University of Karlsruhe (TH) | KIT Karlsruhe Institute of Technology | AGK Department for Applied Geology

Artificial groundwater recharge in Jordan using various water qualities - Large scale potential map and individual test sites in Jordan

L. Wolf, M.Rapp, M.Zemann, H. Werz, A. Sawarieh, W. Ali, H. Hötzl

mail: wolf@agk.uka.de phone: 0721 - 608 7602 homepage: http://www.iwrm-smart.org/

The Lower Jordan River Valley (Figure 1) is a place of extreme water scarcity and constitutes an overexploited closed river basin. No surface runoff reaches the Jordan River and therefore the water level of the Dead Sea as the final sink has already dropped in fifty years by more than 20 m as a result. The only means of introducing additional volumes of water to the area are water imports or reduction of evaporation. Increasing the amount of artificial groundwater recharge, now internationally termed managed aquifer recharge (MAR), would be beneficial to the water availability of the region by reducing evaporation. In this background setting, the research initiative SMART (Sustainable Management of Available Resources with Innovative Technologies) has now been launched to include all available water resources of the Lower Jordan River Valley, namely ground water, waste water, saline water, and flood water into an integrated management concept.

Figure 1: Overview of the study area

Pharmaceutical	LOD	Unit	Wadi Sir WWTP outflow 30.03.2007	Infiltration basin mean[1] values 11.18. - 19.11.2007	Well 3 11.18. - 19.11.2007
Diclofenac	10	ng/l	140	28	< LOD
Gemfibrozil	10	ng/l	1400	172	70
Bezafibrate	10	ng/l	430	26	< LOD
Carbamazepine	10	ng/l	1500	242	180
Atenolol	10	ng/l	1400	26	< LOD
Amidotrizoe Acid	10	ng/l	< LOD	116	110
Iohexol	10	ng/l	360	24800	24000
Iomeprol	10	ng/l	< LOD	74	48
Iopamidol	10	ng/l	< LOD	714	760
Iopromide	10	ng/l	< LOD	1960	1600
Naproxen	10	ng/l	240	< LOD	< LOD

1 = from 4 samples

Table 1: Xenobiotics concentration detected in the infiltration basin, one well and the Wadi baseflow [Zemann, 2008]

Picture 1: Infiltration basin and observation wells [Zemann, 2008]

Managed aquifer recharge on a test site in the Wadi Kafrein, Jordan

The test site (Picture 1) investigates the possibility to infiltrate surface water comprising a mixture of treated wastewater and fresh water with special regard to clogging problems. After 90 days of operation, the infiltration rate still exceeded 1.8 m³/m²/d, demonstrating the excellent infiltration capacity of the unconsolidated gravel sediments in the Wadi (Figure 2). Online monitoring of the water quality showed a strong diurnal cycle of the electrical conductivity (Figure 3). This is a result of the treated wastewater inflow as well as varying usage of fresh water from the springs upstream.
Furthermore the water quality was analysed with respect to national and international standards and a special attention paid to pharmaceuticals and endocrinal disruptors. Nearly all parameters meet the national standards for artificial recharge. In addition to major ions and cations also mobile organic trace substances were analysed in conjunction with TZW Karlsruhe. In the Jordanian Wadi baseflow, concentrations of pharmaceuticals are comparable to some European surface waters, documenting the wastewater influence (Table 1).

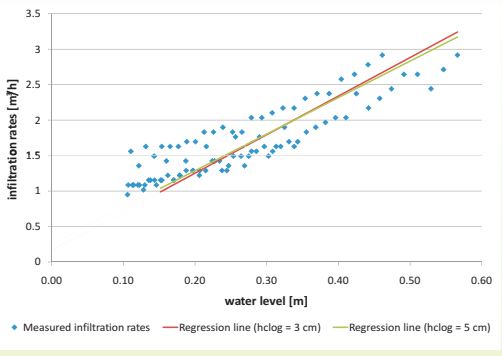

Figure 2: Measured infiltration rates and related water levels at the basin [Zemann, 2008]

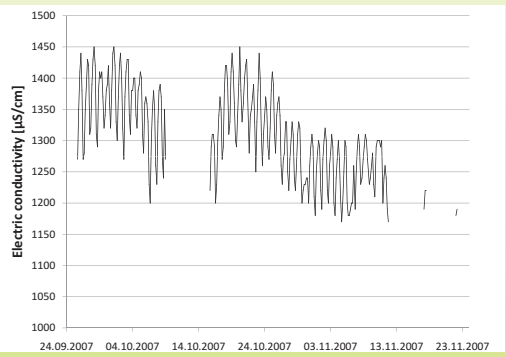

Figure 3: Short term water quality changes in the Wadi baseflow [Zemann, 2008]

Managed aquifer recharge at Wadi ed Dardur

A site for managed aquifer recharge by flood water is currently explored at Wadi ed Dardur, approximately 45 km southwest of Amman (Figure 5). Detailed geological mapping of the area was completed. Within the approximately 20 m wide Wadi a rockfill dam shall be constructed to store water from flash floods and infiltrate it into the fractured sandstone aquifer.
The surface catchment (Figure 4) of the dam delivers around 900 000 m³/year of water. An potential infiltration rate of ~ 0.02 mm/s has been measured with an ring infiltrometer.

