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ORIGINAL ARTICLE

Qualitative Zoning of Groundwater Using GIS (Chemical Parameter of Electrical Conductivity and Total Dissolved Solids), a Case Study: Sabili Plain

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ABSTRACT

This is a study of a part of the wide plain of Dezful-Andimeshk, located in Khozestan Province, Iran, which covers 174 hectares in area. To study the qualitative characteristics of groundwater of this plain, qualitative data from 12 groundwater wells from the water year 1389-90 were used. One of the appropriate methods in hydro-chemical demands for processing and presentation of data of a wide area is to draw the equivalent maps of different parameters. The distribution of equivalent points in an area is of paramount importance in studying the isopotential maps. In this paper, parameter zoning maps of electrical conductivity (EC) and total dissolved solids (TDS) were developed to study the spatial distribution of groundwater constituents of Sabili Plain, using "ArcMap" software.
Keywords: *Sabili Plain, zoning, qualitative analysis, ArcGIS, TDS, EC*

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INTRODUCTION

The area under study, with 174 hectares in area and geographical coordinates of 32° 31' to 32° 46' northern latitude, 48° 40' to 48° 60' eastern longitude, is located in the north-northwest part of Khozestan Province, among the research area of Dezful-Andimeshk. This area is part of the Dez River catchment basin, restricted from north to the mountains, from east to Kohnak (Gelal) seasonal river, from south to Shirin-Ab anticline, and from west to the Dez River. Access to the area is mainly by Ahwaz-Dezful, Ahwaz-Shooshtar and Soosh-Shoostar Class A asphalt roads. Access to the majority of the villages in the area is also possible through Class B and Class C asphalt roads. Figure 1 shows the geographical location of the area.

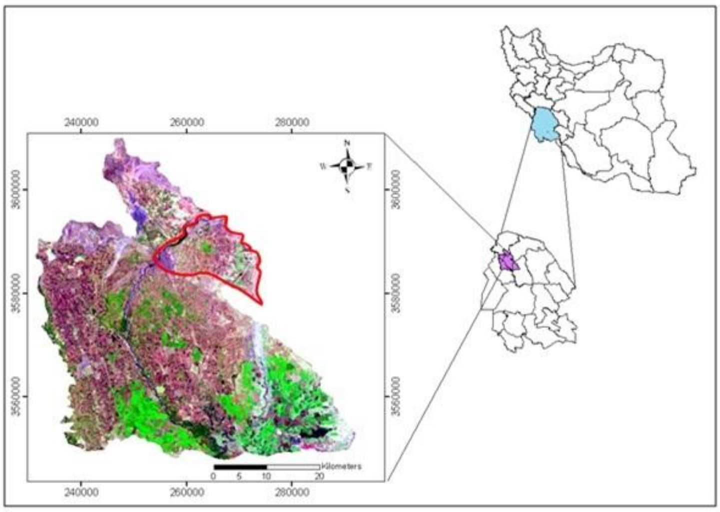


Figure 1. Geographical location of the research area (Sabili) in Dezful-Andimesh Plain

Studying the quality of the aquifer provides water administration and professionals of the field a clear picture of the qualitative changes and the pollution risk of the available water resources. The quality of groundwater in each and every area depends on the hydrogeological and hydraulic characteristics of the aquifer. Major pollutants of the groundwater, including civil, industrial, and agricultural pollutants, etc. can have a negative impact on the quality of water in aquifer (Todd, 2005). As water passes through different layers of the soil and formations existing in the way from upstream to downstream, getting away from the feeding area, and approaching the disposal area, the quality of groundwater will degrade [1].

METHODS

To study the spatial distribution and the process of chemical changes of the groundwater in the area, zoning maps of electrical conductivity and the total dissolved solids were drawn and analysed using the ArcGIS software and Geostatistical Analyst tool.

Electrical Conductivity (EC) spatial Distribution:
This chemical property determines the density of water-ion is able materials. Water that is chemically pure, has a low electrical conductivity, but water with lots of dissolved materials, has a high EC. For EC amounts less than 50,000 mhos/cm, one can use the following formula:

$$EC(\mu mhos/cm) = \frac{TDS(ppm)}{F}$$

Where F is the conversion coefficient for TDS to EC. For water with EC between 1000 to 5000 mhos/cm, this coefficient is 0.64. For waters with EC higher than 5000, this coefficient has been reported to be 0.8.

GEOLOGY OF THE AREA

Geological characteristics of Sabili Plain include lower Miocene deposits up to the contemporary era, which mainly consist of the contemporary alluvial residues and Bakhtiari conglomerates. Due to the presence of bakhtiari conglomerates in higher areas and demolition, erosion and conveyance of materials of this formation, Sabili Plain alluvium, in most parts, consists of coarse and pebble-like materials, which gradually change into granular materials in southern parts. Figure 2 depicts the geology of this area.

