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Seasonal and vertical distributions of porewater phosphorus and iron concentrations in a macrophyte-dominated eutrophic lake

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Abstract: *In this study, variations in total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP) and total iron (TFe) concentrations and pH values in the littoral sediment porewater of macrophyte-dominated eutrophic Mogan Lake (Turkey), were determined depth wise (0-20 cm, on a basis of 5 cm depths) over a period of eleven months. Additionally, water temperature, dissolved oxygen, redox potential, TDP, SRP and TFe levels in the overlying water were measured. Especially in the spring and summer months constituting a large portion of the research period, seasonal variation of SRP at depths between 0-5 cm and 15-20 cm were not found to be statistically significant (p>0.01). However, in the fall and winter months, surface sediment (0-5 cm) SRP values were elevated in comparison with deeper sediment depths. As for TFe values, no clear seasonal variation was evident at different depths. Due to the fact that TFe concentrations in the overlying water (101.25-511.67 mg.m^{-3}) were lower than iron concentrations in the porewater (104.00-783.00 mg.m^{-3}), positive phosphorus release remained at low levels. In this eutrophic lake, in which action is continuing to reduce the external phosphorus load, monitoring SRP variations in the overlying water and porewater would be beneficial.*

Key words: *Phosphorus, Iron, Porewater, Littoral sediment, Overlying water*
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Introduction

It is beneficial to examine the phosphorus level in the sediment porewater when determining the nutrient state and estimating the phosphorus-release dynamic of lakes (Eckert *et al*., 1997; Maassen *et al*., 2003). While the organic phosphorus compounds in sediment are generally in an insoluble state, the dissolution of inorganic phosphate in the sediment porewater plays an important role in phosphorus release from the sediment into the overlying water. Porewater SRP concentrations may vary according to season, sediment depth, lake depth, and macrophyte colonization (Carignan 1984, 1985; Shaw and Prepas, 1989). It has been shown that phosphate chemistry in lake sediment is closely related with iron; especially important is the binding of phosphate to Fe(III) hydroxides, and this state is affected strongly by pH (Sondergaard, 1989; Montigny and Prairie, 1993). Oxidation of the iron (II) in the sediment porewater occurs only when the iron-to-phosphate ratio (Fe/P) is greater than 1.8 and this prevents the transfer of phosphorus into the water column (Shaw and Prepas, 1990).

The change in phosphorus between the sediment and the overlying water is the most important indicator of the phosphorus cycle in natural waters. Likewise, it is known that the phosphorus concentration of the sediment overlying water can be used to determine the nutrient value of a lake (Sondergaard *et al*., 1999). It has been reported that the sediment-water interface, SRP concentration was affected by various factors such as pH, redox potential (Eh) and microbial activity, and showed seasonal variation (Clavero *et al*., 1999; Maassen *et al*., 2003). Phosphorus release from the sediment into the lake water may occur in aquatic environments where porewater SRP values are about 15 to 20 times greater than overlying water values (Enell and Lofgren, 1988).

Lake Mogan is an important recreational area for metropolitan Ankara, Turkey. Moreover, it is under the environmental protection status as 'Golbasi Specially Protected Area' regarding the major source of phosphorus in the area is waste-water, containing detergents and fertilizers applied in the surrounding agricultural areas. Some studies related to sediment phosphorus characteristics were carried out simultaneously in Lake Mogan (Topcu and Pulatsu, 2008; Pulatsu *et al*., 2008). Specific objective of this study was to document whether in clearwater state eutrophic Mogan Lake, which shows extremely low positive and negative diffusional phosphorus release, in littoral sediment porewater total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP) and total iron (TFe) concentrations and pH values vary based on season and depth (0-20 cm; on a basis of 5 cm depth). The findings are discussed using some chemical parameters (dissolved oxygen, pH and redox potential) related with overlying water and low-release data.

Materials and Methods

Study site: Lake Mogan (39°47′ N, 32°47′ E) is situated 20 km south of the Ankara (Fig. 1). The outflow of the lake empties downstream into lake Eymir through a wetland on the north side of the lake. The lake has a surface area of 7.2 km^2, a mean depth of 2.8 m, a lake volume of 13.72x10^{6}m^3 and a theoretical water residence of an average 1.35 times per year. The lake is currently threatened by severe pollution and is highly eutrophic, despite the external phosphorus load (1.52 g m^{-2}y^{-1}) (Fakioglu and Pulatsu, 2005).

