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Investigation of Fresh Water Harvesting from Playa's Wetlands (Case study: South of Daryacheh Namak)

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Abstract

Playas are low-lands which is considered to be the locations of accumulation of superficial and ground waters from higher elevations and these waters have different types of salts and various salinity level. Therefore, because of lack of rainfall and fresh-water both for human and animal useage or even for plants, it is needed to apply proper methods to harvest fresh water from these saline-waters to develop agricultural and animal husbandry industry in this areas. Therefore, the research will try to investigate fresh water harvesting from playa's saline waters with the aid of saloar enegy and without implementation of import and complicated technology. The method is called Evaporating Water Harvesting (EWH). In this method, to install plastic covers on playa's wetlands, productive fresh water obtained by condensation of evaporated water from soil surface (disturbed and undisturbed suface) was measured. Factors such as soil genesis, soil's salts, water table, rate of saolar radiations and atmosphere temperature changes, had influence on the rate and term of water harvesting. The result showed that Daily average of gathered water from 1m^2 soil surface in disturbed statement was 0.3 liter. The Minimum and maximum rates were 0.1 and 0.35 liter in May and July, respectively and Daily average of gathered water from 1m^2 soil surface in undisturbed statement was 0.03 liter. The Minimum and maximum rates were 0.0 and 0.05 liter in May and July respectively. Then SPSS 11 software for being any relationship between sites's water harvesting and environmental factors (such as water table, temperature, relative humidity, sun shine hours) was used. Results showed that the mean correlation of 99 percent had been between rate of sites's water harvesting and temperature and water table factors and 95 percent to sun shine hours. At last, water table map was drawn. This method has some advantages such as producing fresh waters in playas, simplicity and being conomical and so on (see result section), and some disadvantages including limitation by using plastic covers, calcic and gypsic horizons in soil, not being usable in higher water tables (>3m).

Keywords: Fresh water harvesting; Playa's wetlands; Environmental factors

1. Introduction

According to statistics, 95 % growth of world population is in developing countries, accordingly, their bio-environment and natural resources are subjected to ruin (MOE, 1984; Amrolalahi, 1998). In other words, 32 countries of developing countries, have shortage of fresh water resources (FAO, 1973). According to statistics, playa's wetlands in Iran, are considered to be nearly 4 millions ha (Zehtabian, 2006; Mousavi & Shayan, 1984). Because of passing stream's water over highly-soluble formations, resulted sediments have high salinity and finally would have been accumulated in low-lands and constitute playa's wetlands. Wetlands do not have water shortage but they have bad quality. These waters could use in agricultural practices, cultivating of halophytes

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plants such as pistachio and so on, increasing of livestock productions, drinking use for both human and livestock, irrigation and drainage, investigation compatibility of plant species in this region for maintenance and soil reclamation and biological development, also employment (Perihar, 1998; Jackson, 2004). Also, using of this waters in mining section is another strategy. Therefore, it's needed to investigate the possibility of fresh water harvesting of the wetlands (Bernarlds, 2003).

2. Literature review

With respect to other works on water harvesting in other countries, researchers such as Halacy(1995), Jackson (2004), Perihar(1998) and Sharma (1999) performed similar methods, their result showed that the rate of ghathered water from 1m^2 soil surface, was 0.4, 0.25, 0.6 and 0.7, respectively. In Iran related works is not much, for instance, Amrollahi, A. (1998) performed similar study in Siah kouh-Ardakan and obtained daily mean of 0.4 liter. Ghahraman (1987) studied water harvesting and it's optimal utilization in desert and arid lands and expressed water harvesting methods types. Some of these types were usable and others were not usable.

