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Hydrogeological, hydrogeochemical and isotopic study of coastal aquifer in southeastern bank of Urmia Lake

A. Shemshaki[1], Gh. H. Karami[2*]

Abstract

In recent years, along with the drying of Urmia Lake, groundwater quality in some areas of its coastal alluvial aquifers has been significantly deteriorated. Due to existence of evaporative geological formations, the remaining brine from the Urmia Lake and high evapotranspiration in the region, identifying the source of changes in groundwater quality is difficult in this area. In this research, it has been tried to evaluate the factors affecting the degradation of the quality and salinity of groundwater in the study area by stable isotopes of deuterium and oxygen-18 with some quality and quantity parameters of groundwater. The aquifers in the area are mainly caused by precipitation in the upstream of catchment areas and most likely flood from the melting snow. Therefore, reducing snowfall or changing the rainfall pattern from snow to rain effect on the quantitative and qualitative aquifers significantly in the study area. Exploitation of groundwater resources in the region could have a significant role in reducing the surface water into the lake.

Keywords: *coastal aquifer, Urmia lake, salinization, stable isotopes, groundwater flow*

[1] PhD Student, Faculty of Earth Sciences, Shahrood University of Technology, Shahrood, Iran.
[2] Associate Professor, Faculty of Earth Sciences, Shahrood University of Technology, g.karami@shahroodut.ac.ir
*** Corresponding Author**

Extended Abstract:

1. Introduction

In recent years, along with the drying of Urmia Lake, groundwater quality in some areas of its coastal alluvial aquifers has been significantly deteriorated. Due to existence of evaporative geological formations, the remaining brine from the Urmia Lake and high evapotranspiration in the region, identifying the source of changes in groundwater quality is difficult in this area. In this research, it has been tried to evaluate the factors affecting the degradation of the quality and salinity of groundwater in the study area by stable isotopes of deuterium and oxygen-18 with some quality and quantity parameters of groundwater.

2. Materials and methods

The study area is the southeast coastal zone of Urmia Lake, located at 45° 45´ - 46° 03´ E and 37° 05´ - 37° 23´ N in the northwest of Iran. Zarrinehrood, Mordichay and Sofichay rivers are the most important rivers in this region. Zarrinehrood provides about 42 percent of the water entering the lake. In this area, almost all portions consist of the alluvial deposits. However, a small portion in the east of studied area is covered by Permian limestone and/or dolomite limestone with shale. In the north portion of the studied area (i.e. Bonab Plain), the coarse-grained sediments are dominant whereas in the south region (i.e. Miandoab Plain) the fine-grained sediments are absolute majority.

In this study, sampling of groundwater was carried out on 20 shallow or deep wells and 6 dug wells in November 2015 (as the wet season) and May 2016 (as the dry season). At each sampling location, two samples were taken in 500-ml polyethylene bottles. A few drops of nitric acid were added to one of them in each location. The non-acidified and acidified samples were prepared for measuring the major ions (Ca, Mg, Na, K, HCO_3, SO_4 and Cl) and trace elements, respectively. All samples filtered through 0.45-µm membrane filters. The samples were kept in an icebox and delivered to the geological survey of Iran laboratories for analysis.

To prepare the Local Meteoric Water Line (LMWL), the data of stable isotopes of deuterium and oxygen-18 in rainwater samples of the Zarivar Lake basin was used (Mohammadzadeh and Ibrahimpour, 2012). This basin is near the Zarrinehrood river catchment.

The concentration of stable isotopes in various water resources depends more on the source of them. Therefore, by measuring the isotopes of surface water and groundwater resources, their interactions can be determined. By using ion ratios with stable isotopes or comparing ionic ratios with each other, it is possible to identify the origin of quality changes and groundwater salinization in the southeast coast of the Urmia Lake. The trend of changes in the level and direction of groundwater flow is helpful to understanding of the causes of groundwater quality changes and the verification of the results of qualitative and isotopic studies.

3. Results and discussion

In precipitation, the amount of deuterium varied 8.2 to 102.7 (‰) and the oxygen-18 was 2.3 and 15.0 (‰). The average weight of these isotopes is 64.6 and 9.7 (‰) respectively. The Local Meteoric Water Line (LMWL) is obtained as $\delta^2H = 7.7\,\delta^{18}O + 9.9$. The isotope composition of the rivers shows that the share of rain compared to the snow in the Zarrinehrood River is more than the Mordichay and Sofichay rivers. The isotopic composition of groundwater in the area can be divided into two categories. A number of groundwater samples follow LMWL, and the other group is on a lower slope line. The equation of this line, which is the local evaporation line (LEL), is $\delta^2H=\delta 0.5^{18}O-19.8$.

The isotopic composition of the other groundwater samples in the south of the Miandoab aquifer is almost the same Zarrinehrood river, in the north of the Miandoab aquifer is almost the same Mordichay river (SW2) and in the Maragheh-Bonab aquifer is almost the same Sofichay river. Therefore, the rivers have major control on recharge of aquifers in the study area.

Based on the groundwater equipotential map, the groundwater flow directions are from the upstream of the study area toward the Urmia Lake in May 2008. In May 2013, significant changes occurred in the groundwater level and the directions of groundwater flow. The most important changes are the severe reduction of the role of the Zarrinehrood river in recharging the aquifer and reversing the flow of groundwater from the lake toward the coast in the northern and central parts of the study area. In May 2016, the general direction of the groundwater flow has changed to the lake again (except the southwestern of the study).

4. Conclusion

This research shows that various factors play a role in the salinity of groundwater in the study area, which vary in different regions. The dramatic decrease in the aquifers recharge by rivers, especially the Zarrinehrood river, has played a very important role in reducing the groundwater quality. The penetration of the brine from the drying of the lake has been limited to areas of significant thickness from coarse to medium grain sediments. The study of the isotope composition of groundwater in the area shows that the main part of aquifers recharge is formed from lighter waters than the average weighted rainfall of the region. In other words, the aquifers in the area are mainly caused by precipitation in the upstream of catchment areas and most likely flood from the melting snow. Therefore, reducing snowfall or changing the rainfall pattern from snow to rain effect on the quantitative and qualitative aquifers significantly in the study area. It should be noted that in some areas, especially in the middle parts of the bank of Miandoab plain, despite the observation of the effect of saline water penetration on the quality and isotopic factors, there is no proper conformity to the direction of groundwater flow. These effects seem to be due to the decrease in the gradient of fresh/saline groundwater boundary due to a significant increase in the density of saline water in the coastal zone. The deterioration of water quality in the wells also may be resulted due to upconing saline water in wells by over exploitation groundwater in these areas. It may be suggested the future study should be focused on preparation of groundwater mass balance, preparation of numerical modeling and a detailed study of the slope variation of the fresh/saline groundwater boundary to reach a better understanding of the interaction of surface water and groundwater. This study may be helpful in better management and renewing of quality and quantity of water resources in Urmia lake area.

References:

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