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Heavy Metal Contamination of Vegetables: How and How Much?

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Introduction

Heavy metals are very harmful contaminants in food and the environment, and these hazardous metals are non-biodegradable having long biological half-lives. The inferences associated with heavy metal contamination are illustrious concern, particularly in agricultural production systems. Most profound heavy metals and metalloid as contaminants in vegetables include lead (Pb), cadmium (Cd) and arsenic (As), respectively. These metals can pose as a severe health risk to human. So, the hazardous metals must be controlled in all food sources to assure human as well as livestock's health safety. These metals accumulate and contaminate different food chains through various biochemical process and ultimately get biomagnified at various trophic levels and ultimately threatens the health of human.

The contamination of field soil and vegetables by heavy metals is also a global environment issue. They are ubiquitous in the environment through various pathways, due to several natural and anthropogenic activities. In different environmental conditions metals may accumulate to toxic concentration and they cause ecological damages. Anthropogenic contamination include the addition of fertilizers, manures, sewage sludge, various types of insecticides and pesticides to soils, several studies identifying the risks in relation to increased soil metal concentration and consequent plant uptake. Both commercial and residential growing areas are also vulnerable to atmospheric pollution, in the form of metal containing aerosols. These aerosols can penetrate the soil and absorbed by the plant roots, or alternatively be sediment on leaves and adsorbed. Analysis of vegetables grown in the areas near to industry has reported elevated levels of heavy metals contamination.

How heavy metals affiliated with soil and vegetables?

Heavy metals bioavailability to plants is strongly related to the specification and concentration of the elements in the soil because this is where the plants get the heavy metals that they take up. Typically, plants only take up one or two forms of heavy metals from the soil solution. Metal accumulation from soil to plants depends on different factors such as plant species, different plant parts, soil properties, and metal forms. The solubility of the trace metals and their uptake vary with pH and the redox potential within the soil or the root system. The particle size and associated anions also have a great impact on growth and metal uptake by plants. Uptake of heavy metals by plants tends to influence with increasing range, as long as a certain concentration. Uptake has been recorded low when the heavy metal concentration goes beyond the range due to injured plant roots, thus loading to a lower absorbing ability. Therefore it is easy to make errors if the soil pollution records of an area are determined simply from the contents of pollutants in the plant organs. The elevated factors quantify the relative differences in bioavailability of metals to plants and is a function of both soil and plant properties.

How and how much heavy metals transfer to vegetables?

The relative differences in bioavailability of heavy metals to plants and soil and plant properties quantifies on the basis of the transfer coefficient. Relative coefficient is calculated by dividing the concentration of a metal in a vegetable crop by the total metal concentration in the soil. Elevated transfer coefficient represents relatively poor retention in soils or greater effectiveness of plants to absorb metals. Low coefficient demonstrates the strong sorption mechanism of metals to the soil. Soil-to-plant transfer is one of the key components of human exposure to metals through food chain. Plant Concentration Factor or Transfer Factor (TF) is aimportant parameter used to describe the transport of trace elements from soil to plant system and it is also a function of both soil and roots properties.

1. Health effects and risks of vegetable crops

The intake of vegetables contaminated with heavy metals may cause severe human health problems, such as malnutrition, fragile immunological mechanisms, mental growth retardation, and gastrointestinal cancer. The soil–plant transfer of metals and

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metalloids is an important criterion of global human health concern. Accumulation of heavy metals in human bones and fatty tissues through contaminated food uptake, leads to depletion of nutrients and suppresses the immunological defence system. Some metals such as aluminium (Al), cadmium (Cd), manganese (Mn), and lead (Pb) can cause retarded growth and leads to bone fracture, malformation, cardiovascular diseases, kidney and liver dysfunction, and other serious complications to nervous system and immune system. Excessive levels of arsenic in food chain can cause cancer, dermal problems, respiratory complications. Elevated zinc (Zn) levels in the human body can affect the levels of high-density lipoproteins (HDL) and abrupt the immune system mechanism. Copper (Cu) intake can induce liver damage and other gastric-related severe problems. Cu, Zn, and Cr in ground soil can cause non-carcinogenic complications for human such as liver disease, neurological complications, and headaches.

