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# STUDY OF WATER EUTROPHICATION EVOLUTION FOR THE LAKE COLIBITA, BISTRITA NASAUD COUNTY

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***Abstract***

*The paper presents researches carried out during the period 2008-2018 regarding the evolution of the eutrophication process in the Lake Colibita, Bistrita Nasaud County. The research mainly pursued two objectives: the evolution of lake water quality from the eutrophication point of view under real environmental conditions of the area and studied lake; application of the "Surface Modelling System" software program of modelling, analysis and design of surface water in the field conditions specific to the studied lake, both to verify the accuracy of the field and laboratory analyses performed, as well as to expand the researches on other similar lakes in the country.*

***Key words****: eutrophication, nutrients, modelling, monitoring, surface water quality, trophicity.*

## INTRODUCTION

The information elements needed to measure and control the process of eutrophication of lakes water relate mainly to the depth, volume and regime of discharges, to the internal concentrations of nutrients and algae, to the possible harmfully proliferation of algae and other aquatic plants, to the reduction of the oxygen content of the deep lakes waters, to the destruction of the resulting fish, the annual nutritional contributions, the popularity and the characteristics of the soils occupation of the respective river basin (Agafitei A. et al., 2010; Agafitei A., 2017; 2019).

The fight against eutrophication can target both the fundamental causes and the effects (reducing the nutritional contributions to the aquatic plants from the river basin or periodically harvested from the surplus aquatic plants). The most useful seems to be the combination of the two ways.

The fundamental approach can be limited, as far as possible, to the general objectives of managing the eutrophication process.

In most cases, it has been shown that acting on the causes of eutrophication is more effective, easier to remedy than the process of mitigating effects.

A control program based on treating the eutrophication symptoms represents the only viable alternative. Such a program would also contribute to mitigating the negative effects of the eutrophication process (Agafitei A., 2017).

The abundant literature that appears continuously on the concrete cases of eutrophication is increasingly aware of the difficulties of interpretation and typological classification of the basins affected by this pollution process.

We consider that only analysing a number of essential and edifying components of the subsystem and integrating them into a complex ecosystem image, dominated by a systemic integral interpretation, associated with a cybernetic vision, can lead to a correct understanding and interpretation of the eutrophication phenomenon (Agafitei A., 2013).

Eutrophication begins wherever people live, and ends with damage to resources we all use and enjoy; it starts when nutrients get into waters, feed algae, which grows and blocks sunlight, eventually, the algae dies too.

Bacteria digest dead plants, using up remaining oxygen, and giving off carbon dioxide. Fish and other wildlife became unhealthy, or die without oxygen (Agafitei A., 2013).

Protecting water resources starts with sound agricultural and correct waste management practices (Figure 1).

