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RESEARCH ON MONITORING THE ECOLOGICAL QUALITY STATE OF THE BUDEASA RESERVOIR IN THE PERIOD 2018-2022

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Abstract
The Budeasa Dam is part of the Argeş River Basin, which is located in the central-southern part of the country, being between the following geographical coordinates: 43°54'50" - 45°36'30" north latitude and 24°30'50" - 26°44'25" east longitude. It borders the Olt Basin to the north, the Vedea and Olt Basins to the west, the Danube Basin to the south, and the Ialomiţa Basin to the east, with an area of 12,550 km2. The total theoretical water resource is 3,282 million m3, and the usable resource is 2,574.279 million m3 (surface and underground resources). To ensure the water source for various uses, 24 important reservoirs were built with a useful volume of 798.82 million m3. In this paper, we aimed to monitor the ecological quality status of the Budeasa Reservoir during the period 2018-2022. To achieve the proposed goal, we established the following objectives: analysis of the values of physico-chemical parameters in terms of the quality standards that surface waters used for drinking water must meet; analysis of the values of microbiological indicators in terms of the quality standards that surface waters used for drinking water must meet; Study of the dynamics of seasonal variation of limnoplankton during the studied period; analysis of the ecological quality status based on the phytoplankton biological element and the calculated Multimetric Index (MI). Following the monitoring of the Budeasa Reservoir for the period 2018-2022, it is found that: the monitored physico-chemical parameters fall within the limits of NTPA 013, regarding the quality standards that surface waters used for drinking water must meet (Quality Categories A1 and A2); the monitored microbiological indicators fall within the limits of NTPA 013 (Quality Category A2), with the exception of July 2018, when the values of the Total and Fecal Coliforms indicators fell within the limits of Quality Category A3; the monitored microbiological indicators fall within the limits of NTPA 013, regarding the quality standards that surface waters used for drinking water must meet (Quality Category A2), with the exception of July 2018, when the values of the Total and Fecal Coliforms indicators fell within the limits of Quality Category A3.

Keywords: Budeasa, ecological and drinking water quality.

1. INTRODUCTION

The Budeasa Reservoir is part of the Argeş River Basin, which is located in the central-southern part of the country. It borders the Olt River Basin to the north, the Vedea and Olt River Basins to the west, the Danube River Basin to the south, and the Ialomiţa River Basin to the east, with an area of 12,550 km^2. The hydrotechnical scheme for the development of the Argeş River includes the following reservoirs: Vidraru, Oeşti, Cerbureni, Curtea de Argeş, Zigoneni, Vâlcele, Budeasa, Bascov, Prundu, Goleşti (fig. 1). The Budeasa Reservoir is located in the upper basin of the Argeş

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River, downstream of its confluence with the Vâlsan River, 3.5 km upstream of the municipality of Piteşti, in the area of the Budeasa locality, Argeş County.
The hydrotechnical construction was put into operation in 1978. Functions of the BUDEASA reservoir:

- Raw water supply: for the municipality of Pitești and downstream localities;
- Irrigation: for about 5,000 ha of agricultural land;
- Electricity production;
- Flood mitigation.

