

Study of Hydrogeochemistry and Evaluation of the Groundwater Quality for Irrigation and Domestic Purposes in Marand Plain, East Azerbaijan

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Abstract

To study hydrogeochemistry of groundwater, water samples were collected in an area of about 800 km² and 87 locations from Marand plain, Eastern Azerbaijan province. Samples analyzed for major cations and anions and processed by statistical methods. Some of the locations are defined by higher concentration of EC, TDS, Cl, Na and K. Half of the groundwater samples possess Ca-Mg-HCO₃ type of hydro chemical facies, followed by Ca-HCO₃, Ca-Cl and Na-Cl types. Based on US salinity diagram, most of the samples fall in the field of C3-S1, indicating high salinity and low sodium water, which can be used for almost all types of soil with little danger of exchangeable sodium. Majority of the samples are not suitable for domestic purposes and far from drinking water standards. Comparing average electrical conductivity and total dissolved solids of the study area in the recent years revealed that declines in water levels with the extensive agricultural activities and urbanization resulting in the deterioration of groundwater quality in the major parts of the plain.

Keywords: *Hydrogeochemistry, Irrigation and Drinking, Water salinity, Marand plain*

Introduction

It is estimated that about one third of the world's population use groundwater for drinking purpose [1]. Groundwater is the major source of water supply for domestic purposes because it was generally belief that groundwater is healthy and safer [2]. Groundwater is the only water source for domestic, industrial and irrigation uses in Marand plain and so it is really important to guaranty its quality for these different uses. Meanwhile it should be considered that the problems of ground water quality are more acute in areas that are densely populated and thickly industrialized. The quality of groundwater is the result of variety of processes and reactions. Geochemical studies could provide a better understanding of possible changes in groundwater quality as development progress [3]. Assessment of groundwater quality is the main factor which determines whether the water is suitable for domestic, irrigation and industrial purposes or not [4].

The study area is located between latitudes 38° 18'- 38° 46' N and longitudes 45° 15'- 46° 05' E. The region has a semi-arid climate and the average rainfall is 236 mm. Geologically, the area is overlain by young alluvial sediments and quaternary deposits but at the same time different rock units like igneous rocks, Miocene evaporation sediment and Miocene conglomerate affect the quality of groundwater (Fig.1), [5, 6, 9].

Discussion

87 water samples from 74 water wells, 10 Qantas and 3 springs were collected in July and were analysed with standard methods in order to assess the groundwater chemistry and the variety of parameters that related to this factor. Sample locations were selected to cover the entire Marand plain. Furthermore, local surveys were done to determine probable contaminants in quality of water in the area. The results were evaluated with water quality standards given by the World Health Organization [7].

Groundwater chemistry

Results of statistical analysis of physical and chemical parameters of groundwater such as minimum, maximum, median, mean and mode are given in Table.1. The EC values differs from 404 to 5580 (mho cm^{-1}) and the mean value is 1827.7 mho cm^{-1} . Values of pH are from 6.3 to 8.8 with an average of 7.70. This shows the neutral to alkaline nature of groundwater in the region. TDS values also vary from 242 to 3348 mg/l with an average value of 1096.6 mg/l.

Hydro geochemical facies

Geochemical evolution of groundwater was specified through plotting the concentrations of major cations and anions in the Piper diagram [8]. On the basis of Piper diagram, groundwater is divided into five facies including mixed CaMgCl types, CaHCO₃, CaCl, NaCl, and CaNaHCO₃ respectively (Fig.2). Therefore it is observed that alkaline earth (Mg^{2+} and Ca^{2+}) exceeds the other cations and Cl⁻ exceeds the other anions.

Groundwater quality

The chemical parameters of water samples compared with water quality standards [7] and public health standards for domestic uses. The cation concentration indicate that 12,40 and 6.9% of K^+ , Na^+ and Ca^{2+} concentration exceed the standard limit of WHO. For chloride (Cl⁻) 16% of samples, shows more concentrations than maximum allowable limit for drinking water. High amounts of alkaline concentrations in western parts of Marand plain were associated to Miocene evaporation sediments [9].

The comparison of the average electrical conductivity and total dissolved solids from July 2005 to July 2008 indicates that the EC and TDS values had increased in the study area. Also, the unit hydrograph confirms that water levels have declined [6]. Decline in groundwater level due to over-exploitation of the aquifer in the Marand plain has caused the deterioration of groundwater quality in the major parts of the region.

