FUTURE RESEARCH ON COASTAL AQUIFERS

W. de Breuck
Geologisch Instituut S8, Krijgslaan 281, B-9000 Gent, Belgium

All over the world mankind has always been attracted by the sea because of the abundance of food and the transport and trade facilities and tourism. Hence coastal regions are very densely populated areas. One of the essential needs is water, not only for drinking but also for industrial and agricultural activities. Besides in many countries tourism is highly developed requiring huge amounts of water in some seasons. Coastal aquifers often provide a substantial amount of the water needed. In some areas they form the sole resource of water. The proper management of this valuable resource requires a thorough understanding of the delicate balance between fresh and salt water. Too often people realize too late that wells and land are salinized by mismanagement.

Groundwater in coastal aquifers is in a constant but very slow evolution controlled by the geological conditions of the area. The fresh-/salt-water distribution is in a dynamic equilibrium. Any human interference will change this equilibrium but the consequences may only be felt decades later. It is well known that overdrawing in coastal aquifers has caused the salinization of the wells and sometimes the abandonment of large tracts of coastal areas by shortage of good quality water. The reclamation of marsh lands and the subsequent drainage have a long-term salinization effect on the groundwater. Therefor a thorough knowledge of the hydrogeology of coastal aquifers in general and a detailed field survey of every area, where groundwater will be affected in particular is needed if the groundwater resources are to be exploited. Besides human works but also natural events at large distances may influence groundwater conditions in coastal areas.The Aswan dam is changing the fresh-/salt-water situation in the Nile delta in a slow but drastic way.

In most cases no investigation of the salinization of a region is made until the groundwater conditions have become alarming and even dramatic. Since hydrogeological processes evolve

very slowly, remediation will take a long time to provide results if economically feasible at all. Many examples of inadequate management of the groundwater conditions in our countries may be quoted. At present the general situation is known but more research is needed even in countries where already much information is available. Before undertaking remediation measures one should have a thorough knowledge of the situation; otherwise remedies however costly may increase rather than solve the problem.

Recently G.OUDE ESSINK, in his doctoral thesis on the impact of sea level rises on groundwater flow regimes (1996) demonstrated that even without a future sea level rise the salinization process in the subsoil of the Netherlands will continue as a delayed effect of both past and present human activities. In the southern part of Noord-Holland the reclamation of the low-lying Haarlem lake polder in the middle of the 19th century has generated a salt water encroachment in the deep aquifers of at least 1 km a year.

One of the conclusions of ESSINK's study is the recommendation to collect more data of hydraulic parameters, solute concentrations and piezometric levels. This is remarquable since the Netherlands have a longstanding record of collecting data on and observing the groundwater conditions. But even so the author concluded that he did not have enough reliable information for accurately modeling the groundwater conditions in several crucial areas of the Netherlands.

The voluminous work on "Groundwater problems in coastal areas" by CUSTODIO and BRUGGEMAN as a UNESCO report (1987) covers many aspects of the present knowledge of the relationship between fresh and salt water in coastal aquifers drawing information from experiences in many parts of the world. It also generates questions which call for more scientific research and more field investigation.

More research is needed to explain the interaction between water and sediment, especially the clayey part, since the latter plays an important role in the composition of the water as well as the hydraulic behaviour of the formation. Goldenberg and Mandel at the 10th SWIM presented some information on their experiences on reducing the permeability of a sediment by air injection and thus hindering salt-water encroachment. The phenomenon of ion exchange in clayey material has been widely studied but in relationship to groundwater quality evolution and groundwater movement research could provide some very interesting results. Isotopic investigations have been reported in the past but a systematic inclusion of stable as well as radioactive isotope research in ongoing studies may contribute to a better understanding of the salinization/freshening processes. Much research is to be done in the field of modeling of hydrogeochemical conditions and processes.

Considerable attention has been paid to calculations and modeling but much effort will still be needed to develop accessible tridimensional models of groundwater flow accounting for density differences and mass transport. But modeling should be based upon reliable field data. These can only be acquired by an intensive field investigation. In this domain the geophysical methods, which complement the drilling operations, are receiving a renewed interest. During the latest SWIM's few but interesting contributions have been presented. Recent developments in the field of resistivity/conductivity surveying are very promising. At a previous SWIM SENGPIEL presented the results of an airborne electromagnetic survey in Pakistan, whereby fresh-/salt-water conditions were mapped. This method may contribute to a better and faster delineation of the fresh-/salt-water interface. The concept of combining resistivity sounding and traversing can be realized by a multi-electrode approach as proposed by the LUND IMAGING SYSTEM (ABEM). It provides an automatic data acquisition and software for the handling and the representation of the data. Data acquisition is performed by a cable containing a large series of electrodes, which can be combined in different arrays, each entailing its own geometrical factor and determining its apparent exploration depth. The results can be represen-

ted as a pseudodepth section providing a qualitative image of the resistivity distribution and hence the groundwater quality conditions.

A field experience of combined fresh- and salt-water pumping may provide interesting results not only from a scientific but also from a practical viewpoint. By extracting and evacuating salt water at a reasonable cost from a salinized area fresh water resources may be exploited and increased at the same time. The first results may be reported on at the next SWIM.

In general a better dating availability will help to explain the long tem evolution of aquifers regarding their flow as well as their chemical behaviour. Dating groundwater under beaches may provide information on the short term salinization process.

More and faster progress will be made if, as in the past some steps have set, exchange and cooperation between researchers and laboratories could be intensified. In well investigated regions complementary methods could be tested and applied in such a way that these methods could be calibrated and additional information on the region could be gained.

As a sequel to the work of Custodio and Bruggeman one could think of elaborating a practical manual for groundwater management in coastal aquifers destined for technicians and local government officials.