Nutrient Input of Casimcea River and the Main Tributaries into Tasaul Lake *(Razvan Mateescu, Dan Vasiliu, Dacian Teodorescu, Laura Alexandrov)*	"Cercetari Marine" Issue no. 37 Pages 17-31	2007

NUTRIENT INPUT OF CASIMCEA RIVER AND THE MAIN TRIBUTARIES INTO TASAUL LAKE

Razvan Mateescu, Dan Vasiliu, Dacian Teodorescu, Laura Alexandrov

NIRDEP - National Institute for Marine Research and Development
"Grigore Antipa", 300 Mamaia Blvd., 900581 Constanta, Romania
E-mail: rmateescu@alpha.rmri.ro, razvan_doru@yahoo.com

ABSTRACT

The present work presents hydrological and chemical studies of Tasaul's tributaries system. Despite having relatively low average population density in most of its catchment, the Casimcea River has developing problems for management. Much of the river runs through semi-arid parts of the Dobrogea region that contribute little water to the river. The river's headwaters in the Northern Dobrogea Mountains provide most of the runoff that has allowed agriculture and small cities to develop along the river. Waters in parts of the south watershed have already been overall located, largely for irrigated agriculture, threatening the instream flow needs of valuable fisheries and the availability of water for downstream/Tasaul lake users. All these among others provide also several ecological problems into Tasaul Lake, appearing as a terminal basin in the last decades.

KEY WORDS: river discharge, gauging key, hydrograph, nutrients input/loads

AIMS AND BACKGROUND

The 20th century was wetter than average, and it is likely that prolonged droughts will occur in the future. Climate change is warming the basin rapidly, less precipitation to fall as snow, snowpacks to melt earlier, and evaporation to increase. The result will be decreased water supplies and higher concentrations of nutrients and other contaminants in the rivers.

Modifications to the river's channel and catchment are also significant, especially in the Cheia region, due to the hydrotechnical works/dam extension. The dam and its reservoir have caused modifications to flow patterns and increased evaporation. While the impoundments are highly beneficial to residents near the reservoirs, they allow less water to pass downstream, particularly in the summer months when water is in high demand for human activity, and fishes are stressed by high temperature or low oxygen. The catchments of the tributaries are well protected, but most of the river's parts of the basins have been converted to agriculture. Over 50% of wetlands have been drained or filled, limiting the capacity of the basin to accommodate drought. Pollutant loads are not high, nutrients are low level due to poverty of the local people, but the pathogens seems to be higher due to tributary crossing of the waste places/areas of the villages.

A number of recent water management initiatives show some promise for mitigating some of the river's problems, but they will have to be intensified to accommodate both human activity and healthy biota. Coordination between all levels of research institutes and Romanian Waters National Company will be essential, also in the future.

For the purpose of the Tasaul - Estrom Project (determination of the nutrient input in to the lake) was designed and built a hydrometric system for continuous measurement/gauging on the main tributaries of the Tasaul Lake. The hydrometric system extension was the base for load calculations, which is the subject of the present work.

General Features of the Tributary System

The main, permanent tributaries of the Tasaul Lake are Casimcea, Sibioara and Dalufac Spring. On each river was placed a hydrometric station, formed by a limnigraph and a bench-mark, as close as possible to the discharge point into the lake. The results of one year gauging period are showed below.

The Casimcea River system is 60 km long and drains 830.7 km^2 of the central part of the Dobrogea region; it is a complex river system having a total length of its effluents of 93.6 km.

Casimcea river's systems, at the discharge in Lake Tasaul, have mean annual flow of 0.22 m^3/s. Sibioara as well as Dalufac Spring rivers, having a length of appreciatively 7 km, have an average annual flow of 0.037 m^3/s and 0.023 m^3/s, respectively.

For all tributaries system, *seasonality of flows and water* yields are similar, even if there are differences in river magnitude order. There are a series of very small/non-permanent rivers, which become active in flash-floods situations - one of the special cases is Piatra, which is a less than 15 l/s river (dry and hot summers), and is disappearing in the riverside of Casimcea, just before entrance in the lake.

The highest flows of the year in the lower reaches of the Casimcea usually occur in May-June, when the water from melting and precipitation reaches the area. The lowest average flows are in July-August. Also, due to flash floods of the summer, the flows can have different behaviors. In a dry year, as the 2006-2007 periods, flows can be quite variable, depending on temperature and precipitation. Winter flows are typically low, because much of the catchment of the rivers is below freezing in December through February. Groundwater is an important winter water source in many areas.

