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SOME PHYSICO-CHEMICAL CHARACTERISTICS OF VISTONIS LAKE (NORTHERN GREECE)

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ABSTRACT

The temperature, salinity, dissolved oxygen, pH, N/NH_4^+ and P/PO_4^{3-} were monitored for a period of ten months in a northern Greece shallow, brackish lake, fed by three small rivers and connected to the sea through a very narrow outlet. Salinity ranged from 0.4-32‰ at the bottom of the lake, dissolved oxygen reached near zero values in summer; stratification occurred under certain conditions; pH reached 10 in July, while, at the same time, N/NH_4^+ reached a maximum of 3.5 ppm; P/PO_4^{3-} ranged from 40 to 230 μg/l. The extreme values of the physicochemical parameters were in summer and the large plant biomass (phytoplankton and other aquatic plants) indicated high a degree of eutrophication.

INTRODUCTION

The Vistonis Lake is situated in Western Thrace (27° 7′ N, 41° 3′ E), Greece, and is connected to the Porto Lago Bay in the Aegean Sea through a narrow outlet (10m wide, 4m deep). The lake has a surface area of 45 Km^2, a catchment area of 1300 Km^2 and a mean depth of 3m (Fig. 1). The lake has been placed on the list of Protected Wetlands of International Importance, especially as waterfowl habitat, by the Ramsar Treaty (Presidential decree No 191, 19.11.1974).

Three small rivers flow into the lake, the Kossynthos, Trahos and Kompsatos. The Kossynthos, with flows ranging from 3650 lt/sec to 350 lt/sec, passes through the city of Xanthi (40,000 pop., 20 km upstream from the lake) and flows into the northwest section of the lake. At about 1 Km downstream from Xanthi, the Kossynthos receives half of the city's raw sewage and the untreated effluents of a slaughter-house; moreover, the city's solid wastes are dumped on the river's banks, close to the point of discharge of the two types of liquid wastes. There is also a tomato canning industry in the area; its effluents are subjected to aeration and pass through the sandy banks of the river before going into it. The Trachos and Kompsatos rivers flow into the eastern part of the lake, together with a network of drain ditches, which carry the fertilizer and pesticides residues of the intensively cultivated land

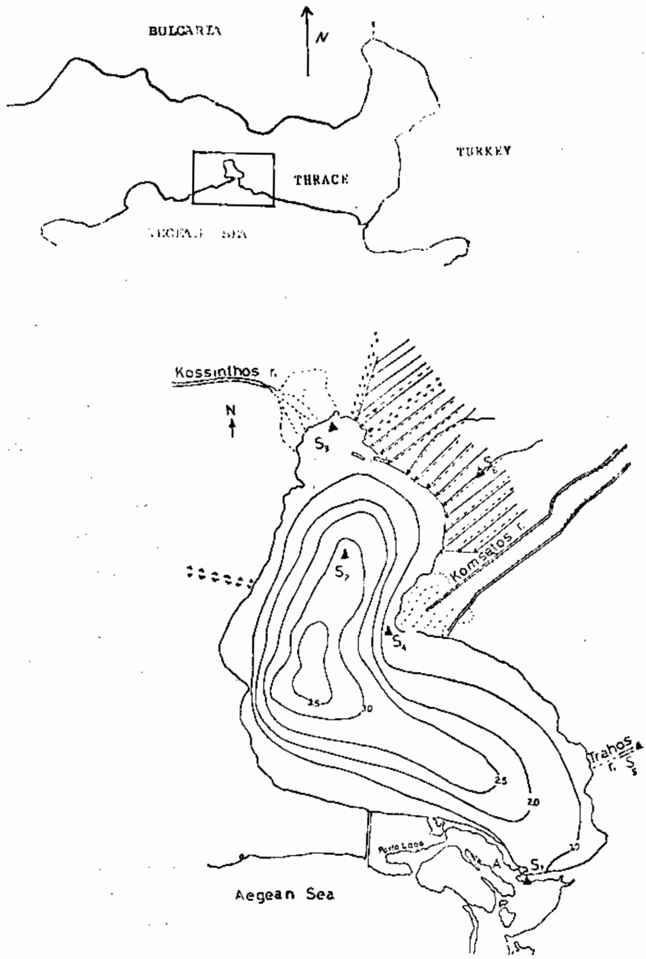

Fig. 1: Vistonis Lake with its inflowing **Rivers**, Isobaths (m) **and Sampling Points**. (Scale: 1:50.000).
A:A shallow part of Porto Lago Bay about 1m deep.
............., ...: Drain ditches.

