Investigation and Classification of Groundwater Salinity Potential in Jovein Plain Aquifer Using GIS

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Abstract

Jovein plain is located in the northeast of Iran between the longitudes 56°30′ to 58°30′ E. and the latitudes 36°15′ to 37°00′ N. One of the major problems in the study area is the increasing salinization of local groundwater. The high levels of salinity, limit the utilization of groundwater for both domestic and agriculture applications. Brackish and saline groundwater resources are important for the future development in many parts of the Jovein city and suburb where fresh groundwater and new surface water supplies are limited, nonexistent or cost prohibitive. This study has been developed to evaluate and classify the groundwater salinity potential in Jovein aquifer using ArcGIS "Spatial Analyst" based on last hydrochemical and hydrogeological data. Hydrochemical data shows that the quality of groundwater in the study area deteriorated after more than two decades of use for irrigation. The results of this study shows, high concentration of salts far exceeding the acceptable limit for various purposes. Spatial map illustrates about 50 % of extent of Jovein aquifer covered by brackish groundwater (1500 mg/l < TDS<700 mg/l), and about 50 % covered by fresh water which TDS is less than 1500 mg/l. Jovein aquifer is divided by eastern and western basin. In the other word, salinization increase from east to west. Several factors such as mineral composition of the aquifer material, geochemical processes, groundwater flow velocity, location of recharge and discharge areas, human action caused salinization in Jovein aquifer. In the eastern part decreasing surface and underground recharge lead to increase salinity. Furthermore evaporate formations such as gypsum and halite caused to intensify problem in the east. In the western part because of increasing lateral and surface recharge, quality of groundwater gradually increased.

Keywords: *Groundwater Salinity Potentials; Classification; Jovein Palin*

1. Introduction

Globally, there are increasing pressures on land, surface water and groundwater resources as a consequence of population pressures and climate change. These pressures help to drive continued land clearing, intensification and expansion of agriculture and rapid urban expansion that disturb the hydrogeological balance and can lead to salinization of land and water resources. With the population growth and irrigation agriculture development, the water resources demand has significantly increased and has led to the over exploitation and so salinization of groundwater. Salinity of groundwater is a useful indicator of the land area at risk from salinity. Acceptable levels of salinity (in terms of targets and trigger levels) for the top few meters of water tables or within a certain depth from the surface will differ depending on the depth of the water table, what the groundwater in an area is to be used for and the effect of groundwater on important assets.

In the Jovein plain, groundwater is the main controlling factor for economic, social and agriculture development. One of the major problems in this area is the increasing salinization

of local groundwater. The high levels of salinity in this area limit the utilization of groundwater for both domestic and agriculture and other applications.
In this joint collaborative study, a data assessment method that can be used for groundwater salinity evaluations is presented. The method evaluate and investigate the spatial relationships between the main salinity classes present in the study area and their typical locations (i.e. areas where the salinity classes are most frequently located) and the sources for salinization using hydrochemical and hydrogeological data in GIS system. This requires computer generated groundwater salinity data that can be readily integrated in GIS. Since obtaining groundwater samples in a fine regular grid is impossible, an accurate interpolation technique to define groundwater salinity at each node of a regular grid from spatially scattered observations is needed. Variations in groundwater salinity tend to be spatially correlated. The theory of regionalized variables makes use of the spatial interdependence in the limited data available to estimate the variable of interest at places where measurements have not been made due to cost of determination and/or initial degree of interest.

2. Geology and Hydrogeology setting

The study area (Jovein plain aquifer) is a part of Kavir Markazi basin in the north east of Iran. The area, as shown in Fig. 1 Located between the Longitudes 460000m to 630000m E and latitudes 4020000m to 4080000m N in the UTM coordinates system (zone 40N). The investigated area is approximately 4938 Km2. The climate is considered semi arid to arid where the average amount of precipitation is 231.4 mm/y for a period of 35 year, evaporation and average temperature is 2996 mm/year and 14.7oC respectively for a period of 15 years.
The geological formations outcropping in the area are mainly volcanic and ophiolitic with carbonate and evaporate rocks. The water bearing formations are mainly young terraces, old terraces, alluvium in major streams, clay flat and slightly gypsiferous. The direction of the regional flow over the whole basin is from the N and S Highlands towards the lowland in the middle part, so the flow moves from east to west. Hydrogeological conditions and geological structure in the study area affect groundwater velocity and Permeability of the aquifer system.

