Indian Journal of Environmental Sciences 24(2) 2020, pp.81-88. ISSN 0971-8958
Green Earth Foundation

HEAVY METALS IN FRUITS AND VEGETABLES GROWN IN VARIOUS PARTS OF THE WORLD: A REVIEW

Kashindye Richard Cherehani and Akanksha Singh Kachhawaha*
Institute of Forensic Science, Gujarat Forensic Science University, Gandhinigar, Gujarat India-382007
***Corresponding Author**: Email: akanksha.singh@gfsu.edu.in

Received: 28th June 2020; Accepted**:** 12th July 2020

ABSTRACT

Fruits and vegetables are produced in large quantity around the World. Vegetables and fruits are essential part of the diet of the humans in many parts of the world as they provide an important role in human nutrition as source of vitamins, proteins, minerals, carbohydrates, iron and other micronutrients. Both quality and quantity of vegetables and fruits are important aspects for nutrition value and heavy metals contamination in vegetables and fruits is considered as one of the most serious issues. The daily intake of heavy metal/s contaminated fruits and vegetables may cause potential risk to human health, hence assessment of heavy metal contamination is important in vegetables and fruits. These review paper summaries variousstudies conducted in various countries on heavy metal contamination in soil, water and the grown vegetables and fruit, and their health risks to human beings.

Keywords: Heavy metals, vegetables, fruits, health risk, wastewater.

INTRODUCTION

Vegetables and fruits containing important minerals,vitamins, proteins, carbohydrates, calcium, iron and fiber are essential for human health (Amin et al. 2013). When contaminated with high level of heavy metals they pose risk to human health (Anastácio et al. 2018, Ecsedi-Angyal et al. 2020). Heavy metals are introduced into the environment either by natural and anthropogenicsources.The presences of heavy metals have negative impacts on the quality of vegetables and fruits decreasing their nutritional value important to human beings.

The term heavy metals refer to those metals with relative high densities more than 4gcm-3. They can be classified as essential (trace) metals such as copper, zinc, iron, manganese, selenium, and cobalt, vanadium and non-essential metals such as arsenic, cadmium, lead, mercury, nickel. Heavy metals are found in the environment through either by natural or anthropogenic source. Above certain limits, these metals can also cause cardiovascular, nervous, kidney and bone diseases, as well as chromosomal aberrations, mutation and carcinogenic (Chen et al. 2014, Zhou et al. 2016). Heavy metals accumulation in the vegetables may depend on plant species as well as temperature, moisture, organic matter, growth stage, nutrient availability and bioavailability of heavy metals in the soil (Naser et al. 2011). Heavy metals are deposited in a large amount in the leafy parts of vegetables, as compared to fruit parts of the crops(Mapanda et al. 2005).Wastewater irrigation significantly contributes heavy metalsin to soils and the nearby water bodies (Singare et al. 2012). Heavy metals are slowly or gradually taken up by the vegetables and fruits grown at the wastewater irrigated fields (Ismail et al. 2005, Farooq et al. 2008).

A continuous consumption of heavy metals contaminated food may result in accumulation of these metals in the body organs, such as kidney and liver, causing a severe toxicity (Sharma et al. 2006). The discharge ofuntreated domestic and industrial wastewaters can pollute waters in the nearby lake or river (Singare et al. 2011). The treated water, reservoirs and groundwater are considered to be the primary sources of irrigation water in most farms throughout the world. The quality of irrigation water and soil have a considerable effect on both plants and human health(Mapanda et al., 2005). The diversity of heavy metals concentration in the soil and water vary from local to regional and even to continental level. Heavy metals are considered to be environmental pollutants because they are toxic, non-biodegradable and tend to bio-accumulate (Tóth et al. 2016). Therefore, analysis of heavy metals in samples such as water, vegetables and fruits, and soils has great important.The purpose of this paper is to review different studies that have been conducted around the world that report heavy-metal in fruits, and vegetables in levels higher than the recommended by the FAO/WHO.

Current Findings of Heavy Metal Contamination of Fruits and Vegetables in Different Countries

Vegetables are vulnerable to heavy metal contamination at their higher concentrations, and large-scale irrigation with wastewater and application of fertilizers for commercial production increase the risk of heavy metals contamination.

