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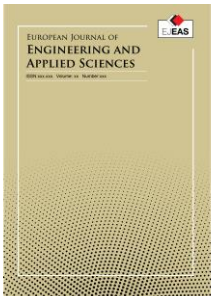

Research Article

Presenting Water Quality Characteristics of Lake Salda, Turkey

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Abstract: Inland water bodies, either flowing or non-flowing all around the world, are under the adverse effect of both the climate change and anthropogenic activities. The water surface areas of lakes and wetlands diminish over time and thus, this global reality brings together the deterioration of water quality especially if such water bodies confront with a variety of human activities exerting pollutants. An example of such a vulnerable ecosystem is the Lake Salda located in the southwestern part of Turkey. This lake has gained the attention of international public due to its similarities with Mars. Over a long period of time, many researches have been conducted in this lake by different disciplines and scientists to better understand its unique features. In this study, water samples from the three selected stations on the lake at three different depths were collected and analyzed on physico-chemical parameters, organic matter content, nutrients, metals and semi metals according to national legislation and Water Framework Directive (WFD) of EU. The results are tabulated and analyzed in detail considering the potential pollution sources arising from the lake's basin. The pollutants are linked with the experimental measurements, and those parameters that exceeded the Environmental Quality Standards (EQS) are underlined. It is for sure that the lake necessitates utmost care and attention according to the results achieved.

Keywords: *Environmental Quality Standards, Lake Salda, Water Quality, Water Quality*

Su Kalitesi Durum Değerlendirmesi- Salda Gölü, Türkiye

Öz. Tüm dünyada iç su kütleleri hem iklim değişikliğinin hem de antropojenik faaliyetlerin olumsuz etkisi altındadır. Göllerin ve sulak alanların su yüzey alanları zamanla azalır ve bu küresel gerçeklik, özellikle su kütleleri çeşitli insan faaliyetleriyle karşı karşıya kalırsa, su kalitesinin bozulmasını beraberinde getirir. Bu tür hassas bir ekosisteme örnek, Türkiye'nin güneybatısında yer alan Salda Gölü'dür. Salda Gölü, Mars ile olan benzerlikleri nedeniyle uluslararası kamuoyunun ilgisini çekmiş, gölün spesifik özelliklerini daha iyi anlamak için farklı disiplinler ve bilim adamları tarafından birçok araştırma yapılmış ve su kalitesi zaman içinde belirli parametrelerle ortaya konmuştur. Çalışma kapsamında gölde seçilen üç istasyondan üç farklı derinlikte toplanan su örneklerinde hem ulusal mevzuatta hem de AB'nin Su Çerçeve Direktifinde (SÇD) belirtilen fiziko-kimyasal parametreler, organik madde içeriği, besinler, metaller ve yarı metallerin analiz sonuçları sunulmuş, Çevresel Kalite Standartlarını (ÇKS) aşan parametrelere dikkat çekilerek potansiyel kirlilik kaynakları ile birlikte sonuçlar değerlendirilmiştir. Elde edilen sonuçlarla göre gölün azami dikkat ve özen gerektirdiği bir kez daha ortaya konmuştur.

Anahtar Kelimeler: *Çevre Kalite Standardı, Salda Gölü, Su Kalitesi, Su Kirliliği*

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1. Introduction

Lake Salda, a local site in Turkey as different from the worldwide recognized areas, bears unique beauty. The lake has attracted a significant number of tourists in the recent years due to the interest of international media as it has some common properties with Mars [1]. The lake has been cited among the major soda lakes of the world [2]. As known, soda lakes occur worldwide and they seem to be associated with active tectonic and volcanic zones. There are 66 soda lakes in the world; among which 24 of them exist in the Asia continent [3].

The water clarity of Lake Salda has been compared with the Maldives and its surface properties with Mars [4]. It has been revealed that the magnesium-rich white rocks found within the lake are also found in Mars as referred by the work of [5]. The most relevant analogy to the Jezero Crater carbonates may be provided by Lake Salda, around which hydro-magnesite strandline terraces lie, including a hydro magnesite-cemented fan delta with beach deposits of hydro magnesite, including stromatolites, and pebbles of lizardite [6, 7]. As known, Jerezo Crater is the landing site of the NASA Mars 2020 rover (Figure 1). Figure 1 shows the image of Lake Salda belonging to June 8, 2020 as observed by the Operational Land Imager (OLI) on Landsat 8. The lake contains alluvial fans full of rock deposits eroded and washed down from the surrounding bedrock.

