The Influence of the Main Pollution Sources on Tasaul Lake's Physical-Chemical Parameters *(Dan Vasiliu, Luminita Lazar, Laura Alexandrov, Victoria Smocov, Adriana Cociasu, Daniela Rosioru)*	"Cercetari Marine" Issue no. 37 Pages 39-50	2007

THE INFLUENCE OF THE MAIN POLLUTION SOURCES ON TASAUL LAKE'S PHYSICAL-CHEMICAL PARAMETERS

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ABSTRACT

Water physical-chemical parameters of Tasaul Lake were monitored seasonally in eight sampling stations, from May 2005 to March 2006. The sampling stations were selected in order to show the anthropogenic impact of the point and non-point pollution sources on the Lake Tasaul ecosystem. The highest nutrient concentrations were observed in the northern and north-western part of the lake. Because of its large catchment area, the Casimcea River plays a major role in increasing the external nutrients loading and carries a large amount of allochtonous particles. Another important pollution point source is Sibioara Farm due to the untreated or low treated waste water. The results provide information on the ecological status of the lake, necessary for taking the most appropriate management decisions for its ecological protection and rehabilitation.

KEY-WORDS: physical-chemical parameters, point and non-point pollution sources, nutrient load

AIMS AND BACKGROUND

Tasaul Lake, the largest lake south of Cape Midia (area of about 2,335 ha and volume of about $49.45*10^6$ m^3, according to Breier (1976); mean depth of 2.4 m and maximum depth of 4 m), is located ~ 20 km north of Constanta, the main city of the Dobrogea region. The region has experienced strong economic and demographic development during last decades.

South of the lake is located Navodari city, that has developed greatly since 1968 (year when the city was declared). During the communist regime there were built more industrial enterprises in the surroundings such as: Chemical Fertilizers Plant, Petrochemical Plant and Sugar Factory.

In the last decades of the 20th century, the main pollution source was the Chemical Fertilizers Plant of Navodari (presently out of work) that influenced chronically the nutrients balance in the lake, shifting to a concentration range unfavorable from ecological point of view (Galatchi, 2005). A large amount of nutrients has been accumulated in sediment and has been released after a couple of years in the water column.

Nowadays, some of the most important pollution sources are: the emission of polluting gases from the Petrochemical Plant Navodari that cannot be quantified; a large amount of lime powder coming from Sibioara Quarry that enters the lake every year (Galatchi, 2005); the discharges of municipal waste water from Navodari city, the residual water from the livestock farms (Sibioara, Piatra etc). Also, the water that flows down from the Casimcea catchment area carrying large soil quantities, fertilizers, herbicides and pesticides, has a negative influence on the lake ecosystem.

The present study aims to point-out the negative impact of the main pollution sources (point or non-point) on the water chemistry of Tasaul Lake.

MATERIALS AND METHODS

During May 2005 - March 2006, water and sediment samples were collected from eight stations network chosen in order to emphasize the negative impact of the main pollution sources around the lake Tasaul Lake on the lake ecosystem (Fig. 1). The samples were taken from the surface layer in May, August, October, November and December 2005, as well as March 2006.

Temperature and pH were measured *in situ* using an YSI (Yellow Spring Instrument) 556 MPS (Multi-Probe-System) and a field pH-meter (model pH315i), respectively.

Chlorinity (here expressed as salinity) was measured using the titrimetric method Mohr-Knudsen (Grasshoff et al, 1998). Dissolved oxygen (DO) was measured by the Winkler method according to Grasshoff et al, 1998, while Biochemical Oxygen Demand (BOD_5) analyses were performed by incubating a sealed sample for five days and measuring the loss of oxygen from the beginning to the end of the test (APHA, 1985).

Nutrients (phosphate, total phosphorus, nitrate, nitrite, ammonia, and silicate) were measured using the standard methods according to Grasshoff et al. (1998). Chlorophyll *a* was extracted with 90% acetone and measured by spectrophotometry using the SCORE UNESCO equations (UNESCO, 1966).