Al Jassir et al. (2005) concluded that vegetables sold in the markets at Riyadh city in Saudi Arabiashowed high heavy metals contamination due to atmospheric deposition of metals on vegetables foliar surfaces during production, transportation and marketing. The finding of the study in comparison with PTDI value suggests that the uptakes of metals through vegetable leaves would not cause any harm to consumer's health though become significant in light of reported daily intakes of Cd and Pb through diet in Saudi Arabia.

Sinha et al.(2006) reported that underground vegetables such as potato (11.81 μg g-1dw), garlic (19.27 μg g-1dw) and turmeric (20.86 μg g-1dw) accumulate the lowest concentration Cr in their edible part, than leafy and fruit vegetables grown in the treated tannery wastewater at Jajmau, Kanpur (India).

Radwan & Salama (2006) have conducted a study to assess heavy metals concentration of zinc (Zn), copper (Cu), cadmium (Cd), and lead (Pb), in various fruits and vegetables sold in Egyptian markets. Their concentrations ranged from 1.36 to 20, 0.83 to 18.3, 0.01 to 0.15 and 0.01 to 0.879 mg/kg for Zn, Cu, Cd and Pb, respectively. Heavy metals concentration of Pb, Cd, Cu and Zn were found to be higher in strawberries, cucumber, date and spinach respectively. The results of this study suggested that there is no significant health hazard to the consumers since the daily intake of metals through vegetables were observed to be below the standard acceptable tolerable level established by FAO/WHO.

Lokeshwari & Chandrappa (2006) reported thatsewage-fed lake water irrigated vegetables such as spinach (*Spinacea oleracea* locally called palak), radish (*Raphanus sativus*), brinjal (*Solanum melongena*), beans (*Phaseolus vulgaris*) and fruits – banana (*Musa paradisica*) are contaminated with heavy metals andCd concentration in spinach (4 μg g-1) and radish (2.5 μg g–1) was beyond the permissible limit. The finding of the study indicates that sewage is the main source of pollution of this lake water.

Tuzen & Soylak (2007) reported that canned foods marketed in Turkey contain heavy metals (μg/g) in the range of 2.85–7.77 for copper, 8.46–21.9 for cobalt, 6.46–18.6 for manganese, 27.5–79.6 for iron, 0.05–0.35 for aluminum, for selenium, 0.93–3.17, 0.19–0.52 for chromium, 0.18–0.75 for nickel, and for zinc, 0.20– 1.10. It is concluded that heavy metals detected in canned foods were within the tolerable daily intake limit; hence it's safe for human consumption.

Farooq et al. (2008) reported Cr, Cd, Cu, Pb and Zn concentration in the vegetables below the recommended standard limits of FAO/WHO, but the leaves of cauliflower, cabbage, spinach, coriander and radish accumulated higher concentrations of Cr (0.546 mg kg^{-1}), Cd (0.073 mg kg^{-1}), Cu (0.923 mg kg^{-1}), Pb (2.652 mg kg^{-1}) and Zn (1.893 mg kg^{-1}) as compared to other edible parts of vegetables such as root, stem and fruit grown in the effluent irrigated fields in an industrial area of Faisalabad, Pakistan. The substantial variation in the metal concentrations among the vegetables analyzed might be because of geological status of the area under study and the ability of plants to uptake and accumulate metals.

Sharma et al. (2009) have conducted a study of heavy metal concentrations in vegetables collected from production and market sites of a tropical urban area of India. The results showed the levels of Zn in lady's finger, palak and cauliflower, respectively, varied from 29.6 to 39.2, 30.1 to 45.5, and 38.6 to 63.3 lg/g, of Cu varied from 9.5 to 21.8, 12.8 to 25.6 and 9.8 to 24.1 l1 μg/g, of Cd varied from 0.5 to 1.2, 0.4 to 1.5, and 0.6 to 2.1 l μg/g, and of Pb varied from 0.3 to 1.2, 0.7 to 1.4 and 0.2 to1.8 l μg/g, respectively, at the production sites. The results of the study suggests that the transportation and marketing of vegetables in contaminated environment contributes to increase in levels of heavy metals in both vegetables collected from production and market sites through surface deposition (Sharma et al. 2009). Thus may pose risk to the consumers.

