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Investigation and Modeling for Buchir-Homeyran Plain, Hormozgan Province, Iran

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Abstract: Buchir-Homeyran plain, with a total area of 78.25 km^2, has a catchment area of about 378 km^2 and is located 360 km west of Bandar Abbas port on the Persian Gulf. This catchment is the extension of the Southern Zagross mountain range covering the western boundary between Iran and its neighboring countries, Turkey and Iraq. Out of the total 132 wells constructed in this plain, 99 wells are actively in operation where, about 10% of these wells are used for domestic purposes. and the rest for agriculture. Favorable climate and a long growing season along with productive soils in the region have created increasing desire for agricultural development and hence increased number of requests for water well drilling in the region. Present water supply from these wells is amounted to about a minimum of 1430 m^3/year and to a maximum of 530,000 m^3/year. Wells operate 186 days/year and have a depth of about 14 to 75 m. In order to respond to the increasing number of well permit requests, groundwater investigation of the Buchir-Homeyran aquifer was initiated using PMWIN 5 software. Calibration of the model was done under steady and unsteady state conditions using groundwater fluctuation data from 13 scattered observation wells recoded bimonthly from 2001 to 2008. Hydraulic conductivity, specific yield and recharge-discharge estimates were created throughout the region with PEST automatic calibrator, local experience and site investigation. Verification of the model made it possible to define a number of groundwater discharge and recharge management scenarios for the region and investigate the impact of the accomplishment of these scenarios. It was determined based on the findings from this model that in order to keep the water budget balance for this aquifer, current groundwater withdrawal and discharge must be decreased by 20%.

Key words: Groundwater · PMWIN · Buchir-Homeyran · Hormozgan

INTRODUCTION

In Iran groundwater plays an important historical role as a source of water for agricultural and domestic use. Population growth and industrial development have increased the demand for water and at present freshwater resources of the country are under serious threat of shortage [1].

Total renewable water of Iran is about 413 BCM (billion cubic meters). Almost 117 BCM is renewed through rainfall where, out of which some 25 BCM infiltrates into soil and 92 BCM joins surface water. Total surface water, including incoming water from bordering countries which is about 13 BCM, is amounted to about 105 BCM. About 41 BCM of the surface water is used and the rest enters to the sea, internal water bodies, or leave to neighboring countries. About 18 BCM of the surface water percolate downwards to groundwater. Total groundwater recharge is thus about 56 BCM. Total groundwater abstraction on the other hand is about 61.5 BCM causing a deficit of groundwater amount by 5.5 BCM [1]. This shortage has caused a rapid declining of groundwater table during recent years.

The rapid increasing number of water wells from 1965 to 1993 is shown in Figure 1a.

The chart in Figure 1a demonstrates that for the 11 years period from 1978 to 1989 and 4 years period from 1989 to 1993, the number of water wells which was permitted to be constructed was about equal (about 100.000 wells) [2]. It is important to note that although the number of constructed wells during the two periods was the same, the extra withdrawal volume of water for the first period was 16 BCM while for the second period was only 7 BCM, (Fig. 1b).

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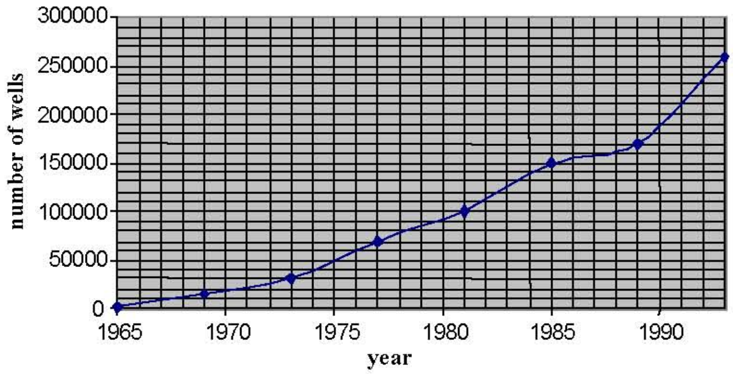