(area estimated at 150 Km^2) surrounding the lake. The lake supports commercial fishing, mainly carp; it had an annual production which reached 470 tonnes in the period 1967-70, but which, by 1975, had dropped to only 130 tonnes.

In this study, an attempt has been made to measure seasonal variations of certain physicochemical parameters, to examine the causes and magnitude of pollution and eutrophication of the Lake; these will determine its tolerance limits. The experience gained can then be applied to similar cases.

SAMPLING SITES

The sample were collected at the following sites:

Station 1 (S_1); at the outlet of the lake with Porto Lago Bay, mean depth 4 m.

Station 2 (S_2); on the lake, about 8 Km north of S_1 and 3 Km south of the mouth of the Kossynthos River, mean depth 3m.

Station 3 (S_3); at the mouth of the Kossynthos River, mean depth 1m.

Station 4 (S_4); at the mouth of the Kompsatos River, mean depth 0.5m.

Station 5 (S_5); on the Trahos River, about 1 Km upstream from the river mouth, mean depth 0.8m.

Station 6 (S_6); on a drain ditch, about 2 Km upstream from the lake.

MATERIALS AND METHODS

Field trips were organized approximately every 10 days for the period January - October 1982. Special field trips took place after intense meteorological events (e.g. heavy rain, ice, prolonged drought). Sampling took place from 9a.m. to 1p.m. Dissolved oxygen and temperature were measured in situ with a YSI model 57 instrument and salinity with a Hydrobios salinity-temperature bridge.

Water samples were drawn from different depths using a Ruttner sampler. They were carried to the laboratory for the measurement of pH. The S_nCl_2 method was used for the determination of orthophosphates and the Nessler method for that of ammonia.

RESULTS AND DISCUSSION

Temperature

Seasonal fluctuations in the surface temperature at S_1 (Fig. 2) show a maximum of 26 $\pm$ 0.5°C in August and a minimum of 4 $\pm$ 0.5°C in January. At S_2, the values were 28 $\pm$ 0.5°C and 4 $\pm$ 5°C respectively. Sampling at S_1 was always performed at 9 a.m. and that at S_2 at noon; this would explain the displacement of the two curves (Fig. 2).

From June to October, the sub surface and bottom temperature at S_1 was higher than that of the surface (Table 1), owing to the presence of a shallow arc (marked A on the map, about 1m deep) between the outlet and the Porto Lago Bay. This length of shallow water with a high salt content gets hot during the day, but, being still heavier, sinks below the fresh water outflow and goes upstream, as evidenced by salinity data displayed in Table 1.

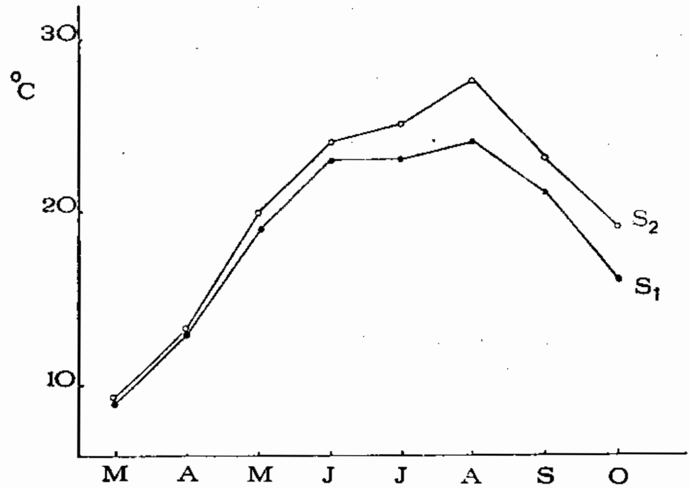

Fig. 2: Seasonal variation in the surface temperature at Stations 1 and 2.

Table 1: Temperature and Salinity profile for Stations 1 and 2.

