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The Contribution of Artificial Charging in Optimal Exploitation of Water Resources, Isfahan, Iran

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Abstract: *In many regions in Iran, groundwater is withdrawn in an exceeded manner. In more than 200 plainsfrom 620 plainsin this country, the level of groundwater is declining. Since 1972, artificial feeding projects have become a major concern with the objective of maintaining the balance of groundwater. As to the structure and construct, it can be claimed that the most common methods of artificial feeding structures the basin and earthworks applied. The water price per m³varies in various areas, whilein the West of Iran, where due to high precipitation water abundance is prevailing, thus, lower price compared to arid and semi-arid areas. According to this study, the average price of extracted water per m³ is about 500 Rls.*

The findings of this study indicate that, in many aquifers (about 200 aquifers) the groundwater withdrawal should be reduced. The artificial feeding projects should be implemented in areas that have been subject to study and are economically efficient. It is recommended to consider the issues related with hydrogeology and hydrology in these studies and to discharge the sediments periodically in order to enhance the efficiency of the projects. Since the aquifers are very deep in Iran,by considering the volume of pores, the feeding should be in a volume that it may increase the groundwater level.

Keywords: *Artificial Feeding, Water Resources, Optimal Utilization*

1. INTRODUCTION

Based on the average rate of precipitation in Iran, that is 250 mm, the annual rate of renewable water resources is 130 billion m^3. From the total annual water resources, surface flow and water infiltrated into groundwater constitute 105 (93 billion in land and 12 billion m^3 joint and entering water) and 25 billion m^3, respectively [1-4].

Groundwater in Iran is categorized in two:

1. Water resources formed by the direct infiltration of rainfall in plains and mountainous areas (25 billion m^3) and surface flows of rivers (13 billion m^3), a total of 38 billion m^3.
2. Consumed water returned to the groundwater.

Although the rate of water formed in this manner is variable, it is estimated that about 18.5 billion m^3 consumed water returns to groundwater resources. According to the groundwater balance sheet, the groundwater feedingrate is about 56.5 billion m^3 and the annual withdrawal is about 61.3 billion m^3, hence the rate of the overdraft is annually at least 4.8 billion m^3 [5-9]. The highest rate of overdraft is found in Barkhar and Najaf Abad plains in Isfahan province and Shahrekord plain in Chaharmahal-Bakhtiariprovince.

The assessment of the process of feeding and discharging of groundwater within the last 10 years indicates that, exceeded withdrawal leads to the infiltration of saline into groundwater resources and increase salinityin fresh water in various regions. The negative balance of groundwater is more evident in the provinces of Khorasan, Isfahan, Kerman, Semnan and Sistan-Balouchestan province. The groundwater discharge rate in different years is indicated in Fig. (1).

