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A preliminary assessment of the water and air quality parameters in and around the Lake Yeniçağa coast

Yeniçağa Gölü kıyıları ve çevresinde su ve hava kirliliği parametrelerinin ön değerlendirmesi

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Abstract

The Lake Yeniçağa is located in the interiors of Western Black Sea, within the borders of the city Bolu and in the north of the town Yeniçağa. It is just in the middle of the Çağa Depression 285 km away from Istanbul and 153 km from Ankara. The Çağa Creek with its 8 branches (Hamzabey, Güzviran, Kaymaz, Ömerli, Kirenli, Fındıklı, Aksu and Kayışlar) flows into the lake. Of these branches, Kaymaz, Ömerli, Kirenli and Fındıklı drift the pollutants from TEM highway, Güzviran the ones from D-100 highway and in addition Hamzabey and Aksu drift agricultural wastes into the lake. This study provides prelimary results obtained from water and lichen samples collected from the Lake Yeniçağa and its surroundings, located in the interiors of Western Black Sea, within the borders of the city Bolu. We aimed to highlight some indicators of pollution parameters, including the quality of water and air in and around the lake, on the basis of ICP-AES and ion chromatography (IC) analysis as well as several measurements results. The results obtained showed an increase in Cl^- and NH_4 levels. In particular, Cl^-, NO_3^{-3} and SO_4^{-2} in the sample taken from the south of the lake littoral are at two or three times higher amounts.

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Moreover, some concentration of NO_2^- and NH_4^+ was detected, which was not identified in the other samples.

As a result of analyses of two different lichens (*Xanthoria parietina* and *Diploschistes scruposus*) carried out to investigate the effect of traffic load on the air quality around the lake, it was observed that the amounts of Fe and Al markedly increased, suggesting a negative effect of traffic-related particles on the area.

Key words: Air and water pollution, land use, ICP-AES, ion chromatography, Lake Yeniçağa, Bolu.

Introduction

Lakes are always geographical attraction centers for both recreational and touristic purposes and are of significance as they beautify and brighten the surrounding areas, resulting in attraction of the human and economic activities (Özgüç 2003). Further, they provide socio-economic opportunities for the human life and other organisms as well, and are natural resources for various economic activities, such as agriculture, tourism, fishing and energy production. However, lakes – in particular those which are suitable for drinking and daily use – are under the threat of pollution due to human interference, which dramatically damages the ecosystem. Water pollution – a common problem of the world – is at critical levels in 9244 km^2 of Turkey's lakes, which accounts for 12% of the total sum.

In this study, we focused on some pollution parameters in and around the Lake Yeniçağa, located in the west Black Sea region of Turkey, which is not rich in lakes, but is teemed with historical, natural and cultural values as well as the vegetation, thermal springs, falls and wild life (Yazıcı and Cin 1997). Currently, the lake area is subject of several pollution problems caused by, for instance, the use of chemicals in agricultural activities, the construction of the industrial estate located at the entrance of the city Yeniçağa in 1973 and insufficient infrastructure. This subject has been dealt in detail within a few recent studies (Saygı-Başbuğ and Demirkalp 2004 a, b). Especially, the underground and surface waters carry the chemicals and organic substances into the lake. Furthermore, the creeks flowing into the lake are of significance in terms of pollution as they have not been ameliorated yet. Pollution on the southern shore of the lake can be easily realized even with naked eye. This is because the Yeniçağa town is near a highway. The traffic load is rather high along the Istanbul-Ankara highway, which is another cause of pollution around the lake. The Lake Yeniçağa is not a closed basin unlike the other typical depression lakes, because lake water discharges into the Mengen (Büyüksu) Stream in the north. The Çağa depression morphologically looks like a closed basin in a surrounding relief, though (Tanoğlu and İnandık 1952-1953). The outlet called the Çağa Creek flows into the Çapak Creek, one of the branches of Mengen (Büyüksu) Stream. The Çağa Creek with its 11.2 km length lies in south-north direction. The Çağa Depression remained as a closed basin for a while, but later lost this characteristic when the lake water started to flow out via the Çağa Creek, which resulted from a capture (Erinç et al. 1961). As a precaution to malaria that broke out in Bolu and the environs in 1955, the Çağa Creek was formed to drain the lake. As a result of the comparison of the depression made by Tanoğlu and İnandık (1952-1953), Erinç et al. (1961) found out that the lake came into existence thanks to tectonic movements (Erinç et al. 1961) while Pekcan (1996) claims that it formed out of limnic-fluvial lake terraces 10 m above the lake level in the west and northwest of the lake and accordingly it was originally larger and 10 m higher than it is today (Pekcan 1996) The southern coast of the lake is 100-150 km north to Istanbul-Ankara highway.

During his stay in Reşadiye in 1934, on learning that the settlers of the area came from Çağa, Atatürk named Çağa as Eskiçağa (Old Çağa) and Reşadiye as Yeniçağa (New Çağa). Northern side of the city Yeniçağa is located by the lake. The area between the lake and the highway is known as Gölyüzü (Lake Side) District, which covers the southern coast of the lake. The west-northern and eastern coasts of the lake are surrounded by the villages Hamzabey, Gölbaşı, Adaköy and Akıncılar. Once local people used to grow sugar beet and potato, but now they grow wheat and barley and raise livestock. Chemicals used in such agricultural activities performed on the three sides of the lake have negative effects on the lake. The construction of the industrial estate located at the entrance of the city Yeniçağa was started in 1973 and finalized in 1984. It was the second largest industrial estate at that time. Although the problems related to the infrastructure were sorted out, wastes and leaks from the drainage have long continued to pollute the lake. The insufficient pumps utilized for the urban drainage and water treatment have difficulty in the granulation of the solid wastes and sometimes break down. If the duration to fix such problems is too long, the waste materials overflow the low-capacity drains and tanks and flow into the lake. Further, due to the abundance of underground water and insufficiency of the infrastructure, the underground and surface waters carry the chemical and organic substances into the lake. Another factor causing pollution and environmental corruption is the creeks flowing into the lake. Some of these creeks have not been ameliorated yet and therefore still pollute the lake. Moreover, the village garbage is not collected, which also increases the pollution, because villagers throw their garbage into the creeks, via which the garbage reaches the lake. The lake is open to powerful northern winds, which carry various pollutants into the lake. Pollution on the southern shore of the lake can be easily realized even with naked eye. Hazardous materials from these settlements in some way reach the lake. Because Yeniçağa is near the highway, it is a "highway city". The traffic flow is very dense because the highway connects Istanbul to Ankara, which negatively affects the lake. The highway is readily used by vehicles with high engine power, such as trucks. These commercial activities contribute to the economy but gas emissions and vehicle wastes pollute the lake water.