	Temperature (°C)						Salinity ‰					
	Station 1			Station 2			Station 1			Station 2		
Depth (m):	0	2,5	4,5	0	1,5	3,0	0	2,5	4,5	0	1,5	3,0
Jan.	4,5	6,2	6,2	–	–	–	1,1	25,8	26,9	–	–	–
Feb.	4,8	4,8	5,2	–	–	–	2,5	2,5	2,3	–	–	–
Mar.	10,0	9,0	9,0	–	9,0	9,0	4,2	4,2	4,4	–	–	–
Apr.	12,5	12,5	12,0	–	–	–	1,7	1,8	1,8	–	–	–
May	18,0	17,0	16,5	18,0	–	17,0	2,8	2,8	2,9	2,7	–	2,6
Jun.	23,0	25,0	25,5	24,0	24,0	24,0	9,8	24,4	25,3	2,5	2,5	2,5
Jul.	26,0	28,0	27,5	27,0	26,0	26,0	5,0	25,4	25,4	2,7	2,7	2,5
Aug.	22,5	25,0	26,2	26,5	25,0	25,0	5,0	28,0	27,5	3,5	3,5	3,5
Sep.	26,0	27,0	27,0	26,0	25,5	25,5	5,4	30,4	30,2	4,6	4,6	4,6
Oct. (19)	17,0	19,0	19	20,0	18,8	19,4	7,8	32,0	32,0	6,0	6,2	12,5
Oct. (29)	15,0	17,0	17,5	–	–	–	7,3	23,5	27,0	–	–	–

The temperature at the other stations follows the seasonal fluctuations of the air temperature (see Table 2).

Salinity

Salinity in the lake is due mainly to the intrusion of the sea though the outlet and the sandy materials of the southern part of the lake.

Salinities vary seasonally, with a minimum of 0.4‰ in winter in the northern section (S_3) and a maximum of 10.4‰ in autumn, just before the rain season, also at S_3. Figure 3 pictures the seasonal variations of salinity at the various sampling sites.

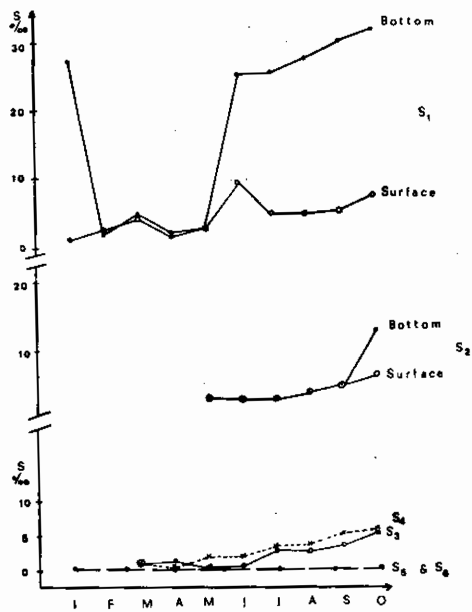

Fig. 3: **Seasonal variation** of Salinity in all sampling Stations of Vistonis **Lake and Inflowing** Rivers.

Table 2: Temperature and Salinity Variation for Stations 3, 4, 5, 6.

	Temperature (°C)					Salinity ‰			
Station	3	4	5	6	Station	3	4	5	6
Jan.	—	—	7,0	—		—	—	0,5	—
Mar.	10,0	9,0	12,5	12,0		1,1	1,1	0,5	0,5
Apr.	13,0	13,0	14,0	15,0		1,3	0,4	0,4	0,4
May	17,0	17,0	15,0	15,0		0,4	2,1	0,4	0,5
Jun.	24,0	24,0	25,0	19,0		0,8	2,1	0,5	0.4
Jul.	22,0	25,5	23,5	17,5		3,0	3,2	0,5	0,3
Aug.	22,0	25,0	23,0	19,5		3,0	3,5	0,5	0,4
Sep.	—	—	—	—		3,9	5,6	0,6	0,4
Oct.	20,2	20,4	17,5	13,6		5,7	6,3	0,8	0,4

At S_1, the water column is mixed from January through March (Table 1). On October 19 and 29 (Table 1), the bottom temperature was 2°C and 2.5°C respectively, higher than that at the surface. The bottom to surface difference in salinity was 24.2‰ and 19.7‰ respectively on the same two dates (Figure 4).

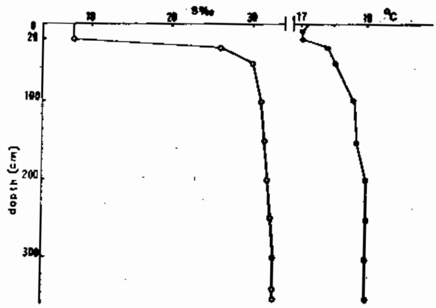

Fig. 4: Salinity and Temperature profiles at Station 1 on October 19. 1982.

