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Macrozoobenthic community structure and dynamics in Cerna River (western Romania)

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Abstract. In order to determine water quality in Cerna River, researchers carried out analyses into the structure and dynamics of benthic macroinvertebrates communities as well as into the physical-chemical factors. 12 Groups of macroinvertebrates were identified. Density, abundance and frequency values recorded for benthic communities varied according to the physical-chemical conditions specific to each sample collecting station. Researchers noticed a direct influence of Băile Herculane town and dam upon the community submitted to study, the maximum density and percentage numerical abundance being established for Oligochaeta and Diptera, benthic groups tolerant to changes in aquatic ecosystems qualitative parameters. The community of organisms including Ephemeroptera, Trichoptera, Plecoptera, Odonata and Coleoptera was characterized by a decrease in density and abundance values upstream - downstream as water quality is more and more degraded. This deterioration is also emphasized by the biotic index EPT/Ch values.

Key words: benthic macroinvertebrates, water quality, Cerna River.

Rezumat. Pentru determinarea calității apei râului Cerna, a fost utilizată analiza compoziției și a dinamicii comunităților de macronevertebrate bentonice, în paralel cu analiza factorilor fizico-chimici. Au fost identificate un număr de 12 grupe de macronevertebrate bentonice. Valorile densității, abundenței și frecvenței comunităților bentonice au variat în funcție de condițiile fizico-chimice specifice fiecărei stații. S-a observat o influență directă a orașului și a barajului Băile Herculane asupra comunității în cauză, valorile maxime pentru densitatea și abundența numerică procentuală fiind stabilite pentru Oligochaeta și Diptera, grupe bentonice tolerante la modificarea parametrilor calitativi ai ecosistemelor acvatice. Comunitatea de organisme reprezentată de Ephemeroptera, Trichoptera, Plecoptera, Odonata și Coleoptera s-a caracterizat printr-o descreștere a valorilor densității și abundenței din amonte către aval, pe măsura degradării calității apei. Aceasta înrăutățire este susținută și de valorile indicelui biotic EPT/Ch.

Key words: macronevertebrate bentonice, calitatea apei, râul Cerna.

Kivonat. A Cserna (Cerna) folyó vízminőségének megállapításának érdekében a bentonikus makroszkopikus gerinctelen fauna összetételét és dinamikáját a víz fizikai és kémiai tulajdonságaival együtt, párhuzamosan vizsgáltuk. Felméréseink során mintegy 12 vízi gerinctelen fajcsoportot azonosítottunk. A bentonikus életközösségekre jellemző denzitás, abundencia illetve előfordulási gyakoriság az egyes mintavételi helyeken mért fizikai és kémiai paraméterek függvényében változott. Kimutattuk Herkulesfürdő (Băile Herculane) és a völgyzáró gát jelenlétének, a vizsgált bentonikus faunára gyakorolt közvetlen hatását. A legmagasabb denzitás és százalékos abundencia értékek a kevéssörtéjű illetve kétszárnyú (Oligochaeta, Diptera) faunára voltak jellemzőek, amelyek tudvalévően jobban viselik a vizes élőhelyek esetleges minőségromlását. A folyási irányt követve romlik a víz minősége, minek betudhatóan egyes fajcsoportok esetében a denzitás és abundencia értékek csökkentek. Ide tartoztak a kérészek, tegzesek, álkérészek, szitakötők és bogarak (Ephemeroptera, Trichoptera, Plecoptera, Odonata, Coleoptera). Ezt a minőségromlást kimutattunk az EPT/Ch biotikus index alapján is.

Kulcsszavak: bentonikus makroszkopikus gerinctelenek, vízminőség, Cserna folyó.

Introduction. The interest in studying benthic macroinvertebrates is sustained by their contribution to turning the allochtone material (the main source of energy in aquatic ecosystems) into biomass, which is then spread across upper trophic levels (Burd et al 2008; Chaloner et al 2010; Lamberti et al 2010).

The importance of benthic macroinvertebrates to biomonitoring studies is also added to the aforementioned interest (Ogbeibu & Oribhabor 2002; Badea et al 2010; Kubosova et al 2010; Eftenoiu et al 2011; Marin et al 2011).

