RESEARCH ON WATER QUALITY IN SMALL AND MEDIUM BARRIER LAKES IN HILLY AREAS WITH BATHUB MODEL

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***Abstract**: Presence in waters of large amounts of nutrients, determine their contamination and the occurrence of eutrophication manifested through an accelerated growth of algae and other higher plant forms. In order to assess the risk of eutrophication of the two barrier lakes studied Cucuteni and Tansa-Belcesti from Bahlui catchment, it was used a model namely BATHUB. Modelling of potential eutrophication, it is expressed through items like total phosphorus, total nitrogen, chlorophyll "a", transparency, organic nitrogen and organic phosphorus. For the two barrier lakes Cucuteni and Tansa-Belcesti was achieved high levels of total nitrogen and total phosphorus caused by diffuse pollution supported mainly by agricultural work practices. The nitrogen and phosphorus nutrients get into the lakes via the river system, and phytoplankton fails to fully assimilate them, which causes maintenance the eutrophic condition for these barrier lakes.*

***Keywords:** barrier lakes, eutrophication, nutrients.*

1. Introduction

Water Framework Directive introduces a new concept on the status of surface waters, and barrier lakes default which is determined on the one hand by ecological status and the other by chemical status [11].

The most important indicator of the ecological status of a barrier lake is the level of eutrophication. Eutrophication is a natural process that evolves over time, and consists of the accumulation of nutrients in an aquatic ecosystem. Eutrophication can be accelerated by human through the discharge of insufficiently treated water in the ecosystem [6]. Advanced in eutrophic lake or hypertrophic lake, eutrophication reach alter the ecological balance of the ecosystem.

Adverse effects can be highlighted on the one hand quantitatively by reducing water transparency, the appearance of floating denser formations, and on the other hand the chemical and biological fields. From the chemical point of view is change the level of oxygen and carbon dioxide, it is influenced the pH, occur anaerobic conditions, and from biologically point of view it is alters odour, toxic algal species occur and thus changes the structure of biota.

The main environmental element to quantify the degree of eutrophication of the barrier lake is algae biomass that represent growth of algae in the lake at a time, depending on the amount of nutrients available in the ecosystem.

To assess trophic conditions and categorization of waters, Vollenweider in 1971 recommended using two criteria, namely concentrations of phosphorus and nitrogen. Hutchinson in 1973 proposed as a criterion to assess eutrophication the transparency and water colour.

The values for total nitrogen and total phosphorus defining the trophic status of a lake are given in Table 1.

Table 1. Indicators of eutrophication in barrier lakes [7]

Number	Stage food	N total, mg/l	P total, mg/l
1	Ultra-oligotrophic	<0,2	<0.005
2	Oligotrophic	0,2-0,4	0.005-0.01
3	Mesotrophic	0,4-0,65	0.01-0.03
4	Eutrophic	0,65-1,5	0.03-0.1
5	Hypertrophic	>1.5	>0.1

These criteria cannot be applied to all categories of waters. Thus in accordance with European requirements for natural lakes and barrier lakes are proposed as criteria for the classification of waters following parameters: P total, N total, primary production average in the growing season, primary production annual, maximum biomass of phytoplankton in the photic zone, chlorophyll "a", the minimum oxygen saturation and the capacity of the aerobic digestion.

2. Additions

Physicochemical, biological, microbiological characteristics of barrier lakes studied, Cucuteni and Tansa-Belcesti, are dependent on the quality characteristics of the Bahlui catchment, likely to diffuse pollution of nitrogen and phosphorus nutrients practices derived from agro-technical works, and to pollution from punctual sources resulting from effluents of agglomerations.

Fig.1. The barrier lake Cucuteni – Water Basinal Administration Prut-Barlad

Barrier lake Cucuteni (Fig.1) is part of the waterworks in the Bahlui catchment. The dam with barrier lake are located on the Voinesti River, right tributary of the Bahlui River, on the territory of town Cogeasca, Letcani, Iasi County. The barrier lake Cucuteni, aims to mitigate flood waves that propagate in the catchment Voinesti, in flood defence of agricultural land downstream of the dam and civil and industrial engineering located in the floodplain of the Bahlui River, downstream from Letcani and the lowlands of Iasi [9].

