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BACTERIOLOGICAL AND ENZYMOLOGICAL RESEARCHES ON THE WATER AND SEDIMENT IN THE GILĂU DAM RESERVOIR – CLUJ COUNTY

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Abstract: The Gilău dam reservoir, situated on the Someşul Mic river has as main purpose to suply with drinking water the city Cluj-Napoca and the nearby vilages. Therefore, the bacteriological studies of the water and sediment are necesary and important to determine the charge degree of the lake water with germs, because over certain limit it can induce negative repercussions on human health.

The samples were taken asepticaly from different places and depths. There were collected ten water and seven sediment samples.

The bacteriological researches were involved the determination of four indicators: the mesophilic heterotrophic bacteria, the total coliform bacteria, the faecal coliform bacteria and the faecal enterococcus. The coliform germs and the mesophilic bacteria have been emphasized in both water and sediment samples, but the recorded values were low. The faecal enterococcus indicator was missing in almost all the analysed water samples (where were present, their number was small). This indicator have not been emphasized in any analysed sediment samples.

The bacteriological studies have been completed with the enzymological ones in order to obtain a complete image on the complex processes that are developing in this habitate. In the sediment samples have been determined the following enzymatic activities: phosphatase, actual and potential dehydrogenase, catalase and non-enzymatic catalytic activity. All the studied activities have been detected in the entire set of the samples, observing differentiates only concerning the intensity of processes.

On the basis of the relative values of the enzymatic activities it was calculated the enzymatic indicator of the sediment's biological quality, ranging between 0.132 and 0.492.

Introduction

The Gilău artificial lake is part of a dam reservoir system of the upper basin of Someşul Mic river.

The Gilău reservoir, with a capacity of 3.9 million m^3 water, has the following functions: mainly-the guarantee with drinking and industrial water of the city Cluj-Napoca and the nearby vilages (the Gherla city and the Aghireş zone); energetics; the averting of the floods; the attenuate of the floods waves and the guarantee with water of the Gilău troutdes [17].

The bacteriological studies of the water and sediment of the Gilău dam reservoir has a special significance, the bacteriological indicators studied can serve

as an appreciation and prognosation criteria for the evolution of water quality, especially in some critical situations (the emptiness of the accumulation lakes, floods, drought), but as basis for the decision in the case of bringing to normal measures of the aquatic ecosystems.

The sediments constitute a key link in the biogeochemical cycle of the elements in the aquatic systems. Here, the mineralisation processes of the organic substances were not degraded in the water column to finale. The enzymological researches on the sediment of the accumulation lake, followed the knowledge completion about the complex processes that happen in these habitates, with a special semnification [14].

In the last two decades the microbiological investigations of surface water have been increased (on rivers and lakes), and aimed mainly on the water hygienico-bacteriological conditions estimation, but also on other microrganism groups present in the water [5,10,12].

In our country there were microbiologically analysed the Bistrița river [18] and the Bicaz, Şerbăneşti and Vaduri dam reservoires [1,2,3,11].

There are no microbiological analyses concerning water and sediment of the Gilău dam reservoir. The enzymatic activity of the Romanian salted lakes sediments allowed a classification of them based on the enzymatic indicator of mud quality (Muntean et al. in 1996) [15].

Materials and methods

The bacteriological analyses were performed in April 2002 on 10 water samples and 7 sediment samples collected room the Gilău dam reservoir.

The water samples were taken on the surface and from different depths, the sampling sites were the following: Someşul Rece upstream reservoir, Someşul Cald upstream reservoir, near the Dam - 0 m, Dam - 3 m, Dam - 6 m, Dam - bottom, Middle of reservoir - 0 m, Middle of reservoir - bottom, Tail of reservoir - 0 m and Tail of reservoir - bottom.

The samples of the sediment were taken at 0 - 10 cm depth, from the following places: Dam - middle, Dam - right border, Dam - left border, Middle of reservoir - middle, Middle of reservoir - right border, Middle of reservoir - left border and Tail of reservoir-middle.

