

Contamination of Groundwater Resource in Zahedan City Due to Rapid Development

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Abstract: Zahedan city, the capital of Sistan and Baluchestan province lies in an arid area in the eastern part of Iran. The scarcity of available water resources in the region along with occurrence of severe drought during the last four years and rapid population growth rate have tremendously increased pressure on groundwater resources. However, large increases in water demand due to high population growth and changing lifestyle with little recharge have strained Zahedan's groundwater resources. This phenomena resulting in serious declines in water levels and quality of groundwater in the major parts of Zahedan aquifer. Water demand in the city is estimated about 45 million liters day⁻¹ in summer. At present, the fresh water resource is limited to groundwater resource. Groundwater is provided from a small aquifer beneath the city that is called Zahedan aquifer with an area about 120 km² and average thickness of about 20 m. Groundwater pollution and problem in water supply appear to be some of the most important reasons inhibiting the sustainable economic development of the city. The quality of groundwater deteriorated sharply during the recent years. The main reasons responsible for the deterioration of the groundwater deal in this paper.

Key words: Groundwater, contamination, population, Zahedan

Introduction

The Middle East countries are characterized by scarce water resources and rapid population growth (El-Fadel *et al.*, 2001 and Haddad and Linder, 2001). Rapid growth and development in Iran as a Middle East country have led to mounting pressures on scarce resources especially in the arid parts of the country to satisfy water demand. Zahedan city the capital of Sistan and Baluchestan province as the most arid province in the country is located close to Pakistan boarder (Fig. 1). The city with a population of more than 600,000 inhabitants has the highest rate of population growth among the big cities of the country. Rapid population growth has changed the city population from 17497 in 1956 to 419518 in 1996 and more than some 600,000 inhabitants in 2003.

Population growth and development of cities over groundwater sources affected the quality of the groundwater under the cities. The effect of urbanization and urban wastewater effluent recharge on groundwater quality have been studied at several locations in the world (Agrawal *et al.* 1999; Foster, 2001 and Foppen, 2002)

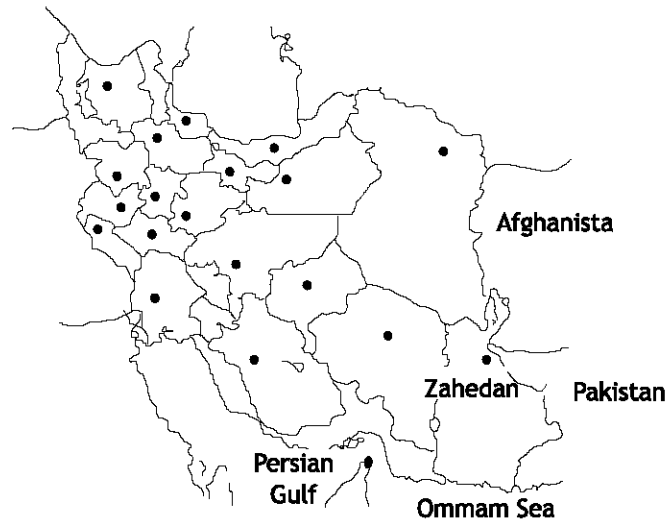


Fig. 1: Location of Zahedan city

The severe drought that hit the region during for the last four years (1998/1999 to 2002/2003), has aggravated the concern over present and future water supply. This parameter has caused stimulated interest in minimizing water shortage by developing non-conventional option including large scale water transport from outside the region either by a long pipeline or by desalination of brackish water. At present, the shortage of water sources and low quality and quantity of groundwater resources is known as the most important obstacle in the way of social and economical development in the Zahedan city.

Groundwater resource

Zahedan city is located in the north of Zahedan catchment and it is entirely depended on groundwater resources. The groundwater beneath the Zahedan city has been provided from a small aquifer with an area of about 120 km² with average thickness of saturated layer about 20 m. This aquifer is called Zahedan aquifer and it is located on the northern part of the catchment. The Zahedan catchment covers an area of 1675 km² and it is drained by Lar River in the north. The catchment is surrounded by a flysch formation in the eastern and northern parts that mainly consists of shale and sandstone and granite and granodiorite in the southern and western parts. The water level in the aquifer varies in different places. In the southern part, water can be found at 55 m below ground surface, whereas in the northern part it is about 10 m below ground surface.

The study area is characterized by an arid climate prone to droughts with extremely low rainfall (Average 84 mm year⁻¹) and with high evaporation rate (Lashkaripour, 2000). The evaporation rate has been reported in the range of 2800-3000 mm annum⁻¹ because of the dry climate with temperature exceeding 40°C in summer. The scanty rainfall is confined to the

winter season and rain usually occurs as thunderstorms and showers. The fresh groundwater in the region is recharged from infiltration of rainwater. Natural recharge rates of the aquifer in not know clearly. As noted by Lerner *et al.* (1990) and Custodio *et al.* (1998), one of the essential difficulty associated with the assessment of groundwater resources is the estimation of natural recharge.

The scarcity of rainfall and occurrence of severe drought during the last four years and rapid population growth rate have tremendously increased pressure on groundwater resources.