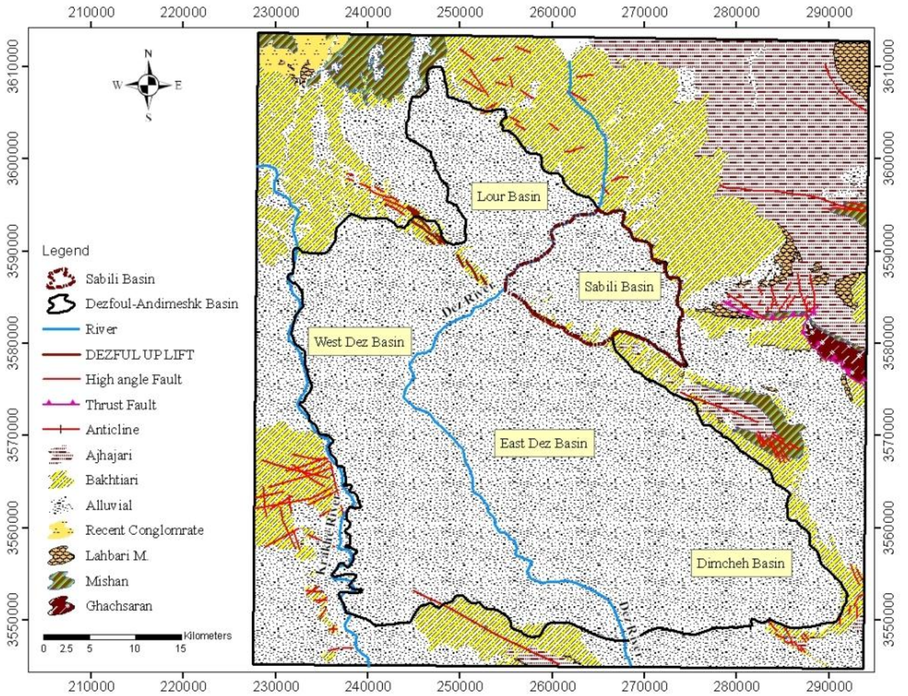


Figure 2. Geological map of the research area (Sabili) in Dezful-Andimesh Plain

RESULT AND DISCUSSION

Numerous researchers have studied groundwater resources, among them we could point to "The Causes of the Salinity of Shahrokht Plain Groundwater [1]", "Hydraulogical Evolution of Sierra Spring in the US [2]", and "A Study of Hydrogeological Characteristics of Zarneh Plain [3]"; Fiziva and colleagues [4] studied the water quality of Zarafshan river using the GIS system, and concluded that studies which need extensive analyses could be carried out utilising the GIS system. Padana and colleagues [5] studied groundwater quality of Afram Plain in Ghana on the basis of SAR- and EC- Fluoride using the GIS system, and concluded that the southwest part of the plain contained high amounts of SAR- and EC- Fuoride, while the northern part contained less amounts of Fluoride allowable for drinking, and water of the area is not suitable for drinking. To study the hydra geochemical properties of groundwater, results from chemical analysis of 13 groundwater samples of the water year 2010-2011 were employed. Table 1 shows the statistical result of chemical analysis of groundwater of the area. Figure 3 depicts the locations of sampling point in the area.

