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# Utilizing plant-based metal signatures to determine metal sources and pathways

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Many metals are of economic interest given their need in industrial, electronic, and green energy applications but can also pose an environmental threat, particularly when transferred into biomass. Here, they may serve as a vector for introduction into the food chain. The translocating mechanisms causing phytoaccumulation or even hyperaccumulation of metals can also result in unique and novel applications of plant-driven metal signatures, namely biogeoprospecting, passive contamination monitoring, or phytoremediation. Many of these applications, however, hinge on the ability of geogenic metal signatures to persist through plant uptake and redistribution. Here, we present metal isotopic data (thallium (Tl) and lead (Pb)) within *Brassica juncea*, a naturally occurring and widely grown mustard plant, to evaluate the ability of biosignatures to reflect the original geogenic or anthropogenic sources of metals.

*B. juncea* was grown in six distinct soil compositions, three reflecting primary Tl sources (various Tl-bearing mineral amendments: a mica, feldspar, and Mn-nodule) and three reflecting primary Pb sources (natural Pb, anthropogenic Pb, and a mixed Pb component), along with a control group. Plants showed significant translocation of both Tl and Pb into above-ground, edible plant tissues (several orders of magnitude greater than the soil values) and varying degrees of isotopic continuity between soil and biomass signatures. Thallium isotopic compositions in plant tissues ranged from $\varepsilon^{205}$Tl = -6.8 to +10.4 with leaf isotopic compositions consistently reflecting the original source composition. Lead, on the other hand, demonstrated a biological partitioning during uptake and translocation, with roots significantly shifting the isotopic composition compared with the soil, but all later-forming plant parts being within error of one another and none showing reproducibility of inherited soil signatures. These trials demonstrate the potential utility and limitations of utilizing single nontraditional isotopic systems in provenancing of metals through plant signatures, but also highlight the potential bioconcentration of multiple heavy metals with pressing environmental and human health concerns.