Geomorphic controls on groundwater arsenic concentrations in aquifers perturbed by large scale pumping

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Groundwater arsenic (As) contamination is widespread throughout South and Southeast Asia. Many of these highly contaminated aquifers lay in the floodplains of large river networks and are heavily exploited for irrigation, industrial, and drinking water supplies. Under natural conditions, these aquifers would discharge into nearby rivers; however large-scale groundwater pumping lowers the watertable below river levels drawing river water into these aquifers.

In fresh sediments adjacent to a heavily pumped aquifer along the Red River in Vietnam we find that recharging river water becomes high in As, with levels exceeding WHO limits by two orders of magnitude 1m below the riverbed. Riverbed porewater samples with pH/Eh values below ferrihydrite stability are uniformly high in As (>50ppb) whereas samples falling in the ferrihydrite stability zone are uniformly low in As (<50ppb). These results suggest that these sediments host highly reactive ferrihydrite which is susceptible to dissolution under mildly reducing conditions. A simple model of this process reveals that both ferrihydrite and As are exhausted from sediments within 30-40 years.

Groundwater As concentrations along depositional reaches of the river, which have reactive Fe and As in recharge areas, are generally 10-50 times greater than WHO guidelines, whereas As concentrations along erosional reaches are almost uniformly below WHO guidelines. We suggest that aquifers in these regions may be susceptible to further As contamination as riverine recharge is drawn in by extensive groundwater pumping, with aquifers down gradient of depositional zones being most vulnerable.