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Evaluation of Groundwater Unit Hydrograph of Kavar-Maharloo Aquifer

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***Abstract*—**Groundwater is one of the most important water resources in Fars province. Based on this study, 95 percent of the total annual water consumption in Fars is used for agriculture, whereas the percentages for domestic and industrial uses are 4 and 1 percent, respectively. Population growth, urban and industrial growth, and agricultural development in Fars have created a condition of water stress. In this province, farmers and other users are pumping groundwater faster than its natural replenishment rate, causing a continuous drop in groundwater tables and depletion of this resource. In this research variation of groundwater level, their effects and ways to help control groundwater levels in aquifer of the Kavar-Maharloo plains in Fars plain were evaluated .Excessive exploitation of groundwater in this aquifer caused the groundwater levels fall too fast or to unacceptable levels. The average drawdown of the groundwater level in this plain were 17 meters during 1995 to 2006. The purpose of this study is to evaluate water level changes in the Kavar-Maharloo Aquifer in the Fars province in order to determine the areas of greatest depletion, the cause of depletion, and predict the remaining life of the aquifer.

***Keywords*—**Aquifer , ground water depletion, water table

I. Introduction

GROUNDWATER has an important role in the environment: it replenishes streams, rivers, and wetlands and helps to support wildlife habitat; it is used as primary source of drinking water and also in agricultural and industrial activities. Around the world, groundwater resources are under increasing pressure caused by the intensification of human activities and other factors such as climate changes. Reductions in groundwater stores have implications for the water cycle because groundwater supplies the base flow in many rivers and it supports evapotransiration in high water table regions. Reductions in groundwater storage also have major implications for water quality because the salinity of the extracted water frequently increases as the volume of the reservoir decreases. Groundwater resources need to be carefully protected because in many regions, withdrawal rates exceed recharge rates. Once modified or contaminated, groundwater can be very costly and difficult to restore. As

Iran is a country in southwestern Asia, located on the eastern side of the Persian Gulf. Covering an area of 1,648,000 square kilometers and is one of the largest countries in southwest Asia. Such factors as the height and direction of mountains disparity of plains and existence of desert, the proximity of seas (in the north and south), as well as directions of seasonal winds have is mainly desert, and most of the places (except northern and north western regions) have less than 300 mm rainfall per year. Average of Iran annual precipitation is about 240 mm. The rainy period in most of the country is from November to May. In the dry period between May and October, rain is rare in most of the country. In other words, it seems that the temporal and spatial distribution of precipitation in Iran is volatile, as 90% of total precipitation occurs in cold and humid seasons and in northern and western parts of the country and only 10% occurs in warm and dry seasons and in central, southern and eastern parts. About 52% of precipitation occurs in 25% of the area of the country, hence some parts of the country will suffer a lack of water resources and water crises in the near future. In many localities of Iran, there is no rainfall until sudden storms, accompanied by heavy rains, dump almost an entire year’s rainfall in a few days. These torrential rains cause floods and local damages. One of the critical concerns of Iran is the evaporation and acute transpiration of surface water under solar radiation.

According to the water comprehensive plan of the Iran country, the total annual precipitation throughout the country as the main water resources in Iran is equal to 413 billion cubic meters, of which 93 billion cubic meters flows as the surface water, 25 billion cubic meters penetrates to the mobile aquifers and the rest becomes un accessible in the form of evapotranspiration from the surface of the land, forests, pastures and dry farming areas. Besides , water resources supplied through precipitation, about 12 billion cubic meters enters our country via rivers which makes the total surface water resources reach 105 billion cubic meters. Considering the 25 billion cubic meters of the underground mobile aquifers, the total renewable water resources of the country reaches 130 billion cubic meters. The studies reveal that about 89.5 billion cubic meter of the total renewable water resources is used for the sectors of agriculture, industry, mines and home usage as the following[1].

- 83 billion cubic meters, that is 93 percent for agriculture;
- 5.5 billion cubic meters, that is 6 percent for home usage;
- The rest for the sector of industry and the other ones.

Water is an essential component of Iran’s history and the success of its economy moving forward [2]. While the average rainfall in dry region of the world is 860 mm, in Fars province average of annual precipitation is about 323 mm. Annual precipitation is 41,000,MCM that 27,000 MCM is evaporated and 8,000 MCM becomes ground water and 6 MCM flow as

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surface water. Water consumption in Fars is about 10.5 billion cubic meters that 2.5 billion cubic meters of it is provided by surface water resources and 8.0 billion cubic meters is provided by the ground water resources . According to this research, 95 percent of the total annual water consumption in Fars is used for agriculture, whereas the percentages for domestic and industrial uses are 4 and 1 percent, respectively.

