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# Role of Carbonate Minerals in Mobilization of Geogenic Contaminants in Indo-Gangetic Plain Groundwater

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Groundwater contamination with geogenic uranium (U), fluoride (F), and arsenic (As) in the densely populated Indo-Gangetic plain (IGP) of South Asia poses severe health risks to millions of people dependent on groundwater for their living. While several studies have reported the prevalence of these contaminants, the mechanisms that drive their mobilization are not well studied. Specifically, the role of carbonate minerals that dominate the IGP aquifers on the extents and rates of contaminant mobilization needs to be understood. Even where the primary sources for some of these geogenic contaminants are not carbonate-associated, the carbonate minerals likely exert secondary controls on contaminant release. For example, F typically originates from F-bearing minerals such as fluorite ($CaF_{2(s)}$), and cryolite ($Na_3AlF_{6(s)}$), yet calcite ($CaCO_{3(s)}$) precipitation-driven fluorite dissolution results in elevated F. Geogenic U, whose primary source in these aquifers is currently unknown, mobilizes in the form of stable U-carbonate aqueous complexes due to its higher affinity towards carbonate, and reductive dissolution of prevalent iron oxides mobilizes sorbed As. In this presentation, results from our recent coupled field-scale and bench-scale investigations that highlight potential controls of specific carbonate minerals on elevated F, U, and As will be discussed. The groundwaters in IGP typically contain dissolved carbonate much higher than carbonate concentration in equilibrium with atmospheric carbon dioxide. Additionally, the groundwater is at saturation with rhodochrosite ($MnCO_{3(s)}$), where manganese (Mn) is typically present as Mn(II) from reductive dissolution of $MnO_{2(s)}$. Geochemical modelling of well-constrained water quality meta-data of Indian groundwaters collected from literature indicated negative correlations of Mn with both F and U. Rhodochrosite precipitation, due to its lower solubility than calcite, inhibits calcite precipitation, which in turn results in lower mobilization of F due to lesser fluorite dissolution. Its precipitation also likely controls U mobilization because of structural incorporation of U in the $MnCO_3$ lattice. In middle Gangetic plain groundwaters elevated with As, surplus Fe(II) is likely controlled by either binary carbonate solids, such as siderite ($FeCO_{3(s)}$) or by solid solutions such as ankerite [$Ca(Fe,Mg,Mn)(CO_3)_{2(s)}$] involving other divalent cations. These results underline the potential role of secondary carbonate minerals on contaminant mobilization in IGP aquifers.