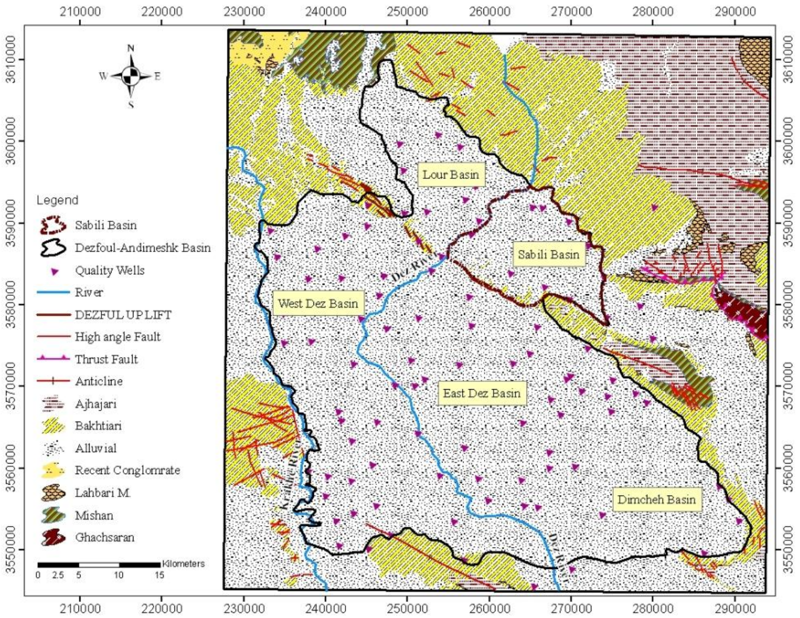
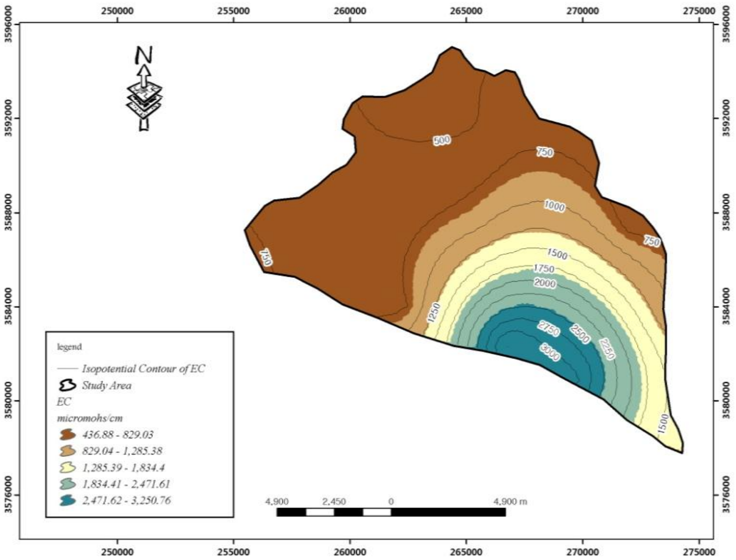


Figure 3. Location of selected points of quality in Dezful-Andimeshk Plain

Table 1. Calculated Amounts of Chloride and Acidity Density in Groundwater (2011)

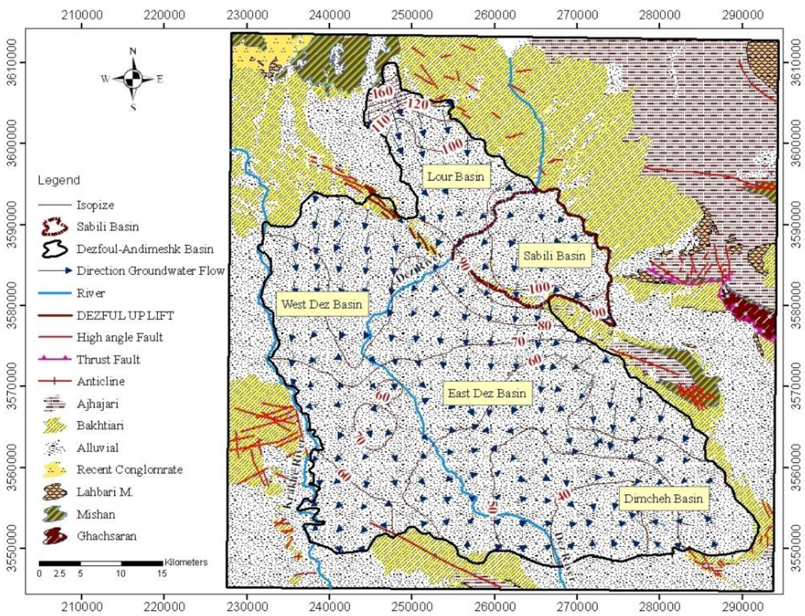
Label	UTMX	UTMY	EC	TDS
Q-01	257703	3588719	649	415
Q-02	258624	3590435	564	365
Q-03	262479	3583968	732	470
Q-04	265201	3592042	927	545
Q-05	265446	3587617	909	582
Q-06	266354	3591975	682	436
Q-07	266648	3582342	3278	2098
Q-08	269613	3580826	3108	1989
Q-09	269641	3590366	742	474
Q-10	271968	3587409	690	441
Q-11	273870	3583645	1000	639
Q-12	274198	3578611	1275	518
Q-13	278275	3580007	914	603
Minimum			564	365
Maximum			3278	2098
Mean			1190	736.5
Standard Deviation (SD)			908.7	585.7

To develop the zoning map of groundwater acidity of the research area, the calculations were first converted to grid format in Surfer software and then to Datformat. These point data were then recalled in ArcGIS, and using the Geostatistical Analyst toolbar, various methods of kriging were employed for interpolation and developing maps of spatial distribution of electrical conductivity, and finally, the final map of electrical conductivity zoning was developed based on the results, which is shown in Figure 4 below.



