MULTI ReUse

Requirements for water reuse in the context of groundwater recharge

Artificial groundwater recharge means the controlled injection of water into a water conducting underground. It is a common method in municipal water management to pursue the following objectives:

- Increase of groundwater availability/storage of freshwater and improvement of groundwater quality before extraction and treatment
- Groundwater management, e. g. for the preservation of ecosystems and to avoid settlement cracks/damage to buildings
- Hydraulic deviation of pollutant flow in the groundwater, e. g. to avoid saltwater intrusion in coastal areas
- Rehabilitation of contaminated groundwater

Figure 1: Surface infiltration of treated wastewater at IWVA in St. Andres, Belgium

Challenges

Groundwater recharge with reused water must not cause deterioration to groundwater or soil quality and therefore only should be carried out under suitable hydrogeological and hydrochemical conditions. Passing the soil, the quality of the infiltrated water changes and therefore also the quality of the groundwater generated. This and the resulting environmental impacts (e. g. groundwater quality, permeability of the soil) need to be considered when reusing water for groundwater recharge.

Depending on the objective and the local conditions, different infiltration technologies are used (surface infiltration, subterranean infiltration or bank filtration). Each technology has other requirements with regard to space and quality of infiltrated water. Water quality can be affected and changed in different ways during the infiltration process and the soil passage. A thorough monitoring of the groundwater quality is necessary and many national and international laws or guidelines require a risk assessment that is consistent with the requirements of environmental and consumer protection.

Precautionary approach for groundwater recharge

If reused water is used for groundwater recharge, next to technological parameters (such as turbidity, oxygen, iron, manganese and dissolved organic carbon (DOC)), especially anthropogenic substances have to be taken into consideration. Hardly degradable organic trace substances such as drugs, household and industrial chemicals as well as microorganisms (viruses, bacteria), but also nutrients such as ammonium, nitrite, nitrate and phosphate fall under this category. During the practical implementation of the MULTI-ReUse process chain special attention has been paid to these parameters. The MULTI-

ReUse project is using flow cytometry for the online monitoring of microbiological pollution to guarantee a permanent control of the water quality along the process chain. Activated carbon adsorption is used to reduce trace substances.

Procedure for the determination of quality requirements

To develop a profile of requirements for infiltration water that can be used for groundwater recharge within MULTI-ReUse, national and international case studies of artificial groundwater recharge were collected and analysed with regard to technological implementation and existing frameworks. In absence of national or local regulations for the artificial groundwater recharge with treated wastewater, legislative texts for groundwater recharge with other raw water sources have been used for orientation. Very helpful in this context have been the EU studies on water reuse, the US EPA Guidelines for Water Reuse (US EPA 2012) and abstracts from the research projects Demoware (Lakretz et al. 2017), Marsol (www.marsol.eu), Demeau (Vilanova et al. 2013), Aquarec ((Wintgens et al. 2005) and Reclaim Water (Hochstrat et al. 2008). The quality parameters for infiltration water were chosen based on the premise to avoid a deterioration of the groundwater quality. Therefore, insignificant threshold values or environmental quality standards were taken as reference values for several parameters (example see table 1). It has to be pointed out that their definition always has to be case specific because of influencing local factors.

Important regulations/laws/guidelines

In Germany, surface water is used for artificial groundwater recharge in a few places with policies and recommendations existing for these kind of procedures. But there are only few cases where treated wastewater is used for groundwater recharge, which is why there is no legal framework for it in Germany yet. In general, high-level guidelines, laws and regulations need to be taken into consideration such as the EU-water framework directive resp. the water resources act and the ground water directive. For concrete cases, the laws of the federal states and the requirements of the regional administrations are decisive in the end.

The water resources act states that groundwater recharge is water usage and therefore subject to approval. It is only permitted if there won't be a detrimental change in water quality. Annex 2 of the groundwater directive defines threshold values for the chemical state of the groundwater. Inorganic parameters as well as substances from pesticides and biocidal products, including relevant metabolites and the sum of tri- and tetrachloroethylenes, fall under this category. A few parameters defined as pollutants are mentioned in Annex 7 and 8 of the groundwater directive but there are no threshold values defined for them.