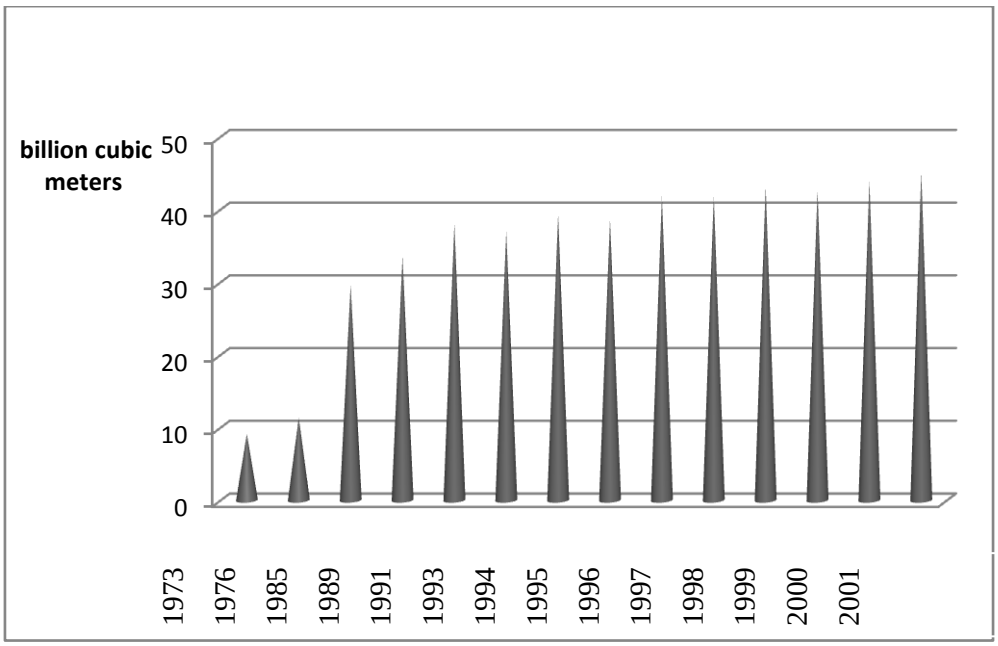

Fig1. *Groundwater discharge rate (wells) in different years*

Artificial feeding is a process through which the surface water is collected and conductedto underground aquifers with the objective of increasing the groundwater level. This process includes various methods like basin construction, flooding, feeding through natural canals and ditches and feeding through wells [10-14]. The study and implementation of artificial feeding in Iran date back to 1972. The objective of these projects is to reduce the groundwater level decline in the areas of overdraft. From 620 plains, water extraction from more than 200 plains isrestricted or is consideredas critical. The essential factors to be assessed in artificial feeding studies include: the water resource to be fed, the underground aquifer, appropriate location and method of feeding, development and implementation of a plan and economic issues [15-23].

2. METHODOLOGY

In this study, the data consist of the descriptions about 144 projects in the provinces of Isfahan and Chaharmahal-BakhtiariIn the exploitation of these projects, public participation is noteworthy, which may lead to the efficiency of the projects and higher lifespan of exploitation.

3. DATA COLLECTION

In this study, the data consist of the descriptions about 144 projects in the provinces of Isfahan and Chaharmahal-Bakhtiari, (Table 1, attachment). The descriptionsare categorized as: project title, executive entity, objective, technical descriptions and project credits.

Table1.*Descriptions of artificial feeding projects in Isfahan and Chaharmahal-BakhtiariProvinces*

Row	Project title	Executive entity	Location	
			Province	City
1	Implementation of artificial feeding in Neyestanak	Isfahan Regional Water	Isfahan	Naien
2	Implementation of artificial feeding in Zafarghand	Isfahan Regional Water	Isfahan	Ardestan
3	Implementation of artificial feeding in Qasreh Cham	Isfahan Regional Water	Isfahan	Shahreza
4	Implementation of artificial feeding in Sefid Dasht	Isfahan Regional Water	Chaharmahal-Bakhtiari	Boroujen
5	Implementation of artificial feeding in Bayazeh	Isfahan Regional Water	Isfahan	Naien
6	Implementation of artificial feeding in Ahmad Abad	Isfahan Regional Water	Isfahan	Shahreza
7	Implementation of artificial feeding in Cheshmeh Shahi (Kord Owlia)	Isfahan Regional Water	Isfahan	Tiran va Karvan
8	Implementation of artificial feeding in Shour Roudkhaneh	Isfahan Regional Water	Isfahan	Shahreza
9	Implementation of artificial feeding in Khour va Biabanak	Isfahan Regional Water	Isfahan	Naien
10	Implementation of artificial feeding in Tumanak	Isfahan Regional Water	Chaharmahal-Bakhtiari	Shahrekord
11	Implementation of artificial feeding in Siah Kouh	Isfahan Regional Water	Chaharmahal-Bakhtiari	Naien
12	Implementation of artificial feeding in city of Natanz	Isfahan Regional Water	Natanz	Natanz

Table 1 (Continue)- Technical descriptions

Row	Diversion channel	Transfer canal	Sediment basin	Feeding basin	Controldam
1	With	500 m length	With	2	
2	120 m length and 1.5 m height	Terrestrial with 700 m length	Volume of 400000 m^3	5 of 10 × 60 m	
3	With crescent-shaped earth works		With	4	
4		7 km length	6		
5	With		With	2	
6		Terrestrial with 1 km length	With	2	
7		7 km length	-	2	300 m crest, 15 height and 500000 m^3 volume
8		-	-	2 of 300000 m^3 volume	
9		-	-	-	-
10		-	-	-	-
11		-	-	-	-
12		-	-	-	-

In some cases, distinguishing the projects belonging to one entity is not possible, since the entities are not distinguished. The assessments indicate that, 36 of the projects consist of earth works, 32 projects consist of feeding basin and 10 consist of wells [24-32].

4. Opinions and Recommendationsfrom Executive Entities

The executive entities are required to give opinions and recommendations regarding artificial feeding projects. According to the information collected from 8 entities, there exists no scientific assessment on the effects of implementing such projects. The observations indicate that the effects of these projects are positive. Moreover, the annual sedimentation reduces the infiltration and the efficiency of the projects. The most effective project is drilling of wells.

The recommendations included the allocation of credits for the purpose of maintenance, evaluation and descaling and defining the comprehensive system of exploitation and maintenance of these projects [33-37].