Lakes are one of the most important components of natural resources. Due to its unique features, Lake Salda has recently attracted the attention of both national and international scientists and some studies have so far been carried out on the lake to explore its main physical, chemical and biological characteristics beyond its interesting geological formation and hydrological behavior. The origin and recharging properties of groundwater and surface water has been investigated by using environmental isotopic, radiocarbon and physicochemical characteristics [8, 9]. In a study conducted on its groundwater characterization, high arsenic concentrations were found and Magnesium Hazard (MH) values were also determined to be an important problem in use as irrigation water [10]. In another recent study, the scientists conducted biotic and abiotic imprints on Mg-rich stromalites [11]. Such researches aim to provide new insights of the formation pathway of Mg-rich carbonates not only for local geological records; but also, for planetary bodies like Mars.

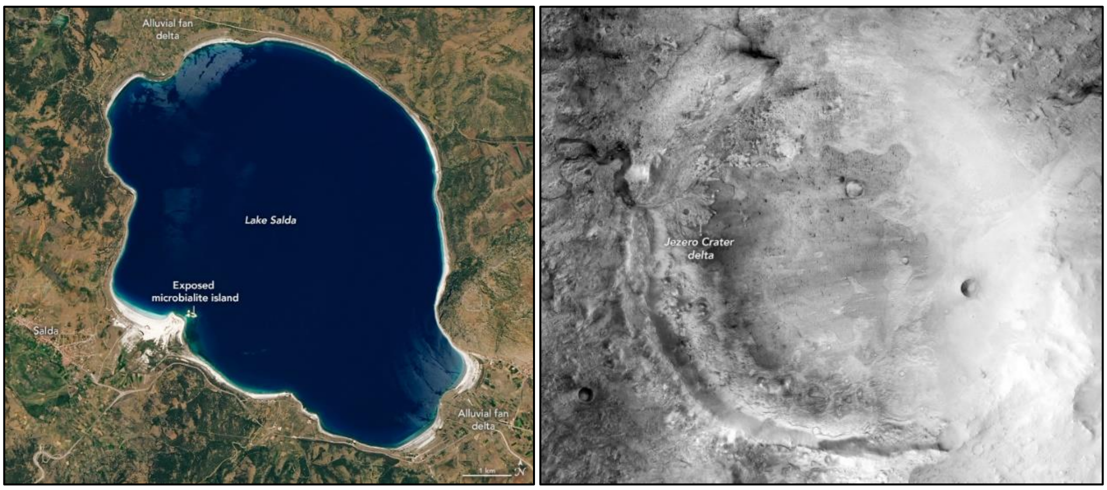

Fig. 1. *Lake Salda in 2020 and Jezero Crater in 2017 [12]*

Almost 4.6% decrease was observed in the water surface area of the lake between 1972-2019 as a result of a spatial analysis with the aid of Geographical Information Systems (GIS), and statistical analysis of the meteorological data and satellite images has been determined. According to the assessment of these works, Lake Salda has also been experiencing adverse effects of climate change over years like many of the other lakes in the same region [13]. Similarly, the shoreline changes in the lake up to 16.35 m/year between 1975 and 2019 were calculated [14]. Based on the results of the study, there was a considerable decrease in the lake area. In another study where the limnological character of the lake was presented, it is indicated that the lake highly is threatened by dropping water levels and organic pollution [15]. In a research conducted to determine the water quality of the lake and to evaluate its prevailing hydro-geochemical processes, it was found that the dominant water type of the lake is Mg-CO_3-HCO_3, and the lake was of Class I in terms of temperature, dissolved oxygen, NH_4 and NO_2 parameters according to USEPA regulations [16]. However, the water belonged to Classes II, III, IV and even V with respect to pH, electrical conductivity (EC), NO_3, biochemical oxygen demand (BOD), oxygen saturation, As and Cr in different periods. The increase in the As and Cr concentrations was considered to be geo-genic in origin.

Even though quite a lot of studies exist on the various features of Lake Salda, an overall water quality characterization and evaluation involving a high number of parameters to determine its physicochemical properties, organic matter and nutrient concentrations together with metals and semi metals presence based on annual water sampling results was lacking. This study attempts to fulfill this gap in the scientific arena through presenting the yearlong monitoring results of 2018 and assessing the water quality status according to the revised National Regulation on Surface Water Quality dated 2021. Conducting studies on the control of pollution in this lake are important not only for the preservation of the existence of natural resources, but also for the sustainability of studies on life at Mars.

