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Research Article

Köyceğiz, Bafa ve Limni Göllerinin (Muğla-Türkiye) Bazı Fiziko-kimyasal Özelliklerinin İncelenmesi

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Öz

Göller en önemli sulak alan ekosistemleri arasındadır. Ekolojik olarak önemli olan göller, özel ekosistemlerdir ve bölgenin su rejimini düzenlemek, karakteristik bitki ve hayvan gruplarının ekonomik, kültürel, bilimsel ve rekreasyonel bir şekilde yaşamalarını ve büyük bir kaynak oluşturmalarını sağlamak gibi birçok önemli role sahiptir.Bunun yanında, çeşitli insan faaliyetleri (balıkçılık, rekreasyon ve turizm, enerji üretimi, atık su emisyonu vd.,)ve doğa için bir sığınak olarak kabul edilen göller, güncel yönetmeliklere göre yönetilmeli ve sömürülmemelidir.
36°17'-37°33` Kuzey enlemleri ve 27°13`-29°46` Doğu boylamları arasında yer alan Muğla, 13328 km^2 yüzey alanına ve çok engebeli bir arazi yapısına sahiptir. Muğla İli, Büyük Menderes, Dalaman ve Eşençayı havzalarında yer alıp, Güneyde Akdeniz, Batıda Ege Denizi ile çevrilidir. Muğla ili, Eşencayı, Dalaman Çayı, Bafa Gölü, Güllük Lagünü ve Köyceğiz Gölü gibi ana su kaynakları ile diğer tatlı su kaynakları bakımından zengindir.
Bu çalışma aylık olarak Haziran 2011 ile Mayıs 2012 tarihleri arasında Köyceğiz, Bafa ve Limni Gölü'nde yapılmıştır. Seçilenbu istasyonlardaki göller su kalitesi yönünden araştırılmıştır.Bu göllerden seçilen toplam 15 istasyon noktasından su örnekleri alınmıştır.
Su sıcaklığı, pH, elektriksel iletkenlik ve çözünmüş oksijen, YSI 556 MPS çoklu prob cihazı kullanılarak sahada ölçülmüştür.Sahadan alınan örnekler Muğla Sıtkı Koçman Üniversitesi Su Ürünleri Fakültesi Temel Bilimler Laboratuvarı'na getirilerek,orto-fosfat, nitrit azotu, nitrat azotu ve amonyum azotu bakımından ölçülmüştür.Bu istasyonlardan alınan su örnekleri fiziko-kimyasal parametreler yönünden incelenmiştir. Çalışmanın sonuçları şu şekilde belirlenmiştir: Su sıcaklığının 11,43 ile28,62^{0}C, pH'ın 6,03 ile 8,90, elektriksel iletkenliğin 403,6 ile 2124 µScm^{-1}, çözünmüş oksijen değerinin 1,73 ile 11,42 mgL^{-1}, nitrit azotunun BDL ile0,12 mgL^{-1}, nitrat azotunun BDLile 25,85 mgL^{-1}, amonyum azotunun BDL ile 1,64 mgL^{-1} ve orto–fosfat değerlerinin BDL ile 1,24 mgL^{-1}arasında değişim gösterdiği saptanmıştır.Fiziko-kimyasal parametreler Su Kirliliği Kontrolü Mevzuatı'na uygun olarak değerlendirilmiştir.Bu çalışmanın bir sonucu olarak, bu göllerdeki kirliliğin çoğunlukla antropojenik faktörler, tarımsal kirleticiler, turizm faaliyetleri, evsel atıklar ve atık su kombinasyonundan etkilendiği görülmüştür.

AnahtarKelimeler: Antropojenik faktörler, Köyceğiz Gölü, Bafa Gölü, Limni Gölü, Fiziko-kimyasal parametreler, Turizm faaliyetleri, Su kalitesi, Su kirliliği

Investigation of Some Physico-chemical Properties of Köyceğiz, Bafa and Limni Lakes (Muğla-Turkey)

Abstract

Lakes are among the most important wetland ecosystems. Lakes which are important ecologically are special ecosystems and have many significant roles such as arranging water regime of the region, enabling characteristic plant and animal groups to live and

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forming a great source economically, culturally, scientifically and recreationally. In addition, the lake as a resource for various human activities (fishing, recreation and tourism, power generation, waste water emissions et al.,) and as a shelter for nature has to be adequately managed and exploited according to the approved regulations.