Table 1. Heavy metals from different sources in vegetables

S. No.	Vegetables	Country where investigated	Sources of contaminants affecting food chains	Heavy metal concentration
1.	Leafy and root vegetables	India	Sewage effluent (inadequately treated)	Cu1.7-12.9mg/kg Pb 0.13mg/kg Zn7.25–24.6mg/kg Cr 0.08–0.38mg/kg Pb 0.02–0.013mg/kg Cu 0.16–0.85mg/kg
2.	Potato	Brazil	Industrial/modern intensive urban agriculture	Below the standard limits hazardous to human health
3.	Green cabbage, radish, spinach, cauliflower and lettuce	China	Sewage effluent (inadequately treated)	Cr0.08–0.38mg/kg Pb0.02–0.013mg/kg Cu0.16–0.85mg/kg Zn0.16–0.53mg/k
4.	Lettuce, leafy vegetables	Spain	Air from industries and vehicle	Ni <0.02mg/kg Hg <0.008mg/kg As 0.005mg/kg Cd<0.005mg/kg
5.	Leafy vegetables	China	Both sewage and industrial waste (from smelter) drained	Cr0.01–0.19mg/kg Pb0.12–0.23mg/kg Cu0.15–0.86mg/kg Zn0.42–0.95mg/kg

6.	Tomato, radish, brinjal, carrot, chilli, garlic, coriander, okra	Pakistan	Metal contaminated ground water	Cr > 0.18mg/kg Pb0.91–3.96mg/kg
7.	Different imported vegetables	Australia	Arsenic-and metal-contaminated ground water	Cr27–774µg/kg Pb35–495µg/kg Cu1–29mg/kg Zn17–183mg/kg Cd3–370µg/kg Mn3–140µg/kg Ni151–10,035µg/kg Pb35–495µg/kg
8.	French beans, beet root	Australia	Urban stormwater	Cr0.00078–0.049mg/kg Pb0.001–0.11mg/kg Cu0.016–0.66mg/kg Zn0.038–0.145mg/kg
9.	Spinach	India	Sewage wastewater (inadequately treated)	Cu0.09mg/kg Cr2.9mg/kg Pb3.1mg/kg Zn10mg/kg Ni3.2mg/kg
10.	Radish	China	Inadequately treated wastewater	Cu0.34mg/kg Cr0.03mg/kg Pb0.07mg/kg Cd0.012mg/kg Zn2.48mg/kg Ni0.07mg/kg
11.	Potato	China	Inadequately treated urban wastewater	Cu1.03mg/kg Cr0.03mg/kg Pb0.067mg/kg Cd0.015mg/kg Zn3.77mg/kg Ni0.054mg/kg
12.	Radish	India	Diverse contamination sources	Cu 5.96mg/kg, Cr nil, Pb nil, Cd nil, Zn 22.5mg/kg, Ni nil.
13.	Cauliflower	China	Urban wastewater	Cu0.6mg/kg, Cr0.02mg/kg, Pb0.03mg/kg, Cd0.014mg/kg, Zn5.45mg/kg, Ni0.68mg/kg.
14.	Lettuce	US (Florida)		As27.3mg/kg,

Conclusion

Metal(s) toxicity in food crops requires a significant attention to determine the level of toxicity. The level of heavy metals in the environment have elevated in recent decades. The human health risks been widely investigated globally. Rapid and accurate mapping of soil-metal contaminations and their remediation can prevent us from the global health risk. Biological practices for remediation, such as PGPR and phytoremediation, practices can be cost effective and environment friendly. Recent eco-feasible innovative techniques such as nanotechnology and awareness of farmers and urban population could boost economy and livelihoods.

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