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Hydrogeochemical characterization of major factors affecting the quality of groundwater in southern Iran, Janah Plain

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ABSTRACT

The Janah alluvial aquifer is located in southern Iran with an arid climate. The type of groundwater in this aquifer is dominantly of sodium chloride and total dissolved solid of groundwater samples range from 1.63 to 335 g/L which confirms that groundwater quality has been severely degraded by salinization. Hydrogeochemical and isotopic investigations were conducted to identify the source of salinity. Total dissolved solids and major ion concentrations were measured at 51 selected sampling sites including springs, wells and surface waters. In addition stable isotopic composition (oxygen-18 and deuterium) was measured in 6 sampling points.

The study indicates that the sources of salinity of the Janah aquifer include dissolution of salt diapir and evaporite rocks, a geothermal spring and intrusion of the river water which function individually or together in different parts of the aquifer. Based on the hydrogeochemical and geological studies conceptual flow models were prepared for different parts of the aquifer which illustrate how each source of salinity deteriorates the quality of the alluvial aquifer. We proposed few remediation methods including construction of cemented channel and sealed basins to improve groundwater quality. These methods would prevent infiltration of low quality water into the alluvial aquifer.

1. Introduction

To prevent salinization of groundwater is of significant importance in the arid and semi-arid regions with limited sources of fresh water. In the arid region of southern Iran, natural processes such as evaporation of groundwater, dissolution of evaporite formations and exposed salt diapirs, intrusion of saline rivers and lakes, and geothermal and deep basin waters are the most probable causes of groundwater salinization (Kouchekzadeh, 2014). Among these factors, salt diapirs, with more than 100 emergent, are the most potential source of groundwater salinization in the area which leads to an increase in the content of certain dissolved chemical species such as sodium, chloride, sulfate, as well as the total dissolved solid of groundwater. In many cases, salt diapirs have been reported as the source of salinization for the alluvial or karstic aquifer in southern Iran. The effect of Darab salt diapir on the quality of adjacent karstic and alluvium aquifers (south of Iran) has been studied by Sharafi et al. (2002). They recognized that the surface saline surface run off originated from the diapir is the cause of salinization in the alluvial Darab aquifer. Using hydrochemical techniques, Raeisi et al. (1996) studied the role of Sarvestan salt diapir and other surrounding evaporite formations in salinization of Sarvestan Plain. They deduced that salt diaper is the main cause of salinization of the surrounding wells and springs in the alluvial Sarvestan aquifer. Lately, Zarei and Raeisi (2010a) studied the karst development in the Konarsiah salt diapir in southern Iran. In addition, Zarei and Raeisi (2010b) studied the effect of the Konarsiah diapir on the adjacent karstic and alluvial aquifers. They recognized how the diapir derived brine flows into the adjacent karstic aquifers and suggested a few countermeasures including excavation of horizontal galleries and construction of cut-off walls to prevent the salinization of the karst water. Mahmoudi (2011) worked on the salinity sources of the karstic and alluvial aquifers adjacent to two diapirs in the Bastak Area, southern Iran. They found that the salt diapirs have no effect on the alluvium whereas it is the major source of salinity of the karstic aquifer.

There are three exposed salt diapirs adjacent to the aquifer. The type of groundwater in this aquifer is of sulfate or chloride type and total dissolved solid of groundwater samples range from 1.63 to 335 g/L which confirms that the groundwater has been severely degraded by salinization. The only source of salinization in the previous works in southern Iran were the exposed salt diapirs in the related study areas and therefore the researchers focused

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on the effect of the salt diapirs on the quality of the aquifers. However, there are a variety of probable sources of salinization in the Janah area including three exposed salt diapirs, a geothermal spring, saline Mehran River and groundwater evaporation from water table.

The Janah alluvial aquifer is located in southern Iran with an arid climate. Intrusion of salt diapir brine into the Janah aquifers might deteriorate the quality of groundwater in some sections of the plain. There are more than 180 agricultural wells drilled in the Janah aquifer using to irrigate palm gardens in the study area. Overexploitation by these wells might result in intruding saline water of the Mehran River to the Janah aquifer. The objectives of this work were to identify the sources of salinization of the alluvial Janah aquifer and to recognize how the salt diapirs influence the quality of the aquifer.

2. Geological and hydrogeological setting

Janah alluvial plain is situated in Hormuzgan Province, southern Iran (Fig. 1). It is a synclinal alluvial plain, surrounded by the Gezeh Anticline and the Darbast Anticline in the northern and southern margins of the plain, respectively (Fig. 1). The outcropped geological formations in the area, in decreasing order of age, are, Hormuz salt (Precambrian–Middle Cambrian), Sarvak limestone (Cretaceous), Pabdeh-Gurpi shale and marlstone (Upper Cretaceous), Jahrum dolomite (Eocene), Pabdeh shale and marlstone (Paleocene) Asmari limestone (Oligo-Miocene), Gachsaran marl and evaporites (Miocene), Guri limestone (Miocene), Mishan marl and shale (Miocene), Aghajari sandstone and marlstone (Mio-Pliocene) and Bakhtiari conglomerate (Pliocene). The salt rock of southern Iran diapirs belongs to the Precambrian–Middle Cambrian Hormuz Formation, with a total thickness of at least 1 km (Kent, 1979). This formation only reaches the surface as salt diapirs.

