Potentially toxic element contamination of European City Soils and Implications for Urban Farming Food Safety

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1. Introduction

Urban farming has experienced increasing attention in the last decades due to its beneficial impact on the social, economic, and environmental stability of the city. However, the contamination of urban soils with potentially toxic elements (PTE) poses a significant challenge to the safety of urban-grown produce. This review consolidates data from studies on PTE contamination in European urban soils, identifying the risks associated with lead, cadmium, mercury, arsenic, among others.

2. Methodology

- Analysis of data covering 91 locations across 46 cities in 17 European countries.
- Discrimination of specific city location from where the samples were recovered.
- Collection of respective national and international regulations and guidelines limiting to the presence of these elements in agricultural soils
- Comparison of measured values to established regulations and guidelines

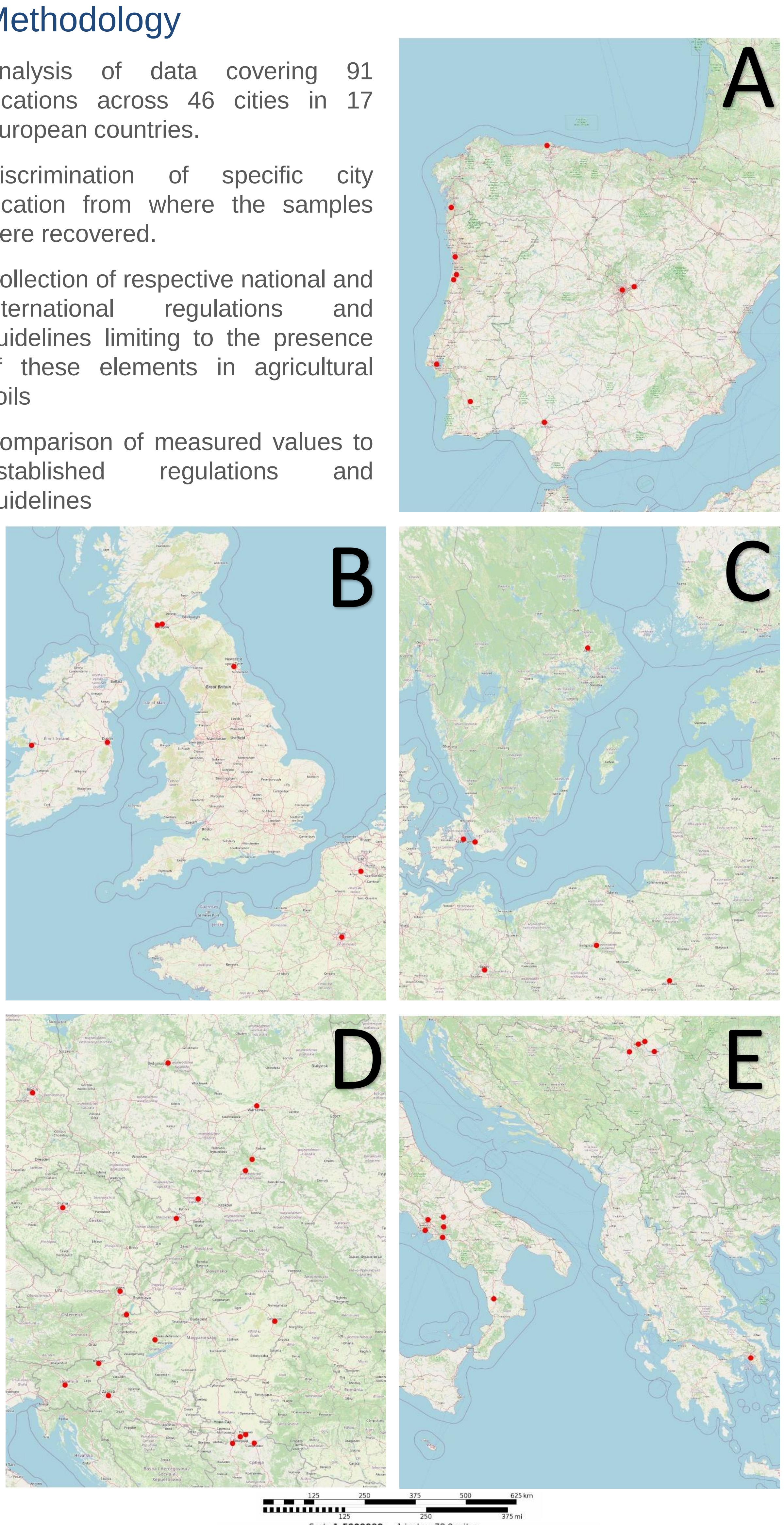

Figure 1 – Geographical Distribution of Sampling Locations Across Europe. A – Iberian Peninsula; B – British Isles and North of France, C – Parts of Central Europe and Scandinavia, D – Central and Eastern Europe, and Balkan Peninsula, E – Southern Italy and Balkans

Table 1 – Limits for potentially toxic elements in soil. All values are reported in mg kg^{-1}d.m.

Regulation	As	Cd	Cr	Pb	Hg	Ni	Cu	Zn
	mg kg^{-1} d.m.							
FAO[1]	50	3	400	300	1	50	80	200
86/278/EEC Directive[5]		1-3		50-300	1-1.5	30-75	50-140	150-300
Sweden [2]	10	0.8	80	50	0.25	40	80	250
United Kingdom	50	3	400	300	1	50-110	80-200	200-300
Spain[3]		1-3	100-150	50-300	1-1.5	30-112	50-210	150-450
France		2	150	100	1	50	100	300
Austria[4]		0.5-2	50-100	50-100	0.2-1.5	30-70	40-100	100-300
Portugal[3]		1-4	50-300	50-450	1-2	30-110	50-200	150-450
