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INVESTIGATION OF THE ISOTOP ATOMIC LEVEL OF GREAT LEAK IN NEMRUT CRATER

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ABSTRACT

Lake Nemrut, the second largest crater lake in the world and the largest in Turkey, is located west of the Lake Van Basin in Bitis province. Due to the region's high rainfall, the isotopic composition of the lake water is influenced by various hydrological processes. While deuterium (^{2}H) and ^{18}O isotopes provide information about regional precipitation and evaporation cycles, tritium (^{3}H) isotope is important because it provides information about the age of water. For this reason, ^{2}H, ^{3}H and ^{18}O isotope levels in lake were examined.

Water samples were taken in September (before the rains started) and in June (after the rains stopped.) In obtained samples were investigated ^{2}H, ^{3}H and ^{18}O isotope levels.

As a result of the analysis of the samples, ^{2}H values were between -27,37 and -28,39, ^{3}H values were between 4.31 and 5.28, and ^{18}O values were between -3.65 and -3.76.

Keywords: Nemrut, Crater, Lake, Isotope atom.

1 INTRODUCTION

Lake Nemrut, the second-largest crater lake in the world, is located between the Tatvan, Ahlat, and Güroymak districts of Bitlis province. Nemrut crater was formed by volcanic explosions and has a mouth width of 48 km^2 and a floor width of 36 km^2. There are a total of 5 lakes, two of which are large, within the crater area at an altitude of 2.247m above sea level in the Nemrut caldera. The western half of the Nemrut Caldera floor is covered with lakes. The

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largest of the Nemrut lakes is the half-moon shaped Lake Nemrut. The average depth of this lake is around 100 meters. A depth of 155 m. was measured at a point on the northwestern edge of the lake. Lake Nemrut has no visible outflow. Figure 1 shows a map of Nemrut Crater.