The study on benthic communities is recommended to be conducted along with the study on physical-chemical parameters as it is considered that a singular analysis of chemical factors indicates a momentary state of water quality (Reice & Wohlenberg 1993; Nedeau et al 2003). Scientific literature sustains the role benthic macroinvertebrates occupy in evaluating water quality as well as the various degrees of tolerance to changes in qualitative parameters of water bodies (Iliopoulou-Georgudaki et al 2003; Arimoro 2009; Korte et al 2010; Shami et al 2010).

No study has been carried out with regard to either the diversity of benthic macroinvertebrates in Cerna River or the investigation into water quality along this river by using macroinvertebrates as indicators. This is the reason why the main objective of this paper was to analyze the structure and dynamics of macrozoobenthic communities and to evaluate water quality on the basis of taxonomic groups as indicators.

Material and Method. Quantitative samples were collected in 2010 during different seasons with a Surber sampler (surface of 1073 cm^2 and net meshes of 250 μm), at 4 stations along Cerna River.

The physical-chemical factors were determined with a 350i/SET multimeter and HACH-LANGE DR2800 spectrophotometer.

Samples were stored in 4% formaldehyde. Laboratory works were conducted to carry identifications to order level, except for Oligochaeta identified to subclass level and Diptera Chironomidae determined to family level (Tachet et al 2000). A number of 48 samples containing 20.447 individuals were processed.

The density $D_i = n_i\ S_p^{-1}$, abundance $A= (n_i\ N^{-1})*100$ and frequency $F = (N_i*100)\ N_p^{-1}$ were further calculated, where n_i represents the total number of individuals for the i species, S_p the total researched area, N the total number of individuals belonging to all species (from the sample or samples studied), Ni the number of stations where i species was identifies, N_p total number of stations (Stan 1995).

EPT/Ch = EPT abundance/Chironomidae abundance = EPT count divided by Chironomidae count. A lower Chironomidae abundance is good (EPT Count = Count of the number of individuals in the three generally pollution - sensitive orders - Ephemeroptera, Plecoptera, and Trichoptera (Semenchenko & Moroz 2005). Confidence limits of the media were calculated at p = 0.05. The mean of the physic-chemical parameters of water from different sampling sites was compared using the non-parametric procedure (Kruskal-Wallis test).

Two sample collecting stations were placed upstream and downstream of Cerna Dam and Băile Herculane town (see Figure 1) as follows:

Pecinișca Site (1): 44º85'601" N-22º40'065" E, altitude 129 m; 7 Izvoare Site (2): 44º91'758" N-22º44'044" E, altitude 192 m; Dumbrava Site (3): 44º96'903" N-22º48'858" E, altitude 253 m; Scărişoara-Medved Site (4): 45º02'072" N-22º55'405" E, altitude 324 m.

The stations habitat varied as follows: *Salix sp.* and *Alnus sp*. (S1), *Salix sp.*, *Alnus sp., Fagus sp.* (S2, S4), *Fagus sp., Carpinus sp., Alnus sp.* (S3).

The coverage degree of the river bed was 80% at the first 3 stations and only 20% at station 4.

The mean values of water depth and river bed stretch for the 4 stations were 26.56±7.03 cm and 15.56±4.17 m.

The sub-layer analyzed was made up of stones and gravel (S1, S2, S3, S4), as well as of sand and boulder (S2, S4).

