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# Contamination Level of Heavy Metals in Vegetables and Soils of Lalmonirhat in Bangladesh

**Md. Matiar Rahman[1*] and Salina Rahman[1]**

[1]*Department of Chemistry, Bangabandhu Sheikh Mujibur Rahman Science and Technology University, Gopalgonj-8100, Bangladesh.*

***Authors' contributions***

*This work was carried out in collaboration between both authors. Author MMR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors MMR and SR managed the analyses of the study. Author MMR managed the literature searches. Both authors read and approved the final manuscript.*

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## ABSTRACT

Vegetables are an important source of nutrients and play a vital role in maintaining good health. Nowadays, vegetables are destroyed by a variety of unwanted contaminants which have become a serious problem. Eating contaminated vegetables can lead to many ailments and disrupt normal body functions. Therefore, the key objective of this study is to determine the contamination level of heavy metals in known vegetables and their growing soils in Lalmonirhat, Bangladesh; Consumers' health risks are assessed by targeted health factor (THQ) and target cancer risk (TCR) analysis. Average concentrations of Mn, Fe, Cu, Zn, Cd and Pb in vegetables were 30.83, 429.27, 9.91, 32.19, 0.58, 8.88 mg/kg, as well as 240.83, 3690.45, 22.88, 65.87, 0.69 and 11.58 mg/kg in growing soils. Concentrations of heavy metals were compared with the recommended value of the World Health Organization and the average Fe, Pb, and Cd concentrations in leaf, fruit and root vegetables exceeded the allowable limit. In addition, the value of TSQ and carcinogenic parameters in leaf, fruit, and root vegetables was higher than 1.0 for Fe and Pb. Therefore, the THQ of Fe and Pb is harmful to humans. Also, the risk of cancer exceeds the USEPA risk threshold ($>10^{-6}$) and the TCR of Pb shows a higher cancer risk, whereas Cd risk is higher. Therefore, the use of this vegetable is of concern and it is strongly recommended to monitor it regularly.

**Corresponding author: Email: matiar@bsmrstu.edu.bd;*

*Keywords: Lalmonirhat; vegetable; soil; heavy metal; contamination.*

## 1. INTRODUCTION

Currently, significant metal pollution may be a terribly dangerous environmental drawback not solely inside the developing country like the People's Republic of Bangladesh however additionally it's a heavy problem globally [1]. The rise of industrial enterprise, varied chemical fertilizers, pesticides and herbicides grime the soil, water and air in agriculture with significant metals. In addition, the capricious disposal of house wastage, animal manure and unused metal elements are very important causes of soil and water contamination [2,3]. The exterior door of significant metal into the food cycle is also a significant manner for humans to express to significant metal [1,4]. The vegetable is an important part of the human diet and a very important supply of minerals and vitamins. Plants similarly as foliose vegetables absorb some significant metals from metal mixed soil. Most of the significant metals are usually placed inside the air in many elements of the vegetable [5]. Significant metals are the main pollutants inside the food chain, which can have an effect on the common biological process worth of vegetables and ultimately these become harmful to human health [6]. Consumption of the significant metal-contaminated vegetables causes significant metals inside the anatomy, damages the polymer inside the body, alters the genetic writing and lowers the energy of the anatomy [7]. Exposure to sure metals, like mercury and lead, can also cause response disorders like inflammatory disease and nephropathy. Also, they inhibit the standard functions of the liver, kidneys and heart [8-9]. Generally, significant metals form a metal advanced complex with the thiol, amino and imino parts of proteins. As a result, proteins lose they are biological operate and cause cell breakdown [10]. Similarly, significant metals have an effect on the vegetative functions of plants and slow biological process, chlorosis, metabolism and plant growth [10].

Recently, many countries have begun to watch and evaluate heavy metals in foods and vegetables. However, there is insufficient information on the extent of heavy metal contamination in Bangladesh. Plants within the study area are polluted due to industrialization, geographical location, household activities and excessive use of fertilizers. Therefore, this study aims to work out the amount of heavy metals in most edible vegetables and to assess the danger of cancer and non-cancer in consumers' health through TSQ and TCR analysis.

