

Hydrogeochemical Characteristics of Bursa Thermal Waters in Marmara Region

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Keywords: Bursa, thermal waters, hydrogeochemistry

ABSTRACT

Bursa city is rich with ground waters, mineral waters and thermal waters is located in the juxtaposition of West Anatolian Extensional Zone and the southern branch of North Anatolian Fault Zone (NAFZ) in north of Turkey. Besides these different tectonic zones, Uludağ massive, which is highest mountain of Western Anatolia, is located in this region.

Thermal waters discharge in the center of city at the north of Uludağ Pluton, the mineral waters reach the surface along Nilüfer creek in a tectonic valley at the south west of the pluton. Cold water springs have been discharged different altitudes from Uludağ to Bursa Plain.

1. INTRODUCTION

Within the scope of an international project, the aim of which was to evaluate the geothermal potential of Bursa region, besides the geothermal sources in the region, the surface water, groundwater, snow samples and some mineral waters in the south of Uludağ have been analyzed within the context of the project. In this study, the part which concerns only thermal waters of the project has been examined.

A comprehensive databank has been formed with the anion, cation (Ca^{+2} , Mg^{+2} , Na^+ , K^+ , Cl^- , SO_4^{-2}) analysis, pH, temperature (T), electrical conductivity (EC), total dissolved suspend (TDS), water soluble oxygen, bicarbonate (HCO_3^-) and $\delta^{18}\text{O}$, δD isotope analysis on a daily basis of some water (Cl^- , SO_4^{-2}) and on a weekly or monthly basis of the specially chosen ones.

2. GEOLOGICAL SETTING

Bursa city is located northwest of Turkey (Figure 1).

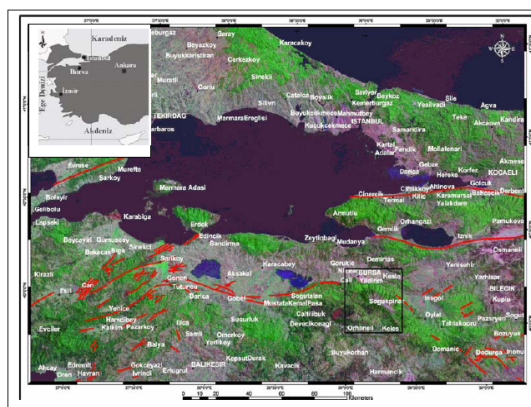


Figure 1: Bursa city location map.

The highest mountain of western Anatolia is Mount Uludağ (2543 m.) and it takes place southwest of Bursa city. Mount Uludağ was represented Paleozoic age high grade metamorphic rocks (Ketin, 1947; Bingöl et al., 1982) such as marbles, amphibolite, gneiss and quartzites and low grade greenschists, serpentines and marbles in the region. Oligocene age granite has been observed high altitude of the mountain also. There are a few cold springs discharge at different altitudes on the mountain.

Meanwhile thermal springs discharge at low altitudes, near the center of Bursa in two sites. In thermal springs area, Neogene sediments such as conglomerate, sandstone, clay, limestone and Quaternary travertine and alluvium units has been observed.

3. TECTONICS

Turkey was strongly affected by the Alpine-Himalayan orogenic belt. The tectonically active areas are concentrated along high stress zones like The North Anatolian strike-slip fault, The East Anatolian transform fault and graben zones in Western Anatolia. Western Anatolian is such a tectonically active region in Turkey which has large grabens (such as Gediz and Menderes Grabens) association with extensional tectonic.

The northwest of Turkey is affected by The North Anatolian Fault Zone (NAFZ). Especially Bursa city and surroundings are affected by south segment of NAFZ and Eskişehir Fault Zone (Figure 2). The segment is called Geyve-İznik Fault and runs north of Bursa (Herece, 1990).

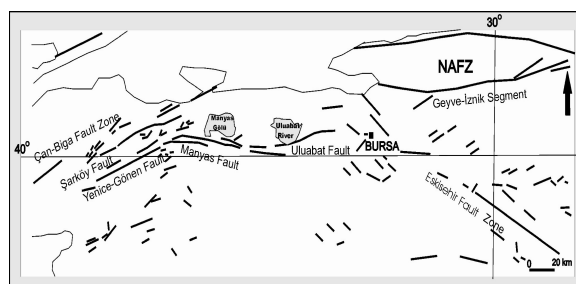


Figure 2: Tectonic lines of Bursa and surroundings (modified Bozkurt, 2001).