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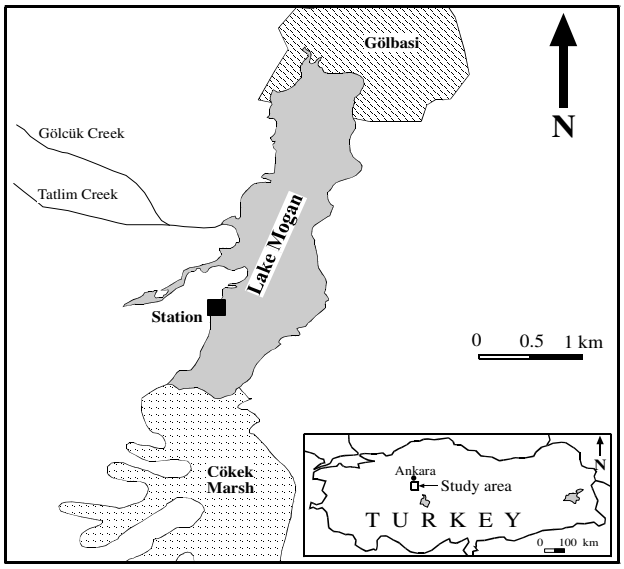

Fig. 1: Map of the lake Mogan with the sampling site

Sediment sampling and laboratory analyses: Sediment samples were collected at monthly intervals except February 2006 between September 2005 and August 2006 using Plexiglas tubes (inner diameter 5.0 cm; length 20 cm) from the 70 cm of the littoral zone in the northwest part of the lake. The selected station was covered primarily by *Chara vulgaris* and *Phragmites australis*, and cattails (*Typha domingensis* Pers.) and two species of rush (*Juncus* spp) during the summertime. After collection, each sample was sliced into four different depths 0-5, 5-10, 10-15 and 15-20 cm. Within 24 hr, the porewater was separated from the sediment particles by vacuum filtration of the sediment samples. The supernatants of porewater and overlying water were filtered through Whatman GF/C filters and then analyzed for TDP and SRP as ascorbic acid method; TFe was analyzed by using the phenantroline method according to standard analytical procedures (APHA, 2005). pH values were measured by a pH-meter prior to filtration.

The overlying water was grained by siphoning from the water located 10 cm above the sediment. The temperature, dissolved oxygen, pH and redox potential of the overlying water were measured in site with WTW portable instruments. Total phosphorus (TP) and total orthophosphate (TO) were measured according to the ascorbic acid method outlined in APHA (2005). Two sub-samples were used in all analyses.

Phosphorus release from sediments into lakewater by molecular diffusion was calculated (Shaw and Prepas, 1990). The mean phosphorus release into lake was calculated for each month.

Statistical analyses: Statistical analyses were performed using the Minitab and MStat programs for Windows. ANOVA and Duncan's multiple-range test were used to evaluate differences in sediment porewater between months and depths.

Results and Discussion

It is a known fact that porewater SRP values are a good indicator for determining the trophic levels of lakes. Quigley and Robbins (1986) reported porewater values of 0.06-10.5 mg m^{-3} for eutrophic lakes and 0.2 mg m^{-3} for mesoeutrophic lakes. Moreover, Istvanovics *et al*. (1989), in a study conducted in eutrophic Balaton Lake, revealed that porewater SRP concentrations varied between 0.032 mg l^{-1} and 0.2 mg l^{-1}. As porewater SRP concentrations in Mogan Lake during the study period varied between 19.05-72.19 mg m^{-3}, our findings are in keeping with the values for eutrophic lakes reported by Quigley and Robbins (1986).

In March, sediment porewater SRP values in the bottom sediments (15-20 cm) measured a maximum of 82.54±2.24 mg m^{-3}. The minimum SRP value in the sediment porewater (19.05±1.30 mg m^{-3}) was recorded at the same depth in April. In the fall and winter months (October, November, December and January), surface sediment (0-5 cm) SRP values were found to be higher than in deeper depths of sediment, reaching a maximum at a depth of 15-20 cm only in the month of March. Over a large portion of the research period (October, December, April, May, June, July and August), especially during the spring and summer months, at depths of between 0-5 and 15-20 cm, seasonal variation of SRP was not found at statistically significant levels ($p>0.01$) (Table 1-4).