Muğla Province, located between 36°17' and 37°33` Northern latitude and 27°13`and 29°46` Eastern longitude, has 13 328 km^2 surface area and a very rough terrain. The province is located in the basins of Büyük Menderes, Dalaman and Eşen Rivers and surrounded by the Mediterranean Sea in the South and the Aegean Sea in the West. Muğla Province is rich in terms of fresh water resources with major water resources in the province being the Eşencay and Dalaman Rivers, Bafa Lake, Güllük Lagoon and Köyceğiz Lake.
This study was carried out between June 2011 and May 2012 in these important lakes; Köyceğiz, Bafa and Limni Lake. These stations, selected these lakes were investigated for water quality aspects. In total 15 stations points were water sampled on these lakes. Water temperature, pH and electrical conductivity, dissolved oxygen were measured on site by using YSI 556 MPS multi-probe instrument. Samples taken from the site were measured in terms of ortho-phosphate, nitrite nitrogen, nitrate nitrogen and ammonium nitrogen in the Basis Sciences Laboratory of Fishering Faculty in Muğla Sıtkı Koçman University.
Water samples, taken from these stations were studied for physico-chemical evidences. Results of the study were determined as: water temperature (11.43-28.62 ^{0}C), pH (6.03-8.90), electrical conductivity (403.6-2124 µScm^{-1}), dissolved oxygen (1.73-11.42 mgL^{-1}), nitrite nitrogen (BDL-0.12 mgL^{-1}), nitrate nitrogen (BDL-25.85 mgL^{-1}), ammonia nitrogen (BDL-1.64 mgL^{-1}) and ortho-phosphate (BDL-1.24 mgL^{-1}). Physico-chemical data were evaluated in accordance with the Legislation of Water Pollution Control. As a conclusion of this study the pollution in these lakes were seen to be mostly influenced by a combination of anthropogenic factors, agricultural pollutants, tourism activities, domestic waste and sewage water.

Keywords: Anthropogenic factors, Köyceğiz Lake, Bafa Lake, Limni Lake, Physico-chemical parameters, Tourism activites, Water quality, Water pollution

1. Introduction

A basic feature of the earth is an abundance of water, which extends over 71% of its surface to an average depth of 3800 m. Over 99% of this immense hydrosphere is deposited in ocean depressions. The relatively small amounths of water that ocur in freshwater lakes and rivers belie their fundamental importance in the maintenance and survival of terrestrial life. Discrepancy among rivers, lakes and their phsical, chemical, and biological properties was the driving force behind the half century of lake classification studies (Wetzel 2001).

Protecting lake ecosystems allows us to offer clean water, healthy food and more. Mismanagement of lake ecosystems leads to increased water pollution, water-related diseases and flood disasters. They are also important for leisure and recreation. Since the beginning of the 20th century 2/3 of European inland water has been lost due to engineering construction works, draining and conversion to arable and the fresh water resources of Turkey are extremely rich, including 200 natural lakes, 2500 reservoirs and 33 rivers with a total area of 1,5 million ha (Anonymous 2000).

The Köyceğiz Lake was established about 7500 years ago. Having an area of 5200 hectares (Table 1), Köyceğiz Lake in the province of Muğla is one of the vastest coastal lakes of Turkey. It bears the name of the village of Köyceğiz (Franzen et al. 2008).

Bafa Lake is located on Delta of Büyük Menderes River. Bafa Lake, formerly a bay of the Aegean Sea, was isolated from the sea as a result of alluvium blockage of the opening of Latmos Bay caused by alluvial deposits of the Büyük Menderes River in 50-300 AD. The lake was developed as a result of delta development of Büyük Menderes (Maeander) river (Kasparek 1988).The Lake Bafa is an alluvial bar lake located in the Aegean Region in the Big Meander river basin in Aydın and Muğla Provinces (Table 1).