In Table 2 we can observe the ecological potential evolution of barrier lake Cucuteni in 2012-2015, by monitoring biological elements, physicochemical general elements and specific pollutants.

Table 2. Ecological potential evolution of barrier lake Cucuteni [7]

Ecological potential of water body in terms of:	**2012**	**2013**	**2014**	**2015**
Biological elements	Good	Good	Good	-
General physico chemical elements	Moderate	Moderate	Moderate	Moderate
Specific pollutants	Good	Good	Good	-
Integrated assessment of ecological potential of water body	Moderate	Moderate	Moderate	-
Elements that led to attainment of the quality objective	Status of oxygen, acidification conditions and nutrients	Status of oxygen, acidification conditions and nutrients	Status of oxygen, acidification conditions and nutrients	-
Chemical status	-	-	-	-

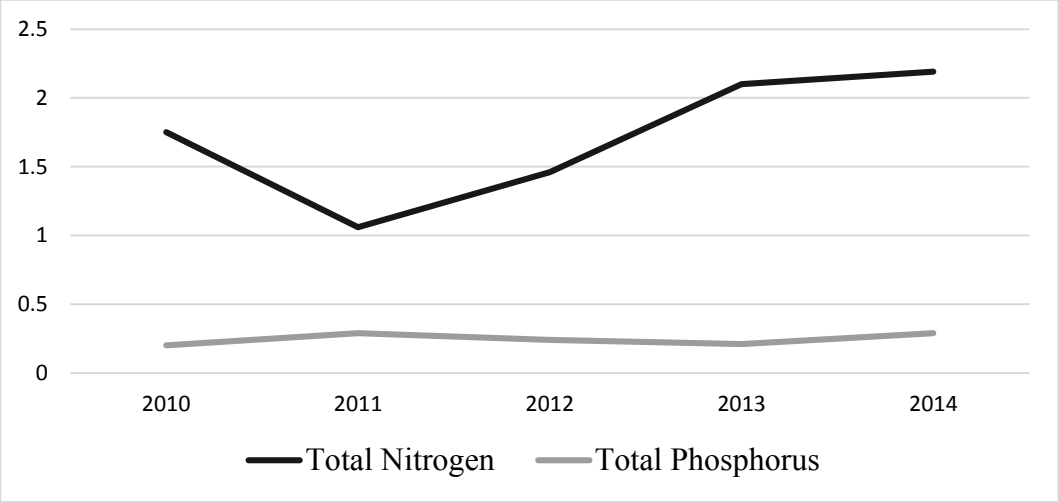

Fig.2. Variation of total nitrogen and total phosphorus in barrier lake Cucuteni in 2010-2014 - middle lake – Data obtained from Water Basinal Administration Prut-Barlad

If we analyse the measured values of total nitrogen in the period 2010-2014, as shown in Fig.2, from the lake Cucuteni, there was a decrease in 2011, then values have a tendency to increase, reaching the maximum in 2014 of 2,19 mg/l. In terms of total phosphorus measured values, they vary slightly in 2010-2014.

Another parameter followed to establish the degree of eutrophication from barrier lakes Cucuteni is transparency whose values are varied relatively low in the period 2010-2014 as shown in Fig.3.

Fig.3. Variation of transparency in 2010-2014 in the barrier lake Cucuteni- middle lake – Data obtained from Water Basinal Administration Prut-Barlad

