Algae Potential of The Deliçermik Thermal Spring Area (Köprüköy-Erzurum, NE Turkey)

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***Abstract*: All over the world, the thermal springs are natural water environments and characterized by specific physical and chemical characteristics. These are ubiquitous features mostly unknown but typically thought to originate from deep sources. Turkey has a unique geographic location at the junction between Asia, Europe and Africa. It is located in an active tectonic orogenic belt with young faults and active volcanisms. In the Deliçermik thermal spring area (Köprüköy-Erzurum, NE Turkey), the thermal spring water flows out from the clayey levels of the geological material belonging to the Horasan Formation aged as Pliocene. The confluent thermal spring water and clayey geological material are taken the form of thermal mud and it use as the thermal mud bath. The Deliçermik thermal spring area hosts thermophilic algae belonging to Bacillariophyta, Chlorophyta, Cyanophyta and Euglenophyta types. In this area, the most common algae detected are Bacillariophyta type.**

***Keywords*: Thermal spring area, Thermal water, Thermal mud, Algae.**

I. INTRODUCTION

The thermal springs, also called the hot springs, spring with water at temperatures substantially higher than the air temperature of the surrounding region. They are thermal aquatic ecosystems distributed all over the world (Bhakta et al., 2016; Rogers, 2019). The most hot springs discharge groundwater that is heated by shallow intrusions of magma in volcanic areas. Some thermal springs, however, are not related to volcanic activity. In such cases, the water is heated by the convective circulation: groundwater percolating downward reaches depths of a kilometer or more where the temperature of rocks is high because of the normal temperature gradient of the Earth'scrust-about 30 °C per kilometer in the first 10 km (Rogers, 2019).

There are several reports on the systematic account of algae and cyanobacteria of thermal springs. Publications are also available on the water quality of thermal springs and their correlation with algae and cyanobacteria occurring there-in and their temperature limit (Jahangir et. al., 2001; Sompong et. al., 2005; Bhakta et al., 2016). The thermal springs harbor population of microorganisms with great commercial importance and interest to the researchers and industry working on enzymes, sugars, compatible solutes and antibiotics. Diversity analysis of such extreme environments has got ample attention due to their diverse and unique ecology, chemistry and opportunity they provide to identify rare compounds and genes (Satyanarayana et. al., 2005; Kuddus and Ramtekke, 2012; Panda et. al., 2015).

Springs are concentrated discharge of groundwater that appears at the surface as a current of flowing water. Thermal springs are springs discharging water with a temperature above that of the normal local groundwater. Most of springs are the result of long cracks in sedimentary rock. Hot springs contained the life even long before they reach the surface, and the warm water of the springs allows an abundant of algae and bacteria to survive which are called as thermophilic microorganisms (Todd, 1980; Naresh et. al., 2013).

Temperature is one of the most important factors govern species abundance and distribution. The high temperatures in soil and/or water exert pressure on microbial species leading to the selection of specific flora capable of tolerating and surviving heat stress. Some species can survive at the elevated temperatures of hot springs, or in various other adverse environments. The defense mechanism cells utilize when confronted with high temperatures in their local environment is known as the heat shock response (Naresh et. al., 2013).

Turkey has a unique geographic location at the junction between Asia Continent, Europe Continent and Africa Continent. It is located in an active tectonic orogenic belt with young faults and active volcanisms. The extensive volcanism, hydrothermal activities and presence of more than one-thousand hot springs prove that Turkey has an important geothermal energy potential. In terms of known geothermal energy resources around the world, Turkey is the 7th richest country (Balat 2006; Ozer and Ozyzicioglu, 2019).

The Erzurum city (NE Turkey) is one of the big provinces that have many hot springs in Turkey, and some hotels have been set up near hot springs, with spring water introduced into the bath inside each hotel pool for hot spring bathing to attract tourists. The Deliçermik Thermal spring area is one of the important hot spring areas of Erzurum known with its healing thermal mud (Akbaba et. al., 2015).

The aim of this study is to draw attention to occurrence of algae causing appearance pollution in the thermal water and thermal mud pools and describe the occurrence of algae the Deliçermik thermal spring area.

