Asian Journal of Chemistry Vol. 21, No. 4 (2009), 3107-3116

Amounts of Nitrogen and Phosphorus Related to Agricultural Pollution Elements in Egirdir Lake

ATILGAN ATILGAN*, ALI COSKAN†, ERDINC ISLER† and HASAN OZ
Department of Agricultural Structures and Irrigation, Faculty of Agriculture
University of Suleyman Demirel, 32260 Isparta, Turkey
E-mail: atilgan@ziraat.sdu.edu.tr

Egirdir lake having surface area 482 km^2, is an inward lake of which is oligotrophic, used for drinking water, irrigation, fishery products, tourism, recreation, fishing and wild life. Lake is potentially polluted by the residential districts as well as agricultural areas. Egirdir lake with its potable water and blue-flagged beach is under the threat of pollution due to the arrival of agricultural and household wastes together with leather industrial wastes in uncontrolled manners. In recent years, the existence of the noticeable green cover in some bays within the lake has made. It is thought that agricultural pollutant elements have reached the lake therefore water samples were taken from the lake in order to identify the concentration of manures with nitrogen and phosphorus which are the most used mineral manures in agriculture. As the sampling points, Kovada lake exit with the inclusion of the close areas on both sides of this exit, the bays on which green cover has occurred, the coast close to the residential districts, the regions with a coast to the agricultural areas and the coastlines with natural vegetation were chose. In the water samples taken from 15 points for the analysis of NH_4^+, NH_3, NO_3^-, NO_2^- and P_2O_5 were carried out. In the first period of sampling ammonium nitrogen was not found in 3 points. The highest NH_4^+ amount found in other points 0.02 mg NH_4^+-N/L. In none of the samples ammonia nitrogen was found. Although there are some differences in water samples with regard to NO_3^--N contents, the defined values in most of the samples were found to be lower in comparison with the acceptable limit values. In none of the samples, NO_2^- amount was found enough to be analyzed. When the values obtained through phosphorus content were examined, 0.096 mg P_2O_5 L^{-1} was found only on the point where residential districts and agricultural areas exist together. In other sampling points, phosphorus levels were found as zero value or that is close to zero. Based on these results, it has been concluded that agricultural production carried out in the region is likely to cause nitrogen and phosphorus pollution throughout the lake. In this study, it has been clearly seen that the actions in which plant nutrient components are defined need to be condensed during the days especially following the manure periods in the bays with lesser water movements within the lake.

Key Words: Egirdir Lake, Nitrogen, Phosphorus, Environmental pollution.

†Department of Soil Science, Faculty of Agriculture, University of Suleyman Demirel, 32260 Isparta, Turkey.

INTRODUCTION

The basic reason of the pollution of surface and underground water is to throw the urban, industrial wastes and waste water away the environment without being purified. The manures and pesticides used in agriculture are also the most important sources of pollution. In recent years, the qualities of underground waters and amounts of the solved elements within these waters close to the surface have begun to change after the intensive agriculture spread and increased throughout the world.

Gang *et al.*[1] reported that total dissolved nitrogen (TDN) concentration in surface water and leachate increase due to N-fertilizer application rate, with peak concentrations occurring 1-2 d after fertilization. A significant difference in TDN is observed between two fertilization treatments within one week after fertilization. Total dissolved phosphorus (TDP) concentration in surface water during the rice growing season exceeds critical value of water eutrophication by a merging as high as 15.8 mg L^{-1} after fertilization, leading to pollution of surrounding surface water.

Animal and vegetable wastes, natural and artificial manures, pesticides and microorganisms carried by the underground waters have reached the lakes and seas as well. Especially, the damages of the agricultural manures and pesticides used in unplanned ways to the lake ecosystems and environment have risen to a level that can damage to lake ecosystems.