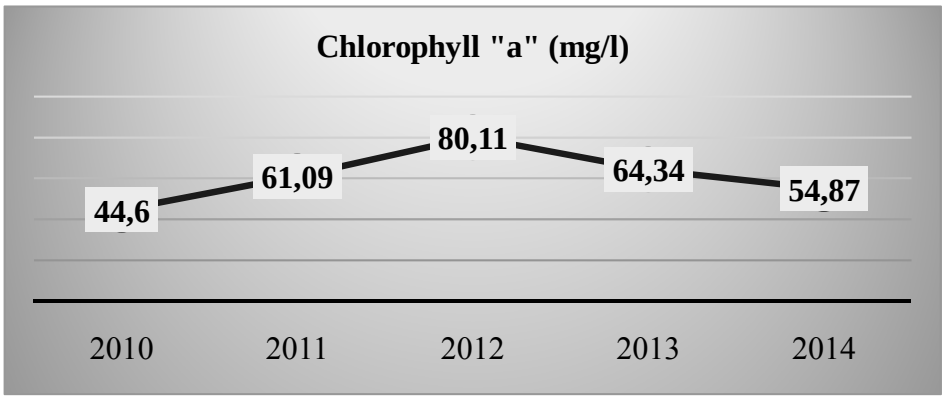

Fig.4. Variation of "chlorophyll a" in 2010-2014 in the barrier lake Cucuteni - middle lake – Data obtained from Water Basinal Administration Prut-Barlad

The differences that arise in the period 2010-2014 of total nitrogen above reveal that the rate of pollutants transport, especially of those from diffuse sources is supported. This is confirmed by the higher values of "chlorophyll" as they were highlighted in Fig. 4.

Fig.5. The barrier lake Tansa-Belcesti – Water Basinal Administration Prut-Barlad

Barrier lake Tansa-Belcesti (Fig.5) is done on the Bahlui River, in the village of Tansa, common Belcesti and it is used to supply water to the Belcesti village, but for irrigation and flood protection too. The barrier lake Tansa-Belcesti ensure with other hydraulic works the flood protection of Iasi [10].

In Table 3 we can observe the evolution of the ecological potential of the barrier lake Tansa-Belcesti in 2012-2015, by monitoring biological elements, physicochemical general elements and specific pollutants.

Tabel 3. Ecological potential evolution of barrier lake Tansa-Belcești [7]

Ecological potential of the water body in terms of:	**2012**	**2013**	**2014**	**2015**
Biological elements	Good	-	Good	Maximum
General physico – chemical elements	Moderate	Moderate	Moderate	Good
Specific pollutants	Good	Good	Good	Good
Integrated assessment of ecological potential of the water body	Moderate	-	Moderate	Good
Elements that led to attainment of the quality objective	Status of oxygen, acidification conditions and nutrients	-	Status of oxygen, acidification conditions and nutrients	-
Chemical status	Good	Good	Good	Good

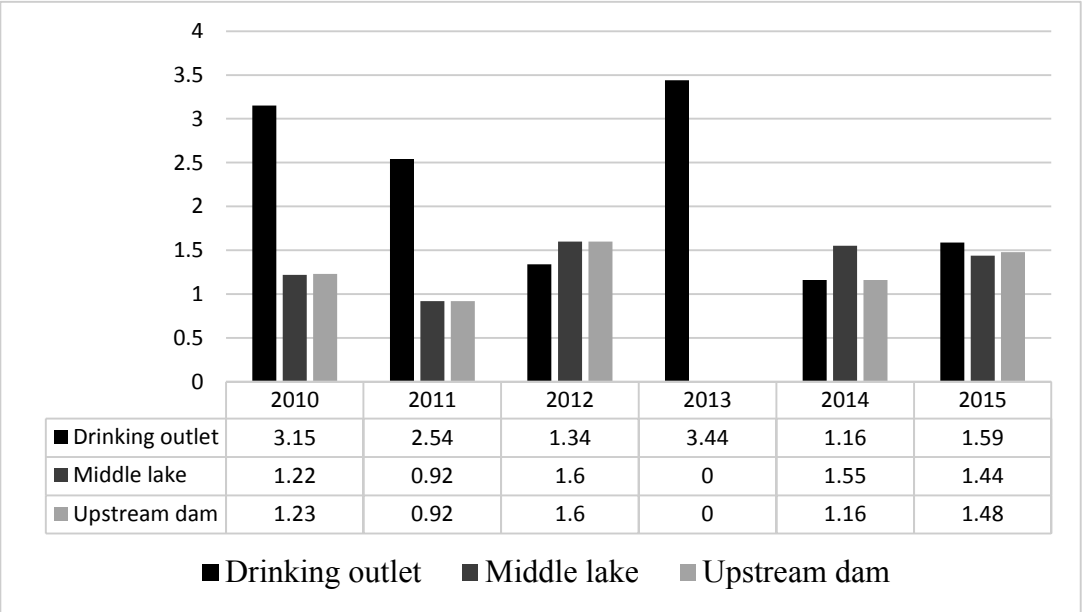

Fig.6. Variation of total nitrogen during 2010-2015 in barrier lake Tansa-Belcesti in three sections of monitoring - Data obtained from Water Basinal Administration Prut- Barlad