Within the scope of this study, anthropogenic point and non-point (diffuse) pollutant loads arising from the lake's basin and ending in the lake were identified and calculated, year-around water samples were taken and experimental analyses were carried out for pollution monitoring. The physico-chemical parameters, organic matter, nutrients, metals and semi metals were evaluated according to both the national water quality standards and Water Framework Directive (WFD) of European Union (EU) [17]. Moreover, the need to reduce pollutants exceeding the Environmental Quality Standards (EQS) were determined based on the quantitative values of pollution loads to which the lake was exposed. In that sense, this article is the first attempt to put forth the detailed water quality assessment that aims to give feedback to the decision-makers and related local authorities in charge of its management for the sake of its sustainability.

2. Materials and Methods

2.1. Study Area

Lake Salda is a natural park located within the district of Yesilova in Burdur Province of Turkey (Figure 2). It has a surface area of 45 km^2 located within a closed basin and stands at 1,139 m above the sea level [18]. It is known as the 3rd deepest lake of the country with a depth of 184 m. It is highly alkaline (pH 8-10) and magnesium rich [19]. The groundwater of the area recharges the lake, where it is intensively used for drinking, domestic and irrigation purposes.

Lake was declared as a Special Environmental Protection Area in 2019, and it has been registered as a 1st degree Natural Protection Area in 1989. At the same time, as the lake has a sensitive and fragile ecosystem, it is classified as an 'Important Plant Area' (IPA) and 'Important Bird Area' (IBA) according to international criteria [20, 21]. Lake Salda owns a rich biodiversity and bears satisfactory sheltering, breeding and nesting conditions for the endemic and endangered species. Within this context, the Ministry of Environment and Forestry of the Republic of Turkey (TR) stated that the area is a habitat to 301 aquatic and terrestrial species belonging to 61 families, among which 20 of such species are endangered and endemic [22]. With its snow-white sand based on its geological properties faces the risk of vanishing. Due to the human-induced activities of the recent years, it has started to darken. The dams and reservoirs built near the lake for providing irrigation water to the agricultural fields, and presence of stone and marble quarries on the mountains and their skirts has significantly cut and/or diminished freshwater entrance to the lake. Therefore, the balance of the water feeding the lake and lost through evaporation has been spoilt recently. The main reasons for the changes in the shorelines were the structures such as irrigation ponds and dams built on the rivers that recharge the lake, and changes in precipitation/temperature conditions [14]. The small beaches on the southwest and southeast coasts of the lake are used for recreational purposes due to the cleanliness of the turquoise-colored water.

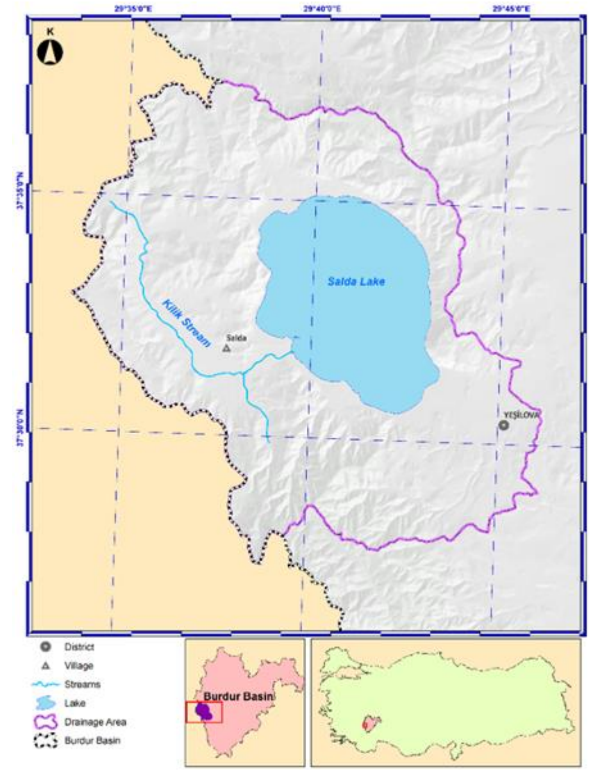

Fig. 2. Lake Salda and its location in Turkey

2.2. Sampling and Analyses

Water sampling study was carried out at three points (L1, L2 and L3) within the lake between January-December 2018. Samples from each of the sampling stations were taken at three different depths; namely, surface, mid and bottom layers. 8 physicochemical, 3 organic matter, 8 nutrient parameters and 27 metal/semi metals were analyzed monthly and/or once every three months representing seasonal variations.

