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Assessment of groundwater recharge in a semi-arid groundwater system using water balance equation, southern Iran

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ABSTRACT

Estimation of the groundwater recharge is extremely important for the groundwater management in semiarid regions. A simple water balance equation is used for quantifying the total annual groundwater recharge during 8 water years (from 2002 to 2010) in the Burazjan aquifer, south Iran. Total annual groundwater recharge was estimated using two approaches: (1) sum of the known inflow components to the aquifer system, and (2) sum of outflow components from the aquifer and annual change in the aquifer storage. Comparison of the results from two approaches shows a considerable difference with an average of 91.30 million m^3/year for the annual recharge. This difference could be caused by (i) error in quantifying the inflow components and/or (ii) missing an unknown inflow component. Sensitivity analysis reveals that the difference in the estimated annual recharge is more than the estimated 20% error in quantifying the components of the water balance equation. However, considering the geological setting and previous investigations, a missed inflow component related to Burazjan Fault is proposed. Contribution of this inflow component in annual groundwater recharge ranged from 33.25 to 132.90 with an average of 91.30 million m^3/year.

1. Introduction

Estimating and quantifying the groundwater recharge as an important component of the water balance is necessary for sustainable groundwater use in arid and semi-arid regions. Southern Iran is characterized by a semi-arid climate condition with a low annual rainfall (average of 200 mm/year). Groundwater is an important resource in the study area due to the low quality of surface water. The study area is located in southern Iran (Fig. 1). Elevation ranges from 80 to more than 1300 m above sea level. The mean annual temperature varies from 15 to 43 °C based on data from the meteorological station of Burazjan, a city in the study area (Fig. 1), for the period of 2002–2010. The water years include long dry periods with short wet sequences. This study attempts to evaluate the natural groundwater recharge of an alluvial aquifer.

Several methods are presented for quantifying groundwater recharge (Scanlon et al., 2002; Seiler and Gat, 2007). These methods range from a point measurement using a lysimeter (Gee and Hillel, 1988; Grasso et al., 2003; Juren et al., 2003; Scanlon et al., 2002; Seiler and Gat, 2007; Xu and Chen, 2005) to a water balance calculation over the entire basin (He et al., 2009; Kendy et al., 2003; Lee et al., 2006; Manghi et al., 2009; Maréchal et al., 2006; Mjemah et al., 2011; Wanke et al., 2008). However, natural conservative tracers (e.g., chloride and stable isotopes) were also used to estimate groundwater recharge (Dassi, 2010; Shurbaji and Campbell, 1997; Wang et al., 2008; Zhu, 2000). The water balance equation as a basic mass balance equation has been widely used for quantifying groundwater recharge. The reliability of results obtained from the water balance equation is related to quality of data used for computing water balance components.

The objectives of this research are (1) estimating the amount of annual natural recharge in an alluvial aquifer using the water balance equation, (2) studying the sensitivity of the annual recharge to conventional error in quantifying water balance components, and (3) understanding and differentiating the inflow components to the aquifer.

2. Geological setting

Geologically, the study area is located in the Zagros Orogen. The Zagros Orogen is one of five structural zones of Iran (Alavi, 2004; Stöcklin, 1974). The Zagros Fold–Thrust Belt is a part of the Zagros Orogen in the Alpine–Himalayan Orogenic System and extends for more than 1500 km in a NW–SE direction from eastern Turkey to the Minab (Zendan) Fault system in southern Iran (Berberian and