If we analyse the measured values of total nitrogen during 2010-2015 in barrier lake Tansa-Belcesti, as shown in Fig.6 there is a significant variation those determined in the

section mains drinking, while in the other section: middle lake and upstream dam, values remain mostly steady. Also highs total nitrogen’s shall be determined in drinking outlet section.

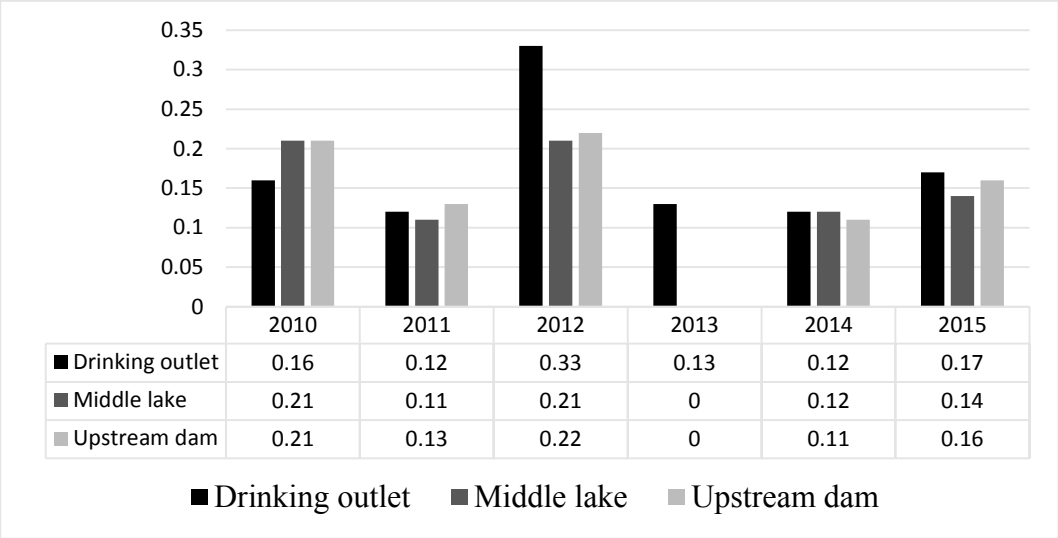

Fig.7. Variation of total phosphorus during 2010-2015 in barrier lake Tansa-Belcesti in three sections of monitoring - Data obtained from Water Basinal Administration Prut-Barlad

If we analyse the measured values of total phosphorus during 2010-2015 in barrier lake Tansa-Belcesti, as shown in Fig. 7 observed that the highest values were determined in 2012, in all three sections of monitoring.

Also in the barrier lake Tansa-Belcesti, values of transparency vary slightly in monitoring sections, this is shown in Fig. 8.