Sediment samples were collected in August 2005 from the same stations. The samples were taken from the upper layer of sediment. In order to point out the vertical distribution of organic and inorganic compounds in sediment, two core-sediments were collected in stations 3 and 6. Both core-sediments were shared in three sections: 0-15 cm (3/1); 15-30 cm (3/2); 30- 75cm (3/3) - in station 3 and 0-15 cm (6/1); 15-30 cm (6/2); 30-52 cm (6/3) - in station 6.

Wet sediment was placed in crucibles and dried at 105 ^{0}C up to constant weight for determination of dry sediment content (DW), then combusted at 550 ^{0}C in a muffle furnace for determination of particulate matter (Allen et al, 1974). Additional sediment samples were centrifuged at 3000 rpm (at temperature of ~ 4°C) for approximately 2 h for pore water separation. The pore water was carefully decanted, then filtered through 0.45 µm fiber glass filters and analyzed for nutrients using the methods described above.

Fig. 1. Map of sampling stations

RESULTS AND DISCUSSION

During the studied period, the surface water temperature followed the normal cycle of air temperature; the highest surface temperatures were observed in August 2005 (maximum of 26.2°C in station 7), while the lowest were found in December 2005 (minimum of 3.0 °C in station 6) (Fig. 2). In terms of horizontal distribution of temperature in August 2005, it can be observed a difference of about 3 °C between the stations 1 (influenced by stone quarries from Sibioara) and 7 (under the direct influence of the municipal waste water discharges). In December 2005, the lowest value of temperature was recorded in the north-western part of the lake (station 6), probably due to the colder tributaries entering the lake.

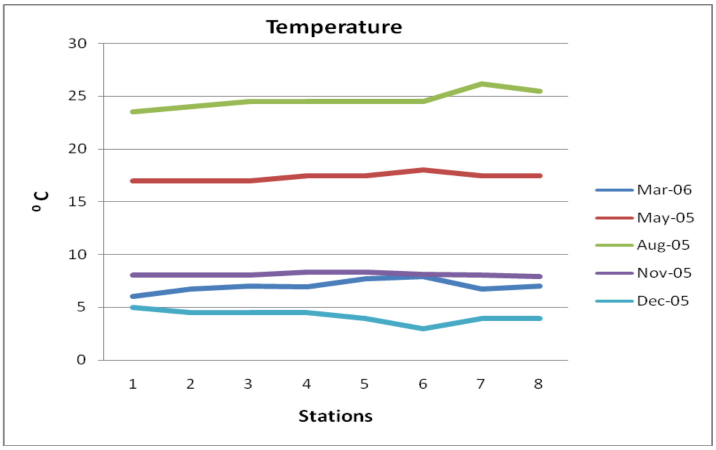
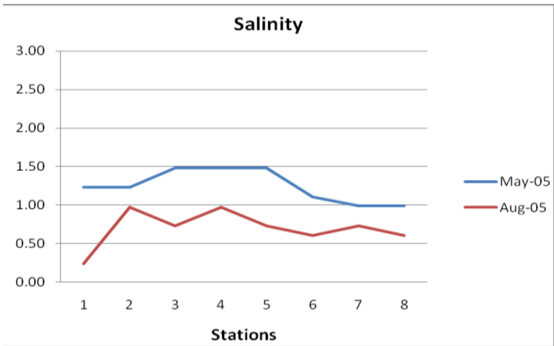


Fig. 2. Seasonal variation of surface temperature

Salinity ranged between 0.24 ‰ and 2.67 ‰ and was correlated with precipitation regime and the Casimcea River flow. The highest salinities were recorded in March 2006 (the maximum was 2.67 ‰ in station 8) in connection with the draught period and currents regime in this period.

In August, November and December 2005 salinities recorded values below 1 ‰. The lowest value (0.24 ‰) was observed in August 2005, in Station 1, probably in connection with increased waste water discharges characteristic for summer season.