Table - 1: Variation of littoral sediment pore water (0-5 cm) total dissolved phosphorus (TDP), total soluble reactive phosphorus (SRP), total iron (TFe), and pH mean values (N=4) in lake Mogan

Months	TDP (mg m^{-3})	SRP (mg m^{-3})	TFe (mg m^{-3})	pH
September 2005	188.79±5.52^{a*}	44.63±1.07^{d*}	783±7.55^{a*}	8.42±0.02^{c*}
October 2005	158.62±1.41^{b}	42.66±1.26^{d}	684±6.93^{b}	8.07±0.02^{d}
November 2005	124.14±1.41^{c}	72.19±4.85^{a}	669±13.30^{b}	8.17±0.08^{d}
December 2005	112.75±0.85^{d}	51.19±1.70^{c}	561±5.74^{d}	8.12±0.05^{d}
January 2006	121.25±0.85^{c}	56.44±0.75^{b}	612±8.49^{c}	7.84±0.12^{e}
March 2006	102.59±1.65^{e}	50.79±1.30^{c}	384±13.10^{e}	8.72±0.06^{a}
April 2006	59.48±2.59^{g}	20.63±0.91^{f}	320±13.10^{f}	8.75±0.03^{a}
May 2006	75.86±2.81^{f}	26.19±1.52^{e}	104±8.00^{h}	8.51±0.04^{bc}
June 2006	76.72±2.17^{f}	23.81±0.92^{ef}	208±9.24^{g}	8.55±0.02^{bc}
July 2006	76.10±1.05^{f}	24.60±1.52^{ef}	200±8.0^{g}	8.61±0.02^{ab}
August 2006	58.00±1.78^{g}	27.38±0.76^{e}	203.20±0.92^{g}	8.55±0.06^{bc}

* = The different lower-case letters in the same column show the differences between months ($p<0.01$)

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Table - 2: Variation of littoral sediment pore water (5-10 cm) total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), total iron (TFe), and pH mean values in Lake Mogan according to months (N=4)

Months	TDP (mg m^{-3})	SRP (mg m^{-3})	TFe (mg m^{-3})	pH
September 2005	174.14±2.23^{b*}	46.60±1.65 ^{bc*}	699±5.74^{a*}	8.35±0.02^{de*}
October 2005	265.52±1.41^{a}	42.00±1.07 ^{cd}	591±5.74^{b}	7.97±0.01^{f}
November 2005	60.34±0.99^{e}	52.50±1.07 ^{a}	600±4.90^{b}	8.30±0.04^{e}
December 2005	48.00±1.08^{g}	45.29±1.65 ^{bc}	564±9.80^{b}	7.90±0.07^{f}
January 2006	61.50±1.32^{e}	47.91±1.65 ^{ab}	597±5.74^{b}	7.97±0.08^{f}
March 2006	92.24±2.58^{c}	46.82±1.52 ^{bc}	216±15.30^{de}	8.63±0.05^{ab}
April 2006	81.04±2.23^{d}	39.68±2.05 ^{d}	280±15.30^{c}	8.71±0.03^{a}
May 2006	58.62±1.41^{ef}	27.78±0.79 ^{e}	224±13.10^{d}	8.52±0.03^{bc}
June 2006	58.62±2.44^{ef}	26.19±1.52 ^{e}	184±15.30^{ef}	8.49±0.01^{bcd}
July 2006	61.67±1.73^{e}	27.78±0.79 ^{e}	176±9.24^{f}	8.56±0.03^{abc}
August 2006	52.23±0.75^{fg}	29.36±0.46 ^{e}	180±1.53^{ef}	8.41±0.03^{cde}

* = The different lower-case letters in the same column show the differences between months ($p<0.01$)

Table - 3: Variation of littoral sediment pore water (10-15 cm) total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), total iron (TFe), and pH mean values (N=4) in lake Mogan