The impacts of agricultural practices especially of fertilizing the soil uncontrolled are seen on the growth of soil, water, air and plants. The negative effects of manure on surface and underground waters are due to the excessive usage of mostly the manures with much nitrogen and partly manures with phosphorus unconsciously. It is known that as a result of wrong and excessive manure usage, drainage and surface flowing waters together with considerable amounts of nitrogen and phosphorus are mixed with the waters[2]. Two basic environmental effects of this situation have been observed. The first one is the increasing nitrate concentration in the reservations of drinking water and the second one is the increasing nitrate concentration in the fresh vegetables of which leaves can be eaten[3,4].

The amounts of nitrogen and phosphorus in water sources are based on the population density, the methods of agricultural fertilizing and the frequency of fertilizing the soil and livestock production in the region. When the average composition of wastewaters is examined, it has been found that the restrictive item regarding eutrophication is phosphorus rather than nitrogen[5].

The addition of nitrate, phosphate and a nitrate phosphate combination to replicated wooden enclosures in Marion lake resulted in significant increases in primary productivity and algal standing crop in each of the 3 types of treated enclosures[6].

Nitrogen compounds mixed in the surface waters can stem from either natural or human reasons. In the existence of human origin nitrogen items, household waste waters, some chemical industries, butcheries and agricultural manures' being carried away with the drainage and rain waters are crucial factors. Nitrogen compounds cause eutrophication with regard to water pollution together with some toxicological problems in drinking waters[7].

Nitrogen is an indispensable foodstuff for all living organisms. Ammonium compounds and nitrates obtained with natural formations aren't enough to benefit from the unit area in the optimum level. We also need to support it artificially with organic or inorganic manures. However, this needs to be completely careful, scientific and with ecological approach. Its quantity and timing according to plant and soil types should be arranged properly.

Nutrients are the components and ions consisting of nitrogen and phosphate. NO_3^- is the most commonly determined nitrogen type in surface and underground water. NH_4^+ is mostly but not much as nitrate. Phosphate is less important as a pollutant because of its low solubility and tendency to hold on to physical environment easily. The main bases of N and P are agricultural practices. Drainage (N) and household waste (P) are the other sources of nutrients[8].

In addition to its rich fishery potential, Egirdir lake is important for irrigation and energy production. Not only Egirdir lake is used not only in irrigation of the neighbour agricultural areas, but also for water requirements of Kovada I and II, hydro electrical power plants are connected *via* a regulator and canal. Most of the drinking water requirement of Isparta (150,000 population) is also supplied by Egirdir lake through the plants completed in the late 1994.

The wastes of Egirdir city had been thrown into the lake before the waste treatment plant was completed in 1995. Today, in Gelendost township (7700 population), household and drainage wastes together with manure wastes from the agricultural areas are still poured into the lake. Besides, the household wastes and drainage wastes in Uluborlu township (5000 population) and Senirkent township (4500 population) together with the harmful wastes gathered on Pupa stream and on the water course are carried into the lake. Similarly, the harmful wastes gathered on Aksu river are poured into the lake. In recent years, because of the deficiency in rain waters, the water of the lake has considerably dropped in quality due to the wastes from the residential areas around it. As there is no waste treatment plant in the residential areas, harmful wastes are constantly poured into the lake and these wastes are gathered at the bottom. Irrigation pumps belonged to the General Directorate of State Hydraulic Work dispatch the clean water above and lead the agricultural areas to be irrigated. Therefore, Egirdir lake is getting polluted continuously day by day.

Zhang *et al.*[9] worked on eutrophic lake in China reported that nitrate was the predominant form of nitrogen in the overlying water, while ammonium was predominant in the interstitial water, indicating that strong oxidative nutrient regeneration occurred near the sediment-water interface. Nitrate could be an important dissolved inorganic matter source for phytoplankton, which in turn influenced the seasonal variations of nitrate concentrations in lake water.

In present study the definition of nitrogen and phosphorus pollutions of Egirdir lake regarding agricultural sources is aimed. For this reason, NH_4^+, NH_3, NO_3^-, NO_2^- and P_2O_5 values of the lake are examined in the samples obtained from 15 points.