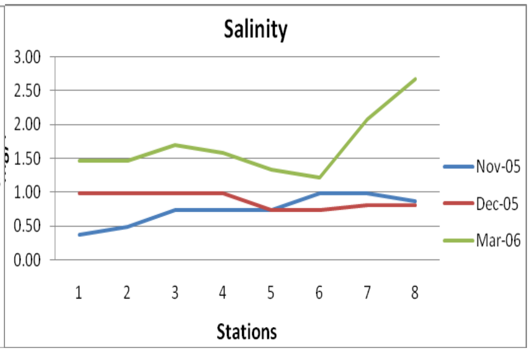
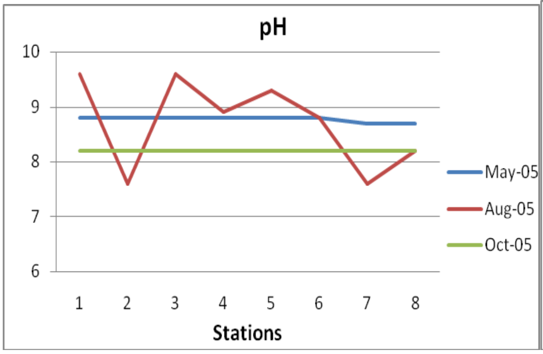


Fig. 3. Seasonal variation of surface salinity

When pollution leads to higher primary productivity, the pH level increases in accordance with the buffering capacity of the lake. Although these small changes in pH are not likely to have a direct impact on aquatic life, they greatly influence the availability and solubility of all chemical forms in the lake (Scheffer, 2004).

During the investigated period, the pH was alkaline in Tasaul Lake (pH values were higher than 8.0 excepting few). pH distribution in the surface layer was homogeneous, excepting August 2005, when pH ranged between 7.6 and 9.6 (Fig. 4). The minima were recorded in the stations 2 and 7 (7.6) and the maxima in stations 1 and 3 (9.6).



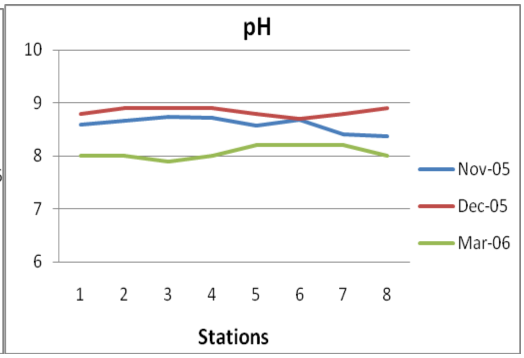


Fig. 4. Seasonal variation of surface pH

The distribution of surface dissolved oxygen was rather homogeneous excepting for August 2005, when DO concentrations ranged between 10.27 mg/l (station 1) and 16.64 mg/l (station 7) (Fig. 5). Although the highest values were recorded in August 2005, the average concentration of DO was higher in winter most probably due to intense wind (stronger mixing processes of water masses). The lowest DO concentrations were recorded in May 2005, probably as a result of reduced intensity of photosyntesis processes (chlorophyll *a* concentrations were minimal for the studied period - Fig. 11).