To categorize the anthropogenic changes in chemical groundwater quality, the German Federal/States Working Group on water (LAWA) defined so called insignificant threshold values for inorganic and organic parameters that mark the line between small changes and damaging pollution. If a groundwater body is connected to a surface water, the surface water directive needs to be considered

Table 1: Suggestions for parameter selection and maximum concentration in the infiltration water depending on infiltration technology

Parameters	unit	direct infiltration[1]	indirect infiltration[2]	source
Turbidity	NTU	0.1	2	US EPA 2012
Escherichia coli	KFU 100 ml	0	1,000	Vilanova et al. 2013
DOC (org. C, solved)	mg/l	1	10	Vilanova et al. 2013
Nitrogen, in total (TNb)	mg/l	10	10	EU UWWTD 1991
Sulphate	mg/l	150	150	Vilanova et al. 2013
Lead	mg/l	0.0012	0.0012	LAWA 2016
PPP[3] and biocides, in total	mg/l	0.0005	0.0005	LAWA 2016
PPP[3] and biocides, single	mg/l	0.0001	0.0001	LAWA 2016

[1] direct discharge into groundwater (via infiltration wells); [2] indirect discharge through infiltration and ground passage (as a natural cleaning barrier); [3] plant protection products

too because the quality of the surface water can't be affected negatively either. Also, the maximum concentrations according to the environmental quality standards are relevant. They apply to some inorganic as well as a number of organic substances that are used in industry, households, for medical purposes and in agriculture.

The topic of water pollution with anthropogenic trace substances is currently under discussion. Some agencies use lists with up to 400 single- and sum parameters for their assessment of water pollution. Those lists also contain substances that aren't officially regulated yet but that are rated according to their health orientation value (valid for human toxicological substances in the drinking water that only inadequately can be assessed) or a preventive precautionary value (derived from convention).

With 62 %, groundwater is the preferred resource for drinking water treatment in Germany. Based on the variety and high number of substances with unknown effects onto the environment and human health, there are very high requirements for recharge water. Water suppliers such as the OOWV therefore demand the general renunciation of water reuse for groundwater recharge in water protection areas.

At EU level, preparations for the development of a regulation were carried out to finally have a legal framework for water reuse for groundwater recharge, among other things. This goal was given up again though. It is not foreseeable, if and when there ever will be a legal European framework for groundwater recharge. Internationally and in a few EU countries there already are suitable laws, regulations and guidelines. Especially the Guidelines for Water Reuse from the American environmental authority EPA (Environmental Protection Agency) and the Australian Guidelines for Water Recycling – Managed Aquifer Recharge are used as template internationally. Table 2 shows an overview of important national and international documents.

Table 2: Selected international requirements and guidelines for water reuse and groundwater recharge

Relevant guidelines for the European Union
EU Water Framework Directive 2000/60/EC
EU Urban Waste Water Treatment Directive 91/271/EEC
EU Groundwater Directive 2006/118/EC
EU surface water directive (2008/105/EG) with environmental quality standards
JRC-Draft: European Commission – Joint Research: Development of minimum quality requirements for water reuse in agricultural irrigation and aquifer recharge Draft V.3.3. (June 2017)
Directives and standards with international relevance
WHO: World Health Organization (2006) Guidelines for the Safe Use of Wastewater, Excreta and Greywater. Geneva, Switzerland
US EPA: US EPA (2012) Guidelines for Water Reuse 2012. Report EPA/600/R-12/618
Australia: NWQMS (2006) Australian Guidelines for Water Recycling, National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)
Australia: NWQMS (2008) Australian Guidelines for Water Recycling, National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2), Augmentation of Drinking Water Supplies
Australia: NWQMS (2009) Australian Guidelines for Water Recycling, National Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2), Managed Aquifer Recharge

Conclusions

Artificial groundwater recharge with reused water can be an appropriate water management measure, which is already implemented internationally and in some EU countries. Biggest challenge right now is the risk of groundwater pollution with anthropogenic organic trace substances. This requires site-specific risk analysis with derived mandatory treatment, operation and monitoring concepts.

In general, groundwater recharge requires a high knowledge of the soil conditions and the groundwater body (soil types, flow directions, permeability, water quality and connection to other water bodies). These have to be identified and modelled by hydrogeological exploration. A mature groundwater monitoring concept is needed too to be able to detect and monitor changes in groundwater quality. Even though there are only few clear national and international regulations and standards, MULTI-ReUse derived some frameworks for the artificial groundwater recharge with treated wastewater based on international examples, superior legislative texts as well as different regulations usually used in municipal water management. The quality parameters chosen reduce the risk of a deterioration of groundwater quality.

Literature

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US EPA (2012): Guidelines for Water Reuse. Washington D.C. United States Environmental Protection Agency.

Vilanova et al. (2013): Decision trees for MAR impact evaluation: identification of optimum conditions to face emerging pollutants removal in MAR systems. Deliverable D12.1. EU research project DEMEAU.

Wintgens et al. (2005): Political and legislative framework conditions for wastewater reclamation and reuse in Europe. In: 20th Annual Water Reuse Symposium, Denver, USA, 18.–21.09.2005.

Short description of the MULTI-ReUse project

Treated wastewater is an important part of the water cycle. It usually is fed into rivers, something that is acceptable from an environmental point of view but for the use in agriculture or industry the water often is unsuitable. MULTI-ReUse closes this gap by developing and implementing of new procedures for the reuse of service water. The aim of MULTI-ReUse therefore is the development, demonstration and evaluation of a modular water treatment system, in order to offer service water in different qualities and quantities for the different purposes and to competitive prices.

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