The Güllük Lagoon, which is important for ecological and aquaculture and covers an area of approximately 2500 da with a depth ranging from 0,5-2,5 m, is one of the 8 lagoons present in the Aegean Region.Limni Lake, which isone of efficiency lagoons of Aegean Region, covers an area of approximately 68 ha (Egemen et al. 1999).

The region which was characterised by extensive tectonic activity in geologic times was also struck by many earthYuakes during historic times. The seismic activity is still going on (Soysal et al. 1981). The springs located in the basin could have been associated with fault extending down Bafa Lake. Some small brooks, groundwater sources located on the floor of the lake, flooding of the Büyük Menderes River and precipitation were freshwater sources fed the lake. The construction of the barrier in 1985 prevented the floods of the Serçin village from the Büyük Menderes River. So it does not enter an important entrance from the river to the lake (Koç2010). This barrier and the decrease in precipitation due to climate change lowered the lake level and increased chemical concentrations.

The Köyceğiz Lagoon Basin, which has been heard in various publications since the 1980s, has begun to draw attention to researchers, environmental advocates and investors with its natural and cultural values. Many agriculture and fishery products providing touristic inputs are raised in this region and they are immediately reached to the sector. Since fresh waters (Lake, streams and rivers) and sea are side by side which ensuring tourism to be formed, Köyceğiz, Bafa and Limni Lakes became one of the most important touristic areas of Turkey (Figure 1). Köyceğiz, Bafa and Limni Lakes which form the basis of tourism, fish culture and oil farm are intertwined here. However, it is mentioned by many researches performed in it that there is an ocular environmental pollution due to the fact that required care and sensitivity are not taken. A rapid but non-planned structuring stands out in the region which is an ideal environment for tourism investments with its natural and ancient values. Especially Köyceğiz Lagoon Basin is the first sample in

Turkey as a planned tourism progress directed by the State which is examined due to damages to natural environment and ecological values. In this context, the regions are included into the "Private Environment Protection Area (PEPA)" set by a decree law dated as 13th November 1989 and numbered as 383. The region is also discussed both for positive and negative aspects of both previous and today's investments in a period in which rationalistic managements with multi-purposes of shorelines are discussed internationally and in which seekings are done. Besides freshwaters, natural lakes, dam lakes were studied in the region (Barlas et al. 1995, Dügel 1995, Özdemir et al. 1995, Barlas et al. 2000, Kazancı and Dügel 2000, Barlas et al. 2002; Özdemir et al. 2003, Yorulmaz et al. 2003, Yılmaz 2004, Balık et al. 2005, Dirican and Barlas 2005, Özdemir et al. 2007, Barlas et al. 2008, Kalyoncu et al. 2008, Erdinç2010 and De Sa Matos Paixao 2011).

2. Material and Methods

2.1. Study area

Muğla province is located between 36°17' and 37°33` Northern latitude and 27°13`and 29°46` Eastern longitude, has 13328 km^2 surface area and a very rough terrain. The province is located in the basins of Büyük Menderes, Dalaman and Esen Rivers and surrounded by the Mediterranean Sea in the South and the Aegean Sea in the West. Muğla province is rich in terms of freshwater resources with major water resources in the province being the Eşen and Dalaman River and Köyceğiz Lake (Anonymous 1998).

2.2.Sampling and Analysis

In total of 15 stations points were water sampled on these lakes (Figure 1). Water temperature, pH, electrical conductivity and dissolved oxygen were measured on site by using YSI 556 MPS multi-probe instrument. Samples taken from the site were measured in terms of ortho-phosphate, nitrite nitrogen, nitrate nitrogen and ammonium nitrogen in the Laboratory of Fisheries Faculty in Muğla Sıtkı Koçman University. The one way analysis of variance (ANOVA) was conducted to evaluate among the sample stations. The Tukey multiple range test was used to discriminate between means. All statistical analyses were performed in the SPSS version 21 statistical software (IBM, New York, NY), and statistical decisions were based on an alpha of 0.05. Results some of physico-chemical analysis from selected stations were calculated as minimum and maximum values were given at Table 2.

