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Evaluation Level Underground Water in Buin Basin (Isfahan province)

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ABSTRACT

The increasing population in recent decades has led to an increased extraction of groundwater resources throughout the country especially in central provinces. This problem has also been increasing in Isfahan province due to reduction of surface water. One of these areas is Buin watershed basin with a space of 1855 km to the north of Zayanderoud dam. This basin includes three aquifers of Chehel Khaneh, Damenedaran and Buin, which have been extended within the alluviums of the Quaternary Period. This research is an attempt to investigate the rate of groundwater decline in these aquifers from 2002 to 2012 and investigate the reasons for the decline related to human and natural factors as well. For this purpose, the rate of the groundwater decline was measured using the interpolation techniques as well as Arc Gis, Excel and SPSS softwares. Results reveal that the average rate of the decline during this 11-year period has been 6 meters and Damenedaran aquifer has had the highest decline of all with an average decline of -8, while Chehel Khaneh has had the lowest decline with an average decline of -1.5. Then, the human and natural reasons for decline were investigated and it was shown that rainfall has had the most effect of all the natural factors, the lowest rainfall has been in 1378, and the groundwater level changes have greatly changed and the decline has increased ever since. Considering human-related factors, the exploitation rate of water resources has greatly increased due to farming reasons, and the number of deep wells has increased from 1140 wells in 2002-2003 to 1304 wells in 2011-2012.

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INTRODUCTION

No one can deny the importance and value of water nowadays, so that experts predict that possible future wars will result from water. Man has been supplying his needed water from different resources. The easiest way of gaining access to water in wet areas is to use these resources, whereas in dry and semi-arid areas where access to surface water is impossible or difficult, the only accessible source is groundwater resources. This ease of exploitation has led to an uninterrupted rush for groundwater resources which are non-renewable. The development of technology in drilling and pumping techniques have been effective factors in the earlier destruction of these resources so that water is extracted under the ground as deep as 150 meters to the ground surface in most areas especially in desert ones. Uncontrolled exploitation of water resources has brought about several problems in different areas including complete decline of aquifers, the need to increase the depth of exploitation, the need to use more cost and energy and ground subsidence phenomenon, such that has made the settlers' migration inevitable. Isfahan province is located in an arid area where the reduced rainfall and consequently the reduced surface water resources have resulted in a high pressure on the groundwater resources in this province, particularly in the big basin of Zayanderoud. This basin has 21 aquifers with different hydrodynamic characteristics. Each one of the aquifers has a different water spread and power, which demands a different rate of exploitation. The exploitation rate of both surface and subsurface water resources of Zayanderoud watershed basin is 4.86 billion cubic meters, about 1.8 billion cubic meters of which goes to surface flows (dams, traditional rivers, springs and drainage water. Therefore, about 62 percent of the water needs of the basin in different parts including drink, industry and agriculture are supplied by groundwater resources. The most important aquifers of the basin are located in the western north, including three aquifers of

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Damenedaran, Chehel Khaneh and Buin, situated in Buin basin which is a sub-basin of Zayanderoud. We have tried in this research to assess the groundwater level in these aquifers, measure the rate of decline in this basin and investigate the causes of decline. Suggestions are made in the final part in order to maintain and protect the groundwater resources and create balance in the aquifers.

The Position of the Area:

