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Soil geochemistry at the continental scale: quantifying the impact of anthropogenic activities

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Detecting and discriminating diffuse, scattered, and local contamination at the continental scale is a non-trivial task but is essential to quantify the human impact on the geochemistry of agricultural soil. At present, the discussion of important topics like ‘the geochemical background’ or the definition of action levels focuses on unusually high element concentrations, probably because people typically work on a local scale in the vicinity of well defined contamination sources, and because elemental toxicity is envisioned as a purely quantitative concept.
Here statistical detection strategies for the anthropogenic impact on the continental scale soil geochemistry based on the GEMAS (GEochemical Mapping of Agricultural Soil) dataset from EuroGeoSurveys are presented and discussed. In such a large scale survey, only samples that were taken close enough to a well defined contamination source will be detected when searching for data outliers. For example in the GEMAS dataset only some of the major cities generate sufficiently large geochemical anomalies to become well visible in the element distribution maps. On the other hand, also natural processes, like mineralisation, or the occurrence of unusual lithologies can cause data outliers, and thus ‘high element concentrations’ can equally well be either of geogenic or anthropogenic origin. Statistical methods to find data outliers are thus not sufficient to reliably detect contamination. Especially diffuse contamination at the continental scale, which by the European Commission is identified as one of eight major threats to soil quality, is difficult to quantify. On the background of the high natural variability of all chemical elements in soil, an addition of diffuse or scattered contamination will rarely lead to unusually high element concentrations, but rather shift or deform the overall data distribution. The main impact of diffuse contamination must even be expected at the low-concentration end of the data distribution. Also scattered sources generate rather ‘overabundant’ element concentrations, and not exceedingly high values. Cumulative probability (CP) plots, based on sufficiently large datasets to be statistically significant, can be used to visualise and to quantify this impact. In common element concentration maps, overabundant element concentrations remain invisible on the European scale. So far, only the shape of the data distribution can be used to efficiently monitor for diffuse contamination at the continental scale. By analyzing the impact of different enrichment and contamination processes on the element concentration CP-plots, it becomes clear why often-used techniques to identify anthropogenic contamination, for example the calculation of enrichment factors (EFs), are bound to fail. Comparing CP-plots of different elements or media provides an interesting new approach to detect specific processes at the Earth surface, and to study the impact of the biosphere on element concentrations in surface soils.