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Hydrological Mechanism for Arsenic Deposits in Meghna River Hyporheic Zone Sediments

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Heavy metal deposits along the interface between aquifers and rivers have been discovered in diverse settings around the world. This so-called "Iron Curtain" is thought to be caused by groundwater flow towards the riverbank. To our knowledge the hydrology of this process hasn't been studied along a tidally influenced, completely fresh river-aquifer system. The Meghna River within the Ganges-Brahmaputra-Meghna Delta (GBMD) experiences tidal fluctuations that propagate over 400 km upstream, from the Bay of Bengal to Sylhet City. River and aquifer water levels also fluctuate seasonally by as much as 4 m as the region receives most of its $\sim$ 2 m of rainfall from June through September. We studied a 10 km reach of the Meghna River 200 km north of the coast where the eastern side of the river is strongly gaining for most of the year. In contrast, the river both gains and loses water to shallow aquifers on the western side. High solid-phase iron (Fe) and arsenic (As) concentrations were previously observed in Meghna riverbank sediments. To test the hypothesis that groundwater discharge is responsible for depositing Fe and As in the riverbank we mapped major and trace element distribution at $\sim$ 100 m spacing on both the east and west side of the river using X-ray fluorescence. The distribution of solid-phase Fe and As were compared to hydraulic gradients, hydraulic conductivity, and ambient liquid-phase concentrations in the riverbank aquifer. Hydraulic gradients were measured with transects of monitoring wells at three locations, and the 30 m deep shallow aquifer was mapped 500 m north and south parallel and orthogonal to each river bank using Electrical Resistivity Tomography (ERT). Resistivity, borehole logging, and slug tests indicate the aquifer dimensions and properties are remarkably consistent at the 3 locations on both sides of the river. Groundwater discharge to the river obtained from Darcy's Law and two independent methods indicate the high As deposits can develop within one season. A 3-D numerical groundwater flow model indicates that river water preferentially moves into the seepage face under the influence of tidal fluctuations. This process, coupled with gaining conditions may be responsible for the formation of the high As zone. Sea level rise and increased groundwater pumping will convert many rivers throughout the world into losing rivers altering this process whereby heavy metals are deposited in river sediments along seepage faces. This may remove an important heavy metal sink and shut off the discharge of other important elements to the oceans.