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Transfer evaluation of potentially harmful elements from uncontaminated and contaminated soils to plant

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Trace elements are chemical elements present in low concentrations in the environment, including: (1) essential elements for plants and/or animals (such as Cu, Mn, and Zn), which sometimes cause human deficiency (frequent for Mo and Se) and toxicity when concentrations are below or above certain thresholds; and (2) elements with no identified biological role, which only cause toxicity to human health above a specific threshold value (cases of As, Cd, and Pb). In agricultural soils, these elements are originated from natural sources (parent material with specific trace element contents), and/or anthropogenic sources (such as industrial activities, organic amendments, or fertilisers). Elements in soils can be transferred to plant through different processes that depend on the element speciation, resulting in distinct bioavailabilities. Understanding the transfer of these elements from soil to plant in agroecosystems is thus fundamental. In this context, we aimed to evaluate the chemical transfer from soil to plant in uncontaminated and gradually contaminated agricultural soils considering various trace elements and rare earth elements (REE) as geochemical tracers. For this purpose, maize growing on four Belgian agricultural soils (Wallonia) with contrasting contamination levels and origins was studied in a greenhouse experiment, including soil, soil solution, and plant samples.

The results showed (1) an influence of soil properties and contamination origin on the availability of trace elements in the studied soils. Elements of anthropogenic origin were more extractable than those of natural origin, but their mobilisation depended on the element considered. Furthermore, (2) the soil-plant transfer of trace elements depended on their speciation, their physiological role(s), and the level of soil contamination. Essential trace elements, such as Zn and Cu, were more transferred to plants than strict contaminants, which were more accumulated in roots. Despite a lower plant translocation, trace element concentrations in plants were higher in contaminated soils than in uncontaminated soils. Finally (3) dissimilar REE patterns between soil/plant samples and soil solution samples were observed, indicating that the soil solution (as intermediate compartments) do not chemically represent the bioavailable fraction of elements.