EXPERIMENTAL

In the research, the results of analysis were evaluated and the pollution level source from agricultural wastes in Egirdir lake were tried to be determined. The water samples taken from Egirdir lake were used as materials. On the 15th of December, 2006 when the weather was windy, on the 22nd of March, 2007 when the weather was rainy and on the 10th of May, 2007 when the weather was sunny that is in 3 periods water samples were taken. The water samples were taken from the southern part of the lake and the area beginning from the Bedre Bay of Egirdir lake to the place including in Mahmatlar village, the way out of Kovada lake together with the close areas to it, bays on which green covers are formed, coast close to the residential areas, the regions of with coasts to the agricultural areas and the coastline with natural vegetation were chosen. Water samples were taken from 15 points. The coordinated points of the sample points of Egirdir lake are given in Table-1. The analysis of NH_4^+, NH_3, NO_3^-, NO_2^- and P_2O_5 were done in the water samples.

TABLE-1
COORDINATIONS OF THE SAMPLING POINTS

Sample points	Coordinations	Sample points	Coordinations
1	37°50′36″N–30°51′58″E	9	37°53′01″N–30°52′14″E
2	37°50′42″N–30°53′11″E	10	37°52′51″N–30°51′34″E
3	37°51′27″N–30°53′59″E	11	37°52′51″N–30°49′22″E
4	37°52′01″N–30°54′12″E	12	37°53′36″N–30°48′53″E
5	37°52′51″N–30°54′16″E	13	37°55′31″N–30°48′16″E
6	37°55′00″N–30°54′46″E	14	37°55′49″N–30°46′40″E
7	37°51′30″N–30°51′05″E	15	37°55′37″N–30°55′21″E
8	37°52′49″N–30°51′33″E		

Egirdir lake on which the study was fulfilled is a tectonic lake which is located in Isparta and extending in the direction of north-south and is formed in the north border of a large sedimentary area. Its tropic level is oligotropic and it is used for drinking water, irrigation, fishery products, tourism and recreation, fishing and wild life. Egirdir lake is located within the coordinated system between 35°37'41" North - 38°16'55" North latitudes and 30°44'39" East - 30°57'43" East longitudes. The elevation of the lake is 917.7 m its length in the direction of north-south is 48 km, its coast length is 150 km and the largest part of it is 16 km.

Kemer Strait makes the lake seen as two parts by narrowing down in the direction of East-West with the distance of 18 km (it shows some differences according to the water level in the lake). In Egirdir lake, the part located in the north of Kemer Strait is known as Hoyran whereas the part located in the south is known as Egirdir part. Although the surface area of Egirdir lake indicates some differences according to the people's water consumption, the maximum area is 479 km^2, its reservoir area is 3321 km^2 and it's the fourth biggest lake of Turkey.

Water samples were taken from the depth of *ca.* 20 cm and at least 1 m distance from the shore of the lake. The bottles in which the water was kept had 500 mL volume and they were used after sterilized. During the sample taking, it was taken care not to be any formations or industrial waste chemical mixtures on the surface of the water. As soon as the samples were taken from the lake, they were brought into the laboratory of Soil Science Department, The Faculty of Agriculture, Suleyman Demirel University in the same day and the analysis of NH_4^+, NH_3, NO_3^-, NO_2^- and P_2O_5 were done.

In the water samples, according to Murphy and Riley[10], phosphorus amount was determined as colorimetric to be 882 nm spectrophotometer. The nitrate and ammonium contents of the samples are identified by measuring the samples prepared, respectively with the methods of Na-salicylic[11] and Na-nitroprusside[12], in 430 and 675 nm spectrophotometer wavelengths.

RESULTS AND DISCUSSION

Egirdir lake with its potable water and blue-flagged beach is under the threat of pollution due to the mixing of agricultural and household wastes together with leather industrial wastes in uncontrolled manners. In recent years, the existence of the noticeable green cover in some bays within the lake has made. It is thought that agricultural pollution elements have reached the lake therefore water samples were taken from the lake in order to identify the concentration of manures with nitrogen and phosphorus which are the most used mineral manures in agriculture.