It was observed than urban waste flows into the lake, which was also proved by the analyses. Recreational wastes caused by the daily visits to the area should be carefully collected to prevent them from flowing into the lake. Settlements should not have infrastructural problems. If there are such problems, they should be sorted as soon as possible.

Yeniçağa, a district of the town Gerede in 1990, possessed a town status by the agreement numbered 3644 of the Board of Ministers published in the Official Newspaper numbered 20553 and dated 20 May 1990. Its population was counted in 1990 as a town for the first time. It is clear from the data[7] that its population increased between the years 1935 and 1990. As understood from 1935 census, its population was 701 and 974 in 1950, 2575 in 1965, 3549 in 1980. When it was characterized as a town in 1990, its population was 5331 and 5929 in 1997, 6364 in 2000, 5796 in 2007 and 5279 in 2008. (Census Results: Turkish Statistical Institute) It can be realized that the population was in a declining trend after 2000. In the face of the increase in the population till 2000, the attempts were inefficient to prevent the pollution in the lake.

This study presents some preliminary results on water and air pollution indicators in and around the Lake Yeniçağa and its environs. Pollution parameters were discussed based on results obtained from several multi-metric analyses, inductively-coupled plasma atomic emission spectrometry (ICP-AES), ion chromatography (IC), pH values, total organic substances, total dissolved solids and electrical conductivity data.

Study area: The Lake Yeniçağa located in the Western Black Sea region, in the north of Turkey, has a latitude of 40° 47' 17" - 40° 46' 23" North, and a longitude of 32° 00' 42" - 32° 02' 09" West. The lake, encompassing an area of 2780 decares and possessing a depth of 12 meters, is a fresh water lake. It is 38 km north to Bolu and has an altitude of 990 metre (Figure 1).

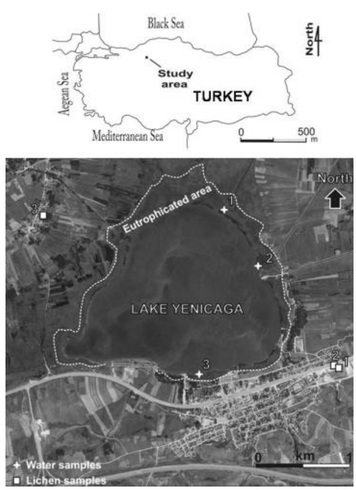


Figure 1. Location map of the study area (a) and sampling sites (b) shown on Google Earth satellite image of the year 2007.

The depression and the lake within the depression lie in east-west direction along the North Anatolia Fault. Because a small amount of the lake water is discharged into the Mengen Stream via a narrow channel, this little depression is not a closed basin at all. The lake occupies the deepest part of the Çağa depression looking like an encircled pit between reliefs (Tanoğlu and İnandık 1952-1953).

These units which morphologically exhibit depression properties are highly important for human geography. Such fields contribute to socio-economic life by its residential, agricultural and touristic opportunities. Lakes beautify and brighten the surrounding and attract the human and economic activities around themselves. Rivers, lakes and inlands shape the geographical structure (Özgüç 2003)

Morphologically, the region is characterized by many depressions in various sizes among the mountains and plateaus of different altitude. Such depressions are tectonically-originated and range along the North Anatolian Fault (NAF) and have significance for human activities, by providing several opportunities for residential, agricultural and touristic purposes. The lake Yeniçağa under consideration is also located in one of these tectonic depressions that lie in east-west direction along the NAF (Tanoğlu and İnandık 1952-1953, Erinç et al. 1961). The so-called Çağa depression morphologically looks like a basin in a surrounding relief, though (Tanoğlu and İnandık 1952-1953) once remained as a closed basin prior to a drainage capture that caused the lake waters to flow out via the Çağa Creek (Erinç et al. 1961). Today, the lake waters discharge into the Mengen (Büyüksu) Stream in the north. The Yeniçağa town a district of the town Gerede in 1990, forms the main settlement. Based on census data from Turkish Statistical Institute, its population did not show a significant change between 1990 and 2008 and ranged between 5331 and 5279. There are several villages on the northwestern and eastern coasts of the lake, such as Hamzabey, Gölbaşı, Adaköy and Akıncılar. The main economical activities are cultivation of wheat and barley and animal breeding.

Material and Method

Operating conditions and instrumentation

Inductively Coupled Plasma–Atomic Emission Spectrometry (ICP-AES Varian Liberty II Sequential Series-Axial, Australia) was used for defining elements (Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb and Zn) within lichen samples (*Xanthoria parietina* and *Diploschistes scruposus*). This equipment was used with Intel Pentium IV PC and Liberty ICP-Expert Sequential (version: v.30) software. The concentrations of Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb and Zn were measured at 396.152, 249.773, 455.403, 317.933, 226.502, 228.616, 267.716, 324.754, 259.940, 766.490, 279.553, 257.610, 589.592, 221.647, 220.353, and 213.856 nm wavelength, respectively. The equipment was calibrated with using ICP multi-element Standard solution VIII (Merck, 24 elements) at 0.1, 1.00, 10.00 and 50.00 mg/l in four dotted measures. Three replicates were done for each measurement and then standard means were calculated. pH, conductivity, total dissolved solids (TDS) and salinity of the water samples were measured with Consort-C864 (Belgium) multi pH-meter.