3. Methodology

The main objectives of this study are integrate all the available hydrochemical data and characterize the hydrochemistry of groundwater and determine reasons for the buildup of salinity in certain wells throughout the area using GIS system. For the purpose of this study a total of 39 abstraction wells were sampled and analyzed for chemistry. The data was analyzed and interpreted using ArcGIS method and Spatial Analyst extension to produce color coded maps. In this study, salinity is consider as salt content of groundwater which determined by Total Dissolved Salts (or Solids) and Electrical Conductivity. TDS is recorded in milligrams of dissolved solid in one liter of water (mg/L) and the standard EC unit is micro Siemens per centimeter (μS/cm) at 25^{o}C. Because the suitability of saline water for irrigation and other application is so dependent upon the conditions of use, including crop, climate, soil, irrigation method and management practices, water quality classifications are not advised for assessing water suitability for these purpose. So water salinity range is classified according to potential uses. Such a classification is given in Table I in terms of TDS and EC.

In this model we organize clip, intersection and reclassify processes that performed on four geodatabase feature classes (watershed, hydrochemicla, hydrogeological and geological data) Using ArcGIS 9.2 Spatial Analyst extension. At the first, watershed data recreated from physiographic data in the basin and converted to raster data. Second, hydrochemical groundwater samples were obtained from abstraction wells converted to feature classes. Then, an interpolation technique known as kriging was used to define groundwater salinity at each node of a regular grid from spatially scattered observations. Local estimates obtained by the kriging procedure are optimal in the sense that they are unbiased and have a minimum variance. Unlike most spatial interpolation techniques used in natural resource surveys, kriging quantifies the spatial dependency by a variogram and provides estimates of the estimation variance which indicate the reliability of the results. Next, interpolated data converted to raster data and a colored map creates and clipped based on watershed raster data. Finally the colored map reclassify based on typical range of salinity category for potential uses as shown in Fig. 2. Groundwater quality can vary significantly in the same aquifer for many reasons including mineral composition of the aquifer material, geochemical processes, groundwater flow velocity, residence time, long-term historical changes in recharge rates, location of recharge and discharge areas and human action such as irrigation, disposal of waste waters, seawater intrusion in response to excessive extraction from coastal aquifers, and the like. The salinity of groundwater in the Jovein Plain increased in several ways. One of the most important sources of salinity is mineral composition of the aquifer material in the area. Outcropping carbonate and evaporate formations in the recharge area (east and northeast) could contribute significantly to the salt accumulation in the aquifer system. The second and the most likely source of potential salinity increase are associated with local irrigation methods. Continued re-irrigation of the soil from the groundwater aquifer is causing a buildup in salinity. Constant irrigation from the groundwater of the same area continues to dissolve the accumulated salts from the soil. The salt is flushed and washed out repeatedly from the soil causing infiltration of the solute into the subsurface thereby increasing the salinity of groundwater. This practice has continued for more than two decades near the productive wells in the area. In addition, groundwater flow velocity, residence time, long-term historical changes in recharge rates, location of recharge and discharge areas are reason can increase salinity of groundwater in study area.

4. Conclusions

Groundwater salinity is a spatially correlated phenomenon and its spatial analysis can be facilitated using the regionalized variable theory. The kriging technique provides interpolated values of groundwater salinity that are optimal and in a fine regular grid which can be incorporated in GIS analysis. As shown in Fig 2. Jovein aquifer is divided by eastern and western area. Brackish groundwater are found mainly in the eastern part of the area (about 50%) due to a combination of false irrigation method, low surface and underground recharge and occurrence of evaporation formation. In the western areas groundwater are mainly fresh because the lateral and surface recharge was increased

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6. References

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7. Appendix

Table I- Typically range for Water salinity categories according to potential uses [11])

