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Does slow and steady win the race? Using the model species Arabidopsis halleri to remediate industrially polluted soils

Charlotte Dietrich[1,2,3], Kamil Bilnicki[1], Urszula Korzeniak[1], Christoph Briese[2], Kerstin A. Nagel[2], and Alicja Babst-Kostecka[1]

[1]Polish Academy of Sciences, W. Szafer Institute of Botany, Krakow, Poland
[2]Institute of Bio- and Geosciences, IBG-2: Plant Sciences, Forschungszentrum Jülich, Germany
[3]RWTH Aachen University, 52074 Aachen, Germany

Hyperaccumulating plants possess complex physiological traits, which allow them to thrive in soils contaminated with trace metal elements (TME). In this study, we address an important but severly understudied aspect of plant responses to TME contamination in industrially polluted soils: root system development. In this context, we present the most detailed spatiotemporal analysis of root systems in a pseudometallophyte species to date. We exposed two contrasting ecotypes of the TME hyperaccumulating model species A. halleri to various treatments of their native and foreign soils. To overcome methodological challenges that have so far prevented an in-depth understanding of root-soil interactions under TME excess, we combined rhizoboxes and multitemporal digital imaging in a novel phenotyping approach. This allowed us to assess root architectural changes as a valuable indicator of plant performance in non-metalliferous (NM) and metalliferous (M) environments, as well as under horizontal layer applications of M and NM soils. We show that environment rather than ecotype determines root growth in A. halleri and that soil properties can cause a cost of tolerance in M soil or induce TME-foraging in NM soil. Importantly, root propagation into M soil was promoted by a non-contaminated “capping” layer that facilitated initial plant development. Growing on this capping layer in the early stage provides plants with a robust and optimal root system that facilitates seedling establishment and subsequent development under TME excess. These findings are relevant for practical applications related to phytoremediation. This matter is urgent, considering that industrial pollution is spreading and hyperaccumulating species are threatened by habitat loss.