INVESTIGATION OF SEA WATER INTRUSION IN COASTAL AQUIFIERS: A CASE STUDY FROM KARABURUN PENINSULA, TURKEY

ALPER BABA[1], CELALETTIN ŞİMŞEK[2], ORHAN GÜNDÜZ[2], ALPER ELÇİ[2], ALİM MURATHAN[3] & HASAN SÖZBİLİR[2]

(1) Izmir Institute of Technology, Izmir, Turkey,
e-mail : alperbaba@iyte.edu.tr
(2) Dokuz Eylul University, Izmir, Turkey,
(3)The General Directorate of State Hydraulic Works, Izmir, Turkey,

EXTENDED ABSTRACT

Groundwater is an important natural resource; as of today, more than 2 billion people depend on groundwater. Determination of the quantity of available water resources is crucial due to continuously increasing water demand and unequal spatial distribution of water in the world. Coastal areas are typically considered to be areas of limited supply and large demand and groundwater is mostly the resource that is used for water supply purposes for coastal communities. Thus, there exist numerous studies in literature that focus on the determination of the groundwater characteristics in coastal regions with particular emphasis on the geological, hydrogeological and hydrochemical properties of coastal groundwater. Coastal aquifers are considered to be significant water resources and are mostly under threat due to salt water intrusion. The reason for salt water intrusion is mostly anthropogenic such as over exploitation but occasionally natural causes like tectonic boundaries or fault lines could be influential. When coupled with low recharge rates that are common in semi-arid regions such as the Mediterranean, effective and sustainable supply of water with sufficient quality and quantity becomes a real challenge for coastal communities.

According to the recent studies, increasing water demand due to population growth results in a necessity for the development of new water resources around the world. This demand yields water scarcity problems which are further amplified by the effects of climate change. Non-homogeneous spatial distribution of the water resources and the regional deviations between supply and demand are the principle factors yielding the water scarcity problem. Considering the ease in utilization and the relatively reduced risk of vulnerability to contamination, groundwater resources turned out to be the most vital resource of fresh water. This situation is particularly observed in coastal regions with semi arid climate such as the Mediterranean where surface waters are limited and population densities are large. Over exploitation of groundwater in these regions is the major cause of sea water intrusion problems (Ben-Asher, 2000; Elkhatib and Günay, 1993; Gordu et al., 2001; Yazıcıgil and Ekmekci, 2003; Karahanoglu et al., 2003; Demirel, 2004; Çamur and Yazıcıgil, 2005; Louvat et al., 1999; Edmunds and Milne, 2001; de Montety et al., 2008).

A perfect example to this situation is experienced in the Karaburun Peninsula, Turkey (Figure 1). The study area is situated about 50 km to the west of City of Izmir, third large metropolitan area of the country. It is not only a significant spot for the city with regards to its tourism potential but also an area of important natural, historical and ecological heritage for Eastern Mediterranean. Karaburun Peninsula is characterized by a complex hydrogeological structure that is based on karstic formations with significant water storage in an otherwise water scarce area. The region also contains several coastal aquifers that are in contact with these karstic structures. Both the karstic and alluvial aquifers of the region were recently found to be under severe salt water intrusion, which significantly altered the fresh water/sea water interface as a result of excessive pumping and fault lines cutting the karstic network.

