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How does paddy soil aging affect Arsenic biogeochemistry? Insights from a 2000-year-old chronosequence

JOSÉ MIGUEL LEÓN NININ[1], E. MARIE MUEHE[2], ANGELIKA KÖLBL[3], ALEJANDRA HIGA MORI[1], BENJAMIN S. GILFEDDER[1], JOHANNA PAUSCH[1] AND BRITTA PLANER-FRIEDRICH[1]

[1]University of Bayreuth
[2]University of Tübingen
[3]Martin Luther University Halle-Wittenberg
Presenting Author: Jose.Leon-Ninin@uni-bayreuth.de

In flooded, oxygen-depleted paddy soils, arsenic (As) represents different risks for rice production depending on its speciation. While inorganic oxyarsenic poses a risk for human consumption due to its carcinogenicity, methylated As species can affect grain yield due to their phytotoxicity. Furthermore, highly mobile and toxic thiolated As species have been recently discovered in paddy soils and adversely affect humans and plant health. The formation of all the above-mentioned species is regulated by biogeochemical properties, such as As availability, carbon (C) content, dynamics of major elements like iron (Fe) and sulfur (S), and the activity of different microbial communities.

Chronosequence studies have shown that long-term paddy use has a direct impact on soil properties that are related to As chemistry, e.g., increasing soil organic C, modifying Fe mineralogy, and reshaping microbial communities. However, how aqueous phase redox chemistry and As dynamics are affected by paddy evolution has not been directly studied, yet. Considering that redox chemistry in paddy soil porewater determines which As species are available for rice plants, it is key to understand the link between paddy soil evolution (aging) and aqueous-phase processes. For this, we incubated paddy soils from a 2000-year-old chronosequence and followed the kinetics of biogeochemical and microbial properties affecting As speciation.

Our results reveal higher As mobilization in young paddies (≤100 years), dominated by inorganic and thiolated As species, while the contribution of methylated and methylthiolated As increased in older paddies. Here, we will present how these contrasting characteristics in aqueous phase redox chemistry and As speciation depending on historical field development could relate to different degrees of success when applying sulfate fertilization for decreasing As mobility. Furthermore, age-related differences in porewater As dynamics could help explain observations of different species dominating the As content in rice grains from different geographical areas.