Ion chromatography (Shimadzu, Japan) was used for defining anion and cation (F^-, Cl^-, NO_2^-, Br^-, NO_3^{-3}, PO_4^{-3}, SO_4^{-2} and NH_4^+) within the water samples. This equipment was used with LC-20AD SP pump, SIL- 10AP Auto sampler, SCL-10A vp system controller, CDD-10A sp conductivity detector, CTO-20AC sp column oven and LC solution (version: 1.23 sp1) software. The equipment was calibrated with using Shimadzu anion (P/N 228-33603-93) and cation (P/N 228-33603-94) standard solution in four dotted measures at different concentrations. Three replicates were done for each measurement and then standard means were calculated.

Element and heavy metal analysis

Each solid sample (0,5 g wet weight) was weighed in a Kjeldahl flask. Ten milliliters (10 ml) of concentrated nitric acid was added to each sample and was heated to 100 ^oC for two hours. Five milliliters of concentrated hydrochloric (37%) acid and 0.5 ml of concentrated sulfuric acid were added and the flask was then heated (120 ^oC) until no white smoke was emitted. The samples were dissolved in 2% of nitric acid and transferred into a volumetric flask. This procedure was repeated three times for every sample. After this solution was put into the ICP-AES apparatus samples tubes, spectroscopic measurement was made under optimum instrumental parameters (Table 1). The minerals (Na, K, Ca, Mg,) and heavy metals (Al, Cd, Co, Cr, Mn, Ni, Pb, Zn, Cu, Mn and Fe) were measured by using ICP-AES and then concentrations obtained were calculated based on standard deviation after making three replicates treated for every sample.

Results and Discussion

Water analyses

Instrumentation and Calibration

Inductively Coupled Plasma–Atomic Emission Spectrometry (ICP-AES) was used for defining elements (Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn, Na, Ni, Pb and Zn) detected within lichen (*Xantoria* sp.) and water samples. The equipment was calibrated with using ICP multi-element Standard solution VIII (Merck, 24 elements) at 0.1, 1.00, 10.00 and 50.00 mg/L in four dotted measures. Three replicates were done for each measurement and then standard means were calculated. Calibration parameters for ICP-AES were shown in Table 2. Calibration Curve and Intensity Spectrum of elements used for ICP-AES were showed in Figure 3-4.

IC was used for defining anion and cation contents (F^-, Cl^-, NO_2^-, Br^-, NO_3^{-3}, PO_4^{-3}, SO_4^{-2} and NH_4^+) within the water samples. The equipment was calibrated at different concentrations using Shimadzu anion (P/N 228-33603-93) and cation (P/N 228-33603-94) standard solutions in four dotted measures. Three replicates were performed for each measurement and then standard means were calculated. Calibration parameters for IC were shown in Table 1. Chromatography spectrum and retention times of F^-, Cl^-, NO_2^-, Br^-, NO_3^-, PO_4^{-3} and SO_4^{-2} using IC was shown in Figure 2.

Table 1. Calibration parameters used for IC analyses

Element	Units	Standards				Retention Time (min)	Curve Type	Equation	R^2
F	mg/L	0.05	0.5	2.5	5.00	4.08	Linear	y = 1.80e-005 x + 7.58e-002	0.999
Cl	mg/L	0.10	1.00	5.00	10.00	5.36	Linear	y = 2.50e-005 x + 0.18	0.999
NO_2^-	mg/L	0.15	1.50	7.25	15.00	6.01	Linear	y = 4.75e-005 x + 0.31	0.998
NO_3^-	mg/L	0.10	1.00	5.00	10.00	7.02	Linear	y = 6.48e-005 x + 0.14	0.997
Br	mg/L	0.30	3.00	15.00	30.00	7.68	Linear	y = 4.46e-005 x + 0.66	0.999
PO_4^{-3}	mg/L	0.30	3.00	15.00	30.00	13.41	Linear	y = 9.97e-005 x + 0.46	0.999
SO_4^{-2}	mg/L	0.40	4.00	20.00	40.00	15.68	Linear	y = 3.37e-005 x + 0.25	0.998
NH_4^+	mg/L	0.20	0.50	1.00	2.00	4.05	Linear	y = 13298.7 x + 395.08	0.997

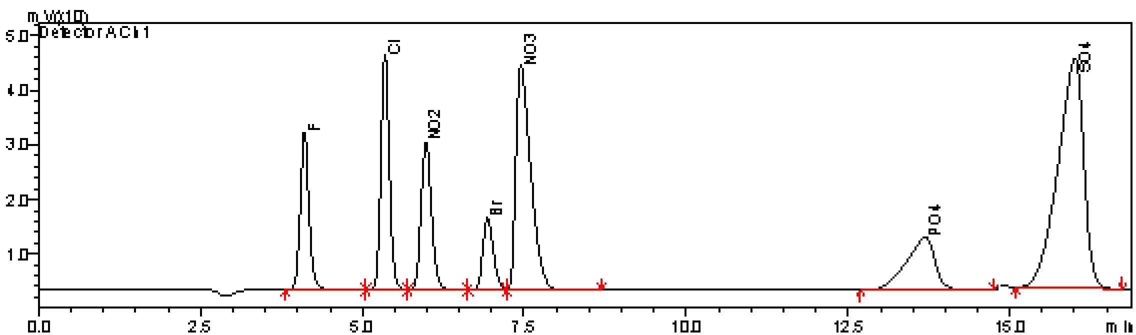


Figure 2. Anion spectrum obtained from IC

Water samples were taken from the northwestern section of the Lake Yeniçağa where the Aksu Creek discharges into the lake, from the section known as Beton İskele (the Concrete Quay) in the east and from the southern shore (Figure 1, Table 3).