Local rainfall data

The long-term mean annual rainfall for Casimcea Basin is 404 mm. The long-term mean annual evaporation rate at Casimcea basin/Tasaul Lake is 125 mm. The figure below shows the recorded annual rainfall for the Cheia hydrometric station - it is highly seasonal. The rainfall gauge at Cheia Hydrometric (Hm) Station is a daily read gauge, and it has a good correlation with the Regional Meteorological Center from Constanta.

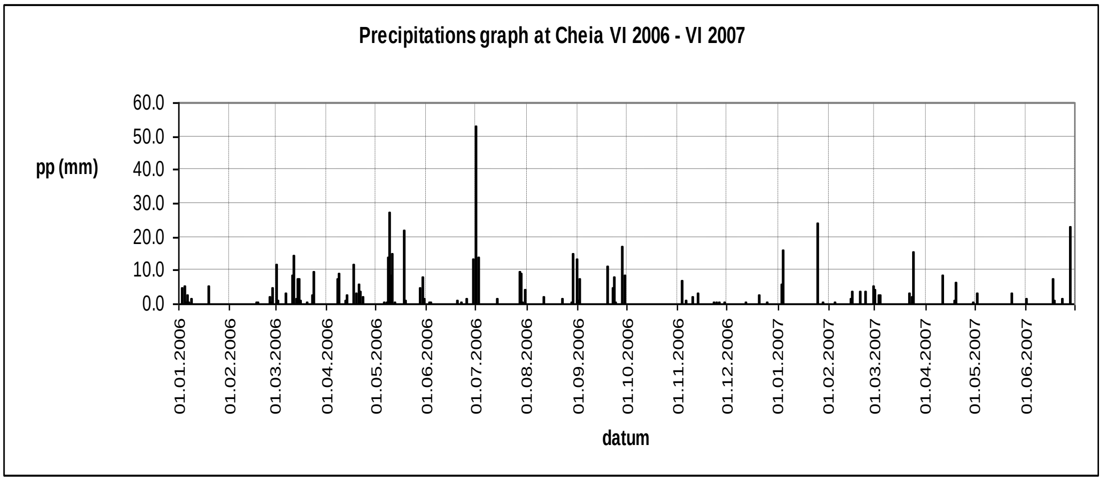

Fig.1. Mean daily rainfall data for Cheia Hydrometric Station showing the range of recorded values (data obtained with the courtesy of "Romanian Waters" Dobrogea-Littoral Directorate)

MATERIALS AND METHODS

To describe the hydrological regime of the tributaries of Casimcea basin and the rest of tributaries located in the northern area of Tasaul Lake, situated in a specific semi-arid climate, a hydrologic analysis within the following tasks, especially for the assumed time interval of 11 May 2006 to 11 May 2007, was performed. The methodology used is the classical one of the technical hydrology applied for the small rivers discharge calculation.

Processing of streamflow gauging stations data

For all currently used streamflow continuous gauging stations/limnigraphs in the Tasaul's tributaries system were obtained the continuous recording of water stage, which were processed from paper hard copies to digitized hourly averaged values for each tributary.

The gauging key/rating curve was graphically represented using P-Q software of BWG, having as input values the values of several discharge calculations provided by HIM software, used in the hydrometrical measurements, developed in this period at different water stages of each tributaries. The currents measurements were done for each tributary using the propellers at hydrometrical section, close to the limnigraphs.

The extension of the discharge calculation at the high waters/levels (segment I) was realized by P-Q software, having as input the discharge/stages values provided by Strikler formula for open channels/free-surface water courses. The Strikler formula is a relation of river discharge and cross section's area:

$$V_m = k_{st} J^{1/2} R^{2/3}$$

Where:
V_m= mean velocity
J = slope
R = hydraulic radius
k_{st} = Strikler coefficient (k_{st} = 1/n, where n is Manning coefficient for open channels)

Analytical methods of the chemical load

Synthesizing the actions, for the purpose of the Tasaul's nutrients input determination, in the time interval June 2006 - May 2007, its tributaries Casimcea, Sibioara, Dalufac and even Piatra (which is a small non-permanent tributary, usually with discharge smaller than 20 l/s) were sampled using Qs sampler devices. The obtained composite samples were determined and the main chemical parameters of the water quality analyzed. The most important are described in Vasiliu's article (this volume, pp.51-65), as follows:

- Chlorinity - titrimetric method of Mohr-Knudsen (Grasshoff et al, 1999), pH - *in situ*, pH-meter (pH315i).
- Chemical Oxygen Demand (COD-Mn) - iodometrically (APHA, 1985).
- SRP (Soluble reactive phosphorus) - 2 h, 0.45µm Millipore filters.
- The inorganic phosphate ions (with ammonium molybdate, in acid medium, forming a phosphomolybdic complex (light yellow color), reduced to a blue colored compound; the color intensity by spectrophotometrically (Murphy and Riley, 1962).
- Total Phosphorus (TP) - with alkaline persulphate oxidation of the organically and inorganically bound phosphorus, completely decomposed to phosphate.
- NO_3-N - nitrate reduction to nitrite in a glass column filled with Cadmium granules, measured spectrophothometrically (Grasshoff et al, 1999).
- NO_2-N - the nitrite ions react with an aromatic amine forming a diazonic compound reacting with a second aromatic amine forming a colored azoic compound; for color intensity using spectrophotometry (Bendschneider and Robinson, 1952).
- NH_4-N - reaction of ammonium ions with hypochlorite, in a slight alkaline medium, to form a monochloramine. This monochloramine forms a blue indophenol complex in the presence of phenol, nitroprusiate and excess of hypochlorite; spectrophotometry (Koroleff, 1969).
- Total Nitrogen (TN) - by combustion at 720˚C and catalytic oxidation/chemiluminescence method and TOC-V CSN Total Organic Carbon Analyzer, Shimadzu (Suzuki et al., 1985).
- SiO_4-Si - with ammonium molybdate in acid medium forming a silicomolybdic complex (light yellow color), reduced to an intense blue colored complex, spectrophotometrically (Koroleff, 1971).

For modeling and calculation of loads in streams the **Bührer model** was used, which assumes the concept of the calculation as an interpolation between measured points/ranges (for composite samples) with appropriate polynomial functions of concentration of run-off - an extension of Taylor series. In this way the transformation (purification, adsorption and desorption) of chemical components on the river, between the source and the gauge/Qs sampler, is taken in consideration based on the assumption that a constant load (y=k/Q) is added to a runoff dependent load, between two curves of the dilution and the concentration of the nutrient - not constant hysteresis curve.

RESULTS AND DISCUSSION

For 2007, there have, however, been rather severe disruptions to the seasonality of flows - summer (May-August) flows in most rivers have declined severely, averaging 40% lower than in the early years of record (of "Romanian Waters" Dorogea-Littoral Directorate). The summer period is very critical for the small rivers - Sibioara and Dalufac - especially due to irrigation at high use during the July-August period. *A climate warming in the Casimcea catchments and its effects on the hydrological cycle* is possible to future extend, as a separate study, because the winter temperatures of 2006-2007 in most areas have increased more than multi-annual average - only two weeks of ice. However, there is a periodicity for the summer floods - both of second half of June 2006 and 2007 (Table 1.)

Table 1. The application of the Strikler formula to Tasaul's main tributaries

HW meas	water level	Q meas	water depth	mean width	water area	mean measured velocity	mean estimated velocity
Casimcea	4.670	0.6	0.950	3.70	2.500	0.250	
Sibioara	2.249	0.035	*0.060*	2.06	0.073	0.050	
Dalufac	11.260	0.01	0.250	1.40	0.081	0.095	
HW calc							
Casimcea	6.500	-	2.000	6.00	8.500	-	1.000
Sibioara	2.600	-	0.410	3.77	1.024	-	0.141
Dalufac	11.900	-	0.640	3.50	1.000	-	0.135

HW meas	wet perimeter	hydraulic radius - R	w-value (Strickler)	slope	Q calc
Casimcea	5.750	0.435	12	0.002	-
Sibioara	1.900	0.039	11.441	0.002	-
Dalufac	1.550	0.052	11.200	0.002	-
HW calc					
Casimcea	8.500	1.000	13	0.002	9
Sibioara	7.650	0.134	14	0.002	1
Dalufac	5.750	0.174	14	0.002	1

After hydrological adjustment of the gauging, keys were also represented analytically using P-Q software, for the purpose of the hourly/daily/monthly and yearly table discharge calculation. Thus, for the selected time period (11.05.2006 - 11.05.2007), the tributaries system the results of mean values of the discharges are the follows (Table 2)

Table 2. Mean values of the discharges of Tasaul Lake's tributaries

River discharge	Min	Mean	Max
Casimcea	0.15000	0.320	2.07
Sibioara	0.014426	0.037	0.092101
Dalufac	0.00600	0.023	0.04

The hydrograph of the water level and the hydrograph of the discharges for Casimcea River were correlated with the similar ones, obtained by "Romanian Waters" Dobrogea-Littoral Directorate for the Cheia Hydrometrical Station, approx. 10 km upstream of Tasaul Bridge (reference) station (Fig. 2 a and b).