In all sampling work, 5-liter prewashed amber glass bottles were shipped to the laboratory. Samples were transported to the laboratory and stored at 4°C until analysis. Temperature, pH, dissolved oxygen, turbidity, secchi disc measurements were carried out in the field.

Pre-processing and analysis of metals was performed in dissolved and total phase according to EN ISO 17294 1-2 methods. Water samples for trace metal analyses were filtered through 0.45 μm acetate-cellulose filters, the filtrate was taken in 50 mL plastic vials and acidified with 0.5 mL of analytically pure HNO_3. After pre-processing and microwave extraction, it was analyzed by ICP-MS device from Agilent Technologies.

The plasma conditions were forward power (1550 w), gas flow rate (15 L/min), auxiliary gas flow rate (0.9 L/min) and nebulizer gas flow rate (1.1 L/min). The recovery was in the range of 85-99%. It was analyzed with the quality control solution before each run (Level of Quantification (LOQ): 0.02-1 µg/L; Level of Detection (LOD): 0.007-0.3 µg/L). The recovery was in the range of 85-99%. Locations of the 3 sampling points are shown in Figure 3.

2.3. Pressures and Threats on the Lake Basin

The limnological character of the lake has been threatened by decrease in water levels and organic pollution [15]. Point and diffuse anthropogenic sources of pollutants were determined in the lake basin that would affect the water quality as follows;

- There are direct domestic wastewater discharges from two settlements to the lake; Yeşilova district with a population of 6908 and Salda Village with 1104 inhabitants. Other than that, there are no other point sources generating pollution in the basin (Point pollutants).
- There exists an unsanitary solid waste landfill in the basin with a surface area of 4756 m^2 (Diffuse pollutants).
- There are four chrome-mining sites (Diffuse pollutants).
- Livestock activities are carried out with annual breeding of 2223 bovine and 13639 ovine (Diffuse pollutants).

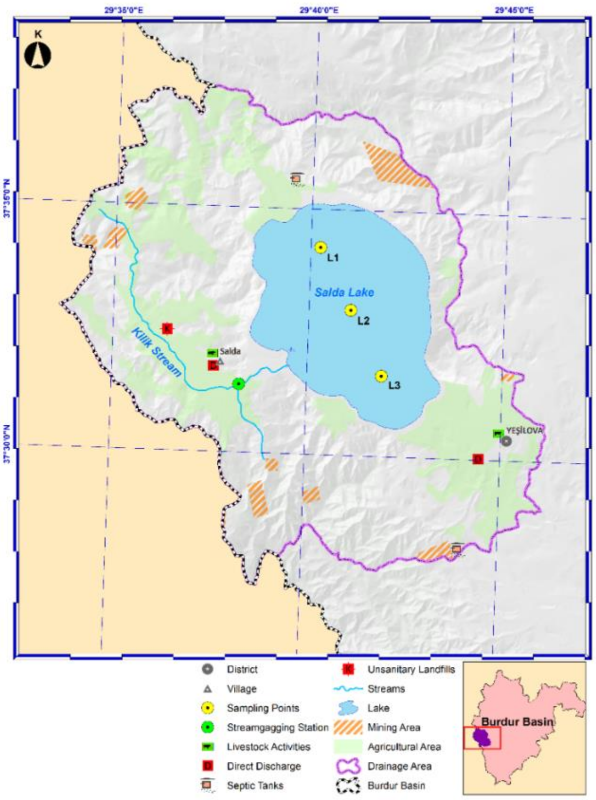

Fig. 3. *Pressures in the lake's drainage area*

3. Results and Discussion

The water quality of Lake Salda has been searched for a yearlong and the results of the experimental analyses are given in detail in Table 2. The data analyses are categorized according to the groups of parameters involved. Physico-chemical parameters, organic matter characterization and derivatives of nutrients are listed initially, and the three Water Quality Classes ranked from best to worst are used to define the situation of the lake according to the Revised National Regulation on Surface Water Quality dated 2021, Annex 5 Table 2 [24].