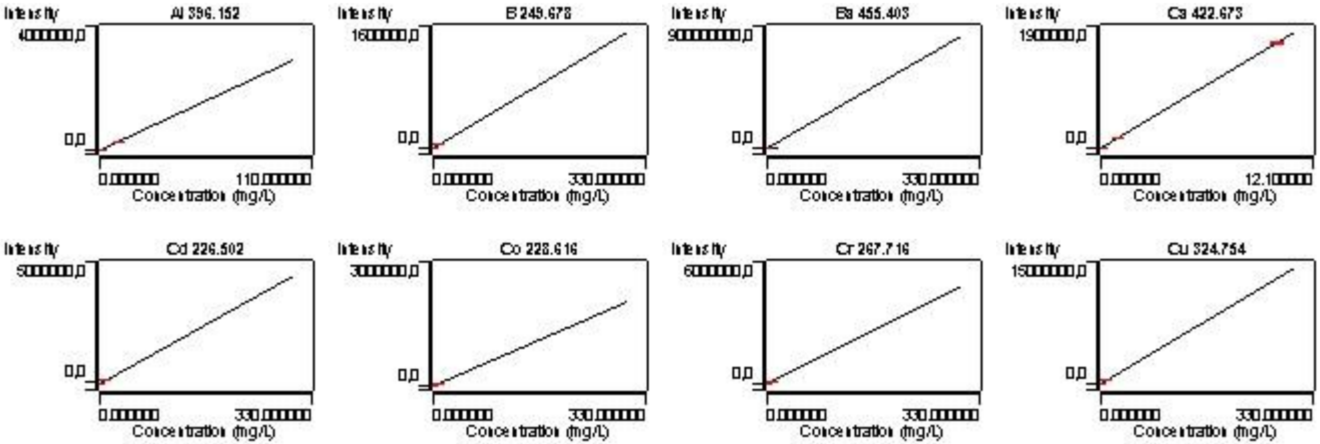
The ICP-AES analyses confirmed that the highest amount was detected for calcium with 73.4 mg/l, followed by sodium with 25.6 mg/l, magnesium with 13.3 mg/l and potassium with 3.42 mg/L at the mouth of the Aksu Creek. The other elements were put into order of their weights as follows; Ba>B>Al>Fe>Cu>Pb>Mn>Co>Ni.

This signifies that heavy metal deposition is not at a critical level at the mouth of the Aksu Creek. It was found out by other measurements carried out in/with the same sample that water has a pH value of 6.98, its electrical conductivity is 605 μS/cm, the amount of total dissolved solids is 361 mg/l and the value of salinity is 0.3 g/l (Table 4). As presented in Table 6, no NO_2^-, Br^- and NH_4^+ were found in terms of the ions F^-, Cl^-, NO_2^-, Br^-, NO_3^{-3}, PO_4^{-3}, SO_4^{-2} and NH_4^+, yet the amounts of Cl^- and NH_4^+ were measured to be 63,39 mg/l and 11,42 mg/l – the highest amounts among the others but insignificant, respectively.

A similar composition was detected in the sample taken around the Concrete Quay, also known as the Bird Paradise. The amounts of calcium, sodium, magnesium and potassium were found to be 74.34, 25.31, 15.58 and 3.36 mg/l, respectively. The weights of the other elements are below 1 mg and the order of their weights is as follows; Al>B>Fe>Cu>Pb>Mn>Ni.

Table 2. Calibration parameters for ICP-AES

Element	Units	Wavelength (nm)	Standards				Curve Type	Equation	R^2
Al	mg/L	396.152	0.10	1.00	10.00	50.00	Linear	y = 6862.88 x + -18.66	0.999
B	mg/L	249.773	0.10	1.00	10.00	50.00	Linear	y = 5025.5 x + 466.80	0.999
Ba	mg/L	455.403	0.10	1.00	10.00	50.00	Linear	y = 2,71934*10^6 x + 14888.7	0.999
Ca	mg/L	422.673	0.10	1.00	10.00	50.00	Linear	y = 22429.7 x + 618.19	0.999
Cd	mg/L	226.502	0.10	1.00	10.00	50.00	Linear	y = 14596.6 x + 406.20	0.999
Co	mg/L	228.616	0.10	1.00	10.00	50.00	Linear	y = 6785.89 x + 111.90	0.999
Cr	mg/L	267.716	0.10	1.00	10.00	50.00	Linear	y = 15986.5 x + 326.62	0.999
Cu	mg/L	324.754	0.10	1.00	10.00	50.00	Linear	y = 47466.4 x + 463.62	0.999
Fe	mg/L	259.940	0.10	1.00	10.00	50.00	Linear	y = 21148 x + 576.71	0.999
K	mg/L	766.490	0.10	1.00	10.00	50.00	Linear	y = 28651.2 x + -3829.09	0.999
Mg	mg/L	279.553	0.10	1.00	10.00	50.00	Linear	y = 422751 x + 62212.80	0.999
Mn	mg/L	257.610	0.10	1.00	10.00	50.00	Linear	y = 95170 x + 3233.49	0.999
Na	mg/L	589.592	0.10	1.00	10.00	50.00	Linear	y = 387397 x + -2485.47	0.999
Ni	mg/L	221.647	0.10	1.00	10.00	50.00	Linear	y = 1924.89 x + 49.64	0.999
Pb	mg/L	220.353	0.10	1.00	10.00	50.00	Linear	y = 943.094 x + 45.17	0.999
Zn	mg/L	213.856	0.10	1.00	10.00	50.00	Linear	y = 13298.7 x + 395.08	0.999


Intensity
Al 396.152
B 249.678
Ba 455.403
Ca 422.673
Cd 226.502
Co 228.616
Cr 267.716
Cu 324.754
Concentration (mg/L)