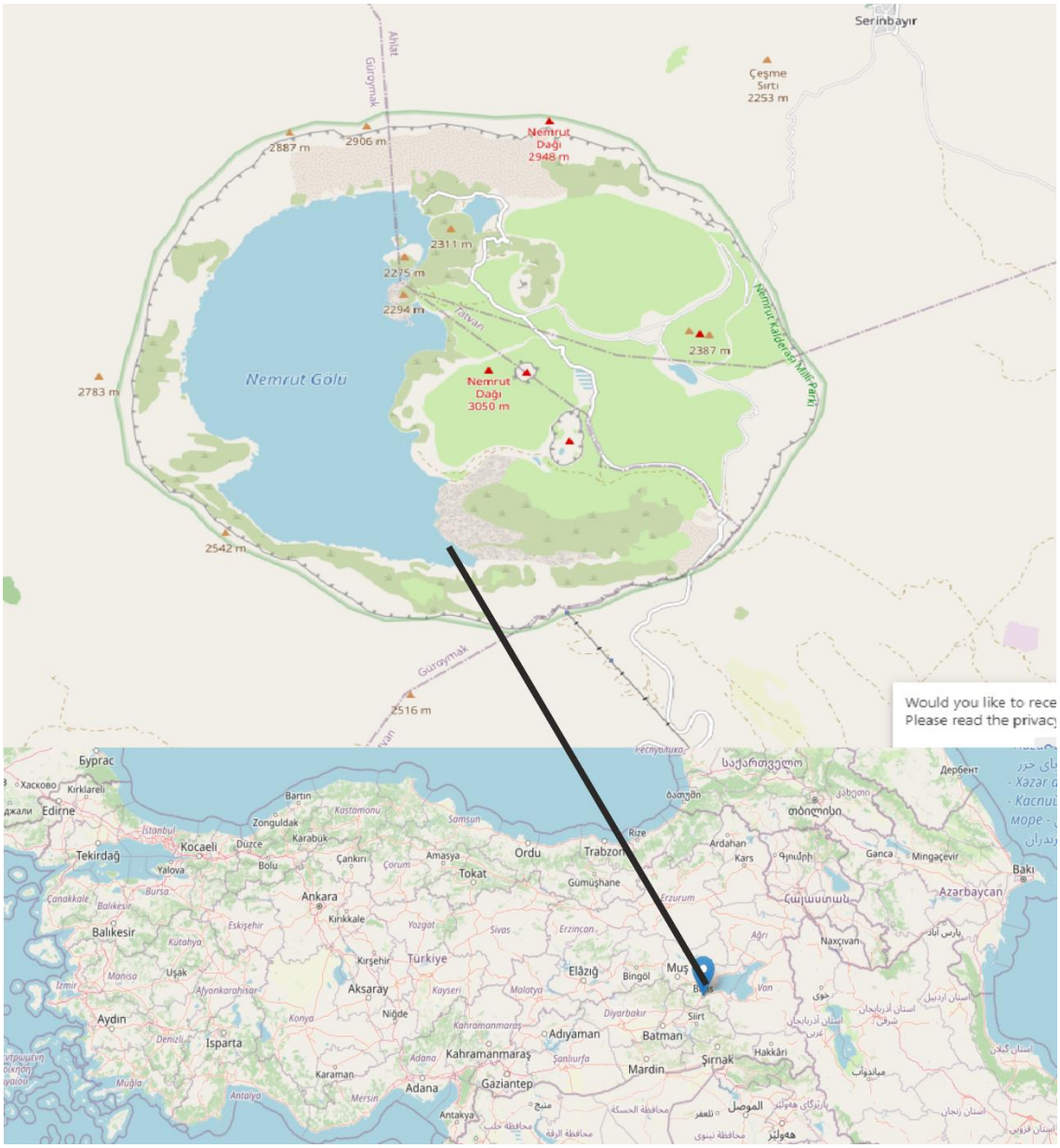


Figure 1. Nemrut crater lake

In a study conducted between 2017-2018 in Nemrut Crater, which is rich in both vegetation and insect species, 93 Pyroloidea and 52 Geometridae species were identified [1]. There are also various studies on the water resources in Nemrut crater. One of these studies was conducted by Kurttaş and Tezcan in 2017. In the study, the water resource potential in Nemrut lakes was investigated. Anion and cation analysis were performed in the water samples taken in the study and the usability of these waters was studied [2]. In another study conducted in the

region, heavy metal concentrations of plants in Nemrut crater were studied. In the study, it was found that the heavy metal levels in the soil and plants in the region were at the levels accepted by the World Health Organization [3]. In another study conducted in Nemrut crater, it was determined that the rocks were composed of compounds such as SiO_2, Al_2O_3 and Fe_2O_3 in the analysis of the rocks with XRF device and that the rocks were stable and the heavy metal leaks in the rocks were very low [4]. In another study conducted in Crater Lake water, it was found that Na, Ca and K levels were 350, 38, 38 mg/L, respectively [5]. Two theses published in the National Thesis Center in 2024 about Nemrut Crater were found. In the first of these, the water quality of the crater lake was examined and the identification and larval development of Aphanius mentoture was examined. In the current thesis, it was determined that the water of the crater lake is suitable for drinking and use [6]. In the second thesis, heavy metal concentrations in sediment and plant samples in the lake were examined [7].

^{2}H and ^{18}O levels in water samples vary depending on the amount of precipitation. At the same time, the level of evaporation in the water depending on the temperature of the region also causes changes in the levels of these isotopes [8]. The level of tritium isotope, which is another subject of this study, is also used to determine the age of water. Yang and Wang analysed isotope levels in moisture in the northern region of the Tibet Plateau. They state that the reason for the excess deuterium in the groundwater is affected by the winds coming from the west [9]. Kralik et al.[10] studied ^{2}H and ^{18}O levels in Austria. They showed that the highest levels of tritium in Austria are found in the Danube and the River March. They state that the reason for this is the nuclear power plants in neighbouring countries. Demer [11]studied the isotope levels of groundwater in Isparta region. According to the data obtained, groundwater is fed from high elevations. Bozdağ [12] investigated the isotope levels of groundwater in Konya Cumra region. Determined that the level of tritium varies depending on the level of precipitation. In a study carried out in the Zonguldak region between 1994-1995, ^{2}H, ^{3}H, ^{18}O levels in groundwater were studied. According to the findings, it was determined that the groundwater is fed by sea-origin precipitation [13].

