# The GEMAS project: results from the comparison of aqua regia and xrf analysis

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The comparison of analytical results from aqua regia (AR) and X-ray fluorescence spectroscopy (XRF) can provide information on soil processes controlling the element distribution in soil. The GEMAS (GEochemical Mapping of Agricultural and grazing land Soils) database including 2211 samples of arable soil (Ap samples, 0-20 cm), and 2118 samples from land under permanent grass cover (Gr samples, 0-10 cm) spread evenly over 33 European countries, is used for this comparison that for the first time compares directly at a continental scale the results obtained from the two analytucal techniques. The GEMAS project was designed to fulfil REACH (Registration, Evaluation and Authorisation of Chemicals) requirements (e.g., land use, sampling depth). It minimised critical error sources by standardisation of sampling procedures, sample preparation and analysis. Analyses for the same suite of elements and parameters were carried out in the same laboratory under strict quality control procedures. Sample preparation has been conducted at the laboratory of the Geological Survey of the Slovak Republic, AR analyses were carried out at ACME Labs, and XRF analyses at the Federal Institute for Geosciences and Natural Resources, Germany.

Element recovery by AR is very different, ranging from <1% (e.g. Ti, Zr, Na) to practically 100% of the reported total concentration, but quite similar among the two soil types. The high recovery of Ca, Mg is due to the complete removal of calcium carbonate by AR, while the high extractability of Fe and Mn suggests high selectivity for this important soil fraction. Recovery is controlled by mineralogy of the parent material, but geographic and climatic factors and the weathering history of the soils are also important. Nonetheless, even the very low recovery elements show wide ranges of variation and spatial patterns that are affected by other factors than soil parent material. For many elements, soil pH have a clear influence on AR extractability: under acidic soil conditions almost all elements tend to be leached and their extractability is generally low. It progressively increases with increasing pH and is highest in the pH range 7-8. Critical is the clay content of the soil that almost for all elements correspond to higher

extractability with increasing clay abundance. Also other factors such as organic matter content of soil, Fe and Mn occurrence are important for certain elements or in selected areas.

This work illustrates that there are significant differences in the extractability of elements from soils. It further illustrates that the extractability of an element is not constant, but is influenced by the bedrock material and weathering intensity of soil, soil pH, soil organic matter and clay content. Consequently, soil risk assessments for elements or metals should be made using effects and exposure values, based on the same extraction method.

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