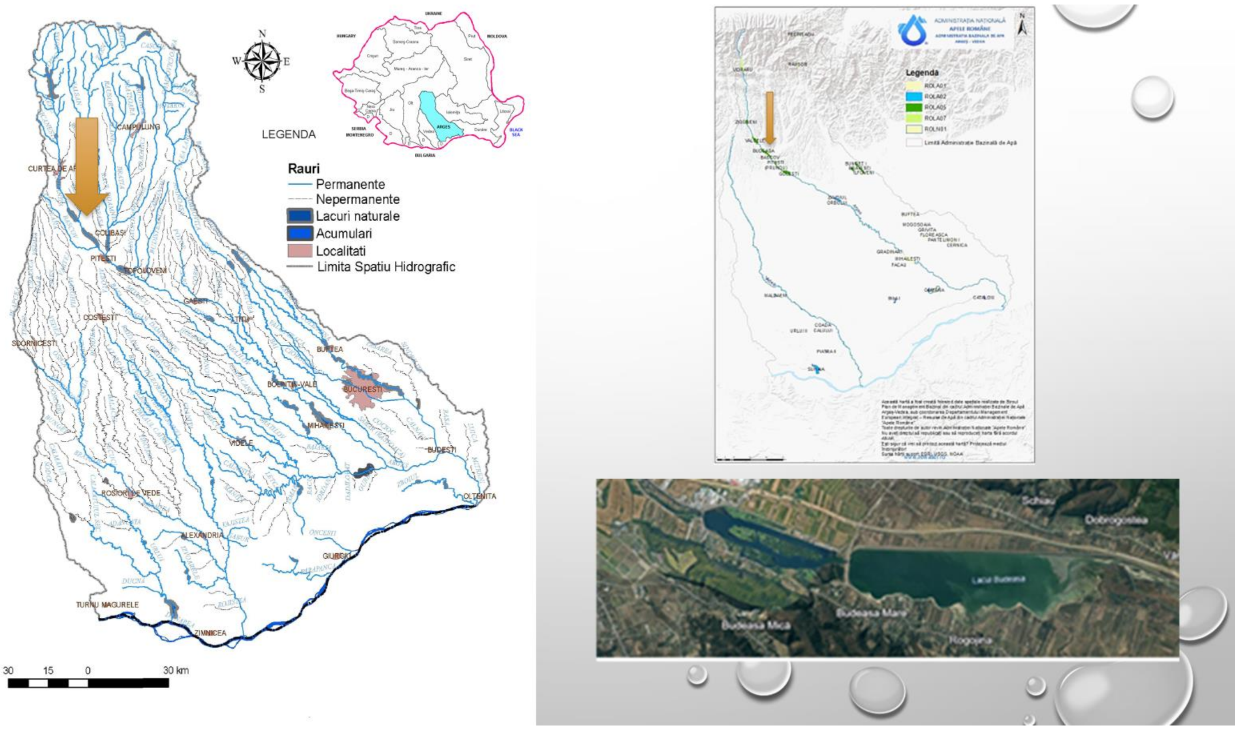

Figure 1. Location of the Argeș-Vedea hidrografical basin within Romania, typology of the reservoirs on the Argeș River, and location of the Budeasa Reservoir.

In this paper, we aimed to monitor the ecological quality status of the Budeasa Reservoir during the period 2018-2022. To achieve the proposed goal, we established the following objectives:

- analysis of the values of physico-chemical parameters in terms of the quality standards that surface waters used for drinking water must meet;
- analysis of the values of microbiological indicators in terms of the quality standards that surface waters used for drinking water must meet;
- Study of the dynamics of seasonal variation of limnoplankton during the studied period;
- analysis of the ecological quality status based on the phytoplankton biological element and the calculated Multimetric Index (MI).

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2. MATERIALS AND METHODS

Water analysis involves a set of laboratory methods and techniques specific to physics, chemistry and biology. The parameters to be determined are determined according to the purpose of the analysis. Obtaining the most accurate results is conditioned by the observance of rules regarding the collection, preservation, transport and processing of samples.

For the present paper, the research was carried out between January 2018 and December 2022. The water samples and the physical-chemical and biological analyses were carried out within the current program of monitoring the water quality of Lake Budeasa in the Laboratory of Physical-Chemical and Biological Analysis within the Budeasa Water Plant. The sampling and analysis of the water in order to assess the ecological quality status based on the biological element phytoplankton, for the calculation of the Multimetric Index (MI) in accordance with Annex 6.1.1.A. of the National Management Plan of the upper basin of the Danube River was carried out by the staff of the specialized laboratory of DAAV;

2.1. COLLECTION, HANDLING AND PRESERVATION OF WATER SAMPLES

Both the sampling and the actual analysis were carried out in compliance with the official rules in force provided in:

- SR EN ISO 5667-3/2018 : Water quality. Withdraw. Part 3: Preservation and handling of water samples,
- SR ISO 5667-5/2017 : Water quality. Withdraw. Part 5: Guide to Sampling Drinking Water from Treatment Plants and Distribution Systems Conservation and Handling of Water Samples,
- in the case of physicochemical parameters;
- The measurement of the water temperature is made immediately after sampling, with a calibrated thermometer, in accordance with the requirements of the sampling standard and is recorded in the sampling report
- SR EN ISO 19458/2007 : Water quality. Sampling for microbiological analysis;
- STAS 6329-90, for the study of phytoplankton structure and dynamics.