Months	TDP (mg m^{-3})	SRP (mg m^{-3})	TFe (mg m^{-3})	pH
September 2005	164.66±1.65^{a*}	42.66±1.26^{b*}	687±5.74^{a*}	8.11±0.01^{bc*}
October 2005	87.93±0.99^{b}	42.00±1.07^{b}	504±4.90^{c}	7.87±0.01^{d}
November 2005	63.80±2.23^{d}	52.50±1.86^{a}	678±11.50^{a}	8.05±0.03^{c}
December 2005	50.00±0.91^{f}	48.57±2.27^{a}	618±7.75^{b}	8.10±0.04^{bc}
January 2006	58.75±0.48^{de}	53.16±1.97^{a}	618±7.75^{b}	7.70±0.09^{e}
March 2006	84.48±4.56^{b}	48.41±1.52^{a}	432±9.24^{d}	8.65±0.04^{a}
April 2006	59.48±0.86^{de}	26.98±0.91^{c}	216±15.30^{f}	8.59±0.04^{a}
May 2006	65.52±2.44^{cd}	40.48±1.52^{b}	464±20.70^{d}	8.52±0.04^{a}
June 2006	71.56±3.82^{c}	39.68±0.91^{b}	352±13.10^{e}	8.51±002^{a}
July 2006	72.31±3.09^{c}	40.48±0.79^{b}	360±8.00^{e}	8.58±0.03^{a}
August 2006	53.88±1.07^{ef}	26.58±0.39^{c}	180±0.80^{f}	8.23±0.05^{b}

* = The different lower-case letters in the same column show the differences between months ($p<0.01$)

Table - 4: Variation of littoral sediment pore water (15-20 cm) total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), total iron (TFe), and pH mean values (N=4) in lake Mogan

Months	TDP (mg m^{-3})	SRP (mg m^{-3})	TFe (mg m^{-3})	pH
September 2005	175.86±1.41^{a*}	37.41±1.26^{d*}	615±5.74^{a*}	7.93±0.01^{e*}
October 2005	93.10±1.41^{d}	42.00±1.07^{cd}	504±9.80^{b}	7.87±0.01^{e}
November 2005	117.24±1.41^{c}	51.19±1.70^{b}	585±5.74^{a}	8.00±0.04^{e}
December 2005	110.75±0.48^{c}	46.60±1.26^{bc}	597±7.55^{a}	8.22±0.05^{d}
January 2006	134.00±0.71^{b}	46.60±1.97^{bc}	603±11.40^{a}	7.62±0.09^{f}
March 2006	139.66±4.11^{b}	82.54±2.24^{a}	328±8.00^{d}	8.86±0.02^{a}
April 2006	61.21±3.56^{ef}	19.05±1.30^{e}	184±8.00^{e}	8.50±0.04^{c}
May 2006	54.31±1.65^{f}	23.01±0.79^{e}	368±9.24^{c}	8.74±0.02^{ab}
June 2006	56.03±2.59^{f}	20.63±0.91^{e}	336±9.24^{cd}	8.62±0.02^{bc}
July 2006	65.12±2.37^{e}	23.81±0.92^{e}	344±8.00^{cd}	8.65±0.02^{bc}
August 2006	54.91±0.46^{f}	23.01±0.46^{e}	163.20±1.31^{e}	7.97±0.01^{e}

* = The different lower-case letters in the same column show the differences between months ($p<0.01$)

Porewater phosphorus concentrations in shallow eutrophic lakes were reported to increase especially in the summer and fall months by Enell and Lofgren (1988) and in the spring and summer months by Carignan (1984) and Ramm and Scheps (1997). In Mogan lake, due to the negative phosphorus release occurring in the summer, no increase was seen in porewater SRP values. Additionally, sediment porewater SRP concentration min and max values were recorded at the beginning of spring; in March, SRP values reached a max of 82.54±2.24 mg m^{-3}, in parallel with the increase in water temperature, falling to a min of 19.05±1.30 mg m^{-3} in April as a result of macrophyte use. The fact that low-level negative phosphorus release values found between April and August changed to positive during the fall appears to be related to seasonal variation in porewater SRP concentrations (Fig. 2).

