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Heavy Metal Accumulation in Vegetable Crops

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Increased activities by humans, intensified industrialization, and modern farming practises have resulted in higher levels of heavy metal contamination in the environment, resulting in toxicity to living organisms. As a result of the use of pesticides, fertilisers, municipal and compost waste, large areas of land have become contaminated with toxic metal and heavy metal release from smelting industries and metalliferous mines. Regardless of being unnecessary and that lack physiological function, some heavy metals, such as Cd, Cr, Pb, Al, and Hg, remain highly hazardous even when present in extremely low levels.

In human nutrition, vegetables are a vital source of vitamins, minerals, and trace elements. They are also a prolific accumulator of heavy metals, which can enter the vegetables through affected resources from agriculture or insufficient cultivation practises. Toxic metals that have become the need of concern due to the report of their contamination in various vegetable crops. The goal of this review is to assess the sources, mechanisms, and consequences of heavy metal uptake by vegetable crops, as well as the consequences for food safety.

Key words: Heavy metals, Contamination and Accumulators

Introduction

Heavy metals are metallic elements with high density and atomic number greater than 20. They can be toxic or poisonous at low concentrations. Heavy metals include transition metals, basic metals, lanthanides, actinides, and some metalloids." The primary elements classified as heavy metals are chromium (Cr), manganese (Mn), cobalt (Co), copper (Cu), zinc (Zn), molybdenum (Mo), mercury (Hg), nickel (Ni), tin (Sn), lead (Pb), cadmium (Cd), antimony (Sb), etc. (Sandeep *et al*., 2019)

Based on their toxicity level: they are classified into

- Extremely poisonous- Ex; Cd, As
- Moderately poisonous- Ex; Hg, Pb, Ni, F
- Relatively less poisonous- Ex; B, Cu, Mn & Zn

Heavy metals are occur near the bottom of the periodic table, they have high densities (>5 g/cm3) they are toxic or poisonous even at low concentration. And they are non-biodegradable. Temperature, moisture, organic matter, and pH all influence heavy metal intake and building up in plant tissue and nutrient availability and metal availability and mobility in the rhizosphere is influenced by root exudates and microorganisms and it is transported by Mass flow in plants.

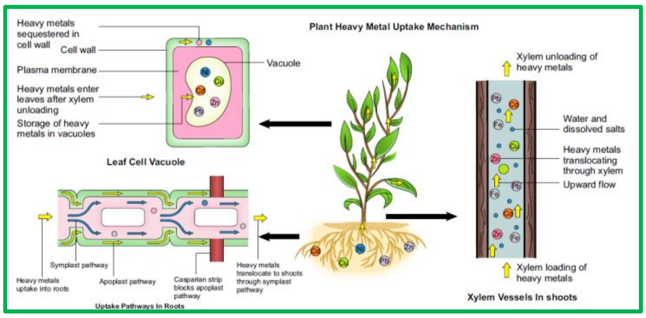


Fig. 1: Plant heavy metal uptake mechanism

Sources of heavy metal contamination

Heavy metals can be found in the environment from a variety of sources, including (1) natural sources, (2) agricultural sources, (3) industrial sources, (4) domestic effluent, (5) atmospheric sources and (6) other sources. (Sandeep *et al*., 2019)

Toxic metals	Industrial uses	Principle toxic effects
Arsenic	Pesticides, herbicides	Skin diseases and lung cancer
Cadmium	Batteries, plastics, pigments, plating	Kidney failure, lung cancer, and bone disease
Chromium	Dyes, alloys, tanning	Effects on the respiratory system, allergic dermatitis.
Lead	Batteries, wire and cable, alloys	Neurological consequences
Mercury	Chloro alkali industry, pesticides	Neurological effects and kidney damage
Manganese	Pesticides, batteries	Central nervous system effects
Zinc	Pharmaceuticals, dyes, Batteries	Gastrointestinal disturbances and anaemia

(Shaban *et al*., 2016)

Criteria for Heavy Metals Accumulation in Plants

1.Accumulating capability: - It is the ability of a plant to accumulate metals in above-ground parts in amounts greater than 100 mg/kg for Cd, 1000 mg/kg for Cu, Cr, Pb, and Co, 10 mg/kg for Hg, and 10000 mg/kg dry weight of shoots for Ni and Zn. **2.Tolerance capability: -** Plants' ability to grow in heavy metal-contaminated areas and show significant tolerance to heavy metals without experiencing negative effects such as chlorosis, necrosis, or a decrease in above-ground biomass.

3. Bioconcentration factor (BCF): - It is defined as the ratio of the total element concentration in harvested plant tissue (C plant) to the total element concentration in the soil in which the plant was growing (C soil).

4. **Translocation factor (TF):** The ability of plants to absorb heavy metals in their roots and transport them from the roots to their above-ground parts (shoots) is known as TF.

Plant response to Heavy metals:

Metal Indicators are plants that reflect soil metal levels, whereas metal excluders limit heavy metal translocation inside them while sustaining relatively low levels in their shoot over a wide range of soil levels. (Baker, 1981) and Heavy metals are taken up by hyperaccumulators in large quantities from the soil.

