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Biogeochemical interdependency in soils adapting to As/Cd contaminants under future climatic conditions

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Metal(loid) ions can be retained by adsorption, absorption, and precipitation within soils. Climatic conditions influence the mobilization and transformation of soil-borne metal(loid)s. The fate and binding modes of As and Cd in soils are often inverted to each other due to opposing charges. Soil microbial communities are either stimulated or inhibited by the addition of metal(loid)s and acclimate eventually to a balanced community. Microbial communities also adjust to climate change by shifting in numbers, diversity, and activity. It currently remains unclear how long soils take to adapt biogeochemically to the amendment of metal/loids, and whether different climatic conditions speed up or slow down this process. Hence, we hypothesize that future climatic conditions will accelerate metal/loid binding in soils simultaneously resulting in faster microbial adaption to the presence of these metal/loids.

To test this hypothesis, we performed an acclimatization experiment in which As and Cd speciation was assessed in oxic soils with the native metal/loid content, with amended As (+15 mg/kg As), and amended Cd (+0.7 mg/kg Cd) exposed to either today's (ambient CO_2 and air temperature) or future climatic conditions (850 ppm CO_2 and +4 °C from ambient). While As moved from the surface to the interior of the mineral, Cd remained at the surface. Future climatic conditions enhanced the movement of As into the mineral structure and did not reach equilibrium within the mineral after six weeks, whereas future climatic conditions forced more Cd to remain at the surface of the mineral equilibrating after three weeks. The involvement of iron minerals in incorporating As into their structure was supported by enhanced microbial iron(III) mineral reduction being temporally stimulated by the presence of As in the first three weeks. In terms of microbial numbers, bacteria and archaea in soils with additional As and Cd adjusted within two to three weeks under future and today's climatic conditions, respectively.

Our findings have implications for the fate and means to investigate metal(oid) cycling under future climatic conditions.