In the above-mentioned period, the sampling and laboratory analyses were done daily, at 8 a.m., except in the case of zooplankton determination, for which the sampling was done weekly. The sampling was made from the raw water supply pipe within the Plant; the pipeline supplies raw water to the treatment plant in the Budeasa reservoir. Within this program, the water quality is permanently monitored, and, based on the chemical and biological results obtained in the laboratory, the treatment doses for water purification are established, which will be provided to the economic agents and the population, in the Municipality of Pitesti and the adjacent areas. For the biological determinations in order to assess the ecological quality status based on the biological element phytoplankton, the sampling was made from Budeasa Lake: section code RO100073050 (raw water intake dam - ROLA05 photic zone). For each sample, a quantity of 1000 ml of water was taken. After sampling, the samples were transported to the laboratory in refrigerated crates at a temperature of 4°C, thus avoiding their alteration.

2.2. PHYSICOCHEMICAL DETERMINATIONS

In the laboratory, the samples intended to determine the values of the chemical indicators did not require special preparation, except for those necessary to determine the dissolved oxygen in water, which was previously fixed in the field and then determined in the laboratory by the iodometric method (based on the oxidation of divalent manganese hydroxide into trivalent manganese

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hydroxide by molecular oxygen dissolved in water, in a strongly alkaline environment). The rest of the physico-chemical analyses (water pH, biochemical oxygen consumption, turbidity, nutrient concentrations (ammonium and phosphates), were carried out in the laboratory, without the samples requiring any processing. The following standardized work protocols were used for the analyses carried out in the laboratory:

- SR EN ISO 10523:2012, for pH determination;
- SR EN ISO 7027-1:2016, for the determination of turbidity;
- SR EN 25813:2000 and SR EN 25813:2000/C91:2009, for the determination of dissolved oxygen content in water (OLD); iodometric method
- The biochemical oxygen intake (BOD_5) was calculated by the difference between the dissolved oxygen concentrations in the samples tested at the beginning and end of the 5-day incubation period;
- SR ISO 7150-1/2001, for determining the concentration of ammonium ions);
- SR ISO 6878/2005, for determining the content of orthophosphates, total phosphorus and total dissolved phosphorus; ammonium molybdate spectrometric method.

2.3. MICROBIOLOGICAL DETERMINATIONS

In the laboratory, the samples intended to determine the values of microbiological indicators are immediately subjected to tests. The handling of the samples is done with great care, the laboratory staff being trained in this regard. The following standardized work protocols were used for the analyses carried out in the laboratory:

- SR EN ISO 9308-1:2015 SR EN ISO 9308 1:2015/A1:2017, for determining the number of *Escherichia coli* and coliform bacteria; membrane filtration method for waters with low bacterial content;
- SR EN ISO 7899-2:2002, for determining the number of enterococci intestinal; membrane filtration method.

The samples shall be sown according to the method standards in force, on broth culture media (Lauryl sulfate, Slanetz-Bartley, Bile aesculine azide agar, Yeast extract agar), thermostatic at specific temperatures of 37°C and 44°C for confirmation of intestinal enterococci.
The reading and reporting of the results is done according to SR EN ISO 8199:2019 Water quality.

