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ORIGINAL ARTICLE

Qualitative Zoning of Groundwater Using GIS (Chemical Parameter of Acidity and Chloride), 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 studies for processing and presentation of data of a wide area, is to draw the equivalent maps of different parameters. In this paper, parameter zoning maps of groundwater acidity (PH) and chloride (Cl) were developed to study the spatial distribution of chemical formations of groundwater of Sabili Plain, using "ArcMap" software.
Keywords: *Sabili Plain, zoning, qualitative analysis, Chloride, acidity, ArcGIS*

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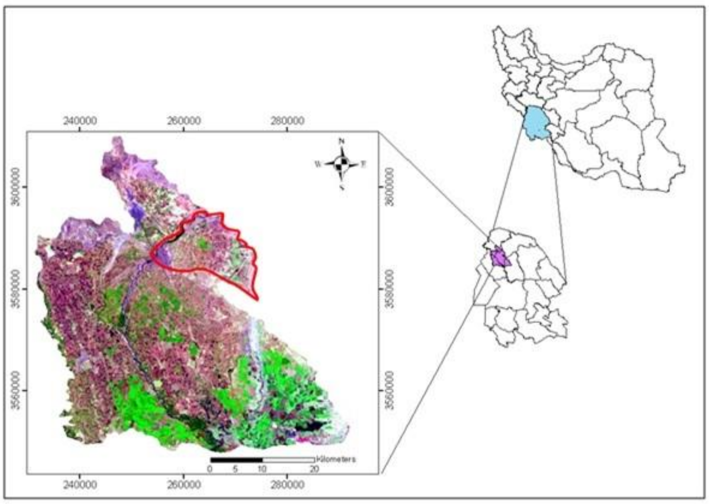
INTRODUCTION

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-Abanticline, and from west to the DezRiver. 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.

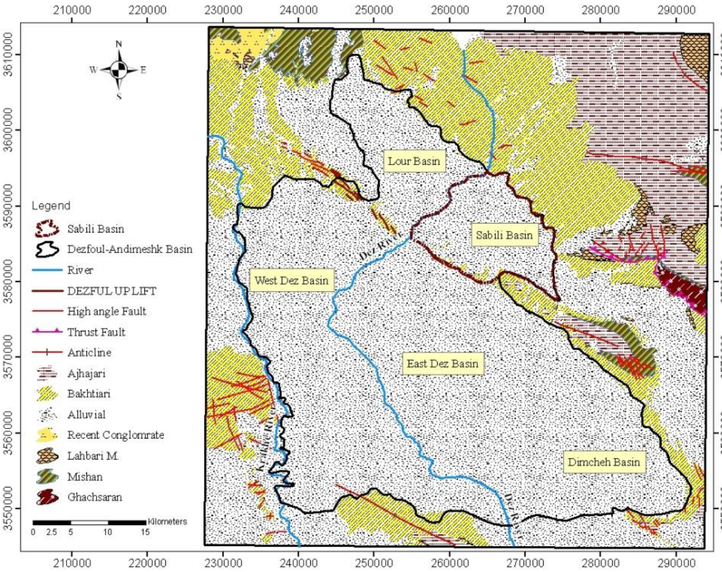


[Figure 1. Geographical location of the research area(Sabili) in Dezful-Andimesh Plain.]

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 [1]. 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 .

GEOLOGY OF THE AREA

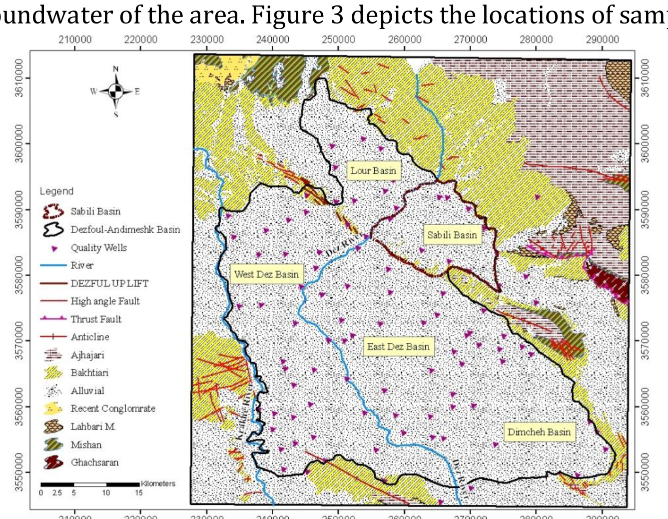
Geological characteristics of Sabili Plain include lower Miocene deposits up to the contemporary era, which mainly consist of the contemporary alluvial residues and Bakhtiari conglomerates. Due to the presence of bakhtiari conglomerates in higher areas and demolition, erosion and conveyance of materials 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-AndimeshPlian.]