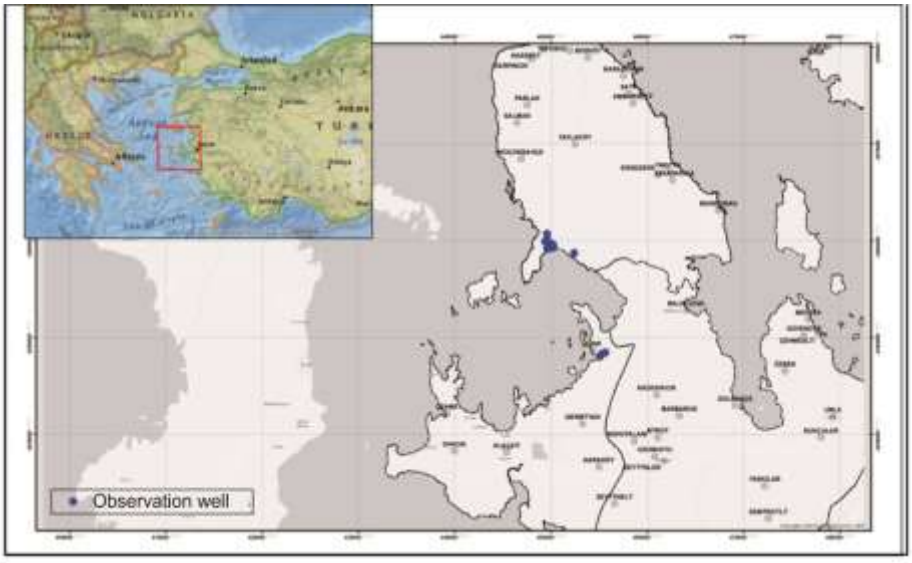

Figure 1. Location of study area

In this study, geological, hydrogeological and hydrochemical properties of the water resources in Karaburun Peninsula are determined and the status of salt water intrusion is assessed. The basement rock of Karaburun Peninsula is the Early–Middle Carboniferous Alandere Formation, which consists of marine limestone (Erdoğan, 1990). The unit is unconformably overlain by Triassic-Jurassic rocks of Karaburun Platform Carbonates and Upper Cretaceous to Paleocene rocks of Bornova Flysch Zone (Figure 2). These rocks are commonly intercalated with andesitic and dacitic lavas, volcaniclastic rocks (Robertson and Pickett 2000), submarine basaltic lavas, and basic pyroclastic and volcaniclastic rocks (Çakmakoğlu and Bilgin 2006; Erkul et al., 2008). Geological studies in the area revealed that significant levels of karstification were observed in the Karaburun Platform carbonates of the region which resulted in the formation of a number of poly and uvala structures. Karst structures of the region are tectonically controlled and tectonic zones are EW and NNE trending. The average flow of the major karst springs of the region are 420 l/s and an additional 200 l/s of water is obtained from wells during summer periods (Figure 3).

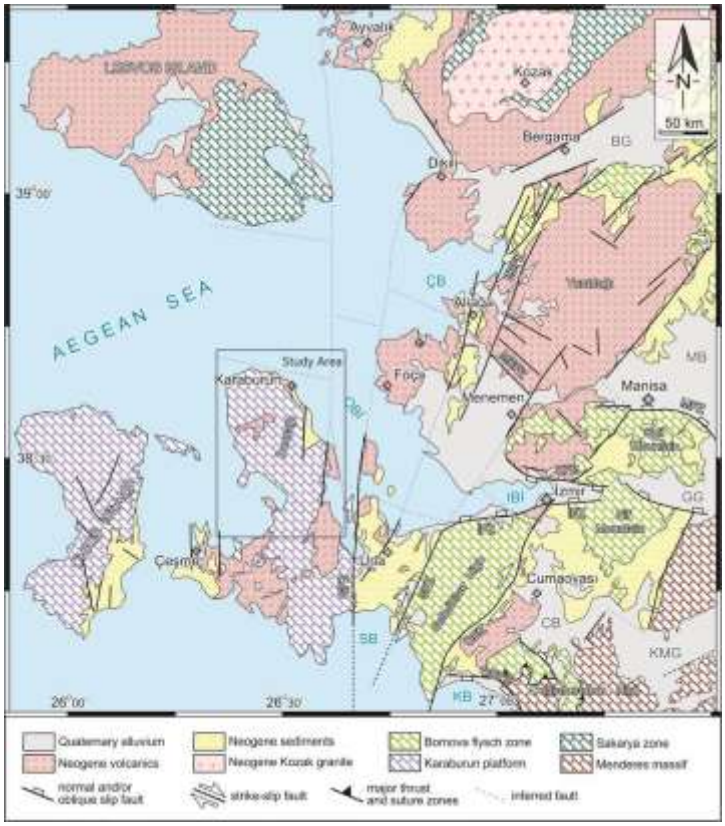

Figure 2. Geological map of study area (from Uzel et.al., 2012).

Figure 3. Karstic spring in study area

Costal aquifers of the Karaburun Peninsula are affected by sea intrusion due to excessive water withdrawal from the wells. Most of wells that supply water to the residential areas of the region are drilled in the costal aquifer. The depths of these wells range from 30 to 200 m. A total of 14 new groundwater monitoring boreholes were drilled in 2014. CTD-Diver type data loggers that measure and store electrical conductivity and water level with time were placed in these boreholes along the costal aquifer. The results from these data loggers as well as other discrete monitoring wells show that electrical conductivity values of water increase in summer months and could reach up to 8000 µS/cm (Figure 4). Data from

one of these continuous monitoring points located in southwest of the area reveal the temporal increase pattern of electrical conductivity as a result of increasing pumping rates during summer period when demand for water reaches its maximum levels in the area (Figure 5). A similar increase in conductivity was also observed in the karstic springs where increased pumping rates are likely to reverse the natural karstic flow pattern and create sea water intrusion along the fault lines.