There have been established four bacteriological parameters for both water and sediment samples, namely: the total number of the mesophilic heterotrophic bacteria (37^oC) (CFU=colony-forming units), the probable number of the total coliform bacteria, the probable number of the faecal coliform bacteria and the probable number of the faecal enterococcus.

In order to determine these four hygienico-sanitary indicators from the water samples we used the methods according to *Drăgan-Bularda* [8,19]. The culture media used were: the gelose (the mesophilic bacteria); the lauryl sodium sulfate (simple and double concentrate) media and Geam-Levin media (the total coliform); the Mac Conkey liquid media (the faecal coliform); the sodium azide (simple and

double concentrate) media and the sodium and purple bromcresol azide media (the faecal enterococcus).

In order to determine the bacteriological indicators from the sediment samples we used the methods according to *Cuşa* [6], the media used being the same with those used for the water samples analysed previously.

The enzymological analyses were performed on seven sediment samples, determinating phosphatase, catalase as well as actual dehydrogenase, potential dehydrogenase and non-enzymatic splitting of H_2O_2. The deactivation of the enzymes in the samples where was aimed the non-enzymatic splitting of H_2O_2, made through thermal treatment at 121°C for one hour in three consecutive days. The methods used in order to determine the enzymatic activities were according to *Drăgan-Bularda* [8].

Due to the fact that the different sediment categories may have a variable water content, that can influence the expression of the microbian charge and enzymatic activities reporting to the sediment weight, the humidity of each sediment sample was established during their preparation for the analyses [6].

On the base of the absolute values of the enzymatic and catalytic non-enzymatic activities from each analysed samples we could be calculated the enzymatic indicators for the sediment quality [15].

Results and discussion

The bacteriological indicators: the total number of the mesophilic bacteria, the probable number of the total coliform bacteria, faecal coliform bacteria and faecal enterococcus have been determinated in all the water samples. Depending on the isolation and association of these bacteria groups and on their quantity variation, one can appreciate the hygienico-sanitary state of the lake water.

The results of the bacteriological analyses are presented in Tables 1 and 2. The bacteriological studies of the water samples indicate the presence of the faecal enterococcus indicator only in 4 of the 10 water samples namely: dam -bottom (60); middle of reservoir - 0 m (82); middle of reservoir-bottom (23) and tail of reservoir - bottom (14), observing a predominance of this indicator at the samples collected from depth. The other studied bacteriological indicators have been present in all analysed water samples, the differences concerning only their quantity. We observed the maximum values of the number of the mesophilic bacteria, total coliform bacteria, faecal coliform bacteria and faecal enterococcus in the Someşul Cald - upstream reservoir and Someşul Rece - upstream reservoir water samples and in water samples collected from depth (dam-bottom; middle of reservoir-bottom and tail of reservoir-bottom). The values obtained from these water samples were higher than the values observed in the water samples collected from the surface.

This increase of the number bacteria in the same time with the depths may be due to the effect of the sedimentation of solid particles. Through sedimentation, the solid particles draw with them the bacteria to the deeper layers, their number

therefore decreasing in the surface zones. The exposed waters to the action of the sun light causes consequently the massive decrease of the microorganisms number not only in the layers immediately under the water surface but on 2.5 - 3 m depth, too [13].

Table 1: Bacteriological analyses performed on water of the Gilău dam reservoir.

Sampling Sites	Hygienic bacteriological parameters			
	Mesophilic heterotrophic bacteria (CFU/ 100 ml)	Total coliform bacteria (no./ 100 ml)	Faecal coliform bacteria (no./ 100 ml)	Faecal enterococcus (no./ 100 ml)
1. Someşul Rece-upstream reservoir	2.315	3.300	3.300	-
2. Someşul Cald-upstream reservoir	4.035	7.000	4.900	-
3. Dam - 0 m	275	700	400	-
4. Dam - 3 m	14.080	3.300	2.400	-
5. Dam - 6 m	12.500	2.200	1.700	-
6. Dam - bottom	28.000	3.400	1.700	60
7. Middle of reservoir - 0 m	3.160	1.400	700	82
8. Middle of reservoir – bottom	37.000	4.900	4.900	23
9. Tail of reservoir - 0 m	1.540	1.100	700	-
10. Tail of reservoir – bottom	64.500	2.400	1.100	14

