

BMBF IWRM R&D Programme

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SMART – IWRM

Report on potential sites for brackish water usage

Part 1:

Western side of the Lower Jordan Rift Valley

WP-3.3, Deliverable 324

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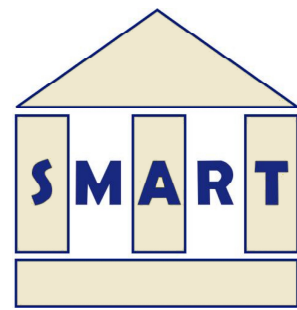
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1. INTRODUCTION

The main goal of the SMART2 project is to increase the total amounts of water for domestic and agriculture usages in the area of the Lower Jordan Rift Valley (LJRV). The major and most important local water resources are fresh water from shallow and deep aquifers. However, due to lack of fresh water resources in the region, secondary origins of brackish and saline water are taken into consideration for local usage. These potential water reservoirs are found in relatively large amounts in the shallow and deep aquifers, mostly coexisting with fresh water.

The main economic activity in this region is agriculture, which naturally and primarily depends on local water resources. The way to ease the water deficit is to consider using water sources of different qualities such as brackish water and treated effluent.

Agriculture in the Lower Jordan Valley and the Arava Valley is partially based on relatively small amounts of brackish water both by direct irrigation and by diluting with secondary effluents for Palm trees or by desalination for drinking purposes and for dilution. For this purpose small desalination facilities were constructed in both Lower Jordan Valley and the Arava Valley.

The source of salinization is salt concentration in the aquifer systems within the Jordan Valley sediments which were covered by the Lisan Lake (ancestor of the Dead Sea). Increasing salinity concentration in the lower part of Jordan Rift Valley act as high risk for the local groundwater resources as well as the stability of the whole system in the area. The saline water is coexisting with the fresh water and utilization of the brackish water should take in consideration the effect on the fresh water body.

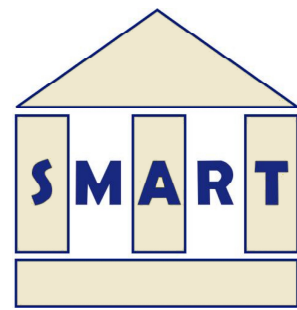
A concept for the sustainable utilization of the brackish water in the IWRM framework is required. Specifically concepts are required for environmental

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impacts such as soil salinization from desalinated water application, brine disposal and energy efficiency. Those points are not included at this report.

Due to geographical and geological aspects, the utilization of the brackish water in the SMART project will be carried out separately for the western and eastern sides of the LJRv.

Therefore, this report concentrates only on the potential sites for utilization of brackish water in the western side of the LJRv. The report summarized the results of various reports especially from Hasan and Guttman (2011) and Flexer, Yellin-Dror and Inbar (2011). These reports were carried out and submitted in the framework of WP 3.3.

The current report illustrates the occurrence of the brackish water in the western side of the LJRv. Furthermore, it recommends (from the engineering and water supply point of view) locations of preferred sites for local desalination plants and facilities.

2. RESULTS

2.1. Major sources of brackish water in the Western side of the LJRv

The reports of Hassn and Guttman (2011) and Flexer, Yellin-Dror and Inbar (2011) resulted in summarizing the brackish resources within the study area.

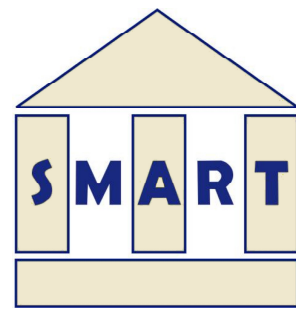
Unfortunately, only few of the suggested sites are available as sustainable resources for direct irrigation and/or desalination usage. Two sources of brackish water were found suitable in the regional aquifer (Judea/ Ajlun Group aquifer) and two other sources which were located in the alluvial aquifer of the valley-fill. In addition, one of the current report conclusion is that the surface water of the Jordan River itself can act as an additional source

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for sustainable brackish water in the area (today there are few pumping stations along the river banks).

2.2. Brackish water in Feshcha Springs (Marsaba- Feshcha basin)

Ein-Feshcha spring group which is located on the upper north-western shore of the Dead-Sea is the major outlet of the calcareous regional aquifer (the Judea/Ajlun Group aquifer). The spring discharge towards the Dead Sea is estimated between 62-67 MCM/year (measured by the Israeli Hydrology Survey). The springs present large storage, characterized over the years by stable discharge with only small annual fluctuations. The springs cover a relatively large area of 3-4km along the Dead Sea shore. The water emerges from the alluvial deposits which are in direct connection with the major aquifer.