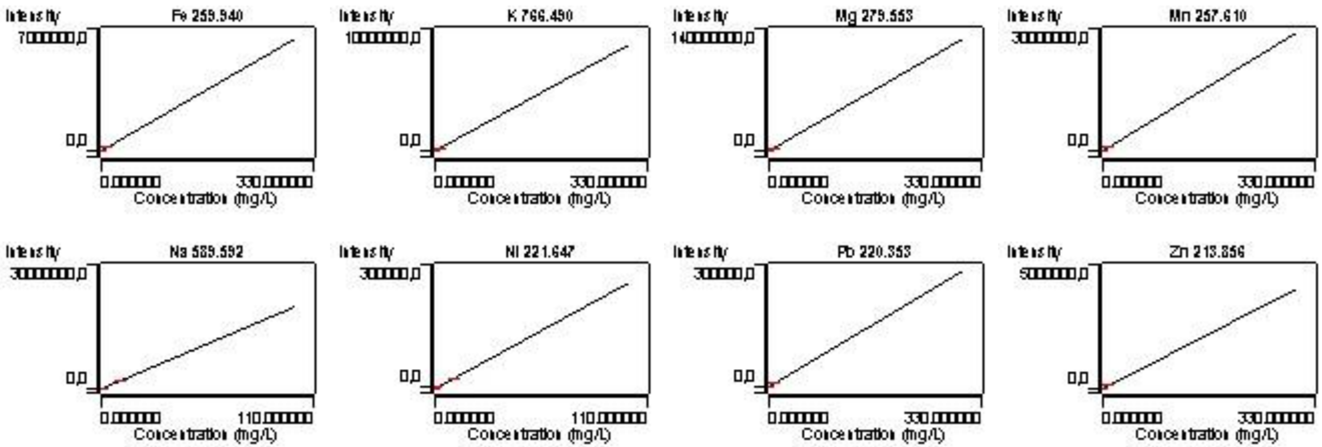
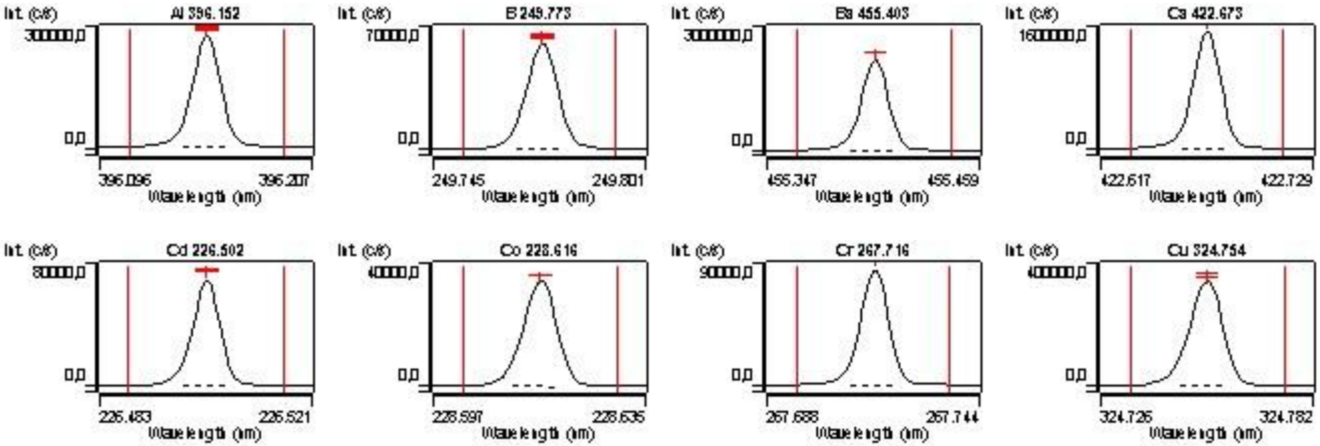


Figure 3. Calibration curves of Elements used for ICP-AES analyses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0,0
396.096
396.207
Wavelength (nm)
Int. (c/s)
B 249.773
70000,0
0,0
249.745
249.801
Wavelength (nm)
Int. (c/s)
Ba 455.403
3000000,0
0,0
455.347
455.459
Wavelength (nm)
Int. (c/s)
Ca 422.673
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0,0
422.617
422.729
Wavelength (nm)
Int. (c/s)
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80000,0
0,0
226.483
226.521
Wavelength (nm)
Int. (c/s)
Co 228.616
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228.597
228.635
Wavelength (nm)
Int. (c/s)
Cr 267.716
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Wavelength (nm)

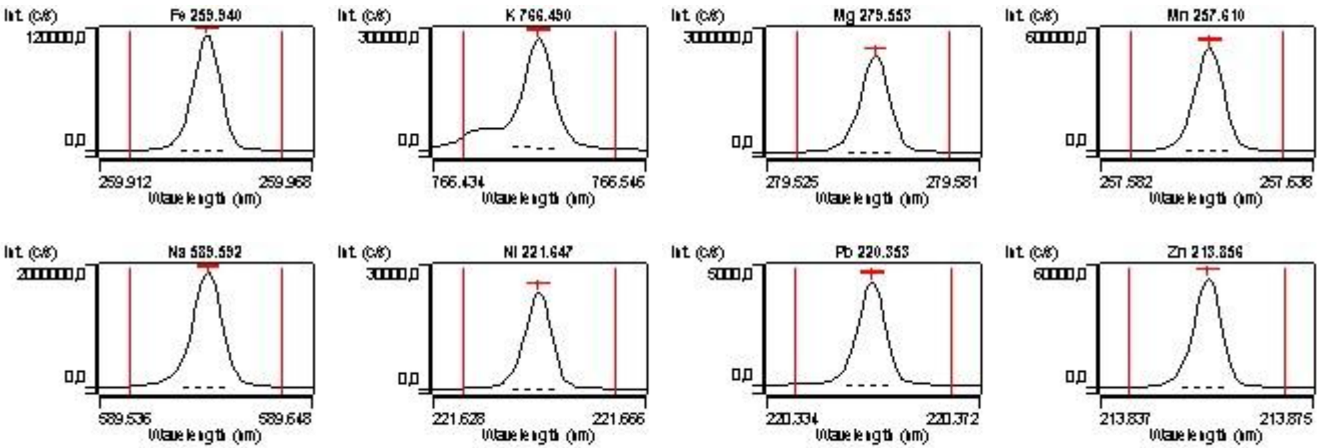

Figure 4. Intensity spectrums of elements used for ICP-AES analyses

Table 3. Results of ICP-AES analyses obtained from water samples.