Table 1. Overview of Köyceğiz, Bafa and Limni Lakes in study area (Kazancı et al., 1999).

Lake Properties	**Köyceğiz**	**Bafa**	**Limni**
Surface measurement (km^2)	55.0	68.6	2.5
Lake Type	Meromictic Lake	Lagoon Lake	Lagoon Lake
Location	Köyceğiz-Muğla Province	Between Muğla-Aydın Provinces	Milas-Muğla Province
Maximum Deep (m)	25	21	3.0
Covering Area (km^2)	250	315	12
Above Sea Level (m)	8.0	2.0	1.0
Climate Type	Mediterranean	Mediterranean	Mediterranean
Coordinates	36º 54' N 28º 38' E	37º 30' N' 27º 25' E	37º 15' N 27º 38' E
Connect Freshwaters	Yuvarlakçay stream, Namnam stream, Kargıcak river	Büyük Menderes river	DSI drainage channel
Number of Stations	7	5	3

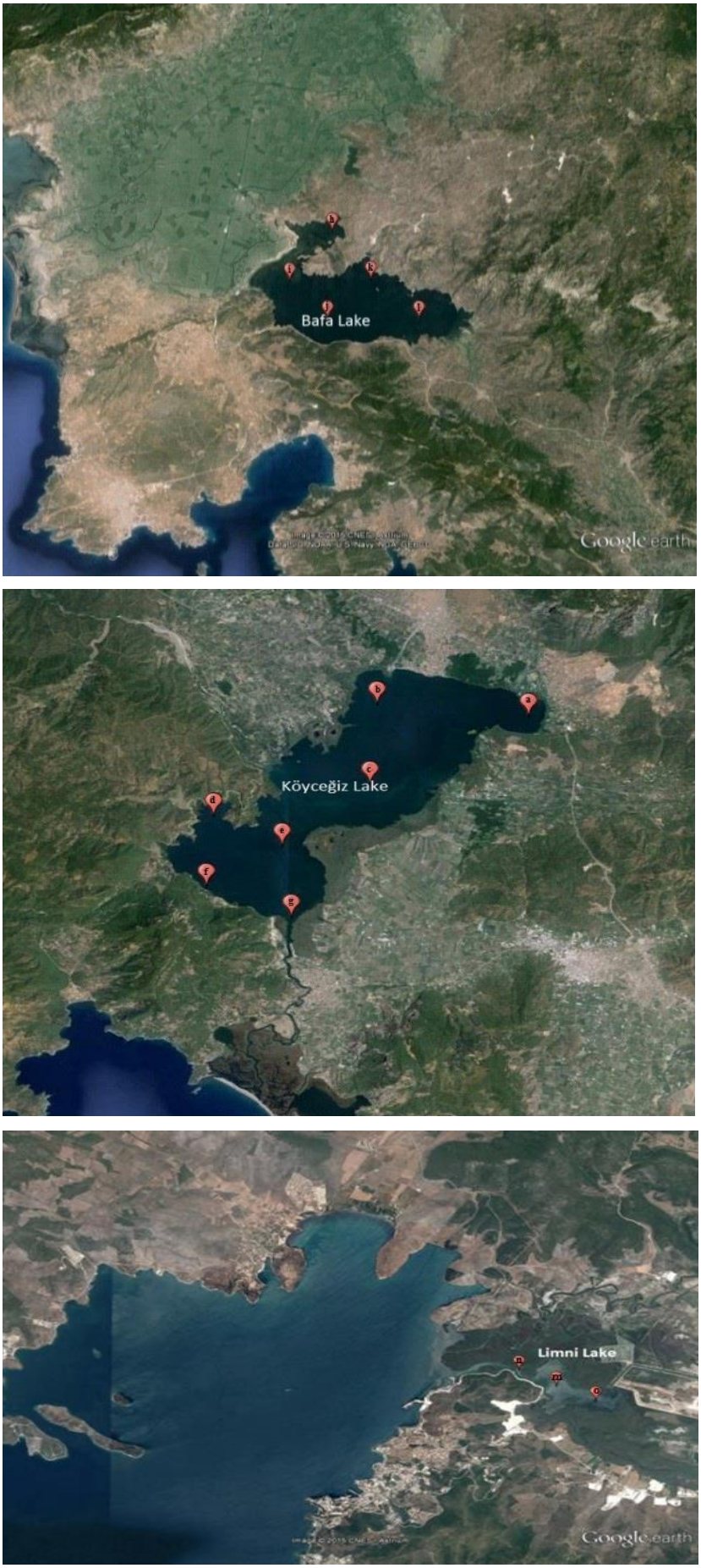

Figure 1. Location map of the study area (from Google Earth).

Table 2. June 2011 and May 2012 valuesof physico-chemical properties at the stations points (BDL: below detection limits).

Lakes / Parameters	Köyceğiz Lake				Bafa Lake				Limni Lake			
	(Min-Max)	n	Std. deviation	Mean	(Min-Max)	n	Std. deviation	Mean	(Min-Max)	n	Std. deviation	Mean
Water Temperature (°C)	11.53-28.62	84	4.83	21.07	14.32-27.33	60	3.72	19.50	11.43-27.99	36	4.58	19.87
pH	7.87-8.90	84	0.24	8.18	7.55-8.61	60	0.31	8.17	6.03-8.28	36	0.40	7.78
Dissolved oxygen (mgL^{-1})	6.01-10.09	84	1.25	7.94	5.03-8.15	60	0.78	7.07	1.73-11.42	36	1.60	6.76