Mohammed & Khamis (2012) collected vegetable samples from farms and urban markets in Zanzibar. After analysis of the samples it was observed that Zn, Fe, Cr and Mn were in higher concentrations in amaranth and Cd, Ni and Pb in cabbage. All mean concentrations of the heavy metals were within the acceptable permissible range except Pb and Cd were in concentrations above recommended tolerable limits of FAO/WHO. It is concluded that consumption of amaranth and cabbage containing higher concentration ofheavy metals may be hazardous to health of the consumers in Zanzibar.

Elbagermi et al. (2012) reported heavy metals in the fruits and vegetables collected from production and market sites in the Misurata area of Libya. Their average concentrations ranged from 0.02 to 1.824, 0.75 to 6.21, 0.042 to 11.4, 0.141 to 1.168, 0.19 to 5.143, and 0.01 to 0.362 mg/kg for Pb, Cu, Zn, Co, Ni, and Cd, respectively. Mean concentration levels of Pb, Zn, Cu, Co, Ni and Cd were detected in higher concentrations in melon, spinach, banana and mango fruits.

Lente et al. (2014) anlyzed metal contents (mg/kg) in the vegetable crops irrigated with wastewater from some parts of Accra were within the standard limit except for Pb in lettuce (10.19 mg/kg), hot pepper (7.61 mg/kg), green pepper (9.44 mg/kg), cabbage, (10.51 mg/kg), and ayoyo (9.05 mg/kg) compared to the FAO/WHO tolerable limit of 0.30 mg/kg for Pb.

Tasrina et al. (2015) investigated source and extent of metal content in different vegetables such as potato, red amaranth, spinach amaranth, carrot, tomato, cabbage and brinjal grown at Paksey, Bangladesh.The concentration of Ni, Cd, Cr, Cu, Co, As (<0.1 mg/kg) and As (<0.03 mg/kg) were found to be below the detection limits whereas of Fe, Mn, Zn were below the permissible limit recommended by WHO respectively. Only lead (Pb) concentration in the vegetables was found at toxic level varying from 0.119 mg/kg to 1.596 mg/kg. The highest lead concentration was found in spinach amaranth (1.596 mg/kg) while it was lowest (0.119 mg/kg)in cabbage. It is concluded that all vegetables grown at Paksey, Bangladesh are not hazardous to human consumption but monitoring should be taken to prevent excessive exposure of heavy metals to the vegetables and environments.

Shaheen et al. (2016) reported that concentrations of heavy metal exceeded the maximum allowable concentration (MAC) set by FAO/WHO for Pb in mango and Cd in tomato among the analyzed fruits and vegetables by inductively coupled plasma mass spectrometry (ICP-MS) in Bangladesh. Pb content in mango was found to be six times higher than the safe limit at production level. THQs of Mn and Cu were >1 for all vegetables, this finding suggests that thehuman consuming these vegetables are in danger of getting cancers and other human disorders.

Rehman et al. (2018) reported heavy metals like copper (Cu), zinc (Zn), chromium (Cr), nickel (Ni), and manganese (Mn) in agricultural soils and food-crops (fruit, leafy and root vegetables), grown in southern selected districts of Khyber Pakhtunkhwa Province, Pakistan. All heavy metals in vegetables were found to be within the acceptable permissible risk limits, except for Cr observed in a higher concentration in all analyzed food-crops in the selected sites in Pakistan. It is concluded that the vegetables were safe for human health as the values of health risk index (HRI) for the heavy metals were less than 1.

