Electrical resistivity survey for predicting Samsor aquifer properties, southeast Iran

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Introduction

Samsor aquifer lies in arid area in Samsor plain about 180 km southwest of Zahedan city in Sistan and Baluchestan province, southeast Iran. This research deals with the assessment of the aquifer conditions and to obtain adequate knowledge of the groundwater resource to protect groundwater supplies as a unique source of water for the region. An electrical resistivity survey which involving vertical electrical soundings (VES) was carried out for evaluating hydrogeological conditions of subsurface sequences. The aquifer conditions such as depth, thickness, and aquifer boundaries investigated. Vertical electrical soundings by Schlumberger array were conducted in the study area. The resistivity Schlumberger soundings which have a maximum current electrode spacing (AB) ranging from 600 m to 800 m were carried out at 301 positions in 31 profiles. Interpretation of these soundings indicates the presence of an unconfined alluvial aquifer with noticeable extent. The average permeability coefficient and resistivity in the southern part, especially southeast is higher than the northern part of the aquifer. The high resistivity of southern part is due to the water quality and the existence of alluvial fan with coarse grain materials. Low aquifer resistivities in the north are associated with finer materials and brackish water. In addition, zones with high yield potential have been determined as best locations for drilling and groundwater exploitations based on the resistivity data.

Discussion

The Samsor aquifer with about 35 km length and about 15 km wide is located in the

Samsor plain that is south toward north extended plain. The samsor plain is characterized by an arid climate with extremely low rainfall (Average 110 mm/y) and with high evaporation rate (3300 mm/y). The scanty rainfall is confined to the winter season and rain usually occurs as thunderstorms and showers. The fresh groundwater in the region is originated from infiltration of rainwater, which has created unconfined Samsor aquifer in the study area.

The Samsor aquifer is the unique exploited aquifer in this region and it is an alluvial deposit aquifer. The aquifer is discharged artificially through a number of dug wells and the galleries that locally called qanat. The newly drilled wells in north and central parts of the aquifer are now used to supply water for agricultural purposes and drinking water.

The purpose of this paper is to use the resistivity data and interpreting geoelectrical soundings to study the aquifer conditions. The VES has proved very popular with groundwater studies due to simplicity of the technique. Water resources of the study area are threatened by increasing population trend with resultant increase in water demand and the stresses of water use for various activities. The need for this research is studying groundwater conditions and protecting groundwater resources.

From geological point of view, Samsor basin is situated in the Flysch zone of eastern Iran. The major portions of the Flysch zone consist of shale, sandstone and limestone. In the Flysch zone, sediments of older than Cretaceous age are absent (Tirrul et al. 1983, McCall, 1997).

Approximately the major part of the aquifer bedrock consists of shale, sandstone and slats mainly green of poor permeability, in the age of Upper Cretaceous and partly Eocene and also clay layer. Furthermore, igneous bedrocks were determined in some locations of the western part. The Quaternary deposits which cover the plain area were composed mainly of fine to medium grain alluvium of Samsor river, gravel to pebble of alluvial fan, sand to gravel and rock debris of the near mountains (Geological Survey of Iran, 1993).

The present study is based on data from the vertical electrical soundings that carried out during November to December 2003; lithological and hydrogeological information from 2 wells; chemical analyses of groundwater samples from the available 4 qanats and 2 wells. These data are used to evaluate the subsurface hydrogeological and structural conditions, to depth of about 250 m. In additions, estimation of the groundwater quality and recommendation for possible site-selections for drilling productive wells suggested. The aquifer Hydrogeological parameters are shown in Table 1.