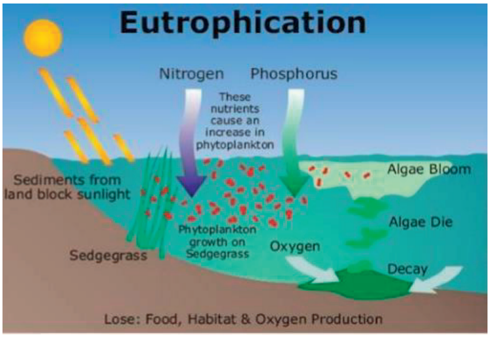


Figure 1. Scheme of the eutrophication process

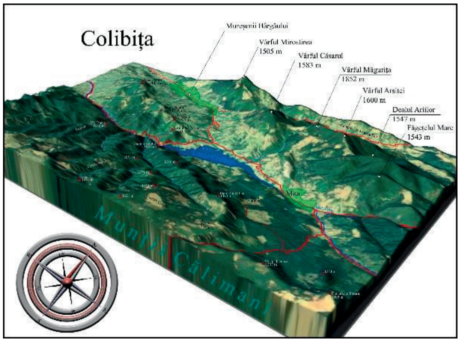


Figure 2. Colibita Lake, Bistrita Nasaud County

## MATERIALS AND METHODS

The Colibita dam is located on the upper course of the Bistrita Transilvana (Ardeleana) River, at approx. 400 m upstream from its confluence to Repedea pr, on the administrative territory of Bistrita Bargaului, from Bistrita Nasaud County.
The access to the site is made on DN 17 (Bistrita - Vatra Dornei), and subsequently on DJ 173A (Prundu Bargaului - Colibita).
The accumulation is located within the site of community importance ROSCI0051 Cusma.
The total area of the site is 44084 ha, according to the Standard Form Natura 2000, so it can be started that the surface of the accumulation, on about 320 ha is insignificant in relation to it. The accumulation has been in operation for over 30 years, so it is already an integral part on this protected natural area.
The accumulation of the same name, delimited by the dam and the mountain slopes, was realized both in order to provide a necessary reserve for the water supply of the localities located downstream on the Bistrita Transilvana River, up to the confluence with the Sieu River and their defence (population, transport infrastructure, water supply networks, sewerage, electricity, gas, telecommunications, agricultural land, livestock farms, etc.) against floods.
The Colibita Lake has a surface of 375,4 ha, a volume of 94,27 mil $m^3$, and a length of about 5 km (Figure 2).

Colibita Lake is currently an important tourist destination for water sports enthusiasts; it has a large surface, and extraordinary views.
The complex water park is renowned in the area (Figure 3).

Figure 3. The complex water park of the Colibita area

Our research aimed the monitoring of lake's water quality, during the period of 2008-2018, regarding the eutrophication process evolution, and was structured on several levels: of, documentation, field, and a synthesis of results obtained by using the "Surface Modelling System" software program of modelling, analysis and design of surface waters in the field conditions.
Calculus of the important factors in the evolution of the trophicity degree of a lake starts from the premise of the use of complex indicators, reflecting not a state of the moment (accidental discharges, thermal pollution etc.), but a tendency, as well as the influence of several primary indicators (temperature, transparency, lightning, depth, circulation etc.).
These factors are: saturation in oxygen, chemical consumption of oxygen, appreciated in $KMnO_4$, the mineralization capacity of the lake (CCO-Mn/$O_2$ report), $N_t/P_t$ report between nutrients, mineral N/$PO_4$, and phytoplankton biomass.

The application of the "Surface Modelling System" (SMS) software program of modelling, analysis and design of surface waters in the field conditions specific to the studied lake, it aims to verify the accuracy of the field and laboratory analyses performed since 2008 to 2018 (Agafitei A. et al., 2010; Agafitei A., 2013; 2019).

Water quality models are usually classified according to model complexity, type of receiving water, and the water quality parameters (dissolved oxygen, nutrients, etc.) that the model can predict. The more complex the model is, the more difficult and expensive will be its application to a given situation.

The behaviour of these models is well understood and has been studied more intensively than have other parameters. Basic nutrient indicators such as ammonia, nitrate, and phosphate concentrations can also be predicted reasonably accurately, at least for simpler water bodies such as rivers and moderate-size lakes. Predicting algae concentrations accurately is somewhat more difficult but is commonly done in the United States and Europe, where eutrophication has become a concern in the past two decades. Toxic organic compounds and heavy metals are much more problematic.

Surface Modeling System (SMS) is the most advanced software system available for performing surface-water simulations in a three-dimensional environment. The reduction of nutrient inputs to water and control of eutrophication locally are shared responsibilities, involving a range of stakeholders. In taking forward this strategy, there are working Government departments, other environmental regulators, industry and interest groups (Agafitei A. et al., 2010).

Tackling eutrophication will be a long-term commitment, linked to the general objective of contributing to sustainable development (Ryding S.O. & Rast W., 1989; Scheffer M., 1998).

Reducing nutrient contributions from sewage treatment works and agricultural sources will be particularly important. In some instances it will be necessary to go beyond the sewage treatment measures set out in the Urban Waste Water Treatment Directive.

Principal hydro-chemical parameters of water quality which were analysed are: air temperature (annual average of 7.5 ÷ $8^0$C), with warm winters (January's average of 4 ÷ -$6^0$C), and summers with moderate temperatures (July's average of 16 ÷ $17^0$C); water lake transparency regime, with maxims of 6 m in Dam section, and of 3 m in "Lake's Tale" section, in October, because of low precipitations from this period; then between 2 and 10 m in November, so we can say that water of Colibita Lake is included in eutrophic - oligotrophic category, with moderate transparency.

In the following of ecological succession Bistrita River - Colibita Lake, physical-chemical parameters were considered as basic criteria in analyzing habitat changes and then biotic ones (Agafitei A., 2013; 2017). Also, hydro-chemical researches we made in lake (2008-2018) considered the principal aspects of the new habitat: morph-metric characteristics (depth, length, and width), water mass dynamic, level oscillations, atmospheric conditions influence, and lake biotic development. For every considered year, we measured the following values (average on depth) of the most important parameters of trophic degree: COD/$O_2$, phytoplankton biomass, saturation in $O_2$, COD, and $N_{min}/PO_4$.

