Assessing trace element contents in surface soils across Switzerland

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Aim

Geochemical soil atlas showing spatial distributions of 22 elements in surface soils:

As, B, Ca, Cd, Co, Cr, Cu, Fe, Hg, Mg, Mn, Mo, Na, Ni, Pb, S, Sb, Se, Tl, U, V, Zn

4'270 samples of the surface soil

Between 2011 and 2015, 4'270 samples of the surface soils (0-20 cm) were collected at 1'153 sampling sites within the framework of the Swiss Biodiversity Monitoring program (BDM). Sites polluted by point sources were excluded.

The sampling sites were evenly distributed on a regular 6 by 4 km grid with altitudes ranging from 199 m a.s.l. up to 2'741 m a.s.l.

Per site, up to 4 samples were collected in a circle (radius of 3 - 3.5 m) outside the sampling area of plants and molluscs.

The soil samples were sieved (<2 mm), dried at 40°C, milled, digested using aqua regia, and subsequently analysed using ICP-MS.

Map of sampling sites

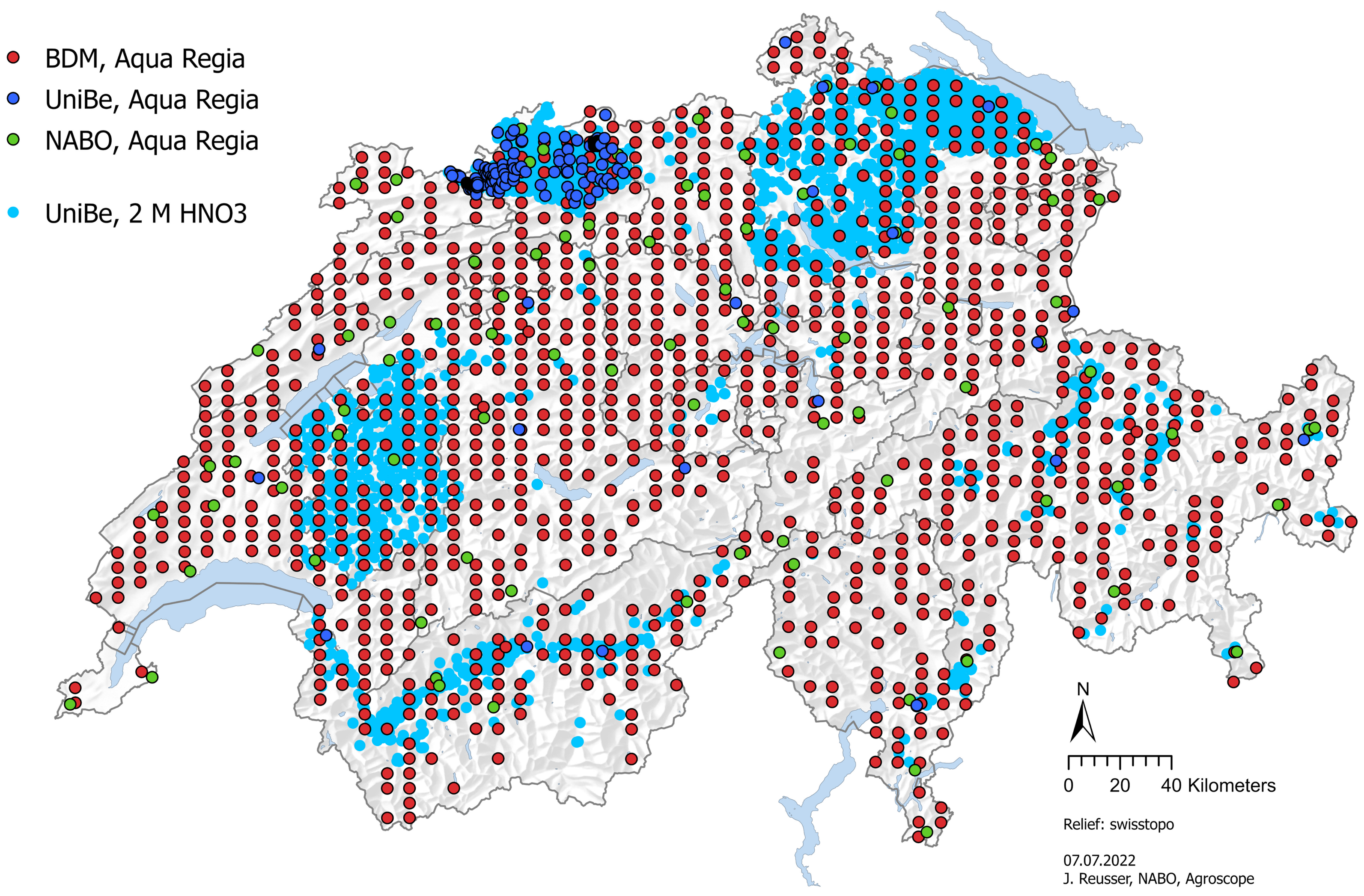


Fig. 1. Sampling sites of the geochemical soil atlas. BDM: Swiss Biodiversity Monitoring program, up to 4 samples per site; UniBe: dataset compiled by Stanisic et al. (2021), University of Berne; NABO: sampling sites of the Swiss Soil Monitoring Network NABO.

The dataset has been complemented with two additional datasets of the NABO and the University of Berne (Fig. 1), including in total **1'497** sampling sites and additional 3'100 sites with measurements of Cd, Co, Cu and Pb in 2 M HNO_3 digests, which were transformed to Aqua Regia concentrations according to Stanisic et al. (2021).