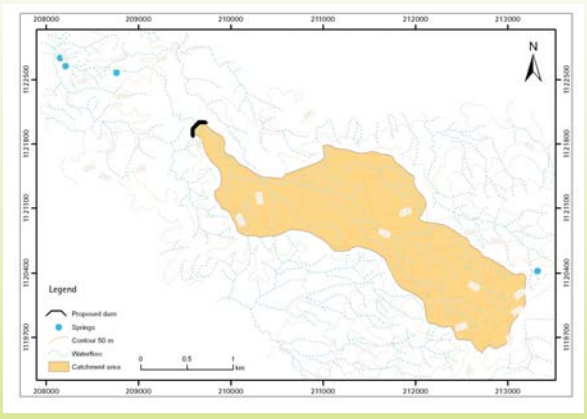

Figure 4: Catchment of the planned dam [Rapp, 2008]

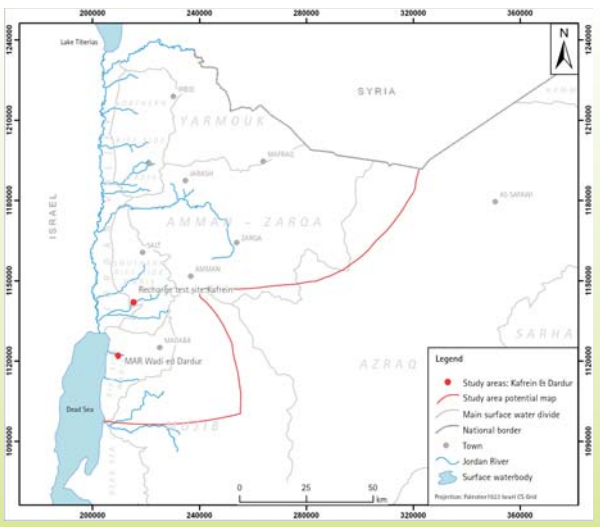

Figure 5: MAR sites in Jordan and location of the Wadi ed Dardur

Mapping potential locations for MAR in NW Jordan

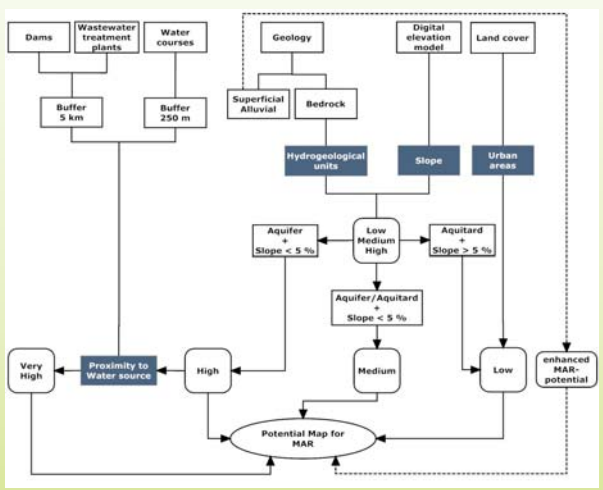

Figure 6: Combination process of thematic layers [Rapp, 2008]

A large scale map (1:200 000) covering 9800 km² of NW Jordan was established to provide a first indication of potential for managed aquifer recharge by surface infiltration (Figure 7). The potential map is based on following criteria: (i) presence of an aquifer close to the surface (ii) slope (iii) availability of water to be infiltrated (iv) land use. The parameters were processed to thematic layers and combined using a GIS-based overlay approach. The resulting areas were delineated to four different potential classes (Figure 6).
Resulting potential areas: low 55 %, medium < 1 %, high 30% and very high 14 %. Therefore 1388 km² in NW Jordan have been evaluated to fulfill the high potential criteria for MAR via surface infiltration: aquifer near or outcropping at the surface, slope < 5 %, absence of urban areas, proximity to at least one water source.

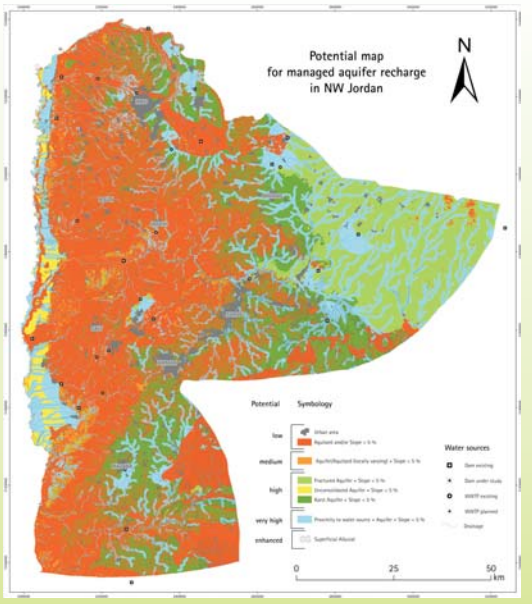

Figure 7: Potential locations for MAR sites in NW Jordan [Rapp, 2008]