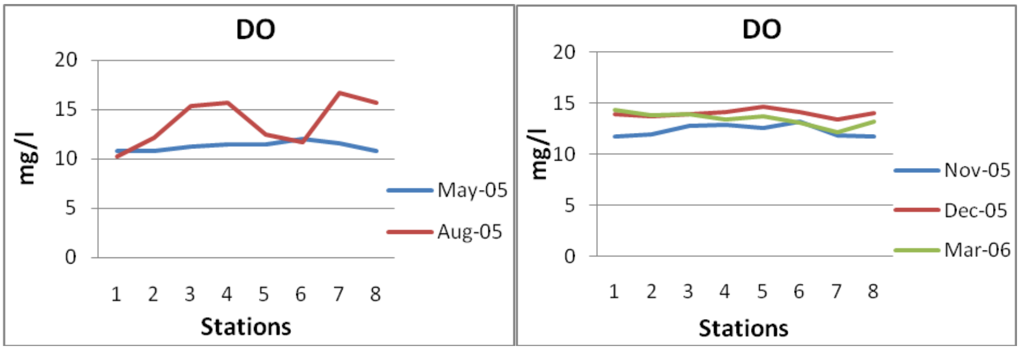


Fig. 5. Seasonal variation of surface DO

The oxygen saturation in the surface layer ranged between 100.2% and 206.9%, thus showing an oversaturation related to strong algal blooms, quite common throughout the year (see Fig. 10). Similar to DO, the oxygen saturation reached the highest values in August 2005, between 121.2% (station 1) and 206.9% (station 7) (Fig. 6).

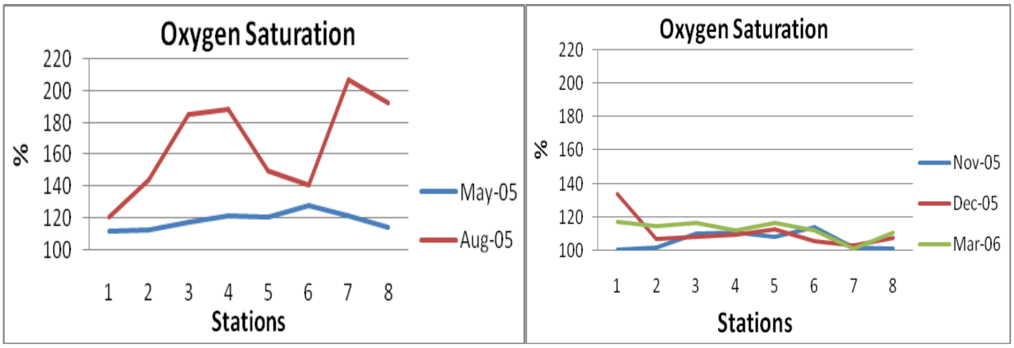


Fig. 6. Seasonal variation of oxygen saturation in the surface layer

Biochemical Oxygen Demand (BOD_5) is a measure of amount of oxygen that bacteria will consume while decomposing organic matte under aerobic conditions.

During the investigated period, BOD_5 recorded values between 2.94 and 8.19 mgO_2/l (both extreme values were measured in March 2006). As is shown in the figure 6, BOD_5 had a non-uniform distribution in the surface layer. The highest values were recorded in August 2005, between 4.74 mgO_2/l (station 2) and 8.13 mgO_2/l (station 3).

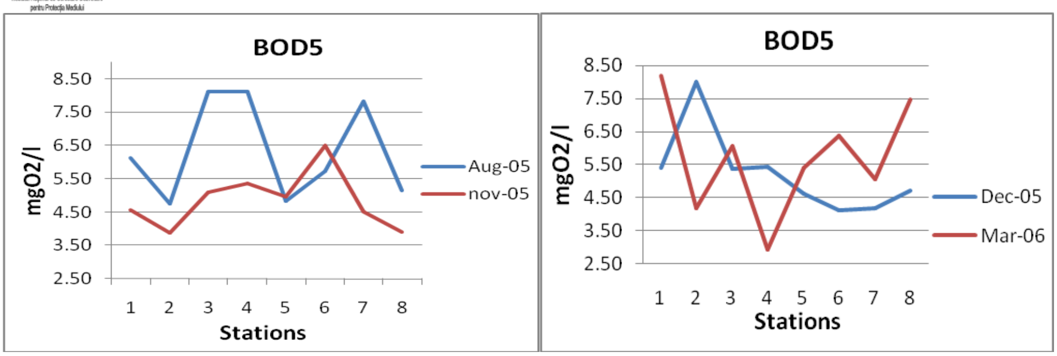


Fig. 7. Seasonal variation of BOD_5 in the surface layer

Phosphate (SRP) concentrations in shallow Tasaul Lake were rather low for a eutrophic system (0.01 - 0.03 mg/l, Fig. 8). The highest SRP values were recorded in May 2005 (between 0.01 and 0.03 mg/l). SRP concentrations decreased in August 2005 because of more intense photosynthesis processes, but values higher than 0.01 mg/l were recorded in stations 5 and 6, probably as a result of higher phosphates input from Casimcea catchments area and Sibioara Farm.