Discussions

The quality of drinking water has been increasingly questioned from a health point of view during the last decade. Common problem include exposure to toxic organic substances, heavy metals, bacteria, increased nitrogen concentration and acidity (Rosborg, *et al.*, 2003).

Zahedan aquifer has been progressively exploited since 1980 and little effort has been given in the past to utilizing water in an efficient manner; despite the critical role plays in society. The factors responsible for the deterioration of Zahedan groundwater are discussed in this part. In the city the traditional focus has been on estimation water quantity, not on assessing its quality. For this reason, the information on groundwater contamination is poor. It can be mentioned that important reason for groundwater deterioration in this city is the lake of adequate water management action.

Rapid growth in both population and water demand with little recharges that have strained Zahedan groundwater resources resulting in serious declines in water level. Moreover, the quality of the Zahedan groundwater resources deteriorated sharply in the recent years. For example, the quality of ground water has shown a downward movement from 1987 to 1996. The city network water that is being supplied from groundwater is undrinkable now. For example, during the period mentioned above, the average value of total dissolved solids (TDS) reached 3635 ppm from 2299 ppm and electrical conductivity (EC) reached 5370 $\mu\text{mhos cm}^{-1}$ from 3537 $\mu\text{mhos cm}^{-1}$. The main reasons responsible for the deterioration of the groundwater are the as follows:

- (a) Uncontrolled and unplanned development of the city in the western and southwestern parts, over that part of the aquifer that providing fresh water, has caused a reduction in natural recharge while at the same time creating new artificial sources of recharge. These factors caused the groundwater to be polluted in a restricted area which city's drinking water wells had been dug there.
- (b) The lack of city sewerage system in the city is one of the main factors that increase groundwater pollution. Because, liquid wastes in the city may enter to groundwater, either directly through deep absorption wells or indirectly by percolation. This type of groundwater pollution usually centers around cities and reported by many researchers (Foster, 2001 and Foppen, 2002)

- (c) Groundwater pumping has exceeded natural recharge in the western part of aquifer and groundwater level has declined from 1980. This factor causes movement of saline water from east and south eastern parts and interaction in the drinking water sources in the western parts. This process affected on the groundwater quality in these parts. The low quality and saline water of the eastern part is due to influence of flysch formation and contact of groundwater with evaporate deposits in this part of the aquifer.
- (d) The location of the city landfill in the eastern part of the city is one of the other factors for groundwater polluting. There is the probability of polluted water and dangerous contaminating water entering groundwater sources from waste deposit.
- (e) Rapid population growth and changing lifestyle in the recent years have increased water demand in city.

The mentioned parameters have caused that the city water pipelines system to become undrinkable gradually in the recent years. It is necessary to stop future deterioration and promote sustainable groundwater development. Therefore, it is necessary to prevent the city to be more developed especially in the western and southern parts. Many researchers reported about pollution of groundwater under cities due to social developing of these areas that caused additional recharge sources from domestic sewage systems (Lerner, 1996; Foster *et al.*, 1999 and Foster, 2001). However, increasing deterioration of this aquifer will cause the groundwater to become unusable even for agricultural purposes in the near future.

At present, about 1.6 million liters day⁻¹ drinking water is obtained from Zahedan groundwater sources and it does not meet the citizen's needs. Therefore, from 1998 40 water tankers have carried the drinking water from Ladiz village close to Taftan mountain about 80 km in the eastern part of the city.

As mentioned earlier, the water of the pipeline system in the city has become undrinkable since last decade. Consequently, the drinking water is available in 13 stations in various places in the city that is distributed by a separate network.

At present, a great federal project by the Ministry of Power is under construction for supplying drinking water. This project will transfer fresh water from Chah-Nemah reservoir to Zahedan city by a pipeline in the length of 193 km. Chah-Nemah reservoir is located in the northeast of Zahedan city close to Zabol city. This reservoir is fed by Hirmand river. Hirmand river originates in Hendokosh mountains in the east of Afghanistan. By completion of the project in the near future in year 2003, the majority of Zahedan Water's customers will begin receiving water of Hirmand river.

Conclusions

Zahedan city in the east of Iran has a great importance as a social and political center for Sistan and Baluchestan province. This city faces a serious water supply challenge driven by scarce water resources, rapid population growth and a climate prone to droughts. Groundwater is of major importance and unique source in providing municipal water supply and for private

domestic in this city. The available water source of Zahedan does not meet the ever-increasing demands of this city.

Large increases in water demand with little recharge have strained Zahedan groundwater resources resulting in serious declines in water levels and quality of groundwater in the major parts of the Zahedan aquifer. Moreover, the aquifer is not well protected and become salinized or contamination through human activities. Valuable part of aquifer has been destroyed by incorrect aquifer development and management. For example, uncontrolled and unplanned development of the city in the western and south western parts over fresh water resources of the aquifer has led real problem of over exploitation and groundwater pollution. Over the period of 20 years, concentrations of almost all major anions and cations increased, especially in the western and southwestern parts of the aquifer. Therefore, it is necessary to prevent the city to be more developed in these areas. However, it can be concluded that one of the main reasons for groundwater deterioration in this city is the lack of adequate water management action.

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