The spring's water maintains the local natural reserve. After crossing the natural reserve, the brackish water is flowing to the Dead Sea and lost there. Our recommendation is to locate the pumping points between the eastern border of the natural reserve and the Dead Sea shore. We believe that capturing the brackish water after it crosses the natural reserve and before it flow into the Dead Sea will not make any damage to the natural reserve.

Hasan and Guttman (2011) assumed that yearly amount of 30 MCM can be used as raw water for desalination facilities. Their recommendation is to focus on the northern part of the Feshcha springs. The salinity in this section is between 1500-2000 mg/l Cl. The desalinated water will be transferred to the local customers in equitable manner.

The analyzed hydro-chemical data reveals that Ein Feshcha water quality varies over short distances implying a flow through heterogeneous fractured system with respect to both hydrogeology and mineral reactivity. Consequently it can be concluded that springs salinization differences are due

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Map Legend

- Spring or conduit
- Swimming pools

1+2 : spring name
 Cl mg/l, year 84
 Cl mg/l, year 2000
 Cl mg/l, year 06/07

The map shows the Dead Sea shoreline with various sampling points labeled with numbers (e.g., 1, 2, 3, 6, 7, 13, 15, 16) and elevation data (e.g., 4898, 11048, 2063, 1974, 2037, 2461, 1870, 1411). A dashed line indicates the shore line according to year 10.3.84. Key locations include Ein feshkha reserve entrance and Ein Tanur. An inset map shows the location of the study area relative to the Dead Sea and surrounding regions (Ein Qana, Ein Ziqim, Amman).

The expected chemical composition of the raw water is as follows (mg/lit):

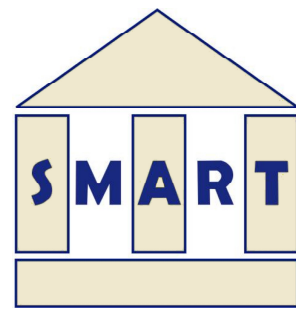
Cl-	Na	K	HCO3	SO4	Ca	Mg	Temp °C
1500-2500	380-860	43-90	170-470	48-82	94-420	150-400	23-31

Most of the pumping wells in the LRV are located inside the eastern monocline flexure that runs along the foothill to the west of the Jordan Valley. Fazaal-1 borehole, located a few hundred meters east of the monocline flexure, was the first deep well drilled in the Jordan Valley that penetrated the

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Judea/Ajlun Group aquifer. The water in this well was saline (up to 4500 mg/l Cl in the lower part of the well) and it was abandoned and followed by Fazael 2 borehole which was drilled in a closer location at wadi aperture that crosses and cuts the monocline flexure. The water in this well was found fresh and stable (about 45 mg/l Cl⁻). This salinity gap between these two wells is explained by the fact that the monocline flexure acts as hydraulic barrier between the fresh and the saline water bodies. All pumping wells, such as Fazael, Gitit and Uja boreholes, drilled to the Judea/Ajlun Group aquifer in Fazael-Uja region, are situated within the monocline and are aimed to pump the fresh water before it flows and lost within the deep basin-fill sediments of the Jordan Valley.

The sources of salinization in the LJRv are residual deep seated brines as well as salt layers and bodies that were deposited during various sea transgression events and penetrate deep formation inside the valley. The cause for salinity rise in several pumping wells is due to hydraulic connection between formations containing fresh water and deep formations containing saline water. The available current knowledge, absence of deep investigation wells inside the valley, makes it difficult to delineate the exact location and nature (fault, wedge-out, inter-fingering etc.) of contact zones between the fresh water and the saline water. It is suggested that pumping the saline water for desalination use will eventually reduce the pressure of the saline water body from the fresh water body and will decrease salinity hazards of the fresh water body.

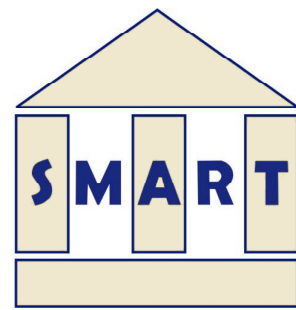
The Judea/Ajlun Group aquifer within the Jordan Valley east to the foothills is situated at depth of a few hundred meters, covered by younger formations (from Mt. Scopus/Belqa up to the Dead Sea/Lisan Groups).

