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Investigation of Groundwater Salinity Resources Using GIS (Case study: Gotvand-Aghili plain)

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Abdolrahim Hooshmand, Shadman Veysi, Mostafa Moradzadeh: Investigation of Groundwater Salinity Resources Using GIS (Case study: Gotvand-Aghili plain)

ABSTRACT

Geochemistry has contributed significantly to the understanding of groundwater systems over the last 50 years. A comprehensive hydrogeochemical study was carried out in the Gotvand -Aghili sedimentary rock aquifer system in Khuzestan province in the southwest of Iran. Groundwater samples were collected and analyzed at 15 sites. The objective of this study was to identify geochemical processes and geological events responsible for the variations in groundwater geochemistry that have been observed in a sedimentary rock aquifer system, including brackish to saline groundwater with GIS software. The results of chemical analysis based on geological processes interpreted ground water quality. The regional distribution of groundwater types shows that the hydrogeological conditions have deterioration of water quality in the east of plain. The Lahbari thrust fault is near the alluvial sediments caused to water quality decline in this part of plain. Also Combination diagrams and isomaps such as electrical conductivity, chloride, sulphate and calcium indicated destruction of water quality because of halide and gypsum solution in Gachsaran formation, and extra water consumption for agricultural purpose in the Gottvan Aghili plain.

Key word: Groundwater, Combination diagram, hydrochemical map, Gottvand Aghili plain, GIS

Introduction

Groundwater is one of the most important natural resources in the world. At present, a significant portion of Iran water consumption is supplied by groundwater sources.

In the last 20 years, the salination and quality reduction of groundwater has become one of the serious environmental problems around the world.

Over the past 50 years, advances in geochemical methods and approaches have aided our ability to interpret hydrochemical processes in groundwater systems, and improved understanding of how structural, geological, mineralogical, and hydrological features affect flow and chemistry in these systems. Significant advances have been made through laboratory experiments, and kinetic and thermodynamic data evaluation, providing essential reaction - process information.

There is considerable literature on the interpretation of geochemical processes in ground waters based on hydro chemical data and model simulations of hypothetical reactions [11].

Regional hydrogeochemical studies have been shown to be valuable to, among other applications, the management of regional aquifers [5], and understanding Groundwater evolution [6,7], tracing groundwater flow [10,2,12], and salinization of groundwater [13].

However, dry climate condition and lack of rainfall in the Gotvand-Aghili plain and also focus on agricultural activities, have increased groundwater extraction. On the other hand due to formation with improper lithology, there are high amount of salt concentrations in most parts of the plain.

Investigation of Combination diagrams, Hydrochemical map such as iso electrical conductivity, chloride, sulphate and other ions maps, can help to find out the parameters that affecte on groundwater quality variation.

Arc GIS was used to map, query, and analyze the data in these studies. Vinten and Dunn [14] studied the effects of land use on temporal changes in

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well water quality. Ducci [3] produced groundwater contamination risk and quality maps by using GIS in Italy. Fritch *et al.* [4] developed an approach to evaluate the susceptibility of groundwater in north-central Texas to contamination. Lee *et al*. [9] developed statistical models for groundwater quality using GIS. Lake *et al*. [8] described the creation of models of groundwater vulnerability using a GIS to combine spatial information on surface leaching, soil characteristics, low permeability superficial (drift) deposits and aquifer type.

In this study, has been used from above methods to identify the reasons of salination and quality reduction of Gotvand Aghili plain groundwater.

Discription of study area:

Gotvand-Aghili plain has area of 230 Km^2 approximately and located in 25 Km of northeast of city of Shooshtar, between 48° 41' to 49° east longitude and 49° 6' to 32° 16' north latitude in Khuzestan province in Iran. Figure 1 shows the location of the study area.