Nassar et al.(2018) analyzedheavy metal levels in some popular vegetables from selected markets in the Saudi Arabia. 15 vegetable species consisting of five leafy {Arugula (*Eruca sativa*), Cabbage (*Brassica oleracea*), Corchorus (*Corchorus capsularis*), Dill (*Anethum graveolens*) and Parsley (*Petroselinum sativum*)} five fruits {Cucumber (*Cucumis sativus*), Eggplant (*Solanum melongena*), Green pepper (*Capsicum annuum*), Tomato (*Solanum lycopersicum*) and Zucchini (*Cucurbita pepo*)}and five tubers {Garlic (*Allium sativum*), Onion (*Allium cepa*), Radish (*Raphanus sativus*), Potato (*Solanum tuberosum*) and Yam (*Ipomoea batatas*)} purchased from the local markets in Rafha Governorate at the Northern Border region in Kingdom of Saudi Arabia were tested for levels of cadmium (Cd), lead (Pb), arsenic (As), iron (Fe), copper (Cu) and zinc (Zn) metals. The levels of Cd, Pb, As, Fe, Cu and Zn ranged from 0.13±0.073 to 1.63±0.96; 0.33±0.18 to 5.38±2.67; 0.020±0.001 to 0.052±0.033; 0.41±0.09 to 10.81±7.29; 0.49±0.13 to 4.37±0.89 and 2.05±0.80 to 94.20±73.28µg/g respectively for all vegetable samples. The highest average concentrations of Cd, Pb, As, Fe, Cu and Zn were recorded in the leafy species as 0.46±0.19 to 1.63 ± 0.96; 0.00 to 5.38 ± 2.67; 0.00 to 0.049±0.031; 2.95±1.47 to 10.81±1.29; 1.42±0.73 to 4.37±0.89; 4.63±1.37 to 21.99±18.60µg/g, respectively. The highest mean levels 94.20±73.28 and 10.81±7.29µg/g were recorded for Zn and Fe in potato and Corchorus respectively; while the lowest mean levels 0.13±0.073 and 0.33±0.18µg/g were recorded for Cd and Pb in garlic and radish, respectively.

Altarawneh (2019) reported levels of selected heavy metals (Pb, Ni, Cd, and Cr) in various widely consumed fruits (banana, apple, and orange) and vegetables (green pepper, cucumber, potato, onion, and tomato) in Jordan by using Atomic Absorption Spectrometry. The results showed that

Pb, Ni, Cd, and Cr concentration varied signiûcantly among samples. Pb, Ni, Cd, and Cr concentration were found to be in the range of 0.33–1.00µg/g-dw,0.81–2.13µg/g-dw,0.07–1.25µg/g-dw,and0.81–2.43 µg/g-dw, respectively. The highest mean levels of Pb (1.0 µg/ g-dw) and Cd (1.25 µg/g-dw) were found in potato while the lowest values in apple (0.33 µg-Pb/g-dw, and 0.07 µg-Cd/g-dw). The lowest concentrations of Ni (0.81 µg/g-dw) and Cr (0.81 µg/g-dw) were recorded in green pepper and banana, respectively, whereas the maximum bioaccumulation of Ni (2.13 µg/g-dw) and Cr (2.43 µg/ g-dw) was detected in orange. The results from this study suggest that long-term consumption of fruits and vegetables is hazardous to human health.

Gebeyehu & Bayissa (2020) reported levels of As, Pb, Cd, Cr and Hg higher thanpermissible limits in the vegetable samples in Mojo area, Ethiopia with concentrations ranging from 1.93–5.73, 3.63–7.56, 0.56–1.56, 1.49–4.63 and 3.43–4.23 mg/kg, respectively. It was observed that leafy vegetable (cabbage) accumulated heavy metals to greater extent compared with tomato. Also the target hazard quotient (THQ) of heavy metals for cabbage intake found were also > 1 for As (5.994), Hg (4.425) and Co (1.946). Similarly THQ for tomato intake were > 1 for As (2.019) and Hg (3.588). The target hazard quotient of both tomato and cabbage indicates that long term consumption of these vegetables had potential risk to human health and can cause disorders like cancer to the exposed population.