The bacteriological analyses of the sediment samples emphasize the absence of the faecal enterococcus indicator in all analysed samples. The other bacteriological indicators were emphasized in all samples, but in different quantities. The values raise in the case of the samples harvested from the peripherical zones and from the tail of reservoir: dam-right border, dam-left border, middle of reservoir-right border, middle of reservoir-left border and tail of reservoir-middle. The maximum values of these three indicators (mesophilic bacteria: 135.66 CFU/g.d.s.; total coliform: 714/g.d.s. and faecal coliform: 336.6/g.d.s.) have been recorded in the sample from middle of reservoir-left border (g.d.s. = g of dry sediment).

The coliform bacteria represent a category belonging to the *Enterobacteriaceae* family. The coliform group is formed by more of bacterial genera including *Klebsiella, Escherichia, Salmonella, Erwinia, Serratia* and other enterobacteria [7,12]. The species of the coliform bacteria group are not patogen strictly speaking, but, in some conditions, can often induce diarrhoea diseases or the infections of the urinary tract. Therefore, they are considered opportunist patogens. Due to this fact the coliform germs are considered as very important indicator organisms. If their number in the natural environment is higher the probability of the presence of patogen microorganisms in the environment increases [13].

Table 2: Bacteriological analyses performed on the sediment of the Gilău dam reservoir.

Sampling Sites	Hygienic bacteriological parameters			
	Mesophilic heterotrophic bacteria (CFU/ g.d.s.)	Total coliform bacteria (no./ g.d.s.)	Faecal coliform bacteria (no./ g.d.s.)	Faecal enterococcus (no./ g.d.s.)
1. Dam – middle	3.914	17.51	11.33	-
2. Dam - right border	79.04	101.92	22.88	-
3. Dam - left border	6.51	73.5	51.45	-
4. Middle of reservoir – middle	4.462	18.35	28.35	-
5. Middle of reservoir - right border	55.59	173.4	6.22	-
6. Middle of reservoir - left border	135.66	714	336.6	-
7. Tail of reservoir - middle	93.97	283.5	178.5	-

g.d.s. = g of dry sediment

The mesophilic microorganisms expressed quantitatively can indicate the presence and sometimes even the pollution level with animal and human residues, both in fresh or fermentation states. The presence of the total coliform bacteria indicates the possibility of faecal contamination and constitutes an alarm signal. The presence of the faecal coliform bacteria certifies recent faecal pollution, so a high potential danger, concerning the possibility associated with the patogen flora within the gate of the digestive entrance. The significance of the faecal enterococcus presence indicate, recent and massive faecal pollution, with an epidemiological potential concerning the infections within the gate of the digestive entrance [6].

The results of the bacteriological analyses on Gilău dam reservoir water and sediment, indicate the fact that the lake has a good hygienic-sanitary state, due to the faecal enterococcus absence in the majority of sampling sites (where they are present, their number is small) and also due to the bacteriological indicators that are present in small number.

Taking into consideration the intestinal origin of these germs and the enteropatogen bacteria and virus, as well the potential infectious and the danger what they constitute for the health, imposes the application of measures for the protection of lake water quality.

The results of the enzymological analyses of the Gilău dam reservoir sediment samples are presented in the Table 3 and Fig 1 - 4.