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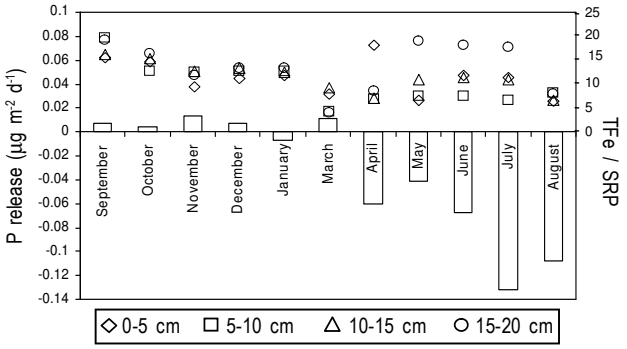

Fig. 2: Monthly mean values of TFe/SRP in different depths (0-5, 5-10, 10-15 and 15-20 cm) of porewater and phosphorus release in lake Mogan

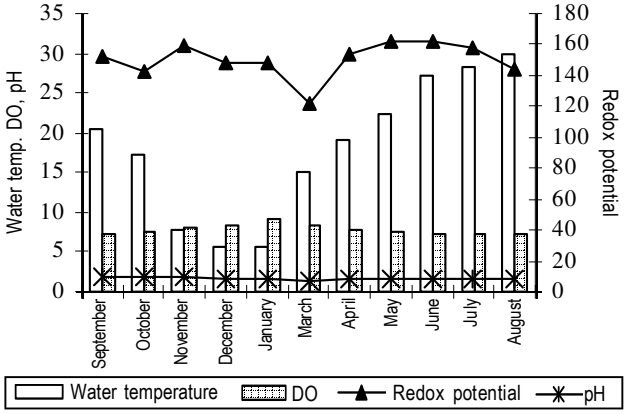

Fig. 3: Some physico-chemical characteristics (water temperature; °C, DO; mg l^{-1}, redox potential; mV and pH) of the overlying water in lake Mogan

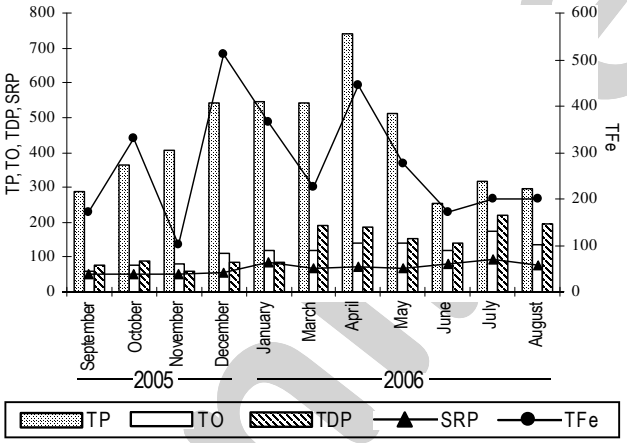

Fig. 4: Monthly mean concentrations of phosphorus fractions TP (total phosphorus, in mg m^{-3}), TO (total orthophosphate, in mg m^{-3}), TDP (total dissolved phosphorus, in mg m^{-3}), SRP (soluble reactive phosphorus, in mg m^{-3}) and TFe (total iron, in mg m^{-3}) of the overlying water in lake Mogan

In this study, porewater SRP concentrations did not show clear differences with relation to depth. These circumstances resemble the results of the Vicente *et al*. (2003) study of two highly eutrophic coastal lagoons (Laguna Honda and Laguna Nueva, Spain), in which porewater SRP in 0-15 cm depths showed no clear vertical pattern. However, Shaw and Prepas (1989) reported that porewater SRP concentrations in deep and mesoeutrophic Narrow lake increased according to depth (0-15 cm).

The presence of macrophytes in aquatic systems creates oxygen in the sediment, and by decreasing the porewater SRP concentration, causes phosphorus release from the sediment into the lake water to remain at low levels (Schneider and Melzer, 2004). Similarly, in our study, dense macrophyte colonization was also directly related with negative phosphorus release.

Sediment porewater TDP minimum and maximum values in the same depth (5-10 cm) were established as follows: the minimum value occurred in December (48.00±1.08 mg m^{-3}) and the highest value occurred in October (265.52±1.41 mg m^{-3}) (Table 1-4). TFe values did not show a clear seasonal variation with respect to depth. Sediment porewater TFe values reached a minimum (104.00±8.00 mg m^{-3}) in May in the surface sediment (0-5 cm). Additionally, the maximum TFe value in the sediment porewater (783.00±7.55 mg m^{-3}) was recorded in September at a depth of 0-5 cm (Table 1-4).

