# An Investigation of Mn Contents in Water and Bottom Sediments from Eğirdir Lake, Turkey

✉Şehnaz ŞENER[1], Ömer ELİTOK[1], Erhan ŞENER[2], Ayşen DAVRAZ[1]

[1]Suleyman Demirel University, Department of Geological Engineering, Isparta/TURKEY
[2]Suleyman Demirel University, Center for Remote Sensing, Isparta/TURKEY
Tel: +90 246 2111322
sehnaz@mmf.sdu.edu.tr

***Abstract*** **-** The Eğirdir lake in the apex of Isparta Angle (SW Turkey) is one of the most important fresh water in Turkey and also used as drinking water source of Isparta city. This study aims to determine the origin of the high Mn concentration in the Eğirdir Lake water and bottom sediments. For this aim, water and bottom sediment samples were collected and Mn concentrations of the samples were investigated. Also, enrichment factor (EF) of the Mn has been calculated to determine origin of the element. According to the obtained results, in the southeast of the lake, Mn concentration is around 196.68 ppb in the lake water and 1134 ppm in the lake sediments, over the maximum acceptable values of World Health Organization and Turkish Standards Institute (0.05 ppm and 0.01 ppm, respectively). Furthermore, in the southwest of the lake, Mn concentration varies between 20.8 – 1.42 ppb in the lake water and 193-227 ppm in the lake sediments. Mn-bearing ophiolitic rocks outcrop around the lake, especially in the southeastern side. Field observations show that anthropogenic-related pollutants are negligible for the Mn contamination in the lake water. Therefore, we speculate that high Mn concentrations in the lake water and bottom sedimants may have been resulted from Mn-bearing ophiolitic rocks outcropping in the southeastern side of the lake by the way of water-rock interaction.

**Key words:** Eğirdir Lake, Enrichment Factor, Mangan, Water-rock interaction, Ophiolite

# Eğirdir Gölü (Türkiye) Su ve Dip Sedimanlarındaki Mn Düzeylerinin Araştırılması

***Özet-*** Türkiye'nin en önemli tatlı su kaynaklarından biri olan Eğirdir Gölü Isparta ilinin içme suyu kaynağı olarak kullanılmakta ve Isparta açısının (GB Türkiye) apeks bölgesinde yeralmaktadır. Bu çalışmanın amacı, Eğirdir Gölü su ve dip sedimanlarında izlenen yüksek Mn içeriklerinin kökenini belirlemektir. Bu amaçla, Eğirdir Gölü'nden su ve dip sediman örnekleri alınarak bu örneklerin Mn içerikleri araştırılmıştır. Ayrıca, Mn elementinin kökenini belirleyebilmek için zenginleştirme faktörü (EF) değerleri hesaplanmıştır. Elde edilen sonuçlara göre, gölün güneydoğundan alınan su örneğinin Mn içeriği 196,68 ppb iken dip sediman örneğinde 1134 ppm Mn tespit edilmiştir. Bu değerler Dünya Sağlık Örgütü (0.05 ppm) ve Türk Standartları Enstitüsü (0.01 ppm) tarafından belirlenen maksimum kabul edilebilir Mn konsantrasyonlarının oldukça üzerindedir. Ayrıca, gölün güneybatısından alınan su örnekleri 20.8 – 1.42 ppb arasında, dip sediman örnekleri ise 193-227 ppm Mn içermektedir. Göl çevresinde, özellikle güneydoğusunda Mn sıvanmalarının gözlendiği ofiyolitik kayaçlar yüzeylenmektedir. Göl çevresinde yapılan arazi gözlemlerine gore, gölde Mn kirliliğine sebep olabilecek antropojenik kökenli kirleticiler ihmal edilebilecek boyuttadır. Bu nedenle, göl su ve dip sedimanlarında ölçülen yüksek Mn konsantrasyonlarının, gölün güneydoğusunda yüzeyleyen ofiyolitik kayaçlarla ilişkili kayaç- su etkileşiminden kaynaklandığı düşünülmektedir.