Fig. 1a: Water well development from 1965 to 1993

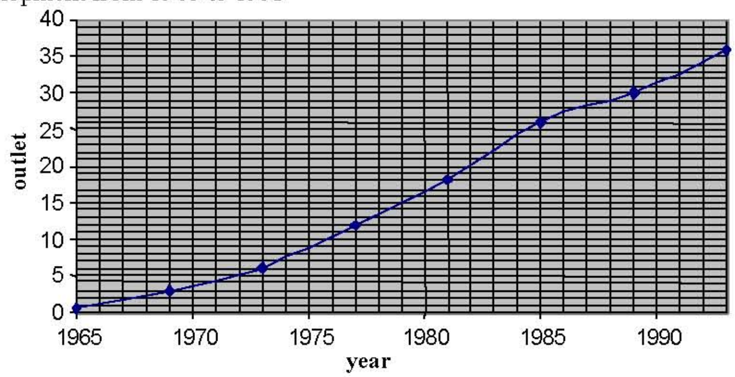

Fig. 1b: Groundwater well abstraction from 1965 to 1993

This decline in the withdrawal rate however, was due to ground water depletion which has been the concern of this study on the groundwater conditions in Hormozgan Province.

Investigation of groundwater conditions in a region for management purposes requires a knowledge about aquifer condition and the effect of water well withdrawal and groundwater recharge on groundwater conditions, at specified locations [3]. This knowledge can be acquired by gathering data from numerous well explorations, performing pumping tests and geophysical measurements for a long period. This approach is lengthy and very expensive. Therefore, mathematical models have been favored as a versatile tool and an indirect method for studying groundwater conditions. These models had been employed for investigating the groundwater conditions of Buchir-Homeyran sub-catchment in Hormozgan Province and suggested appropriate management strategies for the future by using Modflow (PMWIN) package [4, 5].

Study Area: The Buchir-Homeyran sub-catchment is an extension of Southern Zagros Mountain ranges with an area of about 378 km^2 located 360 km west of Bandar Abbas Port on the coastal line connecting

