Goldschmidt 2023 Abstract
https://doi.org/10.7185/gold2023.19746

Oxidation reactions in rapid sand filters: comparing rates and sequence using reactive transport modelling

EMIEL KRUISDIJK, BORIS M VAN BREUKELEN AND DORIS VAN HALEM

Delft University of Technology

Presenting Author: e.kruisdijk@tudelft.nl

Rapid sand filters (RSF) are designed to remove iron (Fe(II)), manganese (Mn(II)), and ammonium (NH_4) from groundwater to provide safe and tasty/aesthetic drinking water. Removal occurs by a combination of physicochemical and biological processes. As the anoxic groundwater is aerated before entering the filter, removal is largely depending on oxidation reactions.

We investigated oxidation of Fe(II), Mn(II), and NH_4 in six Dutch RSF, from which three single media RSF (only sand) and three dual media (top layer anthracite, bottom layer sand). Water quality data was obtained over the depth of all RSF and assessed with a reactive transport model. Rate constants for Fe(II)-, Mn(II)-, and NH_4-oxidation were estimated in the model using PEST. NH_4- and Mn(II)-oxidation rate constants deviated about an order of magnitude over the six RSF, while the pH-dependent Fe(II)-oxidation rates varied more than three orders of magnitude. This highlights the potential to forecast the removal of Mn(II) and NH_4 in RSF, and the need for a more applicable rate equation for Fe(II)-oxidation.

Oxidation of Fe(II) and Mn(II) occurred concurrently in all single media RSF, but sequentially in some dual media RSF. Model outcomes together with geochemical analysis indicated that this is linked to the presence of Mn-oxides in the filter layer, as Mn(II) is only oxidized on the surface of Mn-oxides when present. Fe(II)- and Mn(II)-oxidation occurs sequentially in a non-backwashed RSF when oxygen is not limited, as oxidation of Fe(II) is thermodynamically favourable in these conditions. Fe-oxides precipitate in the top of the filter bed, while the Mn-oxides form lower in the filter. Backwashing mixes the grains and results in Mn-oxides in the top of the filter. This induces surface catalytic oxidation of Mn(II) in the upper part of the filter and thus the concurrent oxidation of Fe(II) and Mn(II). Sand and anthracite do only limitedly mix during backwashing in dual media filters. It can be that Mn-oxides do not end up in the upper part of the filter, and, consequently, Fe(II)- and Mn(II)-oxidation occur sequentially. This phenomenon can be used to engineer the sequence of Fe(II) and Mn(II) oxidation processes in RSF.