Geophysical Research Abstracts,
Vol. 10, EGU2008-A-12311, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-12311
EGU General Assembly 2008

A Decision Aid Tool for the management of coastal aquifers based on sea-intrusion control through recharge with treated wastewater and desalination of brackish groundwater

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Water shortages have intensified in the Mediterranean rim and islands, where population densities are typically high and economic activities intense. The water resources of these areas, often limited/depleted and frequently of deteriorating quality, are expected to come under increased stress according to climate change scenarios. Groundwater is a major element of coastal fresh water resources. We present a scheme for a sustainable development of coastal aquifers in water-stressed, semi-arid coastal areas and islands under demand pressures. The scheme uses brackish groundwater desalination coupled with an effective strategy for controlling sea intrusion and enhancement of the hydrologic budget through re-use of treated wastewater (WW). This strategy is developed on the premise that intense exploitation of coastal aquifers inevitably causes, at least periodically, a certain degree of seawater intrusion. However, this strategy can be economically favourable, compared to seawater desalination or water transfer, and achieve long-term protection of the aquifer. The reasons for this are the relatively low cost of brackish water desalination and the potential to augment aquifer recharge with advanced-treated WW, at only the differential cost to current treatment. With precipitation-derived resources fixed, re-cycled treated WW can be a

non-traditional, cost-effective alternate water source that can meet certain demands.

We focus on a Decision Aid Tool (DAT) for evaluating alternative solutions, based on economic and environmental criteria for a 20-yr planning period, and demonstrate its function with Mediterranean examples. DAT is a modular Visual Basic application capable of launching numerical codes, e.g. the screening code. Its modules concern:

a) Water demand: Estimation of potable water demand and monthly WW volume available for recharge, based on population, visitors, economic activities etc.

b) Desalination: Encapsulation of a desalination technology model, providing the max daily desalination plant capacity required, based on the fresh water demand and on the salinity of the feed water.

c) Wastewater contribution: Determination of the re-cycled water (% of fresh water use) and of its quality, encapsulation of the WW treatment costs in functions and estimation of the agricultural value of re-cycled water unused in aquifer recharge.

d) Screening of scenarios: Given the natural recharge and the pumping rate calculated by the desalination module, the salinity for different (treated WW) recharge profiles is estimated for the 20-yr period. For recharge profiles leading to a deteriorated aquifer quality, an environmental cost penalty is assessed (external cost). Screening finds, via dynamic programming, the optimal flow rates of the recharge well (for a set of pumping and recharge locations), using minimum cost as objective function, subject to meeting the water demand and certain salinity limits. The screening procedure determines the system cost (operational & external cost) of alternative solutions for pumping/recharge rates and sites and ranks them according to cost.

e) Economic evaluation: Net Present Value is calculated for user-selected scenarios. The detailed analysis concerns detailed design of the technical facilities, refined modelling of groundwater dynamics in a stochastic framework, and evaluation of the economic performance of solutions. Thus, apart from investment and O&M costs and including the environmental cost, the revenues from the water supply, including fresh water pumped from the aquifer and desalinated water, are taken into account.