The values of nitrite and ammonia in all the water samples, taken from 15 points in 3 different periods in order to determine the effect of agricultural production to the lake water, were found to be lower than the expected level. For that reason, tables about those values aren't included in this study.

As the first sampling period, (15th December, 2006) the time when Egirdir lake is windy and based on this wavy, was chosen. The measuring results of NO_3^--N, NH_4^+-N and PO_4 in this period were given in Table-2.

When the findings were examined with regard to the determined NO_3^--N values, it was observed that there were certain differences among the sampling points regarding nitrate nitrogen and that even in the periods when the lake had many roughs there was no homogeny mixed in it. The nitrate values in this period were found to be extremely lower than the value of 5 mg NO_3^--N L^{-1} which is the limit value of the first class water quality. When the findings were examined with regard to the values of ammonium, it was noted that there were no ammonium between the two samplings. In other points, the values are lower than the first class water quality. In none of the points except for the 15th sampling zone, phosphorus was observed. The value determined on the 15th point is lower than the limit value of first class water quality. When the first sampling period is examined generally, it can be suggested that water quality of the lake is the first class regarding the examined parameters.

TABLE-2
NO^{-}_{3}, NH_4^+ AND PO_4 CONCENTRATIONS OF EGIRDIR LAKE ON DECEMBER 15, 2006

Sample No.	mg NO_3^-–N L^{-1}	mg NH_4^+–N L^{-1}	mg PO_4 L^{-1}
1	0.031	0.000	–*
2	0.094	0.015	–
3	0.063	0.010	–
4	0.063	0.015	–
5	0.094	0.015	–
6	0.063	0.015	–
7	0.045	0.005	–
8	0.009	–	–
9	0.045	0.005	–
10	0.049	–	–
11	0.031	0.005	–
12	0.049	0.005	–
13	0.063	0.020	–
14	0.040	0.010	–
15	0.174	0.005	0.017

*Under the measurable level.

As the second sampling period, the first day following the rainy period was chosen by considering that nutrition elements could reach to the lake by runoff or leaching. The values of NO_3^--N, NH_4^+-N and PO_4 determined during this period are given in Table-3.

TABLE-3
NO^{-}_{3}, NH_4^+ AND PO_4 CONCENTRATIONS OF EGIRDIR LAKE ON MARCH 22, 2007

Sample No.	mg NO_3^-–N L^{-1}	mg NH_4^+–N L^{-1}	mg PO_4 L^{-1}
1	0.067	0.279	0.008
2	0.290	0.187	–*
3	0.080	0.127	–
4	0.080	0.127	–
5	0.085	0.243	–
6	0.112	0.106	–
7	0.143	0.122	–
8	0.089	0.157	–
9	0.076	0.309	–
10	0.089	0.203	–
11	0.080	0.294	–
12	0.076	0.213	–
13	0.067	0.228	0.096
14	0.067	0.481	–
15	0.192	0.750	–

*Under the measurable level.

In the second sampling period the values determined in the lake water are lower than the first class limit value. However, phosphorus values determined in this period were found to be considerably high when compared with the previous period. When the findings are examined, it is suggested that there is an increase in the values of NO_3^--N and NH_4^+-N. That nitrogen compounds gathered in the air could reach to the surface of the lake because of the rains can be thought as the reason of this. According to Xie *et al.*[13], it was suggested that nitrogen compounds in the air cause nitrogen increase on the earth and lake surfaces by the rain. On the other hand, emissions from agricultural activities, both crop and animal are known to contain gaseous ammonia which through chemical reaction in rainwater changes into ammonium ion[14].

Winchester and Nifong[15] reported that certain trace elements which are strongly associated with air pollution sources in the lake may be contributing significantly to lake water pollution by an atmospheric fallout route.