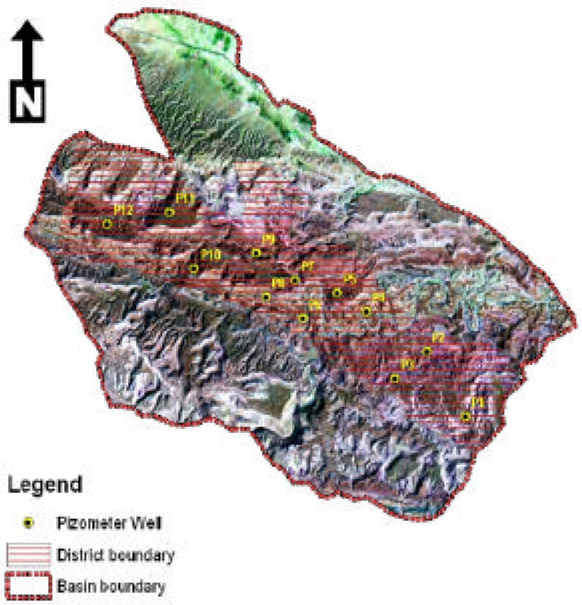

Fig. 2: Buchir-Homeyran catchment with district and basin boundaries

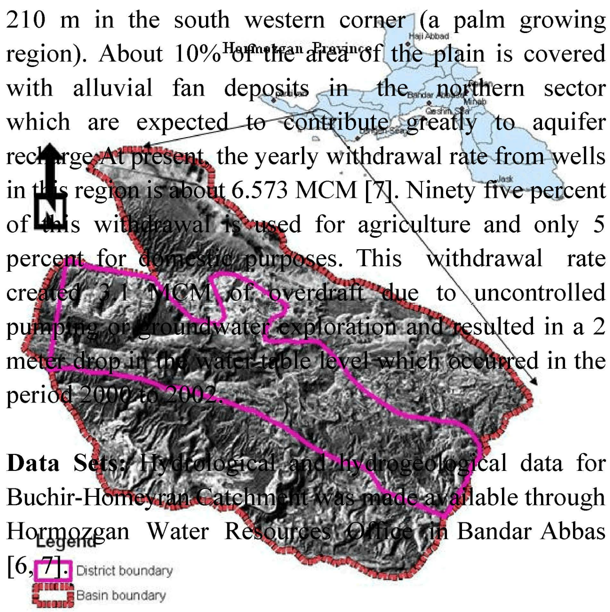

Fig. 3: Catchment area showing basin boundary and the location of pumping wells

Lengge Port to Bushehre Port [6]. Geographically, it lies between eastern longitudes 53° 28' and 53° 49' E and northerly latitudes 26° 57' and 27° 10' N (Fig. 2).

Depth of bedrock was estimated to vary between 70 and 125 meters. Maximum elevation in the catchment is 1470 m in the north western direction and minimum 210 m in the south western corner (a palm growing region). About 10% of the area of the plain is covered with alluvial fan deposits in the northern sector which are expected to contribute greatly to aquifer recharge. At present, the yearly withdrawal rate from wells in this region is about 6.573 MCM [7]. Ninety five percent of this withdrawal is used for agriculture and only 5 percent for domestic purposes. This withdrawal rate created 3.1 MCM of overdraft due to uncontrolled pumping or groundwater exploration and resulted in a 2 meter drop in the water table level which occurred in the period 2000 to 2002.

Data Sets: Hydrological and hydrogeological data for Buchir-Homeyran Catchment was made available through Hormozgan Water Resources Office in Bandar Abbas [6, 7].

Geology: This catchment is located on the Southern Persian Mountain Range. Geological and lithological details can be seen on geological map in Reference. Alluvial fan deposits constitute about 10% of the plain area. These alluvial fans are mainly seen on the northern slopes of Buchir Heights and partly on Aghol

Highlands [6].

Hydrogeology: According to previous studies based on water table maps, wells and exploration data, the aquifer is unconfined. Geophysical cross sections also do not show extended clay pan layers which can create a confined aquifer [6].

Aquifer Thickness: Aquifer thickness varied from 15-40 m. Medium thickness of aquifer is seen around Ahmad Abad Village in the eastern part and around Morady Palm Garden on the west which has a thickness of about 40-65 m. Greatest aquifer thickness that is reaching to about 110 meters is seen in the middle of the plain [6].

Bedrock: Bedrock consists of limestone deposits and has a depth on average of about 70 meters, with a maximum of about 125 meters around the palm garden in the Plain center [6].

Hydrodynamic Coefficients: There was no available record of pumping test data. Therefore, transmissivity was estimated using hydraulic conductivity measurements on well borings of geologic sections and saturated thickness of the aquifer from geophysical measurements. Maximum transmissivity is recorded for the north and was about 3500 m^2/d and the lowest transmissivity was about 100 m^2/d and was around well No-8 and 12 towards the south west [7].

Groundwater Abstraction from Wells: According to data collected for the year 2003, out of 132 existing wells only 99 were in use. Ninety wells were being used for agriculture and 9 for domestic purposes. Maximum withdrawal rate was 53000 m^3/year at Buchir site and minimum rate was 1430 m3/year for Dastkhair well. Production from wells operates on the average of about 186 days per year. Depth of the wells varied between 14 and 75 meters. The total water withdrawal for the year 2003 was 4,82,1382 MCM. Table 1 shows the detailed information about wells production.