2.4. BIOLOGICAL DETERMINATIONS

In the laboratory, samples intended to determine the values of microbiological indicators are immediately tested. The handling of the samples is done with great care, the laboratory staff being trained in this regard.
The following standardized work protocols were used for the analyses carried out in the laboratory:

- SR EN 15204/2007 Water quality. Guide to routine analysis of phytoplankton abundance and composition using reverse microscopy (Utermöhl method).
- "Methodological Guideline for Monitoring the Evolution of Water Quality by Means of Biological Analysis" developed by the National Water Council-Institute of Research and Design for Water Management, 1984 for determining the numerical density of zooplankton organisms.
- The sample was concentrated by filtration on a sand filter, according to STAS 6329-90, remaining, in the end, 20ml; The concentrated sample is then analyzed under a microscope to identify the species and determine their density;

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The counting of phytoplankton organisms was done under a microscope on the Bürker – Türk slide; from each concentrated sample, 4 counts are made per slide, after which the average is made;

For the identification of the species, the existing determinants in the laboratory, representative for the field of study, were used, from which the saprobe indices were also passed, the list of which can be found in the bibliography chapter. For the systematic classification of the identified species in both phytoplankton and zooplankton, a unitary classification system was used, taken from the ITIS Standard Report website.

2.5. Methodological aspects and limit values for the assessment of the ecological status of bodies of water on natural watercourses based on phytoplankton algae communities

For the assessment of the ecological status of natural water bodies based on the phytoplankton biological element, the Multimetric Index (MI) is calculated in each section according to the methodology established by PMBH 2021. The annual assessment of the ecological status is done by averaging all the IM values determined for all sections of the water body. In the case of the multiannual assessment of the ecological status, the average of the MI values for the selected years is made. After obtaining the result, depending on the value obtained, it falls within the limits in the table 1.

Table 1. Reference values for assessing the ecological quality status of reservoirs

ECOLOGICAL STATUS / RESERVOIR TYPE	Very good	Good	Moderate	Poor	Bad
RO04-RO11	0,8	0,6	0,4	0,2	< 0,2
RO10VLR +RO11VLR RO12-RO15	0,92	0,76	0,4	0,2	< 0,2

3. RESULTS AND DISCUSSIONS

A. Monitoring water levels in the Budeasa reservoir during 2018-2022 (mdMN)

Analyzing the multiannual monthly average values for the period 2018-2022, (fig. 2) it is found that the values recorded remain relatively constant throughout the study period, between the minimum and maximum level of exploitation, except for 2021, when in May, July, August and September when the minimum values recorded were very close to the minimum level of exploitation due to the accentuated water deficit in that year.

B. Physico-chemical determinations during 2018-2022

The values of the physico-chemical indicators fall within the limits of Annex no. 1B to the quality standards that surface water used for drinking water must meet (NTPA 013), valid for Categories A1 and A2. The monthly average values obtained for the seven main physicochemical parameters (pH, turbidity, OLD, BOD5, temperature, ammonium and phosphates) were also tracked and analyzed in terms of the dynamics of their variation, in the period 2018-2022 (Fig. 3).

The monthly value of the *pH indicator* during the studied period falls into the Category A1 of quality (6.5-8.5 pH units). The values of the turbidity indicator register the largest variations, with peaks in March and July, in 2018, February and June in 2019, June 2020 and December 2020-March 2021, being related to the phenomenon of flooding (snow melting and heavy rains upstream). Although this indicator is not regulated in NTPA 013, its values are very important,

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causing changes in the doses of reagents used for drinking water at the Budeasa Water Plant (in the technological process of flocculation / decantation). From the point of view of *dissolved free oxygen (OLD)*, the lake's water falls into the Category A1 of quality, throughout the monitored period, with a degree of saturation of over 70%.

The *water temperature values* vary directly proportionally to the air temperature, seasonally, and fall into the Category A1 of quality, in the period 2018-2022. It is found that the temperature and concentration of the OLD vary inversely proportionally, the lower the temperature, the more the concentration of dissolved oxygen increases, and the situation is reversed as the temperature increases.

The biochemical oxygen consumption did not register significant variations during the 5 years, its values falling within the Category A1 of quality.

Phosphate values have insignificant variations; their concentrations are low, falling into the Category A1 of quality.