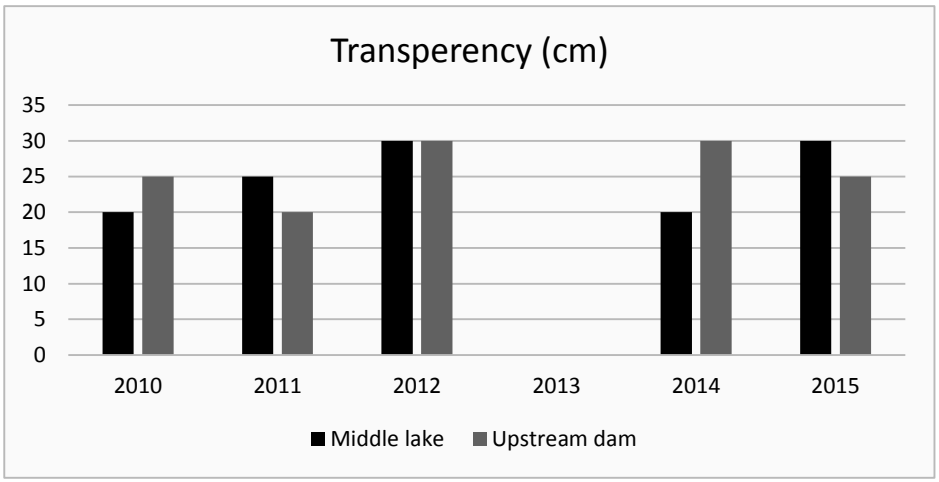

Fig.8. Variation of transparency during 2010-2015 in barrier lake Tansa-Belcesti - Middle lake and upstream dam - Data obtained from Water Basinal Administration Prut- Barlad

In order to assess the risk of eutrophication of the two barrier lakes Cucuteni and Tansa-Belcesti, can be used a quality model for lakes, BATHUB, that consider mass balance of nitrogen and phosphorus nutrients. Modelling of potential eutrophication, it is expressed

through items like total phosphorus, total nitrogen, "chlorophyll a", transparency, organic nitrogen and organic phosphorus. These variables are simulated using empirical relationships, nitrogen and phosphorus dynamics modelling is based on a combination order kinetic models 1 and 2 [5]. BATHUB model involves dividing the barrier lake into different segments/sections if conditions vary enough to justify this.

To rolling model I used available data from monitoring that were purchased from Water Basinal Administration Prut-Barlad.

For barrier lake Cucuteni it was defined one section, namely middle lake, because only in this point water samples were taken to observe the quality of the barrier lake, while for barrier lake Tansa-Belcesti are defined 3 sections: tail lake, middle lake and upstream dam. For each section it is necessary to introduce morphometric data and water quality data (catchment area, bathymetry of reservoir, rate of inflow as well as the quality of water entering the water body from the hydrographical network, chemical characteristics of bottom sediments).

The BATHUB model require also accurate hydrological conditions for the area where the barrier lake is located, including precipitation and evapotranspiration. Later introduce water quality data from existing monitoring.

Following the simulation of water quality from barrier lake Cucuteni with BATHUB model, were obtained data on mass balance for defined section - the middle lake - section 1, as shown in Table 4 and Table 5.

Table 4. Results of mass balance for the middle section lake (Nitrogen)

Components	**TOTAL - N**		**Segment 1**		
	Flow (hm^3/yr)	**Flow (%)**	**Load (kg/yr)**	**Load (%)**	**Conc. (mg/m3)**
Rainfall	1,30	0%	1800	0%	1900
Joining the network	124724,5	100%	694840523,5	100%	2600
Total Flow entered	124724,5	100%	694500120,0	100%	2600
Debit advection	124724,5	100%	676520000,0	99,62%	2550
Diffuse flow	0	0%	2566011	0,38%	-
Total flow	124724,5	100%	679086011,0	100%	2550
Evaporation	0,35	0%	0	0%	-
Increasing retention	0	0%	12	0%	2550
Retention	0	0%	100100	0,4%	-

Table 5. Results of mass balance for the middle section lake (Phosphorus)

Component	**TOTAL - P**		**Segment 1**		
	Flow (hm^3/yr)	**Flow (%)**	**Load (kg/yr)**	**Load (%)**	**Conc. (mg/m3)**
Precipitation	1,30	0%	60	0%	140
Rainfall	124724,5	100%	49150000,0	100%	230
Joining the network	124724,5	100%	49155200,0	100%	230
Total Flow	124724,5	100%	49305000,0	99,77%	220

entered					
Debit advection	0	0%	112054	0,23%	-
Diffuse flow	124724,5	100%	49417054,0	100%	220
Total flow	0,35	0%	0	0%	-
Evaporation	0	0%	3,3	0%	220
Increasing retention	0	0%	10070	0,2%	-

From the results presented tabulated above were obtained that minor errors between measured values and simulated values.