3. Materials and methods

3.1. Study area

The study area is located in southern edge of Daryacheh Namak, 45 kilometer of north-eastern of Kashan in Isfahan province. The area end up from south-side to sand lands, Maranjab caravansary, Koshko field and Yakhb Mountain, from north-side to salt lake, from east-side to Abrizan mountain, Talbour and Sephidab and from west-side to villages, farms and Siahkouh, Sar, Takht Bozorg and Anabeneh altitudes (Fig. 1). The area has lied in longitude 51º 45′ 51″ to 51º 58′ 46″ and latitude 34º 17′ 34″ to 34º 20′ 29″. According to field works, the study area is 5422.448 ha. Mean elevation from sea level is 975m. The area is similar to a narrow and wet-bond near the Salt Lake. The study area according to iso-precipitation map, is located between lines of 100 to 150 mm (mean of 110mm) and the area's atmosphere temperature with respect of annually iso-therm map, is between 17.5 to 23. Annually mean evaporation of Kashan city is 2205.5mm. The rate of sunshin hours is 3028 to 3260 hours. Relative humidity is between 77.8 % in February month and 35 % in June month at 6:30 a.m, according to 35 yearly means. At first, study area determined by using of topography map 1:50000 and informations about the area and field works. Then recognized suitable site for doing research according to following criteria: Most important factor is underground water depth, that should be <3m.

secondly, the possibility of agriculture and animal husbandary and necessity to drinking water in the area must be determined and thirdly, being available road for daily sampling and measurements. Then, by using soil texture digital map which is prepared from accurated digital geology map, resulted two textures (sandy loam, loam sandy clay).

Establishment of sites for water harvesting exerted at these unites from bare lands (near the Lake) to uplands (Fig. 2). Then at these textures for performing of experiments, considered two statement (disturbed and undisturbed features):

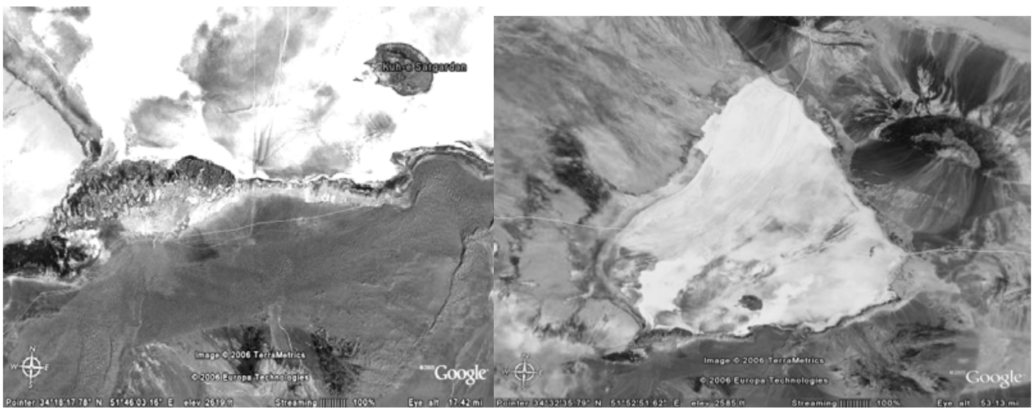


Fig. 1. The area's location (south of Daryacheh Namak) by google earth and ETM$^+$ 2006

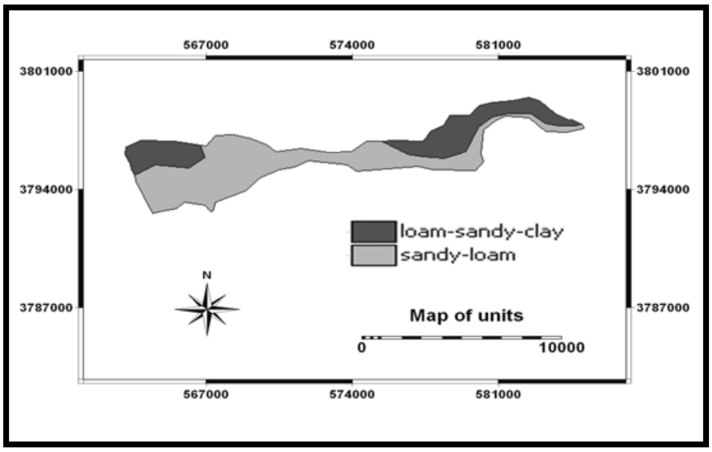


Fig. 2. Reclamation of the area’s soil texture map, resulted from geology map for sites’ installation