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Interpretation of seismic lines carried out in the framework of the SMART-1 indicates that within the Jordan Valley there are areas where the Judea/Ajlun Group aquifer is at a shallow depth (Ankar 2007). These sites are favorable places for prospecting and drillings for brackish water reservoirs within the upper part of the Judea/Ajlun Group aquifer. Applying this data with the hydrogeological conceptual model and the strategic planning program of the region, Mekorot (The Israel National Water Company) located three new sites for drilling within the valley (Fig. 2). Each of the future wells is planned to pump about 1 million cum/year of brackish water with salinity of 2000-2500 mg/lit Cl. This water can be used as an additional supply for irrigation of palm plantations, either directly or by mixing with treated effluence. Some portion can be used as a source for local desalination facilities. The new drilling program is combined with program for connecting and distributing the pumped water through the network in the study area. The expected chemical composition of the raw water is as follows (base on the water composition of Fazeal 1):

Cl-	Na	K	HCO ₃	SO ₄	Ca	Mg	Temp °C
2000- 2500	800- 900	70-80	230-240	75-85	290- 310	250- 270	25

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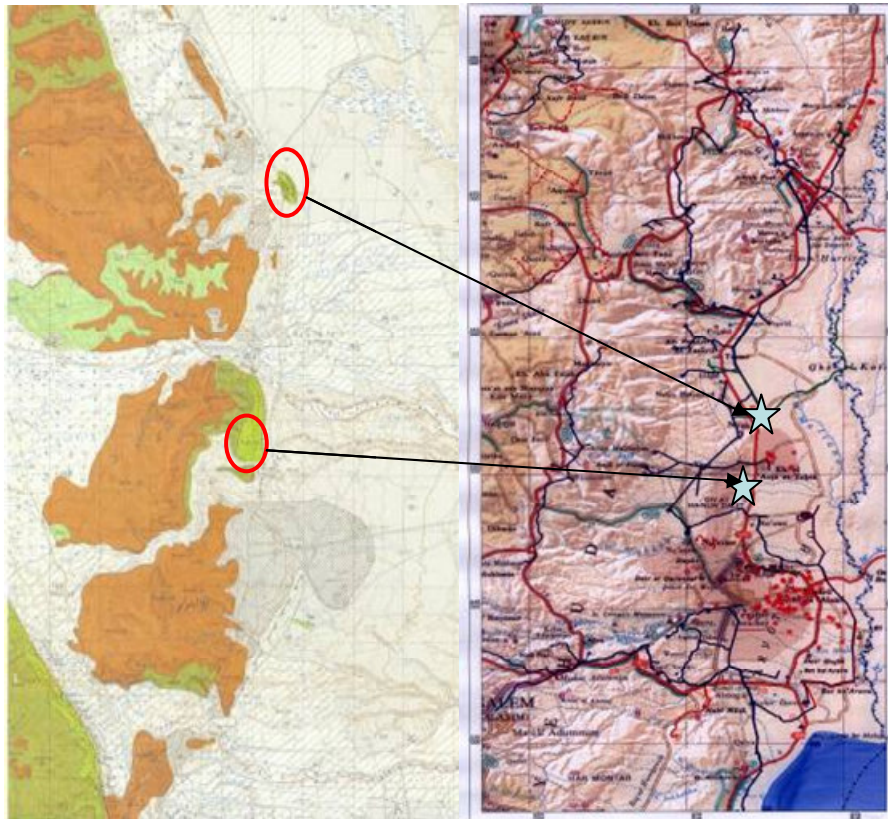


Figure 2: Location of two proposed boreholes for brackish water exploration in Fazeal-Uja basin. (a) Suggested boreholes location presented on a basic geological map; (b) suggested borehole location presented on Mekorot's pipeline system map.

2.4. Brackish water in the alluvial deposits of Jericho and Uja areas

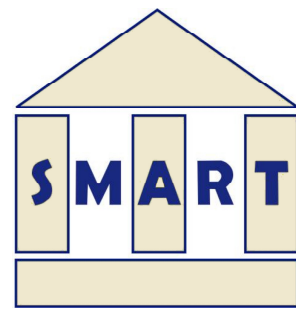
The shallow aquifer in the in Jericho and Uja areas consists mainly of alluvial deposits i.e. clay, silts, conglomerate, chalk, marl and gypsum layers of the Lisan formation. Due to the high water demand in the area of Jericho and Uja as well as consequently high groundwater abstraction rates. Groundwater quality in the alluvial aquifer has been considerably deteriorated.