### 1.1 Geographical Location of the Study Area

Lalmonirhat district which is located on the northern a part of the People’s Republic of Bangladesh. It’s a neighbourhood of the Rangpur Division. It’s encircled by Kochbehar, Jalpaiguri in northwest Bengal, Rangpur within the south, Kurigram within the east and Nilfamari within the west. Lalmonirhat District International border is 281.6 Km. It lies between 26°00 North latitude and 89°25 East longitudes.

## 2. MATERIALS AND METHODS

### 2.1 Sample Collection and Preparation

The leaves, fruits and root vegetables of various species as well as the growing soil of those places were randomly collected from nine related sites in Lalmonirhat, Bangladesh. An outline of vegetables grown during this area is presented in Table 1.

Vegetable samples were washed with water and thus edible parts of the vegetables were cut into small pieces. To get a stable weight, the samples

**Table 1. Description of studied vegetables cultivated in Lalmonirhat locality**

| Sl. no. | Local identity | Common name | Vegetable type | Scientific name | Sample ID |
|---|---|---|---|---|---|
| 01 | Laal Shak | Red Spinach | Leafy Vegetable | *Amaranthus gangeticus* | LS |
| 02 | Palang Shak | Spinach | Leafy Vegetable | *Spinacia oleracea* | PS |
| 03 | Kalme shak | Water spinach | Leafy Vegetable | *Ipomoea aquatic* | KS |
| 04 | Fulcopi | Cauliflower | Fruit Vegetable | *Brassica oleracea botrytis* | FK |
| 05 | Tomato | Tomato | Fruit Vegetable | *Solanum lycopersicum* | TO |
| 06 | Papa | Papaya | Fruit Vegetable | *Carica papaya* | PP |
| 07 | Begoon | Egg Plant | Fruit Vegetable | *Solanum melongena* | BG |
| 08 | Olcopi | Kholrabi | Root Vegetable | *Brassica oleracea* | OK |
| 9 | Moola | Radish | Root Vegetable | *Raphanus raphanistrum* | MU |

were air-dried and 100°C. The soil samples were dried in air at atmospheric temperature and placed in fine powder. Vegetable and soil samples (Mn, Fe, Cu, Zn, Pb, Cd) were absorbed to detect heavy metal concentrations [11]. The concentration of heavy metals within the digestible solution decided employing a nuclear adsorption spectrophotometer (Shimatsu AA-AT1000). The analysis was performed by a general practice described by Era et al., Naja et al [12,13]. All data were calculated using the Statistical Package (SPSS) version 16.0 for Microsoft Excel 2010 and Social Sciences.

## 3. RESULTS AND DISCUSSION

Vegetables are an indispensible part of the human diet and play a vital role in preventing life-threatening diseases. Unfortunately, the largest part of the essential foods is contaminated with heavy metals, which turn into a problem nationally and internationally. Heavy metals give the idea within the crust and are let off the hook decay within the atmosphere. Some heavy metals like Mn, Fe, Cu and Zn are nutrients that are obligatory for the biological functions of the physical body. On the opposite hand, an organism doesn't need Cd and Pb, in order that they are considered toxic elements in nature. To assess the health risks of the Lalmonirhat population in Bangladesh, the contamination level of heavy metals in commonly used vegetables and harvested soil are measured and displayed in Table 2. The mean concentration of Mn, Fe, Cu, Zn, Cd and Pb is 33.91, 356.71, 10.27, 33.59, 0.57 and 9.76 mg/kg in vegetables respectively. During present study, the decomposition of heavy metals in leaf, fruit and root vegetables was determined as Fe> Mn> Zn> Cu> Pb> Cd, Fe> Zn> Mn> Cu> Pb> Cd, Fe> Mn - Zn> Pb> Cu> Cd respectively. Mn, Fe and Cu (excluding Zn, Cd and Pb) concentrations are greater in leafy vegetables than in fruit and root vegetables. Iron is a crucial a part of the human body for physical activity, like the formation of hemoglobin. The tolerance limit is useful to humans, but large doses (450 mg/kg) can cause harmful side effects of the alimentary canal. Additionally, the very best Fe is found altogether vegetables starting from 99.25 to 1661.30 mg/kg counting on the species of the tree. Generally, Fe is involved in photosynthesis and chlorophyll synthesis. As a result, leafy vegetables have higher Fe than fruit and root vegetables [14-17].