For 2008 year, using the mathematical correlations proposed by Caraus, I.D. in 2008, we obtained values between 6,4286 and 7,1002, using mentioned relations; results that Colibita Lake could be considered as an oligotrophic lake, that confirm our previous land conclusions.

For estimate some correlation and logarithmic equations to describe relations between some important water quality parameters from Colibiţa Lake, we considered the following parameters, respectively correlation: dissolved oxygen, function of temperature; organic matter, function of dissolved oxygen; and nitrogen, function of total phosphorus (Caraus I.D., 2002). It was used the average values of the considered parameters, for the analyzed period of time, at h = 20 m depth, in section 1-1 located between two important stations.

In the same way, we could establish correlation between every water parameter; in every lake section we have data, for any depth (Figure 4).

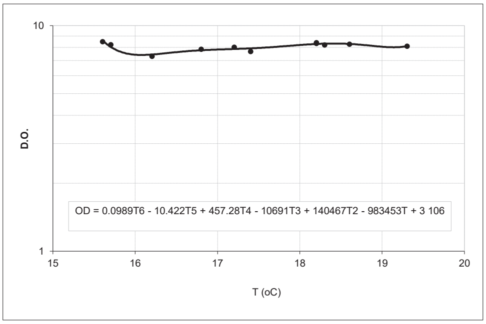


Figure 4. Correlation between D.O. (mg/L) and temperature values ($^0$C)

Using SMS program, between two sections 1-1 and 2-2 established with lake's data, conform existing norms, at h = 20 m, for each node (point), SMS knows automate plane coordinates (x, y) of nodes, in function of three points were we have the coordinates to create the program.
Nodes were made in points where we have data for the selected (wanted) field (lake) parameters. We made the same action for every wanted hydro-chemical parameter (Figure 5).

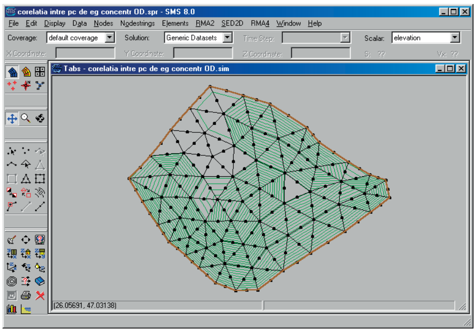

Figure 5. Polygon in MESH mode for dissolved oxygen parameter

On the contour bounded for the data taken from Colibiţa Lake, according to the Romanian standards, at h = 20 m, for each node (point) the SMS program automatically introduces the coordinates in the plane (x,y) of the nodes, according to the three points with coordinates introduced at the beginning, at the request of the program.
The nodes were fixed where the data are known: the values of the selected indicators, from field (lake), at the desired coordinates.

The values for all these points on and from the delimited contour were entered in the program, for each node, in an identical mode for every studied water quality parameter.
In the same manner, we could make any correlation, using SMS software, for every wanted hydro-chemical or biological parameter of the studied lake (Agafitei A., 2017; Leinster P., 2000).
Calculus of the trophic degree, following the algorithm proposed by Caraus I.D. in 2002, concluded to integrating our lake into oligotrophic lakes category.
This result, obtained from mathematical calculus, confirm conclusions made in the experimental field (on lake) after analysing physical - chemical, biological and bacteriological characteristics observed in land researches, between 2008 and 2018.
In the same context are integrated graphic correlations regarding evolution of annual average values of hydro-chemical parameters from Colibita Lake, in the analyzed period of time, into a section (1-1) of this lake, between two important stations, at h = 20 m water depth.
These graphic correlations with logarithmic equations to describe relations permit to establish connections between any two water quality parameters for Colibita Lake (Leinster P., 2000; Caraus I.D., 2002).

## RESULTS AND DISCUSSIONS

From the quantitative point of view, primary production appears, in the analysed lake, as an expression of plankton activity, of the whole ecosystem's state, mode and organization degree (Leinster P., 2000; Agafitei A., 2013; 2019).
*Algae cenozis* structure modification, with an increase of green algae, especially of *Clorococcalae*, also of blue ones and of *Euglenae*, in our lake's ecosystem, due, in time, to a certain increase of biological productivity and at degradation of water quality, with not-wanted consequences on these, also on the environment.
Using SMS software, we can establish correlation for points with the same concentration values for any required parameter important for the monitoring of the

eutrophycation phenomenon in the considered storage lake.