Buin watersheld basin has a space above 1855.26 km2 between longitude of 50 deg. 03 min. to eastern 50 deg. and 41 min., and altitude of 32 deg. and 46 min. to northern 33 deg. and 11 min. in the western north of Zayanderoud Dam. The average height of the basin is ….meters. In general, this region is located in the eastern foot of Zagros high altitudes and its largest space consists of high altitudes. Buin watershed basin which is a sub-basin of Zayanderoud (Gavkhoni) is located between Golpayegan watershed basin in the north and Zayanderoud watershed basin in the south (Shahrokh Castle). Based on the 6-fold divisions of the watershed basins, this basin is a sub-basin of Central Iran. This watershed basin has two main branches of Buin with a length of 48.76 km and Savaran with a length of 46.54 km. Buin branch is joined near Savaran village and comprises Palasjan river and finally joins Zayanderoud river. Buin branch and that part of Plasjan river which is located in the basin compose the main canal of Buin (First Consulting Engineers, 1376:3). Buin watershed basin is divided into three hydrology units of Chehel Khaneh unit, Damanedaran unit and Miandasht Buin unit which respectively have a space of 161.96 km2, 711.22 km2, and 982 km2. The position of these units is such that Chehel Khaneh joins from north to Damanedaran unit in the south and Damanedaranian joins Miandasht Buin unit in the exit part of Daresavaran. Around 64 km of Chehel Kaneh consist of alluviums and the remaining 86 km include hard formations. This unit is located in the northern part of Damanedaran unit and its water runs into Damanedaran unit. This unit ends Miandasht Buin unit in the west and Northern watershed basin (Qom Lake basin) in the north. Damanedaran unit has a space of 711 km 2. The alluvium layers in this unit have a spave of 361 km2 and hard formations have a space of 331 km2. Miandasht Buin unit which is one of the most important and largest aquifers of the watershed basin has a space equal to 982 km2, 518 kilometers of which are alluviums and 475 kilometers of which are high altitudes. This unit ends Namak (Salt) Lake in the north, Chehel Kaneh and Damanedaran units and a part of Chadegan unit in the east, Karon river base in the west and Ardeh Kouhrang and Zayanderoud Lake Dam in the south [5].

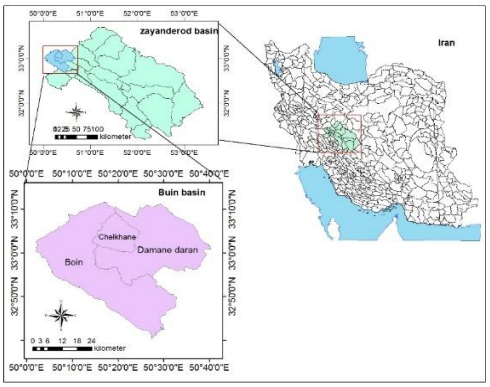

Fig. 1: position of Buin basin hydrologic.

The Research Method:

The research has been conducted using a descriptive-analytic and field method, with the following stages:

Library studies:

Gathering the data on the groundwater level between 2002 and 2012 as well as meteorological data (temperature, rainfall).

Preparing the geological maps, slope, land use, high altitudes, groundwater level, decline, isohyet, and isothermal status.

Analyzing the statistical data using Excel, processing the data related to piezometers by Arc Gis, preparing the decline and water surface maps using Kriging interpolation methods, examining the causes of decline via balance statistics of the basin's water resources and natural factors, determining the drought severity using SPI, conclusion and suggestions.

Discussion and Conclusion:

This basin has three aquifers including Buin, Damenedaran and Chehel Khaneh. The number of the observation wells in this basin is 57 wells, the water surface of which has been measured in the interval between

2002 and 2012. The water level of each one of the basin's wells and the average water level have been measured month by month and then the average annual water level of the wells has been obtained for the entire basin. The position of the wells has been shown in graph (2). After calculating the annual water level, we measured the decline rate and prepared its map(Graph 3).

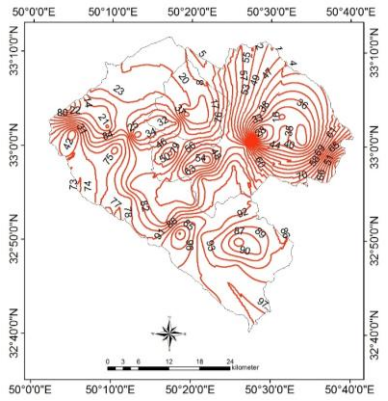

Fig. 2: Position of Buin basin.