Heavymetal accumulation in vegetables

Leafy vegetables like spinach palak accumulate greater amount of heavy metals like Cr, Mn and Fe. (Ansari *et al*., 2021) Melon is reported to accumulate higher amount of Ni and Cu. Gourds and Brinjal have reported to accumulate higher amounts of Cd and the order of heavy metal absorption in vegetables is found to be leafy>melons>solanaceous. (Latif *et al*, 2018)

Effect of Heavy metals on vegetables

- French bean → Excess of Ni decreases dry matter production and excess of **Cd** results in reduction of root: shoot biomass ratio
- Lettuce & Spinach → Excess of **Cu** results in vein browning.
- Radish & French bean → Excess of **Zn** results in leaf blade necrosis.
- Onion, Lettuce & Radish → Excess of **Pb** results in reduction of growth.
- Cucumber → Excess of **Cu** reduces the net photosynthetic rate

Effect of the heavy metals on human health

Toxic metals	Principle toxic effects
Arsenic	Skin diseases and lung cancer
Cadmium	Kidney failure, lung cancer, and bone disease
Chromium	Effects on the respiratory system, allergic dermatitis, kidney and liver damage
Lead	Neurological effects
Mercury	Effects on the nervous system and kidney damage
Manganese	Affects central nervous system
Zinc	Gastro-intestinal disturbances and anaemia

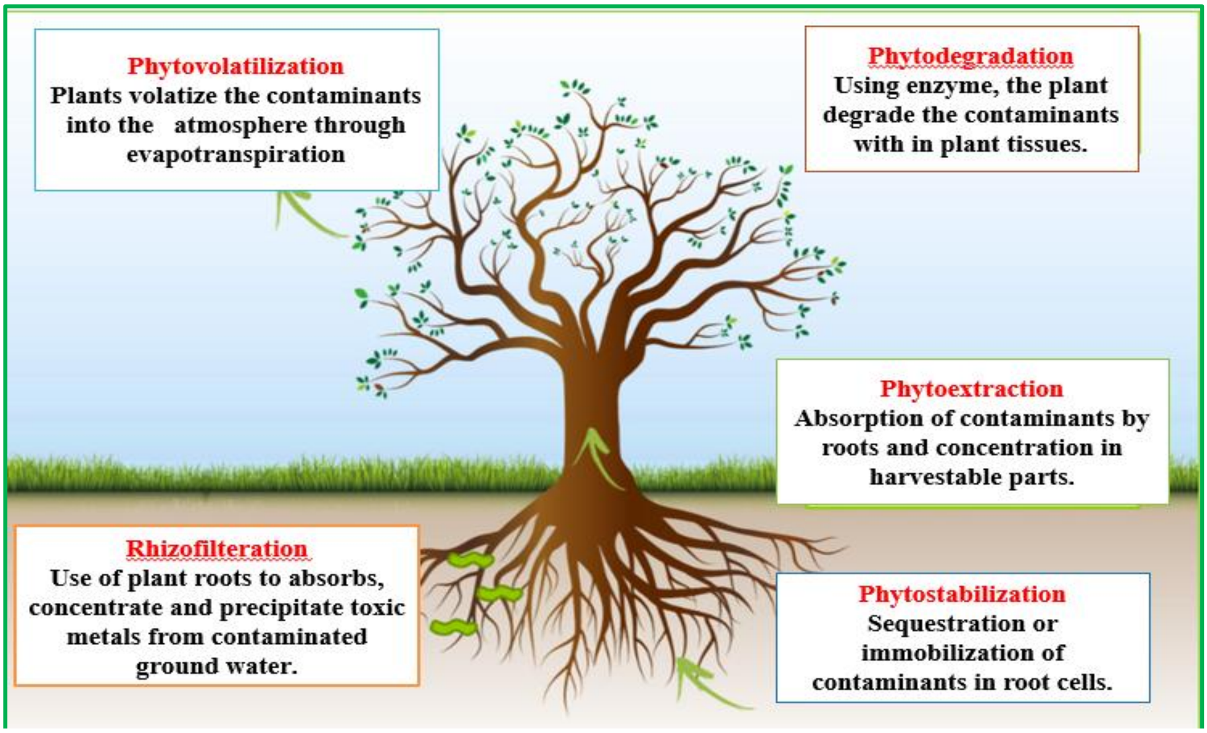
(Shaban *et al*., 2016)

Determination of Heavy Metals

Heavy metal contamination in soil and plant samples can be determined by various instrumental analysis like, Atomic Absorption Spectrophotometry (AAS), Gas chromatography (GC), High performance liquid chromatography (HPLC), Thin layer chromatography (TLC) and High-performance thin liquid chromatography (HPTLC)

Measures to control of heavy metal residue

Metal stabilisation in the soil, crop rotation, soil treatment measures, avoidance of harmful pesticides, sewage treatment in urban and rural areas, and phytoremediation (Shaban *et al*., 2016)



To reduce heavy metal accumulation in vegetable crops, several strategies have been proposed, including phytoremediation, the selection of low-accumulating crop varieties, and proper soil and water management practises. Moreover, monitoring and regular testing of vegetables for heavy metal levels are crucial to ensure food safety and adherence to regulatory standards.

Conclusion

Heavy metals have a negative impact on vegetables, causing acute toxicity in living organisms. As a result, there is a demand for crop varieties that are adaptable as well as resistant to various stresses, and there is an urgent need to properly regulate them for long-term safety and efficacy. Alternative options should be carried out in order to prevent excessive accumulation of these heavy metals in the human food chain and ultimately cause risk to human health. Roof gardening and kitchen gardening in urban and peri-urban areas respectively act a tool to overcome heavy metal toxicity in a way of organic vegetable growing. Understanding the sources, uptake mechanisms, and consequences of heavy metal contamination is essential to implement effective measures for mitigation and ensure the production of safe and nutritious vegetables for the growing global population.

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