It is also considered that rains can carry the soil into the lake together with nitrogen and phosphorus, in the areas with proper conditions for erosion. In this sampling period, phosphorus was determined in two of the sampling points. The phosphorus value in the first point is under the limit value. But, the phosphorus value found in the 13th measurement point was seen as above the limit value therefore, water quality of this point was classified to be second class. It is considered that the high phosphorus value defined in the 13th point was seen because of the mixing of excessive phosphorus as a result of agricultural practices.

In Table-4, the values of NO_3^--N, NH_4^+-N and PO_4^{3+}-P determined in the water samples which were taken at a time when the water was at the highest level with the surface flowing (on May 2007) are presented. When the results were examined with regard to their nitrate content, it was seen that there was a decrease in comparison with the 2nd term. This situation most probably appeared because of the fact that low nitrate loaded waters diluted the lake water. As a result of the research done by Xie *et al.*[13] for Taihu lake of China, it was reported that nitrate values during the times when the water level was low in the lake were higher than the nitrate values during the time when the water level was high. That in the denitrification period nitrate is reduced to molecular nitrogen form and it goes through atmosphere as gaseous forms and that is a factor explaining the decrease in the lake water.

When the ammonium values were examined it was seen that in some points there was an increase while in others there was a decrease together with that the 3rd sampling period was lower in comparison with the 2nd sampling period regarding the average values. When the values were examined with regard to their phosphorus content, it was found that much more phosphorus were detected in more than one point however the determined values were under the permissible limit.

TABLE-4
NO^{-}_{3}, NH_4^+ AND PO_4 CONCENTRATIONS OF EGIRDIR LAKE ON MAY 10, 2007

Sample No.	mg NO_3^-–N L^{-1}	mg NH_4^+–N L^{-1}	mg PO_4 L^{-1}
1	0.045	0.127	0.006
2	–*	0.117	0.006
3	0.022	0.132	–
4	–	0.137	–
5	0.009	0.142	–
6	0.022	0.157	–
7	0.027	0.157	0.010
8	0.022	0.162	0.002
9	0.013	0.228	0.002
10	0.027	0.111	0.002
11	–	0.157	0.006
12	–	0.101	0.010
13	–	0.101	0.006
14	0.045	0.162	0.002
15	0.022	0.142	0.004

*Under the measurable level.

Conclusion and Suggestions

Based on these results, it is diffcult to claim that Egirdir lake is dirty with regard to the examined parameters. However, increases in nitrogen and phosphorus of the lake especially after fertilizing the soil clearly suggest that the lake is under the risk of pollution source of household or agricultural practices. Higher fluxes of ammonium supported a higher biomass of the phytoplankton[9]. It was found that the water quality of the lake turned into the second class of quality in some parts after fertilizing the soil. Around Egirdir lake, which is used as drinking and irrigation water, agricultural practices with uncontrolled manure as well as unplanned urbanization have been going on extensively. Especially, as long as urban waste water continues to come to the lake without any treatments, it is indispensable that the water will lose its characteristic of being drinking water. In Turkey 98.67 % of household waste waters are sent to the streams, lakes and seas without treatment[16].

Some precautions need to be taken for Egirdir lake and similar surface waters because it has been clearly put forward by many researchers that there will be a decrease in Turkish streams due to the global warming in the future. Some precautions should be considered in order the lake not to lose its characteristic for potable water. These precautions can be suggested as follows: (i) Some focal point studies need to be conducted by determining the streams which cause pollution in the lake and waste water discharge of these streams should be prevented immediately. (ii)

Household waste waters around the lake together with the sewer system need to be fixed onto purification system, moreover the purification plant in the system should be made to work effectively. (iii) Extreme fertilization in the agricultural practices around the lake need to be prevented. Farmers should not to be allowed to use fertilization without soil and plant tests. Gang *et al.*[1] studied the effects of reduced fertilizer application on rice yield, nitrogen and phosphorus concentrations in surface water, leachate through field trial and indoor analyses. The results show that rice yield under optimum fertilization treatment does not significantly differ from conventional fertilization treatment and that optimum fertilization saves N-fertilizer by 22 % and reduces runoff N by 30-40 % and leaching N by 32.3 %. (iv) Due to erosion carries nutrients to lake, surface flow should be prevented. (v) The number of early warning systems existing around the lake. To prevent excessive use of pesticides, the number of those systems should be doubled at least. Calibration of these systems should also be realized precisely. (vi) In the production of apple and cherry which are the most important agricultural practices around the lake, the usage of the types resistant to disease and pests should be encouraged. (vii) All agricultural and urban practices in the certain protection area around the lake should prohibit. (viii) Efficient agricultural practices need to be given priority within the areas of which are out of the certain protection area.