Table1. Heavy metals in vegetables of different regions

S. No	Heavy metal	Vegetables/fruits/crops	Area	References	Remarks
1	Fe, Zn, Mn, Cu and Cr	amaranth, bitter gourd, black mustard, bottle gourd, cauliflower, chillies, coriander, cucumber, eggplant fenugreek, garlic, hemp jack tree, kidney bean, maize, okra, pig weed potato spinach, sudan grass, sugarcane, turmeric, vegetable sponge, wheat, yellow mustard	India	Sinha et al. 2006	Heavy metals accumulated more in leafy vegetables than non-leafy vegetables/ crops and Cr in leafy vegetables was found more than in fruit bearing vegetables/crops
2.	Zn, Cu, Cd and Pb	Strawberries, cucumber, date and spinach, potato,spinach, cabbage,mango, orange, watermelon, carrot, tomato,banana, onion, garlic, eggplant, melon, apple, lettuce.	Egypt	Radwan & Salama 2006	The highest mean levels of Pb, Cd, Cu and Zn were detected in strawberries, cucumber, date and spinach.
3.	Fe, Zn, Cu, Ni, Cr, Pb and Cd	Spinach, radish, brinjal, beans and banana.	India	Lokesh-wari & Chandrappa 2006	Some of heavy metals in rice and vegetables were beyond the limits of Indian standards
4	Cu, Zn, Mn, Fe, Se, Al, Cr, Ni and Co	mushroom, corn, pea, mixed vegetable, tomato, red mullet, stuffed grape leaves, pickle, bean, delicatessen	Turkey	Tuzen & Soylak 2007	Heavy metals in canned foods were within the tolerable daily intake limit, hence safe for human consumption
5	Pb, Cu, Cr, Zn and Cd	Spinach, coriander, lettuce, radish, cabbage and cauliflower	Pakistan	Farooq et al. 2008	Pb and Cd were maximum in the leafy vegetables than other metals
6	Cu, Cd, Zn and Pb	Spinach, Lady's finger Cauliflower	India	Sharma et al. 2009	Cd concentration in vegetables from both production and market sites was higher than the EU standard

7	Al, Cr, Mn, Fe, Ni, Zn, Cu, Ag, I, Br, Cd and Pb	Amaranth, cabbage	Zanzibar	Mohammed & Khamis 2012	Pb and Cd found above recommended tolerable limits of FAO/WHO
8	Pb, Cu, Zn, Co, Ni, and Cd	strawberries, cucumber, date and spinach, potato,spinach, cabbage,mango, orange, watermelon,carrot, tomato,banana, onion, garlic, eggplant, melon, apple, lettuce	Libya	Elbagermi et al. 2012	Heavy metals were within the tolerable limits prescribed by the WHO
9	Fe,Mn, Cu, Zn,Pb, Ni, Cr, Cd, Co	Cabbage, lettuce, green pepper, "ayoyo" and hot pepper.	Ghana	Lente et al. 2014	Hazard indexes for vegetables were below 1 hence safe for human consumption
10	Ni, Cd, Cr, Cu, Co, As	Potato, red amaranth, spinach amaranth, carrot, tomato, cabbage and brinjal	Banglad esh	Tasrina et al. 2015	Pb concentration in all vegetables was higher level than that of the permissible limits of different International standards.
11	As, Cd, Pb, Cr, Mn, Ni, Cu and Zn	Brinjal, bean, carrot, green chilli, onion, potato, and tomato and banana, jackfruit and mango	Banglad esh	Shaheen et al. 2016	Pb content in mango was six times higher than the safe limit
12	Cu, Zn, Cr, Ni, and Mn	Wheat, barley, maize, rice, sugarcane, cucumber, bitter melon, ridge gourd, onion, garlic, mint, lady finger, squash-melon, lettuce, spinach, pea, pumpkin, cabbage, cauliflower, potato, bringal, turnips, pepper, carrot, radish, tomato, yam, purslane, Chinese onion, and coriander	Pakistan	Rehman et al. 2018	Cr concentration was higher in all analyzed food-crops
13	Cd, Pb, As, Fe, Cu and Zn.	Arugula, cabbage, corchorus, dill, parsley, cucumber, eggplant, green pepper, tomato, zucchini, garlic, onion, radish, potato and yam	Saudi Arabia	Nassar et al. 2018	Heavy metals in these vegetables were within safe limit levels for human consumption
14	Pb, Ni, Cd, and Cr	Banana, apple, orange, green pepper, cucumber, potato, onion, and tomato	Jordan	Altarawneh 2019	Pb, Cd, and Cr levels were exceeding the maximum allowable concentrations (MACs) of FAO/WHO,
15	Cr, Cd, Zn, Fe, Pb, As, Mn, Cu, Hg, Ni and Co	Tomato, cabbage	Ethiopia	Gebeyehu & Bayissa 2020	Hazard indexes (HI) of both vegetables were > 1. This indicates that long-term consumption had potential health risk to consumers

Table 2. Comparison of lead and cadmium in vegetables published from different parts of the world.

