDI		0.48445	0.08476	0.02370	0.07186	0.00131	0.01387
THQ		0.69207	0.60540	0.64049	0.23953	2.61673	3.85354
TCR		$0.45E^{-1}$	$2.8E^{-3}$	$9.5E^{-4}$	$2.15E^{-2}$	$1.31E^{-6}$	$1.17E^{-4}$
HI (Total)		8.64775					

These parameters for risk assessment were introduced by EPA in the United States for the estimation of potential health risk caused by any chemical contaminant over prolonged exposure [25]. The comparison of EDI values with the respective references dose D_f, it was observed that some heavy metals especially Cd and Pb, EDI values were higher than D_f. According to New York State Department of Health [52], if the ratio of EDI of heavy metal to its D_f is equal to or less than the D_f, the risk will be minimum. But if it is > 1–5 times than the D_f then risk will be low, if > 5–10 times than the D_f, the risk would be moderate and if > 10 times than the D_f, the risk will be high. For Cd and Pb this ratio (EDI/D_f) values was several hundred times greater from their D_f, indicates potential health hazard to the public. The THQ estimated for individual heavy metals through consumption of vegetables are presented in Table 5. The acceptable guideline value for THQ is ≤ 1 [22]. Ambedkar and Maniyan concluded that if the heavy metal concentrations are above the maximum level, recommended by regulatory agencies and depending on daily intake by consumers, might pose a risk for human health [53]. THQ values were less than 1 for all individual heavy metal except Cd (3.8535 mg kg^{-1}) and Pb (2.616 mg kg^{-1}) in studied vegetables. The THQ values of Pb and Cd indicated potential carcinogenic risk to human. Beside this, the combined impacts of all metals (HI) under consideration were higher than the acceptable limit of 1 for all vegetables. So, the consumption of these vegetables is of the biggest concern for non-carcinogenic health effects. Moreover, the percentages of non-carcinogenic risk of Mn, Fe, Cu, Zn, Pb and Cd for studied vegetables in the Jashore, Bangladesh has been displayed in Figure 2(a).

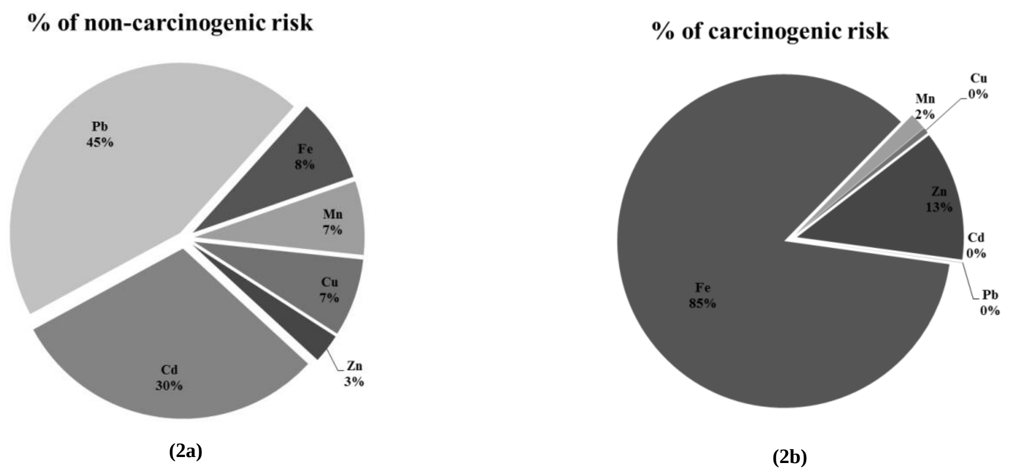

Figure 2. (a) % of non-carcinogenic risk, (b) % of carcinogenic risk of Mn, Fe, Cu, Zn, Pb and Cd in Jashore, Bangladesh

Among these metals Pb, Cd, Fe, Mn, Cu and Zn contributed to risk of about 45%, 30%, 8%, 7%, 7% and 3% in the studied vegetables respectively. Therefore, Pb is the most dominant non-carcinogenic metal in the study area. Humans are often exposed to more than one pollutant and suffer combined or interactive effects [54]. This is because of the toxic effects associated with the exposure to multiple chemicals, often through different exposure pathways. Moreover, the effect of one metal is supposed to be dependent on the others due to the competitive absorption of metal ions in specific tissues of concern. The risk associated with the carcinogenic effects of target metal is expressed as the excess probability of contracting cancer over a lifetime of 71.8 years. The estimated lifetime of TCR is not only a specific estimate of expected cancers but also it is apparently an upper limit of the probability that the individuals may have cancer sometime in his/her lifetime following exposure to that toxic metal [52]. According to NYSDOH [52] the TCR categories are described as; if TCR ≤ 10^{-6} = Low, 10^{-5} to 10^{-3} = moderate, 10^{-3} to 10^{-1} = high, ≥ 10^{-1} = very high. In this study Fe ($2.8E^{-3}$), Cd ($1.17E^{-4}$) and Cu ($9.5E^{-4}$) showed moderate cancer risk and Zn ($2.15E^{-2}$) and Mn ($0.45E^{-1}$) showed high cancer risk to the exposed population whereas Pb ($1.31E^{-6}$) posed no cancer risk. Thus, the TCR of Fe, Zn, Mn, Cu and Pb for study area people is a matter of concern. The percentages of carcinogenic risk of Fe, Zn and Mn in the studied vegetables were observed 85%, 13% and 2% respectively in Figure 2(b). Among them, Fe was marked as the most dominant carcinogen in this study area.

CONCLUSIONS

The present study concluded that the commonly consumed vegetables collected from Jashore, Bangladesh contained various concentrations of heavy metals.

According to the results, the decreasing order of mean concentrations of heavy metals in vegetables and its growing soil were Fe > Mn > Zn > Cu > Pb > Cd and Fe > Mn > Zn > Pb > Cu > Cd respectively. The mean concentrations of heavy metals in the studied soil were observed within the safe limit but in the case of vegetables the concentrations of Pb and Cd were higher than the recommended values of FAO/WHO. Accumulation of higher concentration of heavy metals in the vegetables might be due to anthropogenic activities in this study area. The health risk assessment indices (EDI, THQ, HI and TR) evaluated for this study showed moderate to high risk levels with respect to human exposure through consumption of vegetables. Entrance of Pb and Cd in the food chain is a matter of concern. Thus, regular monitoring of heavy metals in vegetables in this region is strongly recommended and necessary steps should be taken to reduce the probable sources of contamination.

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Conflict of Interests

The authors declare no conflict of interest.

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