Abstract

Research was carried out over the summer of 1995 on the hydrogeology of the Azraq Basin, North East Jordan as part of the groundwater phase of the Jordan Badia Research and Development Programme.

At present abstraction exceeds recharge in the Basin's main aquifer system and piezometry is continuing to fall with no indication of stabilising. Poor quality data means the groundwater system is poorly understood resulting in uncertain predictions of future water levels. In particular permeability distribution and recharge need to be better constrained if the resource is to be managed effectively. This report addresses these two issues through the use of isotope analysis and modelling.

The basin is 12800km^2 in area extending northwards into Syria, the likely recharge zone, and southwards into Saudi Arabia with a topographic low in the central mudflats around the town of Azraq. There are three aquifer systems - the Upper, Middle and Lower. The unconfined Upper Aquifer is of principal concern in this report as it is the most important groundwater resource. It consists of Tertiary basalts and limestone and is underlain by a 200m thick marl aquitard.

Groundwater flow in the Upper Aquifer is radial towards the centre at Azraq. The springs of Shishan and Druze discharging here once fed the extensive Azraq Oasis, wetlands of outstanding biodiversity, which were declared a nature reserve in 1977. With increased abstraction this century, in particular from the AWSA wellfield since 1981, piezometry has fallen. Spring-flow had decreased to zero by 1991 with a consequent desiccation of the Oasis wetlands and destruction of the ecosystem.

The climate is arid and recharge is difficult to quantify with previous estimates ranging from 34 MCM/yr to negligible modern recharge. The latter argues that present piezometry was set up during the last pluvial and is currently decaying. Even the most generous estimate is less than current abstraction which now stands at around 43MCM/yr.

Fieldwork
Piezometric mapping has located a 'recharge mound' in the vicinity of Um el Quttein to the north of the Basin and fieldwork was concentrated here. The area has undergone little prior investigation but is now experiencing active groundwater development due to the local low salinities desired for irrigation farming. All the wells were visited and a well inventory was compiled as only a few of the wells are present on the existing well list drawn up by the Water Authority of Jordan. The local basalt waters were also sampled for major ions, stable isotopes and Carbon-14.

Hydrochemistry
Analysis of the hydrochemistry indicates that the major ion concentrations in the basalt waters are principally controlled by alteration of a sodium-rich plagioclase with secondary contributions from olivine and K-feldspar weathering. There is a tertiary input from dissolution of surface evaporites during recharge.

Stable isotopes
Samples were taken for Deuterium and Oxygen-18 analysis. Although the data shows a fair degree of scatter, the waters plot in a trend off the local meteoric line suggesting evaporation of the rainfall prior to recharge. The $\delta^{18}O$ values indicate that the waters fell at an altitude ranging from 1000 to 800m at a temperature of 7-8°C, in close agreement with previous studies.

Carbon-14
Previous attempts at sampling for Carbon-14 by the addition of barium chloride directly to a large volume of well water have proved unsuccessful as barium sulphate was precipitated out in preference to barium carbonate. This led to large uncertainties in determining groundwater age. This report details a new technique of sampling which increased the yield of barium carbonate by a thousandfold. The results are expected in early 1996 and will be used to assess the magnitude of modern recharge and travel times of groundwater from recharge to discharge.

Modelling
Modelling of the Upper Aquifer was undertaken to investigate its permeability distribution in the northern half of the Basin. The steady-state calibrated model indicates that permeability is strongly influenced by regional geology, with major faults acting as either groundwater conduits or barriers. Assuming modern recharge of 16MCM/yr, horizontal permeability increases from 1 m/day in the north to 20 m/day near Azraq. Along major fault zones permeability can be as high as 300 m/day. Transient piezometry and springflow is adequately simulated with a storativity value of 0.01 for the entire aquifer.