Integrated Water Resources Management in the Lower Jordan Rift Valley

Sustainable Management of Available Water Resources with Innovative Technologies

SMART

Work package 3, Deliverable D 312

Demonstration of artificial recharge site (Uja injection borehole)

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1 Introduction:

Al Uja area is part of the Lower Jordan Valley, where agricultural activities depends totally on the availability of groundwater, which is available in form of springs and groundwater boreholes. During the seventies of the last century, 12 thousand donumes were under irrigation, this area decrease to less than 5000 donumes. This is due to the decreases of the spring discharge during the last 10 years. Currently, agricultural activity depends on the availability of groundwater from 9 boreholes. The total depth of these borehole range between 120 and 80 meters, and these boreholes are taping water from the gravel, sand silt and clay layers of the shallow alluvial aquifer system. The sediments are related to the Lisan and Samra layers of Plio-Plistocene ages . This shallow aquifer system consider are a major source of water not only for Uja area but also for the Lower Jordan Valley.

In Al Uja area the groundwater table locates between 40 in the eastern part and by 80 meters below the ground in the western part of the area. Groundwater salinity increases eastwards in the same direction of the regional groundwater flow. The presence of clay lenses within the sand-silt layers cause a confined condition.

The 9 groundwater boreholes abstract annually about 4.5 MCM. Surface recharge is limited to Wadi Uja drainage system, where limited section of the aquifer exposed to the Wadi. The drilling of a new well in the Upper Uja area show that there is a hydrogeological connection between the carbonate Mountain aquifer system and the Shallow Plio-Plistocene aquifer system. This can explain the source of recharge of the Shallow aquifer system and also explain the relatively low groundwater salinity (2mS/cm) in the western part of Shallow aquifer. Salinity increases up to 7 mS/cm in the eastern part, and lowering the groundwater table are main obstacles facing the development of water sector in Al Uja area. Development of water sector in the LJV depends on using additional water sources, which not used until yet, such as spring over flow, treated waste water and wadi flooding, none of these sources are currently used. In order to use these sources, detailed investigations are needed such as installing sewer system, treatment plant, storage ponds, and small dams for flood water and spring overflow. One of the critical key issue to use these sources (spring and flood water) is where to store water this water that discharge in short time (maximum 20 days spring overflow, and few days flooding water).

In this report we present the results of on-going test about uses of spring overflow in injection borehole. The availability of Infrastructure such as storage pond, pipelines make it possible to implement the test. A water filter system was constructed from local materials to remove suspended solids, and algae from the injected water.

The current running experiment is focusing on storing spring water in Uja borehole. This first test in the West Bank, that deals with artificial recharge. Spring water was stored in a 8000 m3 open surface pond, which locates about 1000 m to the west of the injection borehole, and about 50 meter above the borehole location. The main objectives of this experiment are:

1. To investigate artificial recharge mechanism using injection borehole. Many boreholes are available in the area.

2. To make use of available infrastructure (water canal, storage ponds, filters, etc....) in implementing low cost artificial recharge.

3. To investigate the impact of using first spring water overflow on the quality of groundwater.

4. To identify the mixing process of relatively two types of water (groundwater and spring water).

2 Methodology

Spring water is stored in an open surface pond of 8000 m 3 (Figure 1). Then water transfer through a 6 inch underground pipeline to the experiment site. On the borehole site the raw fresh water has to pass through a row of 16 filters to remove suspended material, and algae (Figure 2, a, b). The different in elevation of about 50 m between the storage pond and the filter site cause a fluid pressure of 5 bar. These filters was built, and constructed from local materials. The opening pore space of the membrane filter is 120 meshes which is equivalent to 149 microns. Spring water must flow through these filters before interring the injection borehole.

Figure 1: surface storage pond for feeding the injection borehole.