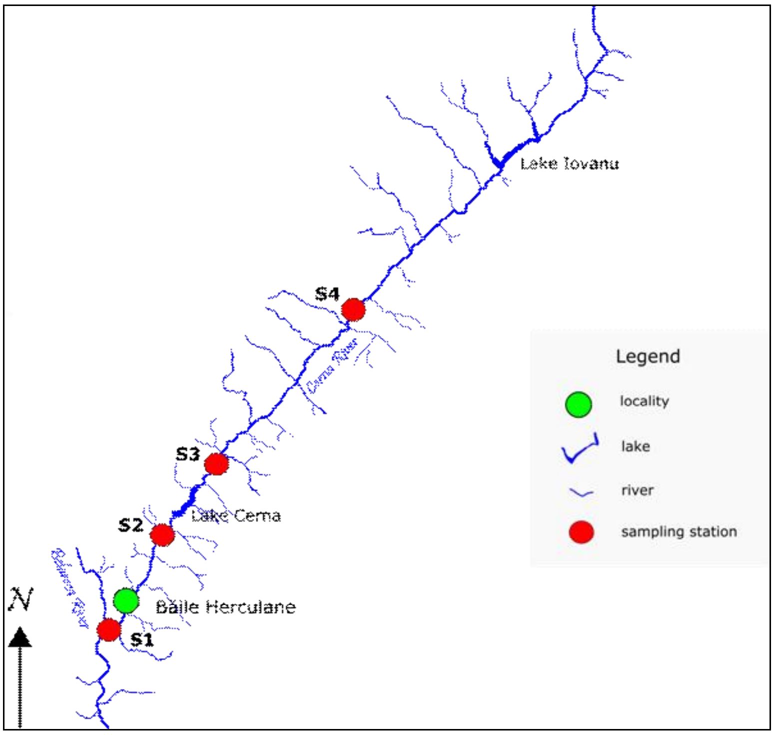

Figure 1. The location of the sample collecting sites on the Cerna River, 2010.

Results and Discussion. The mean values of physical-chemical parameters calculated at each sample collecting site are presented in Table 1.

Table 1

Means of the physical-chemical parameters calculated at the 4 sites, Cerna River, 2010

Physical and chemical parameter values	S1	S2	S3	S4
Water temperature (ºC)	10.00±6.55	8.75±12.55	8.00±4.87	8.50±5.69
Water speed (m s^{-1})	1.44±0.31	1.13±1.51	0.53±0.22	0.71±0.26
pH	7.06±0.08	7.08±9.31	7.02±0.19	7.08±0.09
Conductivity (µs cm^{-1})	996.75±7.9	922.5±1212.97	911±12.45	904.25±5.9
Total Dissolved Solids (mg L^{-1})	227.50±43.63	212.75±279.8	274.25±9.1	230.25±6.27
CBO5 (mg L^{-1})	0.91±0.03	1.05±1.38	1.28±0.05	0.95±0.03
CCOMn (mg L^{-1})	5.30±0.08	5.02±6.59	5.62±0.11	5.10±0.06
Chlorides (mg L^{-1})	4.20±0.08	4.82±6.34	5.23±0.08	5.02±0.04
Sulfates (mg L^{-1})	18.00±0.00	16.00±21.04	16.00±0.00	17.50±0.98
Ca (mg L^{-1})	71.91±0.20	69.93±91.94	69.00±0.10	70.91±0.62
Mg (mg L^{-1})	71.27±0.46	64.51±84.82	66.74±0.63	68.77±0.35
Na (mg L^{-1})	2.49±0.12	2.26±2.98	2.16±0.04	2.37±0.03
K (mg L^{-1})	1.19±0.01	1.16±1.52	1.09±0.02	1.26±0.03
Ammonium (mg L^{-1})	0.51±0.01	0.18±0.23	0.10±0.01	0.22±0.01
Nitrite (mg L^{-1})	0.13±0.02	0.11±0.14	0.08±0.01	0.09±0.003
Nitrogen (mg L^{-1})	5.64±0.16	5.07±6.66	5.82±0.12	6.10±0.06

Physical and chemical parameter values	S1	S2	S3	S4
Cyanide (mg L^{-1})	0	0	0	0
Phenols (mg L^{-1})	0	0	0	0
Detergents (mg L^{-1})	0.003±0.0005	0.002±0.00	0.001±0.00	0.001±0.00
Fe (mg L^{-1})	0.11±0.01	0.08±0.10	0.04±0.00	0.07±0.003
Total Phosphorus (mg L^{-1})	0.20±0.01	0.103±0.13	0.07±0	0.09±0.001
Cr (mg L^{-1})	<0.002	<0.002	<0.002	<0.002
Pb (mg L^{-1})	<0.006	<0.006	<0.006	<0.006
Zn (mg L^{-1})	<0.005	<0.005	<0.005	<0.005
Bicarbonates (mg L^{-1})	218.25±6.85	211.50±278.1	217.00±5.6	239.75±3.03
Permanent Hardness (ºGe)	12.33±0.19	11.63±15.29	12.23±0.19	12.53±0.24
Temporary Hardness (ºGe)	13.72±0.5	13.11±17.24	12.72±0.35	13.33±0.14
Total Hardness (ºGe)	25.93±0.79	24.85±32.67	25.18±0.30	23.12±4.68

Considering the physical-chemical parameters, no significant differences were noticed from one sample collecting station to another (Kruskal-Wallis, $p > 0.05$).