[Figure 4. Zoning of groundwater electrical conductivity spatial distribution]

In order to study the spatial distribution of electrical conductivity, it was necessary to also develop the map of the groundwater flow direction. To do this in Surfer, water level data from Piezometric wells in Dezful-Andimeshk plain area were employed. Figure 5 represents groundwater water level together with flow direction.

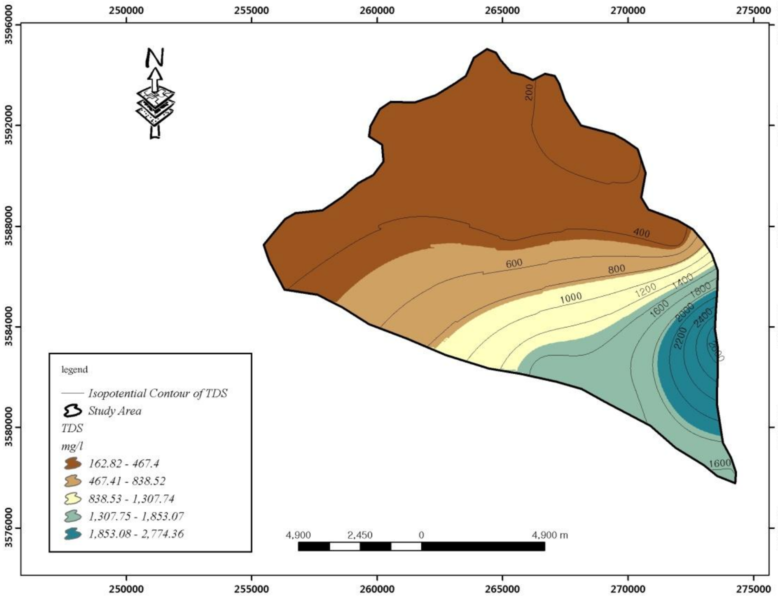


[Figure 5. Groundwater flow direction in Dezful-Andimeshk (Sabili) Plain]]

As shown in fig 4, it is conceived that electrical conductivity in the southern part of the plain is higher while in the northern and western parts is lower. With regard to the groundwater flow direction, we could attribute the low ECin northern and western parts of the plain to its being fed by low-EC water from the Bakhtiari conglomerate formation located in the eastern part of the area and also tothe lack of a strong hydraulic connection between the Dez River on the northwestern border of the plain and the groundwater of the area. While in the southeastern part, regarding the groundwater flow direction, Surbarik River acts as a groundwater feeder for the area, andby bringing water with a high-hydraulic conductivity causes a relative increment in the electrical conductivity of the groundwater. It should be mentioned that the increase in this parameter in the southeastern part of the area could be due to the granularity of the alluvial sediments of the plain and the high degree of silt and clay, which is observable from the logs of the observatory wells in the area. Also, the high degree of EC in the groundwater could be attributed to evaporative impurities which have a high degree of dissolvability.

Total Dissolved Solids (TDS):

In drinking water, TDS mainly includes inorganic salts, with a low amount of organic materials. Main ions affecting TDS include, carbonate, bicarbonate, chloride, sulphate, nitrate, sodium, potassium, calcium and magnesium.TDS parameter is defined to assess and measure all dissolved materials in the water.TDS could have an important effect on the taste of the drinking water. An increase in TDS may result in water not being tasty, and causing digestive diseases in human beings. To develop the zoning maps for TDS, the same procedure as described for EC was followed (Figure 6).



[[Figure 6. Zoning of TDS spatial distribution]]

As is evident from figure 6, groundwater TDS is to its maximum in the southeast part of the region, and decreases moving away to the eastern parts.

This could be attributed, as for the EC parameter, to the feeding of the groundwater from Bakhtiari conglomerate which has a better quality. Also, the good quality of the groundwater regarding TDS, according to observatory well logs of the area, could be due to the coarseness of alluvial sediments of the plain, and the low amount of clay, silt and evaporative sediments inter-layers. The high amount of TDS in the groundwater in the eastern part of the area, with regard to the area being near the Lahbari area, Aghajari and Lahbariformations include impurities such as marnes and chalk, with regard to the flow direction of the groundwater, the water coming from these formations reaches this part of the area, causes an increase in TDS and the quality of the groundwater.

CONCLUSION

With regard to the zoning maps presented for groundwater EC and TDS, principal reasons for the spatial distribution of these two factors could be enumerated as groundwater flow direction, hydrological connection of the groundwater with the Dez River andSurbarik River, geological formations, and alluvial materials forming the plain. The bakhtiari conglomerate formation in the eastern part of the region, could also be considered as an effective factor in the quality of groundwater, due to its being coarse and the lack of impurities such as marnes and chalk, while the conglomerate formation in the southern part plays no important role in the spatial distribution of these two factors, due to its cement-like nature.

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