TDS (mg/l)	EC (µs/cm)	Water Description	potential use for water supply
< 500	< 700	Fresh	Suitable for all purposes
500 – 1000	700 – 1500	Fresh	Suitable for most purposes
1000-1500	1500-2000	Fresh	Suitable for most purposes - upper limit for drinking
1500-7000	2000-10000	Brackish	suitable for only limited irrigation and most livestock
7000-15000	10000-25000	Highly brackish	Some livestock (beef cattle, sheep)
15000-45000	25000-45000	Saline	Limited industrial use, ore processing
> 45000	> 45000	Hypersaline (brine)	ore processing, Brine production

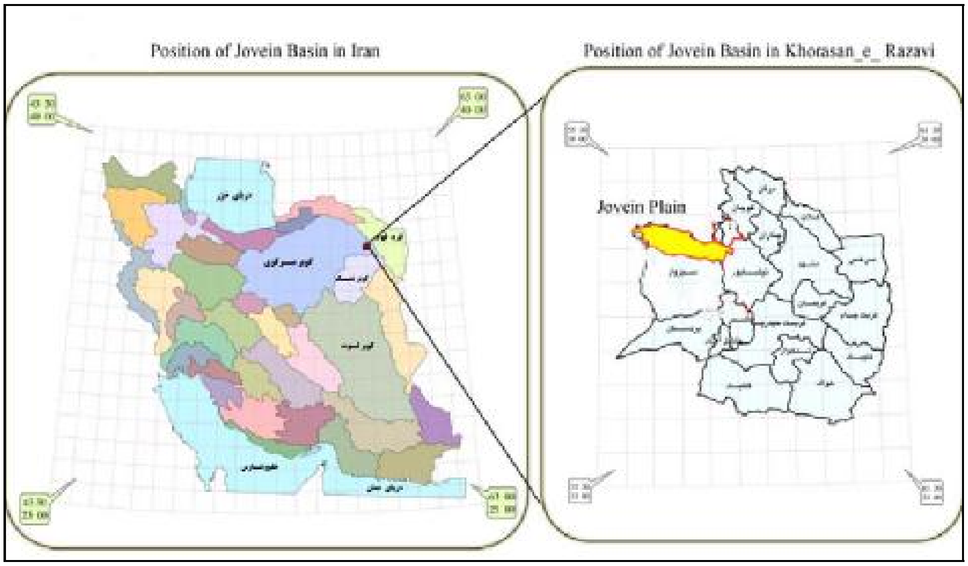

Fig. 1- Geographic Setting of the study area

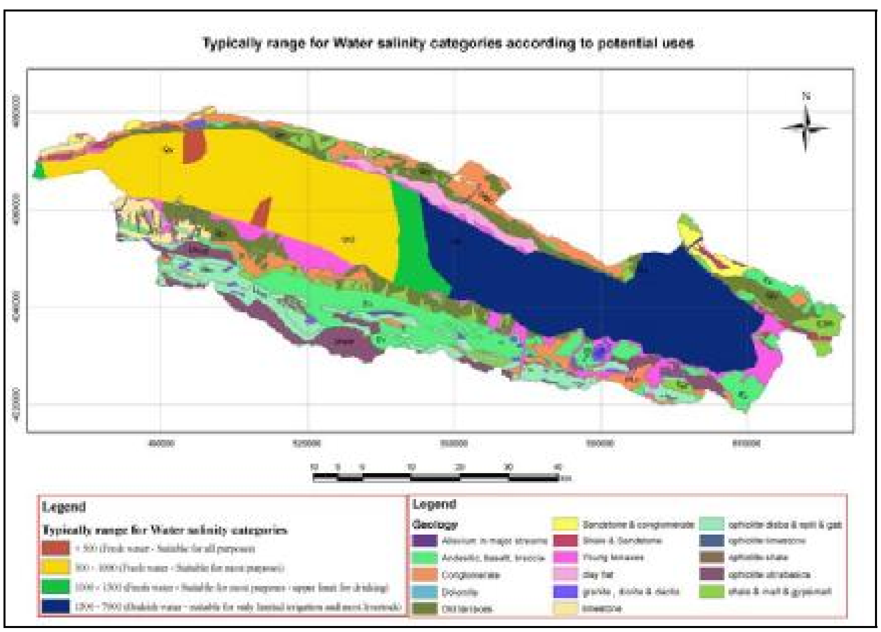

Fig. 2- Groundwater Salinity Map in Jovein Plain