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What determines intraspecific variability in heavy metal hyper-accumulation efficacy of *Arabidopsis halleri*? – Plant traits or soil biogeochemistry?

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Agricultural land degradation through heavy metal contamination threatens food security highlighting the importance of protection and remediation of fertile soils. Phytoextraction is a simple, low-cost technology to reduce harmful heavy metal loadings in soils. The metal-hyperaccumulating plant *Arabidopsis halleri* grows on metalliferous and non-metalliferous soils and shows a high intraspecific variation in leaf cadmium accumulation. Disentangling the contributions of soil and plant parameters driving these differences in metal accumulation between populations and individuals of the same species will ultimately help to improve phytoextraction as a tool for soil rehabilitation.

Here, we quantified aboveground cadmium concentrations in 49 *A. halleri* individuals from eight field sites of varying cadmium contents, i.e. metalliferousity, and categorized them into cadmium hyper- and non-hyperaccumulators based on the defined 100 ppm threshold for cadmium. Subsequently, twelve *A. halleri* individuals were selected as mother plants for a cross-factorial growth experiment on these eight soils. The accumulated concentrations of cadmium in experimentally cultivated *A. halleri* depended on the soil and the plant genotype. In detail, clones derived from hyperaccumulating mother plants accumulated cadmium within a higher range than clones from non-accumulators, independent of total soil cadmium. Irrespective of mother plants, *A. halleri* mostly consistently accumulated higher cadmium within their respective range dependent on soil properties but independent of total soil cadmium. Since soil pH was below 7 for all collected soils which often leads to increased cadmium mobilization, soil parameters such as soil organic carbon and cation exchange capacity became more relevant by negatively correlating with lower cadmium accumulation in *A. halleri*. The relative abundance of many microbial classes present in field soils positively or negatively correlated with total soil cadmium, with alpha-diversity and evenness being highest in soils with medium cadmium contents, but none of these parameters related to cadmium accumulation in *A. halleri*. Nonetheless, the initial soil microbiome may provide a pool of microbes that *A. halleri* selects for to maximize fitness under given environmental conditions.

Our findings suggest that plants possessing high cadmium accumulation potential should be chosen for successful cadmium removal, but whether the plant's ability is fully utilized depends on soil biogeochemical properties.