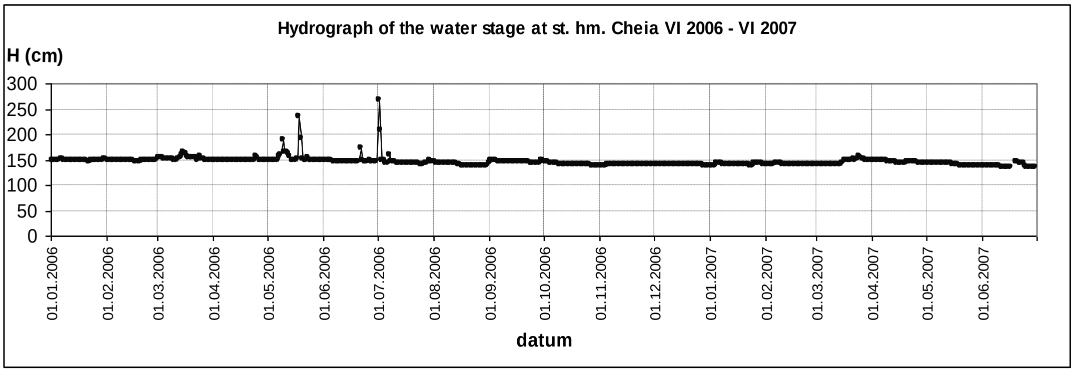

Fig. 2 a. Casimcea's WS hydrographs at Cheia Hm (data obtained with courtesy of "Romanian Waters" Dobrogea-Littoral Directorate)

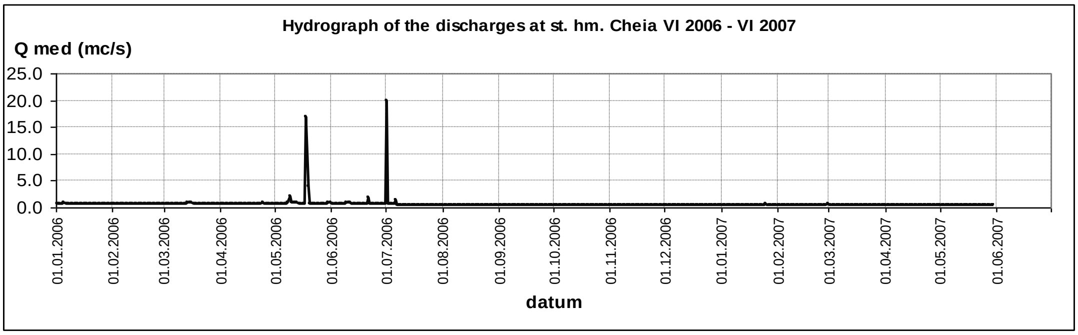

Fig. 2 b. Casimcea's discharge hydrographs at Cheia Hm (data obtained with courtesy of "Romanian Waters" Dobrogea-Littoral Directorate)

The correlation analysis between the results obtained at Cheia belonging to "Romanian Waters" and NIMRD's stations show a good similitude between the water level and discharge hydrographs, as follow the precipitations registered at the Cheia Hydrometric Station (Fig. 3).

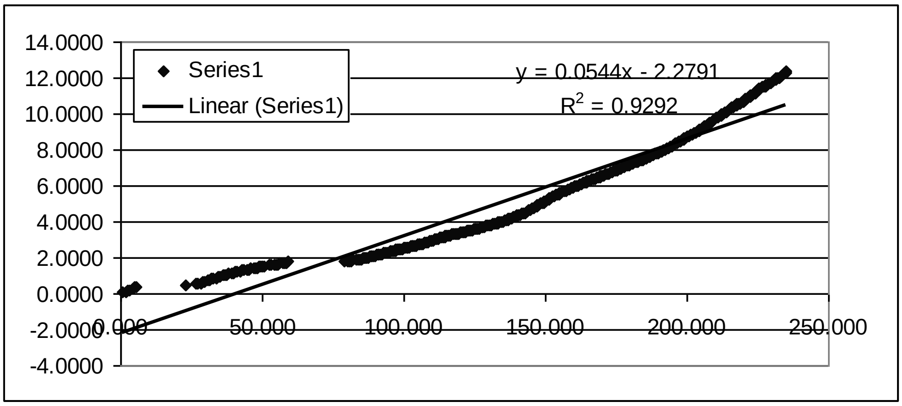

Fig. 3. Correlation graph between discharges calculations for Casimcea and Cheia hydrometric stations