Detailed geochemical study carried out by Marie et al. (2001) and Khayat et al. (2006) were suggesting that the high chloride contents in the local aquifer of Jericho are derived from several sources which include:

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- Up-conning of deep brines.
- Leaching of surface salt crusts within the aquifer.
- Anthropogenic contamination of agriculture return flow and waste water infiltration.
- Residual saline water (brines) resulting from ancient higher Dead Sea water levels. The salts penetrate into the aquiferial formations within the alluvial sequence.

The amount of fresh water that recharge into the alluvial aquifer is limited and unable to push backward the saline water from the well fields. During pumping, the saline water move towards the wells and the salinity rise. This means that the shallow formations that contain fresh water and the deep formations that contain the saline water are hydraulically connected.

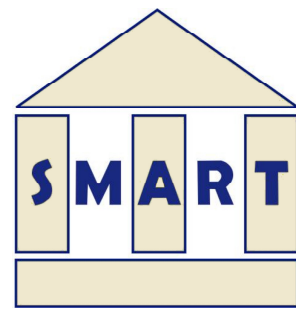
The fresh water acts as a lens or a thin layer that is overlaying the saline water body. In many wells the perforated section causes an artificial connection between the fresh water horizon and the saline water layers. Furthermore, in many wells the permeability is low resulting in large dynamic drawdown. Those conditions (up-conning and lateral movement of saline water) are the origin of salinity rise in this aquifer.

Wells for utilization of the brackish water can be explored and located in an outer ring of the existing well fields (Jericho and Uja well fields).

According to the current study preliminary design, it is recommended to locate 5-6 new wells in the eastern part of the Jericho area as well as 2-3 wells in the eastern part of Uja village. The hourly discharge of each well is expected to be around 100-120 m³/hr and the calculated yearly amount is estimated to be between 0.8-1.0 MCM/yr per well.

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Further recommendations about the wells layout and the exact pumping rate of each well should be accompanied by local flow and transport models.

The salinity is anticipated to be between 1600-2000 mg/l Cl and might increase during pumping either due to the movement of higher amount of saline water from the east or from the depression cone reaching the saline waters in the bottom of the wells.

2.5. Brackish water from the Jordan River

The water in the Lower Jordan River is most of the time saline. Nevertheless, few pumping stations are located on both sides of the river and pump brackish water from the river for agriculture use. Some portion is used for direct irrigation and other portion is used to dilute the secondary effluent. The total brackish water of the area is used solely to irrigate palm plantations.

The exact amount of water pumped from the stations is unknown. According to the pump capacities and the usage, it is assumed that the total pumping of brackish water from the southern part of the Lower Jordan River vary between 3-10 MCM/year.

During the years 2001-02 measurements of the water salinity in a few pumping stations was carried out by Farber (2005). She found that the salinity varies between 1200-3500 mg/l Cl.

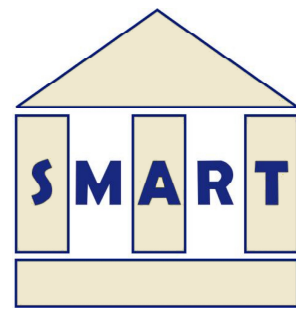
The salinity from Mekorot's pumping station (Gilgal station) is show in Fig. 3 presenting minimal concentration during the winter when the flow is high and the river receive also fresh water from side vadis and a maximal concentration during the summer when the flow is low and the contribution of salty water from the shallow aquifers is dominated.

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Maximum concentration of about 6000 mg/l Cl was measured in summer 2008. Since then, Mekorot ended the pumping from the river.

A high turbidity varies between the winter and the summer. During the winter a value of about 2000 NTU was measured and a low turbidity value of 150 NTU was measured during the summer time. The variation in the turbidity is connected to the flow discharge. Because of the high turbidity concentration, pre-treatment is needed in order to use the river water for desalination facilities.

There are some important tourism sites in the lower part of the Lower Jordan River. Therefore the politics and the stakeholders should decide what is the maximal amount of saline water that can be used for desalination. For a preliminary design the maximum amount of maximum 5 MCM/year of pumped river water is recommended for desalination facilities.

