Ecological and Health Risks Assessment of Potentially Toxic Metals and Metalloids Contaminants: A Case Study of Agricultural Soils in Qatar

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Scheme 1. Definitions and reference values for parameters used to estimate average daily intake (ADI) for non-carcinogenic and carcinogenic risk.

Variables	Physical significance and units	Values	
		Adults	Children
$IngR$	Ingestion rate of soil (mg/day)	100	200
$InhR$	Inhalation rate of soil (m^3/day)	20	7.6
EF	Exposure frequency (days/year)	350	350
ED	Exposure duration (years)	24	6
BW_A	Average body weight (kg)	56.8	15.9
ET_A	Average exposure time (non-carcinogenic, days)	ED×365	ED×365
ET_{ca}	Average exposure time (carcinogenic risk, days)	70×365	70×365
ESA_S	Exposed skin surface area (cm^2)	5700	2800
AF_S	Soil to skin adherence factor (mg/cm^2)	0.07	0.2
ABS	dermal absorption factor	As: 0.03 Other HMs: 0.001	
EF_p	Particle emission factor (m^3/kg)	1.36×10^9	1.36×10^9

Source: USEPA (1997; 2002; 2009; 2013)

Supplementary Table S2. Metals reference doses (RfD)

	Reference Dose Factor (RfD)		
Heavy metals	**Ingestion**	**Dermal**	**Inhalation**
V	7.00E-03	7.00E-05	7.00E-03
Cr	3.00E-03	3.00E-03	2.86E-05
Ni	2.00E-02	5.40E-03	2.06E-02
Zn	3.00E-01	6.00E-02	0.3
Cu	4.00E-02	1.20E-02	4.00E-02
As	3.00E-04	1.23E-04	1.23E-04
Cd	5.00E-04	5.00E-04	5.70E-05
Pb	1.40E-03	5.24E-04	3.52E-03

Supplementary Table S3. As, Cr and Ni cancer slope factors (SF)

	Slope Factor (SF)		
Heavy metals	**Ingestion**	**Dermal**	**Inhalation**
Cr	5.00E-01	2.00E+00	4.20E+00
Ni	1.70E+00	4.25E+00	9.00E-01
As	1.50E+00	3.66E+00	1.51E+00

Supplementary Table S4: Soils physicochemical properties (n = 5) ± SEM

Sampling locations	pH	EC (dS m^{-1})	Total Carbon (%)	Total Nitrogen (%)
1	7.5 ± 0.1	120 ± 0.1	5.5 ± 0.3	0.2 ± 0.0
2	7.6 ± 0.1	116 ± 0.4	4.6 ± 0.1	0.2 ± 0.0
3	7.7 ± 0.5	57 ± 0.0	6.2 ± 0.8	0.3 ± 0.0
4	7.5 ± 0.0	87 ± 0.1	8.9 ± 1.2	0.3 ± 0.0
5	7.16 ± 0.1	1,158 ± 2.6	5.6 ± 0.9	0.3 ± 0.0
6	7.3 ± 0.1	175 ± 0.6	4.7 ± 0.1	0.2 ± 0.0

7	7.4 ± 0.0	123 ± 0.4	5.5 ± 0.1	0.1 ± 0.0
8	7.2 ± 0.0	221 ± 0.1	5.4 ± 0.4	0.2 ± 0.0
9	7.1 ± 0	249 ± 0.1	6.5 ± 0.2	0.2 ± 0.0
10	7.1 ± 0.0	273 ± 0.5	5.8 ± 0.2	0.2 ± 0.0

Supplementary Table S5: Soils ionic contents (mg/kg)

	Anions				*Cations*			
Sampling locations	Chloride	Nitrate	Phosphate	Sulfate	Sodium	Potassium	Calcium	Magnesium
1	551 ± 140	135 ± 59	11 ± 7	1980 ± 595	461 ± 82	178 ± 21	684 ± 199	94 ± 16
2	646 ± 274	439 ± 253	44 ± 2	1264 ± 537	522 ± 181	345 ± 138	219 ± 100	144 ± 69
3	174 ± 25	96 ± 31	39 ± 9	554 ± 179	225 ± 27	133 ± 25	234 ± 23	60 ± 5
4	392 ± 90	10 ± 7	19 ± 2	1059 ± 283	447 ± 82	170 ± 18	368 ± 56	87 ± 17
5	16327 ± 4492	1862 ± 587	4 ± 3	8221 ± 1866	10407 ± 2736	758 ± 190	146 ± 737	53 ± 231
6	100 ± 17	8 ± 1	16 ± 6	5714 ± 2562	108 ± 18	96 ± 9	2541 ± 1130	116 ± 26
7	217 ± 37	26 ± 6	11 ± 5	3085 ± 1945	210 ± 28	98 ± 4	1308 ± 812	40 ± 26
8	420 ± 105	190 ± 98	7 ± 2	5924 ± 469	462 ± 96	172 ± 24	2277 ± 260	195 ± 17
9	674 ± 124	26 ± 15	0.5 ± 0.5	6690 ± 524	696 ± 105	145 ± 12	2570 ± 206	205 ± 24
10	401 ± 89	101 ± 76	N.D	8528 ± 2054	428 ± 82	157 ± 16	3616 ± 992	250 ± 66

Supplementary Table S6. Descriptive statistics of the soil metals concentrations (mg/kg)

Metals	**V**	**Cr**	**Ni**	**Zn**	**Cu**	**As**	**Cd**	**Pb**
Minimum	46.7	39.5	24.1	35.8	11.58	14.2	0.1	5.9
Maximum	120.5	148.1	131.2	168.7	44.9	52.3	0.7	34.2
Mean	75.3	85.7	61.9	92.3	25.6	27.6	0.2	18.1
SD	20.1	24.4	29.1	30.5	7.2	9.7	0.1	7.1
CV	26.7	28.4	46.9	33.1	28.1	35.2	57.9	39.1
Skewness	0.5	0.2	0.9	0.2	0.2	0.5	2.3	0.4

Kurtosis	-0.6	-0.3	-0.3	-0.4	0.0	-0.7	6.6	-0.7
BGV	129	59.5	29	70	38.9	6.83	0.41	27

SD: Standard Deviation;
CV: Coefficient of variation
BGV: Background values (Kabata-Pendias and Mukherjee, 2007; Taylor and McLennan, 1995).

Supplementary Table S 7. The metals correlation coefficients (Pearson's)

	V	**Cr**	**Ni**	**Zn**	**Cu**	**As**
V	1					
Cr	0.69***	1				
Ni	0.90***	0.75***	1			
Zn	0.27	0.20	0.36*	1		
Cu	0.66***	0.51***	0.73***	0.73***	1	
As	0.14	0.05	0.09	-0.20	-0.08	1
Cd	0.20	0.05	0.31*	0.61***	0.48***	0.01
Pb	0.22	0.09	0.28	0.73**	0.57***	-0.40***

***Correlation is significant at P ≤ 0.001
**Correlation is significant at P≤ 0.01
*Correlation is significant at P ≤ 0.05