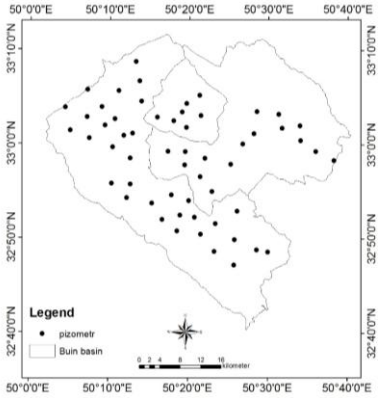

Fig. 3: Map Of Buin Basin Drop.

The average depth of the groundwater in Buin basin has decreased from -27.74 in 2002 to -31.48 in 2012. This shows that the average depth of the basin's groundwater level has had a decline of about 6 meters during 11 years. The results reveal that the groundwater's decline rate has increased year by year and the minimum depth of water has been estimated -3.34 in Mofan and -5.23 in the north of Khang (Sadeghieh), which are both locate in Buin Aquifer. On the average, the maximum depth measured in Damenedaran aquifer has been -71 meters in Darebid and in other parts of ths aquifer. However, the increasing status of depth in Buin and Chehel Khaneh Aquifers has happened gradually, and this has had an increasing status in Damenedaran. Some of the main reasons for this are decreased rainfall and increased exploitation of the groundwater due to farming agricultural crops within the area. About 7 wells of the wells in Damenedaran aquifer have had declines during these years (Darebid Well, Adilipour Lands, Damaneh Turning, between Damaneh and Ashjard, the beginning of Ashan Road, the north of Naft's(Oil) Road, Nilab Lands), such that the average decline of these wells is -14. Some reasons for this are recent droughts, the already-mentioned reasons and the allurium's little thickness within the area, which is equal to 361 km2 and the hard formations in this unit are 331 km2 (Table 1).

The Reasons for Decline:

Human Factors: these factors include exploitation for agricultural, industrial and drinking uses. The basin which has been studied in this research is one of the important areas in terms of agricultural activities. When farmers do need water, this area becomes so short of surface water. This is why groundwater has attracted the most attention in recent years due to the increased population and change of the dry lands into irrigated ones, and this attention has led to excessive exploitation of these resources. Too much extraction of groundwater has influenced Damenedaran aquifer's status greatly , and the changes of the groundwater level in the central areas of Buin Aquifer due to the increased agricultural activities and the excessive drilling of wells for access to more water are increasing (Graph 4).

Table 1: The average of underground water depth (2002- 2012).

Precipitation(mm)	The average of underground water depth (m)	Pizometers number	year	number
425/7	-27/74	56	2002	1
392/1	-25/68	57	2003	2
525/1	-24/58	57	2004	3
445/8	-24/24	57	2005	4
398/2	-22/54	57	2006	5
316/5	-22/87	57	2007	6
214/3	-25/81	56	2008	7
416/8	-27/48	56	2009	8
351/1	-30/22	53	2010	9
285/7	-31/02	54	2011	10
397/2	-31/48	53	2012	11

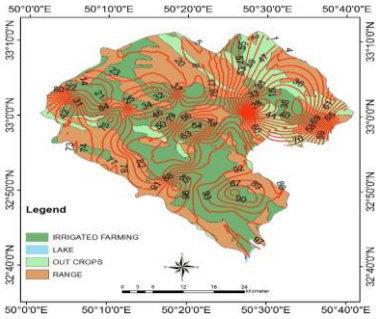

Fig. 4: Integration of land use map and drop map in buin basin .

Based on the information obtained in Billan, about 280 cubic meters of the groundwater (wells, springs and aqueducts) is depleted, and the depletion rate is 155.3 cubic meters in Buin aquifer, 11.8 cubic meters in Chehel Khaneh aquifer and 113.3 cubic meters in Damenedaran aquifer. Of the total rate of depletion, 258.1 millions of cubic meters is used up for agricultural purposes, 0.2 million of cubic meters for industrial purposes and 5.9 millions of cubic meters for drinking purposes. The water resources have greatly increased from 1381 to 1391 so that the number of the deep wells in Damenedaran aquifer which has had the highest decline of all the aquifers has increased from 612 wells in 1381 into 696 wells in 1391 and the number of the semi-deep wells has decreased. This is because most of the semi-deep wells in this aquifer have been changed into deep ones. The number of deep wells in Buin aquifer has also increased from 481 wells in 2002 into 558 wells in 2012, and the number of deep wells in the entire basin has increased from 1140 wells in 2002-2003 into 1304 wells in 2011-2012, indicating that uncontrolled and excessive exploitation and drilling of deep wells during this interval has occurred as a result of the recent droughts and consequently rare rainfall and the reduced surface water, and these are important factors that result in changes of the groundwater level and the decline in this basin's groundwater.