In summer months, stratification occurred, with a mean salinity difference between surface and bottom of about 17.4‰. Stratification, when it occured, was due to differences in salinity, rather than to temperature ones.

There was more mixing at S_2 (Table 1), with a mean salinity difference between surface and bottom of 0.5-1.0‰. On October 19, this difference reached 6‰.

Dissolved oxygen

Surface oxygen exhibits a seasonal change, dropping as the temperature rises (Table 3). In Figure 5, the profile of oxygen at S_1 and S_2 is depicted.

Below 2.0 to 2.5m, the drop is sharp, despite the small depth of the lake. This drop coincides with the phytoplankton spring bloom, which extends into summer and early autumn. Secchi Disc transparency during spring and summer is 20-30 cm (as against 60-100 cm in winter) and the lake has the greenish, soup-like appearance of eutrophic water.

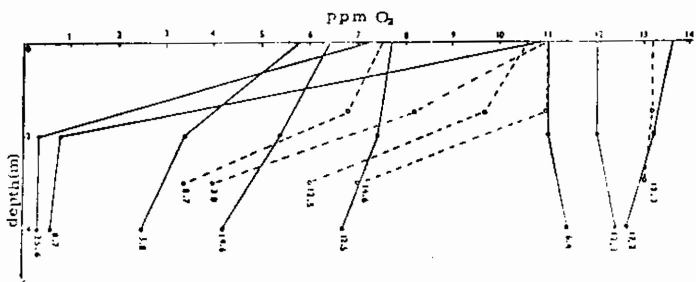

Figure 5: Dissolved oxygen profiles of Vistonis lake (dates as shown)
.... Station 1, ... Station 2.

Table 3: Seasonal change of the surface Dissolved Oxygen (ppm)

Stations	1	2	3	4	5	6
Jan.	14,7	—	—	13,4	11,6	—
Feb.	12,3	—	12,5	14,4	12,7	10,7
Mar.	13,1	13,1	11,5	13,2	10,1	8,4
Apr.	11,0	10,8	12,0	11,2	6,8	10,8
May	8,8	10,4	11,0	9,6	6,9	9,1
Jun.	7,6	12,1	11,9	11,9	7,5	9,2
Jul.	9,5	7,5	10,3	10,2	3,2	7,7
Aug.	6,1	8,3	—	—	—	—
Sep.	8,2	7,7	7,7	7,7	8,0	9,5
Oct.	7,6	7,1	7,0	7,1	7,6	8,9

PH

PH varies seasonally (Fig. 6). In summer, the surface values are higher than those of the bottom, as the result of the dissolved CO_2 consumption in the upper layer.

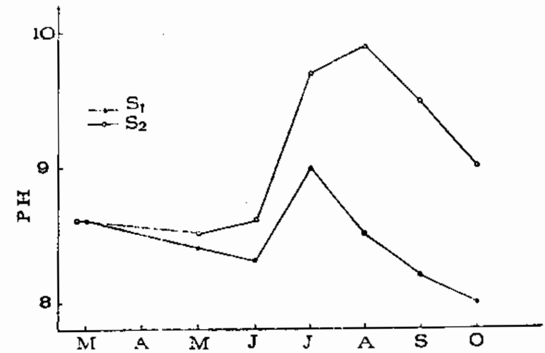

Fig. 6: PH seasonal change at stations 1 and 2.

Ammonia

The measured amounts of N/NH_4^+ ion during the study period ranged from 0.0 to 3.5 ppm, with the maximum at the end of June (see Table 4). During the summer months, the mean concentration was 1.5 ppm. These values can be attributed mainly to the anaerobic decomposition of allochthonous and endogenous nitrogen rich substances near the lake floor. The high amounts of N/NH_4^+, combined with the high PH may produce toxic environment for the lake fauna, especially young fish, quite vulnerable to NH_3 (tolerance limit 0.2-1.5 ppm) (Kannan and Job, 1980). This may be one of the causes of repeated young carps killing in the last few years.

Orthophosphates

The lake is enriched with phosphates originating from the sewage present in the Kossynthos River and the surface flow from the wheat, maize and beet fields within the catchment area.