Once the benthos samples were processed, 12 groups of benthic macroinvertebrates were determined; subsequently, their mean density values are presented in Figure 2.

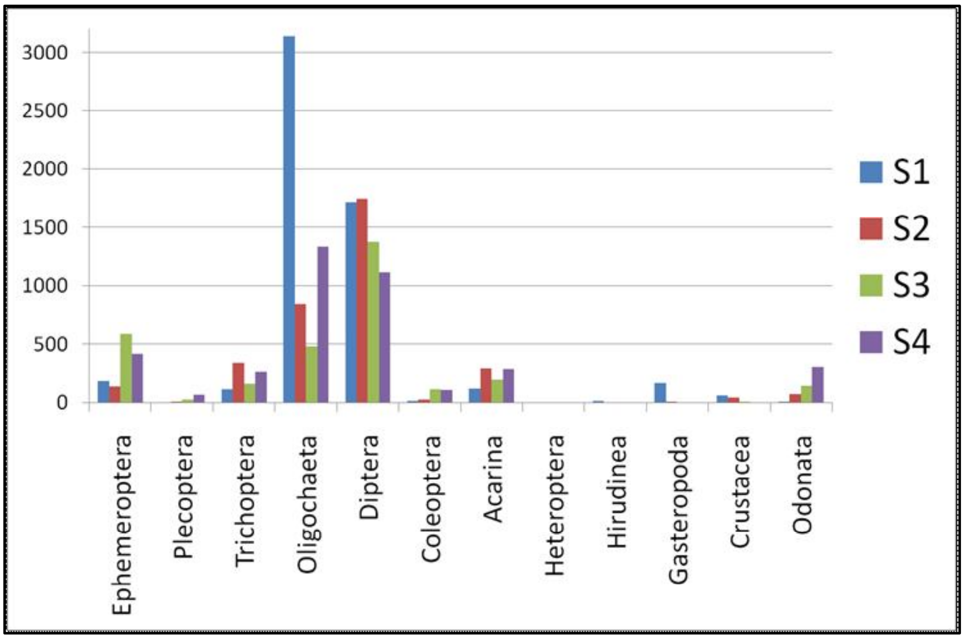

Figure 2. The average density (individuals m^{-2}) of benthic macroinvertebrates in Cerna River, 2010.

The analysis of the main benthic groups as indicators showed a significant influence Băile Herculane town has upon their mean density values (S1) (see Figure 2). Thus, water quality is reflected in the structure of the benthic community through a maximum value for Oligochaeta (12568.28±359.21 individuals m^{-2}) and a minimum value for groups with low tolerance to high values of organic substance (Plecoptera - 6.15±0.18 individuals m^{-2}, Ephemeroptera - 739.92±20.43 individuals m^{-2}, Trichoptera 453.82±15.96 individuals m^{-2}, Odonata - 34.14±1.39 individuals m^{-2}).

At S2, the influence of Băile Herculane Dam was represented by maximum mean density values for Diptera (Chironomidae as predominant family and other families - Rhagionidae, Limoniidae, Blepharoceridae, Ceratopogonidae in a reduced percentage) 6986.75±212.32 individuals m^{-2}) and minimum values for Ephemeroptera (537.78±14.62 individuals m^{-2}). Minimum density values were calculated for other sensitive groups as well (Plecoptera - 30.97±1.01 individuals m^{-2}, Odonata - 276.67±8.93 individuals m^{-2}, Coleoptera - 86.94±3.70 individuals m^{-2}).

In case of Trichoptera, we notice an increase in the density value downstream of Băile Herculane Dam (S2) (1358.67±59.26 individuals m^{-2}), followed by a sharp decrease at the station downstream of the town (S1) (453.82±15.96 individuals m^{-2}). The high density values for Trichoptera recorded at S2 are believed to be due to the presence of certain species with higher tolerance degree.

The maximum densities of the two groups downstream of the pollutant factors are explained through the fact that Oligochaeta and Diptera Chironomidae have a higher tolerance degree as compared to other groups (Plecoptera, Ephemeroptera, Trichoptera, Odonata, etc) (Hamilton et al 2008; Benbow 2009; Courtney & Merritt 2009; Collier et al 2010).

The species of Heteroptera were not present in the benthos of the two stations downstream of Băile Herculane Dam and town (see Figure 2).