Natural Factors: Factors such as recent reduced rainfall and droughts have influenced the decline of the groundwater level of the basin's groundwater.

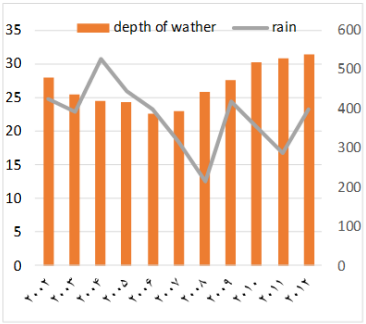

Diagram1: precipitation average and depth of water in buin basin.

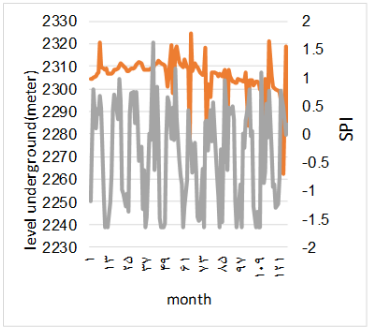

Diagram 2: estatictical level average and severity of drought(2002-2012).

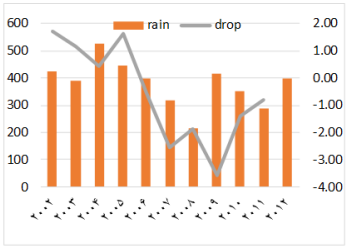

Fig. 3: Annual precipitation average and basin drop (2002-2012).

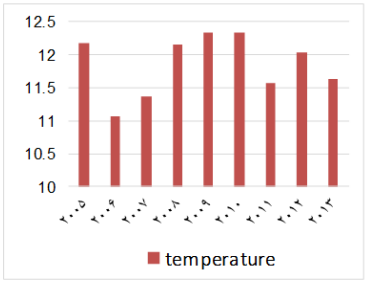

Fig. 4: average of basin Temperature(2005-2013).

The basin's average rainfall and temperature in 2008-2009 indicates the maximum temperature and the minimum rainfall in these years and the basin's drought severity shows the highest level of drought in these years. In terms of the groundwater level changes and the amount of decline, these years have had the maximum changes and decline. In terms of the process of the groundwater level changes during this 11-year period, this period can be divided into two periods: first, the period between 2002 and the late 2005 when the changes have been so mild and gradual that some kind of balance is observed. Therefore, less decline occurs during this period an important reason of which is wet years before this period, during which the groundwater level has returned to the primary state and has maintained its balance. However, from the beginning of 2006 till the end of 2012, the groundwater level changes have been greatly influenced by droughts so that the groundwater level has decreased as drought has intensified, so that the minimum of the groundwater level is equal to the maximum of drought severity. As drought has been so intense during summer months as well as the last month of spring, the groundwater level changes have increased the most during these months. The east of Buin Basin and the path to Buin river from the outer part of the basin to its center have been greatly influenced both in terms of the groundwater level changes and water depth and consequently the effects of seasonal and long-term droughts. Besides, the shortage of surface water resources during drought periods has resulted in an increased pressure on the groundwater resources.

