Geophysical Research Abstracts
Vol. 15, EGU2013-2469-1, 2013
EGU General Assembly 2013

Changes in environment, climate, land-use and population growth cause significant change in recharge on the western coast of Saudi Arabia

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Changes in climate, land-use and population do not necessarily lead to groundwater depletion, but could instead result in rising groundwater levels, which can cause severe problems. In the course of the refurbishment and expansion programme for the Holy City of Mecca (KSA), Jeddah Airport is being expanded to a greater capacity; in addition, rapid development of residential areas of Jeddah is underway. During the last, decade flash floods and rising groundwater levels have been observed. The latter are affecting the foundations of buildings due to uplift and corrosion by highly mineralized water.

The primary objective of this study is investigate the causes of groundwater rise and to propose appropriate measures in order to keep the groundwater table below an acceptable level over the next 100 years. Groundwater hydrographs clearly show impacts of natural climatic and hydrologic changes over the last 30 years. Possibly reasons for groundwater rise in this arid area are climatic impacts by increased precipitation or from an enhanced recharge via wadi leakage or flood control reservoirs. In addition, anthropogenic impacts might arise from leakages from water supply and waste water systems.

In order to identify and quantify possible contributions to groundwater recharge, a numerical groundwater model has been developed comprising a sound investigation of the local water balance. The model addresses an area of approximately 900 km around the city of Jeddah, reaching from the Red Sea to the catchment boundaries of adjacent wadis. Vertically three layers of alluvium, fractured and weathered rock are integrated. Information from many shallow boreholes and some deep boreholes comprising stratigraphy and hydraulic parameters is incorporated. The spatial distribution of recharge is taken from the analysis of existing and planned water supply and waste water networks.

Knowledge from geophysical investigations about aquifer thickness and permeability was used for the transient calibration. Thus, from the groundwater rise with known storage coefficients the leakage was estimated and checked for plausibility. Model evaluation and sensitivity analysis include the identification of key model parameters, the parameter ranges for the prediction of groundwater levels and the characterization of associated uncertainties.

The modelling results show that indeed the anthropogenic recharge caused by leakage from water infrastructure is the most important source of groundwater level rise. Thus, to improve model accuracy, a methodology is needed to cope with limited data availability regarding the leakage from pipelines.

For the design of future management strategies, modelling scenarios are used to quantify the factors with possible impacts on groundwater levels, including Red Sea water level rise due to climate change, as well as potentially significant changes in land use, water distribution systems, waste water management, storm water and flood control, and irrigation.

The model results are used for the design of a field-based groundwater and surface water monitoring system. Based on these measurements, a decision support system for future groundwater control is planned to be integrated into the upgrade of the water and waste water master plan.