At first, in disturbed condition, by using a plastic cover 4*4 m^2 and digging profiles with dimensions 2*2 m^2 and 40 cm depth in uplands(sandy loam) and downlands (loam sandy clay), established the sites. plastic cover overlaid on digged profiles, so that around slope end up to central point and central point filled by a little soil until it’s surface would located lower than around, so that gathered waters resulted from evaporation and then condensation, would transported to the bowl that was situated exactly beneath central point (disturbed statement) (Fig. 3, right). In second statement (undisturbed statement) was made a tent, so that plastic cover overlaid overhead and 4-side slopes ended to one-side, until gathered waters transported to a dish located in one corner. Of course, in each side for uniform slope was installed pipe PVC 110 as half and then plastic cover overlaid overhead (Fig. 3, left). Profile dimension considered 1*2m^2 and study site such as previous one, established in uplands and downlands in related textures.

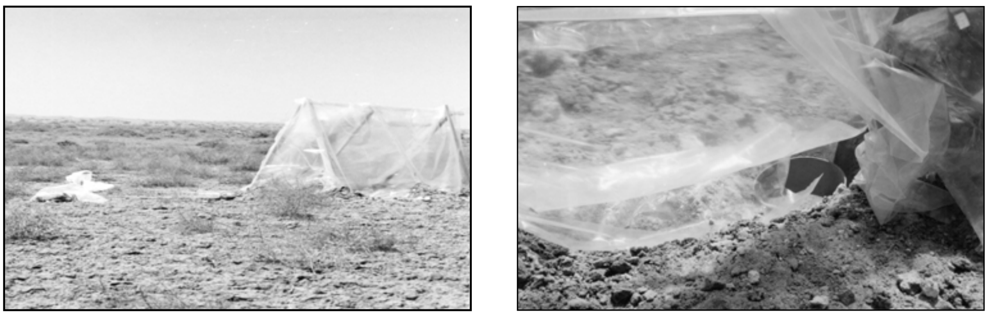


Fig. 3. Undisturbed (left) and disturbed (right) site’s schematic depiction

For recognizing soil’s available humidity for evaporation, soil sampling was made before installing plastic cover. After preparation experiments’s sites, solar radiation make soil’s humidity to evaporate and after striking to plastic cover, would be conconsed and transport to dish. Daily measurements made in two times (10 a.m and 2 p.m), then accounted daily mean. For measuring of temperature and humidity, applied psychrograph and thermograph and relinquished sites installation standards because of artificial circumstances and covered, because of direct sunshine and were regulated in Kashan’s synoptic station. Experiments were made in May, June and July months. After doing measurements, statistical comparision was made and for acquiring to annually mean of water harvesting and reconstruction of sites’s water harvesting data, was made correlation at different insurance levels between sites’s water harvesting and meteorology parameters, and then linear regression analysis of correlation equations of 4 sites were calculated by

SPSS and Excel softwares and drew their related graphs. Then, for acquiring of influence these factors in reconstruction of sites's water harvesting data, was used of multiple regression, id est between the mean of sites's water harvesting and mean of temperature, relative humidity, water table and sunshine hours, was implemented multiple regression by SPSS software and then was acquired related equations. Finally, sites's water harvesting was divided to their own areas and after that related water harvesting was resulted according to each site's water table.

4. Results

As expressed in the materials and methods, humidity percent was measured that it's rate in two sites at first experiment was 22.8 and 10.4, respectively and for second experiment results were 1.8 and 3.1, respectively. Then, the rate of available water in 1m^3 of soil for first experiment sites were 240 and 410 liters and for second experiment were 25 and 16 liters. But all of these water wouldn't be usable. Also, water table map which has key role at evaporation of soil surface, has presented as digital (Fig. 4). Results of measurements are as below (Fig. 5-7):