Heavy metals and other elements	Sampling Locations NE Shore (The mouth of the Aksu Creek)	E Shore (The Bird Paradise)	S Shore
Al (µg/L)	50.67±1.9	69.27±2.2	13.25±1.2
B (µg/L)	62.24±2.2	62.484±2.1	77.78±2.3
Ba (µg/L)	130.16±2.7	135.64±2.8	171.15±3.1
Cd (µg/L)	N.D.	N.D.	N.D.
Co (µg/L)	N.D.	N.D.	N.D.
Cr (µg/L)	N.D.	N.D.	N.D.
Cu (µg/L)	20.33±1.2	22.210±1.3	23.61±1.4
Fe (µg/L)	33.63±1.3	42.34±1.5	131.62±2.6
Mn (µg/L)	12.23±1.1	19.21±1.2	564.45±3.1
Ni (µg/L)	N.D.	7.266±1.1	N.D.
Pb (µg/L)	14.65±1.2	19.43±1.4	17.27±1.4
Zn (µg/L)	N.D.	N.D.	N.D.
Ca (mg/L)	73.46±1.35	74.34±1.38	76.49±1.40
K (mg/L)	3.426±0.26	3.36±0.25	3.67±0.27
Mg (mg/L)	13.31±0.48	13.58±0.49	13.63±0.47
Na (mg/L)	25.60±0.56	25.31±0.55	27.03±0.56

NE: northeast, E: east; S: south, *N.D., Not Determined

The multimetric analysis of the same sample showed that pH value of the water on the eastern shore is 7.48, almost neutral. Its electrical conductivity is 603 μS/cm, the amount of total dissolved solids is 358 mg/L and the value of salinity is 0.3 g/l. This signifies that these values are in accord with the others (Table 4). According to Table 6, the highest ion contents are 38.2 mg/l for Cl^{-} and 10.39 mg/l for SO_4^{-2}. The other values are very close to the ones measured in the samples taken from the mouth of the Aksu Creek.

The data given in Table 6 proves that no NO_2^{-}, Br^{-} and NH_4^{+} were detected in this sample taken from the eastern shore as was in the other samples, yet the amounts of Cl^{-} and SO_4^{-2} were measured to be 64,69 mg/l and 10,39 mg/l – the highest amounts among the others but insignificant, respectively.

The last sample was taken from an apparently polluted section of the lake, which is very close to the settlement centers and used for recreational purposes. Further, this section is where creeks drift the waste materials deposited along the Istanbul-Ankara highway into the lake. This sampling location is also where wastewater is dumped into the lake. It was found out by ICP-AES analysis that the amount of heavy metals Fe and Mn is nearly 4 times higher than in the other samples (Table 3). The highest amount of element detected in the sample is Ca with 76.49, followed by Na (27.03 mg/l), Mg (13.63 mg/l) and K (3.67 mg/l). Other detected elements and heavy metals were put into order of their weights as follows; Ba>Fe>B>Cu>Pb>Al>Ni.

Table 4. The values for pH, electrical conductivity, total dissolved solids and salinity of the water samples.

Sampling location	pH	Conductivity (µS/cm)	TDS (mg/L)	SAL (g/L)
NE shore (the mouth of Aksu Creek)	6,98±0.09	605±4.3	361±1.91	0,3
E Shore (Bird Paradise)	7,48±1.2	603±4.2	358±1.88	0,3
S Shore	6,85±0.09	628±4.5	372±1.94	0,3

Table 5. pH, conductivity and salinity values obtained from several lakes located in the studied region

Year	**Lake**	**pH**	**Conductivity (µS/cm)**	**SAL (g/L)**
2009	*Lake Yeniçağa	6.85-7.48	603-628	0.3
2002–2003	**Lake Yeniçağa	8.38 - 7.72	411 - 482	0.2
2002–2003	**Lake Küçük Ak	8.59 - 9.09	305-346	0.1 – 0.2
2002–2003	**Lake Taşkısığı	7.43 - 7.99	595-631	0.3
2002–2003	**Lake Büyük Ak	7.97 - 7.56	271-385	0.1 – 0.2
2002–2003	**Lake Acarlar	6.44	522	0.3
2002–2003	**Lake Melen	6.23	384	0.2
2002–2003	**Lake Poyrazlar	6.22 - 7.95	241	0.1
2002–2003	**Lake Gölcük	7.10 - 7.72	182 - 224	0.1 – 0.1
2002–2003	**Lake Abant	6.99 - 6.47	209 - 225	0.1 – 0.1
2002–2003	**Lake Karamurat	6.34 - 7.95	263 - 276	0.1
2002–2003	**Lake Sülük	6.47 - 6.7	240 - 264	0.1
2002–2003	**Lake Çubuk	7.32 - 6.66	167 - 176	0.1
2002–2003	**Lake Sünnet	7.12 - 7.22	399 - 428	0.2

* This Study, ** From Taşdemir A. (2008)

Table 6. The amounts of F^-, Cl^-, NO_2^-, Br^-, NO_3^{-3}, PO_4^{-3}, SO_4^{-2} and NH_4^+ determined in the water samples.