For most management purposes, the worst case will be high summer temperatures, which exacerbate problems with dissolved oxygen and algal growth, and low flows, which lead to high concentrations of BOD and other pollutants. Dynamic models will need time-series data on flows, temperatures, and other parameters. In addition to hydraulic data, models require base-case concentrations of the water quality parameters of interest (dissolved oxygen, mercury, and so on).

These are required both to calibrate the models to existing conditions and to provide a base against which to assess the effects of management alternatives (Agafitei A. et al., 2010; Agafitei A., 2017).

The models also need discharges or loads of the pollutants under consideration from the sources (e.g., industrial plants) being studied. The types and amounts of data needed for a given application are specific to the management question at hand (Leinster P., 2000; Ryding S.O. & Rast W., 1989; Scheffer M., 1998).

## CONCLUSIONS

The study led to some major conclusions for the involved researches.

A point often overlooked in the real-world application of water quality models is that they are a means of achieving a set of management objectives, not an end themselves. In many cases, it may not be necessary to use a water quality model at all, even when it is known in advance that a project will affect water quality.

Managers should remember that the accuracy of model projections is severely constrained by the quality and quantity of the available data used to calibrate and test the models. The hypothetical examples given above explicitly assume that these data are readily available, but this will often not be the case in practice.

With characteristic parameters entered into the program, it automatically checks them. Thus, using SMS program, we conducted a conceptual model of the variation in concentrations of dissolved oxygen, organic matter, $NH_4$, and total P in the network.

In the same manner, we can obtain correlations between important indicators for surface water quality in any lake or watershed.

The results for the analysed indicators chosen correspond to previous research conducted on water of the Colibita Lake.

They support the mathematical and graphical calculations and fit the lake water in terms of in the oligotrophic category.

We obtained the same results applying mathematical calculus with Caraus's researcher formula for the entire lake. In the same manner, we can extend the model for any depth of the lake and also for any storage lake.

Expanding research for the whole surface of the lake, possibly taking into account other water depths, we can draw conclusions about trophic lake fits, but also on water quality in the lake, depending on the parameters (data) as known to it.

This study aims establishing the degree of trophicity based on comparison of some trophicity parameters, characteristic of the studied lake: the oxygen regime, phytoplankton biomass, some nutrients with the limits recommended by standards, for a certain trophic stage, and obtaining some goodness notes, from 0 to 10, with the following equivalent:

0-2: polytrophic lake, with the equivalent value 1;

2-4: eutrophic lake, with the equivalent value 3;

4-6: mesotrophic lake, with the equivalent value 5;

6-8: oligotrophic lake, with the equivalent value 7;

8-10: ultraoligotrophic lake, with the equivalent value 9 (Caraus I.D., 1986; 2002; Agafitei A. et al., 2010; Agafitei A., 2019; Ryding S.O. & Rast W., 1989).

The "SMS" program verifies the field data automatically, signalling errors that may occur, thereby contributing to the accuracy of our results.

For the future research we have in aim to extend our work and to build a regional centre of study for hilly lakes of the Moldavian area, Romania, which is rich in such storage lakes.

Other important water quality models used to predict and control surface water pollution are related in Table 1.

Table 1. Short description of water quality models

| *Model* | *Comment* |
|---|---|
| WQAM | Set of methods or mathematical tools used for preliminary analysis of changes in water quality due to changes in loadings. Unlike the other examples, WQAM is not a computer model per se but a collection of simple methods and procedures. |
| QUAL2E | Steady-state model for simulating well-mixed rivers and streams. Commonly used for assessing the impact of changes in point-source discharges on water quality. Especially suited for analyzing the effects of nutrients on algal concentration and dissolved oxygen. Widely applied in the United States and elsewhere. |
| WASP | Flexible, compartmental modeling structure for analysis of a wide variety of pollutants in almost any type of water body. The most powerful and complex of the models discussed here, it also requires more data and expertise for successful application. Extensively applied to water quality assessments in rivers and streams. |
| CE-QUAL-RIV1 | Intended primarily for simulating the dynamics of highly unsteady stream flows, such as those occurring during flood events. Consists of a module for water quantity linked to one for water quality. Although the quantity module has seen numerous applications, the quality module is less widely applied than WQAM, QUAL2E, or WASP. |
| HEC-5Q | Developed primarily for analyzing water flows and water quality in reservoirs and associated downstream river reaches. It can perform detailed simulations of reservoir operations, such as regulating outflows through gates and turbines, and vertical temperature gradients in reservoirs. |

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