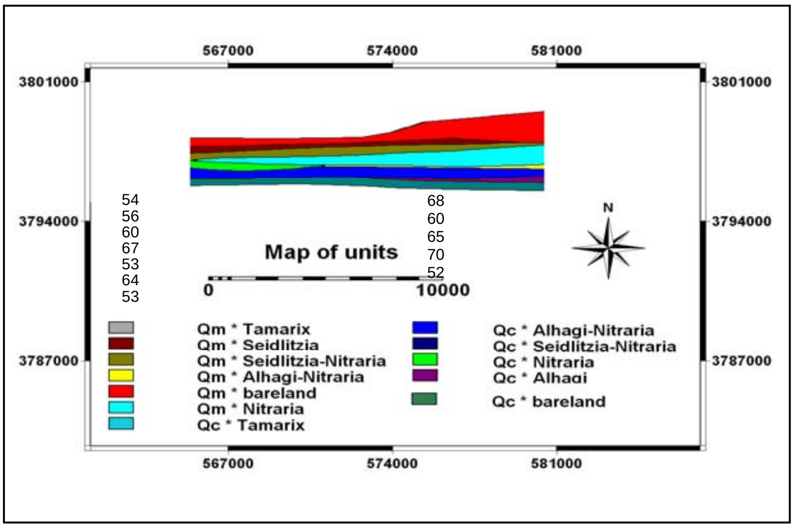


Fig. 4. Water table depth along with units' texture from the Lake to uplands (for calculating regression related to evaporation)