Denmark		0.5	30	40	0.5	15	40	100
Ireland		1	-	50	1	30	50	150
Greece[5]		1-3	-	50-300	1-1.5	30-75	50-140	150-300
Poland[6]		1-3	50-100	40-80	0.8-1.5	20-50	25-75	80-180
Czech Republic[6]	15-20	0.4-0.5	55-90	55-60	0.3	45-50	45-60	105-120
Slovenia		1	100	85	0.8	50	60	200
Croatia[3]		0.5-1.5	50-100	50-100	0.2-1	30-70	40-100	100-200
Germany		1	100	100	1	50	60	200
Italy[1]		1.5		100	1	75	100	300

Legend: 1 – Maximum Permissible Concentration of Potentially Toxic Elements in Soil after application of sewage sludge. 2 - SEPA Guideline values for "sensitive land use". 3 – Maximum values vary according to soil pH. 4 – Maximum values vary depending on the autonomous region. 5 – Lower values correspond to recommended values while higher values correspond to legal limit. 6 – Maximum values vary according to soil characteristics (e.g. Loamy and sandy).

3. Results and Discussion

Table 2 – Examples of Potentially Toxic Element Contamination in European cities.

Country	City	City Zone	As	Cd	Cr	Pb	Hg	Ni	Cu	Zn
			Mean mg kg-1 d.m.							
France	Auby	P	-	**53.4**	-	**1,300**	-	-	-	**7,357**
	Paris	F	-	0.68	-	**320**	**1.57**	-	**102**	**316**
Poland	Katowice	C1	-	**10.33**	-	**781.88**	-	-	**73.03**	**843.73**
		C2	-	**4.23**	-	**170.73**	-	-	23.51	**664.05**
		C3	-	**3.22**	-	**147.55**	-	-	**91.61**	**363.97**
		S	-	**43.67**	-	**1,959.83**	-	-	**155.78**	**974.85**
		P	-	**4.61**	-	**233.02**	-	-	**32.03**	**520.33**
Spain	Avilés	R	16.8	**2.8**	27	**141**	0.74	16.4	**53.3**	**848**
	Sevilla	F	-	**3.04**	35	**119**	-	19.5	42.4	91.6
		P1	-	**2.98**	36.7	**411**	-	16.4	**107**	**229**
		P2	-	**3.01**	40.5	**146**	-	21.6	**56.8**	121
UK	Paisley	B	-	**2.24**	44.98	**386**	-	-	**174**	**435.21**
	Newcastle	C	15	0.28	51	**233**	0.32	26	**77**	**274**
Italy	Naples	C	14.3	0.8	-	**335**	-	15.6	**150**	**323**

Legend: City zone (P – parks and grasslands; C – City centre; F – Urban farm; R – Roadside; S – Smelting facility; B – Brownfield land).

