

THE CORRELATION OF ARSENIC AND MANGANESE IN SOILS AND GROUNDWATERS IN THE BENGAL DELTA TO REDOX CONDITIONS AND MICROBIAL ACTIVITY: GEOCHEMICAL INDICATORS OF HABITABILITY

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The role of Arsenic in affecting microbial life is still a debatable matter. Much investigation and research has explored the mechanisms behind the release of As and factors influencing its accumulation in aqueous systems. Findings suggest that As is released into groundwater under anaerobic conditions following the reductive dissolution of iron oxide phases onto which As is initially adsorbed. These reactions are microbially mediated, and the presence of labile organic carbon is a critical, rate-limiting component in the As release mechanism. Although dissolved organic constituents play a strong role in controlling As mobilization, many inorganic species have also been shown to influence As. Here we also consider manganese (Mn) and focus on two sites in West Bengal and Bangladesh. Mn content is generally understood to vary inversely with As, though the strength of this correlation varies from site to site. We examine two concepts pertaining to two localities: i) the role of dissolved organic carbon in groundwaters at shallower to deeper depths corresponding to dissolved As content; and ii) the correlation between dissolved groundwater components (Mn, Fe, and As and degree of microbial activity, as determined by biomass).

The presence of As has been documented for decades and is therefore of no surprise, however the prevalence of Mn on top of that has only recently been identified, making it particularly important that its release mechanisms and relationship with As is understood. Areas exhibiting both high As and high Mn could exist as a result of adsorbed As onto Mn-oxide sediments, in addition to Fe-oxide sediments, which then under anaerobic conditions could reduce these solid phases and subsequently release both As and Mn into the groundwater consistently. This cannot be the only explanation, because Mn has been observed to accumulate in environments with oxidizing ORPs [oxidative reductive potential]. In most areas, however, where elevated As is coupled with low Mn and vice versa, it is likely that this is not the case. Instead, the As is adsorbed predominantly onto Fe-oxide phases, and the accumulation of dissolved Mn could be inhibited by the Mn-phase mineral precipitation, most probably rhodocrosite. Also, it has been observed that environments with higher alkalinity have lower Mn concentrations, possibly because of the increase in saturation of rhodocrosite and hence the removal of Mn from the groundwaters. Finally, where high Mn and low As is observed, the probable explanation is that the ORP is simply too oxidizing to permit

HCO_3^- that would drive the reaction towards super-threduction of oxides that adsorb As to their surfaces.

It is understood that microbially mediated reductive processes in the presence of labile organic carbon are a critical mechanism in releasing As. Although it is difficult to delineate a single source for supplying the organic carbon in these shallow groundwaters, the fluorescence data indicates that a microbial origin is very probable. This is supported by average FIs being calculated at ~1.7-1.8, which indicate that DOM is derived from extracellular release and leachate from bacteria and algae. However, peaks on EEMs corresponding to humic-like components (A) complicate the issue, as surface water bodies receive significant terrestrial organic matter and/or soil organic matter (T) from the surrounding areas. More humic like dissolved OC may not be only potentially accelerating As release in shallow reducing aquifer system. Biogeochemical reactions and/or more complex microbial mediated processes may be involved to mobilize As in shallow to intermediate groundwaters.

The distribution of these two oxyanions is generally inverse, however many of the studied locations contain both high As and Mn. This phenomenon can possibly be explained by the presence of As adsorbed onto Mn-oxides, resulting in the coupled release of both trace elements upon the reduction and subsequent dissolution of these sediments. More often, however, it is the redox potential that controls their distribution, with more reducing environments containing high As and low Mn, while more oxidized environments contain elevated Mn yet low As. It is known that the microbially mediated reductive dissolution of Fe and Mn-oxides in both Murshidabad and Matlab is driven by the presence of dissolved organic matter. Fluorescence spectroscopy analyses reveal the source of this organic matter to be quite complex, with fluorescence indices denoting a microbial origin while certain peaks on excitation emission matrices suggest a more humic or terrestrial influence. It is therefore concluded that this process is multi-faceted in nature and cannot be delineated to a single source.

Higher release of As can be related to higher bioactivity in these sites. It is also possible that some microbes help concentrate As in the environment to limit the microbial diversity in these sites. This research infers to discuss the overall idea about what the concentration of As and Mn – or their ratio – might tell about habitability and/or microbial diversity in those environments.