Redox-controlled mobility of arsenic and cadmium in paddy soil amended with organic matter, sulfate, and iron oxide

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Organic matter, sulfate, and iron oxide have been commonly used for the remediation of paddy soils contaminated by arsenic (As) and/or cadmium (Cd). These amendments can influence soil redox processes and regulates the mobility of the metal contaminants. However, the underlying chemical and microbial mechanisms are not fully understood at environmentally realistic concentrations.

A paddy soil that contained 33 mg kg^{-1} total As and 0.36 mg kg^{-1} total Cd was amended with rice straw, gypsum, or hematite; the soil was then incubated in microcosms after submergence and redrying [1]. Rice straw significantly promoted the microbial reduction of Fe(III) and As(V) as well as the increase in soil pH after submergence. This resulted in the rapid mobilization of As and immobilization of Cd. Nevertheless, after 8 weeks, the phosphate-extractable As concentration in the straw-amended soil was lower than that in the unamended control soil, possibly due to the precipitation of As(III) in secondary iron minerals. After 5 weeks of re-drying, phosphate-extractable As concentration was higher and dissolved Cd concentration was lower in the straw-amended soil than the control soil, because pH of the straw-amended soil was higher than that of the control soil.

Compared to rice straw, gypsum and hematite had smaller effects on the mobility of As and Cd. Added hematite decreased Cd solubility by approximately 30% compared to the control during the wet and dry periods. Added gypsum and hematite, which inhibited mirobial Fe(III) and As(V) reduction, reduced As mobility by 8–60%.

Molecular biological analyses further showed that rice straw, rather gypsum or hematite, greatly stimulated the growth of iron-reducing bacteria. Moreover, soil As concentrations were related to the abundance and community composition of the *arrA* gene [mediating dissimilatory As(V) reduction], rather than the *arsC* gene [mediating cytoplasmic As(V) reduction] or the *aioA* gene [mediating As(III) oxidation].

[1] Yuan et al. (2019), J. Hazard. Mater. 378, 120672
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