Table 1 Hydrogeological parameters of the aquifer

No.	Parameters		Range
1	Aquifer bedrock depth (m)		50-255
2	Groundwater depth (m)		3-105
3	Aquifer resistivity (Ωm)	Brackish water	5-15
		Fresh water	20-40

Geoelectrical resistivity techniques are popular and successful geophysical exploration for study groundwater conditions in the world. The resistivity of material depends on many factors such as groundwater, salinity, saturation, aquifer lithology and porosity. For example, the resistivity of an aquifer is related to electrical conductivity (EC) of its water. When the groundwater EC is high, the resistivity of the aquifer could reach the same range a clayey medium and resistivity parameter is no more useful to determinate aquifer (Vouillamoz et al., 2002). In addition, limitation can be expected if ground inhomogeneties and anisotropy are presented (Matias, 2002). However, this method has been carried out successfully for exploration of groundwater. This technique is widely used to determine depth and nature of an alluvium, boundaries and location of an aquifer.

This research project deals with the detecting of the aquifer conditions and groundwater quality in the study area. The resistivity survey was completed with 301 vertical electrical soundings (VES) by the Schlumberger array in 31 profiles, with a maximum current electrode spacing (AB) ranging from 600 to 800 m. The Profile spacing was 2 kilometer and sounding spacing was about 1 km. Two of these VES have been conducted adjacent to the dug wells for subsequent calibration process.

A computer program for reducing geoelectrical sounding curves into values of thickness and resistivity of individual layers is described by Zohdy and Bisdorf (1989) was used. In addition, the field curves were interpreted by Russian software IPI7.63. However, thickness and characteristics of the aquifer are fairly well known due to the number of dug wells in the center and north of the aquifer. The key to success of any geophysical survey is the calibration of the geophysical data with hydrogeological and geological ground truth information.

VES success must rely on the careful interpretation and integration of the results with the other geologic and hydrogeologic data for the site. Therefore, litologic information obtained from log could be used to calibrate the VES field curves. Where test hole-log information was available, the solution to automatic interpretation procedure was constrained by keeping know layer thicknesses constant during the program com-

putations.

The boundary of the aquifer, thickness and resistivity of subsurface layers were determined by the electrical survey in this research. From the interpretation of the resistivity curves a four-layer resistivities and thicknesses indicated four subsurface layers. These layers consisting of surface layer (topsoil), alluvium, saturated layer, and bedrock. In some causes more than one layer was evident in the saturated zone but these causes were also treated in this analysis as single layers. Depth and thickness of subsurface layers were identified and dimension of the aquifer and type of bedrock were also indicated.

Average resistivity of thin top layer was calculated 220 Ohm-m. The higher resistivity in the southern part is due to existence alluvial fan that consists of a mixture of gravel, sand and silt. The lower resistivity in the northern part is due to brackish water and finer materials of sand and silt mixed with clay.

Based on the RT map the potential of the aquifer in the whole study area is determined. The best part for future development is southern part and central portion of the aquifer. In these parts, the water quality and quantity of groundwater sources are found with respect to higher aquifer thickness. Furthermore, the boundary of the aquifer and type of the bedrock were indicated based on the geoelectrical data.

Conclusions

This study reveals that surface electrical measurements are effective for study of groundwater condition. 301 VES's have been carried out for identifying the subsurface hydrogeological conditions Based on the interpretation of geoelectrical data, the following conclusions are drawn:

1. Samsor aquifer is an unconfined aquifer with noticeable extent of about 35 km length and about 15 km wide.

2. The alluvial aquifer mainly consists of gravel and sand in the southern and southeastern parts and sand and silt mixed with clay materials in the northern part. The resistivity of the aquifer increases towards the south due to decreasing salinity of water and/or clay content.

3. VES tests revealed four subsurface geoelectric layers; thin top layer, the alluvium, the aquifer and the bedrock respectively.

4. The aquifer thickness increases towards the south, the regional direction of increasing deposition in the basin. The maximum thickness of the saturated alluvial aquifer in the southeastern part has been estimated about 150 m.

5. The bedrock of the aquifer shows different resistivity values due to type of bedrock.

6. The boundary of the aquifer has been determined and zones with high yield potential estimated for future development in the aquifer and for choosing the drilling sites.

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