Potential Toxic Elements pollution status in zones of technogenic impact in Central Regions of Perú

The Regions of Junín, Pasco, Huánuco, and Ancash are included in Central Regions of Perú.

Table S1. Environmental indices used for contamination evaluation.

Geoaccumulation index (IGEO)

Class	Igeo values	Clasification
1	Igeo ≤0	uncontaminated
2	0<Igeo≤1	slightly contaminated
3	1<Igeo≤2	moderately contaminated
4	2<Igeo≤3	moderately to heavily contaminated
5	3<Igeo≤4	heavily contaminated
6	4<Igeo≤5	heavily to extremely contaminated
7	Igeo>5	extremely contaminated

Integrated pollution index (IPI)

Class	IPI values	Classification
1	IPI ≤ 1	low contamination
2	1 < IPI ≤ 2	moderate contamination
3	IPI > 2	high contamination

Table S2. Peruvian environmental quality standards for soils. Values established in Supreme Decree N° 011-2017-MINAM.

Parameters in mg/kg	Land uses		
	Agricultural soil	Residential land / Parks	Commercial/ Industrial/ Extractive land
Arsenic	50	50	140
Barium	750	500	2000
Cadmium	1.4	10	22
Mercury	6.6	6.6	24
Lead	70	140	800

Table S3. Parameters used to assess the risk of exposure of humans to metals in soil.

Parameters	Símbol	Children (1 to < 6 years)	Adults (>18 years)	Source
Body weight of the individual	BW (Kg)	15	70	USEPA 1992
Duration of exposure	ED (año)	6	24	USEPA 2002
Frecuency of esposure	EF (día/año)	350	350	USEPA 1992
Time over which dose is averaged - Carcinogenic	AT-C (día)	25550	25550	USEPA 1989
Time over which dose is averaged - Non-carcinogenic	AT-NC (día)	2190	8760	USEPA 1989
Dermal adherence factor	AF (mg/cm²)	0.2	0.07	USEPA 2004
Accidental soil ingestión rate	IngR (mg/día)	200	100	USEPA 1992
Dermal Surface área exposed	SA (cm²/día)	2800	5700	USEPA 2004
Particulate emisión factor	PEF (m³/kg)	1.4×10^9	1.4×10^9	USEPA 2011
Air inhalation rate	InhR (m³/día)	7.6	20	Lu et al. 2014

Table S4. Particulate emission factor, dermal absorption factor, and oral, dermal, and inhalation reference dose values for the elements under study.

Element	ABS (dimensionless)	RfD$_o$ (mg/kg/día)	RfD$_d$ (mg/kg/día)	RfD$_i$ (mg/kg/día)
Al	1.0×10^{-1}	1	1.0×10^{-1}	1.4×10^{-3}
As	3.0×10^{-2}	3.0×10^{-4}	1.2×10^{-4}	8.6×10^{-6}
Ba	1.0×10^{-2}	2.0×10^{-1}	1.4×10^{-2}	1.4×10^{-4}
Cd	1.0×10^{-3}	1.0×10^{-3}	1.0×10^{-5}	1.0×10^{-3}
Cr	1.0×10^{-3}	3.0×10^{-3}	6.0×10^{-5}	2.9×10^{-5}
Cu	1.0×10^{-2}	4.0×10^{-2}	1.2×10^{-2}	4.0×10^{-2}
Fe	1.0×10^{-2}	3.0×10^{-1}	4.5×10^{-2}	-
Hg	1.0×10^{-3}	3.0×10^{-4}	2.1×10^{-5}	8.6×10^{-5}
Mn	1.0×10^{-2}	4.6×10^{-2}	1.8×10^{-3}	1.4×10^{-5}
Ni	2.0×10^{-4}	2.0×10^{-2}	5.4×10^{-3}	2.0×10^{-2}
Pb	1.0×10^{-3}	3.5×10^{-3}	5.3×10^{-4}	3.5×10^{-3}
Zn	1.0×10^{-3}	3.0×10^{-1}	6.0×10^{-2}	3.0×10^{-1}

Table S5. Risk factor values and slope factors used to calculate carcinogenic risks.

Element	URF (m³/µg)	SF$_o$ (mg/kg/día)$^{-1}$	SF$_d$ (mg/kg/día)$^{-1}$	SF$_i$ (mg/kg/día)$^{-1}$
As	4.3×10^{-3}	1.5	3.7	15
Cr	1.2×10^{-2}	1.0×10^{-4}	5.0×10^{-3}	42
Ni	2.4×10^{-4}	8.5×10^{-3}	3.1×10^{-2}	0.84
Pb	8.0×10^{-5}	8.5×10^{-4}	8.5×10^{-4}	0.28

UFR risk factor unit, SF_o oral slope factor, SF_d dermal slope factor, and SF_i inhalation slope factor. Source: *UFR* values obtained from Liu et al. (2018)

Table S6. Classification of Enrichment factor.

Deficiency to minimal enrichment: $EF < 2$

Moderate enrichment: $2 < EF < 5$

Significant enrichment: $5 < EF < 20$

Very high enrichment: $20 < EF < 40$

Extremely high enrichment: $EF > 40$

Table S7 Classification of contamination factor.

