Geophysical Research Abstracts, Vol. 7, 07589, 2005
SRef-ID: 1607-7962/gra/EGU05-A-07589

Methodologies for optimal management of coastal aquifers: Application to a case study.

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Finding the sustainable pumping rate is a key question when planning management policies for intensively exploited aquifers. This question is classically answered by ensuring a positive water balance: i.e., that abstraction is lower than natural input. This approach suffers from several limitations in coastal aquifers where seawater intrusion may become a natural input in response to excess pumping and where an overall balance does not preclude salinization. In these cases, optimization schemes may be required.

Here, we apply two different methodologies to calculate sustainable abstraction rates in a coastal aquifer. Both are based on combining an optimization process with a numerical model, which has been previously calibrated to reproduce measured heads and chloride concentrations. The first one consists of maximizing pumping rates, subject to positive equivalent freshwater heads along the coast, so as to prevent seawater. This leads to a (quasi-) linear programming problem. The second one consists of optimizing pumping while imposing maximum chloride concentrations allowed in the aquifer, which leads to a non linear optimization problem.

Both methodologies have been successfully applied to the Llobregat Delta near Barcelona (Spain). Both take into account the actual location of the wells and the real pumping rates, trying to maintain the well locations and approaching as much as possible the pumping rates to the current values. Corrective measures have also been implemented into the model and into the optimization process. Despite the presumed similarity of the two methods, they lead to different results because they answer to different questions. Yet both results are informative. While the non-linear approach is more appropriate in that it properly simulates the transient phase of aquifer recovery,

the linear programming method yields easily the shadow prices, which can be used to evaluate the efficiency of different proposed corrective measures. For example, a positive seawater intrusion barrier at the coast of the Llobregat Delta has an efficiency of 1.7, which means that every m3 injected at the barrier allows increasing extractions in 1.7 m3. In short, both approaches are complementary.