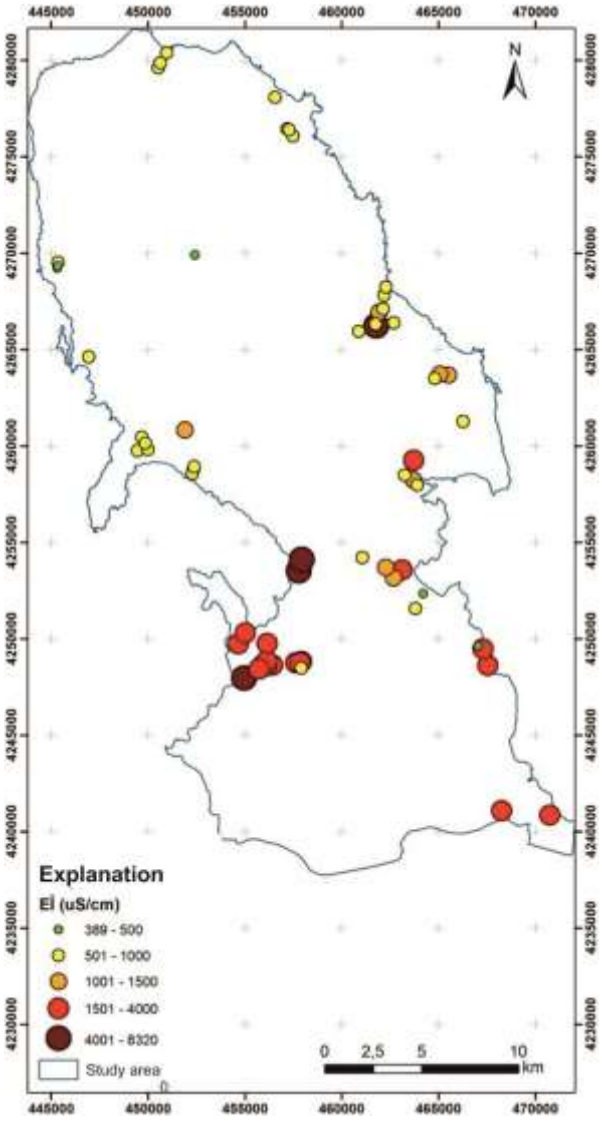

Figure 4. Distribution of electrical conductivity in the study area

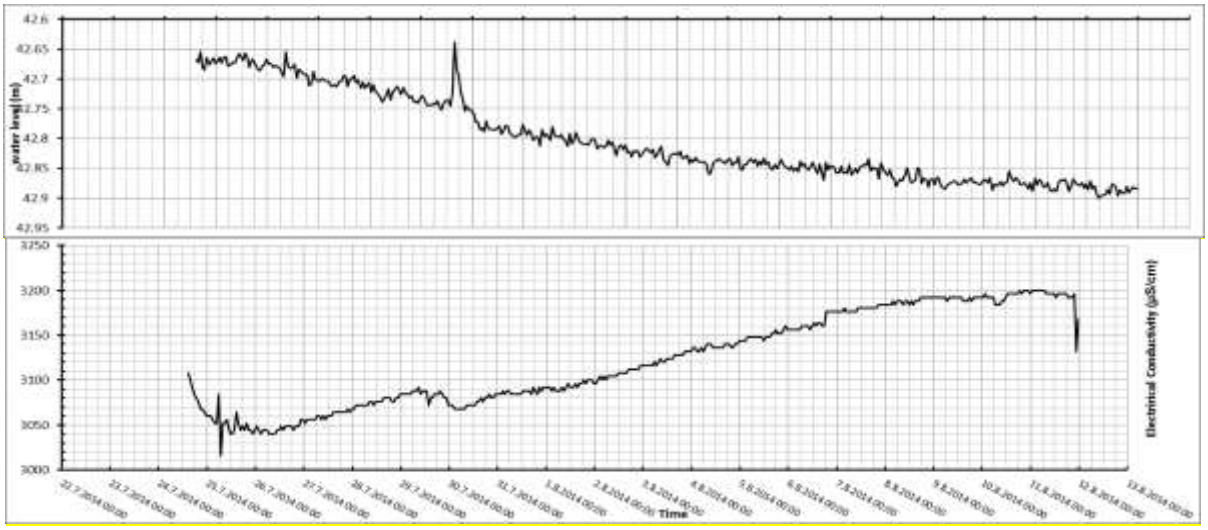

Figure 5. Distribution of electrical conductivity in well 03, southwest of study area

Based on the preliminary results obtained, it is now certain that sea water intrusion has become a serious environmental problem, which directly influence the quality of water resources in the coastal region of Karaburun Peninsula. The coastal aquifers of the region are under stress with demand exceeding the supply in highly populated parts of the region. Over pumping from these aquifers is responsible for elevated rate of sea water intrusion in the region. Thus, detailed studies are deemed necessary to develop new water resources and to find more sustainable pumping patterns from the available coastal aquifers. Otherwise, it would be difficult to stop the sea water intrusion problem in Karaburun Peninsula.

Keywords: Costal aquifer, sea water intrusion, Karaburun Peninsula

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