For the BDM and NABO sites, pH, total C and N, total organic C, texture, $CaCO_3$-content, cation exchange capacity (potential and effective), base saturation, and organic matter content were measured as well.

Outlook

- Multivariate data analysis including additional geodata (pH, precipitation, etc.)
- Mapping the spatial distribution of the element concentrations

Element concentrations

mg/kg	5 %	25 %	Median	75 %	95 %	CV (%)
As	2.7	5.5	**7.9**	12.1	35.2	149
Cd	0.07	0.16	**0.24**	0.36	1.04	115
Co	2.6	6.4	**8.6**	11.8	17.9	83
Cr	10	23	**30**	40	63	230
Cu	6	12	**18**	26	41	87
Ni	6	19	**27**	37	64	231
Hg	0.027	0.046	**0.066**	0.097	0.181	143
Pb	13	19	**24**	31	52	96
Se	0.05	0.20	**0.33**	0.50	0.90	75
V	12	23	**32**	44	75	70
Zn	27	48	**64**	83	128	50

Tab. 1. Element concentrations (mg/kg soil) analysed in aqua regia digests of soil samples using ICP-MS. Number of sampling sites included: 1201. CV: coefficient of variation in %.

Comparison land use types

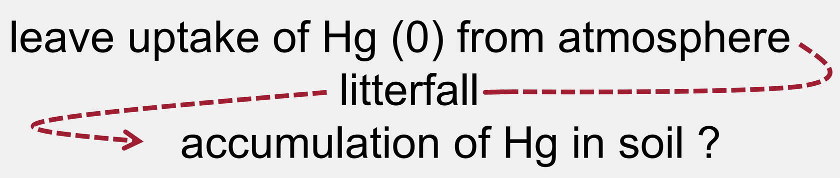
Measured concentrations of trace elements in surface soils were in range of expected soil contents (Tab. 1). Significant differences of element concentrations between different land use types were detected (Fig. 2).

Mercury

- Hg can threaten human and animal health already at low concentrations.
- Hg concentrations were highest in soils under forests.
- Accumulation of Hg in forest soils due to the terrestrial vegetation pump? (Jiskra et al., 2018)

Selenium

- Se is essential for organisms, but can become toxic at high concentrations.
- Concentrations of Se in Swiss topsoils were low, especially in arable fields.
- These potentially Se deficient soils are located in areas of great importance for agricultural food and fodder production.



