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Potential Role of Indigenous Bacteria in Controlling Arsenic Concentration in Mixed–Oxic State Groundwater

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Although arsenic (As) is ubiquitously present in sediments in appreciable concentrations, it is unclear why As mobilization is observed only under certain geological settings, such as in the mixed-oxic state aquifers of the middle-Gangetic plain (MGP) of India. This study was aimed to understand this phenomenon by a detailed investigation of abiotic and biotic components of such aquifers. Batch leaching experiments were conducted with sediments collected at two depths, 10 m (shallow) and 31 m (deep) from a previously identified site in MGP from two locations: As–unpolluted [B1; total dissolved As ($As_{T,diss}$<10 µg/L)] and As–polluted [B2; $As_{T,diss}$>10 µg/L] . The four types of sediments, B1–10, B2-10, B1-31 and B2-31, with total As contents (As_T) of 12.3 mg/g, 14.4 mg/g, 20.1 mg/g, and 20.7 mg/g, respectively, were interacted with As-unpolluted groundwater and glucose (0/1 mM) in the absence or presence an As(V)-reducer, *Citrobacter youngae* IITK SM2 (*CyIITKSM2,* [1]), previously isolated from B2 at shallower depth (7–15 m) . Characterization of porewaters prior to the batch experiments suggested higher $As_{T,diss}$, dominantly present as As(III), in shallower depths of B2 as compared to B1, whereas $As_{T,diss}$ was mostly not detected at deeper depths (15–34 m) in both the locations. Results from the batch experiments indicated $As_{T,diss}$ >10 µg/L as As(III) only from B2-10 in the absence of additional *CyIITKSM2* (Fig.1), which suggested conditions unique to this sediment, such as the presence of indigenous As(V)-reducers that promoted As mobilization. In the absence of *CyIITKSM2,* leachable $As_{T,diss}$ was <10 µg/L in the deeper aquifer sediments although the As_T was higher than in B2-10. When *CyIITKSM2* was introduced to these systems, higher $As_{T,diss}$ was mobilized (Fig.1). Metagenomics of the shallow sediments indicated that ~90% of the bacteria belonged to gut microbiota, whereas such bacteria were <50% in the deeper aquifer. Of this microbiota, many genera are known to metabolize As(V). Sequential extraction of unreacted and reacted–sediment samples suggested that As mobilization was likely controlled by microbially-leachable fractions associated with Fe–oxides. Detailed results elucidating the role of indigenous bacteria in controlling As-speciation in mixed-oxic groundwaters will be presented.

[1]. Verma et. al. (2022), BioMed.Res.Inter., 2022, 1-19 (https://doi.org/10.1155/2022/6384742)

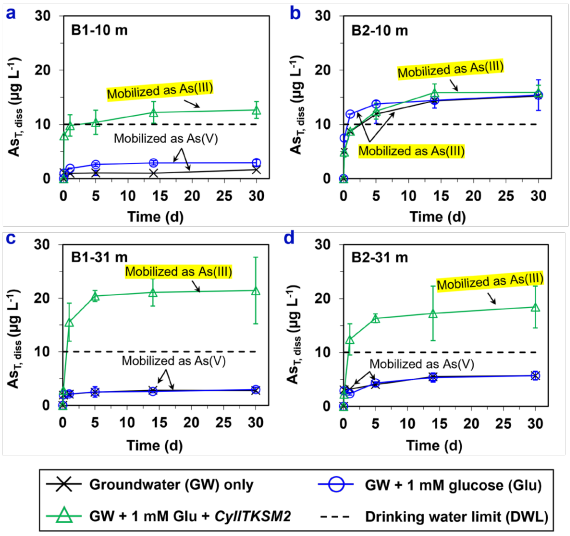

Figure 1. Variation of total dissolved As ($As_{T,diss}$) with time in batch systems initially containing sediments (a) B1-10 m, (b) B2-10 m, (c) B1-31 m, and (d) B2-31 m collected at different depths and locations. B1 and B2 represent As-unpolluted and As-polluted locations, respectively, at the study site in the middle Indo-Gangetic plain. The two locations were chosen because preliminary field surveys indicated groundwater use from these aquifers at 10 m (shallow) and ~31 m (deep) below the surface, which exhibited contrasting groundwater quality parameters.