Because of the low solubility, Pb and Cd are easily concentrated within the soil and most of the time in the atmosphere. Occasional exposure can cause autoimmune disorders like arthritis and renal disorder in the body [8,18-21]. To estimate the pollution rate, heavy metal concentrations were compared with the previously referred value [22–24] identified by FAO / WHO and other similar studies (Table 3) consistent with Figs. 1 and 2, it is often seen that the concentration of Fe, Cd and Pb in vegetables exceeds the allowable limit. The typical density of the Cd is above the other studied result except Varanasi, India and Rajshahi, Bangladesh. Furthermore, the mean concentration of Pb was found to be above all other studies. This will be explained by various sources, including automobile smoke, Leclanche cell batteries, sewage, waste and therefore the advent of heavy vehicles moving faraway from atmospheric deposits. Likewise, the utilization of organic and volatile fertilizers, fungicides, pesticides, fertilizers and biomaterials in their respective areas contributes to the quantity of those heavy metals [25-27].

Cancer and non-cancer health risks were calculated and therefore the results of EDI, HI, THQ and TCR are presented in Table 4 [22]. When comparing the EDI values of heavy metals with relative reference levels (DF), we found that the EDI values of Pb and Cd were above DF for all vegetables, whereas the EDI values of Fe were above that of leaf and DF fruits and vegetables. During this regard, the NY State Department of Health (NYSDO) suggests that if the EDI / DF ratio is a smaller amount than or adequate to DF, the danger is lower. But if this ratio is 1 to five times above DF, the danger is lower. If it's 5 to 10 times above TF, the danger is moderate and if the TF is 10 folds greater, the danger is higher [34]. During this study, the ratio of PT (ETI/TF) to all or any sorts of vegetables was many times above the corresponding TF, indicating its potential for health. The comparison of contamination Level of Heavy Metals in Vegetables with the standard value is shown in the Figs. 1 and 2.

It is a possible risk factor for cancer-free health risks and a suitable guideline value for THQ is $\leq$ 1.0 [19]. Consistent with Ambedkar and Manian, if an individual's THQ value for heavy metal exceeds its tolerance limit, this will cause unhealthy health consequences for humans [35]. During this study, the TSH values of most heavy metals are below the allowable range of Fe (2.5788) and Pb (8.0196); Fe (1.7596) and Pb (5.0581) for fruit vegetables; Fe (1.0074) and Pb (8.2116) for root vegetables. Therefore, TSQ analysis indicates that Fe and Pb are harmful to those living during this cancer-free region. Furthermore, the combined effect of all metals (HI) is above the allowable range (1.0) for all kinds of vegetables. Therefore, regular consumption of leafy vegetables and root vegetables may be a concern for the health risks of non-cancer patients. The value of TCR isn't only cancer that causes cancer but also the danger of cancer in humans [34]. During this study, the danger of cancer depends on the USEPA decision-making process. Long exposure to a specific cancer increases contact and get in touch with time. TCR sections are described consistent with NYSDOH; If the TCR value is a smaller amount than $10^{-6}$, the danger of cancer is low; When the worth is $10^{-5}$ to $10^{-3}$, the danger is moderate; However, the danger is higher and better, starting from $10^{-3}$ to $10^{-1}$ and greater than or equal to $10^{-1}$.

In the present study, the TCR of Cd ($5.2\times 10^{-2}$, $3.8\times 10^{-2}$, $5.9\times 10^{-2}$ for leafy, fruity and root vegetables respectively) is higher than that of Pb ($3.1\times 10^{1}$, $2.3\times 10^{1}$, $3.4\times 10^{1}$ for leafy, fruity and root vegetables respectively). So Cd is more in danger for cancer within the population. Therefore, the TCR of Pb and Cd may affect those within the study area.

Contamination level of Heavy metal was investigated, and Fe (3690.45), Mn (240.83), Cu (22.88), Zn (65.87), Cd (0.69) and Pb (11.58) mg were wont to identify potential sources of contamination. Calculating per kg, respectively (Table 5) the slope order of the heavy metal content is Fe> Mn> Zn> Cu> Pb> Cd. Furthermore, the quantity of individual heavy metals within the soil samples was compared with the quality value provided by Mahabusa et al. [17] (Table 5). Regarding pollution rates, concentrations of Fe-Cu, Zn, Cd and Pb were found to be within the allowable range, apart from Mn in L-04 and L-05. Additionally, the concentrations of heavy metals within the studied soils are often compared with those in other countries (Table 6). This study shows that the concentration of Fe, Cu and Zn in soil samples is less than in Bangladesh and other countries, while Mn, Cd and Pb show some exceptions.

