HYDROGEOLOGICAL, HYDROGEOCHEMICAL AND ISOTOPE GEOCHEMICAL FEATURES OF THE GROUNDWATER SYSTEMS IN ISPARTA AND ENVIRONS, SW TURKEY

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ABSTRACT

The study area is located in the western part of the Tauride carbonate axis forming a north ponting cusp, so-called Isparta Angle, in the SW Turkey. Autochthonous carbonates and flysch type sedimentary rocks form the basement of the area overlain by ophiolitic units of the Lycian nappes tectonically. All these units are cut in places by Pliocene lava extrusions of the Gölcük volcano and covered by Quaternary pyroclasitcs and alluvial deposits. The groundwater flow direction in the Isparta plain is generally from SW to NE which corresponds with the gently sloping of pyroclastic fall deposits from Gölcük caldera in the SW to province capital of Isparta.

Water samples from the study area were collected between May and October of 2006 and 2007. In-situ measurements such as T, pH, electrical conductivity, total dissolved solids, redox potential, dissolved oxygen, alkalinity and acidity tests have been performed during field studies. Moreover, water samples have been analysed for their anions, cations and some trace element contents by ICP-OES and spectrophotometer. Water samples were classified as drinkable quality waters and can be considered as Ca-Mg-HCO3 and Ca-HCO3 type waters. Hydrogeochemical features of the springs and groundwaters in the Isparta plain indicate a water-rock interaction processes including plagioclase, carbonate and silicate weatherings. In-situ measurements and hydrogeochemical analyses show that the waters in the area are well correlated with the drinking water standarts.

The results of the geochemical modelling show that almost all waters are saturated in calcite and oversaturated in dolomite. On the HCO_3^- vs Mg/Ca diagram, water samples having various HCO_3^- ion contents are distributed below the calcite+dolomite dissolution line.

$\delta^{18}O$ and δD isotope ratios of the waters plot along the continental meteoric water line and represent meteoric origin that unaffected from evaporation. ^3H values ranging from 0,7 to 9,4 TU indicate that the waters in the study area are modern groundwaters. On the 3H versus EC-Cl-TDS correlation diagrams, water samples display a distribution in three main groups. Waters in the first group are considered to be deep-circulated waters. The second group waters are characterized by lower EC, TDS and Cl values. ^3H, EC, Cl ve TDS values of the third group waters are higher than the first and second group.

INTRODUCTION

The study area is located in the western part of the Tauride carbonate axis forming a north ponting cusp, so-called Isparta Angle, in the SW Turkey. Autochthonous carbonates and flysch type sedimentary rocks form the basement of the area overlain by ophiolitic units of the Lycian nappes tectonically. All these units are cut in places by Pliocene lava extrusions of the Gölcük volcano and covered by Quaternary pyroclasitcs and alluvial deposits. The groundwater flow direction in the Isparta plain is generally from SW to NE which corresponds with the gently sloping of pyroclastic fall deposits from Gölcük caldera in the SW to province capital of Isparta.

The aims of this study area (i) to investigate hydrogeological and hydrogeochemical features of groundwaters in Isparta and environs, (ii) to monitor the quality of the drinking water by hydrogeochemical methods periodically and (iii) to elucidate the source and age relations of the groundwaters in the area by isotope geochemical methods.

MATERIAL AND METHODS

In the investigated area, 73 water samples were collected between May and October of 2006 and 2007 (Fig. 2). In-situ measurements such as T, pH, electrical conductivity, total dissolved solids, redox potential, dissolved oxygen, alkalinity and acidity tests have been performed during field studies. Moreover, water samples have been analysed for their anions, cations and some trace element contents by ICP-OES and spectrophotometer. The isotope analyses of δD $\delta^{18}O$ ve ^3H in groundwaters were performed in GSF Institute of Hydrology, Neuherberg, Germany.

GEOLOGIC SETTING

Autochthonous units of in the investigated area consist of Menteşe formation, Davras limestone, Çiğdemtepe limestone, Koçtepe formation, Kayıköy formation and Gölcük volcanics. Allochthone units are Gökçebağ complex and Akdağ limestone. All these units are cut by Pliocene to re... by Quaternary pyroclasitcs and alluv...