For *the ammonium indicator*, there is an increase in the period March 2018, February 2019, January, September, December 2020, January 2021, when the values fall into Quality Category A2, the other average values being below the limits of Quality Category A1.

For all physicochemical indicators monitored in the period 2018-2022, the annual average values fall within the limits of Category A1 of quality.

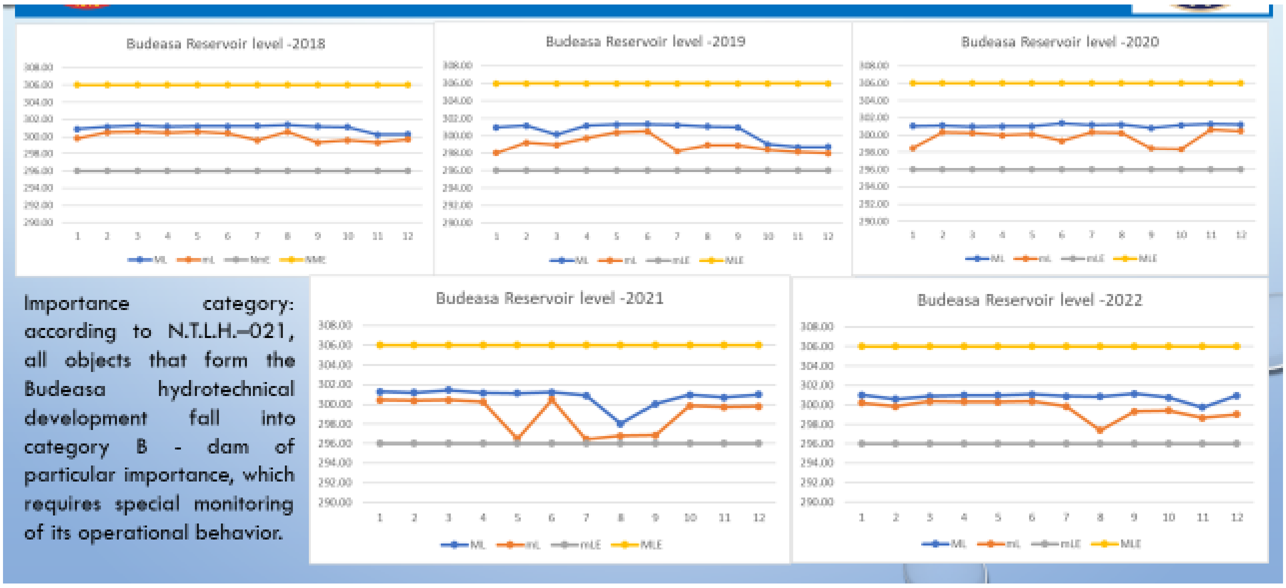

Figure 2. Monitoring water levels in the Budeasa reservoir during 2018-2022 (mdMN)

C. Microbiological determinations during 2018-2022

The values of the microbiological indicators fall within the limits of Annex no. 1B to the quality standards that surface water used for drinking water must meet (NTPA 013), valid for Category A2, except for the average of the values in July 2018, when there is a punctual increase in values (fig. 4). In March 2018, the value of total coliform bacteria and feces increased, but without exceeding the limits of Category A2, while for July these limits were exceeded, respectively the increase of more than two times compared to the limit of the category for total coliform bacteria and more than four times of total coliform bacteria (fig. 4).