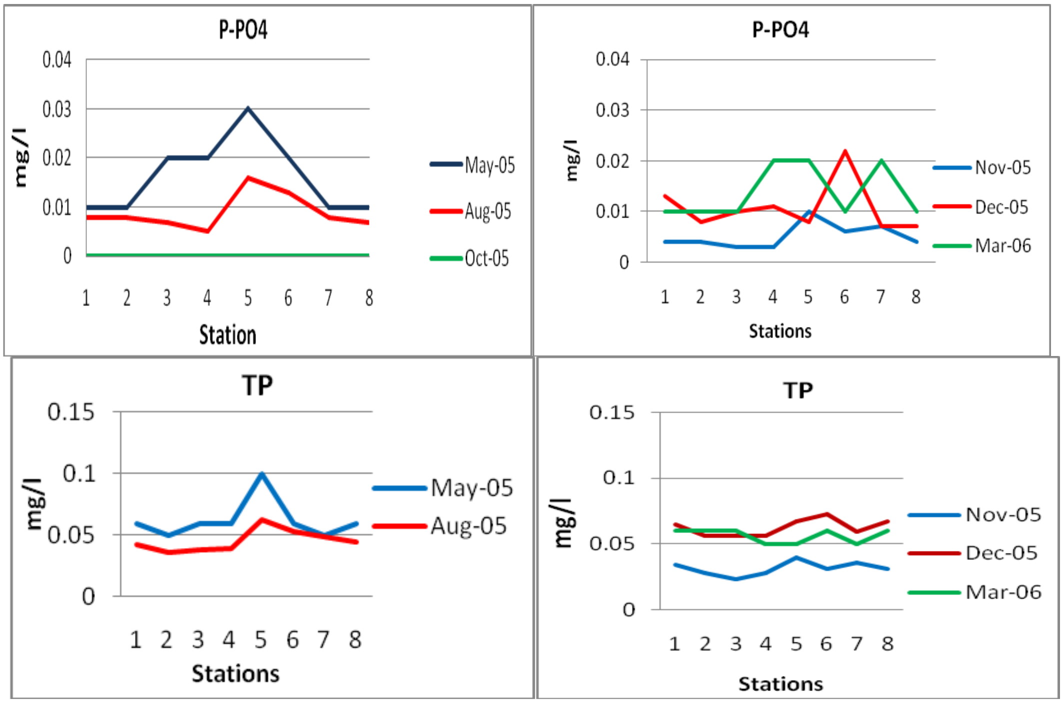


Fig. 8. Seasonal variation of phosphate and total phosphorus in the surface layer

In October and November 2005, the bioavailable phosphorus (SRP) recorded very low concentrations (below detection limit in October) (Fig. 8), probably due to its large consumption in the phytoplankton growth (chlorophyll data are not available for these two months). The highest concentrations for this period were found in station 5 (0.01 mg/l), strongly affected bt the Casimcea River discharges. In December 2005, the highest value was determined in station 6 (0.02 mg/l), also under the influence of tributaries discharges, while in March 2006, the same concentration was found in stations 4,5 and 7.

Similar to SRP, total phosphorus recorded the highest value in May 2005, in station 5 (0.1 mg/l). Values higher than 0.05 mg/l were determined also in December 2005 and March 2006. As is shown in the figure 7, the highest values of total phosphorus were recorded in stations 5 and 6 as a result of external input from the Casimcea basin.