It was realized thought a deterministic statistical correlation, method of double cumulus, between discharges calculated for the two stations. The results of this approach had illustrated two discontinuities of the correlation graph for floods of 18-20.05 and 30.06-3.07.2006; it shows that the reconstruction of recording of the flooding from 18-20.05.2006 were underestimated - at that time, for the runoff caused by a 58 mm rain (according to Cheia's register), the Casimcea and Dalufac limnigraph's flotation-gear fell down, due to the flood wave over the mean estimated level assumed at installation in correlation with relative high of the station's landmark.

Also, for the period of 30.06-3.07.2006, and a runoff caused by a 76.4 mm rain (according to Cheia's register) it is presumed that the vacuum created by the clogging of the limnigraph's pipe would create an inner pressure/suction regime. On the other hand, taking in consideration that Cheia Hydrometric Station was operated four times per day by an observer, it is possible that some picks or special feature of the flood wave can be missed. Similar consideration can be extended for the rest of two gauging stations data.

Flood regime

Due to its climate and its geological feature, for the Casimcea basin/river, as well for the Tasaul's small basins/tributaries, permanent or temporary, the floods represent an important and crucial issue.

As an extreme example, in a flood event, all rivers and especially Casimcea River can arrive/reach 100 times more their normal hydrological regime, with the severe consequences on river morphology and human impact - the massive part of the nutrients input occured, due to washes of the land areas and animal waste deposits.

For the selected annual hydrologic cycle, the flood regime was developed in the normal range/regime, within the May-June month's interval.

From autumn 2006 - spring 2007, once the dam/reservoir of Cheia was functional, the flood regime on Casimcea river is more controlled, and the flood wave was very smoothed as normal (see photos bellow). It is expected that beyond its ecological effect, this dam, if approved by the Romanian Environment Ministry, will have good control on the hydrological regime of the downstream areas.

As an example on this anomalies of the upstream/downstream magnitude is the flood from 18-19.09.2006, occurred with one casualty upstream/in the county, was recorded on Casimcea River, down stream at Tasaul Bridge Hydrometric Station, only with approximately 20 cm variation of the water level.

Fig. 4.a. Flooding areas on Casimcea Basin/Village, having 20 cm recorded variation on Tasaul Bridge limnigraph (event 18-19.09.2006)

Another significant case was registered on Casimcea during the hydrological event of 28-29.06.2007, when the flood wave from upstream of the dam was prolonged two day by the accumulation on the dam's reservoir.

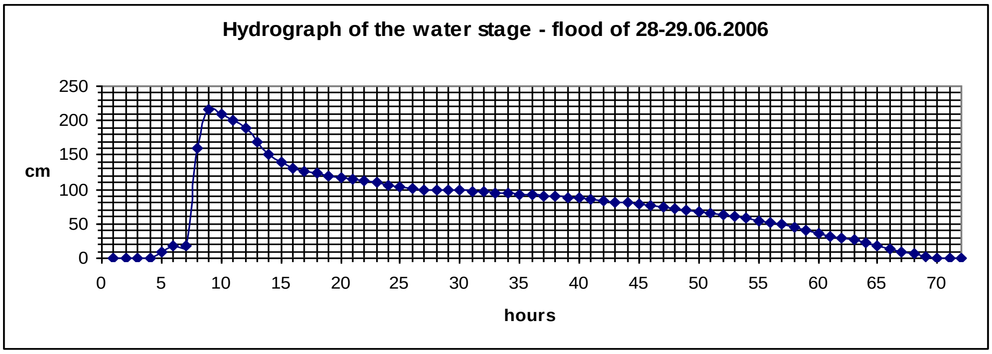

Fig. 4 b, c, d. Flood wave marks - 29.06.2006

Fig. 4, e, f, g. Flood wave regsitration

On 7th August 2007, a flash flood event occurred, when the registered flood wave was very small and delayed at Casimcea, comparative with the water level of the Sibioara and Dalufac gauging stations, due to water retention - limnigrams shapes:

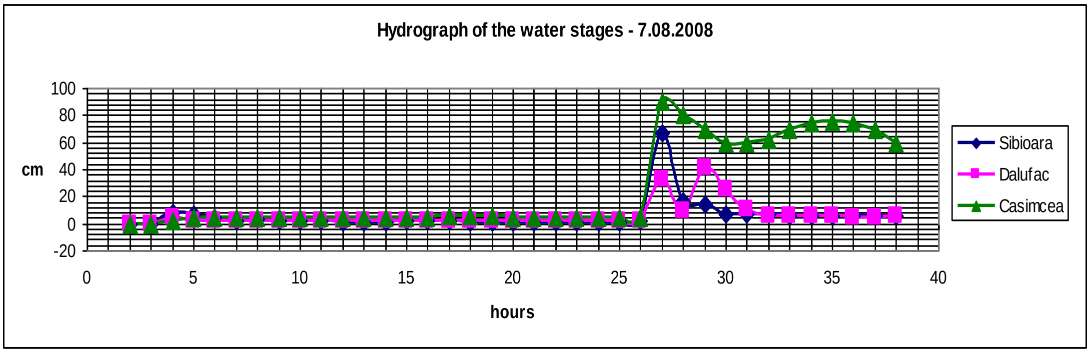

Fig. 4.h. Water levels from 7 to 8 August 2008

It is obvious in the above figure that the Casimcea's flood wave is prolonged, not only for its basin's magnitude, but also due to the hydrotechnical system.

The human impact of the lake's tributary system

The impact coming from the rivers is referred to the nutrient and contaminants input into the lake. The point sources were estimated by area statistics (Boherer model) and specific run-off data determined for each tributary. Integrated (four and after two months, 24 hrs) Q-proportional/composite water samples for chemical analysis are taken in the main tributaries by QS-Samplers every 18 days (to cover all week days) and after first two months, in the interval of each month on a regularly basis. Even pre-experiments were performed, furthermore high flow events are not sampled (as they carry nutrient peak load) by installation of the QS-samplers at a defined high discharge level, because the sampling was not performed in the flood interval due to lack of operational capacity. The procedure carried out for loads calculation is the classical one, the analytic procedure according to ISO 17025.

Before designing a monitoring program of nutrient loads was extended the QA/QC plan, the data quality objectives for the monitoring program were determined, taking into consideration the accuracy, precision, representativeness of measuring points/cross-sections as well for hydrochemical data basis.

The acquired composite chemical data for all tributaries system were placed between large limits, the concentrations being of the same magnitude order. (Table. 3).

Table 3. Limit values for the main chemical parameters of Tasaul's tributaries within the time interval of June 2006 - May 2007

Parameter	Min.	Max.
Chlorinity ($mgCl^-/l$)	66.42	957.63
pH	7.8	8.9
COD-Mn (mgO_2/l)	1.03	12.80
SRP (mg/l)	0.02	0.49
TP (mg/l)	0.02	0.54
SiO_4-Si (mg/l)	1.68	5.44
NO_3-N (mg/l)	0.58	2.42
NO_2-N (mg/l)	0.008	0.121
NH_4-N (mg/l)	0.04	1.87
TN (mg/l)	3.446	15.66
TOC (mg/l)	0.656	15.05

Chlorinity has changed from month to month, mainly due to precipitations and evaporation regime. The smallest values were registered in October. Also the pH values were oscillating within small limits, its maximum values passing smoothly the admitted interval by the normative regarding surface water classification in order to keep the ecologic balance of the water bodies.

Chemical Oxygen Demand (COD-Mn), reflecting decomposable organic matter, was less than 10 mg O_2/l, positioning the tributaries waters in the first and second quality classes, with a ecological state good and very good. Only in few situations the ecological state of the tributary was moderate.

The inorganic nitrogen was present in all forms of nitrate, nitrite and ammonia, the balance was for the nitrate, excepting Dalufac Spring in August and Casimcea, Sibioara and Piatra Rivers in September 2006, when the ammonia form was higher (Fig. 5 a, b, c, d). Thus, while the nitrates frequently oscillated between 1-2.5 mg/l, ammonia was situated at a much lower level, usually under 0.5 mg/l, passing just in few situation this concentration. The comparison between the values regarding the inorganic nitrogen forms and surface water quality normative gave a very good appreciation of the ecological state of these tributaries, within the selected interval.