Following parameters were measured before implementing the experiment, these are:

1. Static ground water table in the borehole.
2. Electrical conductivity and temperature, and depth were measured across the borehole water column. This was carried out by using TLC-instrument.
3. Electrical conductivity and turbidity of spring water before and after the filtration process.

Figure 2 a: inflow, outflow with 16 filters.

Figure 2b: 2 inch filter, and inertial material.

3 Results

Results are divided into two parts; Part I: assessments of water quality of both spring water and

borehole groundwater before the injection, and Part II: assessment of groundwater after injection.

The preliminary results of the experiment excrement are summarized in the following:

3.1 a: Part I: Water quality of spring water quality:

The turbidity of the water ranges between 7 and 10 NTU before filtration and decrease to 2 NTU after filtration. Table 1 summarized some physical and chemical properties before and after filtration process. Algae contents were investigated under microscope. The result shows that the number of algae after filtration is negligible.

Table 1: water quality before and after filtration

Sample	PH	Ec µs/cm	TU NTU	Mg^{2+} mg/l	Ca^{2+} mg/l	K^+ mg/l	Na^+ mg/l	PO_4^{3-} mg/l	SO_4^{2-} mg/l	NO_3^- mg/l	F^- mg/l	Cl^- mg/l	HCO_3^- mg/l	NH_4^+ mg/l
Before filtration	8.0	622	7	37.5	42.7	41.2	44.5	0.05	33.0	25.4	0.0	60.2	305.1	0.09
After filtration	7.9	622	<2	40.2	40.0	41.4	44.9	0.09	32.0	29.0	0.23	60.2	305.1	0.08

1.1 b: Part I: Water quality of the borehole

Electrical conductivity and temperature measurement were carried out before starting the experiment. Figure 3 present the electrical conductivity of groundwater column. Water table located by 38.6 m below the ground and the electrical conductivity was 4.3 mS/cm by this depth, and with increasing the depth Ec-value raised through four steps: 1- increase to 6 mS/cm by a depth 46 m, 2- raised to 7.6 mS/cm by a depth of 52 and then reach 8.6 by a depth 82 meters. These values indicate that water within the aquifer system has different characteristics (Ec-values), which could be related to four groundwater bearing layers.

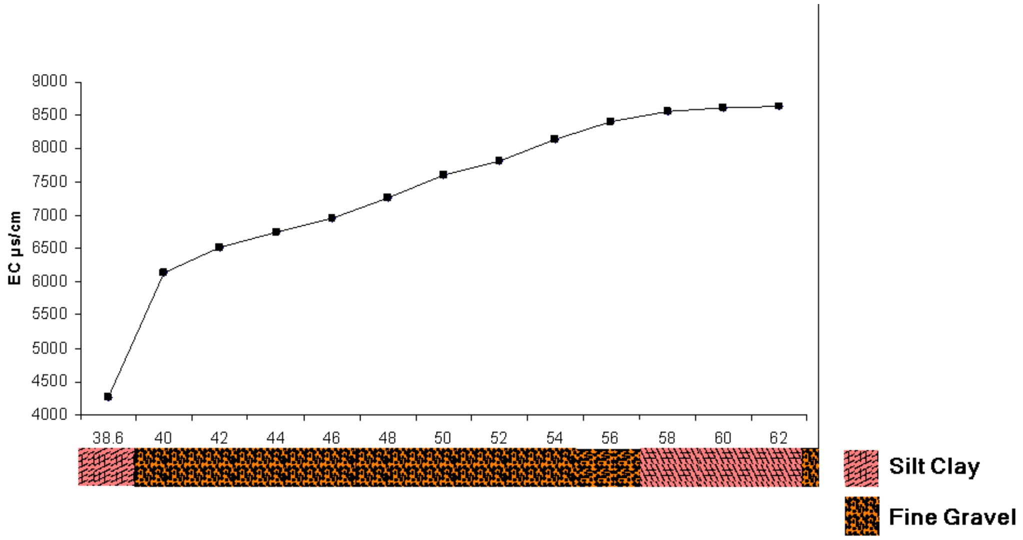

Figure 3: Electrical conductivity profile along the borehole water column (before injection).