**Table 2. Average concentrations of heavy metals (mg/kg) in vegetables**

| Sample ID | Mn | Fe | Cu | Zn | Cd | Pb |
|---|---|---|---|---|---|---|
| LS | 20.18 | 807.12 | 11.45 | 21.41 | 0.74 | 11.11 |
| PS | 23.18 | 665.12 | 12.43 | 48.13 | 0.78 | 12.02 |
| KS | 82.51 | 505.19 | 11.24 | 12.11 | 0.48 | 7.91 |
| FK | 8.21 | 322.41 | 3.89 | 35.11 | 0.39 | 4.42 |
| TO | 20.11 | 415.15 | 9.58 | 33.21 | 0.65 | 12.33 |
| PP | 10.03 | 237.12 | 8.12 | 45.36 | 0.52 | 6.24 |
| BG | 17.57 | 459.73 | 12.78 | 32.31 | 0.21 | 2.62 |
| OK | 36.33 | 300.01 | 8.75 | 30.18 | 0.59 | 11.50 |
| MU | 36.44 | 240.13 | 10.05 | 35.59 | 0.73 | 8.31 |
| Av. conc. in LV | 41.96 | 659.14 | 11.71 | 27.21 | 0.66 | 10.34 |
| Av. conc. in FV | 13.98 | 358.60 | 8.61 | 36.49 | 0.44 | 6.40 |
| Av. conc. in RV | 36.55 | 270.07 | 9.40 | 32.88 | 0.66 | 9.90 |
| Average | 30.83 | 429.27 | 9.91 | 32.19 | 0.58 | 8.88 |

*Where, Av. con = Average concentration, LV = Leafy vegetables, FV = Fruit vegetables, RV = Root vegetables*

**Table 3. Comparison of heavy metals (mg/kg dry weight) in vegetables with similar extracts**

| Location | Fe | Mn | Cu | Zn | Cd | Pb | References |
|---|---|---|---|---|---|---|---|
| Jashore | 190.3 | 33.30 | 9.32 | 28.23 | 0.52 | 5.44 | [12] |
| Dhaka | 1160.0 | --- | 17.63 | --- | 0.33 | 11.50 | [28] |
| Rajshahi | --- | 4.55 | --- | --- | 1.05 | 5.10 | [16] |
| Patuakhali | --- | --- | 42.35 | --- | 2.1 | 8.36 | [29] |
| Narayanganj | --- | --- | 9.36 | 19.75 | 0.167 | 3.70 | [30] |
| Misurata | --- | --- | 3.36 | 8.15 | 0.14 | 0.25 | [31] |
| Changxing | --- | --- | --- | --- | 0.035 | 0.039 | [32] |
| Varanasi | --- | --- | 22.40 | 48.63 | 1.52 | 1.16 | [33] |
| Lalmonirhat | 429.27 | 30.83 | 9.91 | 32.19 | 0.58 | 8.88 | Present study |