**Anahtar Kelimeler:** Eğirdir Gölü, Zenginleşme Faktörü, Mangan, Kayaç-su etkileşimi, Ofiyolit

## 1. INTRODUCTION

Manganese (Mn) is an essential trace element for all living organisms. It plays an important role in various parts of metabolism in humans and animals as well as in microorganisms and plants [1, 2]. It is an abundant element in the earth's crust. It comprises about 0.1% of the crust [3] and occurs in various primary rocks, very often together with iron [4]. It is widely known that highly mobile or soluble Mn(II) is initially released into the environment from hydrothermal fluids or weathering of Mn(II)-bearing rocks, such as mafic silicates, Mn carbonates [5], Mn-bearing cherts and also ophiolitic rocks. Mn concentration in waters may result mainly from I) weathering and solution of Mn from soil and bedrock and transportation into waters, ii) human activities [6], iii) industrial effluent, iv) acid-mine drainage, v) sewage and landfill leachate. It is difficult to remove Mn from

contaminated waters due to its high solubility over a wide pH range [7]. High Mn concentration in waters can cause staining of laundry, variety of serious health risks and add metallic taste to water [8]. Therefore, manganese in sources of water used for human consumption is undesirable.

The Eğirdir Lake, one of the most important freshwater lakes in Turkey with potential to supply 4×109 $m^3$ of water, is bounded by autochthonous carbonates in the west and east. Ophiolitic rocks and Mn-bearing slope-basin deposit of Antalya Complex (Antalya Complex) occur mainly in the lake area and its southern extension (Fig. 1). At present, Eğirdir Lake supplies drinking water to Isparta [9] and it has high Mn concentration. The main aim of this study is to determine the origin of the high Mn concentration in the Eğirdir Lake water and bottom sediments.

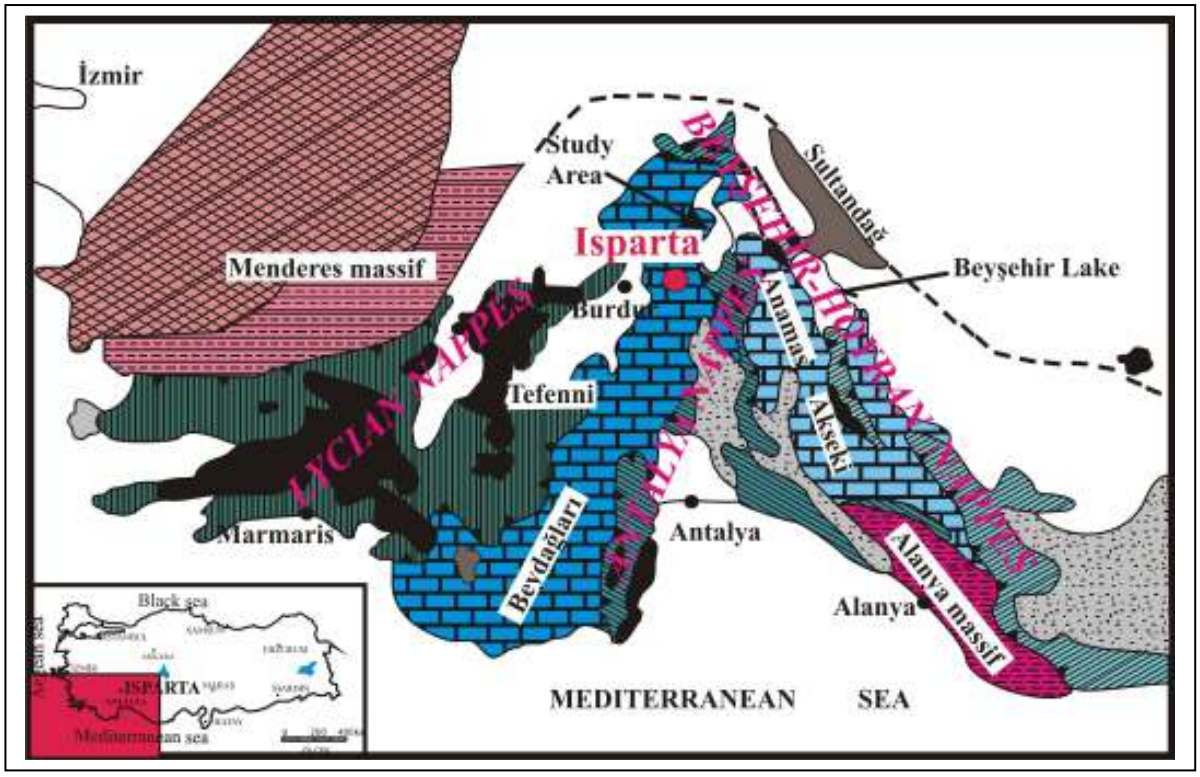


Figure 1. The location map of the study area [10]