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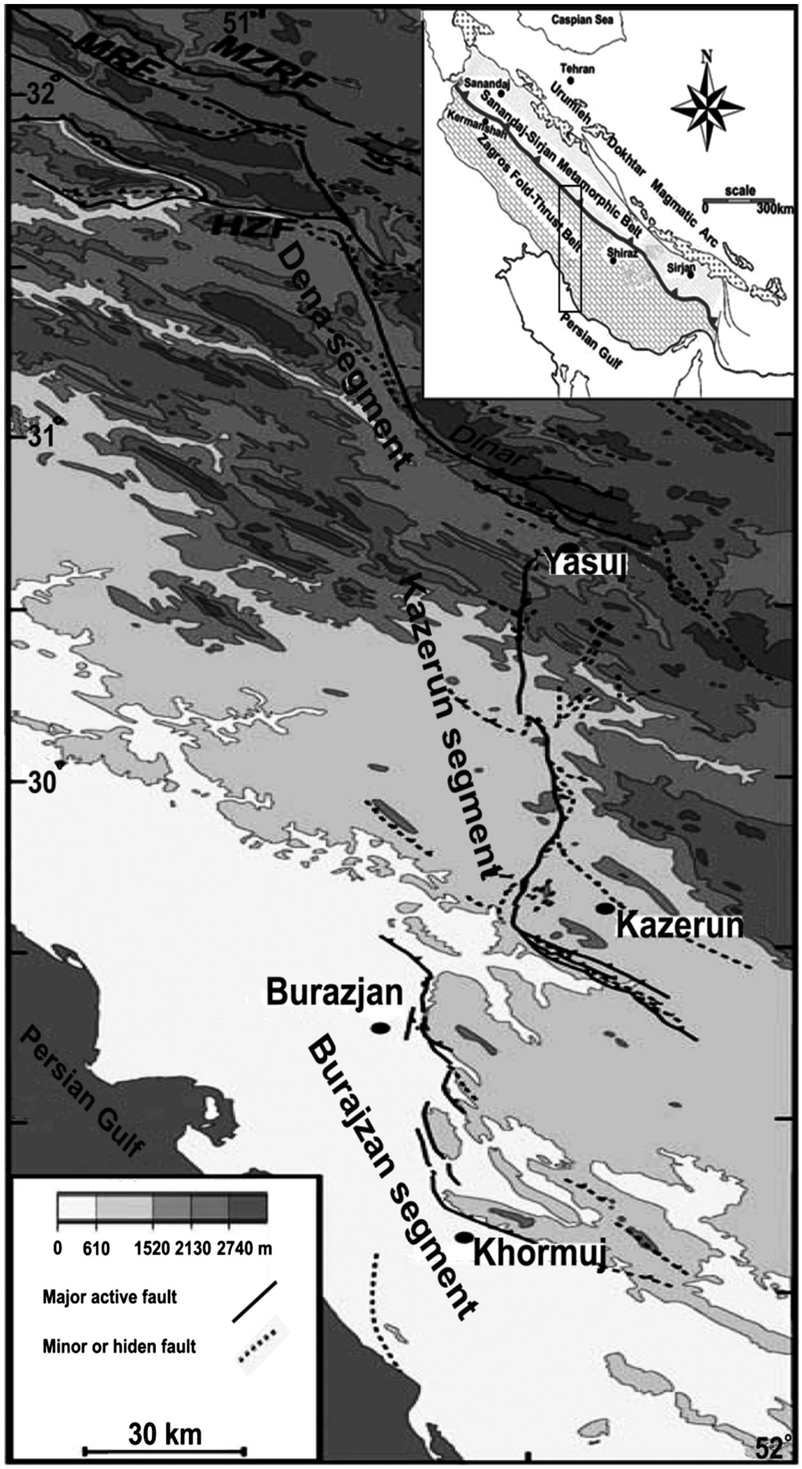

Fig. 1. Active fault segmentation of the Kazerun Fault System. The upper map shows tectonic subdivisions of the Zagros Orogen (Zagros Fold–Thrust Belt, Sanandaj-Sirjan Metamorphic Belt, Urumieh-Dokhtar Metamorphic and the location at the study area). MZRF, Main Zagros Reverse Fault; MRF, Main Recent Fault; HZF, High Zagros Fault.

King, 1981; Stöcklin, 1974). The Zagros Fold–Thrust Belt as a subdivision of the Zagros Orogen consists of large parallel concentric folds related to Neogene inversion of the former Arabian passive margin (Alavi, 2004). The belt is considered to be a complex product of an early Mesozoic separation of the Iranian continental block from the rest of the Gondwana landmass followed by a NE-dipping subduction of the newly generated Neo-Tethyan oceanic crust below the Iranian microcontinents and subsequent collision between the Afro-Arabian and Iranian microcontinents (Alavi, 1994). Regional deformation arising from the Late-Cretaceous to Tertiary collision between the African–Arabian continent and the Iranian microcontinents accounts for the thrusting and large-scale strike-slip faulting associated with crustal shortening in the Zagros Orogen (Alavi, 2004; Sepehr and Cosgrove, 2005). The southeastern part of the Zagros–Thrust Belt is affected by the north-trending, right lateral Qatar-Kazeroun Fault System (Berberian, 1995; Talbot and Alavi, 1996) stretching from the Main Reverse Fault to the Persian Gulf coast. The Qatar-Kazeroun Fault System is one of the longest NNE-trending active strike-slip faults that crosscuts the entire Zagros Fold–Thrust Belt at a high angle. This fault system consists in three