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METHODS AND TECHNIQUES FOR PREVENTION AND CONTROL OF THE WATER EUTROPHYCATION PROCESS IN HILLY LAKES

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Abstract

The paper treats the problem of eutrophication process for some important hilly lakes from Moldavia, Romania. Eutrophycation represents a normal process as time as its evolution is natural, and one of first six major environmental problems from the world lakes and reservoirs. This phenomenon is caused by the over limits increasing of nutrients concentrations (nitrogen, phosphorus) from lake's waters, substances involved through agricultural fields watering, fields on which were applied fertilizers. The paper contains a review of the main methods and techniques for modelling the processes regarding the evolution of lakes water quality. The research took place in the period 2016-2020 and regards main hilly lakes from Moldavia area, Romania.

Key words*: eutrophication, modelling, surface water quality, environmental protection.*

INTRODUCTION

The eutrophication process should not be judged by one criterion or another, but with a set of criteria. In fact, the syntheses elaborated did not subordinate to this vision, reaching the view that this type of organic pollution concerns the abiotic compartment of the ecosystem, at the biotic level, only its effects being felt.

The abundant literature that appears continuously on the concrete cases of eutrophication is increasingly perceived by the difficulties of interpretation and typology of the basins affected by this process.

The process of degradation of environmental factors across the globe has seen a steady ascendant course over the past decades, an increasingly worrying trend, with the amount of pollutants reaching figures that go beyond imagination and continue to grow in almost geometric progression.

A general threat to all surface waters, not spectacular but more dangerous by consequences than acute pollution, is the progressive, often latent, almost unnoticed pollution, but which accumulates the effect of small sources with diffuse pollution and takes chronic forms.

Our paper's subject is such a pollution type: the eutrophication, process of evolution of their quality, especially characteristic of artificial lakes, which brings particular problems from the water treatment technologies point of view.

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Regarding the evolution of the water quality in the lake, a first aspect is related to the initial preparation of the lakes cuvette. These cuvettes include land which, prior to the accumulation, was not in contact with water and may contain deposits of polluting substances. Even in the natural condition, vegetation and other organic substances on these lands can lead to an organic soil pollution of the lakes after their realization.

Therefore, it is necessary to pay special attention to the problem of cleaning the banks and bottom of future storage lakes.

Secondly, during the exploitation, there are some phenomena that did not take place naturally in the natural situation. From the modifying factors that influence or even cause changes in the physical - chemical characteristics of water, we mention: the density difference, which, in different

characteristic areas of the complex arrangements, is determined by the difference in temperature, salinity, suspended matter, etc.; speed variations; evaporation, air currents, dissolution or precipitation of various minerals, etc.; biological activity.
These factors are correlated, the variation of one bringing appreciable changes to the others.
Eutrophication process starts when nutrients get into lakes and oceans, nutrients feed algae, which grows and blocks sunlight, plants die without sunlight, eventually, the algae die too.
Protecting water resources starts with sound agricultural and waste management practices (Figure 1).

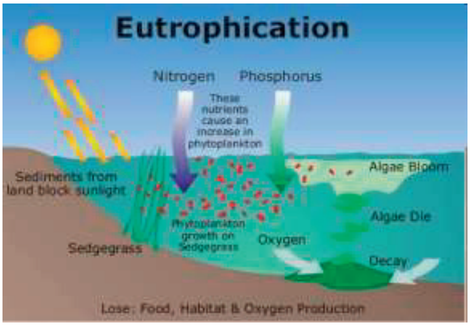

Figure 1. The eutrophication process description

MATERIALS AND METHODS

The analyzed area in this study is located in Moldavian Central Plateau, from Romania (Figure 2).

Figure 2. Moldavian Central Plateau, Romania

From the point of view of anthropical processes, the area of hills and plateaus has undergone increased interventions (urban/rural settlements, communication infrastructures, land use for agricultural crops and animal husbandry, exploitation, mining, forestry) which led to more severe deterioration (through erosion and soil degradation, deforestation, train landslides). Despite these vulnerabilities, the region of hills and plateaus contains a wide range of areas with landscape potential, requiring specific protection (Leinster, P., 2000).
The site under study includes five important lakes in the Central Moldavian Plateau: Lilieci - 262 ha, Bacău II - 217 ha, Galbeni - 1132 ha, Răcăciuni - 2004 ha, and Bereşti - 1800 ha.
All of them are included in a protected natural area of 5,576 ha, located at the confluence of Bistriţa with Siret, and downstream of it.
The site represents a natural area (rivers, lakes, swamps, peat bogs, cultivated arable land, alluvial forests, meadows and pastures) in the middle meadow of Siret; ensuring favourable feeding, nesting and living conditions for several species of migratory, migratory or sedentary birds (Figure 3).