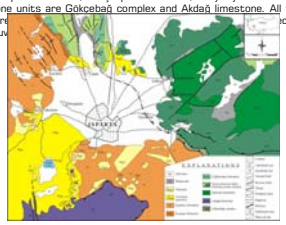

Fig. 1. Geological map of Isparta and environs (compiled from Gutnic et. al., 1979; Yalçınkaya et. al. 1986; Yalçınkaya, 1989; Görmüş and Özkul, 1995; Şenel, 1997; Poisson et. al., 2003)

HYDROGEOLOGY

The rock units in the investigated area are classified as permeable, semipermeable, slightly permeable, and impermeable rocks. The volcanics, which show various litholiogical and sedimentological properties including some pumice layers, are classified as slightly permeable rocks. The trachytes and trachyandesites are classified as semipermeable rocks. The ophiolite complex consists of impermeable rocks. Koçtepe formation and Isparta flysch units can be considered as impermeable rocks. The limestone in the study area is of permeable karstic rock. The alluvium deposits are classified as permeable rocks. Among these hydrogeological units, the alluvium, volcanic tuffs, and limestones are of the aquifers in the area (Fig. 2; Demer, 2008).

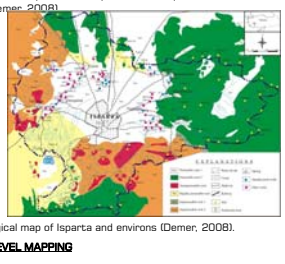

Fig. 2. Hydrogeological map of Isparta and environs (Demer, 2008).

GROUNDWATER LEVEL MAPPING

A groundwater level mapping of Isparta and environs has been performed (Fig. 3). This map shows that the main groundwater flow direction in the Isparta plain is from SW to NE, which corresponds with the gently sloping of pyroclastic fall deposits from Gölcük caldera in the SW to province capital of Isparta (Fig. 4; Elitok et. al., 2008; Özgür et. al., 2008; Demer, 2008).

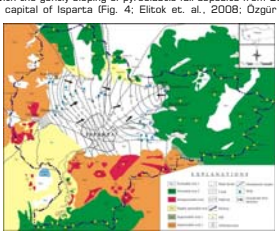

Fig. 2. Hydrogeological map of Isparta and environs (Demer, 2008).

Fig. 4. Groundwater flow direction in Isparta plain and relationship with the pyroclastic fall deposits of the Gölcük volcano.

HYDROGEOCHEMISTRY

In-situ measurements in Isparta plain and environs were realized in various locations between May and October of 2006 and 2007. (Tab. 1).

Tab. 1. Results of the range of in-situ measurements.

Parameter	Range
pH	6,85-8,40
Eh (mV)	87-336
EC (mS/cm)	170,50-917
Dissolved O_2 (mg/l)	2,51-11,09
TDS (mg/l)	119,35-641,90

Moreover, water samples have been analysed for their anions, cations and some trace element contents by ICP-OES and spectrophotometer (Tab. 2).

Table 2. Result of the range hydrogechemical analyses.

Parameter	Range (mg/l)
Na^+	0,82 - 39,56
Mg^{2+}	3,38 - 45,29
K^+	0,15 - 13,84
Ca^{2+}	26,16 - 234,30
Cl^-	2,50 - 57,00
SO_4^{2-}	6,00 - 86,00
NO_3^-	4,50 - 57,00
HCO_3^-	109,80 - 555,10

The results of hydrogechemical analyses were evaluated in Schoeller diagram of drinkable waters. According to Schoeller diagram, the waters in the area can be considered as very good quality and good quality waters (Fig. 5). The Piper diagram of this waters shows a range from Ca-Mg-HCO3 to Ca-HCO3 type waters in the investigated area (Fig. 6).

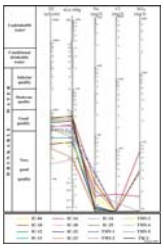

Fig. 5. Schoeller diagram of the water samples collected during October 2007.

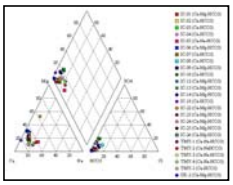

Fig. 6. Piper diagram of the water samples collected during October 2007. (o: drinking water; □: irrigation water)

In the classification with using of SAR (sodium absorption ratio) and EC values, the waters in the investigated area can be considered as moderate salty waters (C2-S1). These waters show no salinity hazards and can be used for watering of plants. In comparison, some waters are of salty waters (C3-S1) which form no sodium hazards (Fig. 7).