Following the simulation water quality from barrier lake Tansa-Belcesti with BATHUB model were obtained mass balance data for three defined sections: tail lake - section 1, middle lake - section 2 and upstream dam - section 3.

The following are shown graphically in Fig.9 and Fig.10 the results of the model compared with measured values.

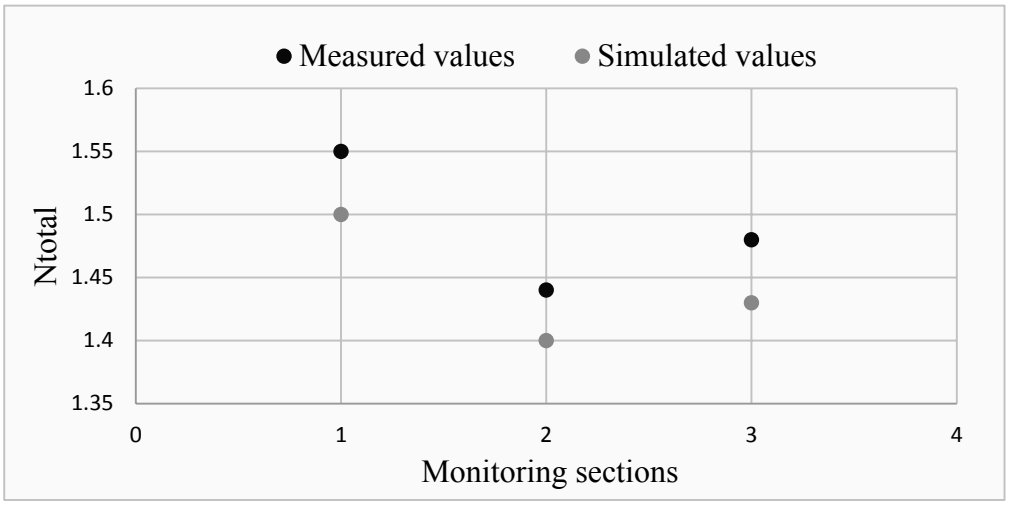

Fig. 9. Changes in total nitrogen of barrier lake Tansa-Belcesti in three monitoring sections

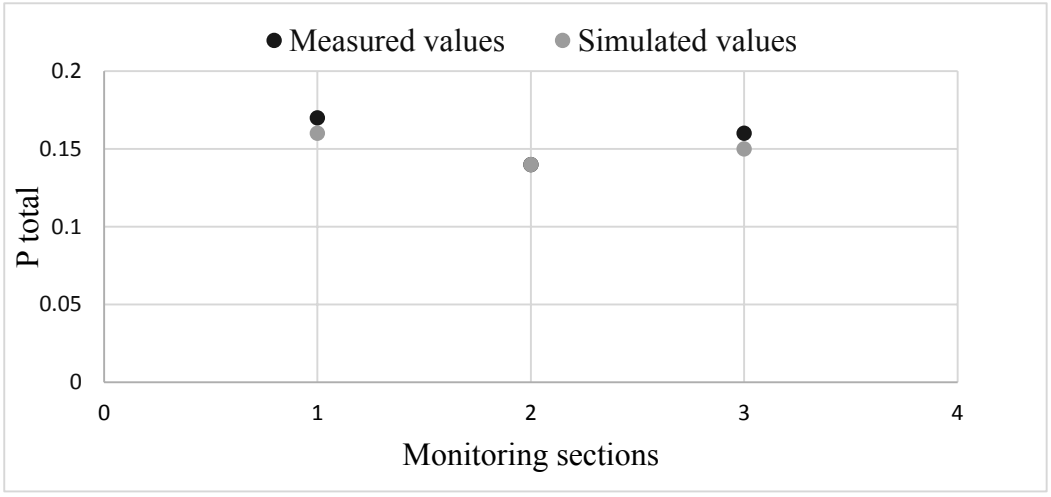

Fig. 10. Changes in total phosphorus of barrier lake Tansa-Belcesti in three monitoring sections

The lowest results for total nitrogen and total phosphorus is recorded in middle section of the lake.