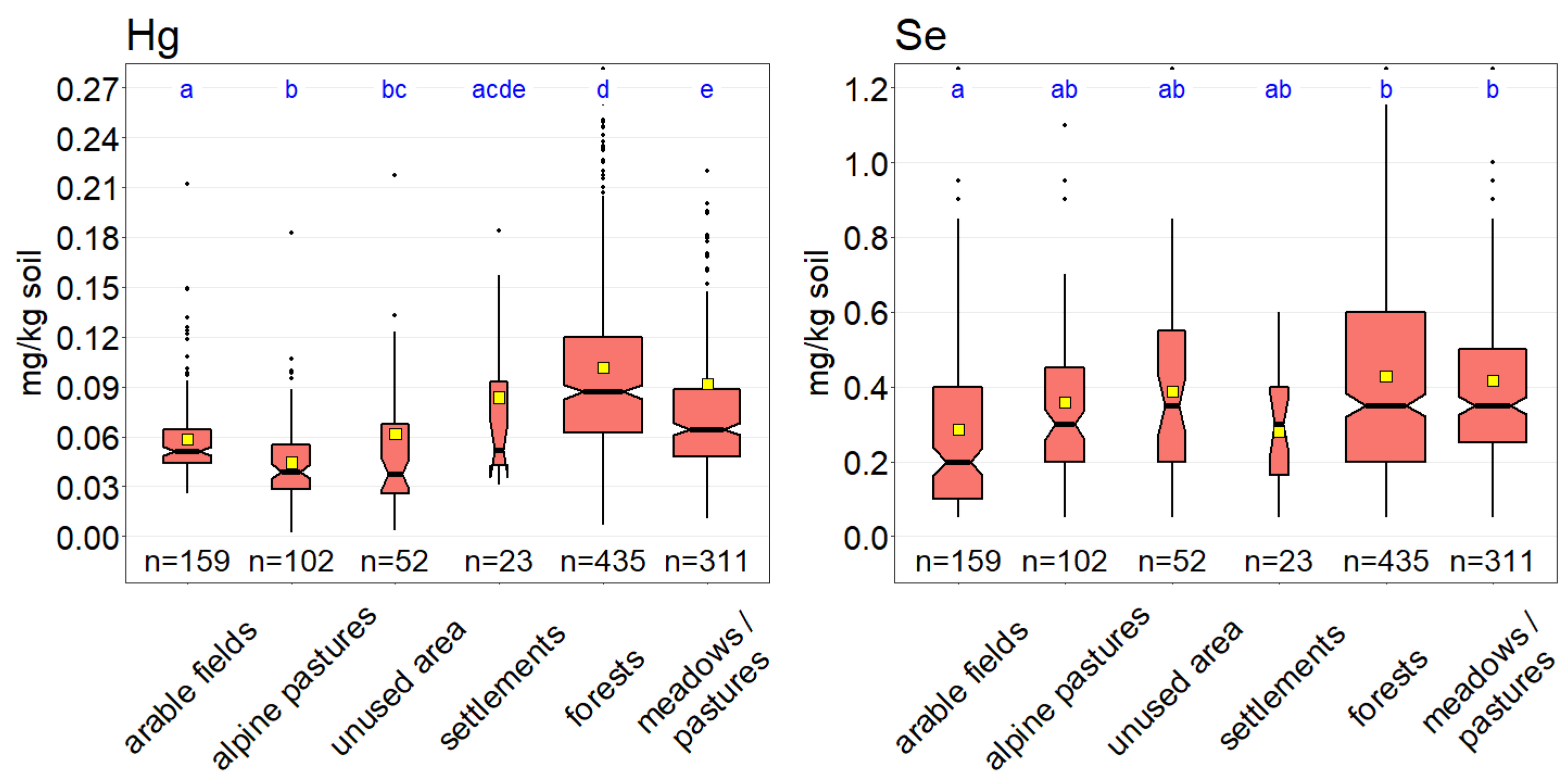


Fig. 2. Comparison of the Hg and Se concentrations (mg/kg soil) between land uses of the BDM dataset. Yellow square: mean value. Letters in blue: significance levels (p<0.001).

The geochemical soil atlas will be available in 2023

Literature:
Meuli, R.G., Wächter, D., Schwab, P., Kohli, L., Zimmermann, R., 2017. Connecting Biodiversity Monitoring with Soil Inventory Data – A Swiss Case Study. Bulletin BGS 38, 65–69.
Stanisic, L., Blum, J., Bigalke, M., 2021. Zusammenfassender Bericht über bestehende Studien und Untersuchungen zu geogenen Schadstoffgehalten in Böden und Gesteinen der Schweiz.
Jiskra, M., Sonke, J.E., Obrist, D. et al. A vegetation control on seasonal variations in global atmospheric mercury concentrations. Nature Geosci 11, 244–250 (2018).

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