EVALUATION OF ECOLOGICAL POTENTIAL OF BARRIER LAKES ON PHYTOPLANKTON AND PHYTOBENTHOS AS REQUIRED BY THE WATER DIRECTIVE 2000/60/EC

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***Abstract**: The principle on which biological analysis is based in order to assess water quality is that throughout organisms evolution, they have adapted to particular environmental conditions. Biological quality elements used to evaluate the ecological potential of barrier lakes are phytoplankton and phytobenthos. The evaluation of the ecological potential in terms of biological elements is obtained by applying the "worst element" principle. The worst potential given by biological elements is the "moderate" potential. During the analysis of the quality state of barrier lakes in the Prut-Bârlad basin, based on biological elements, it was observed a favorable trend in terms of water quality. So if in 2012 there were 4 barrier lakes (with good ecological potential) reaching the environmental objective, in 2014 their number increased to 15 (4 barrier lakes with maximum potential , and 11 with good potential).*

***Keywords:** phytoplankton, phytobenthos, barrier lakes, ecological potential.*

1. Introduction

The principle on which biological analysis is based in order to assess water quality is that throughout organisms' evolution, they have adapted to particular environmental conditions and knowing these circumstances, it can be appreciated the biocenosis structure, and vice versa, determining plant and animal populations and also the environmental factors of the living space.

It was found that pollution with chemical minerals and that produced with organic matter are the most common and cause the phenomena of eutrophication, low oxygen concentration, mortality of fish, decreased biodiversity, bioaccumulation, persistence and toxicity of micropollutants, changes in pH, organoleptic changes, increased turbidity, inability to use the water as drinking water source. Depending on their capacity to adapt, some species of organisms living in water polluted with organic matter, they are known as biological indicators of water quality indicators of workload with organic or saprobity degree water. It is known also a category of organisms that live in clean waters, with little loading with organic substances, that are known as biological indicators of water cleanliness .

For water quality assessment it is aimed whether the number of indicator species is very high, and this is possible in highly polluted areas, or in the very clean ones. Only then it can be clearly established the quality status of water bodies. The analysis is based on biological water all reactions of organisms to environmental conditions.

Besides analyzing biological quality of water bodies, it can be made also a chemical analysis, presenting both advantages and disadvantages. Chemical analysis provides information about features available only at the time of sampling, while biological analysis provides information that is valid for a longer period. This advantage is because bodies do not respond immediately to changing environmental factors, but on a longer period. Thus if pollution is strong and occurs suddenly, organisms can die immediately, wheares when it takes place gradually a change in the ecological balance is made. Some species slowly disappear, and others who can adapt to the new conditions multiply. Therefore arises a characterizing new type of polluted water biocenosis.

Another advantage is that biological analysis can give information on the degree of intoxication of the ecosystem, while chemical analysis can reveal information only if the measurements are repeated frequently and over a long period.

Biological analysis can not provide quantitative and qualitative information on the amounts of pollutants, therefore, it is necessary to complete the two methods (Integrated monitoring of water quality, 1999).

2. Additions

The evaluation of the ecological potential in terms of biological elements is obtained by applying the "worst element" principle. The worst potential given by biological elements is the "moderate" potential. Biological quality elements used to evaluate the ecological potential of barrier lakes are phytoplankton and phytobenthos (National management plan, 2010*)*.

Phytoplankton is monitored with a frequency of 4 times/year, from may to september for surveillance program and for the operational program.

Surveillance monitoring is to assess the status of all waters within the river basin and to provide information to: validate the impact assessment procedure, effective design of future monitoring programs, evaluating the long-term trend of variation from water resources, including due to the impact of anthropogenic activities.

Establishes operational monitoring of water bodies in the catchment that may not meet environmental objectives and the status of water bodies possible risk and assess any changes in the status of these water bodies. Operational program stops when water bodies reach at a good condition.

Phytoplankton is sensitive to the following pressures: intake of nutrients, organic pollution, changes in the level and general degradation. The assessment is made at section level and then at the body of water.

The selected parameters for assessing the ecological potential of barrier lakes regarding phytoplankton are: the index number of taxa (the taxa that are identified in a sample), index of biomass (what defines the weight of a sample algae/station/water body, momentary or average), chlorophyll "a" (the concentration of the pigment in a sample/station/water body, momentary or average), biomass cyanobacteria abundance (cyanobacterial biomass is reported in the total biomass of algae in the sample) and diversity index Shannon-Wiener.

The following tables presents the proposed values for each of the selected parameters for the 3 types of ecological potential, as defined in the Water Directive 2000/60/EC (maximum ecological potential, good and moderate), star classification, including reference guide for state values (National management plan, 2010).