In Table 2, the number of samplings throughout the year are shown by n, while minimum, maximum, average, median and standard deviation values are calculated. All the measurements of the lake throughout sampling period are compiled and analyzed. Average values are considered for defining the water quality classes defined in the national regulation which is in full compliance with Water Framework Directive (WFD) of EU.

In terms of dissolved oxygen, BOD_5 and nutrients Class I quality has been attained and the alkaline character with pH 9, as a major property of the lake, is clearly observed.

Due to the unique characteristics of Lake Salda, it is known that heavy metal concentrations of natural origin are quite high. This situation causes problems in the evaluation of heavy metals measured in the lake in accordance with WFD standards, and the measured values are determined above the limit values in almost all cases. According to WFD, Member States are required to calculate natural background concentrations (NBC) for metal compounds where concentrations prevent compliance with the relevant EQS. Accordingly, the EQS for the relevant pollutants is taken as equal to the revised annual average (AA) environmental quality standards (AA-EQS) as a result of the

- Agricultural activities prevail on an approximate area of 3121 hectares. Total annual fertilizer use has been calculated as 3645 tons in the basin [23] (Diffuse pollutants).
- Highways with two or more lanes pass through the south and southeast of the lake as part of the main transportation network (Diffuse pollutants).

Leachate arising from the unsanitary landfill, agricultural irrigation return flow, animal manure, mining outputs, and vehicles emissions are addressed as the different types of diffuse pollutants arising from the lake basin. The point loads calculated from the available sources and the diffuse loads estimated either by obtaining data from the local officials or by using unit loads appearing in the literature are given in Table 1 in the form of percent distribution of Total Nitrogen (TN) and Total Phosphorous (TP) [23].

Table 1. Total N and P loads in the lake basin

Parameters	Total Nutrient Load (t/year)	Point Sources (%)	Diffuse sources (%)
TN	203.5	7	93
TP	14	17	83

natural background concentration calculations.

Variety of semi metals and metals are analyzed according to annual average (AA-EQS) and maximum allowable concentration (MAC) regarding the EQS stated in RSWQ (2021) Annex 5-Table 3 [24]. The averages derived from the results indicate that the lake is rich in Mg and Na concentrations as expected. Al, Zn, Fe, Pb, Co and Ni exceeded the AA-EQS in the lake.

As, Fe and Al were abundant in the aquatic ecosystem, both were chosen as reference metals [25]. On the other hand, it has been revealed that Fe, Mg, Ni, Zn and Co sources can be associated with agricultural activities. These metals are known to be applied to the soil by fertilizers and pesticides in agricultural land [26, 27]. The contents of Co and Ni are commonly found in household products (stainless steel, batteries, etc.), and there are numerous ways of increased input of Pb, Co and Ni from urban areas such as domestic wastewater discharge, fossil fuel burning, etc. [26, 28]. Nickel is one of the priority substances according to WFD and Turkish standards, and is one of the important pollutants of anthropogenic origin in aquatic environments. It is used in the combustion of biomass and fossil fuels, domestic wastewater discharge, etc. As such, various resources are available for Ni [29, 30].

When the results obtained from this study are compared with the previous research of [16], Al (2-109 μg/L); Pb (0-16.4 μg/L); Zn (0.7-77.90 μg/L) values were consistent with the concentration levels obtained in this study, and the values measured for Fe (15-97 μg/L) and Ni (1.1-19.10 μg/L) were found to be lower than this study. The previous study also reported high As and Cr concentrations which were determined to be of geo-genic origin [16].

Among the parameters given in Table 2, those that will reveal the characteristics of the lake (temperature, electrical conductivity (EC), dissolved oxygen, alkalinity, Fe, Mg, Al and Ni) were further selected and the quality changes in the lake based on sampling depth (surface layer, mid layer, bottom layer) and time were also evaluated (Figure 4). Accordingly, when examining the temperature change with varying depth, it was observed that the temperatures on the surface varied on the average around 16 ^{0}C, 13 ^{0}C at the mid-depth and 11^{0}C at the bottom layer. Although the changes do not differ according to the location, the surface temperatures increased to 24^{0}C in July-August months. In February-March, when the temperature in the lake decreased the most, it was observed that the surface temperatures decreased to 7-8^{0}C.

EC values of the lake were high, and while the measured values from surface and mid-layers were close to each other, a slight decrease was observed at the bottom layer in all the three sampling points. No significant change was observed spatially and temporally.