The temperature of the water column profile ranged between 23.7 ºC to 26.5 ºC, and the temperature changes occurred also in four steps, first with 23.7 ºC in a depth of 42 m, second with 24.6 ºC by a depth of 50 m, third with 25.9 C by a depth of 56 m, and fourth with 26.5 ºC by a depth 82 m (see Figure 4).

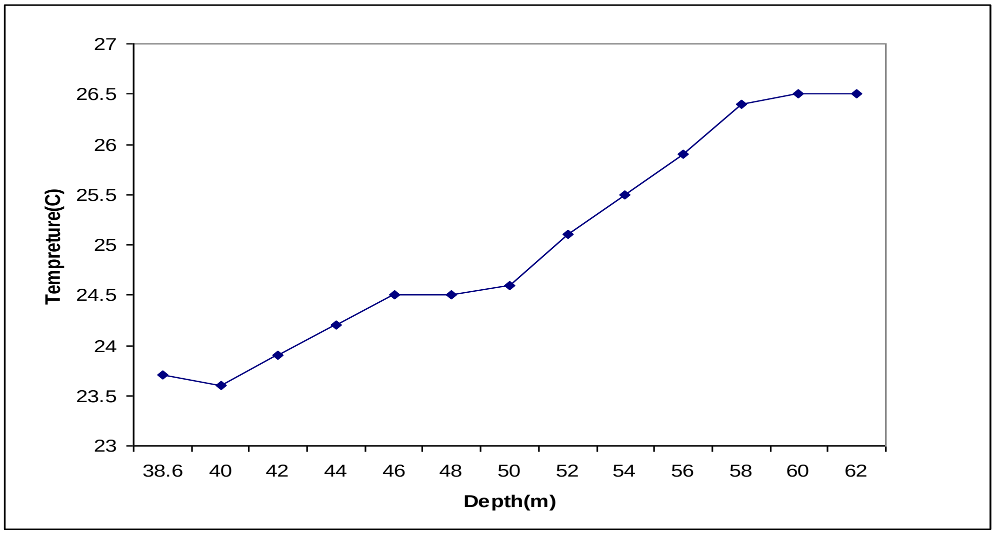

Figure 4 : Temperature profile along the borehole water column (before injection).

3.2 Part II: Assessments of groundwater after injection:

The experiment was carried out for four times during the period of 15/2-21/02/2012. Water injected by a depth of 52 m (Figure 5). The water flow was 120 m ^{3}/h for duration of 3 hours for the first time, and was 40 m3/hour for a duration of one hour, and the third test was 215 m3/h for duration was 3 hours, and the fourth test was also 200 m ^{3} /h for three hours duration. During the injection processes, groundwater table raised from 38.6 m to 32.5 m below the ground level.

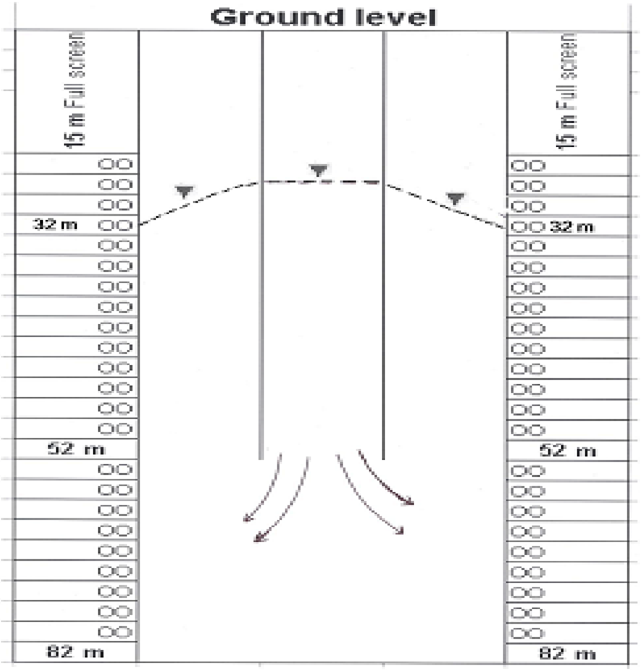

Figure 5: Schematic diagram for the injection borehole during the tests .

