

Supplementary Materials

Concentrations of HMs in agricultural soils vary between countries (Table S1). Representative surveys of soil show how frequently observed HM concentrations exceed allowable limits, and the wide range between average and maximum concentrations of many elements (Table S2). Many jurisdictions also regulate the concentrations of HMs that accumulate in edible portions of plants (Table S3) which are significantly higher than the maximum allowable limits recommended by Codex Alimentarius commission (Table S4).

Table S1. Maximum allowable concentrations of HM elements in agricultural soil in several countries.

Country	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn
mg kg ⁻¹ soil								
Australia	20	3	50	100	1	60	300	200
Canada	20	3	250	150	0.8	100	200	500
China	20 – 40	0.3 - 0.6	150 – 300	50 – 200	0.3 - 1.0	40 – 60	80	200 – 300
Germany	50	5	500	200	5	200	1000	600
Tanzania	1	1	100	200	2	100	200	150
Netherlands	76	13	180	190	36	100	530	720
New Zealand	17	3	290	>10 ⁴	200	N/A	160	N/A
United Kingdom	43	1.8	N/A	N/A	26	230	N/A	N/A
United States	0.11	0.48	11	270	1	72	200	1100

Source: [244].

Table S2. HM contamination in the soil of arable lands through suspected agricultural practices.

HM Elements	MAX level mg kg ⁻¹ soil	Mean BKG level mg kg ⁻¹ soil	FD*	Survey site	References
As	280	16.8	16.7	241 farm soil samples from peninsular Malaysia	Zarcinas et al., [50]
Cd	2.02	0.12	16.8		
Co	38.7	2.8	13.8		
Cr	72.7	25.9	2.8		
Cu	114	16.4	7.0		
Hg	0.86	0.15	5.9		
Ni	73.5	13.7	5.4		
Pb	90.0	26.4	3.4		
Zn	137	38.0	3.6		
Cu	99.9	16.7	6.0	Soil samples from Huizhou (Guangdong Province), China	Cai et al., [245]
Zn	248	57.2	4.3		
Ni	112	14.9	7.5		
Cr	81	27.6	2.9		
Pb	108	44.7	2.4		
Cd	1.12	0.10	11.2		
As	137	10.9	12.6		
Hg	3.39	0.22	15.4		

MAX = maximum values; BKG = Average background values; *FD = Fold difference: MAX values/ BKG values.

Table S3. A summary of concentration fold differences of several HM elements in the edible plant parts of a number crop and vegetable species reported in some studies.