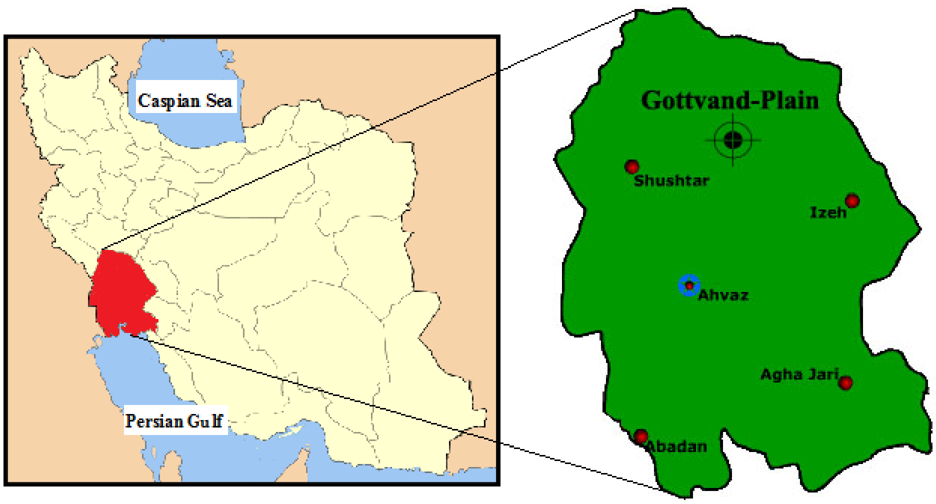

Fig. 1: Khuzestan province and location of Gottvand Aghili plain

The study area has been limited to Reshte Mountain from north, Bakhtiyari formation from west, Shoor River from south and Gachsaran formation from west.

The major geological structures in this area, are Reshte mountain anticline (with the north west to southeast direction) and Lahbari thrust fault. There are several folded fault formation in this area that including from past to present, Gachsaran, Mishan, Aghajari, Lahbari, Bakhtiyari conglomerate and sediments of present time respectively.

Lahbari thrust fault operation in east of the plain, causes the exposure of Gachsaran formation in near of alluvial sediments and this way causes undesirable effect on water quality in this area.

Due to hydrological studies, aquifer of Gotvand Aghili plain is unconfined and has been composed from gravel, sandy gravel, silty sand and silty clay sediments. Water table level plans investigation indicates underground water flows follows to surface topography and are directed from eastern to western and southern parts. Also these plans show that Bakhtiyari formation outcrops mostly in northern parts and Gachsaran formation outcrops in eastern parts of plain.

Material and Methods

In this study, first the alluvial aquifer quality characteristics in Gottvand-Aghili plain, the water chemical characteristics of 15 wells in this area in January 2009, have been gathered and analyzed. Then for investigating the origin of salinity and affecting processes on groundwater quality, hydrochemical diagrams such as combined diagrams and Piper diagram, were prepared using AqQa 2003. After that, iso electrical conductivity, chloride and sulphate maps were drawn using Arc GIS 9.2 software.

Discussion:

Hydrochemical diagrams:

For drawing the groundwater quality diagrams of Gotvand Aghili Plain, Piper chemical and Combination diagram were used. Often Piper diagrams are mainly used for determining the water type, hydrochemical facieses and geochemical evolution paths. Although determination of geochemical evolution paths using Piper diagram in aquifer, has not complete certainty, altogether Piper diagram has been used for geochemical evolution paths of underground water. Also hydrochemical facieses are used to explain the variation in water chemical composition.

Piper diagrams of groundwater samples, indicated sulphate and calcium ions are dominant in the aquifer (Figure 2). Generally considering to Piper diagram, one major and one minor geochemical evolution paths are definite. Figure 2 shows the groundwater geochemical evolution, containing hydrochemical facieses of sulphated calcic (magnesia) to sodium chloride(calcic).

Although in this evolution path, chloride relative concentration increases but sulphate relative concentration decreases approximately. Sulphate concentration reduction does not mean the reduction in absolute concentrations of sulphate, but this case indicates that increasing rate of chloride concentration is more than increasing rate of sulphate. Considering to geochemical aspects, groundwater evolution paths relates to dissolution of gypsum and halide evaporite minerals that cause to groundwater salinity of Gotvand Aghili plaine.

The source of these evaporate minerals and water salinity are Gachsaran formation and its gypsum and salty remain parts in alluvium. This case affects on groundwater quality extensively and increases the concentration of Total Dissolved Solids (TDS) and groundwater sulphate and chloride in south and southwest of the study area..

Increasing the amount of bicarbonate in some groundwater samples with less amount of EC and TDS, relates to local recharge of aquifer from Bakhtiyari formation.