Another explanation of higher phosphorus concentration in northern of the lake (stations 5 and 6) could be the bottom sediment resuspension that may occur due to the lower depth in this part of the lake and strong wind (especially in cold season).

The most important inorganic nitrogen forms in surface waters are ammonium, nitrite and nitrate anions. Aquatic plants take up nitrate and ammonium, while nitrite represents an intermediate product within the N cycle. The total input of nitrogen compounds has a temporal variation and it depends on soil using and other influences.

In May 2005, the oxidized inorganic nitrogen forms ($N\text{-}NO_3$ and $N\text{-}NO_2$) showed higher concentrations, while ammonia recorded minima (Fig. 9). In August 2005 nitrates and nitrites showed significant lower concentrations, except stations 5 and 6 (0.376 mg/l and 0.941 mg/l, respectively) probably in connection with abundant rainfall that brought significant quantities of inorganic nitrogen from the Casimcea basin, agricultural lands and pastures surroundings north-western part of the lake.

During the warm season the ammoniacal nitrogen represented the main inorganic nitrogen form ($N\text{-}NH_4$ values were higher in August, October and November 2005 - Fig. 8), probably due to the organic matter decomposition processes which are favored/intensified by higher temperatures. In the cold season (December 2005 and March 2006), nitrate was the main form of inorganic nitrogen in Tasaul Lake. The highest $N\text{-}NO_3$ concentrations during the winter were recorded in northern and north-western part of the lake (0.846 mg/l in December, in station 6 and 1.34 mg/l in March 2006, in station 5).