Table 1. The proposed values for the index number of taxa

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01- 04	ROLA01+ROLA02	22	16	12	<12
ROLA05	ROLA03	19	12	10	<10
ROLA06- 11	ROLA04+ROLA05+ ROLA06	20	14	10	<10
ROLA12- 14	ROLA07	17	13	9	<9

Table 2. The proposed values for cyanobacteria biomass abundance index

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01- 04	ROLA01+ROLA02	7	12	29	>29
ROLA05	ROLA03	3	6	10	>10
ROLA06- 11	ROLA04+ROLA05+ ROLA06	2	6	15	>15
ROLA12- 14	ROLA07	1.5	4	11	>11

Table 3. The proposed values for for chlorophyll "a"

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01+02	ROLA01	5	20	50	100
ROLA03+04	ROLA02	10	20	50	100
ROLA05	ROLA03	9	9	16	28
ROLA06+08	ROLA04	3	5	10	50
ROLA07+10	ROLA05	1	3	8	12
ROLA09+11	ROLA06	3	5	10	20
ROLA12+13+14	ROLA07	1	2	3	8

Table 4. The proposed values for phytoplankton biomass index

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01- 04	ROLA01+ROLA02	4	7	10	>10
ROLA05	ROLA03	5	7	9	>9
ROLA06- 11	ROLA04+ROLA05+ ROLA06	2	5	8	>8
ROLA12- 14	ROLA07	1	2.5	4	>4

Table 5. Values proposed for diversity index Shannon - Wiener

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01- 04	ROLA01+ROLA02	2,7	2,3	1,8	<1,8
ROLA05	ROLA03	2,6	2,2	1,8	<1,8
ROLA06- 11	ROLA04+ROLA05+ ROLA06	2,5	2,1	1,7	<1,7
ROLA12- 14	ROLA07	2,5	1,9	1,3	<1,7

For each indicator is calculated the Environmental Quality Ratio (RCE) based on the value obtained and the matching guide value for the corresponding reference state. It is always divided the lesser to the greater for a ratio between 0 and, and where the values obtained are higher than the guide values for the corresponding reference state, the Environmental Quality Ratio is considered equal to 1.

When calculating the RCE there should be studied the proposed values for each index reference and for the reference status and ecological potential to see their trend, of increase or decrease from the maximum ecological potential to moderate ecological potential.

For barrier lakes, for selected indices it was proposed a weighting of their importance for the assessment of the ecological potential, as follows: index number of taxa (10%), index of biomass (20%), chlorophyll "a" (15%), biomass cyanobacteria abundance (30%) and diversity index Shannon-Wiener (25%).

This formula is used to determine multimetric index:

$$\text{Multimetric}_{\text{index}} = 0.1 * RCE_{INT} + 0.2 * RCE_{CYANO} + 0.3 * RCE_{BIO} + 0.15 * RCE_{CHL} + 0.25 * RCE_{ID} \quad (1)$$

The multimetric index value will give the ecological potential, which must be between 0 and . In order to grade the ecological potential it is proposed to subdivide the multimetric index values as follows: maximum ecological potential - min. 0.8, good ecological potential - min. 0.6, moderate ecological potential - min. 0.4.

In case of more seasonal results, the evaluation of the ecological potential of barrier lakes is based on the annual average of the multimetric index, including those for which there are several stations. There are not taken into account the values of the parameters from the tail of the lake. The assessment of the ecological potential is based solely on data provided by middle lake and dam sections.

Phytobenthos is monitored 1 time/year for the surveillance program and 2 times/ year for the operational program. Valuation is at section level and then at the body of water.

Phytobenthos is sensitive to the following pressures: intake of nutrients, organic pollution, changes in the level and general degradation.

Parametrii selectați pentru evaluarea potențialului ecologic al lacurilor de acumulare pe baza fitobentosului sunt mai putini decat in cazul fitoplanctonului, si anume: indice numărul de taxoni , indice de diversitate Shannon-Wiener si indice de troficitate TDI.

The following tables presents the proposed values for each of the selected parameters for the 3 types of ecological potential, as outlined in the case of phytoplankton (National management plan, 2010).