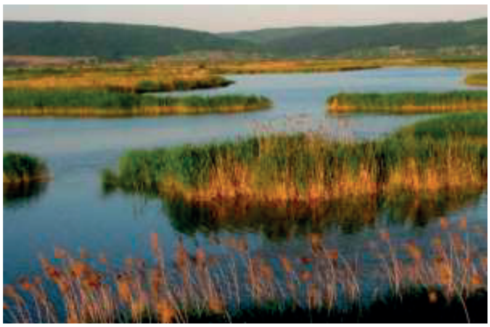

Figure 3. Galbeni Lake from the Moldavian Central Plateau, Romania

The lands bordering the lakes are predominantly arable. On some parts of this area it predominate lands with meadows, often interrupted by clumps of forests or cultivated fields.
The urban areas of the localities are located in the vicinity of the protected natural area Bacău, Iteşti, Siretu, Bazga. In the Northern part of Bacău Lake we find forested plots.
Regarding the property and use of water gloss, due to the fact that the main function of accumulation lakes is the production of

electricity, being artificial accumulations, they all are leased to Hydroelectrica S.A.

The space related to the lakes has a special biodiversity, due to the habitat conditions on which offers them; it is also characterized by an active seasonal life.

Mostly of the species, 36% are summer guests and an insignificant number of species are guests of winter; this justifies the special role of the site, especially as a breeding area.

At the same time, the passage species are extremely numerous, providing 47% of the total species encountered.

Calculus of the important factors in the evolution of the trophyc 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.

Also, the application of the “Surface Modelling System” (SMS) software program v. 13.1 of modelling, analysis and design of surface waters in the field conditions specific to the studied lakes, it aims to verify the accuracy of the field and laboratory analyzes performed since 2016 to 2020.

Our research aimed the monitoring of these five lakes water quality, during the mentioned period, regarding the eutrophication process evolution, and was structured on several levels: documentation, field, trophic degree calculus, and a synthesis of results obtained by using the “Surface Modelling System” v. 13.1 software program (Figure 4).

Figure 4. Surface Modelling System (SMS) v. 13.1 software program

The behaviour of these models is well understood and has been studied more intensively than have other parameters.

There are two methods for building models in the SMS program: the direct approach and the conceptual modelling approach. In the first method, the direct approach, the first step is to create a "mesh" or a "grid" (grid).

Model parameters, source data, and background conditions are directly assimilated to networks, nodes, and network elements. This type of approach is only suitable for simple models.

The most effective approach for building realistic, complex, concrete models is the conceptual modelling approach. It creates a conceptual model using GIS objects, including points, arcs, and polygons.

The conceptual model is built independently of the net or grill. It is a high-level description of the area, including geometric features such as channels and dams, bottom conditions of the modelling range, flow rates, etc. and characteristics of the water surface, such as the bottom conditions, the physical, chemical, biological properties of the studied area, etc.

Once the conceptual model is complete, a network of nets or grids is automatically built by the program to fit the conceptual model, and the model data is converted from this model to the elements and nodes of the network of networks.

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.

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.

With regard to nutrient pollution from agriculture, we will promote a general reduction of nutrient inputs to water from the main sources, complemented by more concerted action in catchments where the impacts or risks justify this approach.

In Galbeni Lake, for instance, the main hydro-chemical parameters of water quality which were analyzed are: air temperature (annual average of 7.5 ÷ 8^0C), with warm winters (January's average of 4 ÷ -6^0C), and summers with moderate temperatures (July's average of 16 ÷ 17^0C); water lake transparency regime, 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 the Galbeni Lake is included in eutrophic - oligotrophic category, with moderate transparency.

We proceeded in the same manner with every studied lake in our research, and their trophic degree is around oligotrophic stage.

Between two sections 1-1 and 2-2 established with Galbeni Lake's data, conform existing norms, at a depth of h = 20 m, for each node (point), SMS knows automate plane coordinates (x, y) of nodes, in function of three points where 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 hydrochemical parameter of our study's lakes. For instance, in the particular case of phosphorus, the network looks like in Figure 5.

We could make the same correlation, using SMS software, for every wanted hydro-chemical or biological parameter of the studied lakes, at every depth and in any section.