	Heavy metal concentration (mg/kg)											
	India[a]		Jordan[b]		Saudi Arabia[c]		Pakistan[d]		Bangladesh[e]		Bangladesh[f]	
vegetables	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd	Pb	Cd
Cabbage	NA	NA	NA	NA	2.30-3.65	0.40-0.77	1.92±0.04	0.07±0.01	NA	NA	0.12±0.01	<0.1
Tomato	NA	NA	0.85 0.04	1.08 0.08	2.15-3.93	0.20-0.44	NA	NA	0.005±0.01	0.056±0.01	0.161±0.01	<0.1
Banana	NA	NA	0.37 ± 0.05	0.08 ± 0.01	NA	NA	NA	NA	0.003 ± 0.003	NA	NA	NA
Cauliflower	0.20-1.80	0.60-2.10	NA	NA	NA	NA	1.29-1.37	0.06-0.07	NA	NA	NA	NA
Spinach	NA	NA	NA	NA	NA	NA	2.25 ±0.09	0.04 ±0.001	NA	NA	NA	NA
Potato	NA	NA	1.00±0.15	1.58±0.07	0.28-0.62	0.15-0.37	NA	NA	0.01±0.01	0.01±0.01	0.38±0.02	<0.1
Onion	NA	NA	0.74±0.06	1.03±0.05	NA	NA	NA	NA	0.03±0.02	0.02±0.02	NA	NA
Cucumber	NA	NA	0.93±0.13	0.93±0.03	NA	NA	NA	NA	NA	NA	NA	NA
Egg plant	NA	NA	NA	NA	4.10-7.10	0.30-0.59	NA	NA	0.01±0.01	0.04±0.03	0.47±0.01	<0.1
Mango	NA	NA	NA	NA	NA	NA	NA	NA	0.64±0.56	0.01±0.0		
WHO/FAO safe limits	5	0.3										

[a](Sharma et al. 2009), [b](Altarawneh 2019), [c](Nassar et al.2018), [d](Farooq et al. 2008), [e](Shaheen et al. 2016) and[f](Tasrina et al. 2015)

Table 3. Comparison of iron and nickel in vegetables published from different parts of the world

	Heavy metal concentration (mg/kg)									
	Ethiopia[a]		Ghana[b]		Turkey[c]		Zanzibar[d]		Bangladesh[e]	
vegetables	Ni	Fe	Ni	Fe	Ni	Fe	Ni	Fe	Ni	Fe
Cabbage	4.13 ±0.20	490.5 ±3.18	1.77± 1.03	37.19± 7.39	0.18± 0.02	47.7 ± 3.7	MDL	574.2 ± 72	<0.1	7.28 ± 0.14
Tomato	1.86 ±0.05	85.10 ±0.17	NA	NA	NA	NA	NA	NA	0.16± 0.01	6.44 ± 1.8
Cauliflower	NA	NA	NA	NA	NA	NA	NA	NA	<0.1	6.93 ± 0.71
Spinach	NA	NA	NA	NA	NA	NA	NA	NA	0.54± 0.02	58.09 ± 1.3
Potato	NA	NA	NA	NA	NA	NA	NA	NA	<0.1	68.67 ± 4.53
WHO/FAO safe limit	67	425								

[a](Gebeyehu & Bayissa 2020), [b](Lente et al. 2014), [c](Tuzen & Soylak 2007), [d](Mohammed & Khamis 2012) and [e](Farooq et al. 2008).

Table 4. Comparison of zinc and copper in vegetables published from different parts of the world.