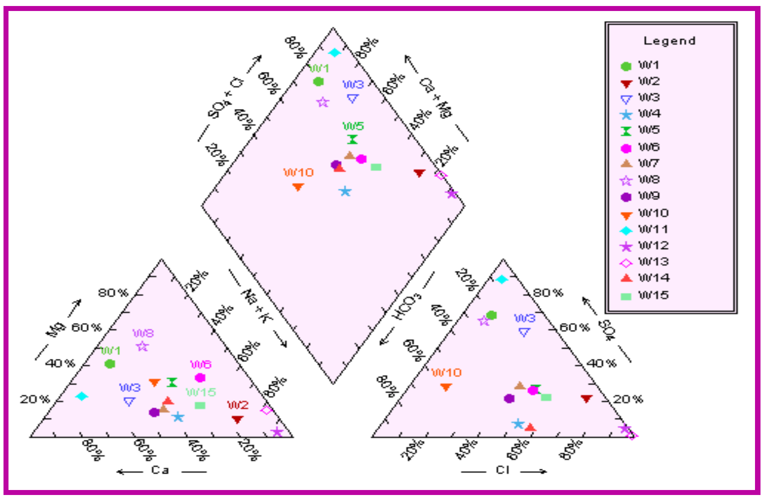

Fig. 2: Combination diagram of Gotvand Aghili plain

For understanding the geochemical processes that affect on groundwater salinity of Gotvand Aghili Plain, different combination diagrams have been prepared. Combination diagrams are important instruments for cognition of salinity source. Generally combination diagrams are used to determine the underground water sources.

Two-variable diagrams of Total Dissolved Ions (TDI) vs Calcium, Sodium, Chlorine and Sulphate are shown in figure 3. Due to these diagrams, Calcium and Sulphate concentration with TDI has a linear relationship that indicates gypsum dissolution in this aquifer. Also non-linear relationship between bicarbonate with Calcium and TDI, shows a non-carbonate source in Calcium supply. Correlation between Sodium and Clorine combination diagrams and also each of these ions with total dissolution ions, indicates halide dissolution in the plain.

Hydrochemical plans of groundwater samples of Gotvand Aghili plain:

For investigating the spatial distribution of hydrochemical data, iso EC, Cl and SO_4 maps were prepared using Arc GIS 9.2.

Due to iso EC map, the maximum amount of electrical conductivity is shown in south parts of study area. The amount of electrical conductivity varies from 732 to 4854 umho.cm^{-1} in north parts to south parts respectively.

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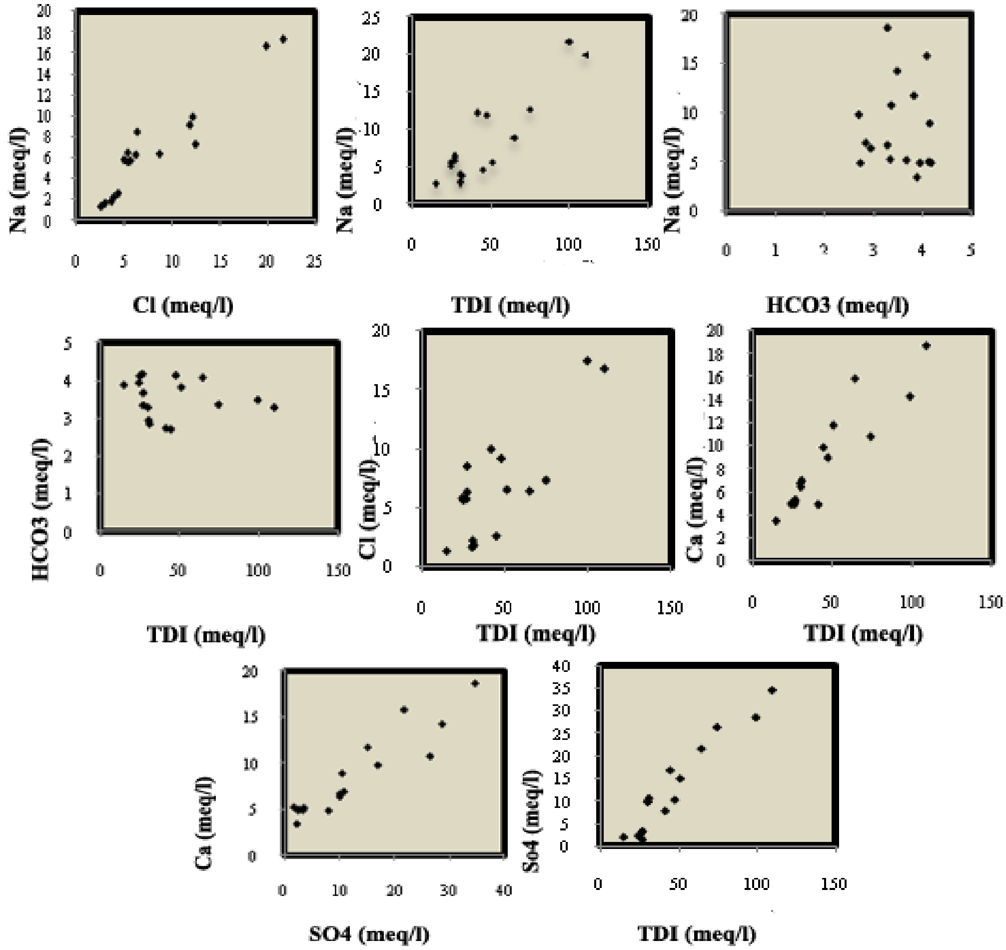