Instructive seminars about environmental pollution need to be given beginning from primary schools and individuals' responsibilities about the next generations' environment should be taught to other people. In a research conducted around Antalya district, a high correlation was found between the careful usage of sources in agricultural production and education[17].

REFERENCES

1. Z. Gang, W. DeJian and C. XiaoMin, *Chin. J. Eco-Agric.*, **16**, 327 (2008).
2. B.S. Guttman, Biology, McGraw-Hill, ISBN: 0-697-223-66-3, Iowa (1999).
3. M.R. Karaman, A.R. Brohi, A. Gunes, A. Inal and M. Alpaslan, *Turk. J. Agric. Forest.*, **24**, 1 (2000).
4. H.H. Oruc and S. Ceylan, *J. Fac. Veterinary Med., Uludag Univ.*, **20**, 17 (2001).
5. Anonymous, State Ministry of Urban Environment and Forestry, Environmental Case Report, http://www.malatyacevreorman.gov.tr/ced/rapor/su.pdf (2002).
6. M. Dickman, Changes in Phytoplankton Following Nitrate and Phosphate Additions to Large Enclosures in Marion Lake, British Columbia, Aquatic Sciences - Research Across Boundaries, Volume 35, Number 1/March (1973).
7. A. Girgin, Agricultural Irrigation and Water Pollution from Environmental Point of View. http://atilagirgin.blogspot.com/2007/10/evre-aisindan-tarimsal-sulamalar-ve-su_30.html, (2007).
8. T.C. Daniel, A.N. Sharpley, R. Wedepol and J.L. Lemunyon, *J. Soil Water Conserv.*, **49**, 30 (1994).
9. M. Zhang, J. Xu and P. Xie, *Environ. Geol.*, **55**, 1 (2008).
10. J. Murphy and J.P. Riley, *Anal. Chem. Acta*, **27**, 31 (1962).
11. W. Fabig, J.C.G. Ottow and F. Muller, *Landwitsch, Forsch.*, **35**, 441 (1978).

12. Deutsche Einheitsverfahren Zur Wasser-Abwasser Und Schlammuntersuchungen, Fachgruppe Wasserchemie in der Gesellschaft Deutscher Chemiker (ed.) Verlag Chemie, Weinheim/ Bergstrasse (BRD) (1983).
13. Y.X. Xie, Z.Q. Xiong, G.X. Xing, G.Q. Sun and Z.L. Zhu, *Pedosphere*, **17**, 200 (2007).
14. K. Stephen and V.P. Aneja, *Atmospheric Environ.*, **42**, 3238 (2008).
15. J.W. Winchester and G.D. Nifong, Water Pollution in Lake Michigan by Trace Elements from Pollution Aerosol Fallout, Water, Air and Soil Pollution, Vol. 1, No. 1, November (1971).
16. B. Cakmak, T. Akuzum, N. Ciftci, Z. Zaimoglu, B. Acar, M. Sahin and Z. Gokalp, Usage and Improvement of Water Sources, Union of Chambers of Turkish Engineers and Architects, Chamber of Agricultural Engineers, 4th Technical Congress, January 3-7, 2005, 1:191-211 (2005).
17. A. Atilgan, M. Erkan, B. Saltuk and T. Alagoz, *J. Ecol.*, **15**, 1 (2006) (in Turkish).

(*Received*: 14 July 2008; *Accepted*: 21 January 2009) AJC-7166