4. HYDROGEOCHEMISTRY

In Bursa city, two different thermal water types, so called Çekirge thermal waters and Kükürtlü thermal waters can be determined which are different physical, chemical characteristics and geographical positions.

Çekirge main thermal waters are Vakıfbahçe, Zeyninene, Küplüce springs and they discharge from Neogene age conglomerate, sandstone, clay, limestone formation to surface.

Their water temperatures change 36-46°C, their conductivity change 500-600 $\mu\text{S}/\text{cm}$ and their pH values change 7-7.5 dissolved oxygen change 1.5-11 mg/l depend on seasonal effects.

Kükürtlü thermal waters discharge from lower altitudes and Uludağ metamorphic schists and marbles are aquifer in the region. Travertine precipitations are observed near the discharge of water in Kaynarca springs.



Figure 3: Travertine precipitation in Kaynarca region.

Kükürtlü main thermal waters are Kaynarca and Karamustafapaşa springs in the region. Kaynarca is the hottest spring in the city and its maximum annual temperature is 80°C. Karamustafapaşa spring maximum annual temperature is 60°C. These spring conductivity changes 850-1390 $\mu\text{S}/\text{cm}$ and their pH values change 6.5-7.8 and dissolved oxygen values change 2.4-10 mg/l.

All these hot springs are using in bath and medical purposes in hotels in Bursa city.

4.1 Seasonal Effects on Hydrogeochemistry in Çekirge Thermal Waters

The hottest spring of Çekirge Thermal Waters is Vakıfbahçe spring. Their T, pH, EC, dissolved oxygen values has monitored for a year (Figure 4a to 4d).

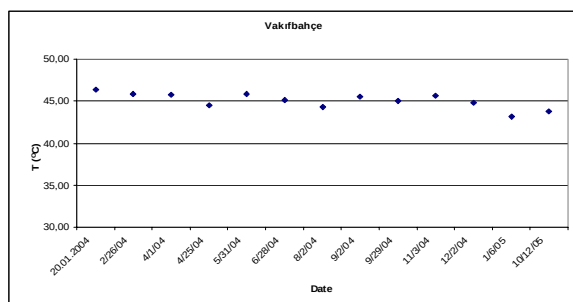


Figure 4a: Seasonal effects on temperature values in Vakıfbahçe spring.

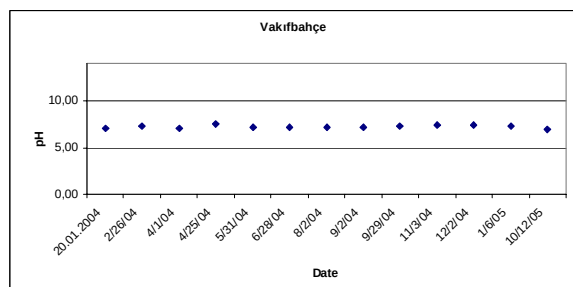


Figure 4b: Seasonal effects on Ph values in Vakıfbahçe spring.

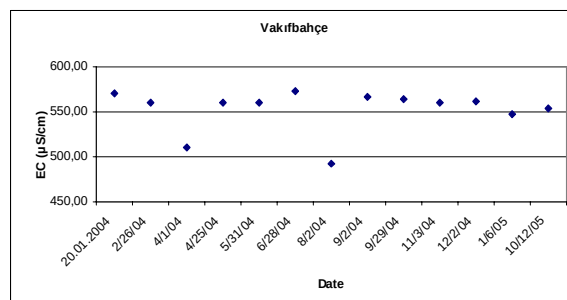


Figure 4c: Seasonal effects on EC values in Vakıfbahçe spring.

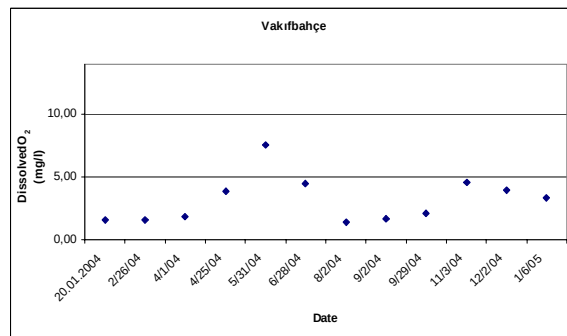


Figure 4d: Seasonal effects on dissolved Oxygen values in Vakıfbahçe spring.