	Heavy metal concentration (mg/kg)											
	India[a]		Saudi Arabia[b]		Egypt [c]		Pakistan[d]		Bangladesh[e]		Bangladesh[f]	
vegetables	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu
Cabbage	NA	NA	2.91-6.74	3.57-4.67	2.30-3.65	0.40-0.77	0.54 ±0.05	0.16 ±0.01	NA	NA	2.65± 1.23	NA
Tomato	NA	NA	14.20-174.2	0.73-0.59	6.17–9.81	1.36–2.11	NA	NA	2.0 ± 0.2	9.72 ± 0.56	2.82 ± 1.86	NA
Banana	NA	NA	NA	NA	4.00–6.12	2.14–2.68	NA	NA	0.24 ± 0.003	0.95± 0.04	NA	NA
Cauliflower	38.60-63.30	9.80-24.1	NA	NA	NA	NA	0.68 ±0.05	0.21 ±0.02	NA	NA	NA	NA
Spinach	NA	NA	NA	NA	18.0–22.8	3.50–5.90	0.46 ±0.02	0.92 ±0.03	NA	NA	NA	NA
Potato	-	-	21.84-79.13	0.75-0.93	6.11–8.90	0.59–0.98	NA	NA	3.02 ± 3.0	4.3 ± 0.51	3.09 ± 0.64	NA
Onion	NA	NA	6.40-55.34	0.68-1.75	11.1–11.9	1.25–1.98	NA	NA	3.45 ± 0.13	3.63± 0.31	NA	NA
Cucumber	NA	NA	0.65-3.46	0.91-0.79	16.2–26.9	4.11–8.34	NA	NA	NA	NA	NA	NA
Egg plant	NA	NA	2.33-5.48	0.54-0.53	8.76–15.3	1.22–1.98	NA	NA	0.567 ± 0.03	6.82± 0.55	3.21 ± 0.98	NA
Mango	NA	NA	NA	NA	NA	NA	NA	NA	0.60± 0.01	7.89± 0.31	NA	NA
WHO/FAO safe limits	60	40										

[a](Sharma et al., 2009), [b](Nassar et al., 2018),[c](Radwan & Salama. 2006),[d](Farooq et al., 2008), [e](Shaheen et al., 2016) and [f](Tasrina et al. 2015).

CONCLUSION

The metal contents in fruits and vegetables in different countries exceed the maximum permissible tolerable limit recommended by FAO/WHO. Their consumption can pose risk to human health. To avoid fruits and vegetables from heavy metals contamination, monitoring sources of heavy metals mayreduce exposure of soils, water, fruits and vegetables to high levels of heavy metals. Also continuous assessment of different kinds of fruits and vegetables in production sites and markets should be conducted to reduce exposure of heavy metals to human through consumption of contaminated food crops which can endanger the health of consumers.

REFERENCES

Al Jassir, M. S., A. Shaker and M. A. Khaliq. 2005. Deposition of heavy metals on green leafy vegetables sold on roadsides of Riyadh City, Saudi Arabia. Bulletin of Environmental Contamination and Toxicology75(5): 1020–1027.

Altarawneh, R. M. 2019. Levels of selected heavy metals (Pb, Ni, Cd, and Cr) in various widely consumed fruits and vegetables in Jordan. International Journal of Environmental Analytical Chemistry00(00), 1–8.

Amin, N. U., A. Hussain., S. Alamzeb and S. Begum. 2013. Accumulation of heavy metals in edible parts of vegetables irrigated with waste water and their daily intake to adults and children, District Mardan, Pakistan. Food Chemistry136(3–4): 1515–1523.

Anastácio, M., A. P. M. dos Santos., M. Aschner and L. Mateus. 2018. Determination of trace metals in fruit juices in the Portuguese market. Toxicology Reports5: 434–439.

Chen, Y., P. Wu., Y. Shao and Y. Ying. 2014. Health risk assessment of heavy metals in vegetables grown around battery production area. Scientia Agricola71(2): 126–132.

Ecsedi-Angyal, M., E. Tatár., M. Óvári., K. Kurin-Csörgei., G.Záray and V. G. Mihucz. 2020. Determination of low-level arsenic, lead, cadmium and mercury concentration in breast milk of Hungarian women. International Journal of Environmental Analytical Chemistry100(5): 549–566.

Elbagermi, M. A., H. G. M. Edwards and A. I. Alajtal. 2012. Monitoring of heavy metal content in fruits and vegetables collected from production and market sites in the Misurata area of Libya. ISRN Analytical Chemistry 1–5, doi:10.5402/2012/827645.

Farooq, M., F. Anwar and U. Rashid. 2008. Appraisal of heavy metal contents in different vegetables grown in the vicinity of an industrial area. Pakistan Journal of Botany40(5): 2099–2106.

Gebeyehu, H. R and L. D. Bayissa. 2020. Levels of heavy metals in soil and vegetables and associated health risks in Mojo area, Ethiopia. PLoS ONE15(1): 1–22.

Ismail, B. S., K. Farihah and J. Khairiah. 2005. Bioaccumulation of heavy metals in vegetables from selected agricultural areas. Bulletin of Environmental Contamination and Toxicology74(2): 320–327.