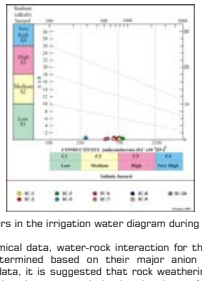

Fig. 7. Classification of waters in the irrigation water diagram during October 2007.

In the light of hydrogeochemical data, water-rock interaction for the groundwater in the Isparta plain has been determined based on their major anion and cation changes. According to the obtained data, it is suggested that rock weathering, namely plagioclase weathering, has been played an important role in the chemistry of the groundwaters. In addition to ionic changes in whole waters, carbonate and silicate weathering has been observed. In the HCO_3-SI diagram, the water samples plot generally along the calcite saturated line and above the dolomite saturated line (Fig. 8). Mg/Ca-HCO_3^- diagram (Fig. 9) indicates that the groundwaters in the study area are calcite dissolution waters.

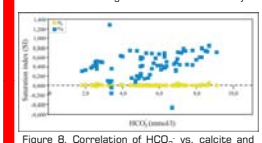

Figure 8. Correlation of HCO_3^- vs. calcite and dolomite saturation index of the groundwaters from the study area (from Barbieri et al., 2005)

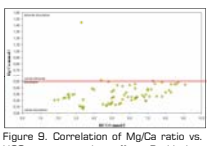

Figure 9. Correlation of Mg/Ca ratio vs. HCO_3^- concentrations (from Barbieri et al., 2005).

ISOTOPE GEOCHEMISTRY

20 water samples were taken from spring and groundwaters for the $\delta^{18}O$, δD ve ^3H isotope analyses. Fig. 11 shows distribution of $\delta^{18}O$ vs δD isotopes of the various types of waters in Isparta and environs. In this diagram, water samples taken in this study plot generally along the continental meteoric water line (Fig. 10).

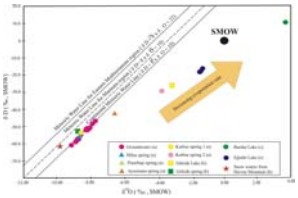

Fig. 10. δD vs $\delta^{18}O$ plot of the various type of waters in Isparta and environs (a: from Demer, 2008; b: from Karagüzel et al., 1999; c: from Altınkale, 2001).

^3H values of the waters range from 0.7 TU to 9.4 TU. On the ^3H versus EC-Cl-TDS correlation diagrams, water samples display a distribution in three main groups (Fig.11). Waters in the first group are considered to be deep-circulated waters. The second group waters are characterized by lower EC, TDS and Cl values. ^3H, EC, Cl ve TDS values of the third group waters are higher than the first and second group.

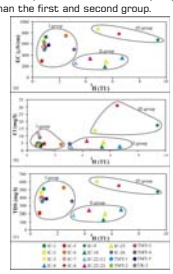

Fig. 11. a) ^3H vs EC, b) ^3H vs Cl, c) ^3H vs TDS correlation the waters from the study area (correlation diagrams taken from Yüce, 2001)

CONCLUSIONS

In-situ and hydrogeochemical analysis values of the water samples taken between May and October in 2006 and in 2007 are comparable with the drinking water standards of Turkish Standards Institution (TS 266, 2005), World Health Organisation (WHO, 2006), Unated States-Environmental Protection Agency (US-EPA, 2002), European Union (EU, 1998). Irrigation waters supplied mainly from the wells were classified as I. and II. type quality waters according to the Quality Criteria of the Inner Continental Water Reseources interpreted in the Water Contamination Control Regulations (SKKY, 1998).

It is concluded that seasonal changes of major anion and cation values of the waters taken from the same locations are conformable. In the light of hydrogeochemical data, water-rock interaction for the groundwater in the Isparta plain has been determined based on their major anion and cation changes. According to the obtained data, it is suggested that rock weathering, namely plagioclase weathering, has been played an important role in the chemistry of the groundwaters. In addition to ionic changes in whole waters, carbonate and silicate weathering has been observed. $\delta^{18}O$ vs δD isotopes of the waters taken from the study area plot generally along the continental meteoric water line. ^3H values of the waters range from 0.7 TU to 9.4 TU.

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