In all sediment samples have been detected all the studied enzymatic activities. The sample tail of reservoir-middle is characterized by more intense enzymatic activity. In the case of this sample 4 maximum values have been registered: the phosphatase activity (409.24 mg phenol/g.d.s.) (Fig. 1), the catalase activity (0.971 mg H_2O_2 decomposed / g.d.s.) (Fig. 2), the non-enzymatic splitting of H_2O_2 (3.692 mg H_2O_2 decomposed/g.d.s.) (Fig. 2) and the actual

dehydrogenase activity (0.185 mg formazan/g.d.s.) (Fig. 3). Another maximum value has been obtained in the middle of reservoir-middle sample for the potential dehydrogenase activity (0.263 mg formazan/g.d.s.) (Fig. 3). Otherwise, in the case of this sample one observed the presence of increased values for other enzymatic activities, too: the phosphatase, catalase, actual dehydrogenase activity and non-enzymatic splitting of H_2O_2.

The quality of the sediment is characterized by the intensity of the enzymatic activities defined by the values of the enzymatic indicators of the quality. Higher enzymatic indicators quality rises the sediment's enzymatic potential [4].

Theoretically the enzymatic indicator may exhibit values between 0 (when no activity exists in the samples studied) and 1 (when all the real individual values are equal to the maximal theoretical individual values of all activities) [15].

The value of the enzymatic indicator of quality (Table 3, Fig. 4) reflects that the sediment from the place of collecting tail of reservoir-middle is characterized by the intense enzymatic activity, presenting maximum values. Another increased value of the enzymatic indicator of the quality has been observed in the case of the sediment middle of reservoir-middle sample.

On the basis of the results for the enzymological analyses on the Gilău dam reservoir sediment samples it is evident that the zones from the middle of the lake have a sediment with a higher enzymatic activity than the peripherical zones of the reservoir.

We observed that the non-enzymatic splitting of H_2O_2 activity is more intense than the catalase activity (minimum values: catalase - 0.971 mg H_2O_2 splitting/g d.s.; non-enzymatic - 3.692 mg H_2O_2 splitting/g d.s.). The phosphatase activity has been registered with the highest values in all sediment samples, compared with other studied enzymatic activities. The highest values of the phosphatase activity could be possible due to the acumulation of the organic remnants in the sediment [9].

The dehydrogenase activity measures the respiration potential of the sediment microflora, therefore reflects the current microbian activity of the sediment. The low values of the dehydrogenase activity demonstrate the presence of the lower microbian potential in Gilău dam reservoir sediment. The potential dehydrogenase activity is more intense than the actual one, fact that reflects the stimulative action of the carbon easy assimilation on the enzymes synthesis by the living microorganisms [14].

Added glucose has a constant but weak stimulating effect on dehydrogenase activity in the sediments of the lake. A possible explanation could be the presence in these sediment of sufficiently high amounts of organic substances, which provide a good development of microorganisms, their activity being characterised by the maintenance of a relatively high level of the actual dehydrogenase activity [16].

Table 3: Enzymatic and catalytic non-enzymatic activity analyses performed on the Gilău dam reservoir sediment.

Sampling sites	Activity exprima-tion	Phosphatase activity	Catalase activity	Non-enzim. catalytic	Dehydrogenase activity		EISQ
					actual	potential	
1. Dam - middle	a.v. r.v.	197.24 48.19%	0.561 57.83%	1.731 46.89%	0.071 38.39%	0.1 37.93%	0.229
2. Dam - right border	a.v. r.v.	337.07 82.36%	0.438 45.08%	2.285 61.89%	0.103 55.73%	0.143 54.47%	0.217
3. Dam - left border	a.v. r.v.	257.04 62.81%	0.837 86.24%	2.658 71.99%	0.076 41.19%	0.093 35.39%	0.297
4. Middle of reservoir - middle	a.v. r.v.	387.07 94.58%	0.824 84.89%	2.887 78.19%	0.184 99.24%	0.263 100%	0.456
5. Middle of reservoir -right border	a.v. r.v.	158.4 38.70%	0.502 51.74%	1.161 31.45%	0.077 41.46%	0.080 30.61%	0.193
6. Middle of reservoir - left border	a.v. r.v.	51.84 12.66%	0.323 33.24%	0.861 23.32%	0.018 10.07%	0.019 7.42%	0.132
7. Tail of reservoir - middle	a.v. r.v.	409.24 100%	0.971 100%	3.692 100%	0.185 100%	0.243 92.52%	0.492

a.v. = absolute values;
r.v. = relative values;
EISQ = Enzymatic indicator of sediment quality