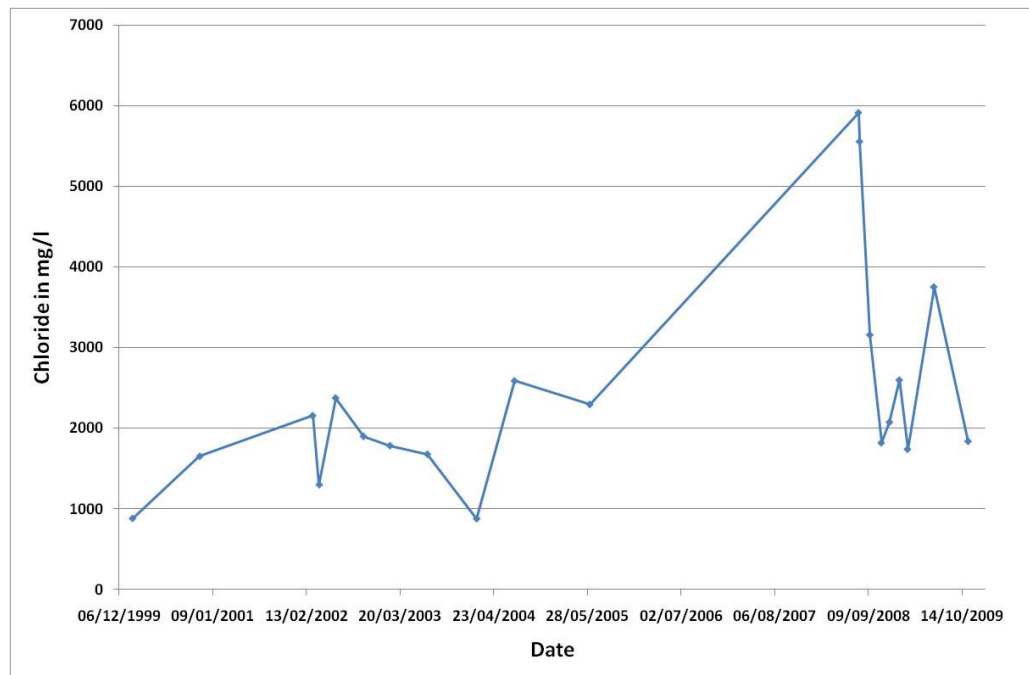


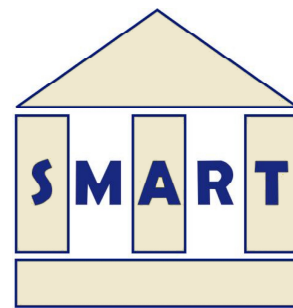
Figure 3: Presentation of chloride concentration of pumped river water in Gilgal pumping station.

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3. SUMMARY

The current report integrates the amount, locations and quality of brackish water resources in the western side of the LJRVR based on previous studies as well as exploration of sites for brackish water utilization.

The nature of the report is technical/engineering. Efforts were made to locate sites for utilization of brackish water from the various sources in order to produce preliminary forecast and recommendation of the volume and salinity of water that can be explored from each site. Accurate endorsements can be achieved only by future detail survey.

The potential resources of brackish water that were mentioned above are as follows: the regional Judea/Ajlun Group aquifer in the area of the Feshcha springs as well as the Fazeel area; the alluvial shallow basin-fill sediments in the Jordan Valley (Jericho and Uja region); direct pumping from the Jordan River (Fig. 4).

The table below summarizes the preliminary recommendations from each source.

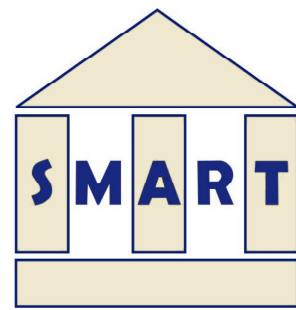
Site	Well/station	Yearly pumping MCM	Expected salinity mg/l
Feshcha Sp.	2	30	1500-2000
Jericho	5-6	4-5	1600-2000
Uja	2-3	1.5-2	1600-2000
Fazeel	3	3	2000-2500
Jordan River	3-5	5	1000-6000

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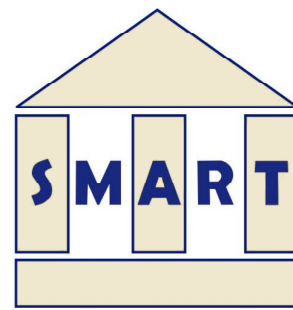
The report does not apply to the questions of how many desalination plants and/or facilities are needed for the utilization of brackish water as well as potential solutions for brine disposal.



Figure 4: Proposed sites for utilization of the brackish water in the LRV.

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