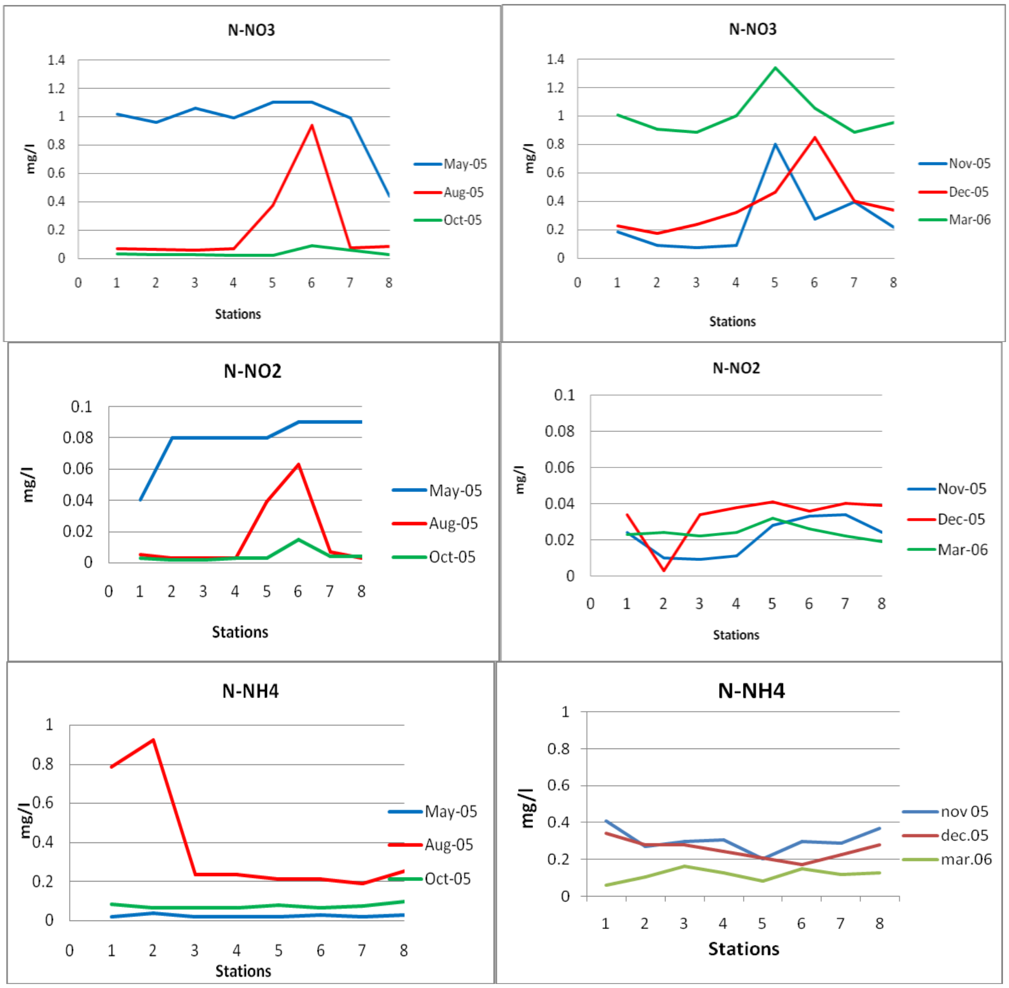


Fig. 9. Seasonal variation of nitrogen inorganic forms (N-NO_3,N-NO_2, and ammonia) in the surface layer

Silica compounds are very important for diatoms and some silico-flagellates growth. During the investigated period, silicates showed large variability, with important seasonal changes.

In May 2005 and March 2006, silicate concentrations were very low (between 0.04 and 0.05 mg/l in May 2005 and between 0.03 and 0.06 mg/l in March 2006, respectively - Fig. 10), most likely related to the diatoms growth. The highest silicate concentrations were observed in northern and north-western part of the lake (stations 5 and 6).

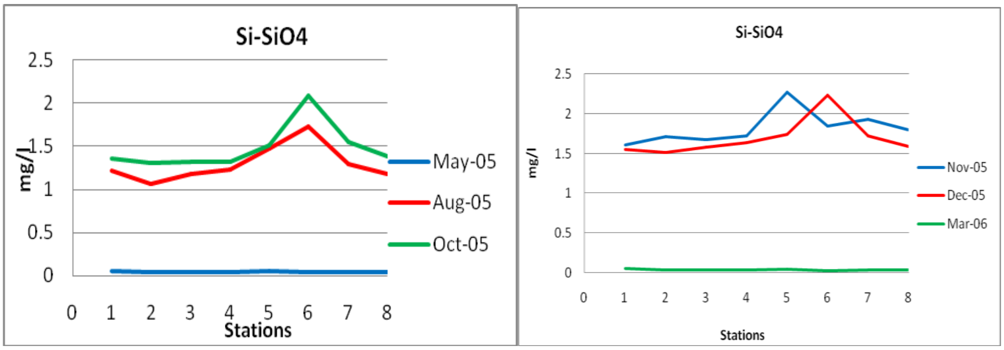


Fig. 10. Seasonal variation of silicates in the surface layer of Lake Tasaul

Chlorophyll *a* (the main indicator of phytoplankton biomass) recorded very high concentrations in the surface layer during the investigated period (excepting May 2005, when it varied between 8.58 µg/l - station 3 and 30.28 µg/l - station 1). Maxima were recorded in March 2006, between 90 µg/l (station 5) and 118 µg/l (station 1), most probably linked to a strong diatoms bloom (characteristic for this period). However, the very high chlorophyll concentrations suggest intense photosynthesis processes during the whole year.