3.2.1 Water Table

The static water table of the borehole located by 38.6 m below the ground, and after 5 minutes of running the experiment, water table raised to 34.0 m below the ground, and during the rest of experimental time, water table raised additional two meters. The raised of water table did not depends on the volume of injected water.

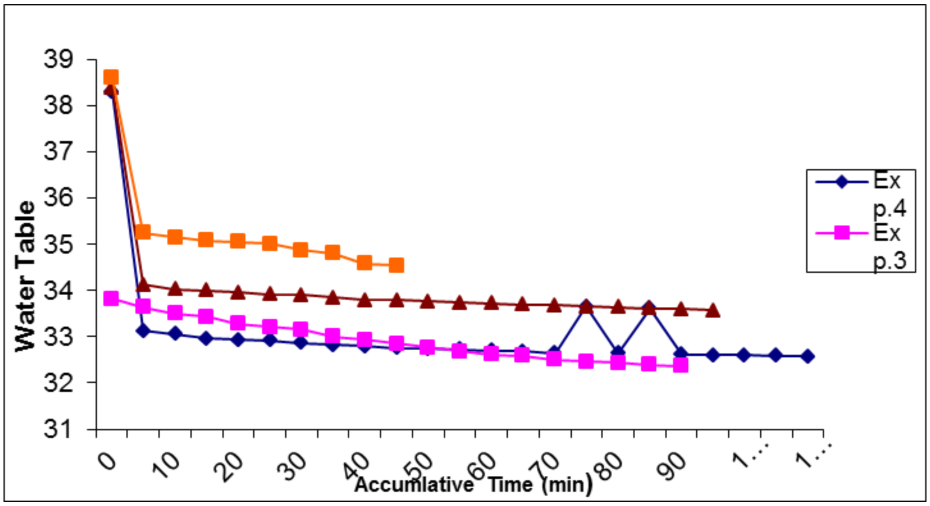

Figure 6: water table reaction during the four injection tests (120, 40, 215, and 200 m3/h).

3.2.2 Electrical conductivity

The electrical conductivity value of the injected spring water 622 uS/cm. Figure 7a, b present the Electrical conductivity of water column within the borehole profile. The measurements carried out after three hours for the first experiment. The Ec-values of the first 58 meter depth range between 1300 and 834 uS/cm, between 60 m depth 66 m , the Ec-values range between 3097 and 1420 uS/cm. From 68 to 78 m depth, the Ec-values range between 984 to 503 uS/cm. These results indicate that there are three water bearing layers with different physical and chemical characteristics. After conducting the first experiment, no water was pumped from the borehole.