Table 6. The proposed values for the index number of taxa

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01+02	ROLA01	20	14	7	<7
ROLA03+04	ROLA02	22	15	6	<6
ROLA05	ROLA03	19	13	8	<8
ROLA06+08	ROLA04	21	15	7	<7
ROLA07+10	ROLA05	20	13	7	<7
ROLA09+11	ROLA06	23	17	8	<8
ROLA12+13+14	ROLA07	13	10	5	<5

Table 7. Values proposed for diversity index Shannon - Wiener

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01+02	ROLA01	2,5	2	1,5	<1,5
ROLA03+04	ROLA02	2,4	1,9	1,5	<1,5
ROLA05	ROLA03	2,5	1,9	1,6	<1,6
ROLA06+08	ROLA04	2,6	2,1	1,7	<1,7
ROLA07+10	ROLA05	2,6	2	1,7	<1,7
ROLA09+11	ROLA06	2,5	1,8	1,6	<1,6
ROLA12+13+14	ROLA07	2,8	2,2	1,8	<1,8

Table 8. The proposed values for trophic index (TDI)

Typology	New tipology	Reference value (min)	Maxim ecological potential (min)	Good ecological potential (min)	Moderate ecological potential (min)
ROLA01+02	ROLA01	4	5,4	6	>6
ROLA03+04	ROLA02	4,2	5,9	6,6	>6,6
ROLA05	ROLA03	3	3,9	5,4	>5,4
ROLA06+08	ROLA04	4	6	7,5	>7,5
ROLA07+10	ROLA05	3,8	5,5	7,2	>7,2
ROLA09+11	ROLA06	3,2	5,2	7,2	>7,2
ROLA12+13+14	ROLA07	2,5	3,6	4,2	>4,2

There are calculated the Environmental Quality reports (RCE) for each mentioned index. In calculating RCE, each index is related to the matching guide value for the corresponding reference state. It is always divided the lesser to the greater for sub-par ratio between 0 and 1, and where the values obtained are higher than the guide values for the corresponding reference state, the Environmental Quality Ratio is considered equal to 1. When calculating the RCE there should be studied the proposed values for each index reference and for the reference status and ecological potential to see their trend, of increase or decrease from the maximum ecological potential to moderate ecological potential.

For selected indices it was proposed a weighting of their importance for the communities of benthic diatom algae and for the evaluation tge the ecological potential as follows: index number of taxa (30%), Shannon-Wiener diversity index (40%), trophic index (30%).

This formula is used to determine the multimetric index:

$$\text{Multimetric}_{\text{index}} = 0.3 * RCE_{INT} + 0.4 * RCE_{ID} + 0.3 * RCE_{TDI} \quad (2)$$

The multimetric index value will give the ecological potential, which must be between 0 and 1. In order to grade the ecological potential it is proposed to subdivide the multimetric index values as follows: maximum ecological potential - min. 0.65, good ecological potential - min. 0.40, moderate ecological potential - min. 0.40.

The environmental objective for surface water body is considered to be achieved when the body of water falls in very good or good ecological status or maximum ecological potential or good.

Achieving the objective environmental situation nationwide, for barrier lakes, shown in the table below:

Table 9. Situation ecological potential of barrier lakes nationwide

Year	**Barrier monitored**	**Touching the environmental objective Ecological potential Maxim/Good**	**Not touching the environmental objective Ecological potential Moderate**
2012	106	53	53
2013	113	57	56
2014	112	62	50

Thus, in 2014 , nationwide, a larger number of barrier lakes reach environmental objective.

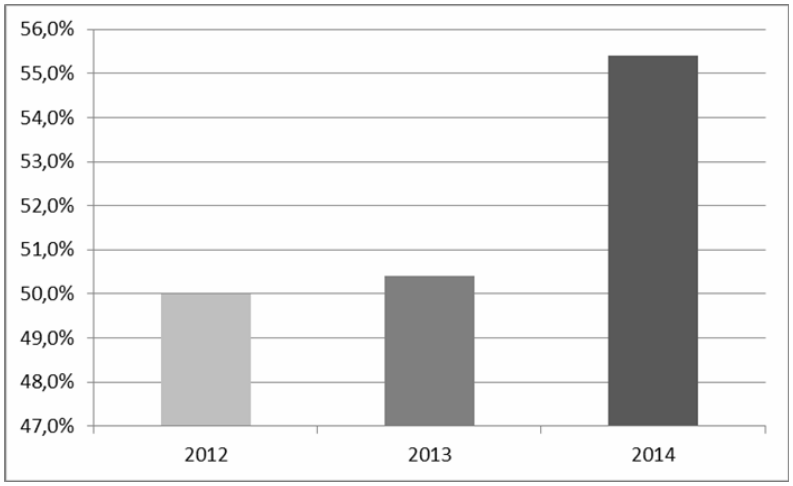

Fig. 1. Rester number of lakes that reach the environmental objective

In the space river Prut – Bârlad, applying the criteria of delimitation of water bodies, identifying a total of 46 bodies of water - lakes, comprising 66 reservoirs (Water quality bulletin, 2014).

Among them, in 2012, there are 20 barrier lakes monitored based on biological elements.

