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Laboratory investigations of iron and manganese precipitates formed during in-situ iron removal by ozonation: Understanding the effects on the Atlantis Aquifer permeability

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Iron and manganese clogging of production boreholes by abiotic oxidation and biofouling reactions at the primary Atlantis Aquifer is threatening the sustainability of the groundwater supply scheme. The current approach to controlling the production borehole clogging is through monitoring and rehabilitation procedures. However, these approaches are not dealing with the source of the problem which is the Fe^{2+} and Mn^{2+} ions in solution. From the Robey et al. [1] preliminary investigation it was proposed that in-situ iron removal by ozonation was a feasible method to apply in the Atlantis Aquifer for preventing the clogging. This method treats the source of the clogging problems by periodically injecting a volume of ozonated water into the anoxic aquifer. In the aquifer, the Fe^{2+} and Mn^{2+} ions are oxidised and form iron and manganese oxyhydroxides on the mineral surfaces, creating an oxidation zone. When abstraction is resumed, the native groundwater transverses this oxidation zone which functions as a subsurface filter and adsorbs further Fe^{2+} and Mn^{2+}, which ultimately delays the movement of the ions towards the borehole.

The in-situ iron and manganese removal technology has been proven successful abroad for decades with no long-term risk of reducing the aquifers permeability[2, 3] but the local impacts on the Atlantis Aquifer sediments has not been explored. In addition, international in-situ iron and manganese removal studies have used aeration or oxygen gas as the oxidant for oxidising the mobile ions, whereas this study uses dissolved ozone to change the redox conditions in the aquifer.

The objective of this study is to determine and examine the effects of in-situ iron and manganese removal by ozonation on aquifer sediments. This includes characterisation of the Springfontein Formation sediments (the Atlantis Aquifer production boreholes target unit) in terms of permeability, porosity and morphology prior to the application of the in-situ ozone treatment. Laboratory scale simulations and experiments will then be set up to mimic the aquifer conditions while the in-situ iron removal treatment is applied. These experiments will be repeated over different time intervals in order to examine the changes found in both water and sediment over time. Sediment characterisation prior and post treatment will be done by means of XRF, XRD, SEM and CT analyses, whereas changes in water chemistry will be done via IC and ICP-MS analyses. This will provide an understanding of the physical and chemical characteristics of the sediment generated by the treatment prior to initiation of a long-term field study.

References:

[1] Robey K et al. (2014) Water Research Commission Report No. 2070/1/14
[2] Mettler S et al. (2001) Groundwater 39:921-930
[3] van Halem D et al. (2011) Applied Geochemistry 26:116-124