Computer Model: The groundwater modeling package PMWIN (Chiang and Kinzelbach, 1998) was used in this study. This model uses a finite difference calculation scheme to solve the following equation:

$$\frac{\partial}{\partial X}(K_X \frac{\partial h}{\partial_X}) + \frac{\partial}{\partial_y}(K_y \frac{\partial h}{\partial y}) + \frac{\partial}{\partial_z}(K_z \frac{\partial h}{\partial z}) = S_s \frac{\partial h}{\partial t} - I$$

Table 1: Number of abstraction wells and total withdrawal rate MCM/year

		Groundwater withdrawal									
		For Agricultural use			For Domestic use out of catchment area			For Domestic in B-H catchment area			
Year	Season	Seasonal	Total	No of wells	Seasonal	Total	No of wells	Seasonal	Total	No of wells	Total
2000	Autumn	0.6019	2.042	81	0.1166	0.47	5	0.0248	0.099	4	0.743
	Winter	1.4398			0.3495			0.0744			1.864
2001	Spring	1.3118	5.933	95	0.4120	1.68	6	0.0745	0.298	4	1.806
	Summer	0.7336			0.4120			0.0745			1.228
	Autumn	2.1641			0.4120			0.0745			2.659
	Winter	1.7323			0.4120			0.0745			2.218
2002	Spring	0.1458	4.669	105	0.5598	1.68	8	0.0745	0.244	4	2.088
	Summer	0.8119			0.5598			0.0745			1.446
	Autumn	2.4029			0.5598			0.0745			3.037

In which Kx, Ky and Kz are hydraulic conductivity in 3 principal directions, h is hydraulic head, Ss specific storage and t is time.

Model Assembly: The model assembly was carried out in steps by preparing the input variables where, they will be assigned to model grids.

Grid System: The aquifer was covered by a grid system consisting of 23 rows and 53 columns. Cell dimensions were 500 × 500, 250 × 500 and 250 × 250 meters.

Boundary Conditions: There is no flow and streamline from boundaries except from the southern boundary which is taken as constant head.

Model Parameters

Time: Since well observation data were given for each month, time intervals were taken to be 30 days and stress period was taken to be 6 months. There were 5 years of observation data therefore total number of stress periods was 10.

Initial Hydraulic Head: Water table level for March 2000 was taken to be the starting point for calculations.

Observation Well Data: There were 13 wells in the area were observed, out of which data of only 11 wells were reliable. Weekly and biweekly observation readings for these wells were amounted to about 1771 observation well records.

Calibration: The optimization criterion was based on minimizing the difference between observed and calculated water levels predicted by the computer model according to root mean square error defined by:

Equation 3

Where $h_{calc,i}$ are the calculated heads, $h_{obs,i}$ the observed heads and n the number of observations. Calibration of the model was performed in 3 steps.

Step 1: Steady state calibration for the estimation of aquifer hydraulic Conductivity.

Step 2: Unsteady State Calibration for estimation of Specific yield.

Step 3: Unsteady State Calibration for the estimation of well pumping abstractions.

For steps 1 and 2 three months well observation data for spring of 2001 and for step 3 well observation data from March 2001 to March 2005 were used.

Calibration Results: Hydraulic conductivity and specific yield maps created as a result of calibration with PEST are shown in Figure 4 and Table 2 gives values for the area close to observation wells.

Comparison between the calculated and the observed water levels for observation wells are shown in Figures. 5a, 5b. Figure 5a shows the correlation between measured and calculated water levels with their variances. Figure 5b shows the variation of the measured and calculated groundwater elevation head with time. Calculated and observed elevation heads are shown to be very close with a maximum difference of 0.025 m in observation of well No 5 and a minimum of 0.019 m in observation of well No 11. Root mean square error for observed and calculated water levels are given in Table 2 is 0.887.