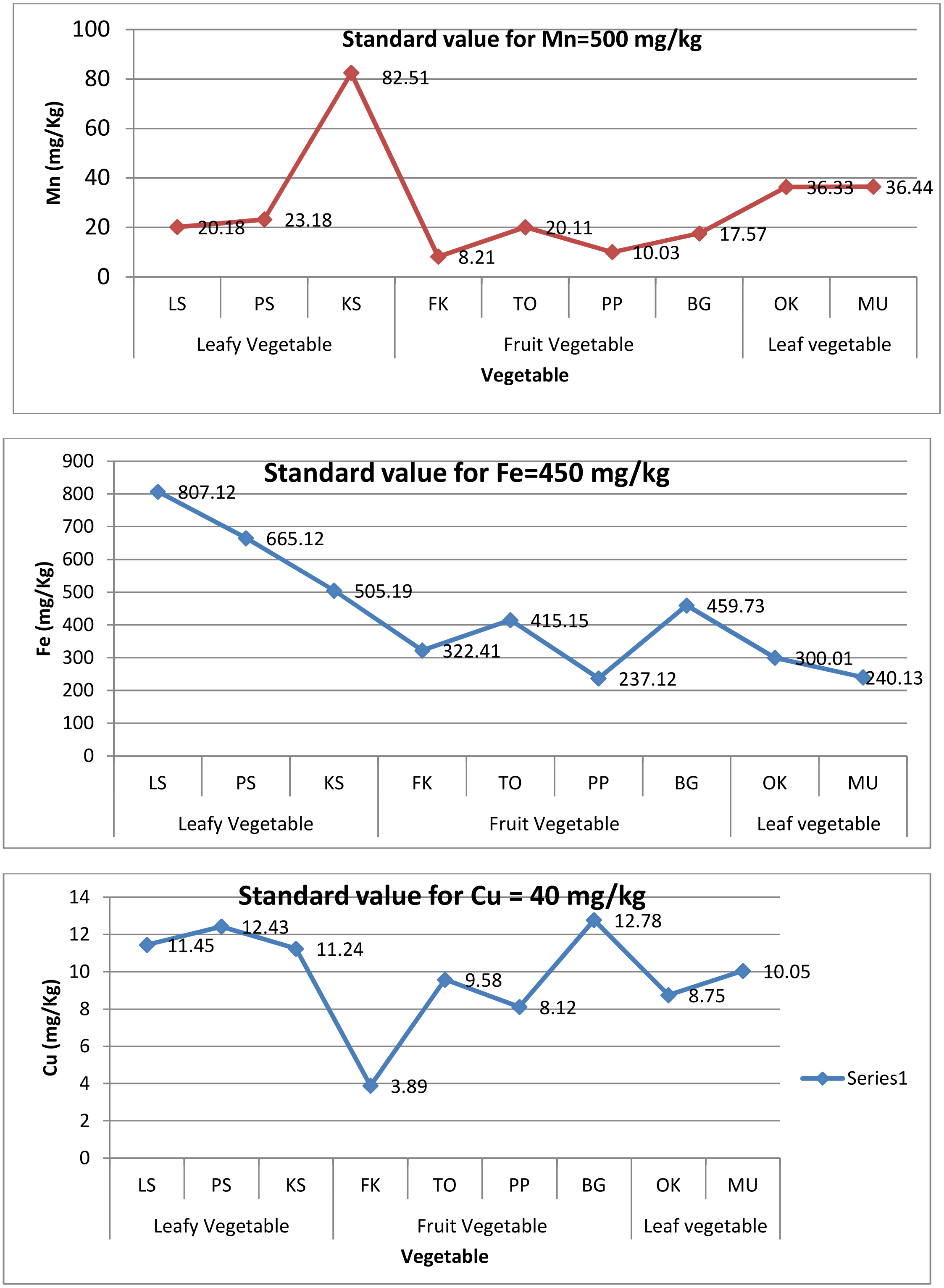


**Fig. 1. Comparison of contamination level of heavy metals in vegetables with the standard value**

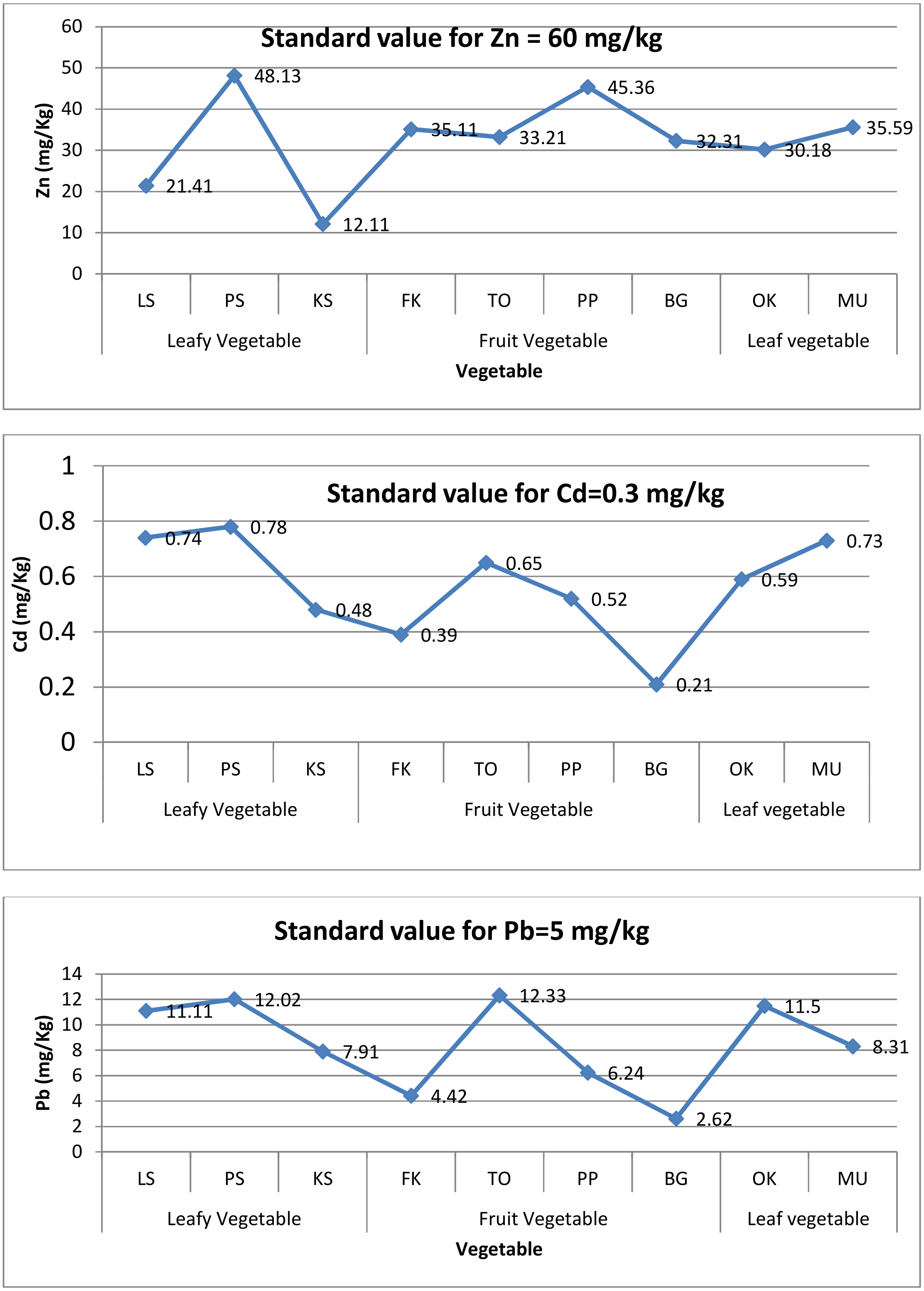


**Fig. 2. Comparison of contamination level of heavy metals in vegetables with the standard value**

**Table 4. Leafy, fruit and root vegetable's EDI, THQ, HI and TCR**

| Parameters | Sample types | Fe | Mn | Cu | Zn | Cd | Pb |
|---|---|---|---|---|---|---|---|
| EDI | Leafy Vegetable | 1.6052 | 0.1402 | 0.0468 | 0.0821 | 0.0381 | 0.0116 |
| | Fruit Vegetable | 1.3417 | 0.0451 | 0.0214 | 0.0944 | 0.0011 | 0.0127 |
| | Root Vegetable | 0.8352 | 0.0936 | 0.0201 | 0.0899 | 0.0016 | 0.0227 |
| THQ | Leafy Vegetable | 2.5288 | 0.8587 | 0.9199 | 0.2402 | 0.5413 | 8.0136 |
| | Fruit Vegetable | 1.7196 | 0.3223 | 0.5369 | 0.3148 | 0.3597 | 5.0541 |
| | Root Vegetable | 1.0174 | 0.6688 | 0.5029 | 0.2999 | 0.5481 | 8.2136 |
| HI | Leafy Vegetable | | | | 132.15 | | |
| | Fruit Vegetable | | | | 8.45 | | |
| | Root Vegetable | | | | 10.73 | | |
| TCR | Leafy Vegetable | | | | | $3.1\times 10^{1}$ | $5.2\times 10^{-2}$ |
| | Fruity Vegetable | | | | | $2.3\times 10^{1}$ | $3.8\times 10^{-2}$ |
| | Root Vegetable | | | | | $3.4\times 10^{1}$ | $5.9\times 10^{-2}$ |