4.2 Seasonal Effects on Hydrogeochemistry in Kükürtlü Thermal Waters

The hottest spring of Kükürtlü Thermal Waters is Kaynarca spring. Their T, pH, EC, dissolved oxygen values has monitored for a year (Figure 5a to 5d).

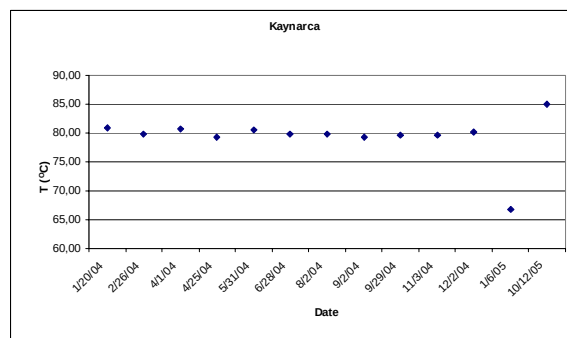


Figure 5a: Seasonal effects on temperature values in Kaynarca spring.

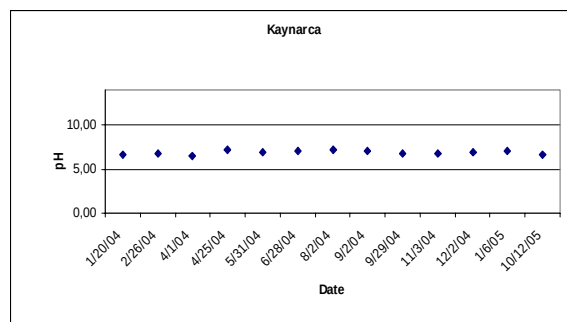


Figure 5b: Seasonal effects on pH values in Kaynarca spring.

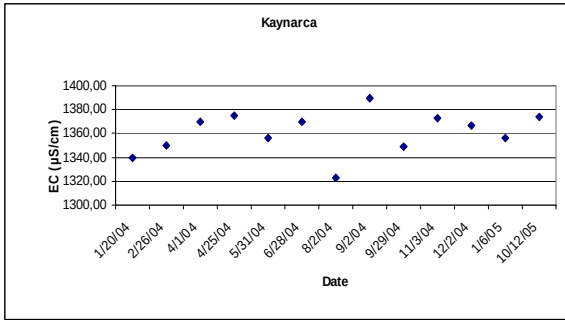


Figure 5c: Seasonal effects on EC values in Kaynarca spring.

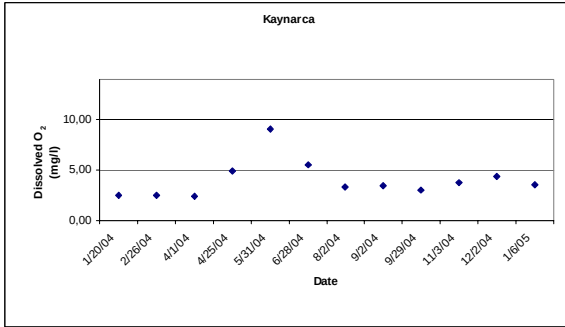


Figure 5d: Seasonal effects on dissolved oxygen values in Kaynarca Spring.

5. CONCLUSION

Cold water springs have been discharged different altitudes from Uludağ to Bursa Plain and thermal waters discharge in the center of city at the north of Uludağ Pluton.

In the city center, thermal waters temperatures has changed between 36-46°C in Çekirge region and 43-80°C in Kükürtlü, their conductivities has changed between 500-600 µS/cm and 850-1390 µS/cm.

Seasonal changes have monitored for the physical compositions during a year. According to monitoring results, although pH values almost stable both in Çekirge and in Kükürtlü regions; temperature, conductivity and dissolved oxygen values have changed during a year. These changes look effects of Mounth Uludağ. Winter time, after snowfalls to Mounth Uludağ, spring time melted snows mixed with cold waters and goes to Bursa Plain, this process reach to thermal waters at low altitudes.

It shows that there is a fastly interaction thermal waters and cold waters in Bursa region.

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