When looking at the change of dissolved oxygen throughout the depth of the lake, it was observed that the values were around 8.6 mg O_2/L at the surface and increased to 9.3 mg O_2/L at the mid-layer and to 9.6 mg O_2/L at the bottom layer. The measured levels in each period and at each point in the lake were observed as above the WFD "very good" water quality level of 8 mgO_2/L. Dissolved oxygen levels increased from April to September during the year Regarding the organic matter concentration in the water ecosystem, one can say that BOD_5 presents Class I characteristics as expected in parallel to dissolved oxygen levels. However, COD concentrations lie within Class II and Class III characteristics indicating the presence of chemically oxidizable organic matter in the water rather than biologically degradable organics. Nutrient concentrations expressed in terms of nitrogen (N) and phosphorous (P) parameters and their derivatives, indicated no serious problem on the average; however, the maximum values detected underline the reality that there are signs of nutrient pollution in the lake system at certain time intervals. This situation is important nutrients arise both from untreated domestic discharges and from any of the diffuse pollutants experienced in the basin of the lake.

The lake is an alkaline lake and its alkalinity level was detected around 1030 mg$CaCO_3$/L. There was no significant change in the alkalinity level in the lake depending on the location and depth. When the change over time was examined, it was observed that the highest values were obtained in September and October during the year of inspection.

Concentration of iron (Fe), as a heavy metal, generally increase with depth in stagnant water bodies. It can be stated that the variation of iron concentrations measured in the lake with depth varied according to the sampling point. As generally expected, in L1, iron concentration slightly increased with depth. In L2 and L3 points, the surface and bottom layer concentrations were close and higher, while the mid-layer concentrations were slightly lower. The concentration values in L3 varied over a wide range.

There is no classification or limit value for magnesium (Mg) among the WFD standards. When the change in Mg concentrations with depth in the lake was examined, it was observed that the mean values were quite close to each other in L1 and L2, and there was no significant change with depth. Concentration levels at these points varied around 350 mg/L. In L3, while the mid-layer and bottom layer Mg concentrations were close to each other and the values observed at other sampling points, some of the measurements exceeded 500 mg/L concentration on the surface layer of the lake.

Nickel (Ni) concentrations measured in the lake were generally around the AA-EQS value. The highest value was measured at the mid-layer of the L1 station. While the concentrations measured at the surface and bottom layers at the L1 point were closer, the concentration value measured at the medium level was high. An increase was observed in the level as one goes deeper at the L2 point. In L3, on the other hand, higher levels were observed at the surface.

Aluminum (Al) values measured in the lake were well above the limit value. In general, concentration levels ranging from 20-80 mg/L, although it varied in a wide range at the mid-layer in the

L1 station, closer values were obtained in terms of averages. At L2, lower and varying values in the narrow range were determined on the surface, slightly higher but wider range measurements were detected at L2 and L3 points. At the L3, the highest value was measured at the surface, and at the bottom point values were within an average of around 50 mg/L; but were varying in a wider range.

