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Potential of using arsenic-safe aquifers as sustainable drinking water sources in arsenic-affected areas of Bengal basin, India and Bangladesh

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Naturally occurring arsenic (As) in Holocene aquifers in Bengal basin (India and Bangladesh) have undermined a long success of supplying the population with safe drinking water. Several studies have shown that many of the tested mitigation options have not been well accepted by the people. Instead, local drillers target presumed safe groundwater on the basis of the colour of the sediments. The overall objective of the study has thus been focused on assessing the potential for local drillers to target As safe groundwater. The specific objectives have been to validate the correlation between aquifer sediment colours and groundwater chemical composition, characterize aqueous and solid phase geochemistry and dynamics of As mobility and to assess the risk for cross-contamination of As between aquifers in areas of southeastern Bangladesh and West Bengal. Drillings to a depth of 60 m revealed two distinct hydrostratigraphic units, a strongly reducing aquifer unit with black to grey sediments overlying a patchy sequence of weathered and oxidised white, yellowish-grey to reddish-brown sediment. The aquifers are separated by an impervious clay unit. The reducing aquifer is characterized by high concentrations of dissolved As, DOC, Fe and PO_4^{3-}-tot. On the other hand, the off-white and red sediments contain relatively higher concentrations of Mn and SO_4^{2-} and low As. Groundwater chemistry correlates well with the colours of the aquifer sediments. Geochemical investigations indicate that secondary mineral phases control dissolved concentrations of Mn, Fe and PO_4^{3-}-tot. Dissolved As is influenced by the amount of Hfo, pH and PO_4^{3-}-tot as a competing ion. Laboratory studies suggest that oxidised sediments have a higher capacity to absorb As. Monitoring of hydraulic heads and groundwater modelling illustrate a complex aquifer system with three aquifers to a depth of 250 m. Groundwater modelling studies illustrate two groundwater flowsystems: i) a deeper regional predominantly horizontal flow system, and ii) a number of shallow local flow systems. It was confirmed that groundwater irrigation, locally, affects the hydraulic heads at deeper depths. The aquifer system is however fully recharged during the monsoon. Groundwater abstraction for drinking water purposes in rural areas poses little threat for cross-contamination. Installing irrigation- or high capacity drinking water supply wells at deeper depths is however strongly discouraged and assessing sustainability of targeted low-As aquifers remain a main concern. Delineation of safe aquifer(s) that can be targeted by cheap drilling technology for tubewell (TW) installation becomes highly imperative to ensure access to safe and sustainable drinking water sources for the As-affected population in Bengal Basin. In order to replicate the salient outcomes of the Matlab study results, an investigation was carried out in West Bengal, India covering an area of $\sim$100 km^2 to investigate the potentiality of brown sand aquifers (BSA) as a safe drinking water source which is currently being practiced in the area for safe tubewell installation. The results revealed salient hydrogeochemical contrasts within the sedimentary sequence designated as shallow grey sand aquifers (GSA) and the brown sand aquifers (BSA) within shallow depth ($<$ 70 m). These two sand groups with all possible variability in the colour shades were analogous to the reducing and the oxidized sequences as delineated aquifers based on the sediment color as perceived by the local driller in Matlab. Although the major ion compositions indicated close similarity, the redox conditions were markedly different in groundwater abstracted from the two group of aquifers. The redox condition in the BSA is delineated to be Mn oxy-hydroxide reducing, not sufficiently lowered for As mobilization into groundwater. In contrast, lower Eh in groundwater of GSA, along with the enrichments of NH_4^+, PO_4^{3-}, Fe and As reflect reductive dissolution of Fe-oxyhydroxide coupled to microbially mediated oxidation of organic matter as the prevailing redox process causing As mobilization into groundwater of this aquifer type. The outcomes of the study has thus established a scientific knowledge linking relationship between the colour of aquifer sediments, redox conditions and hydrogeochemical parameters that provides unique opportunity for the local drillers in rural communities to target As-safe aquifers for well installations in Bengal basin.