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Influence of filter age on Fe and Mn removal in dual media rapid sand filters used for drinking water production

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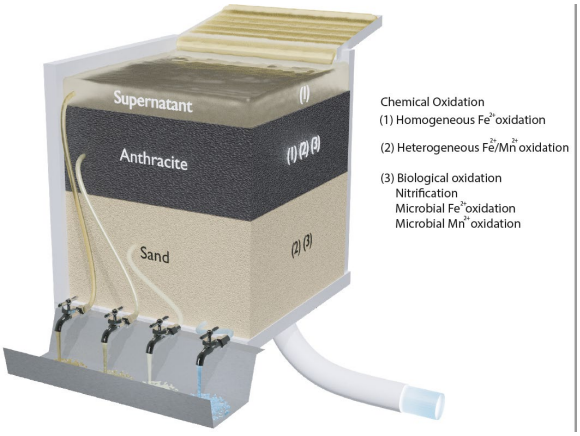

Rapid sand filtration is a common method for removal of iron (Fe) and manganese (Mn) from anoxic groundwaters used for drinking water production. In this study, we combine geochemical and microbiological data to assess how filter age influences Fe and Mn removal in dual media filters, consisting of anthracite overlying quartz sand, that have been in operation for between ~2 months and ~11 years. We show that the depth where dissolved Fe and Mn removal occurs is reflected in the filter medium coatings, with a combination of XRD, sequential extractions and SEM-EDS revealing the formation of ferrihydrite in the anthracite in the top of the filters (< 1 m), while birnessite-type Mn oxides are mostly formed in the sand (> 1 m). Removal of Fe is independent of filter age and is always efficient (> 97 % removal). In contrast, for Mn, the removal efficiency varies with filter age, ranging from 9 to 28 % at ~2-3 months after filter replacement to 100 % after 8 months. After 11 years, removal reduces to 60-80%. The lack of Mn removal in the youngest filters (at 2-3 months) is likely the result of a relatively low abundance of mineral coatings that adsorb Mn^{2+} and provide surfaces for the establishment of a microbial community. 16S rRNA gene amplicon sequencing shows that *Hyphomicrobiaceae spp.* and *Gallionella spp.* are present after the initial ripening (7 months), suggesting a role of these microorganisms in Mn^{2+} and Fe^{2+} oxidation, respectively. Our results highlight the strong effect of filter age on Mn^{2+} removal. We show that ageing of filter medium leads to the development of thick coatings, which ultimately leads to preferential flow, as reflected in a lower residence time of the water in the filter. We suggest using age-specific flow rates to increase the contact time with the filter medium in older filters to improve Mn^{2+} removal.