In this study, the time-dependent changes of ^{2}H, ^{3}H and ^{18}O isotopes previously investigated in Nemrut Crater Lake were analysed.

2 MATERIAL AND METHOD

Water samples were taken in September (before the rains started) and in June (after the rains stopped.) In obtained samples were investigated ^{2}H, ^{3}H and ^{18}O isotope levels. Samples were taken from 4 different points. Water samples were taken in polythene bottles and sent to the DSI isotope analysis laboratory to examine their isotope composition.

3 RESULTS AND DISCUSSION

In this study, ^{2}H, ^{3}H and ^{18}O levels in the large lake located in Nemrut Crater within the borders of Bitlis Province were analyzed. In the study, water samples were taken from different parts of the lake at different time periods and sent to Ankara DSI Isotope analysis laboratory and analyzed. According to the results of the analysis, ^{2}H isotope level was found between -27.37 and -28.39 and ^{18}O values were found between -3.65 and -3.76. In addition, ^{3}H values were found between 4.31 and 5.28. The shift of the ^{3}H value from 4.31 to 5.28 indicates the evaporation of water during the summer period. If the ^{3}H value is between 1-8 TU, these waters are called mixed waters (recent water+ old groundwater) [14]. The tritium level in our samples is in the range of 1-8 TU. This may suggest that the water in the Great Leak in Nemrut Crater is a mixture of both new and old water. If the ^{3}H level is between 0.8-4 TU, these waters are recharged before and after 1952. If the ^{3}H content is between 5-15 TU, these waters are recharged after 1987 [15]. Considering these data, it can be claimed that the Great Leak in Nemrut Crater was recharged before and after 1952.

Deuterium excess is calculated according to the following formula

$$\text{d-excess} = \delta^{2}H - 8 \times \delta^{18}O$$

d-excess ranges from ≈ 2.5 to 1.7%. These values differ from the global meteoric water line (GMWL, d=10). At the same time, we can say that there is evaporation by looking at this parameter.

In 2019, a thesis study conducted in Nemrut Crater found that the ^{2}H level was -33 and the ^{18}O level was -3. [16]. In our study, water samples were taken in October 2023 and June 2024. When compared with the results obtained in our study, an increase in ^{2}H level is observed. A negative increase was also observed at ^{18}O level. The reason for this change is likely to be the increase in water evaporation or isotope transfer from rocks to water due to precipitation. In the present study, While the highest tritium level found in the thesis was 4.5, the highest

tritium level found in our study was 5.28. When the results are compared, it can be said that an increase in ^{3}H level has occurred. In a study published in 2012, in the Great Leak in Nemrut Crater ^{2}H level was found to be -64.5 and ^{18}O level was found to be -9.57 (according to VSMOW) [17]. When the above two studies and our study are compared, it can be easily seen that there are time-dependent changes in ^{18}O and ^{2}H levels.

Zhou et al. [18] studied isotope atomic levels in the Avoca River in Australia. They examined the levels of ^{18}O, ^{2}H, ^{222}Rn, ^{3}H, ^{14}C and ^{36}Cl in the river. They found the ^{3}H level in the range of 1.64-5.11 TU. The study shows that the normal value is 2.8-3.2 TU and they attribute the higher values to the late winter season. Another study examining ^{2}H, ^{3}H, ^{18}O levels was conducted in Tibet. The study was conducted in the Kaindam Basin in the north of the Tibetan plateau. In the study, ^{18}O levels were found in the range of -14.8 to 3.97 [19]. The study, which examined the recharge processes of groundwater resources, was conducted between 2013 and 2016 on the Perth coast of Pottnest Island, Australia. The ^{2}H level was found to be in the range of -18.4- (-16.5), the ^{3}H level in the range of 0.74-1.16 and finally the ^{18}O level in the range of -4.2- (-3.9) [20]. Kralik et al.[21] analyzed ^{2}H, ^{3}H, ^{18}O levels in different regions of Austria. They found the highest ^{3}H levels in Austria in the Danube River. Costa Lima et al. [22] studied isotope levels in the San Francisco basin in Brazil. ^{18}O level was found in the range of -6.52-(-2.78). ^{2}H levels were also found in the range of -42.9 -(-11.1). One of the studies was conducted by Yurteri. In this study, the isotope content of the wetlands in Seyfe Lake was investigated. This study utilized isotope techniques that will help to understand the hydrogeologic processes in the Seyfe Lake basin. Tritium analysis could not be performed in this study [23]. Uras et al.[24] utilized isotope atoms in their studies and reached information about the origin of waters and the quality of spring waters.

