Biogeochemical transformation of Fe, As, Mn and N in household sand filters for As removal in Hanoi, Vietnam

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In the Red River delta of Vietnam, As concentrations in groundwater reach up to 1000 µg/L, and the water also contains significant concentrations of Fe(II), Mn(II), and NH_4^+. Household sand filters are applied to remove As, Fe and Mn from water that is used for washing and drinking purposes. Previous work on As, Fe, and Mn removal processes in one of the sand filters revealed a complex interplay of abiotic and microbially catalyzed processes including the potential for nitrification. However, there are still several open questions: i) How does the As removal efficiency change at different Fe(II)/As(III)/Mn(II)/NH_4^+ ratios, ii) how does the water composition influence the formation of black MnO_2 minerals during microbial oxidation of Mn(II), iii) can this black mineral layer be used as a visual indicator for a functioning filter, and iv) how does NO_3^- formation affect water quality? Therefore, field work and a series of column experiments in the lab were implemented to investigate the transformation of As, Fe, Mn and N in sand filter materials that were collected from 6 filters in 3 villages south of the Red River. We sampled inflow and outflow water as well as sand material. The groundwater analysis showed a range of Fe/As ratios from 50 to 195 with Mn(II) and NH_4^+ concentrations ranging from 0.17 to 0.85 and 1 to 20 mg/L respectively. A heterogenous stratification of brown, orange, grey and black minerals in different sand filters was observed. The material was therefore collected from different depths for mineralogical analyses and for column experiments that were fed with artificial groundwater with different ratios of Fe(II):As(III):Mn(II), with and without NH_4^+. The water composition in the outflow was continuously monitored. At the end of the run, the sand from the columns was collected for solid phase analysis (As, Mn, Fe) by XRF, and microbial community analysis by qPCR and DNA sequencing. The results provide a better understanding of sand filter performances at different geochemical conditions so that recommendations can be given to the sand filter operators for safer usage.