To ascertain the suitability of groundwater for different consumptions, it is essential to classify the groundwater based on their TDS values [10]. Approximately 55% of samples in the region are fresh water while the rest of the samples represent brackish water based on this classification. Only 19.5% of the samples have TDS less than 500 mg/l and can be used for drinking without any problem based upon classification of Davis and Dewiest [11], whereas only 2% are not suitable for irrigation purposes. Study of electrical conductivity of groundwater in Marand plain reveals that 48% of the samples are within the permissible limit ($\text{EC} < 1500$) and 40% of the samples fall in not permissible limit ($\text{EC} = 1500\text{-}3000$).

S.A.R (sodium adsorption ratio) is an important parameter for irrigation because it is a

measure of alkali/sodium hazard to crops. The analytical data plotted on the US salinity diagram [12, 13], (Fig. 3) to determine groundwater suitability for irrigation purposes. Results show that approximately 42% of the groundwaters fall in the field of C3-S1, indicating water of medium-high salinity and low sodium and can be used for irrigation. However 26.5% of the samples fall in the field of C4-S2, indicating high salinity and medium alkalinity hazard. One sample comes under C4-S4 classification and may not be suitable for irrigation.

Conclusion

The hydrochemical analysis demonstrates that the groundwater in Marand plain is fresh to brackish water and neutral to alkaline in nature. The alkaline earth ions ($\text{Ca}^{2+} + \text{Mg}^{2+}$) are more than alkaline ions (Na^+ and K^+) and value of Cl^- is more than the other anions. This leads to a CaMgCl type of groundwater. However few groundwater samples represent CaHCO_3 and NaCl types. Sodium value of groundwater in one third of the study area exceed the permissible limit for drinking and the TDS values in 29% of samples are higher than World Health Organization (WHO) standard and 40% of the samples are classified as not permissible based on Electrical conductivity. 42% of the groundwater samples are in the field of C3-S1 on the Wilcox diagram and can be used for irrigation in almost all types of soil with little danger of exchangeable sodium. SAR values and the sodium percentage (Na %) in locations indicate that majority of the groundwater samples are suitable for irrigation. Due to population and agricultural activities growth, the aquifer of the Marand plain is already being over-exploited which caused the salinity of groundwater and would be making it unsuitable for the domestic purposes and the irrigation of some lands in the study area.

Table 1: Statistical characteristics of different chemical parameters in groundwater of the region

Water quality parameters	EC	TDS	pH	Ca	Mg	Na	K	HCO ₃	CO ₃	Cl	SO ₄
Numbers of samples	87	87	87	87	87	87	87	87	87	87	87
Mean	1827.7	1096.6	7.69	91.56	58.4	199.06	6.36	340.7	1.67	360.3	118.02
Standard deviation	1220.2	732.1	0.5	66.86	41.36	153.31	5.59	172.2	5.67	379.8	88.93
Maximum	5580	3348	8.8	336	218.4	798.1	29.64	945.5	42	1712.9	496.8
Minimum	404	242.4	6.3	17.6	4.32	6.67	0.04	100.65	0	8.8	4.8
Mode	984	590.4	7.5	66.4	39.36	184	3.9	183	0	443.7	48
Median	1514	908.4	7.7	67.6	45.6	172.5	5.07	305	0	221.8	96

All values are in mg/l except pH, EC (mho cm^{-1})