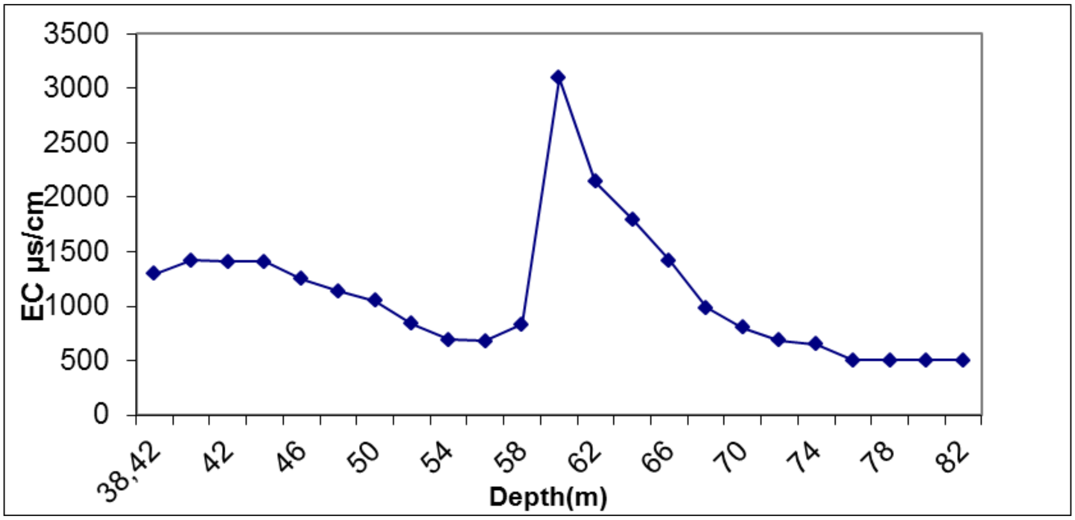

Figure 7,a : Ec-values after 3 hours, first experiment .

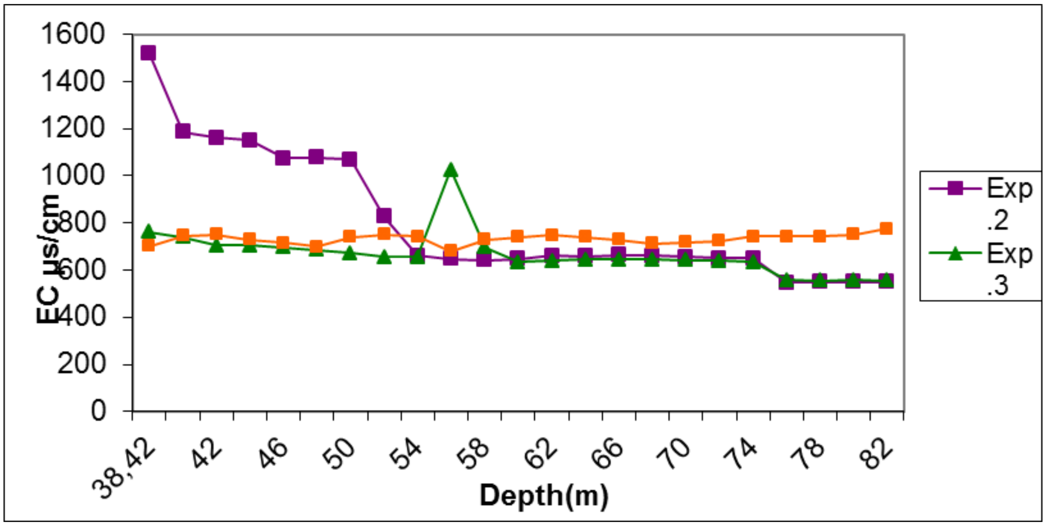

Figure 7, b: Ec-value after 1 hour for experiment 2, 3 hours for experiment 3, and 3 hours for experiment 4.

Figure 7 b show, that there is a different in the Ec-values between the second and the third/fourth test for the first 54 meters, and then the three experiment show the same trend. After a depth of 74 m the Ec-values drop to less than the Ec-value of the injected water, which means changing in water chemistry due to the mixing process between both water types take places.

3.2.3 Temperature

Water temperature was measured before and after the injection experiments. Figure 8 summarized the results. Water temperature before the experiment range between 23.7 and 26.5 C, and drop down between 21.9 and 18.1C, after carrying out the injection test, these values cope with the values of injected water, that originate from the spring and exposed to the local weather.