Groundwater and water resources management plays a key role in conserving the sustainable conditions in arid and semi-arid regions. Groundwater is one of the most important water resources ,making it fundamental to people life and economic development in Fars province. There are many reasons why society has found it so useful to develop groundwater, but among the most important are:

- aquifers are very convenient sources of water because they are natural underground reservoirs
- many aquifers are also able to offer natural protection from contamination ,so untreated groundwater is usually cleaner and safer than its untreated surface water equivalent;
- groundwater is relatively easy and cheap to use. It can be brought on-stream progressively with little capital outlay and boreholes can often be drilled close to where the water supply is needed;
- it is a resource that is organizationally easy to develop; individuals can construct, operate and control their own supply, often on their own land.

Land surface deformation associated with groundwater overexploitation is a serious challenge for plain aquifers of Fars province and other regions of Iran , particularly in semiarid and arid region. For example in the Greater Tehran area, the capital of Iran with a population of 14 million people, groundwater discharge has exceeded natural recharge over the last decades, causing significant drawdown of groundwater level and land subsidence.

II. MATERIALS AND METHODS

Kavar – Maharloo plain is located in Fars province in the south part of I. R. of Iran, and it has mild and rainy winters and dry summers.

The majority of the rain producing air masses enter the region from the west and the north-west, yielding relatively high precipitation amounts for those areas. Towards the south and south-east, rainfall is decreases. Furthermore, winter precipitation in the north-west area is in the form of snowfall, but for other areas it is mostly in the form of rain. The mean annual precipitation for the Fars province ranges from 50 to 1000 mm [5,6].

In different regions of Fars province such as Kavar – Maharloo plain groundwater plays a key role in all forms of development. In the last years, aquifers development have been continued in order to fundamental of economic development and water supplies for different usages sectors such as domestic, industrial and specially for irrigation usages.

Groundwater aquifer management plays a key role in conserving the sustainable conditions in arid and semi-arid regions[7] specially in Fars.

Growing Fars people population causes more use of fresh water resources in order to more crop production. Crop production in the arid regions of Fars consumes large quantities of water. While the production of 1 kg of grain in the temperate zone takes less than 0.5 m3 of water, 1.5–2.5 m3 is normal in the arid zone. Irrigated crop production in the arid zone therefore exerts a heavy toll on the available scarce fresh water resources [8]. Groundwater is, however, the main and more reliable resource of irrigation. Both over-exploitation from aquifers to address the irrigation needs, and drought events have caused severe water table level drop in many areas. Where groundwater is used for irrigation, aquifers are also being depleted at an alarming rate. In Iran, the current groundwater abstraction exceeds the safe yields by some 15%–20% and water tables in some irrigated areas are falling at 0.5– 1.0 m per year [9]. The situation is equally alarming in some parts of the Indo-Gangetic plains in India, the North China Plain and in the south-west of the USA [8].

One of the most fundamental skills in groundwater hydrology is the ability to accurately measure and interpret the depth to groundwater in an observation well or piezometer. Measuring the elevation of the potentiometric surface is a routine task for any groundwater professional; however, the difference between a professional and the summer help is that a professional is capable of understanding the resulting measurements. In order to reliably interpret groundwater measurements, you must be familiar with a few basic ideas. Groundwater level is the level of the water table, the upper surface or top of the saturated portion of the soil or bedrock layer that indicates the uppermost extent of groundwater. It can be expressed as a height above a datum, such as sea level, or a depth from the surface.

To determine groundwater elevation above mean sea level, use the following equation:

$$\boldsymbol{E_W = E - D}$$

where:

$\boldsymbol{E_W}$ = Elevation of water above mean sea level (m) or local datum

$\boldsymbol{E}$ = Elevation above sea level or local datum at point of measurement (m)

$\boldsymbol{D}$ = Depth to water (m)

Ground water level data were collected observing wells or piezometers over long-term periods and summarized on hydrographs. A hydrograph diagrams the fluctuation of ground water levels during a given period of time (most hydrographs use annual cycle) and allows for comparison of ground water levels from year to year.

III. RESULTS AND DISCUTIONS

The data and other information of monthly groundwater level of some observation wells , which was recorded continually during 1995 to 2006 were evaluated ,then has been used in this study. These wells are distributed among the study area to indicate the trend and fluctuations of groundwater level all over this plain. The data recorded for each well consisted of average monthly water table level ,with totally 132 data measurements for each well during the 11 years as show as table 1 [2,5,6,10].