Phosphate concentration is low during the summer months, with a mean value of 40 μg/l. From the middle of August, it starts to rise, reaching 230 μg/l by the end of September. These changes may be attributed to the high biomass in summer and its decomposition in late summer. Higher bottom concentra-

Table 4: Mean monthly Concentration of N/NH_4^+ (ppm) in Vistonis Lake and Inflowing Rivers

Station	1			2			3	4	5	6
Depth (m)	1	2,5	4,5	0	1,5	3	0	0	0	0
Jan.	0,35	–	0,73	–	–	–	–	–	–	–
Feb.	0,60	0,30	0,10	0,49	–	–	–	–	–	–
Mar.	2,80	2,50	2,15	1,05	–	–	0,34	1,67	4,50	0,20
Apr.	0,49	0,28	0,46	0,71	–	–	0,50	0,83	0,85	0,10
May	0,75	0,50	0,50	0,10	0,00	0,00	0,29	0,05	0,10	0,34
Jun.	2,40	2,42	1,50	0,35	0,55	0,50	1,72	0,06	0,76	1,57
Jul.	2,30	1,10	4,30	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Aug.	1,00	0,50	0,10	0,70	1,36	1,54	1,30	2,27	–	2,07
Sep.	1,90	0,70	0,10	0,63	1,52	0,32	1,88	0,38	1,92	2,26
Oct.	0,62	0,22	0,20	0,40	0,47	0,20	0,80	0,75	0,70	0,22

tions might result from the release of phosphates from the sediments, phenomenon favored by the low oxygen content and the still high decomposition rates.

Phytoplankton

Microscopical examination, following the Utermöhl method (1958), showed that *Microcystis* sp. was primarily responsible for the bloom in summer and early autumn. *Anabaena* sp. was the second most abundant colony, whilst chlorophyta formed an even smaller part of the population, with various species of *Scenedesmus*. In early spring, diatoms formed a large part of the phytoplankton, with *Melosira* sp. and *Stephanodiscus* sp. predominant. *Cyclotella* sp. was found also in the northern part of the lake. Ciliated protozoans, such as *Vorticella* and various species of tintinnididae, were found occasionally at the Kossynthos inflow site (S_3). These bioindicator species, together with the concentrations of P/PO_4^{3-}, N/NH_4^+ and dissolved oxygen values, may indicate the extent of eutrophication of this water body.

DISCUSSION – CONCLUSION

Some of our major findings from this study for 1982 are as follows:

1. The observed temperature variations agree with those reported by Fotis *et al.* (1976) for the period 1972-73-74. Temperature ranges are similar to those reported by Anagnostidis and Economou-Amilli (1980) for the Ioannina Lake (north-western Greece).
2. Salinity varies seasonally; throughout the year, it is lower in the

northern part of the lake (i.e. farthest from the sea). The lowest value (0.4‰) was in winter in the northern section; the highest (32‰) was in October at the bottom of the channel. Salinity variations depend upon the intensity and the time of rainfall. During October 1982, stratification was observed throughout the lake.

3. Problems of dissolved oxygen appear in summer and autumn and in the lower water layers. Dissolved oxygen levels below an acceptable range have been recorded since 1972 and reported already by Fotis *et al.* (1976).
4. Transparency of the lake from Secchi Disc readings varies from 30 to 50 cm, similar to those recorded for 1972-73 (Fotis *et al.*, 1976). PH values, on the other hand, are higher than in 72-73; for example, the 1972 high was 8.4. A value of 10 was recorded in August 1982.
5. The N/NH_4^+ and P/PO_4^{3-} ratios have been measured in the lake for the first time; their variations depended upon temperature and phytoplankton concentrations (Ruttner, 1971). The highest N/NH_4^+ concentration was recorded in summer, due to anaerobic conditions at that period. The highest P/PO_4^{3-} concentration was recorded in September, due to decomposition of the biomass. For the Ioannina Lake (situated approximately 300 Km south-west from the Vistonis Lake), in October, the N/NH_4^+ values varied from 100 to 170 μg/l, while the P/PO_4^{3-} value varied from 40 to 60 μg/l (Anagnostidis, 1980). In the Vistonis Lake, in October, these values were much higher, indicating a higher degree of eutrophication.

In summary, the lake has high concentrations of toxic substances, problems with dissolved oxygen, high pH values and very low transparency. According to the taxonomy proposed by Hershman (1976), Vistonis Lake corresponds to the 6th trophic level.

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