Arsenic removal from groundwater by household sand filters: Comparative field study, model calculations, and health benefits

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Abstract: Arsenic removal efficiencies of 43 household sand filters were studied in rural areas of the Red River Delta in Vietnam. Simultaneously, raw groundwater from the same households and additional 31 tubewells was sampled to investigate arsenic coprecipitation with hydrous ferric iron from solution, i.e., without contact to sand surfaces. From the groundwaters containing 10-382 μg/L As, 99%, 90%, and 71%, respectively. The concentration of dissolved iron in groundwater was the decisive factor for the removal of arsenic. Residual arsenic levels below 50 μg/L were achieved by 90% of the studied sand filters, and 40% were even below 10 μg/L. Fe/As ratios of ≥50 or ≥250 were required to ensure arsenic removal to levels below 50 or 10 μg/L, respectively. Phosphate concentrations >2.5 mg P/L slightly hampered the sand filter and coprecipitation efficiencies. Interestingly, the overall arsenic elimination was higher than predicted from model calculations based on sorption constants determined from coprecipitation experiments with artificial groundwater. This observation is assumed to result from As(III) oxidation involving Mn, microorganisms, and possibly dissolved organic matter present in the natural groundwaters. Clear evidence of lowered arsenic burden for people consuming sand-filtered water is demonstrated from hair analyses. The investigated sand filters proved to operate fast and robust for a broad range of groundwater composition and are thus also a viable option for mitigation in other arsenic affected regions. An estimation conducted for Bangladesh indicates that a median residual level of 25 μg/L arsenic could be reached in 84% of the polluted groundwater. The easily observable removal of iron from the pumped water makes the effect of a sand filter immediately recognizable even to people who are not aware of the arsenic problem.

Index Keywords: Arsenic; Concentration (process); Filters (for fluids); Groundwater pollution; Oxidation; Precipitation (chemical); Artificial groundwater; Coprecipitation; Sand filter; Water treatment; arsenic; dissolved organic matter; ferric ion; ground water; iron; manganese; phosphate; phosphorus; Arsenic; Concentration (process); Filters (for fluids); Groundwater pollution; Oxidation; Precipitation (chemical); Water treatment; arsenic; comparative study; groundwater pollution; oxidation; pollution control; precipitation (chemistry); removal experiment; rural area; aqueous solution; article; Bangladesh; biodegradation; chemical composition; comparative study; concentration (parameters); controlled study; dissolution; filter; health status; heavy metal removal; household; human; human tissue; major clinical study; model; oxidation; precipitation; rural area; sand; surface property; Viet Nam; water pollution; water treatment; Arsenic; Filtration; Hair; Humans; Models, Theoretical; Precipitation; Silicon Dioxide; Vietnam; Water Pollutants, Chemical; Asia; Eurasia; Red River Delta; Southeast Asia; Viet Nam

Year: 2006
Source title: Environmental Science and Technology
Volume: 40
Issue: 17
Page : 5567-5573
Cited by: 29
Link: Scorpus Link
Chemicals/CAS: arsenic, 7440-38-2; ferric ion, 20074-52-6; iron, 14093-02-8, 53858-86-9, 7439-89-6; manganese, 16397-91-4, 7439-96-5; phosphate, 14066-19-4, 14265-44-2; phosphorus, 7723-14-0; Arsenic, 7440-38-2; Silicon Dioxide, 7631-86-9; Water Pollutants, Chemical
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ISSN: 0013936X
CODEN: ESTHA
DOI: 10.1021/es060144z
Language of Original Document: English
Abbreviated Source Title: Environmental Science and Technology
Document Type: Article
Source: Scopus
Authors with affiliations:

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