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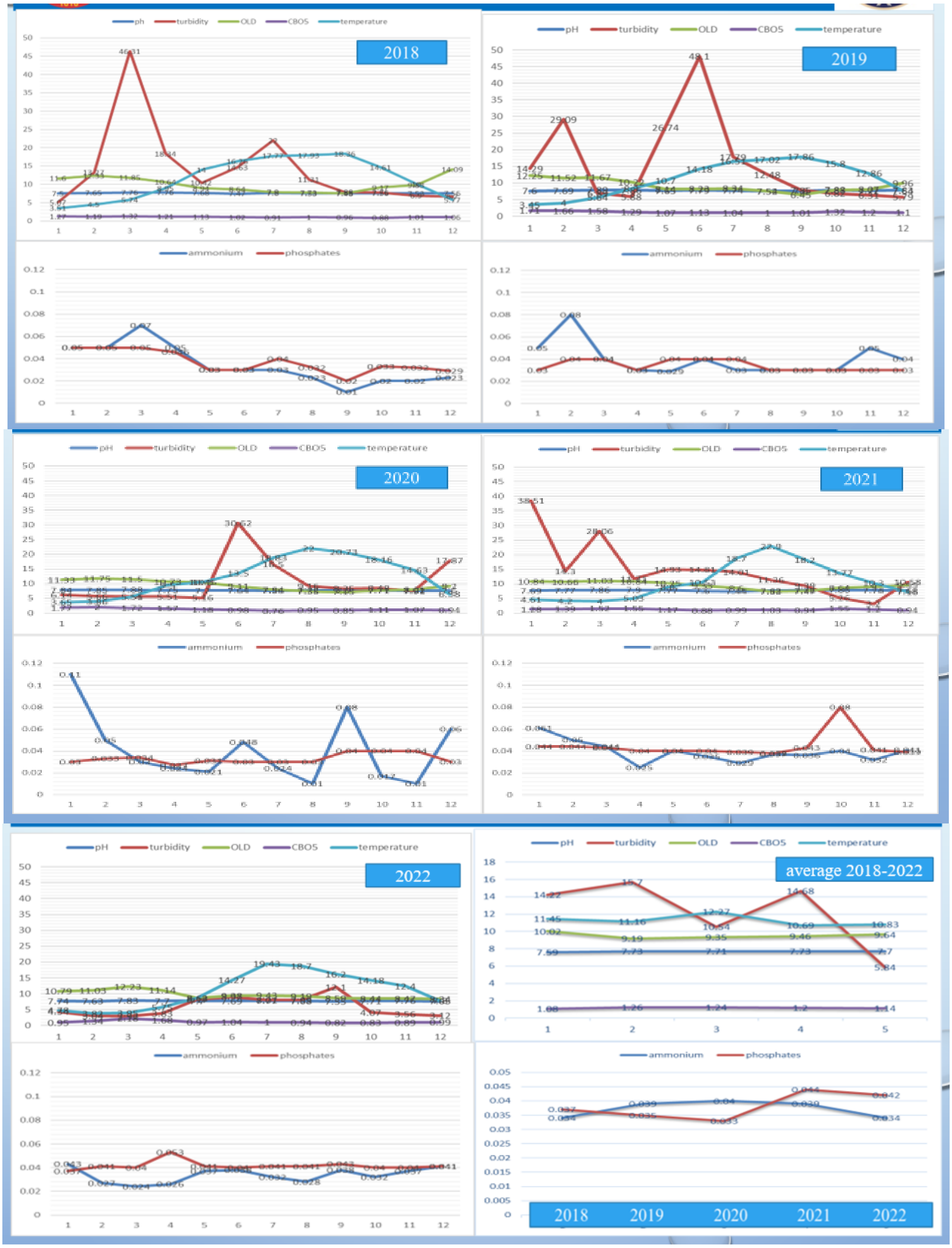

Figure 3. Physico-chemical indicators during 2018-2022: pH (unit. pH), turbidity (FNU), free oxygen dissolved - OLD (mg/l), CBO5 (mg/l), temperature (°C), ammonium (mg/l), phosphates(mg/l)

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This increase can be explained by the execution of cleaning and maintenance operations of raw water intakes. In order not to negatively influence the quality of drinking water, the dose of disinfectant was increased, both in the pre-oxidation phase and in the case of final disinfection, monitoring being carried out in all phases of the technological process. Significant increases in the values of microbiological indicators are recorded in June 2019, respectively in January and March 2021, their values are within the limits of Category A2. For all microbiological indicators monitored in the period 2018-2022, the annual average values fall within the limits of Category A2 of quality.