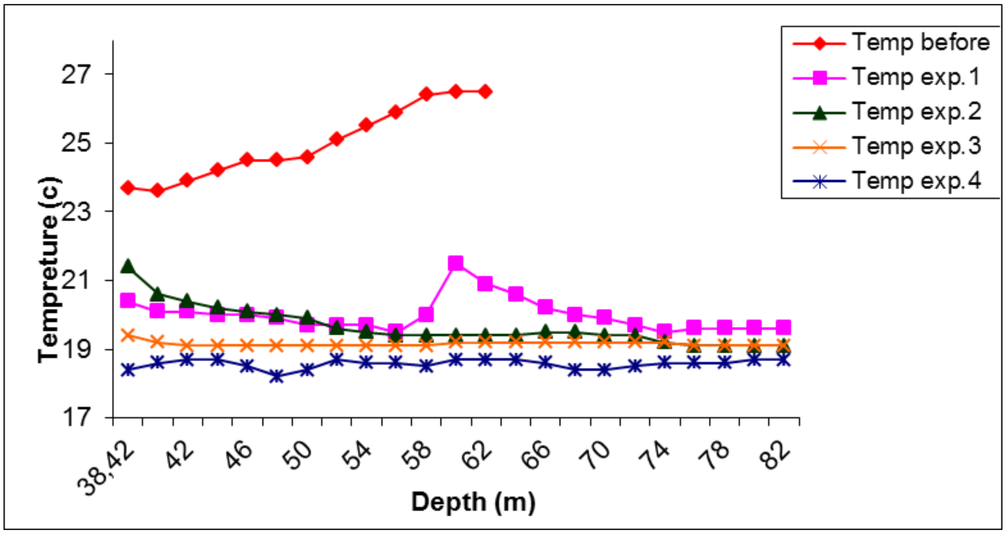

Figure 8: temperature of water profile before and after the tests.

3.2.4.Water pumping recovery

After 48 hours of the last injection test, water was pumped from the borehole with a rate of 70 m3 /h for 8.5 hours duration. Ec-values and temperature were measures during the pumping test. Table 3 present the result of these measurements. It shows that after 8.5 hours the Ec-value reach 3800 uS/cm, taking into account that the original Ec-value of the water was 6500 uS/cm, also temperature increases with continuing of pumping. Figure 9 a, b shows the relationship between accumulative pumping rate and temperature and electrical conductivity. Table 4 summarized the changes in water chemistry after three and 8 ½ hours.

Table 3 : Ec-values and temperature measurement with time .

Time	Ec µs/cm	Temperature °C
11:15	833	19.0
12:15	1257	19.4
1 :15	1742	20.5
2 :15	2219	20.6
3 :15	2698	21.2
4 :15	3118	21.9
5 :15	3526	22.0
6 :15	3878	22.2