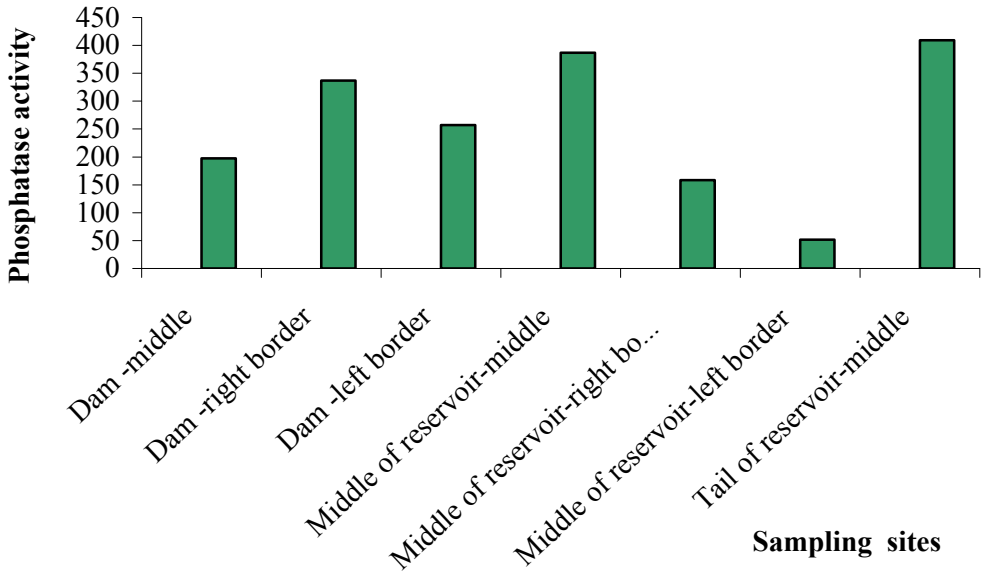

Fig. 1: Intensity of the phosphatase activity in the Gilău dam reservoir sediment samples.

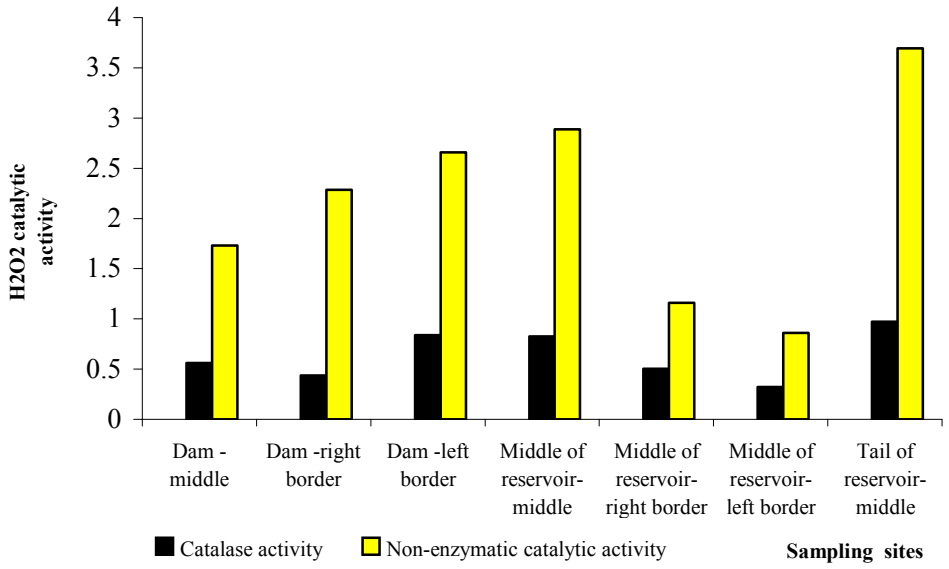

Fig. 2: Catalase activity and non-enzymatic catalytic activities in the Gilău dam reservoir sediment samples.