	F^- (µg/L)	**Cl^- (mg/L)**	**NO_2^- (mg/L)**	**Br^- (mg/L)**	**NO_3^- (µg/L)**	**PO_4^{-3} (µg/L)**	**SO_4^{-2} (mg/L)**	**NH_4^+ (µg/L)**
NE shore (the mouth of Aksu Creek)	141±3.5	63,39±0.4	*N.D.	*N.D.	152±3.6	97±2.1	11,42±0.12	*N.D.
E Shore (Bird Paradise)								
S Shore	136±2.2	64,69±0.4	*N.D.	*N.D.	149±3.5	83±1.9	10,39±0.10	*N.D.
	19±4.1	68,6±0.5	0,23±0.05	*N.D.	410±3.9	*N.D.	30,07±0.19	165±3.8

*N.D.: Not Determined

Table 7. Heavy metals identified by ICP-AES analysis of the lichen samples

Heavy metals	S Shore (*Xanthoria parietina*) (µgg^{-1} dry wt)	E Shore (*Xanthoria parietina*) (µgg^{-1} dry wt)	E Shore (*Diploschistes scruposus*) (µgg^{-1} dry wt)
Al	483.948±2.28	3248.80±5.49	7341.71±7.23
B	10.3533±0.87	3.78739±0.26	5.22487±0.41
Ba	39.2784±1.15	37.9577±0.83	98.4194±1.37
Cd	0.422080±0.04	1.26438±0.06	1.79849±0.07
Co	0.640027±0.06	4.98384±0.11	8.44484±0.28
Cr	4.86603±0.41	46.0599±0.95	68.1085±1.06
Cu	11.1559±0.63	13.9951±0.53	18.5266±0.62
Fe	667.655±3.29	3858.05±6.4	7249.79±7.58
Mn	57.0194±1.16	97.1713±1.48	250.546±2.35
Ni	2.67628±0.22	48.5111±1.15	95.8722±1.86
Pb	5.50325±0.30	25.7962±0.87	19.9424±0.68
Zn	61.5992±1.19	45.4132±1.20	59.3953±1.51

The analyses of the same sample yielded 6.85 as the pH value, 628 µS/cm for electrical conductivity, 372 mg/L for total dissolved solids and 0.3 g/l for salinity (Table 4) and these values exhibit a significant difference from the other values.

Data presented in Table 6 reveal that only PO_4^{-3} was not identified and unlike the other samples, values for Cl^- turned out to be 3 or 4 times more than those of NO_3^{-3} and SO_4^{-2}. Moreover, unlike the other samples, NO_2^- and NH_4^+, an important pollution indicator, were not detected in the others. Thus, the south coast of the lake is much polluted, which also confirms that pollution is at a critical level in the south of the lake. Previous research also demonstrated in detail nutrient (ammonia, nitrite and nitrate) concentrations (Saygı-Başbuğ and Demiralp 2004a) and a strong eutrophication potential in the lake water (Saygı-Başbuğ and Demiralp 2004b).

Lichen Analyses

Because lichens are important indicators of air pollution, the lichens *Xanthoria parietina* and *Diploschistes scruposus* found in colonies in the study area were used as biomonitoring tools. In fact, lichens are symbiotic organisms which capture and trap pollutants and heavy metals (Cd, As, Pb, Cr, Zn, Ni, Sn, Cu etc.) originated from fallen metal vehicle parts, fossil fuel-induced acid rain besides various pollutants like SO_2 and NO_2 induced by vehicle smokes and waste oils, thus they are effective biomonitoring means for pollution studies. Lichens are widely used to monitor air pollution and previous studies give detailed accounts about the utilization of lichens as biomonitors (Ferry et al. 1973, Skye 1979, Conti and Cecchetti 2001). In Turkey, our knowledge on this subject is restricted with a few studies, confirming that air pollution and air quality can be monitored by lichens (John 1989, Sommerfelt and John 2001).

In the study, we discussed about the concrete data on air quality or pollution provided by elemental and heavy metal content of two different lichen species (*Xanthoria parietina* ve *Diploschistes scruposus*) collected from the southern and eastern parts of the Lake Yeniçağa. The results are presented in Table 7 and 8.

As Table 7 indicates, Fe and Al are at the most critical level among all the other heavy metals. It is known that the origins of these heavy metals are particles released by vehicle parts, tires and the ones aloft because of the traffic load (Bargagli 1995, Conti et al. 2009).

The ICP-AES analysis of the lichen sample *Xanthoria parietina* picked in the southeast of the lake indicates that Fe and Al have the highest levels with 49.63% and 35.97%, respectively. The order of the weight percentages of the other heavy metals except for Zn (4.57%), Mn (4.23%) and Ba (2.92%) are as follows; Cu>B>Pb>Cr>Ni>Co>Cd.

The same samples of lichen were taken also from the eastern shore of the lake and the percentages of Fe and Al were found out to be 51.91% and 43.7%, respectively. Other heavy metals over 1%, except for Mn with 1.3%, are as follows; Ni>Zn>Cr>Ba>Pb>Co>B>Cd

Fe and Al were found in critical amounts in *Diploschistes scruposus* sampled in order to make a comparison with *Xanthoria parietina* and their ratios were 47.63% and 48.24%, respectively. Ratio of Mn to the total sum is 1.64%. The other heavy metals only account for 2.44% of total heavy metal deposition.

The scatter graph (Figure 5) drafted to make a comparison among heavy metal depositions indicates that heavy metal deposition due to air pollution is at high levels along the highway in the eastern shore. In particular, levels concerning Fe and Al are high in the sample *Diploschistes scruposus*. Zn, Mn and Ba are at more critical levels than the other in the southeastern shore.

When the elemental contents of the lichens were discussed, it was discovered that the dominant element was Ca with (67.2%), followed by K (19.51%), Mg (9.57%) and Na (2.69%). Whereas levels of the Na deposition are similar in all the samples that of Ca is excessively high in the samples taken from the rock surfaces in the eastern shore. However, pollution rates of these elements are not significant, but reflect the elemental deposition resulting from mineral decomposition on the rock surfaces where lichens grow.

Table 8. Comparison of the average heavy metal contents within some lichens in different localities elsewhere. Partly modified from Nayaka (2003).

