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Hand-held XRF – a contribute to improve soil sampling strategy?

Introduction

Defining areas with geo(anthropo)genic elevated heavy metal contents in (top)soils in scale 1:10.000 or higher need a dense grid for soil sampling. Can field measurements by hand-held XRF support soil sampling strategy for necessary analysis in aqua regia extract according to German Federal Soil Protection Ordinance (BBodSchV, 1999)?

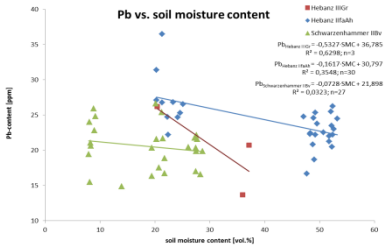
Materials and methods

At a subset (5 semiterrestrial sites, 6 terrestrial sites) of a grid based screening (total 190 sites) with a hand-held XRF (NITON XL3t, Analyticon Inc.) composite sample covering the whole depth of a soil pedon were taken and analysed in aqua regia.

The effect of soil moisture upon XRF-measurements was analyzed for 79 steel-ring soil samples under defined dewatering steps of -63 hPa (pF 1,8), -316 hPa (pF 2,5), and -15849 hPa (pF 4,2 and the soil moisture noted.

Grid based screening with hand-held XRF around Freihung/East Bavaria

Measurement at soil pedon



Moisture dependent XRF-signals of lead (Pb) exemplified for 3 riparian horizons. “SMC” means soil moisture, “R²” is measure of determination, and “n” is sample number.

Results and Discussion

Correlations XRF – aqua regia show for Pb and Zn acceptable results. Differentiation according to groundwater influence even improve results.

		kf [cm/d]	fine pores [%]	medium pores [%]	narrow wide pores [%]	wide pores [%]	bulk density [g/cm³]
Pb [ppm]	SC	-,214	,633	-,317	-,126	-,100	-,067
	Sig	,610	,067	,406	,748	,798	,865
	N	8	9	9	9	9	9

Tab. 1: Rank correlations between Pb-content and soil physical parameters. SC = Spearman correlation coefficient.

Exemplified for Pb-contents of three riparian horizons along the river Eger (NE-Bavaria), there occurred a clear effect of soil moisture upon XRF-signals. Drier soils showed higher metal contents than wet soils. In contrast to other studies this also holds true for heavy atoms like Pb (atomic number = 82) and can be observed to soil moisture contents <20 vol.%. For this, a complex of further factors such as fine pore fraction for the Pb-content (Tab. 1) could indirectly affect soil moisture distribution and thus the XRF-signal.

Conclusion

Grid based screening of the study area using hand-held XRF measurements combined with about 20 % additional expert selected soil sampling for wet chemistry analysis allow the calculation of a correlation XRF vs. aqua regia and the translation of XRF data to ´pseudo´aqua regia data. Soils texture and soil parent material are assumed also to have influence of XRF measurements. Also soil moisture has a pronounced effect upon XRF-signals. In XRF-screenings this should be taken into account to allow for a retrospective moisture correction.

Editor: Bavarian Environment Agency
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