Table 2. Water quality characteristics of Lake Salda

Parameters		**Water Quality Classes***			**n**	**Max.**	**Min.**	**Aver.**	**Median**	**Std. Dev.**
Physico-chemical		**I**	**II**	**III**						
Temperature	°C	-			108	24.60	7.20	13.46	12.10	4.86
pH		6-9	6-9	6-9	108	9.72	7.89	8.99	9.29	0.58
Electrical Conductivity	µS/cm	< 400	1000	> 1000	99	2113	1909	2081	2081	28.91
Dissolved O_2	mg/L O_2	> 8	6	< 6	106	11.32	7.84	9.17	9.18	0.94
Turbidity	NTU	-			36	3.83	<0.02	0.67	0.55	0.83
Secchi Disc	M	-			12	15	6.40	11.22	11.70	3.37
TSS	mg/L	-			36	31.40	<2	2.15	1	5.26
Alkalinity	mg/L	-			36	1444	811	1031	924	229
Organic Matter										
BOD_5	mg/L	< 4	8	> 8	36	4.42	<2	1.13	1	0.59
COD	mg/L	< 25	50	> 50	36	138	10	65.02	58.40	40.92
TOC	mg/L				36	51.03	2.29	20.73	22.52	14.60
Nutrients										
NH_4-N	mg/L	< 0.2	1	> 1	36	0.44	<0.02	0.06	0.01	0.12
NO_2-N	mg/L				0	0.00	0.00	-	-	-
NO_3-N	mg/L	< 3	10	> 10	36	0.40	0.07	0.21	0.20	0.09
TKN	mg/L	< 0.5	1.5	> 1.5	36	0.87	<0.1	0.24	0.17	0.21
Organic N	mg/L				36	0.59	<0.08	0.19	0.13	0.18
TN	mg/L	< 3.5	11.5	> 11.5	36	0.98	<0.5	0.38	0.25	0.24
TP	mg/L	< 0.08	0.2	> 0.2	36	0.37	<0.075	0.06	0.04	0.08
Orto P	mg/L	<0.05	0.16	>0.16	0	0.00	0.00	-	-	-
Metals and Semi metals		**EQS**			**n**	**Max.**	**Min.**	**Aver.**	**Median**	**Std. Dev.**
		AA-EQS		**MAC-EQS**						
Aluminum	µg/L	2.2		27	36	138.14	10.75	46.58	42.37	25.62
Antimuon	µg/L	7.8		103	36	0.75	<0.3	0.33	0.15	0.21
Arsenic	µg/L	53		53	36	3.38	0.34	0.98	0.89	0.55
Copper	µg/L	1.6		3.1	36	4.07	<0.3	1.44	1.45	1.17
Barium	µg/L	680		680	36	14.64	2.21	6.40	5.80	2.57
Beryllium	µg/L	2.5		3.9	36	3.94	<0.3	0.44	0.15	0.75
Bore	µg/L	707		1472	36	840.61	<33	441.65	418.08	171.34
Zinc	µg/L	5.9		231	36	80.05	<0.3	29.86	27.81	18.63
Iron	µg/L	36		101	36	171.25	18.13	56.19	49.26	36.39
Silver	µg/L	1.5		1.5	36	0.74	<0.3	0.29	0.15	0.21
Cadmium	µg/L	< 0.08		< 0.45	108	0.55	<0.007	0.08	0.04	0.09
Tin	µg/L	13		13	36	1.73	<0.3	0.48	0.46	0.38
Calcium	mg/L				36	85.82	0.79	7.52	5.36	13.38
Cobalt	µg/L	0.3		2.6	36	2.01	<0.03	0.27	0.19	0.34
Chromium	µg/L	1.6		142	36	1.05	0.31	0.68	0.69	0.22
Lead	µg/L	1.2		14	108	25.32	0.98	2.39	2.01	2.40
Magnesium	mg/L				36	601.95	318.61	350.67	344.35	46.24
Manganese	µg/L				36	5.17	<0.3	2.02	2.11	1.14
Nickel	µg/L	4		34	108	86.08	0.60	4.69	3.36	8.62
Potassium	mg/L				36	32.03	21.85	27.02	27.47	2.95
Sodium	mg/L				36	1994.65	208.35	294.21	231.59	291.80
Titanium	µg/L	26		42	36	13.10	<3.3	2.37	1.65	2.27
Vanadium	µg/L	1.6		97	36	3.05	1.19	2.19	2.18	0.35

*Class I: Potable water quality; *Class II: Slightly polluted; *Class III: Polluted, **Natural Background Concentrations