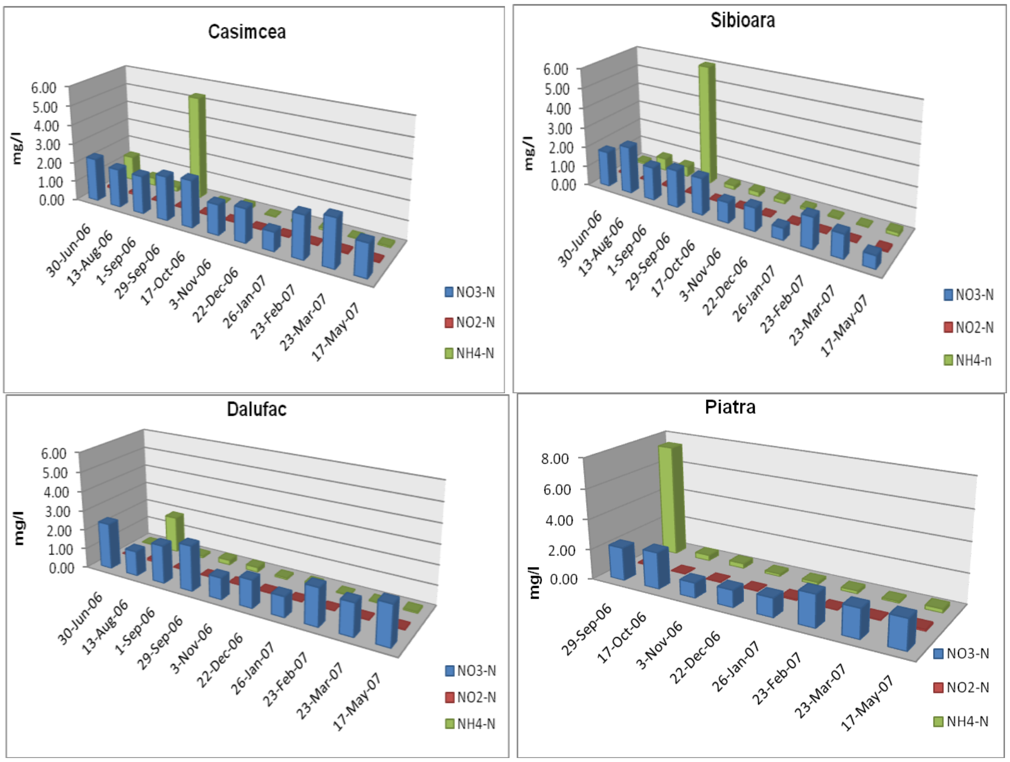

Fig. 5 a, b, c, d. The concentration of inorganic nitrogen forms in Casimcea and the other Tasaul's tributaries during June 2006 – May 2007

The total nitrogen had registered an appropriated level in tributaries of Sibioara, Dalufac and Piatra, where most values were between 4-6 mg/l, good ecological status (Fig. 6. a, b, c). In the most part of the time at Casimcea and, in August, at Sibioara, the maximum level had passed 7 mg/l, inserting the respective water in quality classes III and IV, moderate-poor ecological state. In the same time, it is appreciated that inorganic nitrogen represented much less than 50% from the total nitrogen, the main share being for the organic fraction.