These isotopes are of great importance in understanding the interaction between geothermal waters and rocks (water-rock relationship). With these isotopes, important information can be obtained about the paths and origins of the waters. In particular, they can help to estimate the temperature of the geothermal reservoir in the region where a geothermal system is located. At the same time, these isotopes reveal the evolution of a geothermal system. The ^{2}H and ^{18}O isotopes are two isotopes of direct interest in interpreting a geothermal system. Because ^{2}H and ^{16}O isotopes have higher vapor pressure than H and O. Thus, when water evaporates, the vapor is enriched in ^{16}O and H, while ^{18}O and ^{2}H remain liquid [25]. Nemrut crater is located in a region with excessive rainfall. Since the region is volcanic, the isotopes in

the rocks are likely to pass into the water with precipitation. In this study, one of the possibilities of high isotope atoms may be isotopes coming from rocks.

^{3}H values are between 4.31 and 5.28. According to the ^{3}H analysis of the waters in the study area, it is understood that the TU value in the water samples taken from the lake is close to 5. As a result of the results obtained here, the waters with TU values in the range of 1-8 can be expressed as a mixture of current and old waters. Our findings provide a valuable contribution to understanding the hydrological cycle of the lake ecosystem and its effects on water quality. There is a significant relationship between water quality and the isotopes ^{2}H, ^{3}H, and ^{18}O. These isotopes serve as hydrological indicators used to determine the origin, circulation, and age of water. ^{2}H and ^{18}O are utilized to understand how water changes through processes such as evaporation, precipitation, and groundwater movement. ^{3}H, on the other hand, is a radioactive isotope and an important indicator for determining the age of water. It is especially used to assess the renewal process of groundwater and the sustainability of water resources.

Furthermore, this study provides a basis for future research in similar lakes. In conclusion, the analysis of the isotopic composition of water is an important tool for the sustainable management and conservation of lake ecosystems.

4 CONCLUSION AND SUGGESTIONS

Since it is a crater lake, it can be said that the lake water interacted with the atmosphere for a long time. Furthermore, the narrow range of values (for both $\delta^{2}H$ and $\delta^{18}O$) indicates that the lake is a mixture of old and new water. Deuterium excess parameter - Evaporation effect is evident.

As the crater lake is a closed basin, isotopic enrichment is expected. Source of water according to the results obtained;

- Meteoric water (rain and snow) can be argued to be the main source.

- Since the lake is volcanic, it is possible that there is a geothermal contribution.

- It can be claimed that the effect of evaporation-condensation cycle is evident.

In addition, when compared with the results obtained from the studies carried out in Nemrut Crater Lake in 2012 and 2019, it was determined that there was a noticeable change in the concentration of isotopes depending on time.

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Conflict of Interest Statement

There is no conflict of interest between the authors.

Statement of Research and Publication Ethics

The study is complied with research and publication ethics.

Artificial Intelligence (AI) Contribution Statement

This manuscript was entirely written, edited, analyzed, and prepared without the assistance of any artificial intelligence (AI) tools. All content, including text, data analysis, and figures, was solely generated by the authors.

Contributions of the Authors

Sample collection and manuscript preparation were carried out by Ayşe Gül Çetinarslan.

Sample collection, data processing, and manuscript preparation were carried out by Engin Yılmaz.

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