Fig. 3: Combination diagrams of groundwater samples of Gotvand Aghili plain

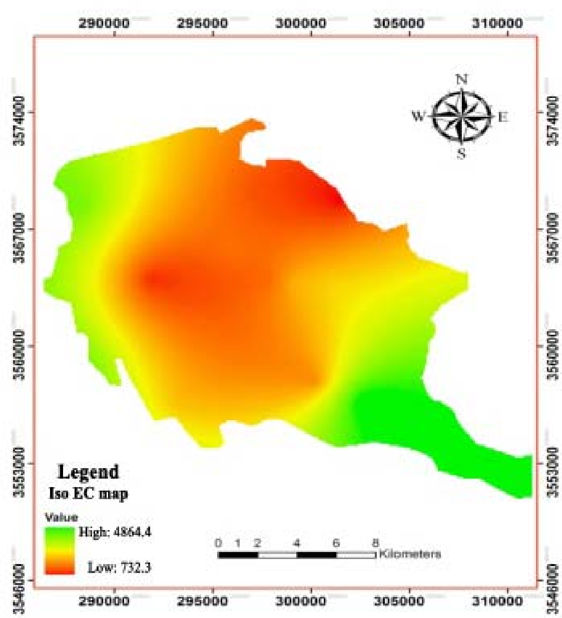

Fig. 4: Iso electrical conductivity map of the Gotvand Aghili plain

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Considering to Figures 5 and 6, calcium variation trend follows the spatial distribution of sulphate in alluvial aquifer. Therefore is concluded, the source of these ions is dissolution of gypsum. Figures 7 and 8 shows that the spatial distribution of Sodium and Chlorine have same trend. It seems that dissolution of salty minerals affect on these ions supply.

Also increasing trend of dissolution ions of groundwater is equal to electrical conductivity trend and follows the groundwater flow direction especially in direction of plain exited parts. The most important reasons of high concentration amount of ions in groundwater especially in direction of plain exited parts are: the high water table level in this parts in comparison with other parts, agricultural activities effect, salt remains with high concentration in this part in comparison with other parts and surface water flow in the southern parts of plain with high salt concentration that it is called Shoor river.