The percentage numerical abundance (%) values that were calculated for each of the 4 stations were presented in Figure 3.

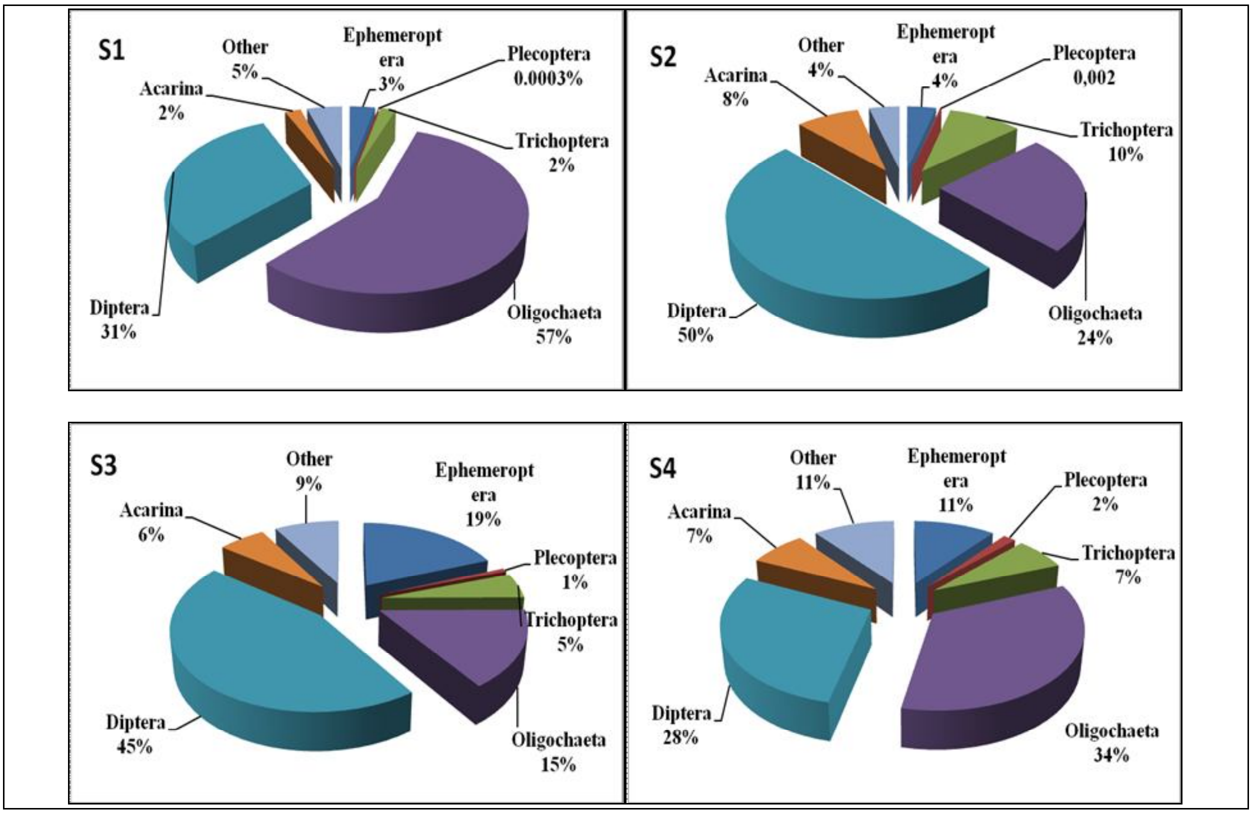

Figure 3. Percentage numerical abundance (%) of benthic invertebrates in the Cerna River, 2010 (Other = Coleoptera, Heteroptera, Hirudinea, Gastropoda, Crustacea, Odonata; Diptera = Chironomidae, Rhagionidae, Limoniidae, Blepharoceridae, Ceratopogonidae).

The deterioration of water quality stemming from both the dam and the town of Băile Herculane led to changes in the percentage numerical abundance values of macroinvertebrates communities submitted to study (see Figure 3).

Although the group of Plecoptera, which is known to be very sensitive, is not dominant in the benthic communities analyzed (Zhou et al 2008; DeWalt 2009; Varnosfaderany et al 2010; Menetrey et al 2011), this group was characterized by a decrease in abundance values from S4 to S1. This tendency may be tracked in case of other less tolerant groups (Ephemeroptera, Trichoptera) that are directly influenced by the change in water qualitative parameters (Hamada et al 2002; Allan 2004).