Thus, the distribution of the barrier lakes under evaluation of the biological elements is :

Table 10. Rating barrier lakes in the basin Prut - Bârlad on phytoplankton and phytobenthos in 2012

Barrier lakes monitored	**Distribution of barrier lakes according to the assessment of the biological elements**			
	Max	**Good**	**M**	**Without compliance**
20	0	4	14	2

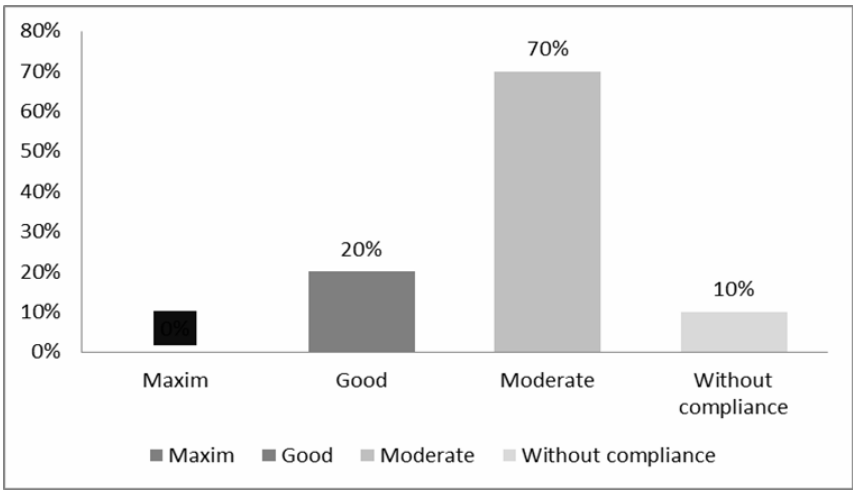

Fig. 2. Integrating biological elements for establishing ecological potential of barrier lakes in the basin Prut - Bârlad in 2012

In the year 2014 are monitored 21 barrier lakes and the result of the biological evaluation is shown in the table below:

Table 11. Rating barrier lakes in the basin Prut - Bârlad on phytoplankton and phytobenthos in 2014

Hydrographic basin	**Barrier lakes monitored**	**Distribution of barrier lakes according to the assessment of the biological elements**							
		Phytoplankton				**Phytobenthos**			
		Max	**B**	**M**	**Without compliance**	**Max**	**B**	**M**	**Without compliance**
Prut	12	5	3	3	1	5	4	2	1
Barlad	7	2	4	0	1	2	4	0	1
Siret	2	0	1	1	0	1	0	1	0
Total	**21**	**7**	**8**	**4**	**2**	**8**	**8**	**3**	**2**

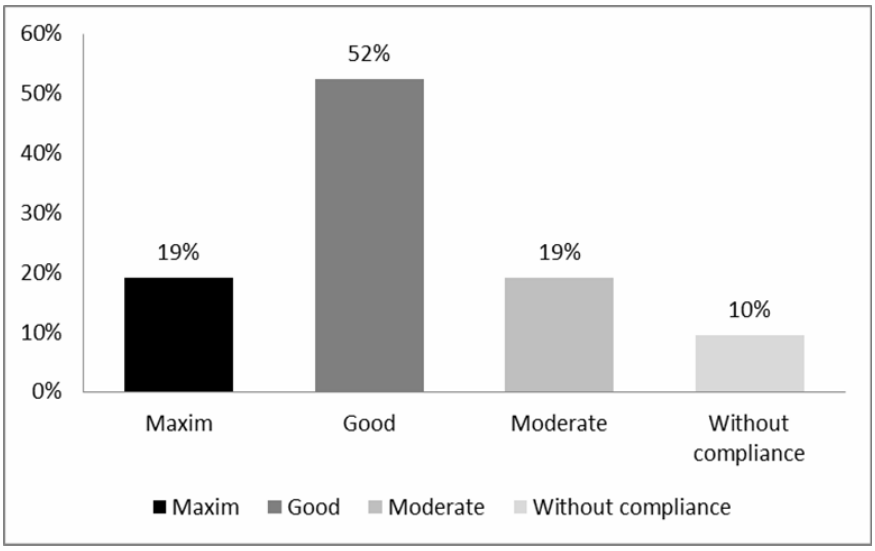

Fig. 3. Integrating biological elements for establishing ecological potential of barrier lakes in the basin Prut - Bârlad in 2014

3. Conclusions

During the analysis of the quality state of barrier lakes in the Prut-Bârlad basin, based on biological elements (phytoplankton and phytobentos), it was observed a favorable trend in terms of water quality. So if in 2012 there were 4 barrier lakes (4 barrier lakes with good ecological potential) reaching the environmental objective, in 2014 their number increased to 15 (4 barrier lakes with maximum potential , and 11 with good potential).

The objective is to simulate and evaluate measures to improve to talk about water quality under the Water Directive 2000/60/EC.

4. References

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