Electrical conductivity (μScm^{-1})	403.6-1204	84	230.05	710.93	868-2124	60	276.06	1525.93	600-1857	36	239.60	816.63
Nitrite nitrogen (NO_2-N)(mgL^{-1})	0.02-0.04	84	0.00	0.02	BDL-0.02	60	0.00	0.00	BDL-0.12	36	0.02	0.05
Nitrate nitrogen (NO_3-N)(mgL^{-1})	BDL-14.33	84	2.16	1.15	BDL-25.85	60	5.74	5.18	1.01 - 15.38	36	3.52	4.22
Ammonia nitrogen (NH_4-N) (mgL^{-1})	0.03 -1.03	84	0.21	0.13	BDL-1.64	60	0.38	0.34	0.13 - 1.29	36	0.41	0.52
Ortho-phosphate (PO_4-P)(mgL^{-1})	0.02 -0.26	84	0.06	0.10	BDL-0.52	60	0.09	0.10	0.06 - 1.24	36	0.41	0.44

Water samples were taken from the surface layer at the selected sampling points. Water analysis results were evaluated in accordance with "Quality Criteria of Inland Water Resources Categories" of Water Pollution Control Regulation (Table 3) (Anonymous 2008). Most of the sites on water sources were of 'high and poor' status (Table 4).

Table 3. Water quality of stations on lakes to WPCR (Anonmyous 2008).

Water Parameters / Lakes	T (°C)	pH	DO (mgL^{-1})	NO_2- N (mgL^{-1})	NO_3-N (mgL^{-1})	NH_4-N (mgL^{-1})	PO_4-P (mgL^{-1})
Köyceğiz	Good	Moderate	Good	Moderate	Moderate	Poor	Moderate
Bafa	Good	Moderate	Good	Poor	Poor	Poor	Moderate
Limni	Good	Good	Moderate	Poor	Mod-Poor	Poor	Poor

Tablo 4. Quality Criteria of Inland Water Resources Categories of Water Pollution Control Regulation (Anonymous 2008).