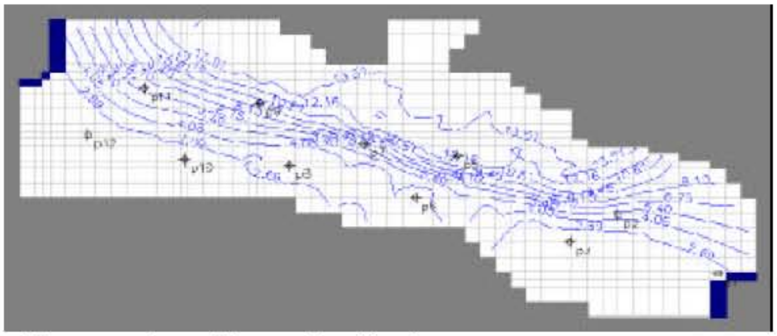

Fig. 4a: Hydraulic conductivity map estimated by model calibration

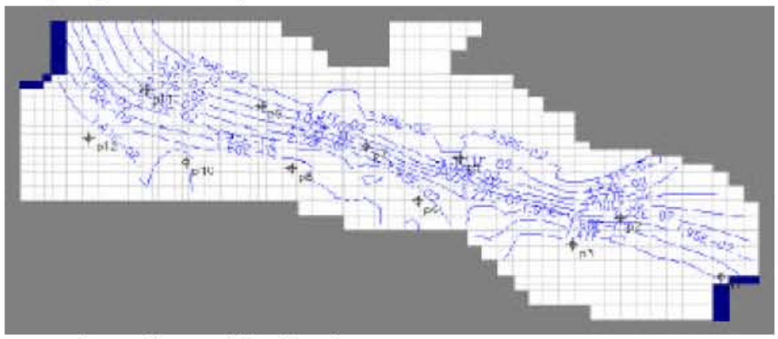

Fig. 4b: Specific storage map estimated by model calibration

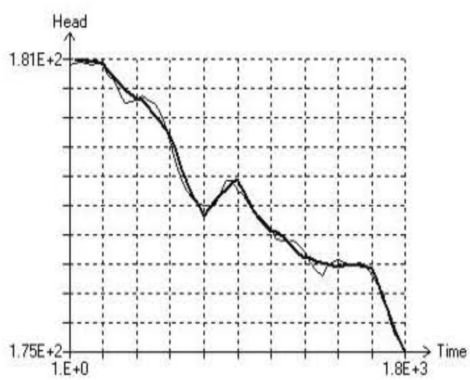

Fig. 5a: Correlation between measured and calculated water levels

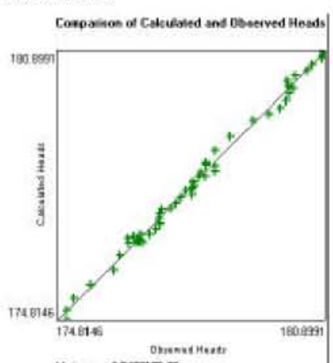

Fig. 5b: Variation of measured and calculated groundwater elevation head with time

Table 2: Hydraulic conductivity and specific yield results created by model calibration with pest at observation well locations

Obs. Well location	Hydraulic conductivity	Specific yield
P1	2.96	0.014
P2	5.20	0.019
P3	2.69	0.014
P5	12.60	0.033
P6	4.00	0.020
P7	6.75	0.022
P8	3.20	0.017
P9	9.45	00.03
P10	2.96	0.014
P11	2.75	0.025
P12	2.96	0.014

Using the Model for Groundwater Management: To lower the aquifer withdrawal rate and reestablish a steady state condition with safe yield, the calibrated model was used. Groundwater withdrawal was decreased in successive steps while other parameters remained unchanged. This study showed that a 35% reduction of pumping rates for a period of 5 years, would reestablish the desired steady state condition sought. Model results for these successive decreasing pumping rates after 1, 2 and 5 years are given in the Figures 6a, 6b and 6c.