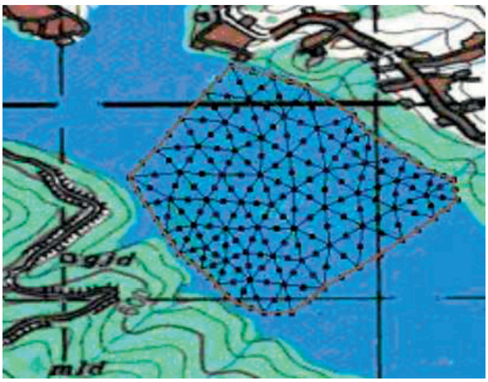

Figure 5. Correlation between points of equal concentration for P total in Galbeni Lake

These graphic correlations, with logarithmic equations to describe relations, permit to establish connections between any two water quality parameters for Galbeni Lake.

Using SMS software, we can establish correlation for points with the same concentration values for any required parameter important for the monitoring of the eutrophication phenomenon in the considered hilly lakes.

For estimate some correlation and logarithmic equations to describe relations between some important water quality parameters from Galbeni Lake, we considered the following parameters, respectively correlation: dissolved oxygen, function of temperature; organic matter, function of dissolved oxygen; nitrogen, function of total phosphorus.

It was used the average values of the considered parameters, for the analyzed period, at h = 20 m depth, in section 1-1 located between two extreme stations.

With these values, it was obtained the correlation, also the logarithmic equations. In the same way, we could establish correlation between every water parameter, and for every lake section we have data, for any depth (Figure 6).

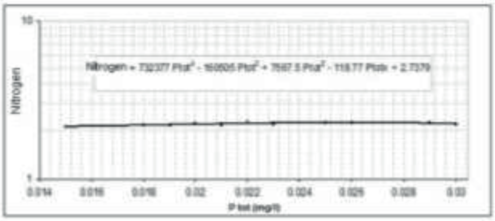

Figure 6. Correlation between nitrogen (mg NO_3/L) and total phosphorus (mg/L) values

Algae cenosis structure modification, with an increase of green algae, especially of *Clorococcalae*, also of blue ones and of *Euglenae*, in our lake's ecosystems, 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 (Eilers and Peters, 1988; Scheffer, 1998).

Calculus of trophic degree, following the algorithm proposed by Caraus, I.D. (1986), concluded to integrating the Moldavian Central Plateau's lakes into oligotrophic - mesotrophic lakes category. This result, obtained from

mathematical calculus, confirm conclusions made in the experimental field (on lake) after analyzing physical - chemical, biological and bacteriological characteristics observed in land researches, between the researches period.
The objectives proposed by using such a model for the lake under study are the following:
1. Comparison and verification of data taken in the field (on the lakes), and processed in the laboratory;
2. Verification of the result of the calculation of the degree of trophycity with the help of the credit rating system proposed by Caraus, I.D. (1986);
3. The study of the evolution of water quality in the lake through a high-performance program, frequently used by foreign researchers in solving surface water quality problems.
The evolution of the ecological potential, but also of the chemical state in the studied period was followed for the storage lakes from Moldavian Central Plateau, and the three from trace accumulations were evaluated in more detail from the perspective of the evolution of specific indicators eutrophication (total nitrogen, total phosphorus, chlorophyll *a*, transparency) and to establish the trophic stage (Agafiţei, A., Gabor, V., 2018).
The final conclusions regarding the quality of the accumulation lakes from hilly areas combining legislation in the field, theoretical studies, current monitoring and the results of quality models (Agafiţei, A., Agafitei, M., 2002).

CONCLUSIONS

Quality models allow specialists concerned with monitoring the quality of resources to go to the bodies of water most permissible for improvements in ecological and chemical view. Many of the knowledge gained over the years were based on physical models, but current science focuses mainly on model development mathematics (Ryding and Rast, 1989).
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 (Florescu, M.A., 1983).
Tackling eutrophication will be a long-term commitment, linked to the general objective of contributing to sustainable development.
Starting from the purpose for which the quality of a body of water is modelled, it will decide on the degree of detail of the biological component of the model (the number of parameters of quality and the connections between them), the spatial resolution used for the geometric discretization of the physical system, the type of equations that mathematically render the processes and last but not least the necessary input data used to calibrate the mathematical model (Agafiţei, A., 2000-2002).
Errors between measured and simulated values in the monitoring sections of of the accumulated accumulation lakes, for the two quality indicators - total nitrogen and total phosphorus, may be due to the calculation hypothesis established when running the model, by which the defined section is downloaded directly to the downstream section.
The results should be confirmed by using the model taking into account a possible flow/ exchange between any pair of segments/ sections of the respective storage lake.

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