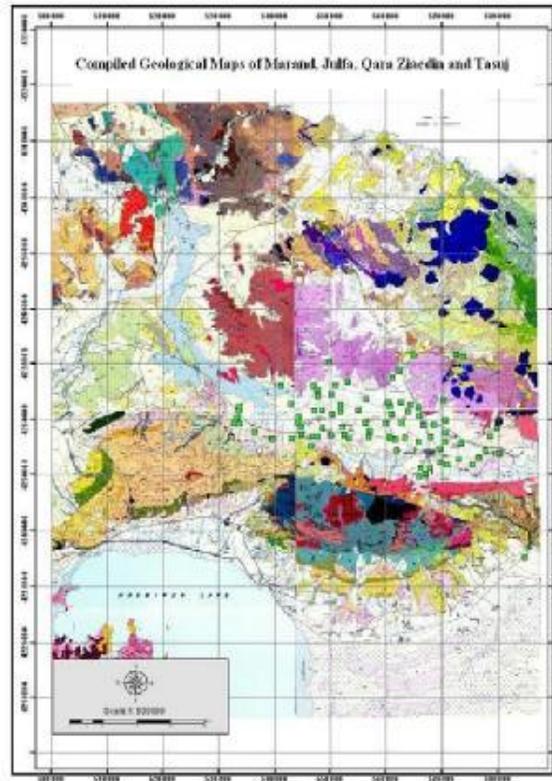


Fig. 1 Geological setting of the study area and Sampling locations

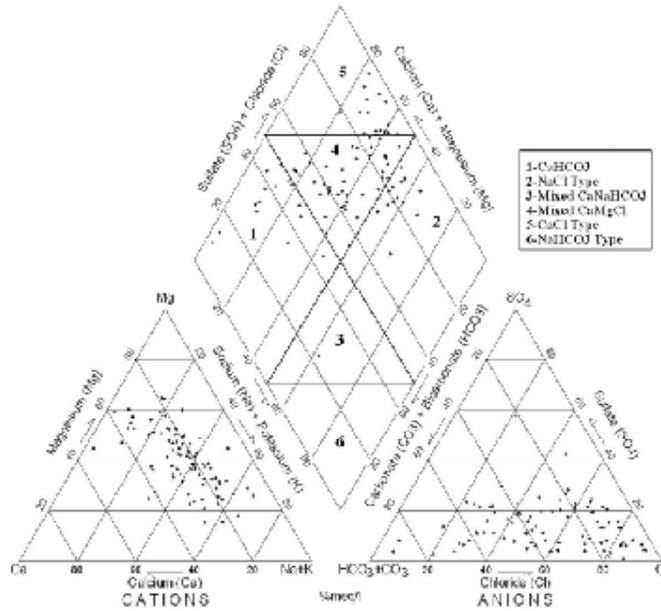


Fig. 2 Piper diagram showing hydrochemical facies of groundwater

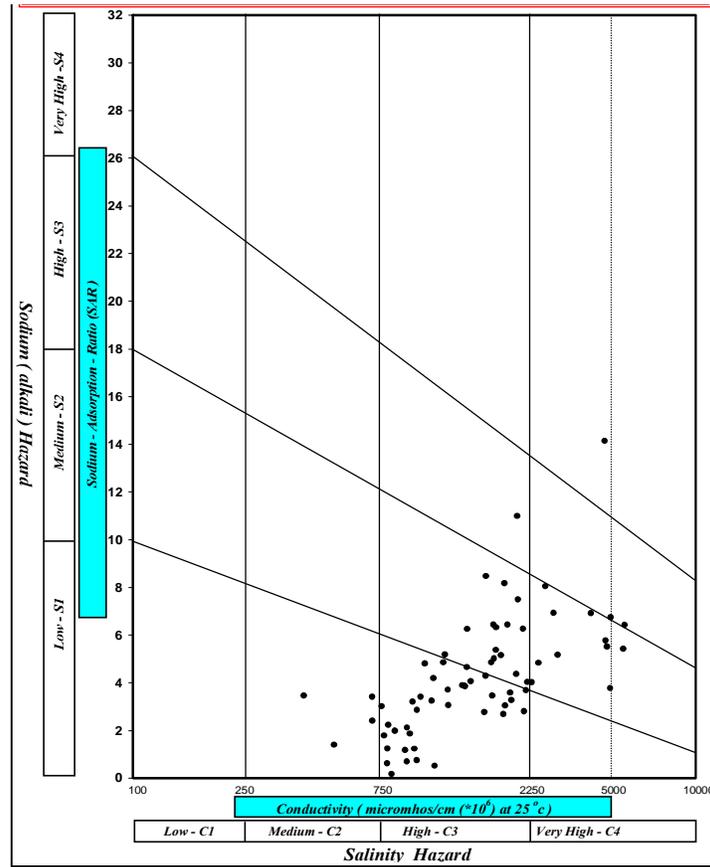


Fig. 3 Salinity and alkalinity hazard of irrigation water in US salinity diagram

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