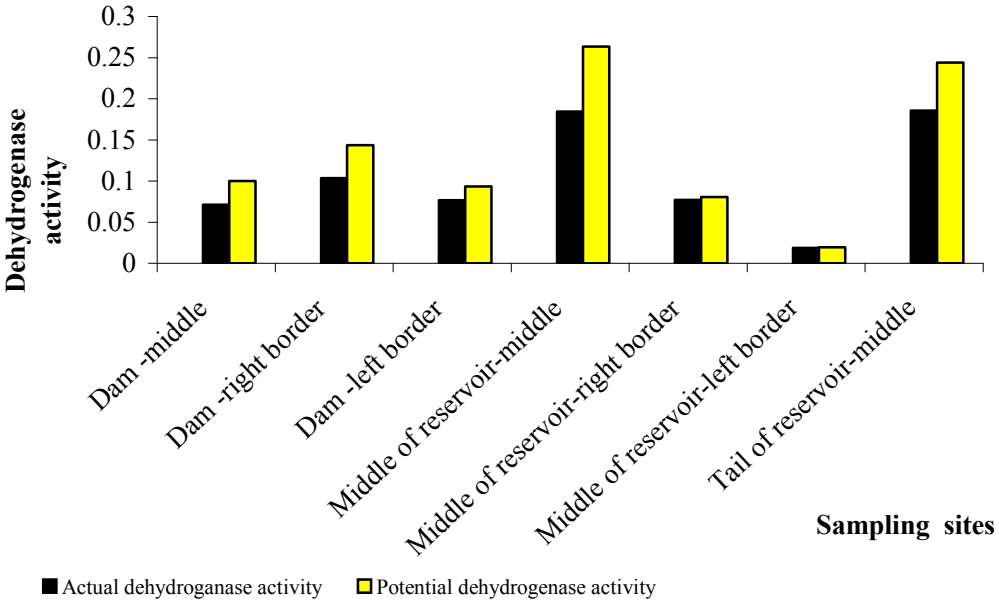

Fig. 3: Actual and potential dehydrogenase activity from the Gilău dam reservoir sediment samples.