Species	As	Cd	Cr	Cu	Hg	Ni	Pb	Zn	Ref.
	Fold differences								
Rice	2.0	3.6	7.3	1.6	2.1	3.2	2.9	6.3	Zarcinas et al., [50]
Chili	2.3	2.2	2.6	8.0	7.3	1.8	1.4	1.6	
Corn	1.9	2.0	7.4	1.4	2.4	1.8	4.8	1.5	
Long bean	1.9	2.5	1.9	1.8	-	2.1	4.2	1.4	
Mustard	1.0	2.8	4.3	1.5	3.1	1.8	2.3	1.7	
Angled loofa	1.8	2.8	-	1.6	1.4	2.1	2.0	1.4	
Brinjal	1.9	1.9	1.2	1.8	-	1.5	2.7	1.2	
Cabbage	2.2	3.5	3.8	5.6	3.8	2.2	3.1	2.0	
Cocoa	2.2	2.5	2.9	1.9	2.6	2.0	4.1	1.5	
Cucumber	2.0	2.0	1.2	1.1	1.1	1.3	1.4	1.3	
Groundnut	1.0	1.6	1.8	1.2	3.0	2.5	2.9	1.1	
Lady's finger	1.9	2.5	3.8	1.7	2.8	1.4	4.9	1.5	
Spinach	1.7	4.3	2.8	1.6	1.6	1.9	3.2	3.0	
Water convolvulus	3.2	2.1	2.4	2.0	1.5	1.6	2.9	2.0	
Corn	-	2.7	-	5.6	-	-	2.3	2.1	Jung, [64]
Jujube	-	1.1	-	1.1	-	-	1.9	1.3	
Perilla	-	1.3	-	1.2	-	-	1.2	1.5	
Soybean	-	4.2	-	1.8	-	-	1.6	3.0	
Pepper	-	1.3	-	3.0	-	-	3.2	1.1	
Onion	-	2.4	-	1.4	-	-	1.4	5.3	
Cabbage	-	7.0	1.8	1.8	-	1.0	3.8	1.6	Berihun et al., [58]
Swiss Chard	-	6.0	2.0	1.2	-	7.0	9.5	2.5	
Kale	-	27	2.3	1.5	-	1.5	7.1	4.6	
Tomato	-	11	1.0	1.2	-	1.9	5.9	1.3	
Potato	-	26	1.1	7.0	-	2.7	9.5	3.0	
Onion	-	17	1.2	1.3	-	1.2	-	1.0	
Lettuce	-	1.0	1.1	1.0	-	6.5	2.4	3.4	
Lettuce	-	-	-	-	56.5	-	-	-	Li et al., [246]
Amaranth	-	-	-	-	71.5	-	-	-	
Spinach	-	-	-	-	63.2	-	-	-	
Tomato	-	-	-	-	62.5	-	-	-	
Egg plant	-	-	-	-	54.7	-	-	-	
Pepper	-	-	-	-	31.9	-	-	-	
Cucumber	-	-	-	-	18.3	-	-	-	
Cowpea	-	-	-	-	31.7	-	-	-	
Rice	-	-	-	-	77.8	-	-	-	
Maize	-	-	-	-	12.7	-	-	-	
Vegetables									Ahmed et al., [16]
Area A	14.3	1.7	22.6	0.5	-	-	22.1	3.1	
Area B	13.3	1.5	14.7	0.4	-	-	18.3	3.0	
Area C	11.0	2.0	20.7	0.5	-	-	22.2	3.4	

Fold differences: maximum/background levels.

Table S4. Maximum allowable limits of certain HM elements in food plants and plant-derived food commodities recommended by Codex Alimentarius commission.

Type of edible plant product	Maximum limit (mg Kg ⁻¹)				
	Cd	Pb	As	Cu	Fe
Brassica vegetables	0.05	0.10	-	-	-
Bulb vegetables	0.05	0.10	-	-	-
Fruiting vegetables	0.05	0.05	-	-	-
Leafy vegetables	0.20	0.30	-	-	-
Legume vegetables	0.10	0.10	-	-	-
Pulses	0.10	0.10	-	-	-
Root and tuber vegetables	0.10	0.10	-	-	-
Stalk and stem vegetables	0.10	-	-	-	-
Vegetable oils	-	-	-	0.01R/0.40C	1.5R
Cereal grains	0.10	0.20	-	-	-
Rice	0.40P	Na	0.20P/0.35H	-	-
Wheat	0.20	0.20	-	-	-
Cranberry	-	0.20	-	-	-
Currants	-	0.20	-	-	-
Elderberry	-	0.20	-	-	-
Fruits	-	0.10	-	-	-
Mushrooms	-	0.30	-	-	-
Canned fruits	-	0.10	-	-	-
Mango chutney	-	0.40	-	-	-
Canned vegetables	-	0.10	-	-	-
Preserved tomatoes	-	0.05	-	-	-
Olive oils	-	0.40	-	-	3.0
Palm oil	-	Na	-	-	5.0 to 7.0C
Cucumber pickles	-	0.10	-	-	-
Canned chestnuts	-	0.05	-	-	-
Fruit juices	-	0.03 to 0.05	-	-	-

P = polished, H = husked, C = crude, R = refined. Source: CF/14 INF/1 [247].