The depth at which SRP and TFe reached a maximum (10-15 cm) was the same for the months of May, June and July. During the research period, average sediment porewater TFe/SRP ratios on the basis of depth were found as follows: at 0-5 cm, 11.05; at 5-10 cm, 9.81; at 10-15 cm, 11.19; and at 15-20 cm, 13.28 (Fig. 2).

During the research, the sediment porewater TFe/SRP ratio varied according to depth, with its highest value at 19.15 in September at a depth of 5-10 cm and the lowest ratio at 3.91 in March at 15-20 cm. The maximum mean positive and negative SRP fluxes were determined as 0.013 µg $m^{-2}d^{-1}$ in November and -0.132 µg $m^{-2}d^{-1}$ in July, respectively.

The ratio of iron to phosphorus in porewater is used as an indication that iron binds to phosphorus in oxygenated water. In this study of Mogan lake, the average porewater TFe/SRP value was established as 11.33. Taking into account TFe/SRP values reported by Shaw and Prepas (1990) and Lehtoranta and Heiskanen (2003) as 1.8 and 3.6, respectively, it is clear in our study that phosphorus release from the sediment was prevented. The porewater TFe and SRP concentrations affected the TFe/SRP ratios and reduced the release of phosphorus into the oxic overlying water. While the high TFe/SRP ratio resulted in negative phosphorus release in the sediment in May, June and July at depths of 15 to 20 cm, the low TFe/SRP ratios found in these months at depths of 5 to 10 cm is a sign of the irregularity of the movement of phosphorus between the depths (Fig. 2).

In our study, porewater pH values generally varied between 7.51 and 8.86 (Table 1-4) and did not reach the elevated values that could cause the release of phosphate from Fe(III) hydroxides, as had been reported in some studies (Montigny and Prairie, 1993; Eckert *et al*., 1997). In the selected station, porewater pH values did not appear to be directly related with overlying water

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Table - 5: Variation of overlyingwater water temperature, dissolved oxygen (DO), pH, total phosphorus (TP), total orthophosphate (TO), total dissolved phosphorus (TDP), soluble reactive phosphorus (SRP), total iron (TFe) and redox potential (Eh) mean values (N=4) in Lake Mogan,