Water Quality Parameter	Water Quality Classification			
	I (High)	II (Good)	III (Moderate)	IV (Poor)
Water Temperature (°C)	25	25	30	>30
pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0
Dissolved oxygen ($O_2 mgL^{-1}$)	8	6	3	<3
Ammonia nitrogen (NH_4-N mgL^{-1})	0.002	0.01	0.02	>1
Nitrite nitrogen (NO_2- N mgL^{-1})	0.002	0.01	0.05	>0.05
Nitrate nitrogen (NO_3-N mgL^{-1})	5	10	15	>20
Ortho-phosphate (PO_4-P mgL^{-1})	0.02	0.16	0.65	>0.65

3. Results and Discussion

Table 5. Results of physico-chemical properties of water samples taken from the Köyceğiz Lake

Locations	T (ºC)	pH	DO (mgL^{-1})	EC (μScm^{-1})	NO_2- N (mgL^{-1})	NO_3-N (mgL^{-1})	NH_4-N (mgL^{-1})	PO_4-P (mgL^{-1})
a	20.45±5.14	8.16±0.25	7.20^{c}±0.89	587.58^{cd}±86.19	0.02^{a}±0.00	0.78±0.73	0.05^{b}±0.01	0.08^{b}±0.05
b	21.30±4.40	8.14±0.22	7.27^{bc}±0.69	736.50^{bc}±153.69	0.02^{a}±0.00	0.97±1.50	0.01^{b}±0.21	0.11^{b}±0.06
c	20.69±5.35	8.25±0.29	8.53^{ab}±1.26	791.75^{ab}±266.75	0.01^{b}±0.00	0.95±1.40	0.07^{b}±0.01	0.06^{b}±0.21
d	21.31±5.01	8.13±0.21	7.93^{ab}±1.70	897.25^{ab}±101.93	0.02^{a}±0.00	0.93±1.94	0.09^{b}±0.04	0.10^{b}±0.04
e	21.91±5.79	8.30±0.28	8.65^{a}±1.14	496.33^{d}±48.87	0.02^{a}±0.00	0.51±1.49	0.04^{b}±0.02	0.08^{b}±0.06
f	18.91±2.67	8.12±0.20	8.91^{a}±0.69	522.38^{d}±73.77	0.02^{a}±0.00	1.74±2.70	0.06^{b}±0.02	0.07^{b}±0.03
g	22.88±5.04	8.18±0.24	7.08^{c}±0.62	944.75^{a}±260.66	0.02^{a}±0.00	2.20±3.87	0.48^{a}±0.36	0.20^{a}±0.04

Mean ± SE with common superscripts in the same line are not significantly different (p>0.05).

Köyceğiz Lagoon Basin in Private Environment Protection Area is unique in the world by its geographical properties (lakes, lagoons, freshwaters, drains and sea systems). Water temperature, pH and nitrate nitrogen values are similar on all the stations in Table 5.Annual differences weren't statistically significant ($p > 0.05$) The DO value was the lowest in the a station (7.20±0.89 mgL^{-1}) and the highest in the f station (8.91±0.69 mgL^{-1}) in Köyceğiz Lake as presented in Table 5.Annual differences were statistically significant ($p < 0.05$).DO values were low at all stations. This decrease was expected as a result of hydrological conditions and untreated wastewater discharges.Water quality at Köyceğiz Lake II. class in terms of DO values. EC,ammonia nitrogen and ortho-phosphate values were the highest in the g station in Köyceğiz Lake (Table 5). And nitrite nitrogen value was the lowest in the c station (0.01±0.00mgL^{-1}) in Köyceğiz lake (Table 5). High ammonia levels in water cause various problems in fish such as damaging the gills and blood hemoglobin.Most fish species can only tolerate 0.02–0.10mgL^{-1} of ammonia (Pulatsü and Çamdeviren 1999).Water quality at Köyceğiz Lake IV. class in terms of NH_4-N values (Table 3).In terms of o-PO4, the water of the Köyceğiz lake can be classified as class III according to the (WPCR 2008).

Table 6. Results of physico-chemical properties of water samples taken from the Bafa Lake

Locations	T (ºC)	pH	DO (mgL^{-1})	EC (μScm^{-1})	NO_2- N (mgL^{-1})	NO_3-N (mgL^{-1})	NH_4-N (mgL^{-1})	PO_4-P (mgL^{-1})
h	18.41±3.73	8.26±0.28	7.32±0.79	1353.75±173.61	BDL	6.49±6.29	0.18±0.33	0.07±0.05
ı	18.51±3.03	8.12±0.25	7.19±0.77	1505.00±275.72	BDL	6.31±4.90	0.21±0.16	0.07±0.03
j	19.19±3.52	8.20±0.29	7.20±0.80	1458.75±253.22	BDL	2.62±2.11	0.39±0.42	0.08±0.06
k	20.60±3.72	8.15±0.34	6.97±0.73	1683.91±225.02	BDL	2.49±1.67	0.45±0.35	0.19±0.16
l	20.79±4.42	8.11±0.37	6.67±0.79	1628.25±333.83	BDL	7.98±8.90	0.48±0.49	0.10±0.07

Mean ± SE with common superscripts in the same line are not significantly different (p>0.05).