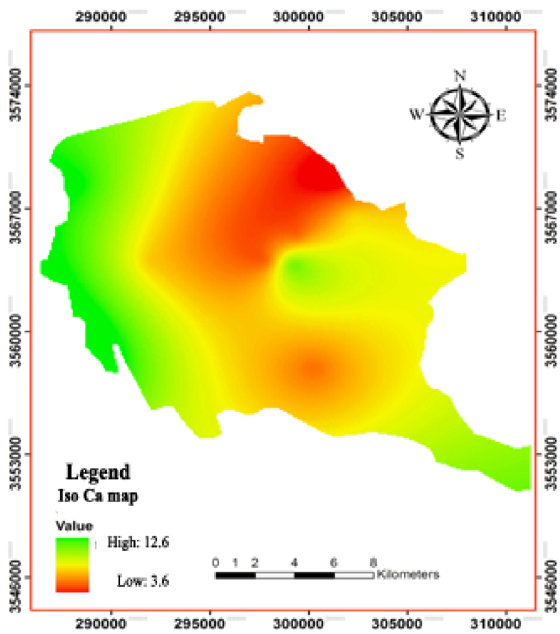

Fig. 5: Iso calcium map of the Gottvand plain

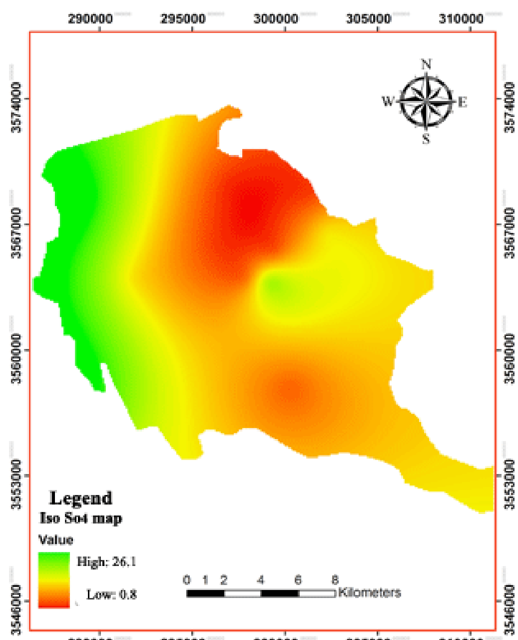

Fig. 6: Iso Sulphate map of the Gottvand plain

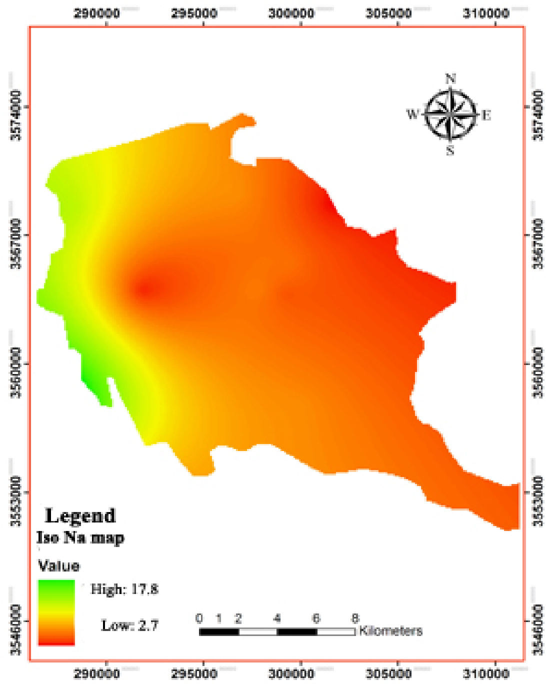

Fig. 7: Iso Sodium map of the Goottvand plain

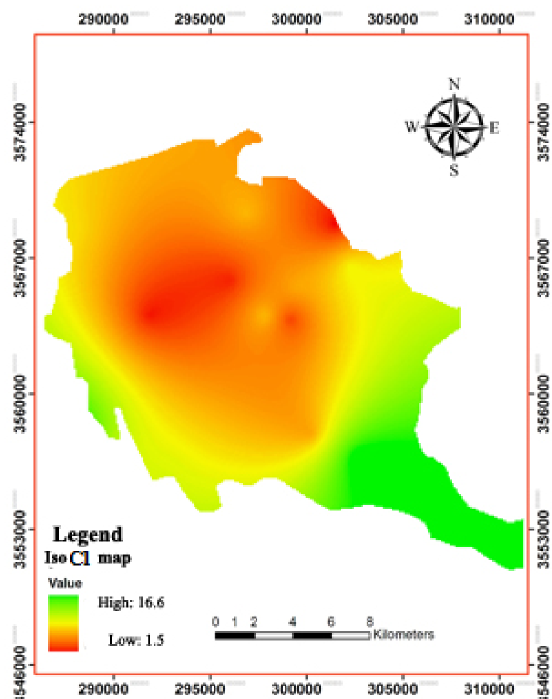

Fig. 8: Iso chlorine map of the Gottvand plain

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Conclusion:

Lahbari thrust fault operation in the plain east parts, causes Gachsaran formation is closed to alluvial sediments of Gotvand Aghili plain.The dominated groundwater type in study area are sulphated calcic and sodium chloride because of gypsum and salty evaporite minerals dissolution of Gachsaran evaporate formation respectively. Combination diagrams and iso electrical conductivity and different ions maps indicates the groundwater quality deterioration because of different processes such as dissolution of halide and gypsum in Gachsaran formation.

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