IAH-MAR
Managed Aquifer Recharge

International Association of Hydrogeologists

Historical Overview of Enhanced Recharge of Groundwater in Qatar

Abdulaziz A. ***Al-Muraikhi*** *and Mohamed* ***Shamrukh***

Environment Affairs, Ministry of Municipality and Environment, P.O. Box 7634, Doha, Qatar
e-mail: aaal-muraikhi@mme.gov.qa or msmahmoud@mme.gov.qa

Introduction

Qatar occupies a peninsula which projects into the Arabian Gulf and occupies an area of 11627 km^2. Qatar has a warm desert climate with mild winters and hot summer. The mean annual rainfall is approximately 70 to 80 mm. Qatar is known for its scarcity of renewable water resources. Until 1953 the population of Qatar was entirely reliant on groundwater for its potable and agricultural water. In 1953 the first desalination plant was commissioned and the country's desalination capacity has been increased over the years so that in 2017, almost all water demand for municipal and industrial use is produced by desalination. However, water for agricultural irrigation is almost entirely derived from pumped groundwater. In 2013, the volume of groundwater pumped for agricultural use was estimated to be 218 Mm^3. This abstraction resulted in a small decline in water level together with an associated deterioration of water quality (MoE 2009). Managed aquifer recharge with natural waters is estimated at almost 10.7 Mm^3/yr and so significantly augments the estimated natural recharge (rainfall and irrigation return) of 75Mm^3/yr. There is managed recharge of deep aquifer with stormwater and recycled water in urban areas which is estimated at almost 33 Mm^3/yr. Thus total managed aquifer recharge contributes about 44 Mm^3/yr which has reached 17% of the total groundwater use of 260 Mm^3/yr in 2010 (Margat and van der Gun 2013) and there is potential for further expansion of MAR.

MAR Projects and Efforts

Eccleston and Harhash (1982) have described the hydrogeology of Qatar. The extent of the aquifers of Qatar has been subdivided into two main hydrologic provinces: Northern and Southern. Smaller groundwater provinces have subsequently been added to this conceptual model, the Abu Samra, Doha and Aruma Groundwater Basins. The main aquifers where MAR is practised in Qatar are the Eocene-age Rus Formation and the underlying Paleocene-age Umm er-Radhuma (UER) Formation. In some areas these two layers are interconnected and in hydraulic continuity to the extent that they can be considered as forming a single aquifer (Abdel-Wahab et al. 2008). There are two small members which are Simsima Member; and Abarug (Dammam) Member.

The bulk of the aquifer recharge in Qatar is derived from rainfall; other recharge inputs include urban recharge (mainly restricted to the area of Doha) and agricultural irrigation returns which are isolated throughout the country. Two different types of recharge mechanism are generally recognized in Qatar. Direct or diffuse recharge from widespread infiltration of rain water at or near to the point where rain falls. The second one is localized recharge (also called indirect or focused recharge) where surface water runoff accumulates in localized depressions with no surface water outlet. Previous estimates have shown that the contribution from focused recharge appears to be the most important recharge mechanism in Qatar being, on average, 4 to 9 times greater than diffuse recharge (Kimrey 1985, Entec 1994 and MoE 2009). This is considered to be due not only to the concentration of surface runoff in the depressions, but also due to the elevated storage capacity and permeability of the bedrock underlying the depressions.

In 2009, a significant project was carried out in Qatar to study the artificial recharge of aquifers (MoE 2009). To augment the natural recharge, a total of 313 passive recharge wells as identified by MoE Study have been installed across Qatar. The recharge wells installed in Qatar are ‘passive’ gravity recharge wells in which no active injection is undertaken and water accumulated above ground-surface enters the recharge well and infiltrates into the aquifer under the force of gravity. 166 of these recharge wells to enhance natural recharge from rainfall have been identified as occurring within depressions and the remaining 147 recharge wells outside of depressions. To facilitate modeling of rainfall-runoff-recharge, the SWAT2005 model has been applied. Analysis of groundwater level data from 44 recharge wells in Qatar for the period 2001 to 2007 and injection tests from 27 recharge wells show that capacity for a recharge well to infiltrate surface water varies widely. Recharge well infiltration capacity has been determined from 30 injection tests.

Modeling results indicate that the 161 existing recharge wells which are included in the model contribute 10.7 Mm^3 to groundwater recharge in an average hydrological year in addition to the natural recharge which the model calculates as being 75 Mm^3. The model has been used to estimate the optimal number of recharge wells required to enhance and infiltrate all surface water accumulations within 5 days after the most extreme rainfall event in the average hydrological year. Using only those depressions that were retained after applying the selection criteria to determine the most favorable depressions in non-urban areas, the model predicts that 1502 recharge wells are required to inject all the ponding water generated during the largest storm (~20 mm) in an average hydrological year within a 5 day period. It is observed that there are already 114 of those 161 existing recharge wells in the depressions selected as being the most favourable (thus, 1,388 additional recharge wells are required). Model indicated that 47 existing recharge wells are not required in the optimal total number of recharge wells. The managed aquifer recharge contribution of both the optimum and current number of recharge wells (i.e. 1,549 wells) for the average year would amount to 33.5 Mm^3, as shown in Figure 1. A plan to construct more recharge wells has been produced but implementation is not yet decided.

