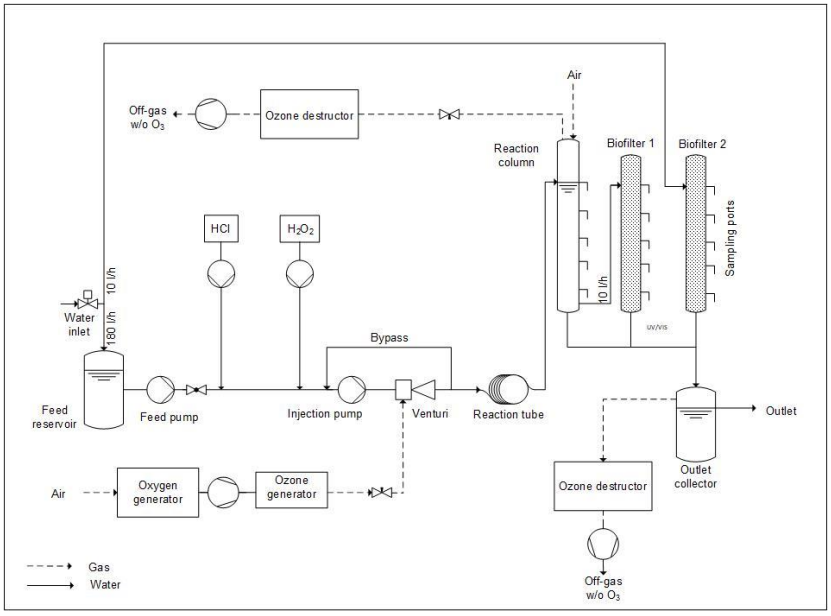
2 Research projects

2.1 COL_EX: Removal of dissolved organic carbon from groundwater containing humic acids (decolorization) – possible applications and limits of treatment processes



Project Duration

01.07.2018 – 31.03.2021

Funding

DVGW-Project No.: W 201917

Introduction

Many groundwaters exhibit color caused by organic components due to regional deposits of peat or lignite sands in the aquifers.

- The coloration of drinking water is limited by the German Drinking Water Ordinance TrinkwV (spectral absorption coefficient, SAK_{436} = color, < 0.5/m).
- Though increased coloration by humic substances is typically non-hazardous, it might cause aesthetic problems, leading to complaints by consumers.
- Increased concentrations of humic substances are undesired, as they can foster biological growth in the water distribution system and may lead to the formation of chlorinated disinfection by-products.
- Groundwaters with high coloration are often anaerobic and therefore contain high concentrations of iron and manganese. Presence of organic components in water may negatively affect removal of iron and manganese.

Currently, the DVGW set of rules does not contain any information on process selection to achieve decolorization in the context of groundwater treatment. Moreover this shall be done in a sustainable and cost-efficient manner.

Research Goals

Three technologies (flocculation/precipitation, oxidation, ion exchange) are examined for their decolorization efficiency and the respective performance limits. The evaluation is carried out with the aim of developing recommendations for action in the DVGW set of rules, as well as minimizing the use of energy and chemicals and the entire life cycle costs.

Approach

Experiments with the relevant processes have been performed both in the laboratory and at selected waterworks sites. The project partner TZW Dresden has operated a pilot plant for flocculation and oxidation with $KMnO_4$. DVGW-TUHH has been operating a pilot plant for ozonation/biofiltration at two waterworks. Additional experiments on decolorization by anion exchange and by ozonation have been conducted at lab-scale.

Recent Results

In the final project period, the experimental results from the pilot tests have been evaluated and compared to obtain recommendations for process selection. Criteria for process selection have been summarized, starting with limitations of use of the different processes. The core part of the recommendations is the overview of reduction rates of coloration and DOC that can be obtained with the investigated processes, see table 1.

Table 1: Reduction rates of SAK_{436}, SAK_{254} and DOC with the treatment processes investigated in pilot scale. *Carix data for DOC and SAK_{254} has been obtained in pilot tests in the BMWi project Suleman.

Process	Flocculation + Filtration	$KMnO_4$ + Filtration	Ozonation + Biofiltration	CARIX
Typical dosage	0,8 – 2,0 mg Fe/mg DOC_0 0,4 – 1,0 mg Al/mg DOC_0	0,3 – 0,6 mg $KMnO_4$/mg DOC_0 2 – 4 mg/l $KMnO_4$	0,2 – 0,4 mg O_3/mg DOC_0 0 – 2 mol H_2O_2/mol O_3	Ion exchange capacity depending on water quality
Reduction SAK_{436}	30 – 70 %	20 – 40 %	40 – 80 %	> 70 % expected
Reduction SAK_{254}	30 – 70 %	10 – 20 %	20 – 40 %	ca. 70 %*
Reduction DOC	30 – 60 %	5 – 10 %	5 – 20 %	ca. 50 %*

The table shows the range of reduction rates that can be expected and the typical range of dosage of flocculant or oxidant. If a strong reduction of coloration above 40 % is needed, oxidation with $KMnO_4$ cannot be used. For a strong reduction of DOC above 20 % only flocculation/filtration oder CARIX are suitable processes. The processes that are suitable for the treatment goal are then further evaluated using first the limitations of use (e.g. no possibility of sludge disposal or high bromide concentration of water resulting in bromate formation during ozonation) and in the next step the additional selection criteria (e.g. costs, integration in existing treatment, disposal).

Conclusion and Outlook

Our results show that flocculation/filtration, ion exchange and ozonation/biofiltration are applicable for substantial color removal in groundwater treatment. Depending on water quality parameters and on the current treatment scheme, one or another process can be advantageous to reduce coloration. To summarize the results, we have extracted parameters and treatment targets to simplify decision making on the favoured treatment process. Besides technological criteria, life cycle costs have been estimated. The project partner TZW Dresden has contributed data on flocculation and oxidation with $KMnO_4$. All results are available in the project report W 201917 via DVGW online.

Project Partners

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