II. MATERIAL AND METHOD

2.1. Site Characteristics

The study area covers the Deliçermik thermal spring area (Köprüköy-Erzurum, NE Turkey). It lies at approximately 50 km East of Erzurum between Latitudes 39°56′ to 40°07′ N and Longitudes 41°46′ to 41°56′ E, Turkey. This area is located on the Erzurum-Kars Plateau (near the Southern margin), which was formed by extensive Miocene-Quaternary thick lave-pyroclastic flows with clastic sedimentary intercalations. The study area consists of Miocene, Pliocene and Quaternary units. These units are almost unconformity among each other, with some exceptions of conformable at several locations (Fig. 1).

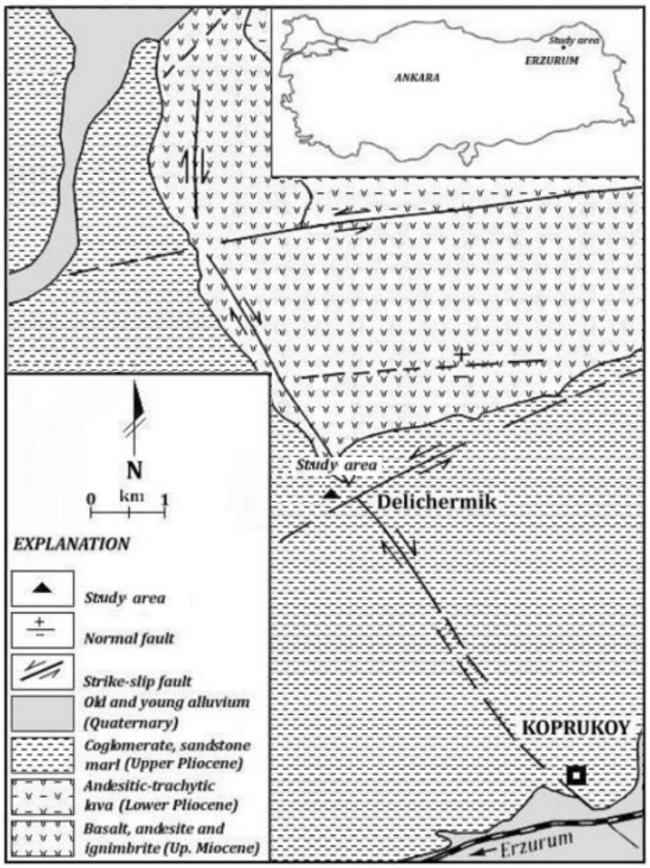

Fig. 1. Geological map of study area (modified Kalkan et. al., 2012)

The thermal mud takes place in the Horasan Formation. This geological unit includes tuffite and clay intermediate levels in some places. The sandstone with fine granular and shale-marl with yellow color get involved in the upper side of this formation. The clayey levels consist of some fossils such as *Dreissensia*sp., *Gastropoda*sp. *and Congeria*sp. (Rather, 1969; Yilmaz et al., 1988; Keskin, 1998; Dagistan, 2001; Kalkan et. al., 2012).

2.2. Sampling and Analysis

To collect algae samples from the Deliçermikhermal spring area (Köprüköy-Erzurum, NE Turkey), field studies were undertaken during summer months of 2019. The sampling operation was carried out in the thermal mud pool at the Horasan Formation representing the mixture of thermal water and the clayey materials of Horasan Formation. The algae samples were harvested from both surface of thermal water pool and surface of thermal mud pool where these were present. The samples were stored in portable cooler boxes while being transported to the laboratory for analysis.

2.3. Algal Identification

For identification purposes only, microscopic observations were conducted biological laboratories of Ataturk University, NE Turkey. Morphological types were identified to the genus level and classification of algae was done using references in literature (Entwisle et al., 1997; van Vuuren et al., 2006; Jonker et. al., 2013).

III. RESULTS AND DISCUSSION

In the Deliçermik thermal spring area (Köprüköy-Erzurum, NE Turkey), hot spring water has a 26 ℃ of temperature and a flow rate of about 3 L/s. The Deliçermik hot water source is hot water with sodium-calcium-bicarbonate-carbon dioxide. The source has HCO_3-> Cl^- anion and Na^++ K^+> Ca^+> Mg^+ cation. The hot water is rich in carbonate and bicarbonate according to its cations, and water rich in sodium and potassium according to its anions. According to results of analysis, it has a total molten mineral content of 2878.52 mg/L (Özdemir 1972; Kılıç, 2018).