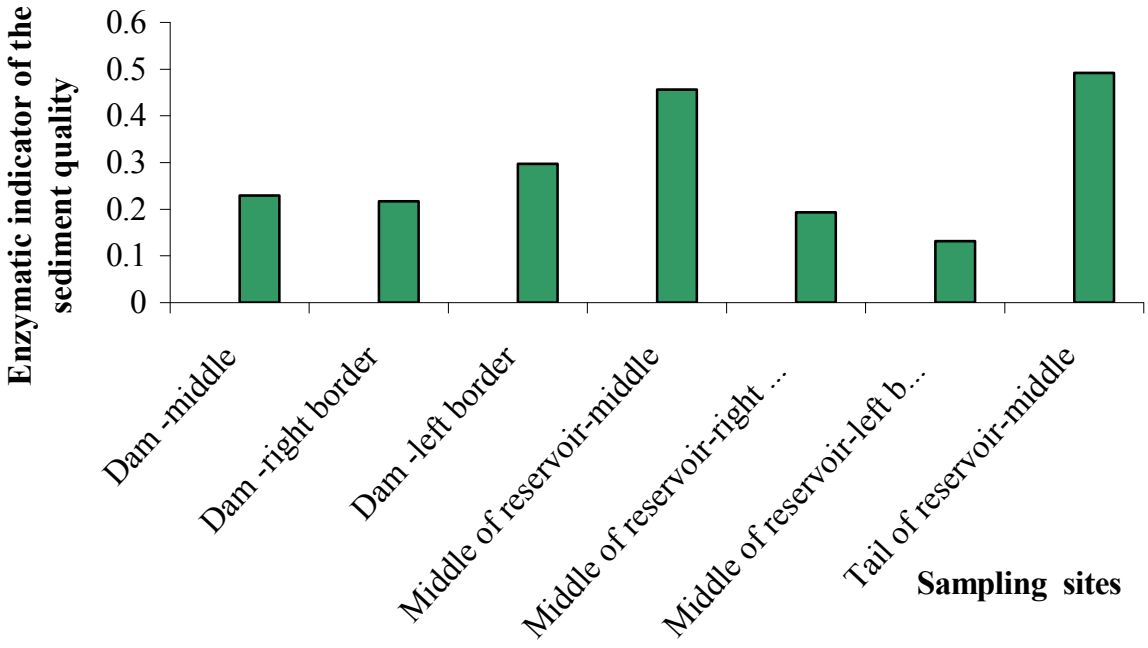

Fig. 4: Enzymatic indicator of sediment quality (EISQ) of the Gilău dam reservoir.

Conclusions

1. The results of the bacteriological analyses on the Gilău dam reservoir water and sediment indicate that the reservoir has a good hygienic-sanitary state, due to the absence of the faecal enterococcus in the majority of sampling sites (where they are present, their number is small) and due to the small number of other bacteriological indicators present.
2. Taking into consideration the potential infectious of these germs and the danger what they constitute for the health imposes the application of measures for the reservoir water quality protection, considering also its complex use.
3. From enzymological point of view, there have been studied the following activities: phosphatase, catalase, actual and potential dehydrogenase and catalytic non-enzymatic activity (non-enzymatic splitting of H_2O_2) in 7 sediment samples collected from Gilău artificial lake. All the enzymatic activities and the non-enzymatic activity have been emphasized in all the sediment samples.
4. The enzymatic indicator of the sediment quality has been recorded with maximum values (0.492 and 0.456) in the sediment samples collected from the middle zones of the reservoir (tail of reservoir-middle and middle of reservoir-middle), that indicate the presence of high enzymatic potential in these zones, comparatively with the other analysed zones.

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CERCETĂRI BACTERIOLOGICE ŞI ENZIMOLOGICE ASUPRA APEI ŞI SEDIMENTULUI LACULUI DE ACUMULARE GILĂU – JUDEȚUL CLUJ

(Rezumat)

Situat pe râul Someşul Mic, lacul Gilău are drept scop principal alimentarea cu apă potabilă a municipiului Cluj-Napoca şi a altor localități din jur. De aceea, pentru determinarea gradului de încărcare a apei lacului cu germeni care în anumite cantități pot avea repercusiuni negative asupra sănătății omului, studiile bacteriologice asupra apei şi sedimentului lacului sunt necesare şi importante.

Probele au fost prelevate din diferite puncte de recoltare şi de la diferite adâncimi, cele de apă fiind în număr de 10, iar probele de sediment în număr de 7.

Cercetările bacteriologice au constat în determinarea a 4 indicatori: bacterii mezofile, bacterii coliforme totale, bacterii coliforme fecale şi enterococi fecali. Germenii coliformi şi bacteriile mezofile s-au evidențiat în toate probele studiate, atât de apă cât şi de sediment, dar valorile înregistrate au fost scăzute. Enterococii fecali a fost absenți în majoritatea probelor de apă analizate (acolo unde au fost prezenți, numărul lor a fost mic). Acest indicator nu s-a evidențiat în nici una dintre probele de sediment analizate.

În vederea alcătuirii unei imagini complete despre procesele complexe care se desfăşoară în acest habitat, cercetările bacteriologice au fost completate cu cele enzimologice. În probele de sediment s-au determinat următoarele activități enzimatice: fosfatazică, dehidrogenazică actuală şi potențială, catalazică şi catalitică neenzimatică. Toate activitățile studiate au fost detectate în toate probele analizate, observându-se diferențieri doar în ceea ce priveşte intensitatea proceselor.

Pe baza valorilor relative ale activităților enzimatice s-a calculat indicatorul enzimatic al calității biologice a sedimentului, ale cărui valori au fost cuprinse între 0,132 şi 0,492, reprezentând, deci, activități enzimatice de intensitate moderată.