In the recent years, a dramatic increase in discharge of aquifers were observed ,because the population growth and economic development needs to supply of water more and more in different sectors of water usages for instance domestic, industrial and specially for irrigation purposes.

Population growth, urban and industrial growth, and agricultural development in Fars have created a condition of water stress. In Fars province, farmers and other users are pumping groundwater faster than its annual natural recharge rate, causing a continuous drop in groundwater tables and depletion of this resource. In this research variation of groundwater level , their effects and ways to help control groundwater levels in some plains of Fars were evaluated .

The fluctuation and changing trend of ground water level in the study area were evaluated during 11 years. Based on evaluation of aquifer unit hydrographs which provide for this plain as was showed in figure 1,it is evidence this plain have had a negative groundwater balance and was showed a considerable decrease in the groundwater level.

TABLE I
THE DATA OF RAINFALL AND GROUNDWATER LEVEL

Time	**Rain (mm)**	**Ground water level (m)**
Apr. 1995	69.30	1492.36
May. 1995	5.00	1491.96
June. 1995	0.00	1491.19
July. 1995	0.00	1490.56
Aug. 1995	1.20	1489.68
Sep. 1995	0.00	1489.01
Oct. 1995	28.00	1489.00
Nov. 1995	0.00	1489.78
Dec. 1995	209.50	1490.59
Jan. 1996	177.50	1491.39
Feb. 1996	109.00	1492.22
Mar. 1996	169.00	1492.84
Apr. 1996	41.00	1493.81
May. 1996	2.00	1493.67
June. 1996	0.00	1493.01
July. 1996	5.00	1492.26
Aug. 1996	0.00	1492.24
Sep. 1996	0.00	1491.45
Oct. 1996	0.00	1491.71
Nov. 1996	2.50	1491.81
Dec. 1996	7.00	1492.21
Jan. 1997	68.50	1492.49
Feb. 1997	14.50	1492.92
Mar. 1997	119.00	1493.01
Apr. 1997	89.50	1493.38
May. 1997	0.00	1492.38
June. 1997	0.00	1491.51
July. 1997	0.00	1490.45
Aug. 1997	0.00	1489.09
Sep. 1997	0.00	1488.02
Oct. 1997	4.00	1488.43
Nov. 1997	27.00	1489.17
Dec. 1997	132.00	1489.99
Jan. 1998	154.00	1491.06
Feb. 1998	169.50	1491.71
Mar. 1998	112.00	1492.47
Apr. 1998	20.50	1492.89

May. 1998	3.00	1492.44
June. 1998	0.00	1490.72
July. 1998	0.00	1489.62
Aug. 1998	0.00	1489.55
Sep. 1998	0.00	1488.83
Oct. 1998	0.00	1488.82
Nov. 1998	0.00	1489.11
Dec. 1998	0.00	1489.00
Jan. 1999	137.00	1489.30
Feb. 1999	232.50	1489.95
Mar. 1999	124.00	1490.66
Apr. 1999	2.00	1491.74
May. 1999	0.00	1490.67
June. 1999	0.00	1489.83
July. 1999	2.00	1488.74
Aug. 1999	0.00	1488.06
Sep. 1999	8.00	1487.24
Oct. 1999	0.00	1486.83
Nov. 1999	0.00	1487.81
Dec. 1999	24.00	1488.06
Jan. 2000	228.00	1488.56
Feb. 2000	17.00	1489.55
Mar. 2000	0.00	1490.10
Apr. 2000	0.00	1489.69
May. 2000	0.00	1488.64
June. 2000	0.00	1487.28
July. 2000	0.00	1485.93

Aug. 2000	0.00	1484.94
Sep. 2000	0.00	1484.35
Oct. 2000	17.00	1483.47
Nov. 2000	89.00	1483.82
Dec. 2000	89.50	1485.22
Jan. 2001	18.50	1485.99
Feb. 2001	26.00	1486.79
Mar. 2001	28.50	1487.23
Apr. 2001	0.00	1486.26
May. 2001	1.50	1485.61
June. 2001	3.50	1483.15
July. 2001	0.00	1482.38
Aug. 2001	0.00	1481.47
Sep. 2001	0.00	1480.53
Oct. 2001	0.00	1479.74
Nov. 2001	4.50	1479.29
Dec. 2001	60.00	1481.84
Jan. 2002	131.50	1482.92
Feb. 2002	82.00	1483.93
Mar. 2002	70.00	1484.63
Apr. 2002	59.50	1484.65
May. 2002	0.00	1484.43
June. 2002	0.00	1483.64
July. 2002	0.00	1482.82
Aug. 2002	0.00	1481.65
Sep. 2002	0.00	1480.12
Oct. 2002	0.00	1478.12