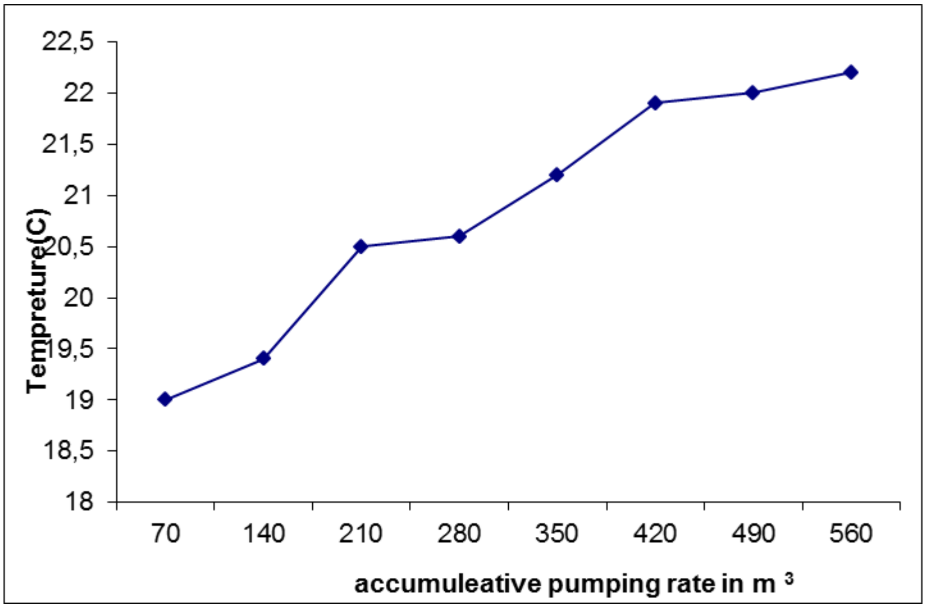

Figure 9 a: relationship between accumulative pumping rate.

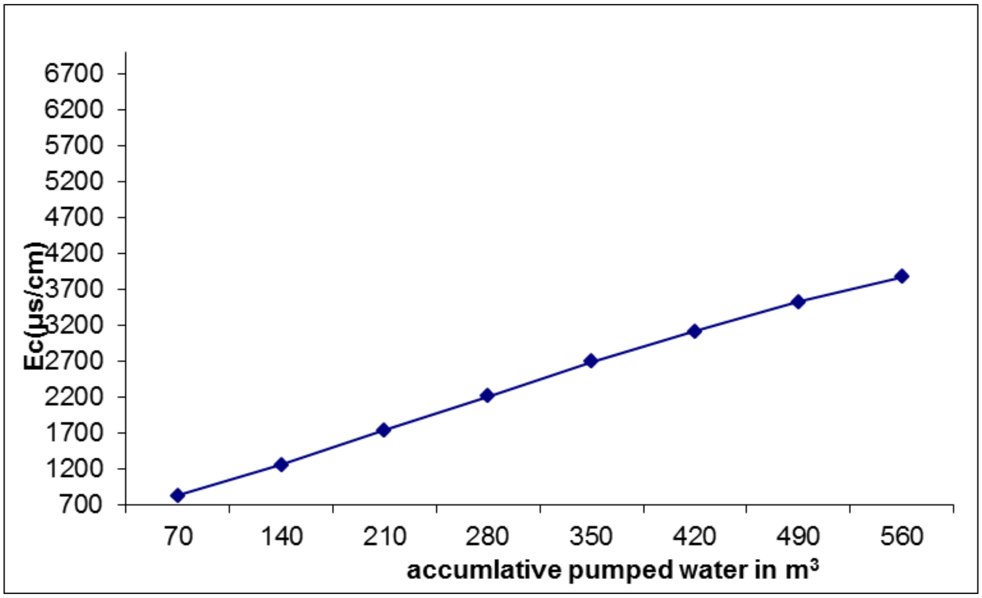

Figure 9 a: relationship between accumulative pumping rate and Ec-values.

Table 4: chemical analysis for the pump water after 3 and 8:30 hours of pump:

Sample	PH	Ec µs/cm	Mg^{2+} mg/l	Ca^{2+} mg/l	K^+ mg/l	Na^+ mg/l	PO_4^{3-} mg/l	SO_4^{2-} mg/l	NO_3^- mg/l	F^- mg/l	Cl^- mg/l	HCO_3^- mg/l	NH_4^+ mg/l
After 3 hours	7.7	**2135**	48.7	89.97	51.1	112.07	0.3	225	27.7	0.6	**443**	317.3	0.4
After 8:30 hours	7.6	**3927**	51.6	152.3	57.3	124.1	0.3	200	23.6	0.2	**1002**	414.9	0.2

4 Conclusion:

The current results, of our running artificial recharge experiment in Uja area, shows that using injection borehole to recharge the shallow Plio-Plistocene aquifer is a good choice to sustain and manage the local aquifer system. In this experiment we used spring overflow during this winter. Water filter system was developed by the research team from local material. One of the obstacles that we met was where to store the discharge of the spring which was about 500 l/s. During the current time, the injection of spring overflow is continuing, we expect that at the end of this season additional and complete information will be available.