Three salt diapirs are emergent in the area (Fig. 1) including Kemeshk salt diapir (the western diapir), Darbast diapir (southern diapir) and Gezeh diapir (the eastern diapir). Kemeshk salt diapir is emergent in the eastern plunge of the Dehnow anticline. This diapir presents a negative-relief morphology. Bosák et al. (1999) classified Iranian diapirs in terms of their activity into four classes of active, passive, ruined and unbreached diapirs. Kemeshk diapir is a ruined diapir which its diapirism has been ceased long ago such that there is no salt rock outcropped in this diapir anymore. Darbast salt diapir is emergent in the Darbast anticline in the south of the Janah aquifer. In contrast to Kemeshk diapir, Darbast diapir is an active salt diapir with extensive salt rock exposure. The diapir includes a main salt body of 3 km in diameter (central part) flowing on the surrounding terrains as a tongue-like salt glacier. The maximum elevation of the Darbast diapir is 1450 m.a.s.l. (meter above sea level) and the total height difference with the Janah plain is nearly 1100 m. Gezeh salt diapir is an active diapir of elliptical shape located in the northeast of the Janah plain. This diapir is exposed in the southern flank of the Gezeh anticline. The summit of the Gezeh diapir lies at 940 m.a.s.l. Janah plain comprises an unconfined aquifer, namely Janah aquifer. There is no bore hole or well intersecting the bed rock of the aquifer. However field observations suggest Mishan impermeable Formation as bed rock of the aquifer. The deepest well in the aquifer is 85.4 m deep still in the alluvium which proposes that the thickness of the Janah aquifer is at least about 90 m in the central sections. The level of groundwater ranges 354.2 m.a.s.l. in well W0 located in western zone (Kemeshk area) to 289.0 m.a.s.l. in well W33 located in eastern zone (Gezeh area). The general flow direction of groundwater in the Janah aquifer is from west to eastward in the Janah aquifer (Fig. 1), although the flow direction changes locally in a few sections. For example the flow direction in the central section indicates a south–north component. Depth to water table ranges 10.5–28 m in the Janah aquifer (Sedehi, 2012). The subsurface hydraulic connectivity of the Janah plain with carbonate formations outcropped in the adjacent anticlines is mostly interrupted by impermeable Mishan and Gachsaran formations (Fig. 1).

Mehran River flows from west to east through the Janah plain. The quality of the river water is deteriorated before entering the Janah plain due to draining saline groundwater of the Lamerd Plain. The Mehran River finally flows into Persian Gulf. The average total dissolved solid (TDS) of the river water is 9.89 g/L at its inlet to the Janah plain, station R1 (Sedehi, 2012).

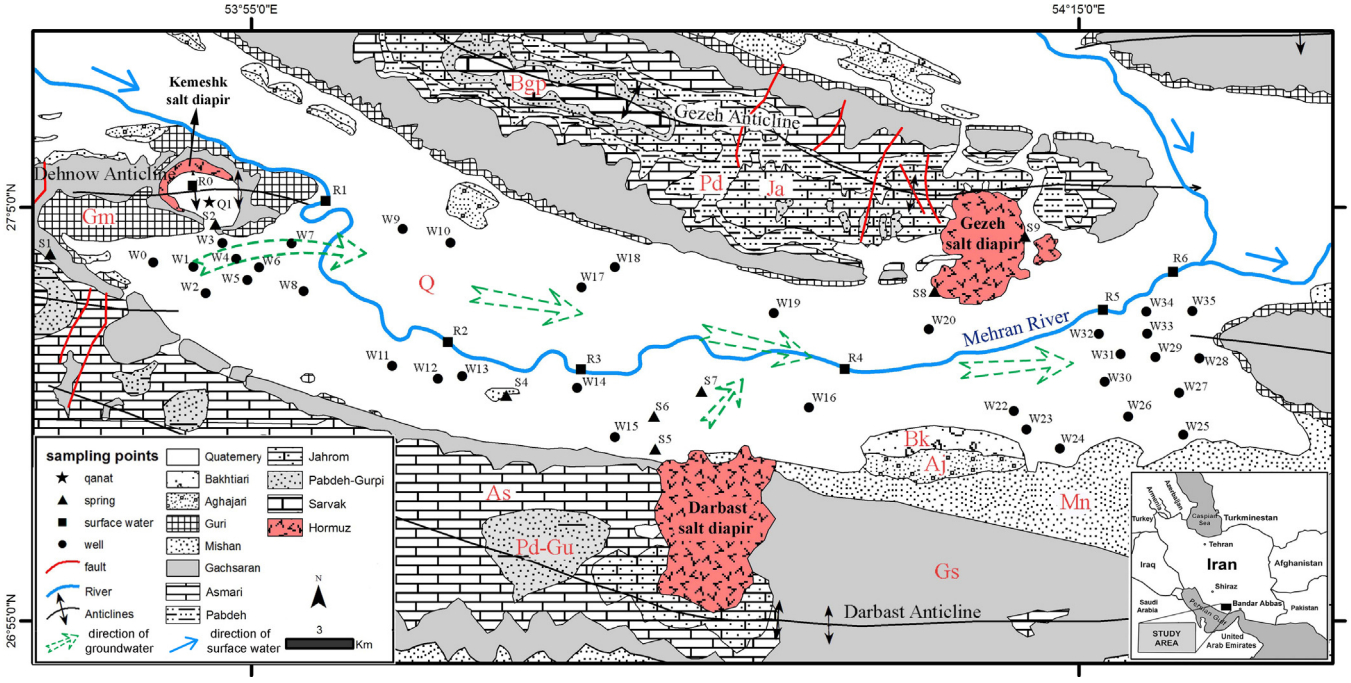

Fig. 1. Geological map and location of sampling points.