End of project popular science description

Introduction

Economic growth, agricultural development and improved living standards have increased water consumption in China, especially in the North China Plain (NCP). As a result, groundwater tables have declined at rapid rates of up to 1 m/year in NCP primarily due to intensive irrigation. In response to this development, the "South-to-North Water Transfer Project" (SNWT) was initiated. Currently, the SNWT mitigates the urgent need for an increased water supply, but it does not directly contribute to the replenishment of depleted groundwater aquifers, unless groundwater pumping is significantly reduced. It is therefore necessary to manage surface and groundwater resources conjunctively, without further depleting the aquifer. Beyond the NCP, the city of Jinan is famous for its natural springs. However, with the development of social economy, the contradiction between water supply and spring preservation is acute. Multi-source artificial groundwater recharge is considered one of the effective measures for water resources management in Jinan.

The MAR-China project addresses the potential of utilizing "low value" reclaimed water (treated wastewater) and floodwater through Managed Aquifer Recharge (MAR) to replenish the groundwater aquifers of the North China Plain (NCP). Our aim is to investigate how MAR can contribute to rehabilitation of groundwater aquifers. This requires an improved knowledge of the treatment and degradation processes occurring during MAR and subsequent storage. In addition, the full potential is best explored using spatially distributed hydrological modelling to quantify the effects of realistic MAR implementation through scenario analysis.

A main argument for improving our knowledge of treatment and degradation processes during infiltration of reclaimed water is that incidental recharge due to uncontrolled large scale use of reclaimed water for landscaping and environmental flow purposes in the North China Plain. This is already a threat to groundwater quality by introducing not-so-biodegradable contaminants of emerging concerns such as antibiotics and by mobilizing geogenic contaminant such as arsenic.

Results

Our studies have shown that in water-sediment systems, the removal of antibiotics is primarily via biodegradation involving microbes, however, the degradation is usually incomplete with unknown degradation products (metabolites), and subject to variable retention time and kinetics.
As a result, recharge of reclaimed water should be controlled through MAR and water quality should be monitored.

The quantitative potential of MAR in the NCP has been studied by combining satellite remote sensing and large-scale modelling of the water system and quantification of major water uses for irrigation and human consumption. The developed models have been utilized for scenario testing of various water management measures, including MAR. The results have illustrated that MAR has a potential to limit the current groundwater decline trend locally by replenishing the local aquifers with stormwater runoff or reclaimed wastewater. However, in order to abate the massive regional scale groundwater decline, other measures such as reduced irrigation and large-scale water transfer schemed are required.

As an example of the local potential of MAR, the strong seepage zone in the upper reaches of Yufuhe River has been shown as a unique place for karst water recharge in the Jinan spring domain. Since the dry season in 2015, Yufuhe River has released water from multiple sources to replenish the source, which has raised the groundwater level in the western area of Jinan and played an important role in maintaining the annual flow of Jinan spring water. The main water sources for MAR in Yufuhe River is the South-to-North Water Transfer project and the Yellow River. It has been shown that sulfate in the SNWT water, the clay fine particles and trace organic matter in the Yellow River water are the biggest risk items affecting the environment and health in the Jinan area.

Recommendations

To protect human and ecosystem health, regulations governing water recycling will need to address risks associated with incidental recharge, and better yet, develop regulations enabling managed aquifer recharge to take advantage of the soil-aquifer systems natural attenuation abilities in a more controlled manner.

Yufuhe River multi-water source recharge plays an important role in the protection of the Jinan spring area. To protect the perennial flows of the Jinan springs and to maximize ecological, economic and social benefits the optimal development and utilization of MAR through the local karst systems needs to be studied further.

MAR can be highly beneficial at local scale but cannot revert the ongoing groundwater decline trends at regional scale, where water saving measures needs to be employed.