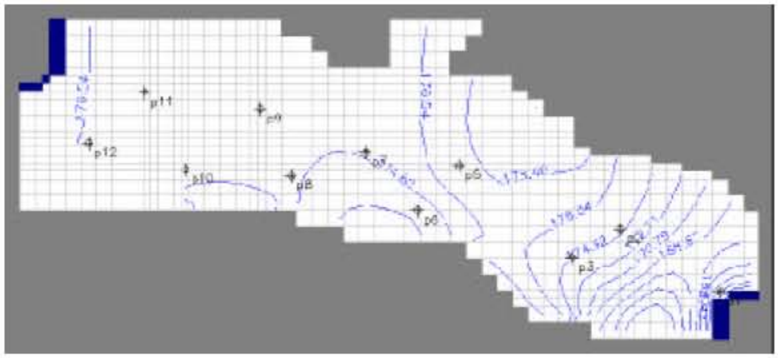

Fig. 6a: Groundwater level contours as a result of reduction of 35% withdrawal (After 1 year)

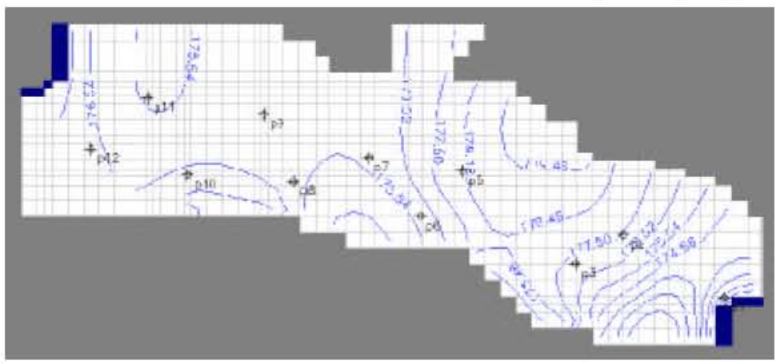

Fig. 6b: Groundwater level contours as a result of reduction of 35% withdrawal (After 2 year)

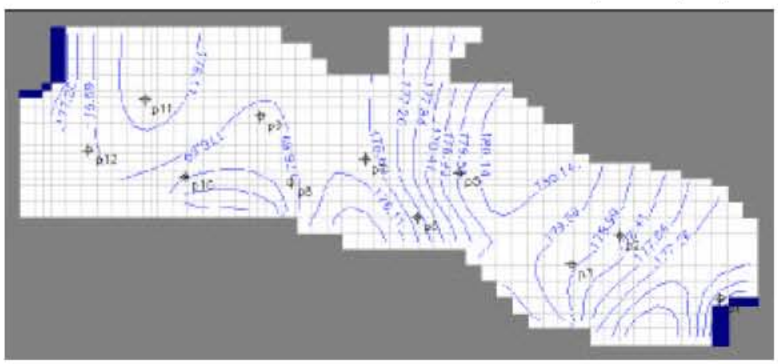

Fig. 6c: Groundwater level contours as a result of reduction of 35% withdrawal (After 5 year)

REFERENCES

1. Alizadeh, A., 2008. Principles of Hydrogeology, Ghods Razavi publishers, Mashad, Iran.
2. Kazemi, M., 2006. Groundwater modeling and environmental impacts of water well over pumping in Rafsenjan plain, M.Sc thesis, Shahid Bahonar University of Kerman, Iran.
3. Anderson, M.P. and W.W. Woesner, 1992. Applied Groundwater Modeling, Academic Press, San Diego, pp: 381.
4. Keresic, N., 1997. Quantitative Solutions in Hydrogeology and Groundwater Modeling, Academic Press, San Diego, pp: 381.
5. Mc Donald, M.G. and A.W. Harbaugh, 1998. Modflow A modular three - dimensional finite differences groundwater flow model. U.S. Geological Survey. Open File Report.
6. Hormozgan Regional Water Resources Office HRWR, 2003. Geophysical Investigation Report of Buchir-Homeyran plain, Bandar Abbas, Iran.
7. Hormozgan Regional Water Resources Office HRWR, 2005. Groundwater Investigation Report of Buchir-Homeyran plain, Bandar Abbas, Iran.