Lichen species	Cr ($\mu g g^{-1}$ dry wt)	Pb ($\mu g g^{-1}$ dry wt)	Fe ($\mu g g^{-1}$ dry wt)	Zn ($\mu g g^{-1}$ dry wt)	Cu ($\mu g g^{-1}$ dry wt)	References
Xanthoria parietina	4.86-46.05	5.50-25.79	667-3858	45.41-61.59	11.15-13.99	This Work
Diploschistes scruposus	68.10	19.942	7249.79	59.39	18.52	This Work
C. candelaris (L.) Laundon	5.18	ND	7556	95.76	23.72	Nayaka, 2003
D. consimilis (Stirton) Awasthi	35.59	149.15	7081	198.14	22.22	Nayaka, 2003
P. leucosorodes Nyl.	3.04	31.92	570	79.86	5.84	Nayaka, 2003
P. nanospora (A. Singh) Upreti	36.43	175.9	1506	231.01	18.28	Nayaka, 2003
P. cocoes (Swartz) Nyl.	9.53	63.63	12056	103.3	16.3	Nayaka, 2003
D. aegialita (Afz. in Ach.) Moore	34.57	46.4	6887	98.6	8.99	Nayaka, 2003
C. candelaris (L.) Laundon	95.29	623.95	6926	157.496	19.75	Nayaka, 2003
L. leprosa Fée	29.92	154	3121	128.15	9.84	Nayaka, 2003
P. petricola Nyl. In Crombie	19	83.33	9202	133.05	115.19	Nayaka, 2003
P. petricola Nyl. in Crombie	18.47	101.4	5538	105.38	338.12	Nayaka, 2003
B. isidiza (Nyl.) Hale	12.99	22.05	22721	102.73	86.02	Nayaka, 2003

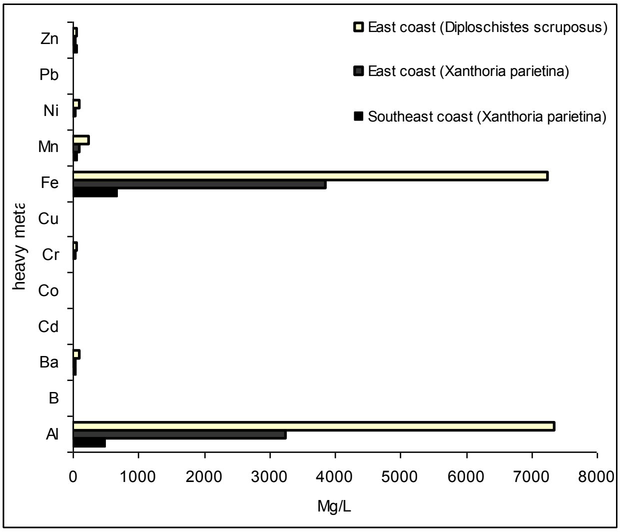

Figure 5. Scatter graph related to heavy metal by ICP-AES analysis of the lichen samples

Conclusion

Our results demonstrated that the level of pollution in the Lake Yeniçağa was not at a critical level to affect water quality. However, pollutant-laden creeks and the Istanbul-Ankara highway constitute a potential risk for the possible increase in both the quality of the lake waters and air as well. The present data demonstrate high a amount of Cl^- and SO_4^{-2} in the samples. The sample taken from the southern shore contains Cl^-, NO_3^{-3} and SO_4^{-2} 3 or 4 times more than the others and points to NO_2^- and NH_4^+ deposition, not detected in the other samples. It was also concluded that the amounts of Fe and Mn are 4 times higher in the sample taken from the southern shore than in the other samples. We found no significant difference among pH values, electrical conductivity, total dissolved solids and salinity of each sample. Fe and Al depositions were high in the samples that were analyzed in terms of air pollution especially in the ones collected along the highway. This case shows that traffic load of Istanbul-Ankara highway leads to a heavy metal deposition around the lake. In order to avoid environmental pollution, facilities should be established away from cities, basins and agricultural areas. Increase in pollution decreases the amount of the oxygen in the water, endangers and further destroys the water organisms. It is necessary that no physical and human conditions be put in danger just for the sake of some economic rent. One of the major future problems will be the danger posed by the deposition of waste materials. Therefore, the conditions of the creeks must be ameliorated and hazardous effects of the sewers must be eliminated. Although too late to act, the Lake Yeniçağa was taken under preservation by the Wetlands Conservation Project in 2008.

Özet

Yeniçağa gölü Batı Karadeniz Bölgesinin iç kesiminde, Bolu ili sınırları içinde, Yeniçağa şehrinin kuzey kenarında olup, İstanbul'a 285 km. Ankara'ya ise, 153 km uzaklıkta Çağa depresyonunun orta kısmında yer almaktadır. Göle toplam sekiz adet dere (Hamzabey, Güzviran, Kaymaz, Ömerli, Kirenli, Fındıklı, Aksu ve Kayışlar) karışmakta bir adet dere ile (Çağa) boşalmaktadır. Bunlardan Kaymaz, Ömerli, Kirenli ve Fındıklı dereleri TEM otoyolunun, Güzviran deresi de D-100 karayolunun atıklarını, Hamzabey ve Aksu dereleri de tarımsal atıkları göle taşımaktadır. Bu çalışmada Batı Karadeniz Bölgesi'nin iç kesimlerinde, Bolu ili sınırları dahilinde yer alan Yeniçağa Gölü ve çevresinden alınan su ve liken örneklerinden elde edilen ön sonuçları sunuldu. Su ve hava kirlilik parametrelerine ait bazı ICP-AES ve IC analizleri yanı sıra çeşitli ölçüm sonuçlarına göre değerlendirildi. Elde edilen sonuçlar Cl^- ve NH_4 seviyelerinde artışı göstermektedir. Özellikle göl littoralinin güney kıyısından alınan örnekteki Cl^-, NO_3^{-3} ve SO_4^{-2} 2-3 kat fazla oranlarda çıkmıştır. Ayrıca bu kesimde diğer örneklerde tanımlanmayan NO_2^- ve NH_4^+ konsantrasyonları da tespit edilmiştir. Trafik yükünün göl ve çevresindeki su-hava kalitesini araştırmak amacıyla iki liken türünün (*Xanthoria parietina* and *Diploschistes scruposus*) analizleri Fe ve Al miktarlarının fazla olduğunu, dolayısıyla trafik kaynaklı partikül birikiminin olumsuz etkilerini ortaya koymaktadır.

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