

**THE USE OF GEOGRAPHICAL INFORMATION
SYSTEMS (GIS) AND REMOTE SENSING TO
INVESTIGATE GROUNDWATER QUALITY IN
THE AZRAQ BASIN, JORDAN**

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ABSTRACT

Jordan is a country that faces "absolute water scarcity" and may not be able to meet its water needs by the year 2025. Groundwater is the major water resource for many areas of the country and the only source of water in some areas. Most of the groundwater basins in Jordan are already exploited beyond their estimated safe yield. Total safe yield for all basins was estimated to be *ca.* $418.5 \times 10^6 \text{ m}^3 \text{ yr}^{-1}$ yet the consumed water from these basins was $479 \times 10^6 \text{ m}^3 \text{ yr}^{-1}$. Groundwater is the second largest contributor to the irrigation sector at $258.4 \times 10^6 \text{ m}^3 \text{ yr}^{-1}$ and it is the largest source for domestic consumption at $182.8 \times 10^6 \text{ m}^3 \text{ yr}^{-1}$.

A variety of human activities stemming from agricultural, industrial, community and residential sources, as well as the misuse of groundwater resources, have contributed to the deterioration of groundwater quality in Jordan. There are three types of pollution that affect groundwater (i) use and overuse of biocides and fertilizers and irrigation return flows, (ii) cesspools in towns, villages and refugee camps and (iii) use of vehicles with oil spills, lead and corroded particles.

In this study, the groundwater resources in the basalt aquifer of the Azraq Basin have been evaluated through the use of GIS and remote sensing. Remote sensing was used to map the agricultural activities in the study area between 1990 and 2000 using several satellite images and aerial photographs. It was estimated that the cultivated area changed from *ca.* 29 ha in 1990 to 185, 442 and 1087 ha in 1992, 1998 and 2000 respectively.

The DRASTIC model was implemented within a GIS environment to investigate the groundwater vulnerability. It was found that *ca.* 84% of the study area had moderate vulnerability and the remainder had low vulnerability. *Ca.* 15% of the study area had possible sources of contamination and moderate groundwater vulnerability, while only *ca.* 3% of the study area had a low vulnerability and no possible source of contamination. There was no statistically significant difference between the average nitrate concentrations for wells in low and moderate risk areas (Mann Whitney U test, $p < 0.05$). However, it was found that six wells in the moderate vulnerability zone had

nitrate concentrations greater than the maximum nitrate concentration in the low vulnerability zone.

A GIS-based model was developed to estimate nitrate leaching from cesspools and agricultural land. It was found that nitrate leaching from agricultural sources was much higher than that derived from cesspools. It was estimated that *ca.* 0.3 to 0.7 kg household⁻¹ year⁻¹ could leach to groundwater from cesspools in the study area. The estimated nitrate leaching from agricultural sources could reach up to 483,281 kg year⁻¹

Several management scenarios were implemented within a GIS environment to minimise nitrate leaching from both cesspools and agricultural fields. It was estimated that emptying the cesspools on regular basis (*ca.* 2 months) could minimise or eliminate nitrate leaching from this source. Farmers could use information on available nutrient concentrations in the soil, irrigation water and organic manures to estimate the optimum fertiliser requirement. This scenario could reduce nitrate leaching by up to 99%.

Other scenarios were suggested in order to minimise nitrate leaching from cesspools that included better design criteria and the possibility of constructing a local sewage treatment plant in the area.