## 2. MATERIAL AND METHOD

The Eğirdir Lake is a tectonic lake that lies in the north–south direction in the apex of Isparta Angle. The surface area of the Eğirdir Lake is 46 800 ha, the average depth is 7 m. and the volume of the lake is estimated to be 3276 $hm^3$ [11]. The lake is the second largest freshwater lake in Turkey which is used for different purposes such as irrigation, tourism, fishing and drinking water need of Isparta [10]. However, water quality in the lake is affected from several factors such as insecure landfills, sewerage discharges, agricultural applications etc. Furthermore, rock units around the lake area most probably play an important role on the water quality due to water-rock interaction.

Water and sediment samples were taken from seven different locations (Fig. 2). Water samples were stored in polyethylene bottle and acidified with $HNO_3$ to protect water samples. They were analyzed at the ACME Laboratory (Group 2C & 2D ICP-MS) and Mn contents of the waters were determined.

Sediment samples were taken from the bottom of the Lake using Birdge Ekman Grab (15 cm x 15 cm) and analyzed at the same laboratory (Group 1F-MS ICP-MS) in order to determine Mn contents. Mn-bearing ophiolitic rocks outcrop around the lake, particularly in the southeastern side of the lake. Rock samples were taken from the ophiolitic rock units and analyzed at the ACME Laboratory to determine their Mn content. Using the data obtained in the analyses, the EFs of Mn elements have been calculated according the following equation:

***EF = Cx.Cn (ambient) : Cx.Cn (background)***

Where;

***Cx;*** is the concentration of the X element whose enrichment is to be determined

***Cn;*** is the concentration of the N normalizing element assumed to be uniquely characteristic of the background.

In our case, the ambient consists of samples of lichens while the background consists of samples of the surrounding soils. Elements with EF values that are significantly higher than 1 can be considered not originated from the local soil background and may be attributed to long transportation phenomena from other natural and/or anthropogenic sources, or, in some cases, to a possible referential uptake. In this study Al was used as normalizing element in calculations.

## 3. RESULTS AND DISCUSSION

The concentrations of Mn in water and sediment samples collected from the seven sampling points are given in Table 1 and the EF values of the Mn can be seen in the same table. Mn concentrations of the water samples vary between 20.8 – 1.42 ppb, and 193-227 ppm in the lake bottom sediments. In the southeast of the lake Mn concentrations are higher (with 196.68 ppb in the lake water and 1134 ppm in the lake sediments) than its other sides (e.g. 20.8 – 1.42 ppb in the lake water and 193-227 ppm in the lake sediments, Fig. 2).

The maximum acceptable Mn concentration for drinking water is 0.05 ppm and 0.01 ppm according to the World Health Organization [12] and Turkish Standards Institute [13], respectively. According to field observations, for 6 and 7 numbered locations, anthropogenic-related pollutants are negligible for the Mn contamination in the lake water. However, Mn-bearing siliceous rocks of Antalya Complex outcrop in the southeastern side of the lake. A drainage system, Çay stream, occurs in the Mn-bearing ophiolitic rocks and discharge to the Eğirdir Lake. Mn content of one sample (M-1) taken from Mn-bearing siliceous rocks is 1284 ppm. Considering the highly mobile or soluble nature of Mn, it is more plausible to think that the higher Mn content in the Eğridir lake water may have been resulted from Mn-bearing ophiolitic rocks in the southeastern side of the lake by the way of water – rock interaction (Fig. 3).