Low contamination: $Cf < 1$

Moderate contamination: $1 < Cf < 3$

Considerable contamination: $3 < Cf < 6$

Very high contamination: $Cf > 6$

Table S8 Classification of contamination degree

Low level of contamination: $C_{DEG} < 6$

Moderate level of contamination: $6 < C_{DEG} < 12$

Considerable level of contamination: $12 < C_{DEG} < 24$

Very high level of contamination: $C_{DEG} > 24$

Table S6. Number of samples in each category of ecological index assessment using background values by the median ± 2 MAD method for soils of the project.

	As	Ba	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Zn
$I_{GEO} \leq 0$	27	28	26	24	28	26	29	29	25	28
	93.1%	96.6%	89.7%	82.8%	96.6%	89.7%	100%	100%	86.2%	96.6%
$0 < I_{GEO} \leq 1$	1	1	1	5	1	3			3	1
	3.4%	3.4%	3.4%	17.2%	3.4%	10.3%			10.3%	3.4%
$1 < I_{GEO} \leq 2$	1		2						1	
	3.4%		6.9%						3.4%	
$2 < I_{GEO} \leq 3$										
$3 < I_{GEO} \leq 4$										
$4 < I_{GEO} \leq 5$										
$I_{GEO} > 5$										
FE<2	21	20	21	25	24	21	23	24	18	23
	72.4%	69%	72.4%	86.2%	82.8%	72.4%	79.3%	82.8%	62.1%	79.3%
2≤FE<5	6	9	5	3	5	8	5	4	8	4
	20.7%	31%	17.2%	10.3%	17.2%	27.6%	17.2%	13.8%	27.6%	13.8%
5≤FE<20	2		3	1			1	1	3	2
	6.9%		10.3%	3.4%			3.4%	3.4%	10.3%	6.9%
20≤FE<40										
FE≥40										
Cf<1	24	26	22	21	25	22	23	24	21	22
	82.8%	89.7%	75.9%	72.4%	86.2%	75.9%	79.3%	82.8%	72.4%	75.9%
1≤Cf<3	4	3	5	8	4	7	6	5	7	7
	13.8%	10.3%	17.2%	27.6%	13.8%	24.1%	20.7%	17.2%	24.1%	24.1%
3≤Cf<6	1		2						1	
	3.4%		6.9%						3.4%	
Cf≥6										
|P|<1										26
										89.7%
1<|P|≤2										3
										10.3%
2<|P|≤5										
|P|>5										

Table S7. Number of samples in each non-carcinogenic risk assessment category in soils from the "Nueva Yanango - Nueva Huánuco 500 kV link and associated substations" project.

		As	Ba	Cd	Cr	Cu	Hg	Mn	Ni	Pb	Zn
Children	HI < 1	1	29	29	19	29	29	6	29	23	29
		3.4%	100%	100%	65.5%	100%	100%	20.7%	100%	79.3%	100%
	HI > 1	28			10			23		6	
		96.6%			34.5%			79.3%		20.7%	
Adults	HI < 1	26	29	29	29	29	29	29	29	29	29
		89.7%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	HI > 1	3									
		10.3%									

HI non-carcinogenic risk index. Percentage values are about the total of the samples analyzed in the study.

Table S8. Number of samples in each category of carcinogenic risk assessment in soils from the project.

		As	Cr	Ni	Pb
Children	TCRI<1.0x10^{-6}	1	29	29	29
		3.4%	100%	100%	100%
	1.0x10^{-6}< TCRI ≤ 1.0x10^{-4}	27			
		93.1%			
	TCRI > 1.0x10^{-4}	1			
		3.4%			
Adults	TCRI<1.0x10^{-6}	1	29	29	29
		3.4%	100%	100%	100%
	1.0x10^{-6}< TCRI ≤ 1.0x10^{-4}	28			
		97%			
	TCRI > 1.0x10^{-4}				

TCRI total carcinogenic risk index. Percentage values are about the total of the samples analyzed in the study
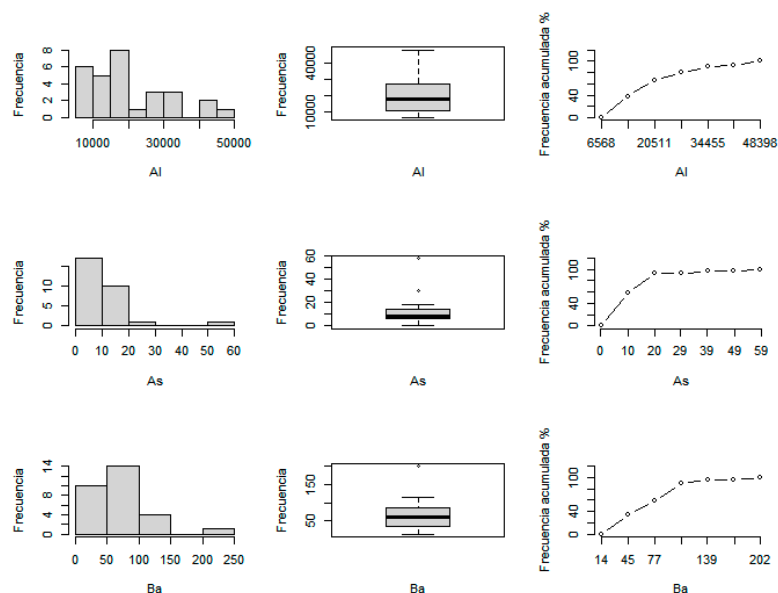