5. Findings: Final Price Assessment

In order to assess the final price, 50 projects with complete information are selected. Through the descriptions related to the credits, feeding volume, annual cost of exploitation, lifespan and interest rate of each project the final rate is calculated. The lifespan of the projects is considered 20 years and the interest rate is 15 %. The annual cost of exploitation is equal and 2% of the initial costs of the projects. The average of final price was 567 Rls in 2004, that is, a considerable amount. The final price in the western areas is lower compared to that of central arid areas due to abundant rainfall, accessible water and application of less expensive methods. The distribution of final price of various projects is presented in Fig. (2).

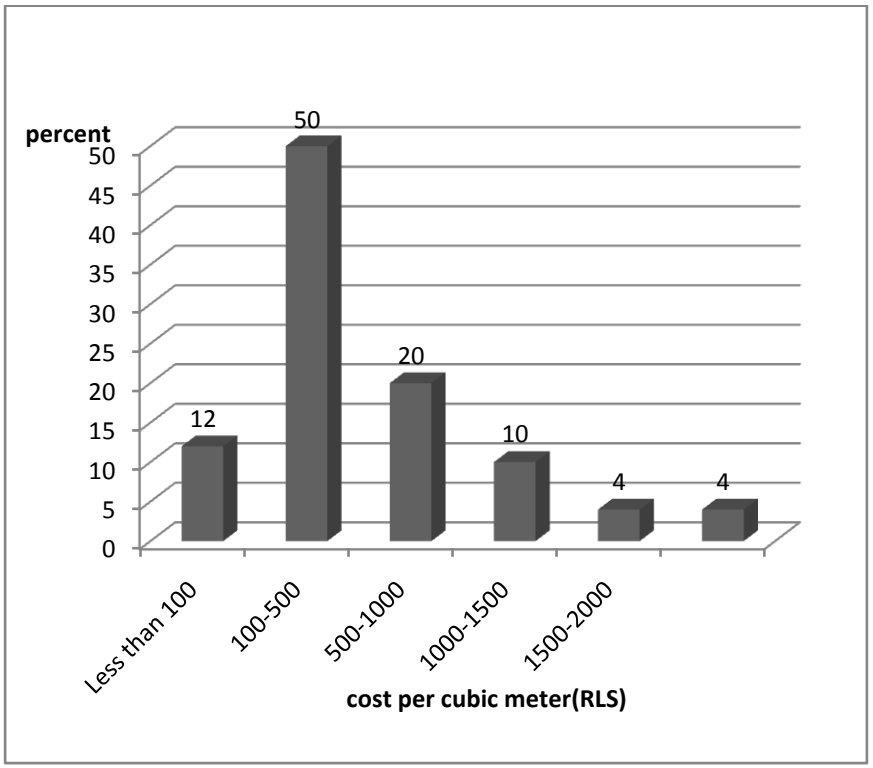

Fig2.*The distribution of final price of various projects*

6. Result and Recommendations

The following recommendations and suggestions if implemented would justify such studies:

1. According to feeding and discharging volume of groundwater it is indicated that, the overdraft is not compensable and the quintessential issue is tosustaingroundwater by preventing the overdraft. Hence, methods like prohibiting the exploitation of unauthorized wells, application of water and electricity intelligent counters and establishment and training of groundwater users'associations (GUA) may be effective.
2. The level of aquifers is low in Iran; hence direct water injection methods may boost the well efficiency, a method requiring high quality water. In some cases, the construction and exploitation of basins and other methods related to the surface may be easier and less expensive, although the

application of basin faces issues like increase in sedimentation and difficulty in conducting the water to the aquifers.

3. The sediments are factors that may lead to the deficiency of the projects. The dry season is the appropriate time for annual sediment dredging[38-39].
4. According to the findings obtained here, in the western provinces due to the abundance of surface water and application of less expensive methods the implementation is at lower cost and the final price is lower compared to other regions.
5. The depth of underground aquifers, injected water volume and amount of sediments are factors to be considered in the evaluation of these projects. In cases where the level of sediment is high in the injected water, the underground aquifer is very deep and the volume of injectedwater is very low, the project may not be successful [40-44]. Thus, the precise assessment of these parameters together with the parameters of hydraulic conductivity and porosity of soil are recommended in the studies of these projects.
6. In the exploitation of these projects, public participation is noteworthy, which may lead to the efficiency of the projects and higher lifespan of exploitation.
7. In order to facilitate the evaluation of the projects, it is recommended to include the descriptions of each project in the construction agreements separately [45-86].

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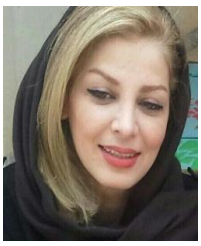

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