



Maximum residue limits (MRLs) of heavy metals in agricultural soil, irrigation water and crops.

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Agricultural crops are an essential resource for human life and livestock. Irrigation water quality and soil quality are essential parameters for crop growth, quality and yield. The presence of heavy metals in agricultural crops has become a serious concern as it poses a significant health hazard to humans and livestock. Heavy metals are deposited into soil and crops through natural activities and human (anthropogenic) activities (Figure 1).

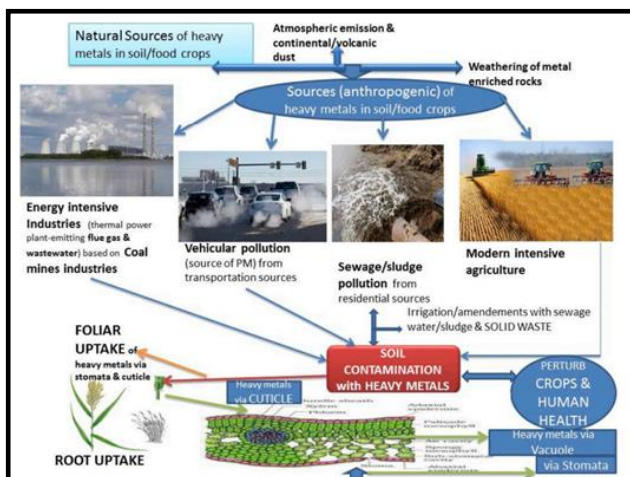


FIGURE 1: Natural and human activities that contaminate soil and food crops with heavy metals and their mode of uptake in plants, which eventually results in ingestion by the consumer (Rai *et al.* 2019).

Heavy metal occurrence

The natural occurrence of heavy metals in the environment is due to natural weathering of metal-bearing rocks and volcanic eruptions (Malan *et al.* 2015). Anthropogenic activities release biologically-available forms of heavy metals into the environment (ul Islam *et al.* 2007). The agricultural sector is one of the most significant anthropogenic contributors to heavy metal deposition, which can occur through the

addition of fertilizers, sewage sludge, manures, and pesticides. These practices may increase the soil heavy metal concentration, resulting in plant uptake. Although some heavy metals such as iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) are essential micronutrients for plant growth, others such as mercury (Hg), cadmium (Cd) and lead (Pb) are not required even in small amounts by any organisms.

Sources of heavy metals in agrochemicals

The presence of toxic heavy metals in soil media could result from the continuous use of synthesized fertilizer and agrochemicals. Also, irrigation with contaminated water contaminates crops with heavy metals (Tiwari *et al.* 2011). Chemically synthesized fertilizers and agrochemicals are used for greater crop yield and to supply both macronutrients and micronutrients, however, they may have heavy metals in their composition in addition to the desirable elements (Nacke *et al.* 2013). Moreover, studies show that some manufacturers of micronutrient formulations and pesticides import industrial waste from developed countries and use it as a raw material for fertilizer and agrochemical production (Gonçalves Jr and Pessoa 2002; Alves *et al.* 2016).

Heavy metal uptake and translocation

Plant roots are a major absorber of heavy metals from soils (Delbari and Kulkarni 2011). Primarily, they are absorbed in the apoplast of the roots and transmitted further into other parts of the plant cells. Their translocation takes place in different parts of the plant through various pathways and results in a reduction in

growth by altering the physiological, biochemical and metabolic activities of the plants (Gupta et al. 2019).

World health organization (WHO) and Food and Agricultural Organization (FAO) recommendations

WHO and FAO have established the maximum allowable limits (MRLs) of heavy metals in crops, irrigation water and soils (FAO/WHO 2002, 2011).

TABLE 1: MRLs of heavy metals in crops, irrigation water and soils (FAO/WHO 2002, 2011).

Chemical element	Maximum permissible levels in soil (ppm)	Maximum permissible levels in crops (ppm)	Maximum permissible levels in irrigation water (ppm)
As	20.0	-	0.1
Cd	3.0	0.1	0.01
Co	50.0	50.0	0.05
Cr	100.0	-	0.55
Cu	100.0	73.0	0.017
Fe	50000	425.0	0.50
Mn	2000	500.0	0.20
Ni	50.0	67.0	1.40
Pb	100.0	0.3	0.065
Se	10.0	-	0.02

Heavy metal concentrations that are above these limits are considered dangerous to the consumer. Both the cumulative and persistence properties of metals and their toxicity affects the human diet. Therefore, the requirement for the analysis of metals in crops, soil and irrigation water in comparison with international standards is indispensable. The assessment of heavy metal contamination of foodstuff is also an important food quality assurance (Ali and Al-Qahtani 2012).

Analysis of heavy metals

The Analytical Services laboratories of the KwaZulu-Natal Department of Agriculture and Rural

Development (KZNDARD) employs Inductively Coupled Plasma-Optical Emission Spectrometry (ICP-OES) analytical techniques to determine the concentrations of certain heavy metal in soils (Cu, Mn and Zn), irrigation water, crops and animal feeds (Cu, Fe, Mn and Zn) as they are also essential micronutrients. However, they are required in very small amounts and can easily become toxic to plants and consumers at higher concentrations. The results obtained in the laboratories are used to formulate fertiliser recommendations and other related advice for KZNDARD clients.

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