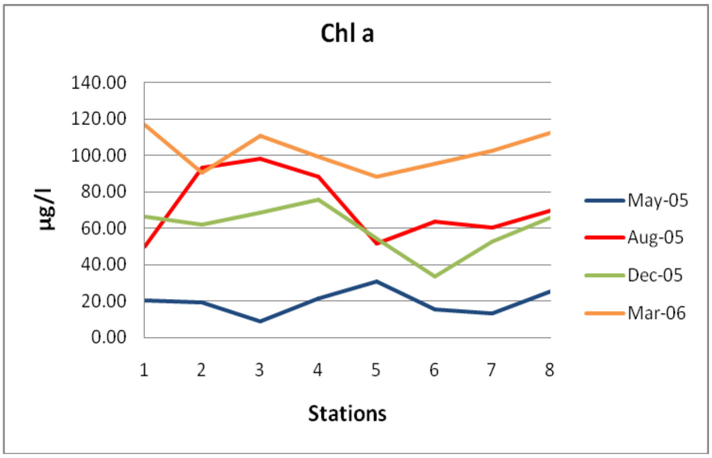


Fig. 11. Seasonal variation of surface chlorophyll *a*

Physical-chemical parameters of Tasaul Lake's sediments showed quite large temporal and spatial variability, influenced by the pollution sources placed around the lake (Table 1).

Table 1. Physical-chemical parameters of sediments in Tasaul Lake (August 2005)

Station	Dry sed g/100g ww	Org. Matter g / 100g dw	$P\text{-}PO_4$ mg/100 g dw	TP mg/100 g dw	$Si\text{-}SiO_4$ mg/100 g dw	$N\text{-}NO_3$ mg/100g dw	$N\text{-}NO_2$ mg/100 g dw	N-NH4 mg/100g dw
1	54.16	3.07	0.82	1.89	5.45	2.87	0.13	8.01
2	52.71	5.00	2.55	3.07	12.94	4.19	0.19	18.25
3/1 0-15 cm	23.69	13.65	4.70	6.19	46.33	14.23	0.57	79.94
3/2 15-30 cm	30.03	12.30	1.59	2.33	18.31	4.10	0.20	39.51
3/3 30-75 cm	34.82	11.66	3.87	4.95	23.36	4.59	0.30	36.45
4	27.93	11.00	2.72	3.78	18.71	7.79	0.28	36.09
5	55.37	7.86	1.42	2.29	13.32	3.20	0.23	19.92
6/1 0-15 cm	49.72	9.76	1.57	2.11	18.90	3.40	0.25	27.47
6/2 15-30 cm	53.54	11.17	3.11	3.94	21.40	4.26	0.34	32.20
6/3 30-52 cm	53.74	11.26	2.69	4.11	21.40	4.26	0.34	32.20
7	32.71	11.73	5.92	7.52	35.48	11.17	0.49	69.83
8	44.26	7.12	2.25	2.95	13.21	0.61	0.23	25.40

The lowest concentrations of organic matter and nutrients were determined in the station 1 (in the south-western part of the lake), in front of waste water discharging point of Navodari city.

The sediment collected from station 3, stratum 0-15 cm recorded the maximum concentrations of organic matter, phosphorus, silicates, nitrates, nitrites, and ammonia. Although they remained high, the concentrations decreased with depth. High concentrations were also recorded in the station 7.

In the north-western part of the lake (station 6), the sediments recorded organic matter and nutrients concentrations lower than in station 3, but they increased with depth.

CONCLUSIONS

The seasonal changes of physical-chemical parameters in the surface layer of Tasaul Lake were normal, being influenced by thermal and hydrological regime.

Tasaul Lake is subject to strong anthropogenic pressures which influence the water chemistry. The pollution sources (point and non-point) cause important input of nutrients. These nutrients are readily consumed due to intense photosynthesis processes carried out throughout the year, thus the concentrations are not very high.

The highest nutrients concentrations were recorded in northern and north-western part of the lake (stations 5 and 6). The Casimcea River brings a large amount of nutrients in the lake, both dissolved and particulate (biological matter and allochthonous rock material). High concentrations of nutrients measured in the station 6 were due to the untreated waste water discharging from Sibioara Farm and agricultural and livestock activities in north-western part of Tasaul Lake. Besides these, the higher concentrations of nutrients in found in the northern part of Tasaul can be also a consequence of nutrient internal loading (phosphorus release from sediments can occur because wind-induced resuspension).

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