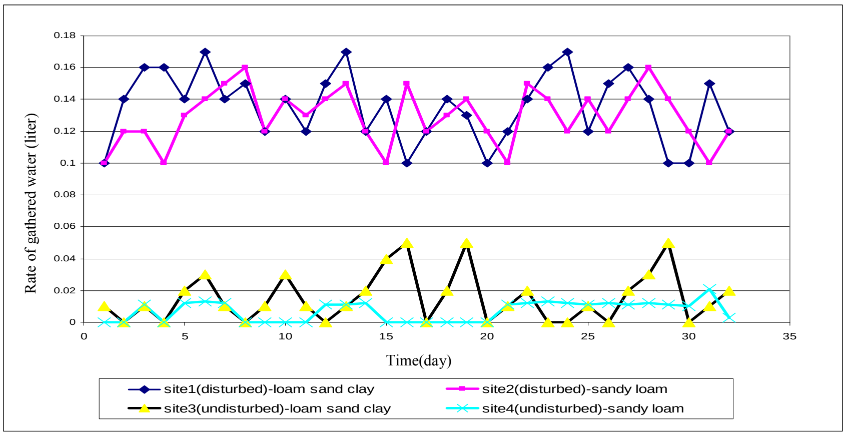


Fig. 5. Water harvesting rate from disturbed and undisturbed sites in May

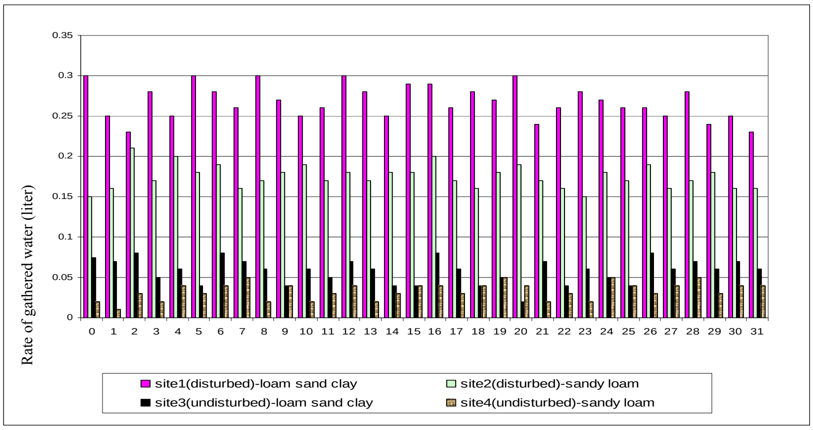


Fig. 6. Water harvesting rate from disturbed and undisturbed sites in June

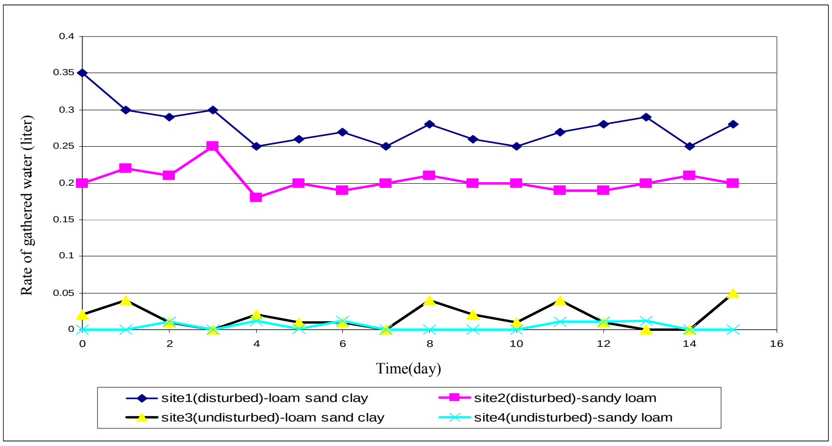


Fig. 7. Water harvesting rate from disturbed and undisturbed sites in July

At below, correlation, linear regression of sites with climatic factors (temperature, relative humidity, water table and sunshine hours) is presented (Tables 1-3 and Fig. 8):

Table 1. Correlation between sites' water harvesting rates and climatic factors (temperature, relative humidity, water table and sun shine hours) in May

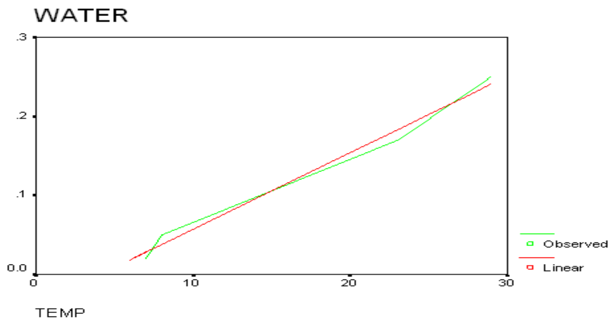
	Water harvesting	Temperature	Relative H.	Sun shine	Water table
Water harvesting	1	0.998**	0.829	0.942	0.990
Temperature	0.998**	1	0.799	0.922	0.979
Relative H.	0.829	0.799	1	0.654*	0.883
Sun shine	0.942	0.922	0.957*	1	0.948*
Water table	0.990*	0.979*	0.883	0.973*	1

Table 2. Correlation between sites's water harvesting rates and climatic factors (temperature, relative humidity, water table and sun shine hours) in June

	Water harvesting	Temperature	Relative H.	Sun shine	Water table
Water harvesting	1	0.651	0.749	0.965*	0.993
Temperature	0.651*	1	0.652	0.503	0.631
Relative H.	0.475*	0.623	1	0.754	0.685
Sun shine	0.965*	0.503	0.841	1	0.948*
Water table	0.994**	0.631	0.643	0.985*	1

Table 3. Correlation between sites's water harvesting rates and climatic factors (temperature, relative humidity, water table and sun shine hours) in July

	Water harvesting	Temperature	Relative H.	Sun shine	Water table
Water harvesting	1	1.000**	0.899	0.991**	0.996**
Temperature	1.00**	1	0.887	0.994**	0.977**
Relative H.	0.889	0.887	1	0.843	0.867
Sun shine	0.956*	0.945*	0.843	1	0.952*
Water table	0.996**	0.997**	0.867	0.999**	1



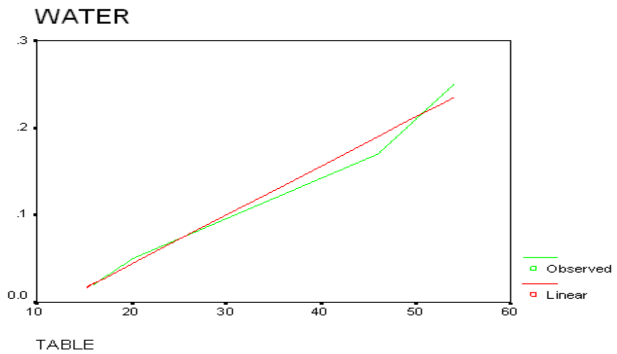


Fig. 8. Linear regression between sites' water harvesting and climatic factor (temperature) and water table in May

5. Discussion and Conclusion

Multiple regression Results between harvested water rate and climatic factors (temperature, relative humidity, water table and sunshine hours) in May, June and July at disturbed statement and lome sandy clay texture are as below respectively:

