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Groundwater quality degradation of an aquifer in Iran central desert

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ABSTRACT

Hydrochemical quality of groundwater in an aquifer in central Iran adjacent to central Kavir desert was analyzed in this study. The dominant type of groundwater in the area is Na + K_Cl + SO4 which is mainly different from the common type of fresh waters in Iran (Ca_HCO_3). The spatial distribution of anions and cations as well as EC obeys an increasing pattern eastwards. Due to high concentrations of SO_4^{2-}, Cl^-, K^+ and Na^+ all of the water samples are not categorized in suitable ranges for drinking use. Regarding agricultural use suitability of regional groundwaters, except for 4 samples in central parts of the study area which show high salinity hazard, all other samples are absolutely not applicable for agriculture due to extremely high values of EC. Illegal groundwater pumping mainly for regional agricultural use during recent years has caused groundwater quality degradation due to saline water intrusion from eastern areas (central Kavir desert and salt lake) and connate water upcoming from deeper aquifers. As the main use of water in the study area is contributed to agriculture, implementing modern mechanized irrigation techniques accompanied by planting crops with low water demand and high tolerance against salinity may be recommended.

1. Introduction

Industrial development accompanied by population and consumption growth has imposed heavy pollution loads to natural resources [1–3]. Water resource contamination is one of the major challenges in the way of sustainable development [4]. From the total accessible fresh water all around the world more than 90% is contributed to groundwater resources. Accordingly, sophisticated attention towards monitoring the quality and quantity of such resources would play a key role in achieving the global sustainable development in near future.

The importance of groundwater as an alternative water supply is increasingly recognized, in response to escalating costs and decreasing quality of surface waters [5–8].

The need for water has produced an increasing withdrawal of groundwater in sensitive areas like desert environments, where aquifers may suffer from saline water intrusion and upconning, which consequently results in a deterioration of its quality [9]. Groundwater salinization occurs in many aquifers around the world [10–12]. Understanding the origin and mechanisms of the salinization process is an important point for preventing further deterioration of groundwater resources.

Many investigations have dealt with the origin of saltwater in coastal aquifer and several sources have been identified like; evaporite dissolution [13], downward leakage from surficial saline water through failed or improperly constructed wells [14], deep brines or upward flow from deep saline water [15], fossil seawater [16] or present seawater intrusion often due to excessive pumping [17].

Iran is located in a semi-arid area with an average annual precipitation less than one third of that of the world. Furthermore, spatial and temporal distribution of the regional precipitation is not integrated. Iran is one of 27 countries that are likely to face increasing water shortage crises between now and 2025 unless action is taken to reduce current water consumption [18]. Accordingly, lack of water resources is observed in most parts of the country. Groundwater supplies provide more than half of the total annual water demand in Iran, however the recharge of such resources is less than half of the total extracted amount. The uncontrolled groundwater use accompanied by successive famines in recent years has adversely affected the quality and quantity of Iran's aquifers; particularly in central parts where high temperature and low precipitation rates make the conditions more severe.

In the central Iran, during the last decades, development activities, both in urban and agricultural sectors, has rapidly increased; often