Water temperature, pH,dissolved oxygen,electrical conductivity,nitrite nitrogen, nitrate nitrogen,ammonia nitrogen,ortho-phosphatevalues are similar on all the stations in Table 6.Annual differences weren't statistically significant (p>0.05).Water quality at Bafa Lake was IV. class in terms of NO_2–N,NO_3-N andNH_4-N values. Similary the nitrate and nitrite, levels were reported low in Lake Bafa (Yılmaz and Koç 2014).There is intensive agricultural activity (green housing and citrus fruits) around Köyceğiz, Bafa and Limni Lake with most of the farmers using significant amounts of chemicals (mainly pesticides and fertilizers) to earn more. The amount of the dissolved oxygen in the lakes generally gives information about the pollution level and the productivity of a lake (Koç 2008). And Water quality at Bafa Lake II. class in terms of DO values.This parameter is similar to Köyceğiz Lake. Low oxygen

concentrations will also affect the types on fish and invertebrates that inhabit the area (Yılmaz and Koç 2014). DO values are suitable for fish survival.

Table 7. Results of physico-chemical properties of water samples taken from the Limni Lake

Locations	T (ºC)	pH	DO (mgL^{-1})	EC (μScm^{-1})	NO_2- N (mgL^{-1})	NO_3-N (mgL^{-1})	NH_4-N (mgL^{-1})	PO_4-P (mgL^{-1})
m	19.85±5.23	7.80±0.25	6.33±1.05	751.16±83.27	0.04^{b}±0.00	2.74±2.04	0.49±0.42	0.27±0.34
n	20.61±4.60	7.82±0.30	7.56±1.60	782.75±245.367	0.05^{ab}±0.18	5.60±4.87	0.53±0.41	0.43±0.39
o	19.13±4.13	7.73±0.59	6.39±1.87	916.00±314.36	0.06^{a}±0.03	4.33±2.64	0.54±0.44	0.61±0.47

Mean ± SE with common superscripts in the same line are not significantly different (p>0.05).

Water temperature, pH, dissolved oxygen, electrical conductivity, nitrate nitrogen, ammonia nitrogen, ortho-phosphate values are similar on all the stations in Limni Lake (Table 7).Annual differences weren't statistically significant (p>0.05).The NO_2-N value was measured as the lowest in the m station (0.04±0.00mgL^{-1}) and the highest in the o station (0.06±0.03mgL^{-1}) as presented in Table 7.In all of the 3 stations, significant differences were determined in the annual NO_2-N levels (p<0.05).The averagenitrite–nitrogen level was reported to be 0.043 $mgL^{-1}$and 0.147mgL^{-1}in the Uluabat and Mogan lakes (Iscen et al.2008, Demir et al. 2014).Ortho-phosphate upper limit is accepted 0.02 mgL^{-1} for lakes which have no problem with algae. However, all values are above this limit in this study. It shows that lake has a problem with algae.

4. Conclusion

Conclusion of this study the pollution in these lakes were seen to be mostly influenced by a combination of anthropogenic factors, agricultural pollutants, tourism activities, domestic waste and sewage water. Biological diversity and ecosystem should be protected. Water budget should be controlled and optimum usage balance of water should be constituted. Moreover, activities which will pollute water sources and effect beds of these resources should be prevented.

Activities of agriculture and tourism in the region should be arranged. Awareness in the region should be increased. And also,present income sources should be increased and alternative income sources should be created.Public people should work in new projects, facilities should include a public relations expert, environmental education studies should be done for women and children and participationof these studies should be provided.

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