Additionally, calculated EF values given in Table 1, are >1 for all of sediment samples. Therefore, the water – rock interaction scenario have also been confirmed with enrichment factor for southeast of the lake. But, in 4 numbered location is north side of the Yalvaç Stream discharge points and the anthropogenic-related pollutants can be move in the lake via stream flow. Because, domestic and industrial wastewaters, including effluents from leather tanneries are discharged, without being purified, into Yalvac Stream, which flows into Egirdir Lake directly or via the drainage canal [14].

Table 1: Sampling points and Mn Concentrations of water and bottom sediments with EF values

| Sampling Locations | Mn Concentration (Water-ppb) | Mn Concentration (Sediment-ppm) | Enrichment Factor (EF) |
|---|---|---|---|
| **1** | 2.85 | 158 | 3.8 |
| **2** | 1.17 | 193 | 4.9 |
| **3** | 1.42 | 227 | 5.3 |
| **4** | 20.8 | 591 | 11.8 |
| **5** | 6.11 | 619 | 12.76 |
| **6** | 196.68 | 1134 | 34.7 |
| **7** | 17.12 | 1065 | 31.6 |
| **M-1** | 1284 ppm (rock sample) | | - |

## 4. CONCLUSION

The Eğirdir Lake is a tectonic lake in the apex of Isparta angle and one of the most important freshwater lakes in Turkey. In the southeast of the lake, Mn concentrations are higher with 196.68 ppb in the lake water, over the maximum acceptable values of World Health Organization and Turkish Standards Institute (0.05 ppm and 0.01 ppm, respectively). In bottom sediments of the lake, Mn content was determined between 158 ppm and 1134 ppm. Also, calculated EF values were found as > 1 for all sediment samples. This case shows that Mn not originated from the local soil background, it can be related with natural and/or anthropogenic sources. According to lithologic units outcrop around the lake, Mn-bearing ophiolitic rocks can cause high Mn contents in lake water and sediments. Also, Yalvac Stream can transport Mn into Eğirdir Lake directly or via the drainage canal.

Manganese in sources of water used for human consumption is undesirable. Taking into consideration the Eğridir lake is used as drinking water, it should be studied in detail and urgent preventions should be taken.