Months	Water temp. (°C)	DO (mg l^{-1})	pH	TP (mg m^{-3})	TO (mg m^{-3})	TDP (mg m^{-3})	SRP (mg m^{-3})	TFe (mg m^{-3})	Eh (mV)
September 2005	20.50^{e*}	7.15^{f}	9.25^{b}	288.75^{g}	59.54^{h}	77.90^{g}	37.08^{e}	170.67^{h}	152.50^{d}
	±0.29	±0.03	±0.00	±4.16	±0.82	±1.05	±0.83	±1.44	±0.29
October 2005	17.16^{g}	7.45^{ef}	9.27^{b}	362.50^{e}	75.44^{g}	89.43^{f}	37.38^{e}	328.66^{d}	142.50^{f}
	±0.03	±0.03	±0.00	±2.41	±0.54	±1.63	±0.98	±1.87	±0.29
November 2005	7.75^{i}	8.08^{bc}	9.43^{a}	404.40^{d}	81.82^{f}	58.23^{h}	37.83^{e}	101.25^{i}	159.50^{bc}
	±0.14	±0.05	±0.00	±10.30	±1.07	±0.69	±0.64	±1.25	±0.29
December 2005	5.65^{j}	8.25^{b}	8.99^{c}	541.53^{b}	111.15^{e}	83.25^{fg}	40.18^{de}	511.67^{a}	148.00^{e}
	±0.03	±0.14	±0.00	±4.03	±0.96	±1.60	±0.61	±1.81	±0.00
January 2006	5.55^{k}	9.15^{a}	8.98^{c}	548.05^{b}	120.11^{d}	82.90^{fg}	63.31^{a}	365.72^{c}	147.50^{e}
	±0.03	±0.03	±0.00	±2.19	±0.67	±5.30	±0.72	±1.09	±0.29
March 2006	15.10^{h}	8.33^{b}	7.40^{h}	543.31^{b}	117.53^{d}	189.25^{bc}	49.45^{c}	224.31^{f}	121.75^{g}
	±0.07	±0.06	±0.04	±3.75	±2.70	±0.95	±0.24	±3.58	±0.63
April 2006	19.10^{f}	7.90^{cd}	7.63^{g}	740.16^{a}	138.15^{bc}	184.50^{c}	52.38^{bc}	445.85^{b}	153.25^{d}
	±0.04	±0.06	±0.09	±3.46	±0.73	±1.50	±0.76	±4.38	±0.48
May 2006	22.33^{d}	7.58^{de}	8.12^{e}	510.63^{c}	141.50^{b}	152.75^{d}	52.14^{bc}	277.62^{e}	161.50^{ab}
	±0.06	±0.05	±0.06	±4.83	±1.65	±1.11	±0.69	±8.02	±0.65
June 2006	27.15^{c}	7.38^{ef}	8.35^{d}	254.33^{h}	119.59^{d}	139.25^{e}	59.37^{ab}	171.69^{h}	162.25^{a}
	±0.06	±0.05	±0.06	±3.94	±1.46	±1.49	±0.57	±8.68	±0.25
July 2006	28.20^{b}	7.30^{ef}	8.40^{d}	316.33^{f}	171.60^{a}	221.00^{a}	69.03^{a}	199.88^{g}	158.25^{c}
	±0.07	±0.04	±0.04	±2.00	±1.34	±1.47	±0.73	±0.43	±0.25
August 2006	29.93^{a}	7.38^{ef}	8.03^{f}	297.81^{g}	135.21^{c}	193.75^{b}	58.22^{ab}	200.89^{g}	144.50^{f}
	±0.05	±0.03	±0.03	±0.48	±1.01	±1.31	±0.23	±0.88	±1.32

* = The different lower-case letters in the same column show the differences between months ($p<0.01$)

pH values. It is thought that this is a result of the fact that pH was measured at different depths.

The minimum and maximum values recorded during the entire study period for the temperature, dissolved oxygen, pH, TDP, SRP, TFe and redox potential of the overlying water are presented in Fig. 3 and Fig. 4, respectively. The overlying water TFe concentrations (101.25-511.67 mg m^{-3}) were found to be lower than those in the sediment porewater (104.00-783.00 mg m^{-3}) (Fig. 4).

In this study conducted in Mogan Lake, the fact that dissolved oxygen concentrations in the overlying water varied between 7.15-9.15 mg l^{-1} (Fig. 3), was the most important cause of the low positive phosphorus release. In our research, overlying water pH values (7.40-9.43) were not high enough to promote phosphorus release from the sediment to the lake water.

The lowest redox potential value in the overlying water of Mogan Lake was established at 121.75 mV; the fact that negative values were not encountered during the research period played an important role in the prevention of phosphorus release from the sediment.

The ratio of sediment porewater SRP values reported in our study (19.05-72.19 mg m^{-3}) to SRP concentrations in the overlying water (37.08-69.03 mg m^{-3}) was a maximum of 1.05; this value is much lower than the 15-20 times higher rate of established phosphorus release reported by Enell and Lofgren (1988).

Macrophyte presence in Mogan Lake supports the fact that, as reported by Carignan (1985) and James *et al*. (2004), rooted aquatic macrophytes reduce aquatic system's nutrient concentration. In this context, the macrophyte harvesting procedure currently being undertaken by the local government appears to be suitable for the control of macrophytes in the lake. In addition, initiatives are in progress to reduce the amount of external phosphorus load. However, at the point when the external phosphorus load is stopped, the internal phosphorus load becomes active and this situation may increase the contribution of internal load in eutrophication (Sakadevan and Bavor 1998, Heidenreich and Kleeberg 2003). The low SRP concentration gradients between the overlying water and the porewater in Lake Mogan play a role in the continued low phosphorus release from the sediment under aerobic conditions. In the light of this fact, the monitoring of SRP variations in the porewater and the overlying water could potentially result in changes to the in lake phosphorus cycling mechanisms, with lake sediments switching from net sinks to net sources of SRP. This feature is of potential importance in relation to management strategies related with lake sediment.

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