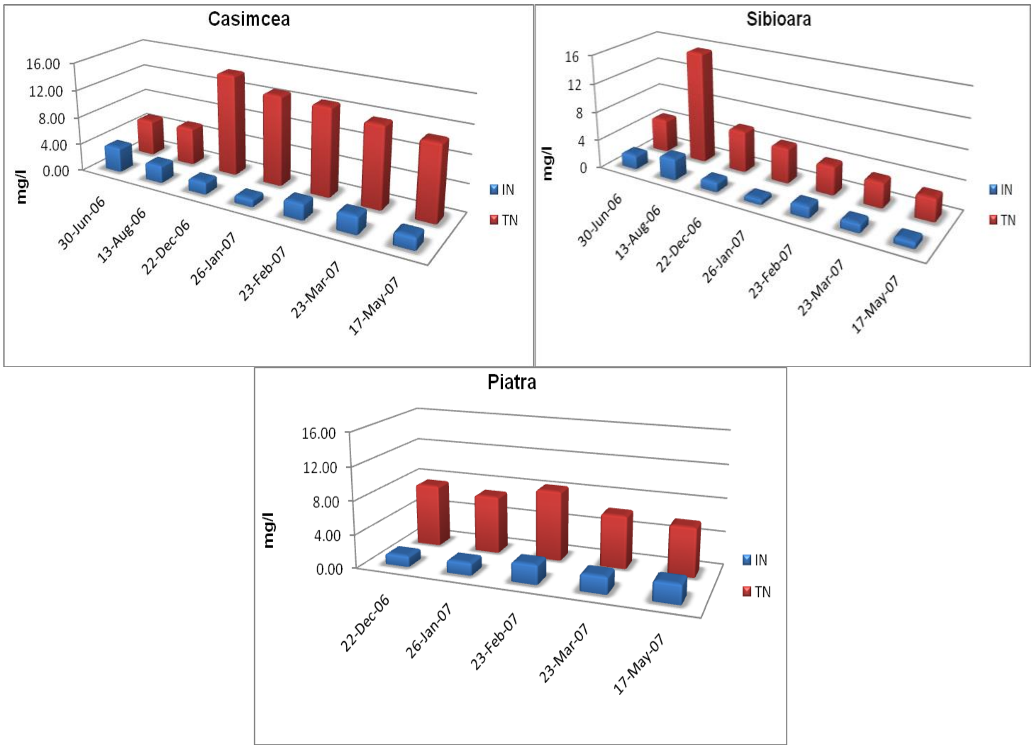

Fig. 6. a, b, c. The inorganic and total nitrogen concentrations in Casimcea and the other tributaries during June 2006-May 2007

Relating to SRP concentration in the Casimcea River (the main Tasaul Lake's tributary), the highest value was measured (like in the case of inorganic nitrogen) at the end of September 2006 (Fig. 7). These values can be associated with the increasing flow of Casimcea River in September 2006 (correlated with low chlorinity) (Vasiliu et al., 2007).

Despite of quite high SRP content recorded in the warm season of 2006, SRP concentration in Tasaul Lake was below 0.04 mg/l in the surface layer suggesting a quickly consumption by phytoplankton (Vasiliu et al., 2007).

Following Figure 8, higher values of TP entering the lake during warm months (the highest values were registered in August and September 2006) can be observed.

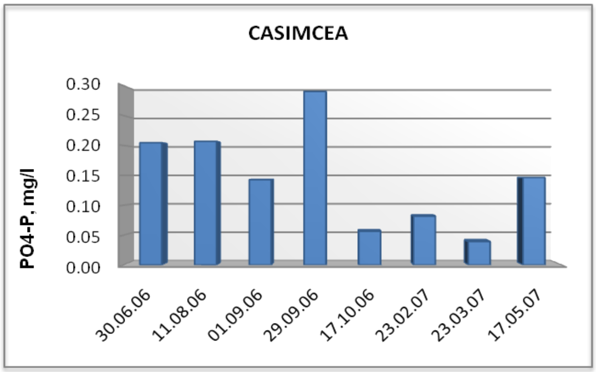

Fig. 7. SRP concentrations in Casimcea during June 2006-May 2007

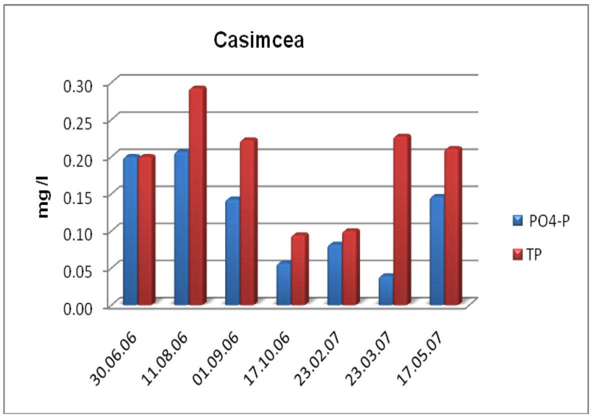

Fig. 8. SRP and TP in Casimcea during June 2006-May 2007

The results of the calculation for the selected time interval 2006-2007, and the data/samples available emphasize that the nutrient input of Casimcea in the Tasaul Lake as a main tributary is in the range of 3.17 tones/year of total phosphorus and 660.58 tones/year of total nitrogen. For the rest of the tributaries the input is subsequent with its magnitude order.

CONCLUSIONS

Even if it is in good ecological condition almost all of the year, the tributary system is expected to have much more input into the Tasaul Lake. Because the flood waves where not sampled directly in their development, the data are not describing the wash process which is happening during the flood. Even the method for load calculation was good, it is expected for future approaches to develop an operational monitoring of the inputs.

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