Modeling groundwater recharge and seawater intrusion in the Quaternary coastal plain aquifer of the Wadi Watir Delta, Sinai, Egypt

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Abstract

The Wadi Watir Delta in Sinai, Egypt consists of an alluvial and sandy clay aquifer underlain by impermeable Precambrian basement. The scarcity of rainfall during the last decade and high pumping rates has increased salinity and degraded water quality in the main water-supply wells along the mountain front and along the coast. This degradation has required a reduction in groundwater production.

The main factors controlling groundwater salinity in the delta are water-rock interaction, seawater intrusion, and mixing with deep saline water. Water chemistry and stable isotopes in groundwater including $^{87}Sr/^{86}Sr$, $\delta^{37}Cl$ and $\delta^{81}Br$, were utilized to evaluate the groundwater geochemical evolution, sources of groundwater mixing, and the amount of seawater intrusion along the coast. Also, $^{87}Sr/^{86}Sr$, $\delta^{37}Cl$ and $\delta^{81}Br$ of various aquifer rocks were determined to assist in understanding the groundwater flow system.

Inverse geochemical modeling was used to identify possible geochemical processes that account for the chemical and isotopic changes in groundwater. Possible models are presented that quantify the amount of water-rock interactions, mixing and evaporation.

The isotopic results were utilized to develop a three-dimensional, variable-density, flow and transport model using the SEAWAT modeling environment. The models were calibrated using groundwater level changes and salinity variation. The models estimate average annual groundwater recharge and simulate annual groundwater pumping, upwelling of saline water from beneath the well field, and seawater intrusion along the coast for different pumping scenarios.

Keywords: groundwater sustainability, groundwater modeling, seawater intrusion, water chemistry, isotopes, Wadi Watir Egypt.

MICROBIAL BIOMINERALIZATION AS A TECHNIQUE FOR GROUTING FINE APERTURE ROCK FRACTURES

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Abstract

For many engineering applications, such as sealing tunnels, shafts and boreholes, it is necessary to limit fluid flow through fractures. The particle size of conventional cementitious grouts limits the size of fractures into which they can penetrate. To address this issue increasingly microfine and ultrafine cement grouts are becoming commercially available. Despite this the radius of penetration remains dependent on the grout viscosity alongside injection pressure, pumping rate, grout setting time and grout cohesion: lower viscosity aqueous solutions potentially have a greater radius of penetration. In addition cementitious grouts typically undergo volumetric shrinkage during setting. In many applications this change in volume may not be of particular importance but in others where a very low hydraulic conductivity is a critical design criterion, such as borehole sealing for carbon storage reservoirs and tunnel sealing for nuclear waste repositories, this reduction in volume may be significant.

This study investigates the use of microbially induced carbonate precipitation (MCP) as a technique for grouting fine aperture rock fractures. Two types of laboratory experiment have been conducted: sealing fractures at the 10cm-1m scale between transparent polycarbonate plates; and sealing artificial fractures within granite cores. We investigate both the hydraulic and mechanical properties of the MCP grout. We show that the grout has the potential to seal fractures with apertures less than 100 microns, that it can 'biologically re-heal' when damaged and that the shear strength can be greater than traditional cementitious grouts.