The great concentration of organic substance downstream of the city is proved by the dominance of Oligochaeta in benthic communities by a percentage greater than 50%.

The frequency values were as follows:

- At S1, the groups with 100% frequency were Ephemeroptera, Diptera, Oligochaeta, Trichoptera, Hirudinea, Gastropoda and Crustacea. Acarina recorded a 75% frequency, the 50% value being established for Plecoptera, Coleoptera and Odonata.
- At S2, a 100% presence was established for Ephemeroptera, Trichoptera, Oligochaeta, Diptera, Crustacea, Coleoptera and Acarina. The following values were recorded for the other groups: Plecoptera (75%), Gastropoda, Odonata (50%) and Hirudinea (25%).
- At S3, the frequency value varied from 25% (Heteroptera) and 50% (Odonata, Gastropoda) up to 75% (Plecoptera) and 100% (Ephemeroptera, Trichoptera, Diptera, Oligochaeta, Crustacea, Coleoptera).
- At S4, the maximum frequency values were established for Plecoptera, Ephemeroptera, Trichoptera, Oligochaeta, Diptera, Coleoptera and Acarina. The other groups had a lower frequency value (50% - Heteroptera, Gastropoda, Odonata; 25% - Crustacea).

Taking into account the results obtained by applying the Mann-Whitney test, we can advance the hypothesis according to which the effects of pollutant factors were reflected only in changes to the structure and dynamics of benthic macroinvertebrates not in changes to water physical-chemical properties.

The role of certain physical parameters, such as speed and water temperature, may be crucial in structuring benthic organisms (Nilgün & Dügel 2008; Ramesh et al 2009; Getwongsa et al 2010), the station downstream of Băile Herculane dam and town (S1) being characterized by slightly higher physical parameters values as compared to the other sample collecting sites.

The progressive deterioration of water quality is marked by the decrease in the biotic index EPT/Ch value from the witness station (S4) to the station downstream of the town (S1) (see Figure 4). This index is recognized in the scientific literature as one of the indexes reflecting the water pollution degree (Woodcock & Huryn 2005; Pastuchová 2006; Dos Santos et al 2010).

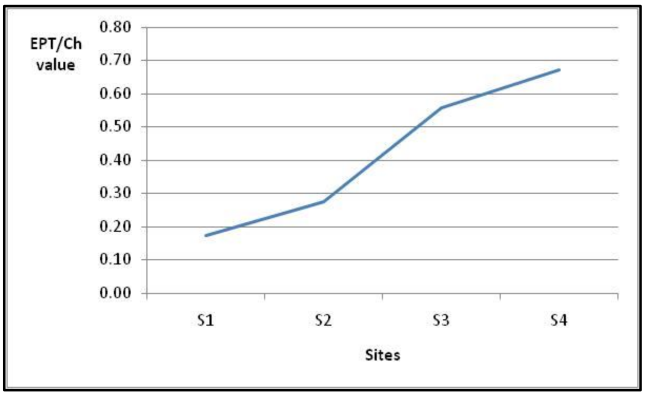

Figure 4. EPT/Ch Biotic Index values in Cerna River, 2010.

Conclusions. 12 Groups of benthic macroinvertebrates were identified: Ephemeroptera, Plecoptera, Trichoptera, Oligochaeta, Diptera, Coleoptera, Acarina, Heteroptera, Hirudinea, Gastropoda, Crustacea and Odonata.

The highest mean density and percentage numerical abundance values were established for Oligochaeta and Diptera at the stations downstream of Băile Herculane dam and town. The community of sensitive organisms (Plecoptera, Ephemeroptera, and Trichoptera) recorded high values in the benthos of stations upstream of the two pollution sources monitored in the present study.

The deterioration of water quality in Cerna River upstream-downstream is emphasized by the calculation of the EPT/Ch biotic index which undergoes similar decrease.

The present study highlights, in all ways, the fact that Băile Herculane storage dam and town has a strong impact on the benthic fauna community.

These findings are not supported by the investigation of physical-chemical factors, since they represent a current situation. Therefore, it is essential that the investigation into the aquatic ecosystem quality should consider the benthic macroinvertebrates community as well.

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