When analysing the values of transparency in the barrier lake Tansa-Belcesti as shown in Fig.11, there is a big difference between the spring season and the summer. The difference in transparency between the two seasons is 30 cm, more for the spring season, which is shown in the Figure below:

Lower values measured during the summer-autumn may be due to suspended solids in water and presence in the lake of aquatic organisms which are making up the plankton (in particular phytoplankton) and that is developed intensely during this period.

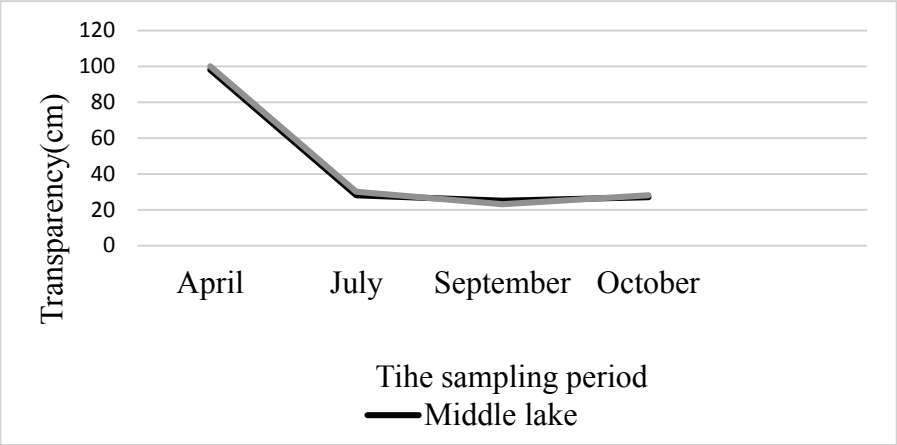

Fig.11. Variation of transparency in barrier lakeTansa-Belcesti

3. Conclusions

Both the barrier lake Cucuteni, as well as barrier lake Tansa-Belcesti, it was achieved high levels of total nitrogen and total phosphorus, that fact claiming the diffuse pollution caused mainly by agricultural practices. Nutrients reach the lakes via the river system, and phytoplankton fails to assimilate them fully, causing maintaining the eutrophic conditions for this barrier lakes.

4. References

1. *Giurma I., - Integrated Water Resource Management, Politehnium Iaşi, 2010;*
2. *Jolankai G., - Hidrological chemical and biological processes of contaminant transformation and transport in river and lake sistems, IHP- IV Project H-3.2, UNESCO Paris, 1992 and IHP-V Projects 8.1, 2.3, and 2.4, 2000 Venice Office;*
3. *Jula G., Serban P., - Monitoring and characterization of surface water quality in accordance with the Framework Directive 200/60/EC in the field of water, Magazine Hidrotehnica 46, 9, 324-329;*
4. *Minea, I., - Chemistry and lakes water quality assessment from southern hilly plain of Jijia –Bahlui basin;*
5. *Păduraru C., Thesis – Contributions to improve methods of monitoring water quality of surface resources, "Gheorghe Asachi" Technical University of Iasi, Faculty of Hydrotechnics, Geodesy and Environmental Engineering, 2012;*
6. *Varduca, A., Water Quality Protection, H*G*A*, Bucureşti, 2000;*

7. *ANAR ("Romanian Waters" National Administration) - Water Basinal Administration Prut-Barlad Iasi - Synthesis of water quality in Prut-Barlad catchment for the years 2010 2011, 2012, 2013, 2014, 2015;*
8. *ANAR ("Romanian Waters" National Administration) - Water Basinal Administration Prut-Barlad Iasi - Management plans of Bahlui catchment;*
9. *ANAR ("Romanian Waters" National Administration) - Water Basinal Administration Prut-Barlad Iasi - Operating rules – Technical report for barrier lake Cucuteni;*
10. *ANAR ("Romanian Waters" National Administration) - Water Basinal Administration Prut-Barlad Iasi - Operating rules – Technical report for barrier lake Tansa-Belcesti;*
11. *Framework Directive (2000/60/EC).*