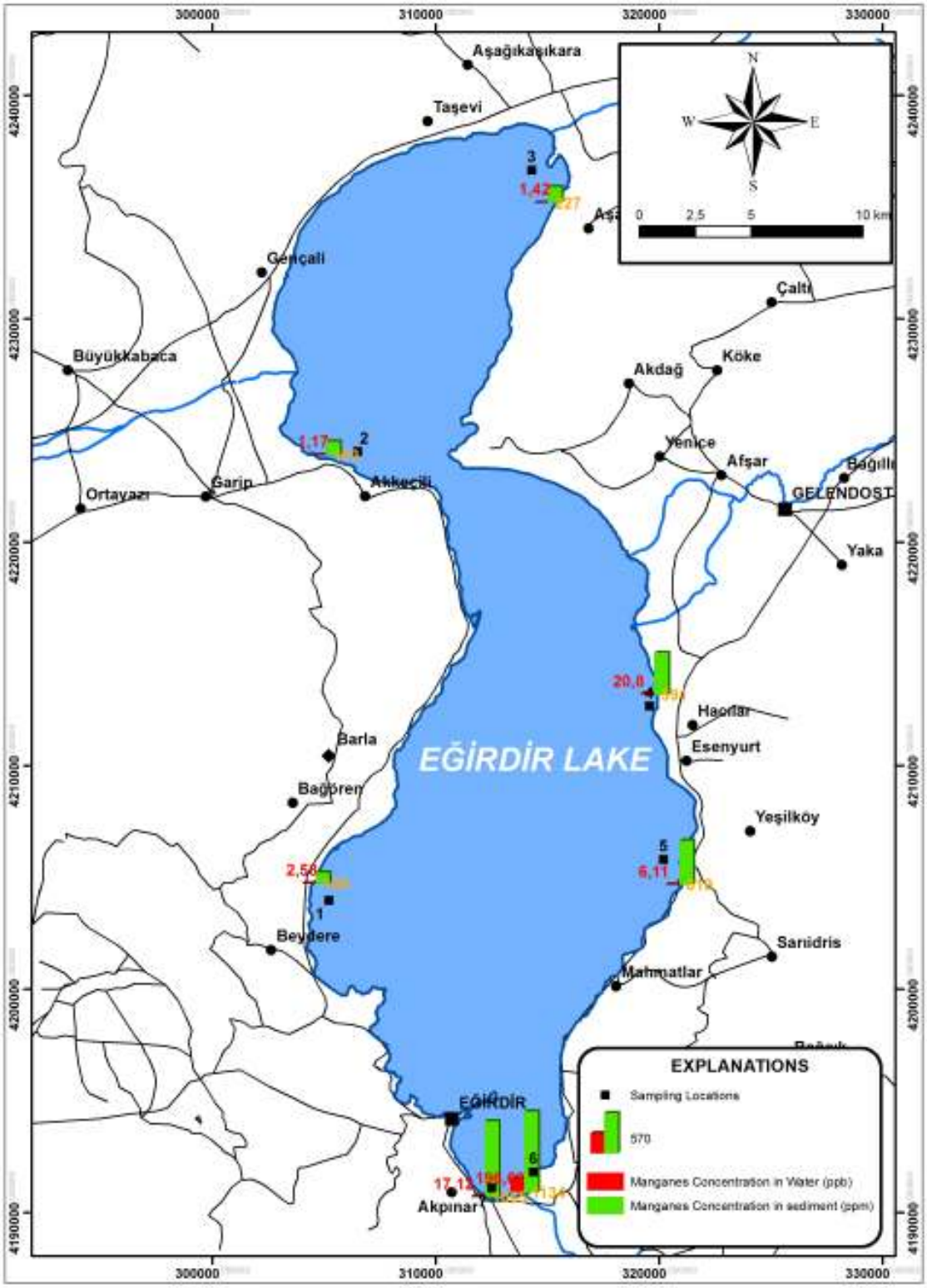


Figure 2. The location map of the sampling points

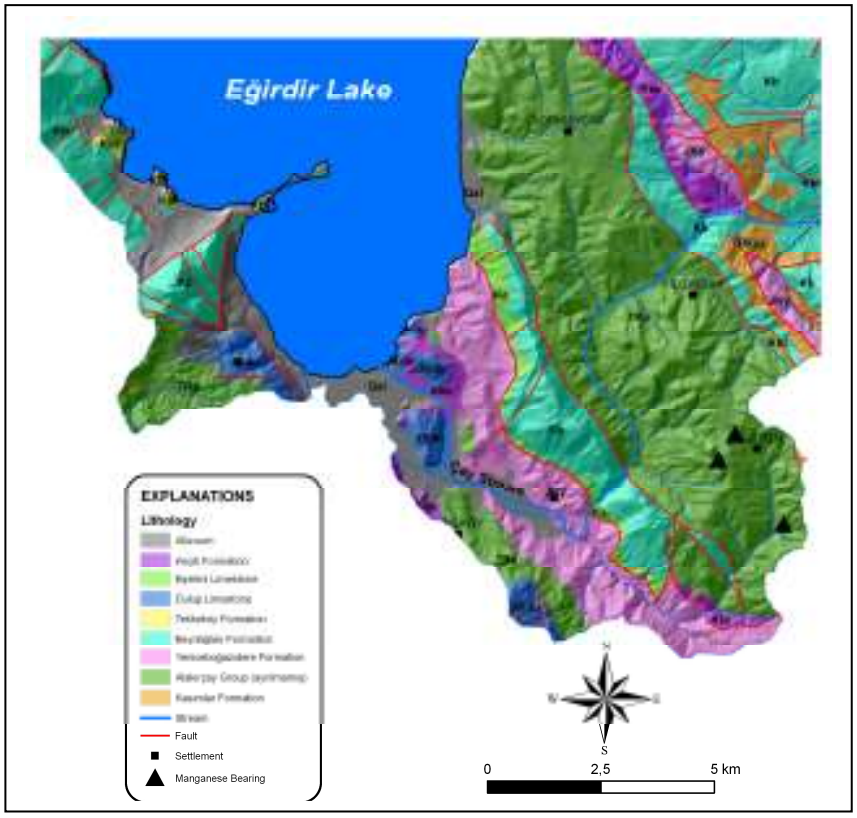


Figure 3. The geology map of the study area [modified from 15,16]

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