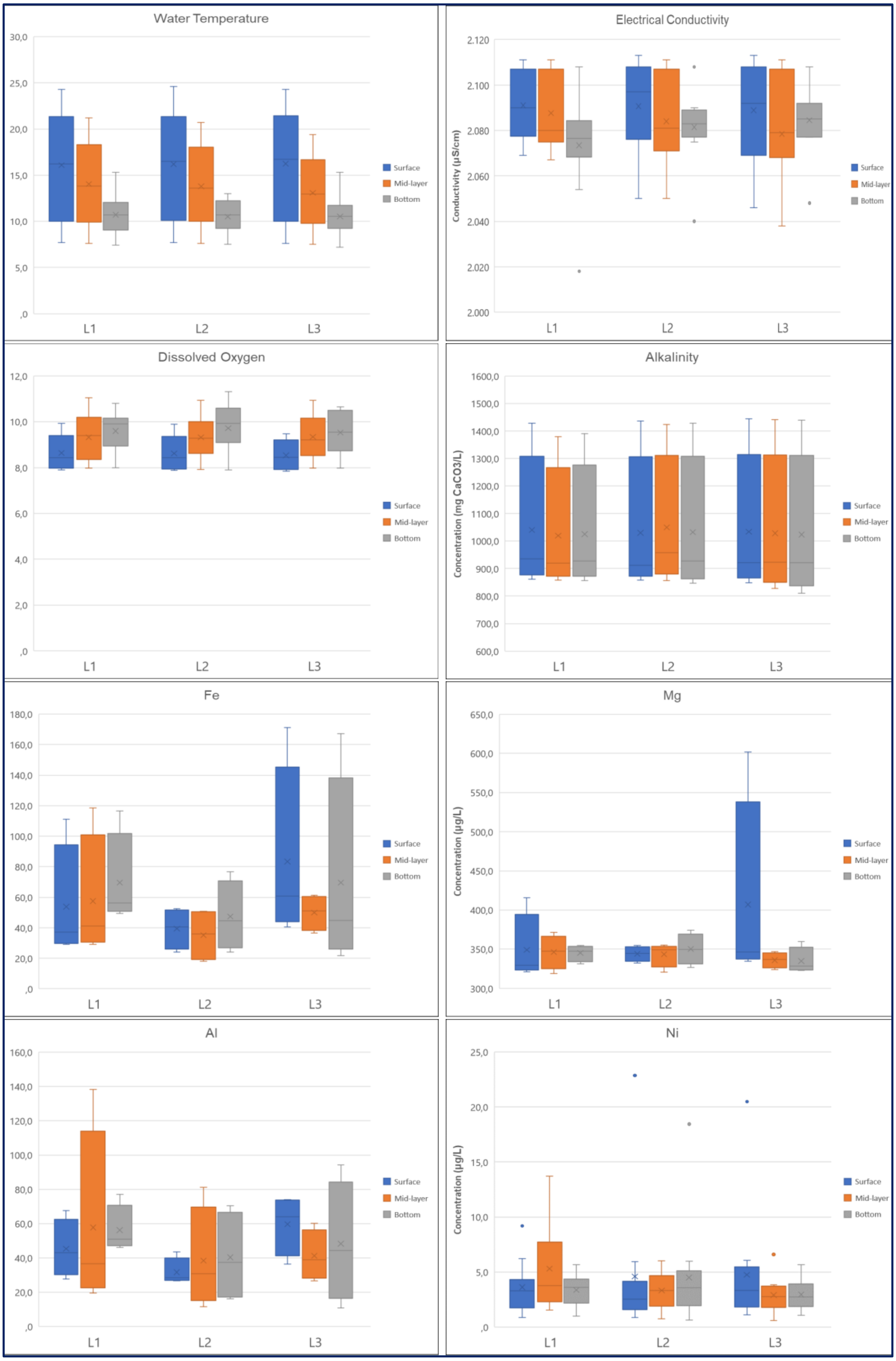

Fig. 4. *Variations of some parameters with depth*

4. Conclusion

Lake Salda, due to its natural intrinsic properties and unique features, it is observed within this study that anthropogenic activities and water loss through climate change effects accelerated its degradation as is the case in many of the world's stagnant water ecosystems. In that sense, Lake Salda is one of the lakes that should be taken under protection in due time. Therefore, as an initial step towards its protection from any further human-induced activities, the Turkish Government declared this lake and its basin as a Special Protection Area in 2019.

It is crystal-clear that the increase in anthropogenic activities will adversely affect the characteristics of any lake in the world. Thus, within the scope of this study, the existing pollution in the lake was put forth according to land-based sources of pollutants detailed as point and non-point (diffuse loads, monitoring of polluting parameters via experimental analyses were conducted for a year long, and thus, the prevailing water quality was presented for the attention of especially decision-makers and politicians so as to urge them to take the necessary measures to further prevent the deterioration of such a vulnerable lake ecosystem. Previous water quality determination efforts were rather based on some parameters; however, this study covers all the parameters that takes place in both the WFD and in the revised National Regulation on Surface Water Quality dated 2021.

Author Contribution

Data curation – A.H., A.T.; Formal analysis – A.H.; Investigation – A.T., A.H.; Data Collection – A.H., A.T.; Processing – A.T.; Literature review – A.H, A.T; Writing, review and editing – A.T., A.H.

Declaration of Competing Interest

The authors declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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This study utilized the corresponding data of various parameters analyzed during the realization of RBMP.

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