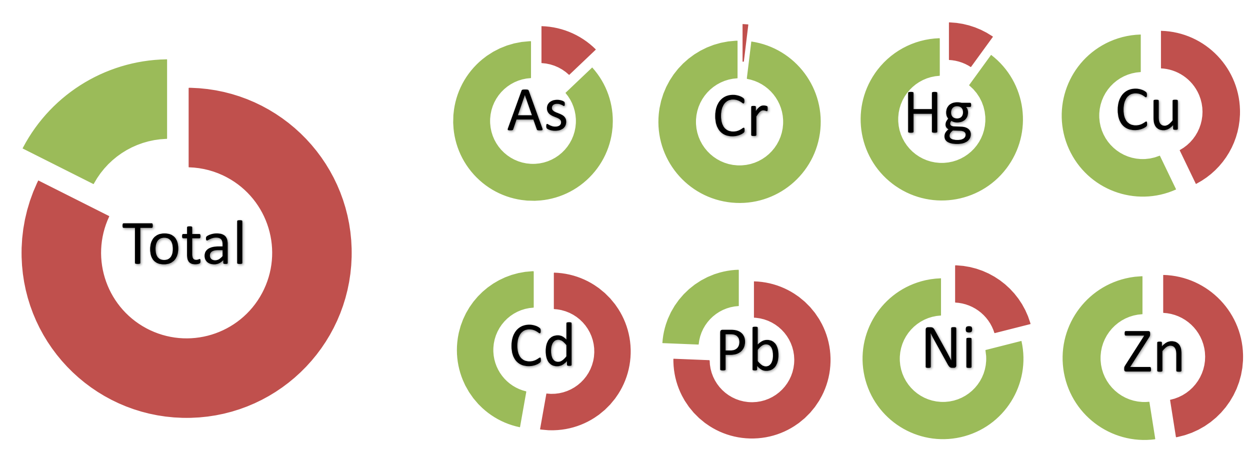

Figure 2 – Illustrative representation of the proportion of specific PTE contamination in European cities. Legend: Red – above regulatory limit; Green – below regulatory limit

- Lead concentrations exceed regulatory and/or guideline limits in 76.4% of locations.
- Some cities exhibit extreme contamination due to historical or contemporary industrial activity:
    - Auby, France (zinc production): Median Pb values 1300 mg/kg, max >3000 mg/kg.
    - Katowice, Poland (smelter presence): Average Pb values near 2000 mg/kg.
    - Glasgow, Scotland (urban parks and allotments): Mean Pb 971 mg/kg, min 250 mg/kg—above multiple national and European regulations.
- Cadmium (Cd) and Zinc (Zn) are also widespread: 52.8% and 47.5% of tested locations exceeded regulatory limits. Correlated with industrial activity (Katowice, Auby, Sevilla, Avilés).
- Mercury (Hg) contamination detected in Glasgow and Paris but only measured in 15 cities. Maximum levels exceeded thresholds in Prague, Torino, Ljubljana, Maribor, Sevilla and Newcastle.
- Accumulation of toxic elements in urban soils often occurs with other contaminants, suggesting common pollution sources.
- Limited analysis focusing on single contaminants can lead to overlooking significant pollution.
- A holistic approach is needed to assess heavy metal contamination comprehensively.

4. Conclusion

There is strong evidence of widespread soil contamination, with over 80% of analyses reporting values exceeding recommended or regulatory limits for safe agricultural practices.

Tracing this contamination is challenging, as soil pollution often involves multiple metals, making it difficult to identify the primary sources. Moreover, focusing solely on specific pollution sources or targeted contaminants may overlook significant concentrations of other unexamined elements.

The accumulation of these metals in edible plants poses potential dietary risks, highlighting the need for risk assessment studies to better understand human exposure through the consumption of urban-grown produce.

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