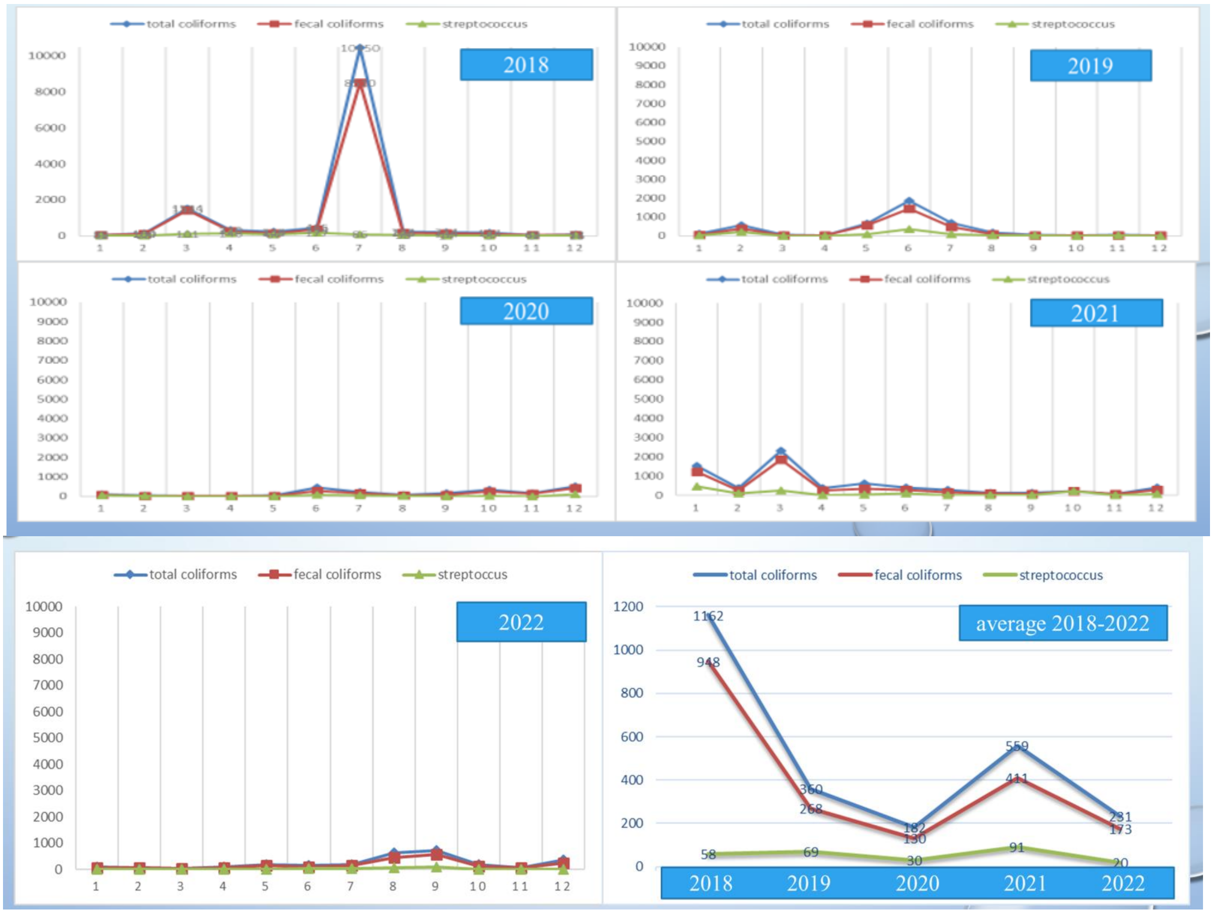

Figure 4. Microbiological indicators during 2018-2022: Total coliforms (no/100 ml), fecal coliforms (no/100 ml), streptococci (no/100 ml)

D. Evolution of limnoplankton during 2018-2022

From the point of view of biological analysis (fig. 5), in the case of phytoplankton, it is found:

- for 2018, increases in values in February, followed by insignificant variations during the year, with a slight increase in September;
- in 2019, 2020 and 2022 there are increases in the spring and autumn periods;
- in 2021, the highest values are recorded in July and September.