(1) harvested water rate = *5.523T – 1.067RH + WT + 4.62 SUN + 1.326*
(2) harvested water rate = *7.124T – 3.61RH + 1.959WT + 5.28 SUN – 0.584*
(3) harvested water rate = *1.436T – 1.464RH + 4.952WT + 0.4 SUN + 2.856*

In sandy lome:
(1) harvested water rate = *4.453T – 0.084RH + 0.02WT + 3.47 SUN + 2.347*
(2) harvested water rate = *6.114T – 2.35RH + 0.5249WT + 6.28 SUN +3.485*
(3) harvested water rate = *1.235T – 2.154RH + 2.654WT + 0.121 SUN -2.115*

at undisturbed statement and lome sandy clay texture:
(1) harvested water rate = *3.348T – 6.885RH + 2.422WT + 2.440 SUN -1.685*
(2) harvested water rate = *2.547T – 2.365RH + 2.541WT + 3.569 SUN +2.587*
(3) harvested water rate = *5.658T – 9.357RH + 1.134WT +0.214 SUN +2.3987*

In sandy lome;
(1) harvested water rate = *2.5473T – 2.147RH + 2.310WT + 3.547 SUN -0.087*

(2) harvested water rate = $4.552T - 2.654RH + 2.547WT + 4.652\ SUN - 0.247$

(3) harvested water rate = $2.223T - 2.314RH + 2.687WT + 1.847\ SUN + 3.235$

According to results, Daily average of gathered water from 1m^2 soil surface in disturbed statement was 0.3 liter. The Minimum and maximum rates were 0.1 and 0.35 liter in May and July respectively and Daily average of gathered water from 1m^2 soil surface in undisturbed statement was 0.03 liter. The Minimum and maximum rates were 0.0 and 0.05 liter in May and July respectively. According to the equations and other data, factors such as sunshine hours rate, soil genesis, water table depth, and atmosphere roun-the-clock temperature changes are influent factors at harvested water rate. The influence of above factors could be explained as below; Soil texture near the Salt Lake is heavier (has more clay) and water table is higher (50-60 cm), accordingly, doing evaporation function and it's term is further, because clay texture has finer capillary tubes and capillary action in finer tube is stronger than wide tube (such as sandy texture, lome texture has the middle properties of sand or clay and is the best texture), but at uplands, water table is lower and soil textures are more sandy, then doing evaporation function and it's term is less. About sunshine effect, it is clear that in warmer months (July: 0.35 and 0.05 in both statement), the harvested water would be further. Finally, temperature has straight effect, id est, when the temperature increases, the evaporation rate and accordingly the gathered water rate increases.

The results of other similar works by researcher such as Halacy (1995, 0.4 liter), Jackson (2004, 0.25 liter), Perihar (1998, 0.6 liter) and Sharma (1999, 0.7 liter) and Amrollahi, A. (1998, 0.4 liter) was in 1m^2 soil surface in general and some of them didn't apply some of environmental factors as ours (for instance Halacy applied only temperature and water table) and some of them didn't considered soil texture (for example Perihar). Soil texture as studied at the research, had a strong influence in evaporation rate. In general, different results in different researches like above are related to environmental circumstances at study area. For example Amrollahi (1998) showed that soil texture of the area was more clay and accordingly acquired 0.4 liter water in general, or water table in Prihar's research area lied in 42 cm and accordingly acquired 0.6 liter, but in present study clay was pretty high only near the Lake, not all places in the area and the average of water table was 56 cm. Generally this method has some advantages and some disadvantages as below:

The possibility of it's application is great in playas, saline and wetlands that have fresh water problems. Because of producing of fresh water gradually, the gathered wter would be fresh and without contamination. Since, most water requirements is in warmer months, accordingly at this method water harvesting rate in warmer month increases.This method don't need to apply advanced technologies, manufacturing great tanks, electric energy or fossil fuel, expert group and auxiliary materials for sparing and maintaining.

Because of severe sunshine at playas, using of ordinary plastic wouldn't be possible, therefore, it's needed to use glass or resistant plastic materials, that are expensive. This method hasn't implementation in large-scale. In highly-water table depth (>3m), wouldn't be practicable. Calcic and gypsic horizons, would limitate water productivity. This method wouldn't be usable in different places and needed to be investigated other water supply methods.

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