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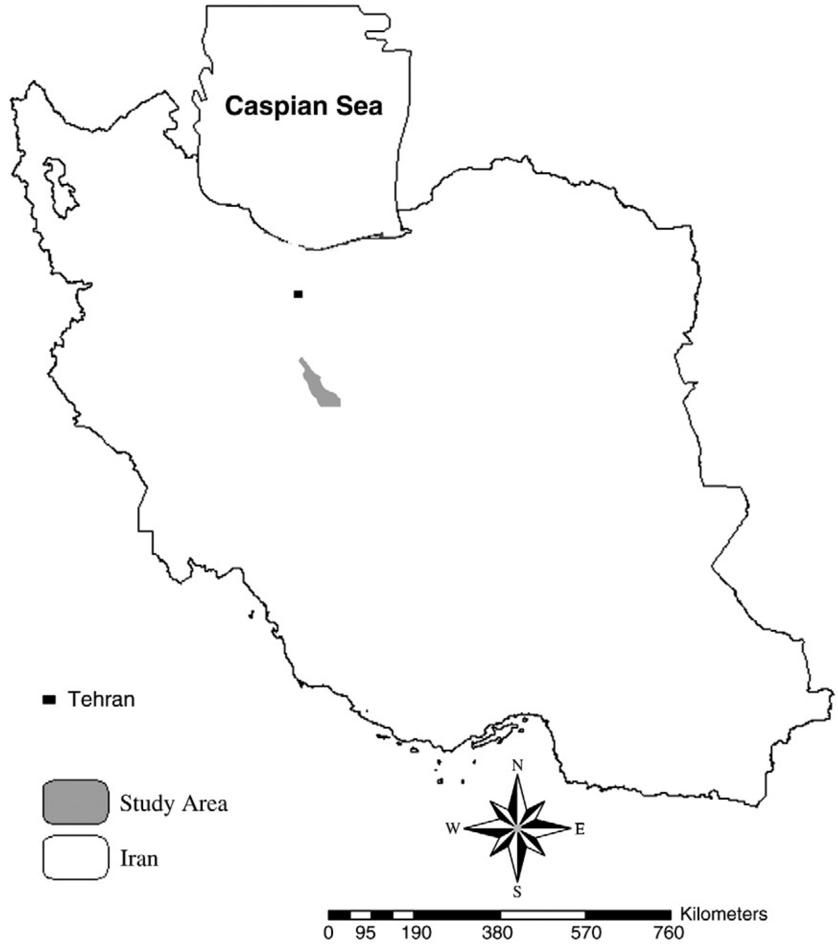

Fig. 1. Study area in Iran.

without adequate planning. The enhanced anthropogenic pressure together with improved standards of living has substantially increased the demand for water. The consequence has been a greater exploitation of groundwater resources, which are the only available source, in this area, for drinking, agricultural and industrial purposes. The importance of the groundwaters in the area should not be underestimated because they are the only water resource for drinking and agricultural purposes not only for the people living in this area but also for those who live in the surrounding areas. Despite the lack of alternative water sources, the groundwater hydrogeochemistry of the region remains poorly understood. Salinization and decreasing water levels increase the need for a comprehensive understanding of the groundwater system that would yield better management of the resource.

The aim of this study is to analyze the hydrochemical quality of groundwater in an aquifer in central Iran adjacent to central Kavir desert in order to assess the suitability of the waters for different uses.

2. Study area

Being located between 51° 05′ and 51° 54′ longitudes and 33° 45′ and 34° 23′ latitudes, the study area with an average area of 1500 km^2 is stretched in a northwest-southeast direction in the central Iran. From the east and north the area in confined with central Iran Kavir desert and salt lake, while the western and southern boundaries are defined by relatively high mountainous areas. With an average width of 20 km, the area is the main land in the region that is considered for agricultural and urban use during recent decades. The maximum and minimum elevations within the study area are 1200 m in western margins and 800 m in eastern boundaries respectively. The location of the study area in Iran is shown in Fig. 1.

3. Materials and methods

In order to appropriately cover the area 20 boreholes were considered for sampling the groundwater. The location of sampling points is shown in Fig. 2. Parameters like pH, EC, TDS (total dissolved solids), major cations (Na^+, K^+, Ca^{2+} and Mg^{2+}) and major anions (CO_3^{2-}, HCO_3^-, SO_4^{2-} and Cl^-) were taken into consideration.

pH and electrical conductivity (EC) of each water sample were measured at the sampling points by a digital pH and EC meter, respectively. TDS was determined gravimetrically at 105–110 °C [19]. In laboratory the duplicate aqueous samples of about 1000 ml of each batch collected from 20 sampling sites, were filtered through polycarbonate filter (0.45 mm pore size) and the samples were divided in two parts. One part was used for analysis of anions, while second part treated with 2 ml of concentrated HNO_3 for metal analysis.

The acid-treated water samples were analyzed for the determination of major cations by further 20-time dilution with ultra pure water. Ca^{2+}, Na^+ and K^+ were measured by flame photometry, while Mg^{2+} was determined by the flame atomic absorption spectrometer (FAAS).

In case of anion concentrations, sulfate, chloride, bicarbonate and carbonate have been measured by HACH DR/2000 (direct reading