Figure S1. Histograms, box-plot, and cumulative frequency plots for Al, As, and Ba concentrations (mg/kg) in the study area, Peru.
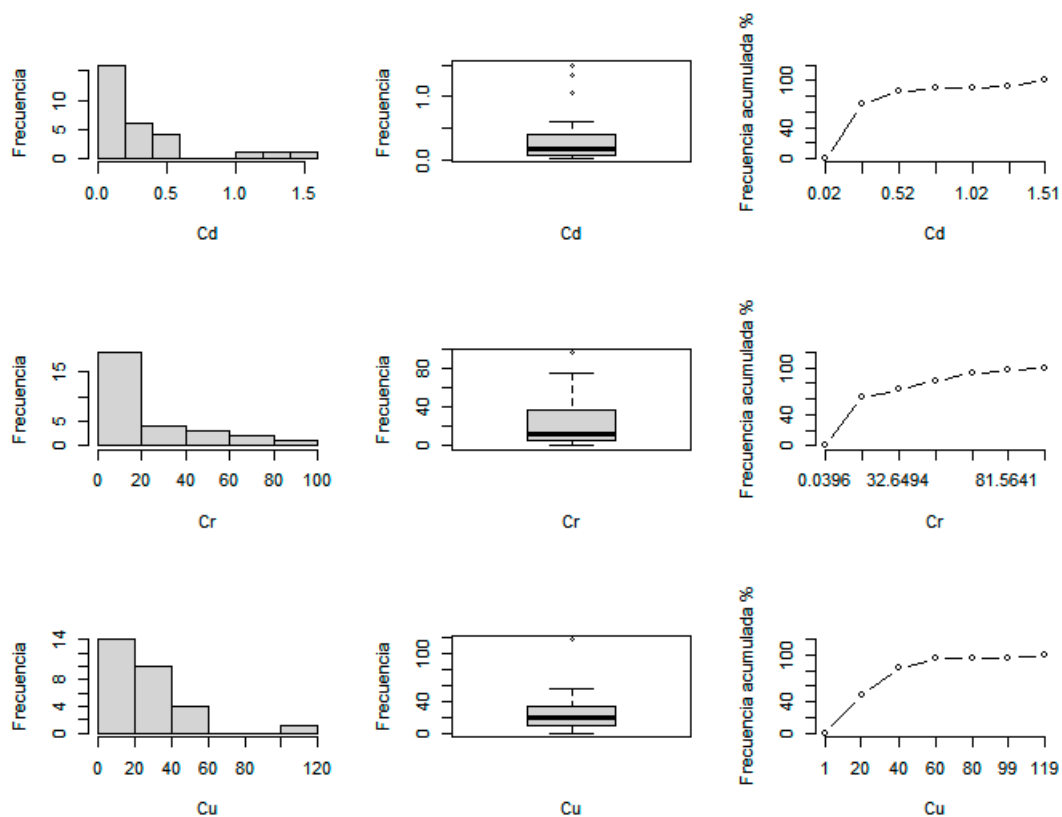
Figure S2. Histograms, box-plot, and cumulative frequency plots for Cd, Cr, Cu, Fe, Hg, and Mn concentrations (mg/kg) in the study area, Peru.
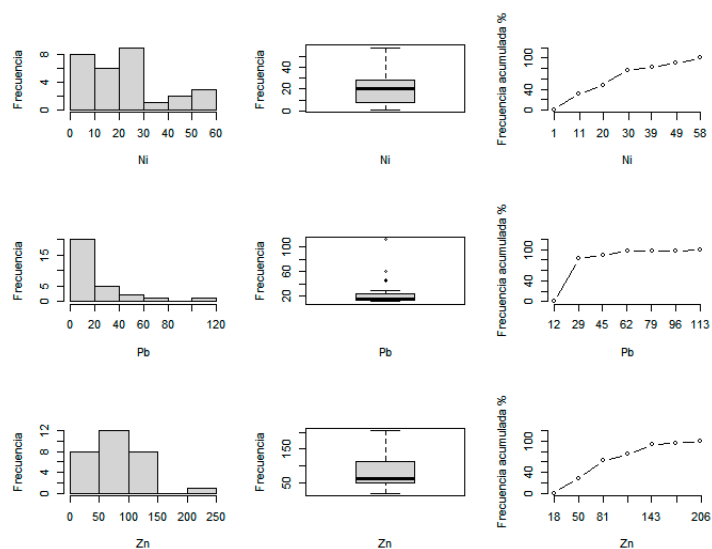

Figure S3. Histograms, box-plot, and cumulative frequency plots for Ni, Pb, and Zn concentrations (mg/kg) in the study area, Peru.