Nov. 2002	4.50	1478.22
Dec. 2002	60.00	1478.64
Jan. 2003	164.00	1479.61
Feb. 2003	119.00	1480.57
Mar. 2003	103.50	1481.76
Apr. 2003	27.50	1482.81
May. 2003	0.00	1482.53
June. 2003	0.00	1482.06
July. 2003	0.00	1481.45
Aug. 2003	0.00	1478.73
Sep. 2003	0.00	1478.54
Oct. 2003	0.00	1477.74
Nov. 2003	3.00	1478.18
Dec. 2003	121.00	1478.31
Jan. 2004	215.00	1479.17
Feb. 2004	39.53	1481.42
Mar. 2004	11.50	1481.78
Apr. 2004	38.00	1481.43
May. 2004	2.50	1480.41
June. 2004	0.00	1479.21
July. 2004	0.00	1478.74
Aug. 2004	0.00	1478.27
Sep. 2004	0.00	1477.37
Oct. 2004	0.00	1477.53
Nov. 2004	40.00	1478.11
Dec. 2004	436.00	1478.22
Jan. 2005	206.50	1481.42
Feb. 2005	43.00	1482.85
Mar. 2005	20.50	1484.07
Apr. 2005	2.50	1483.05
May. 2005	0.00	1482.70
June. 2005	0.00	1481.72
July. 2005	0.00	1480.84
Aug. 2005	0.00	1480.21
Sep. 2005	0.00	1479.40
Oct. 2005	0.00	1479.20
Nov. 2005	115.50	1479.83
Dec. 2005	14.50	1481.26
Jan. 2006	215.50	1481.47
Feb. 2006	88.50	1482.58
Mar. 2006	52.00	1482.44
Apr. 2006	7.50	1480.93
May. 2006	63.50	1480.73
June. 2006	0.00	1479.39
July. 2006	0.00	1478.56
Aug. 2006	0.00	1477.45
Sep. 2006	0.00	1477.14

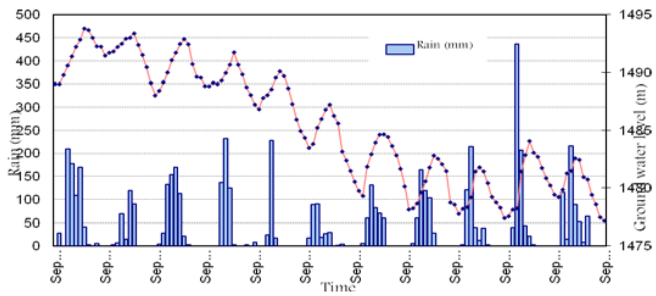

Fig. 1 The rainfall(mm) and groundwater hydrograph(m) of Kavar-Maharloo plain

IV. CONCLUSIONS

This study shows that groundwater levels in the Kavar-Maharloo plain are dropping. However, not all areas covered by the aquifer will encounter the same issues at the same time. Decline is not uniform across the entire this Plain. The effects of groundwater change are not shared equally. The future of irrigation in the region depends on the two variables of well location and the depth of the well. By understanding these variables farmers can properly plan for the future. The groundwater level of Kavar-Maharloo aquifer shows a steady decline of groundwater at a rate of about 1.54 meters per year. Excessive exploitation from aquifer in this plain , specially where groundwater levels fall too fast or to unacceptable levels not only reduced available water resources and well yields but could cause some other negative effects as follow as :

- Continuing the dramatic decrease caused result in the drying-up of shallow wells, increased pumping costs, reduced borehole yields and efficiencies, the need to deepen or replace boreholes and, in coastal areas, saline intrusion

- Groundwater pumping has effected on the pore water pressure in porous media beneath the ground surface and thus increasing the effective stress from the overlying strata on the matrix of the aquifer. When the increase in effective stress is greater than a critical value, known as the pre consolidation stress, the sediment compaction becomes irrecoverable or inelastic and sedimentary aquifer systems can be compacted groundwater subsidence can occurred.

The following suggestion are recommended for ground water management and aquifer improvement in Fars province:

1-promote the water productivity in the plains

2-Design and construction of artificial groundwater recharge projects can change the trend of groundwater level

3- Control and measuring of wells discharge.

4- Establishment of groundwater user associations in the plains.

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