The Role of Geological Factors and Slope and Height on the Groundwater Decline of Buin Basin:

Since Cretaceous formations in the watershed basin has a large space and the thick arbitolina limestones of the grey layer around the foot and the southern half of Daran have a considerable height and are completely folded and have many anticlines and synclines, these resources have a high value in terms of Karstic water

resources and have many springs. However, there are other deposits related to cretaceous formations consisting of marly formations and lime in the north and east of the foot extending from the western north to the eastern south. These deposits are unimportant in terms of groundwater supply and transmission and it seems that these geological formations lead to the shortage of groundwater and the groundwater level changes in Damanedaran Aquifer. On the other hand, these formations have occurred more in a large part of the basin which is composed of anhydrite, salt and lie. Alluviums of the Fourth Period are seen abundantly throughout the area and the largest part of Damanedaran and Miandasht Buin plains are composed of elements of limy, igneous materials, sands and clays which are related to this period and the groundwater tables often lie in these sediments (Graph 5).

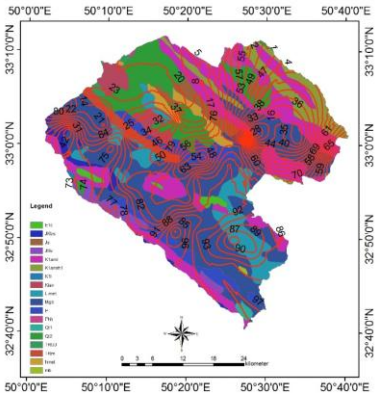

Fig. 5: Integration of water drop and basin geology.

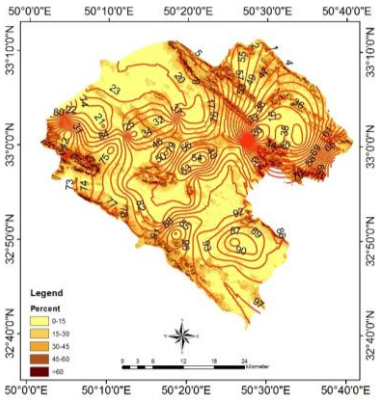

Fig. 6: Integration drop map and basin slope.

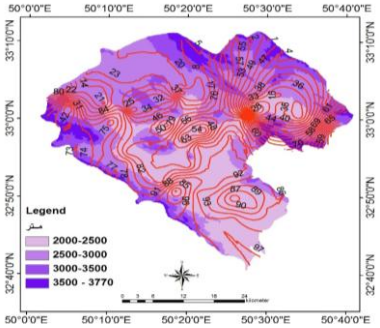

Fig. 7: Integration of drop map and elevation points.

It has been shown in graphs (6 & 7) that those spots with greater decline have a slope of 0-15 percent and are in line with the levels of the plain and that those spots which have higher slopes have a higher decline and thus it is the centers of plains which are faced with declines. In those areas where the decline lines have become close to one another, the severe changes of water level and consequently the water decline are found more.

Results:

Irrigated farming is so common in this watershed basin and farmers exploit the groundwater resource in Buin aquifer too much. This is why Buin river has faced considerable decline in recent years. In Damanedaran aquifer, besides farming and exploitation of groundwater resources, the direction of the slope is such that the groundwater resources have moved toward the center and have left the watershed basin. Therefore, drainage density reduction should also be considered a factor which leads to severe changes of the groundwater level and decline in groundwater in comparison with the other two aquifers. Chehel Khaneh aquifer has a better status than the other two aquifers in terms of groundwater level changes and groundwater decline. The integration of the decline map with geology, slope, land use and high altitudes made us conclude that the decline spots in the basin had a slope of 0-15 percent and included the basest spots (2000 meters) and cretaceous formations with salt, lime and anhydrite and the agricultural lands.

Population growth, an increase in the lands farmed by farmers and an increase in water needs in the basin especially for agricultural purposes have resulted in drilling a large number of deep and semi-deep wells and uncontrolled extraction of water from the water tables of this watershed basin. Therefore, disallowed drilling of wells and more importantly, the recent droughts in this watershed basin will lead to arid wells in this basin, especially in Damanedaran aquifer.

Suggestions:

a) Changing the farming method and using new ways of irrigation in order to stop the wasting of the water resources and to irrigate plants just much as needed,
b) Preparing the land use planning document by the related organizations,
c) Identifying and exploiting the karstic water resources,
d) Controlling the rate of exploitation of wells by installing smart counters, and
e) Developing plans to forbid exploitation of vulnerable aquifers.

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