In the case of zooplankton, no significant numerical variations are recorded during the 5 years. The annual average values vary only for the phytoplankton biological indicator, with a minimum of 440 specimens/liter in 2021 and a maximum of 1662 specimens/liter in 2019.

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E. Assessment of ecological status during 2018-2022

For the assessment of the ecological status of natural water bodies based on the phytoplankton biological element, the Multimetric Index (MI) was calculated in accordance with Annex 6.1.1.A. of the National Management Plan of the upper basin of the Danube River. In April, during the monitored period, the ecological quality status is very good in 2018, good in 2021, 2022 and moderate in 2019, 2020 (Fig. 6). In June, during the monitored period, the ecological quality status is very good in 2018, 2020, good in 2020 and moderate in 2021, 2022. In August, during the monitored period, the ecological quality status is very good in 2021, good in 2018, 2021, 2022, and moderate in 2019. In October, during the monitored period, the ecological quality status is very good in 2018, good in 2019 and moderate in 2020, 2021, 2022. During the monitored period, the ecological quality status is good in 2018, 2019, 2020, 2021 and moderate in 2022. The highest value of the annual average of the multimetric index is recorded in 2018, with a decrease in it for the period 2021-2022.

Figure 5. Evolution of the limnoplankton in the Budeasa reservoir during 2018-2022: phytoplankton (no/l), zooplankton (no/l)

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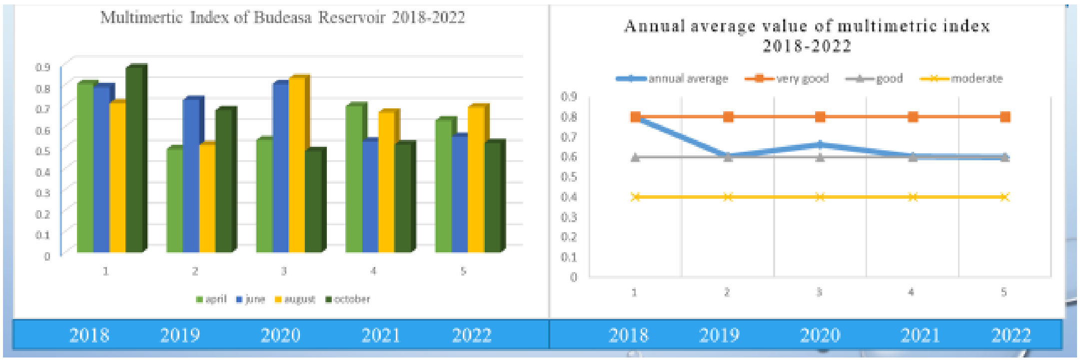

Figure 6. Evolution of the multimetric index in the Budeasa reservoir during 2018-2022

4. CONCLUSIONS

Following the monitoring of the Budeasa Reservoir for the period 2018-2022, it is found that:

- the monitored physico-chemical parameters fall within the limits of NTPA 013, regarding the quality standards that surface waters used for drinking water must meet (Quality Categories A1 and A2);
- the monitored microbiological indicators fall within the limits of NTPA 013 (Quality Category A2), with the exception of July 2018, when the values of the Total and Fecal Coliforms indicators fell within the limits of Quality Category A3;
- the monitored microbiological indicators fall within the limits of NTPA 013, regarding the quality standards that surface waters used for drinking water must meet (Quality Category A2), with the exception of July 2018, when the values of the Total and Fecal Coliforms indicators fell within the limits of Quality Category A3.
- the numerical evolution of phytoplankton shows normal seasonal variations with increases in the spring and autumn periods.
- In the case of zooplankton, no significant numerical variations are recorded during the 5 years;
- following monitoring based on the biological element phytoplankton and the calculation of the Multimetric Index (MI), we can conclude that the ecological quality status is good, with variations between moderate and very good.

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