In the Deliçermik thermal spring area, hot spring water flows out from the clayey levels of the geological material. These levels are belonging to Horasan Formation aged as Pliocene. Horasan formation includes tuffite and clay intermediate levels in some places. Sandstone with fine granular and shale-marl with yellow color get involved in the upper side of this formation.

These levels consist of some fossils such as *Dreissensia*sp., *Gastropoda*sp. *and Congeria*sp. (Rather, 1969). Although the clayey levels contain high amounts of micro and macro fossil shells and residual minerals, mainly quartz, plagioclase and feldspar, their higher smectite contents gave them thermal mud features (Cara et al., 2000; Dagistan, 2001; Karakaya et al., 2010; Kalkan et al., 2012). The confluent thermal water and clayey geological material are taken the form of thermal mud and it is used as the thermal mud bath.

This thermal spring area hosts thermophilic algae belonging to *Bacillariophyta, Chlorophyta, Cyanophyta* and *Euglenophyta* types (Pabuçcu, 1993; Kalkan et al., 2012; Kılıç, 2018). In this area, the most common algae detected are *Bacillariophyta* type. this is the most dominant algae type between the *Bacillariophyta, Chlorophyta, Cyanophyta* and *Euglenophyta* type. The similar findings were obtained from some studies (Altuner and Aykulu, 1987; Altuner and Gürbüz, 1988; Pabuçcu, 1993; Kılıç, 2018). The algae grovn in the hot spring water flows out from the Horasan Formation and the swimming pool are shown in the Figs. 2 and 3, respectively.

Fig. 2. The algae occurance in the thermal spring water flowing out from the Horasan Formation

Fig. 3. The algae occurrence in the swimming pool of thermal spring area

The occurrence of algae in thermal springs is influenced by the mineral composition and water temperature of the spring (Castenholz, 1969; Pabuçcu, 1993; Sember, 2002; Sompong et al., 2005). Generally, the diversity of algal species increases from 0 °C to 25 °C and decreases at temperatures >30 °C, while biomass increases with temperature from approximately 0 °C to 30 °C and decreases from 30 °C to 40 °C (Dallas, 2008). According to literature records, algae occurrences are restricted below 55 °C, but their formation was found at 68 °C (Winterbourn, 1969; Atlas and Bartha, 1987; Jonker et al., 2013).

Knowledge of the association between the geology and algal distribution could facilitate the identification of specific thermal spring niche ecosystems. Conversely, some algae might be able to act as indicators of geology and specific heavy metals (Jonker et. al., 2013).Because the amount of smectite clay mineral is too high, the mud media of thermal mud pool is very suitable media for the growth of microorganisms (Jahangir et. al., 2001; Veniale et al., 2006; Kalkan et al., 2012). The dense algae growth indicates that the thermal mud media contains abundantly smectite clay minerals preparing the suitable media for the algae occurrence.

The algae grown in the thermal water and thermal mud media is an undesirable situation for their users. Because these algae exhibit unsightly appearance and cause visual pollution in the thermal spring areas. This situation adversely affects sustainable management in thermal areas. Therefore, algae must be removed from these areas or algae formation should be prevented. In the algae removal practices, it should take into account human health and environmental impacts for sustainability.

IV. CONCLUSIONS

In this study, the thermal water, thermal mud and algae occurrence of the Deliçermik thermal spring area was evaluated and the findings was discussed. The water of thermal spring has a 26 ℃ of temperature and a flow rate of about 3 L/s. The water of thermal spring flows out from the clayey levels of the geological material. The clayey levels contain high amounts of micro and macro fossil shells and residual minerals, mainly quartz, plagioclase and feldspar. Their higher smectite contents gave them thermal mud features. The thermal spring area hosts thermophilic algae belonging to *Bacillariophyta, Chlorophyta, Cyanophyta*and*Euglenophyta* types. In this area, the most common algae detected are *Bacillariophyta* type. The algae must be removed from these areas or algae formation should be prevented for the sustainable management in thermal areas. In the algae removal practices, it should take into account human health and environmental impacts.

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