DISCUSSION

Numerous researchers have studied groundwater resources, among them we could point to "The Causes of the Salinity of Shahrokht Plain Groundwater. "Hydrological Evolution of Sierra Spring in the US [2]". To study the hydra geochemical properties of groundwater, results from chemical analysis of 13 groundwater samples of the water year 2009-10 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-AndimeshkPlain]

Table 1.Calculated Amounts of Chloride and Acidity Density in Groundwater (Aban 2009)

Label	UTMX	UTMY	Cl	pH
Q-01	257703	3588719	2.03	8.3
Q-02	258624	3590435	1.74	7.7
Q-03	262479	3583968	1.93	7.8
Q-04	265201	3592042	2.18	7.8
Q-05	265446	3587617	3.16	8.2
Q-06	266354	3591975	1.85	8.3
Q-07	266648	3582342	22.99	8.8
Q-08	269613	3580826	21.74	8.3
Q-09	269641	3590366	2.4	8.3
Q-10	271968	3587409	2.14	8.1
Q-11	273870	3583645	1.26	8.4
Q-12	274198	3578611	4.51	8.9
Q-13	278275	3580007	1.7	7.4
Minimum			1.26	7.4
Maximum			22.99	8.9
Mean			5.4	8.2
Standard Deviation (SD)			7.6	0.4

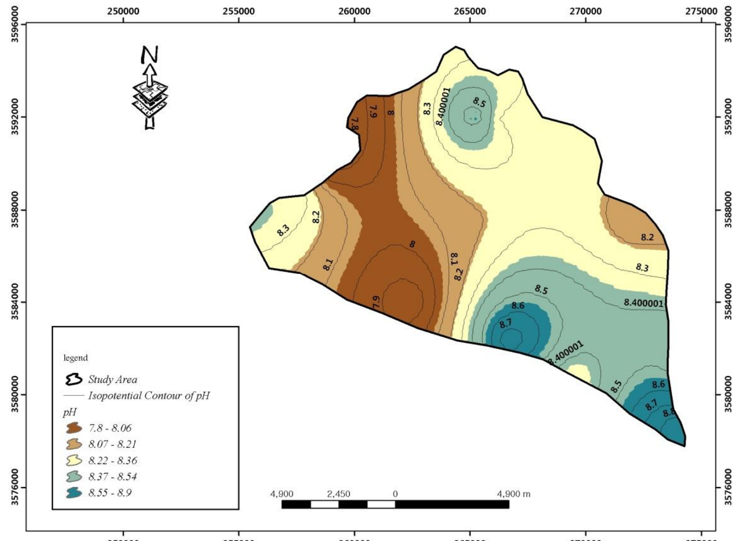
As shown in Table 1, the density of groundwater chloride in representative points of quality ranges from 1.26 mg/L in Q-11 to 22.99 mg/L in Q-07. As to the acidity of the groundwater, according to Table 1, it is concluded that the density of this quality parameter has a range of 1.5. To study the spatial distribution and the process of chemical changes of the groundwater in the area, zoning maps of electrical conductivity and the total dissolved solid materials were drawn and analysedusing the ArcGIS software and Geostatistical Analyst tool.

Acidity (PH) Spatial Distribution:
The value of PH shows the acidity or basic property of the environment.This characteristic not also causes a change in the taste of water, but alsodamages the water system by corrosion.EPA (2009), WHO (2008), EU water quality union (1998), and other organisationshave proposed the following standards for PH, presented in Table 2 below.

Table 2.Maximum of allowed PH according to EPA, WHO and EU

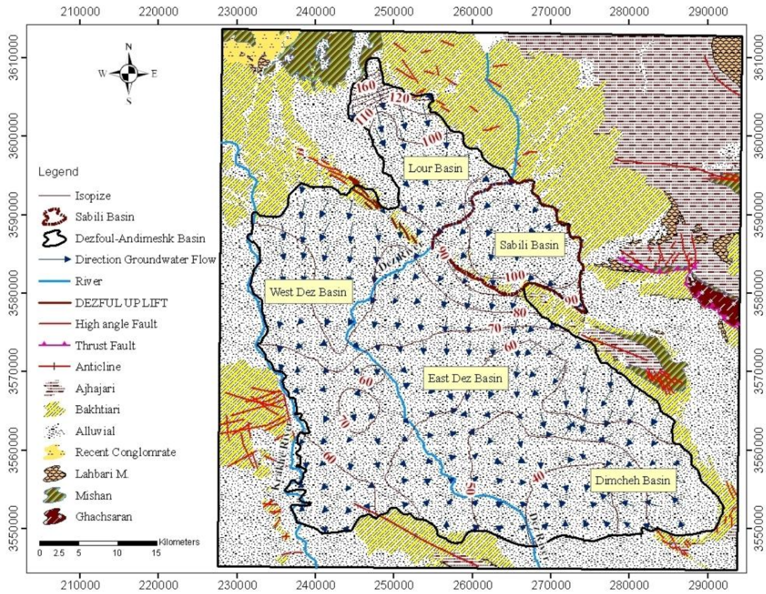
Iran's Ministry of Energy1993		Australia1996 Canada 2008		EU (1998)		WHO (2008)	EPA (2009)		Contaminant (MCL)
Secondary	Primary	Secondary	Primary	Secondary	Primary		Secondary	Primary	
7- 8.5	6.5-9.2	6.5-8.5	-	6.5-9.5	-	No Guideline	6.5-8.5	-	pH

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 Data format. These point data were then recalled in ArcGIS, and using the Geostatistical Analyst toolbar, various methods of kriging were employed for interpolation and develoingmaps of spatial distribution of electrical conductivity, and finally, the final map of acidity zoning was developed based on the results, which is shown in Figure 4 below.