Lente, I., J. Ofosu-Anim., A. K. Brimah and S. Atiemo. 2014. Heavy metal pollution of vegetable crops irrigated with wastewater in Accra, Ghana. West African Journal of Applied Ecology22(1): 41–58.

Lokeshwari, H and G. T. Chandrappa. 2006. Impact of heavy metal contamination of Bellandur Lake on soil and cultivated vegetation. Current Science91(5): 622–627.

Mapanda, F., E. N. Mangwayana., J. Nyamangara andK. E. Giller. 2005. The effect of long-term irrigation using wastewater on heavy metal contents of soils under vegetables in Harare, Zimbabwe. Agriculture, Ecosystems and Environment107(2–3): 151–165.

Mohammed, N. K and F. O. Khamis. 2012. Assessment of heavy metal contamination in vegetables consumed in Zanzibars. Natural Science 4(8): 588–594.

Naser, Habib Mohammad Sultana, S., N. U. Mahmmud., Rebeca Gomes and S. Noor. 2011. Heavy metal levels in vegetables with growth stage. Bangladesh Journal of Agriculture Research 36: 563–574.

Nassar, O., H. Nasr., M. El-Sayed and A. E.-N. Kobisi. 2018. Heavy Metal levels in some popular vegetables from some selected markets in Saudi Arabia. Egyptian Journal of Botany 58(3): 627–638.

Radwan, M. A and A. K. Salama. 2006. Market basket survey for some heavy metals in Egyptian fruits and vegetables. Food and Chemical Toxicology 44(8): 1273–1278.

Rehman, Z. U., S. Khan., M. T. Shah., M. L. Brusseau., S. A. Khan and J. Mainhagu. 2018. Transfer of heavy metals from soils to vegetables and associated human health risks at selected sites in Pakistan. Pedosphere 28(4): 666–679.

Shaheen, N., N. M. Irfan., I. N. Khan., S. Islam., M. S. Islam and M. K. Ahmed. 2016. Presence of heavy metals in fruits and vegetables: Health risk implications in Bangladesh. Chemosphere152: 431–438.

Sharma, R. K., M. Agrawal and F. Marshall. 2006. Heavy metal contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bulletin of Environmental Contamination and Toxicology77(2): 312–318.

Sharma, R. K., M. Agrawal and F. Marshall. 2009. Heavy metals in vegetables collected from production and market sites of a tropical urban area of India. Food and Chemical Toxicology 47(3): 583–591.

Singare, P. U., A. G. Jagtap and R. S. Lokhande. 2011. Water pollution by discharge effluents from Gove Industrial area of Maharashtra, India: Dispersion of heavy metals and their toxic effects. International Journal of Global Environmental Issues 11(1): 28–36.

Sinha, S., A. K. Gupta., K. Bhatt., K. Pandey., U. N. Rai and K. P. Singh. 2006. Distribution of metals in the edible plants grown at Jajmau, Kanpur (India) receiving treated tannery wastewater: Relation with physico-chemical properties of the soil. Environmental Monitoring and Assessment 115(1–3): 1–22.

Tasrina, R. C. , A. Rowshon , A.M.R. Mustafizur , I. Rafiqul I and M.P. Ali. 2015. Heavy metals contamination in vegetables and its growing soil. Journal of Environmental Analytical Chemistry 02(03). DOI:10.4172/2380-2391.1000142.

Tóth, G., T. Hermann., M. R. Da Silva and L. Montanarella. 2016. Heavy metals in agricultural soils of the European Union with implications for food safety. Environment International 88: 299–309.

Tuzen, M., and M. Soylak. 2007. Evaluation of trace element contents in canned foods marketed from Turkey. Food Chemistry102(4): 1089–1095.

U. Singare, P., R. M. Mishra and M. P. Trivedi. 2012. Heavy Metal Pollution in Mithi River of Mumbai. Frontiers in Science 2(3): 28–36.

Zhou, H., W. T. Yang., X. Zhou., L. Liu., J. F. Gu., W. L. Wang., J. L. Zou., T. Tian., P. Q. Peng and B. H. Liao. 2016. Accumulation of heavy metals in vegetable species planted in contaminated soils and the health risk assessment. International Journal of Environmental Research and Public Health13(3):289. doi: 10.3390/ijerph13030289.