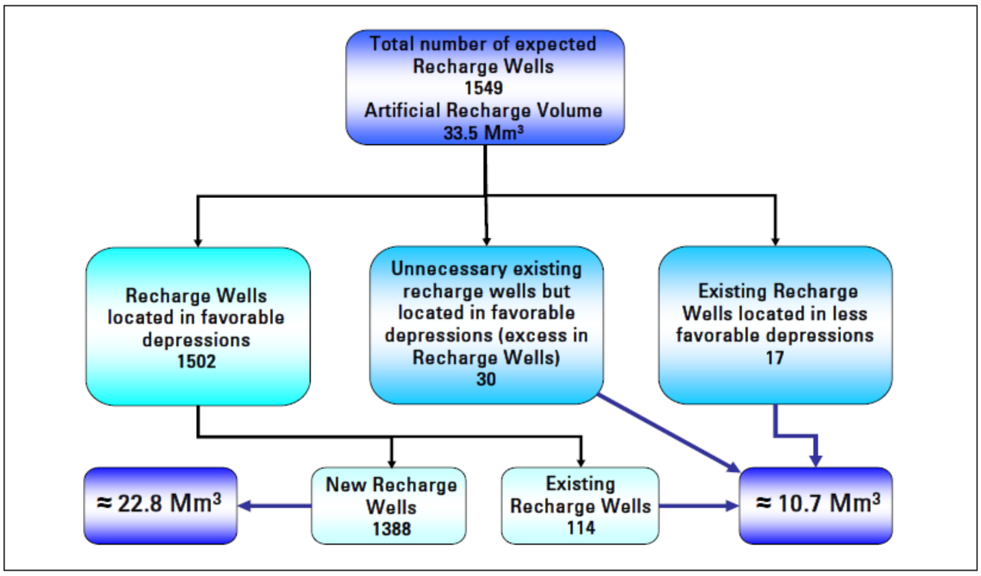

Figure 1. Optimal number of recharge wells and quantity from MoE 2009 Study

A sensitivity analysis indicates that the cost-benefit of any future recharge well array is highly dependent on the permeability of the sub-surface, the allowed time of ponding of water in depressions, the selection of favorable depressions, and the storm rainfall amount used in the design. It is important to note that the model results show that the potential for managed aquifer recharge is similar in the southern and northern parts of Qatar although this is dependent on the rainfall distribution (MoE 2009).

Two other types of MAR are implemented in the urban area of greater Doha. Excess recycled water (mainly high quality treated effluent) and collected stormwater combined with surficial groundwater are recharged using deep wells. This managed practice started in 2008. The main objective of this recharge is to dispose the excess recycled water and to improve the quality of deep groundwater. Recharged water is of better quality than the groundwater in the receiving aquifer. For example, Total Dissolved Solids (TDS) in recharged water is 1,100-6,000 mg/l which is considerably fresher than the deep groundwater having 15,000-25,000 mg/l TDS. This practice of urban MAR is in an experimental phase, with precise environmental monitoring and is seen as a temporary solution until it is evaluated. Ongoing work continues to assess and evaluate this MAR practice in urban areas in Qatar. There is continuous monitoring of quantity and quality of both the recharged water and the receiving environment (i.e. deep groundwater between 100 and 400m) and shallow groundwater (i.e. less 50m). 3D groundwater simulations are applied to help in this assessment of managed recharge in the urban area.

Current Types of MAR in Qatar

As mentioned above, there are three types of MAR in Qatar. The first type is the recharge wells in depressions in non-urban areas to augment the natural rainfall recharge in north and south groundwater basins. The second is the use of deep recharge boreholes in Doha basin for disposal of relatively fresh recycled water. The last involves the recharge via deep boreholes in Doha basin for temporary disposal of the collected urban stormwater combined with surficial groundwater after necessary treatment. This temporary disposal is helping to improve the quality of deep groundwater by reducing its salinity. Table 1 shows the recharge amounts of the three categories.

Table 1: History of managed aquifer recharge in Qatar (in 10^6 m^3/year)

Period	Recharge wells			Total
	Rainwater and stormwater (non- urban area)	Recycled water (urban area)	Stormwater and shallow groundwater (urban area)	
1981-1990	5.3	0	0	5.3
1991-2000	8.0	0	0	8.0
2001-2010	10.7	26.0	0	36.7
2011-2015	10.7	31.0	2	43.7

Data derived from MoE 2009 study and from Qatar government internal reports.

References:

Abdel-Wahab, A. A., Amer, K. and Shamrukh M., 2008, An advanced technology for groundwater treatment in the northern aquifer of the state of Qatar. WSTA 8th Gulf Water Conference, Manama, Kingdom of Bahrain, March 3-6, 2008.

Eccleston, B.L. and Harhash, I.E., 1982. The hydro-geology of Qatar. Ministry of Industry and Agriculture, Dept. of Agricultural and Water Research, 1982.

Entec, 1994. Artificial recharge of groundwater in northern Qatar. Report prepared for Ministry of Municipal Affairs and Agriculture, Dept. of Agricultural and Water Research, Entec Hydrotechnica, July 1994.

Harhash, I.E. and Yousif, A.M., 1985. Groundwater recharge estimates for the period 1972-1983. Ministry of Industry and Agriculture, Dept. of Agricultural and Water Research, February 1985.

Kimrey, J.O., 1985. Proposed artificial recharge studies in northern Qatar. Open-File Report 85-343, United States Geological Survey, Orlando, Florida.

Margat, J., and J. van der Gun. 2013. Groundwater around the World. CRC Press/Balkema.

MoE, 2009, Studying and developing the natural and artificial recharge of the groundwater aquifer in the State of Qatar - project final report. GWAP project, Ministry of Environment (MoE), Qatar, August 2009.