**Table 5. Size of heavy metals (mg/kg) within the soil sample of Lalmonirhat, Bangladesh**

| Sampling sites | Mn | Fe | Cu | Zn | Cd | Pb |
|---|---|---|---|---|---|---|
| L-01 | 182.67 | 3760.77 | 35.14 | 49.5 | 0.71 | 11.97 |
| L-02 | 168.22 | 3865.64 | 34.62 | 63.78 | 0.86 | 10.78 |
| L-03 | 204.11 | 3768.39 | 17.81 | 72.76 | 0.71 | 12.49 |
| L-04 | 262.46 | 3748.97 | 15.56 | 64.84 | 0.85 | 11.17 |
| L-05 | 272.81 | 3843.24 | 24.2 | 71.75 | 0.73 | 11.47 |
| L-06 | 276.97 | 3742.68 | 18.72 | 61.74 | 0.62 | 11.38 |
| L-07 | 261.77 | 3856.95 | 23.53 | 66.85 | 0.59 | 9.08 |
| L-08 | 274.55 | 3739.19 | 23.65 | 74.86 | 0.64 | 12.78 |
| L-09 | 227.25 | 3838.84 | 17.43 | 84.75 | 0.6 | 12.48 |
| L-10 | 277.56 | 2739.87 | 18.19 | 47.86 | 0.66 | 12.17 |
| Mean | 240.83 | 3690.45 | 22.88 | 65.87 | 0.69 | 11.58 |
| Ref. value [17] | 270 | 40000 | 30 | 100 | 1 | 50 |

**Table 6. Average concentrations of heavy metals (mg/kg) in growing soil are compared with similar studies [12]**

| Study area | Mn | Fe | Cu | Zn | Cd | Pb | Ref. |
|---|---|---|---|---|---|---|---|
| Entire Bangladesh | 669.56 | 37247.15 | 54.29 | 202.81 | 1.26 | 9.4 | [17] |
| Jashore, Bangladesh | 199.38 | 3773.29 | 11.85 | 49.58 | 0.68 | 12.61 | [12] |
| Iswardi, Bangladesh | 283.50 | 15684.70 | 21.43 | 123.283 | 0.538 | 68.84 | [28] |
| Chittagong, Bangladesh | 160.79 | -- | 32.63 | 139.30 | 2.43 | 7.33 | [36] |
| Mymensingh, Bangladesh | 182.33 | 24683.33 | 49.10 | 123.19 | -- | 59.39 | [37] |
| Bogra, Bangladesh | -- | -- | 131.87 | 28.46 | 6.95 | 9.6 | [38] |
| Gazipur, Bangladesh | -- | -- | 36.18 | 176.66 | 0.2 | 75 | [39] |
| Dhaka, Bangladesh | -- | -- | 75.04 | 103.34 | 0.52 | 3.84 | [40] |
| Dhaka, Bangladesh | -- | 1715.80 | 39.14 | 115.43 | 11.42 | 49.71 | [1] |
| Rosetta, Egypt | -- | 65387.8 | 92.8 | 156.3 | 13.5 | 45.7 | [41] |
| West Africa | -- | 6224.92 | -- | 275.57 | 1.42 | 28.76 | [42] |
| Nador, Morocco | 263.00 | 76429.00 | 37.50 | 73.00 | -- | -- | [43] |
| Palermo, Italy | 519.00 | -- | 63.00 | 138.00 | 0.68 | 202 | [44] |
| Sialkot, Pakistan | -- | 17991.62 | 26.85 | 94.2 | 36.8 | 121.4 | [45] |
| Fuyang, China | -- | -- | 40.77 | 159.85 | 0.37 | 40.59 | [46] |
| Lalmonirhat, Bangladesh | 240.83 | 3690.45 | 22.88 | 65.87 | 0.69 | 11.58 | Present study |

## 4. CONCLUSION

From this study, we were able to set up a database on the contamination of well-known vegetables and heavy metals in the growing soil of Lalmonirhat in Bangladesh. Although concentrations of heavy metals in the soil are within the permitted limits, the concentrations of Fe, Cd, and Pb in vegetables exceed the safe limits recognized by the US FAO/WHO. Avoiding vehicle emissions, excessive use of wastewater in agricultural areas, pesticides and pesticides Human activities Heavy metals in vegetables, To assess consumers' health risks, various health risk indicators (EDI, THQ, HI and TCR) were calculated to control people's high health risks. Consuming contaminated vegetables is a major concern for cancer and cancer-free health activities. Therefore, stringent monitoring and effective measures should be taken to prevent heavy metals from entering the food chain.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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