[Figure 4. Zoning of groundwater acidity spatial distribution]

In order to study the spatial distribution of acidity, 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]]

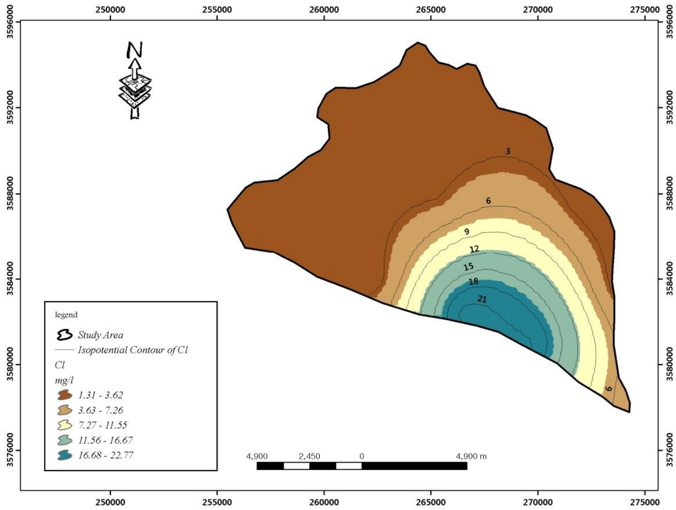
As shown in Table 4, it is conceived that acidity level of the groundwater in the area varies from 7.8 to 8.9, and on the eastern border of the area, the amount of this parameter follows a descending trend from southern parts to the northern parts of the plain, where the Dez River is flowing.Such a trends is also observed on the southern border of the area from east to west, along the Bakhtiari formation, which the acidity increases past the Bakhtiari formation to the west. With regard to the groundwater flow direction, we could attribute the suitability of acidity level in northwestern parts of the plain to its being fed by acidity-neutral water from the Bakhtiari conglomerate formation located in the eastern part of the area. While in the southeastern part, regarding the groundwater flow direction, water coming to this area after passing through the Mishan formation and Lahbari area, as a result of dissolution of marnes in this formation, causes an increase in the groundwater acidity level.

Chloride (Cl)

This ion is found in most natural waters. Chloride usually comes from natural resources such as salt domes, evaporative deposits, saltwater (brine), and domestic and industrial waste water. Chloride is an evaporative material which easily dissolves in water and is not stable in the atmosphere. Because of this strong oxidising effect, Chlorine has been used as a disinfectant in refining and disinfecting water resources for a long time [4]. In most stones, Chlorine is found with a lower density than it is found in groundwater. But alluvial stones, especially the evaporative ones, significantly contain more chlorine than is found in plutonics and metamorphic rocks. Generally, chlorine comes from four natural sources (Kresic, 2007):

1. Chlorine of old sea water confined in sediments
2. Dissolution of evaporative minerals, such as Halite, gypsum and anhydride
3. Evaporation of surface and groundwater's
4. Dry fallout from the atmosphere, especially in dry areas

Naturally, chlorine enters hydrological cycles from solid or liquid waste, fertilisers, and road salt. The amount of chlorine is less than 30 mg/L in drinking natural water, and higher amounts indicate intermixture of waters containing minerals or man-made contaminents [5].
To develop the map of spatial distribution of groundwater chlorine the same procedure was followed as with water acidity (Figure 6).



[Figure 6. Zoning of spatial distribution of groundwater chlorine density]]

As is evident from figure 6, the density of groundwater chlorine is to its maximum in the southeast part of the region, in sampling points of Q-07 and Q-08, and the density lowers when moving away from these points. Due to the fact that the density of chlorine in this part is less than 30 mg/L, it could not be attributed to man-made contaminants; rather, it could be credited to Halite in the area, that the dissolution of Halite causes a local increase in groundwater chlorine density. Also, as could be concluded from figure 6, the lowest amount of groundwater chlorine is measured in the quality points adjacent to the Dez River, which could be attributed to the fact that the water fed to the groundwater from river sports a good quality of chloride which in turn lowers the amount of groundwater chlorine.Also, the low density of chlorine in the eastern part of the research region seems with water from the conglomerate formation at the eastern part of the region has a good quality, and the conglomerate formation acts like a quality filter, causing the density of chlorine and the quality of groundwater.

CONCLUSION

With regard to the zoning maps presented for groundwater acidity and chlorine density, principal reasons for the spatial distribution of these two factors could be enumerated as hydrological connection of the groundwater with the Dez 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. Also, the dissolution of marnes materials in the Mishan and Lahbari formations are one of the effective factors in determining the acidity of the groundwater.

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