RESEARCH ON THE WATER QUALITY OF THE SASAR RIVER (NW ROMANIA) USING THE NORMALIZED GLOBAL BIOLOGIC INDEX (NGBI)

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Abstract. In order to elaborate the ecologic diagnosis of the Sasar river basin, the Normalized Global Biologic Index (NGBI) was used. This index is standardized in the French normatives of determining the quality of flowing waters [6, 7].

The NGBI method allows the assessment of the general quality of a stream by analyzing the benthic macrofauna, the synthetic expression of the general biologic quality.

The investigated area is mostly included within the industrial perimeter of Baia Mare, where the most significant the most significant is the mining industry.

The maximum amount of the species belonging to the zoobenthic communities were recorded for upstream of Blidari station followed by the Valea Măriuții station. Severe alterations of the macroinvertebrate communities, in decreasing order of the impact intensity, were recorded in the following stations: Valea Firizei, downstream of Baia Sprie, upstream of Baia Mare and downstream of Baia Mare, the main cause being the anthropic perturbations.

Keywords: Normalized Global Biologic Index, taxonomic abundance, anthropic pressure, Romania

INTRODUCTION

The alteration of a flowing water is evidenced by the more or less brutal simplification of the biocenosis [13]. In other words, the structure of the benthic macroinvertebrates can reflect the ecological condition of the respective water course [8] Presently, the macroinvertebrates are organisms that are mostly used in the determination of the biotic indexes which reflect the quality of water bodies [6, 7].

The method of the biotic indices, based on standard tables of invertebrates, was introduced in 1964 by the Trent Biotic Index (TBI). The Trent Biotic Index was fundamental to all the biotic indexes which appeared until now: the Graham Index (1965), the French Biotic Index (1967), the Irish Biotic Index (1972), the Danish Biotic Index (1984), the Extended Trent Biotic Index) (1978) etc. [5].

The French Biotic Index (1967) [12], was at the basis of the General Quality Biologic Index [14] from which the Normalized Global Biologic Index subsequently evolved [16].

In the context in which the Framework Directive 60/2000 of the European Union [17] on the domain of water recommends the member states the developing of some biotic indices, adapted to the conditions of every state, the elaboration of an integrated biotic ecologic index – Romanian Integrated Biotic Index RIBI - was proposed for Romania, which, along with the macroinverebrates communities, to include also the species of fishes [3, 6, 7].

The hydrographic basin of the Sasar River covers a surface of 311 km^2, being situated in the Baia Mare depression, and it is surrounded by the basins of the following rivers: Săpânța to the North, Iza to the East and Lăpuş to the South-West [2].

As about using the land, 73.18% of the surface of the river basin is occupied of forest land, the farming land occupies 18.75% of the area, and the inhabited area represents 8.07% mainly urbane centers (97% of the total of the inhabited area).

Most of the watercourses of the Sasar River basin are located on hilly and highland areas, the dominant lithologic

Substrate being comprised of pebbles and sand. The average annual rainfall is between 500-700 mm, and the average temperature of water varies within the interval of 8-10 ^{0}C.

To obtain the specter of the biocenotic and quality modifications of water of the Sasar river basin, particularly induced by the anthropic factor, there were chosen stations located upriver and downriver of the impurification sources (station upstream of Baia Sprie-2, station downstream of Baia Sprie-4, station Valea Firiza-8, station upstream of Baia Mare-9, station downstream of Baia Mare-10), stations exposed to incidental pollutions (Valea Limpedea-3, Valea Morii-5, Valea Gordanului-6) and stations with reduced or even absent anthropic impact (stations: Valea Mărițiii-1, upstream Blidari-7) (Fig.1).

Figure 1. Location of the sampling stations within the hydrographic basin of the Sasar River (http://en.wikipedia.org)

Table 1. Description of the sampling stations

STATIONS	Valea Măriuţii	Upstream Baia Sprie	Valea Limpedea	Downstream Baia Sprie	Valea Morii	Valea Gordanului	Upstream Blidari	Valea Firiza	Upstream Baia Mare	Downstream Baia Mare
CODE	1	2	3	4	5	6	7	8	9	10
General Information										
Altitude (m)	600	400	450	300	380	360	600	230	220	200
Order	II	II	II	III	II	II	II	III	IV	IV
Temperature of water (ºC)	8.4	8.5	9.0	8.7	9.9	9.8	8.2	8.2	9.8	10.0
Type of watercourse	Medium	Turbulent	Medium	Medium	Medium	Medium	Muddy	Medium	Medium	Calm
Level of water	Medium	Medium	Medium	Medium	Minimum	Minimum	Medium	Medium	Elevated	Elevated
Effluents	N/A	N/A	N/A	Industrial and household	Agriculture	Agriculture	N/A	Industrial and household	Industrial and household	Industrial and household
Substrate composition										
Granulometry (dominant)	Boulders (40-50 cm)	Boulders (40-50 cm)	High sized stones (6-20 cm)	Pebbles	Pebbles	Pebbles	Boulders (40-50 cm)	Slabs	Sand and mud	Mud
Physical Components										
Width (m)	1	3	4	5	1	1	3	25	20	25
Deep (cm)	20	50	30	50	30	30	30	40	40	60
Type of banks	Simple	Steep	Steep	Steep	Terraces	Terraces	Steep	Terraces	Steep	Terraces
Nature of banks	Natural	Natural	Natural	Partially natural	Natural	Natural	Natural	Partially natural	Artificial	Artificial
Vegetation of banks	Arbores	Arbores and shrubs	Arbores	Arbores	Arbores	Arbores	Arbores	Shrubs	Arbores and shrubs	Shrubs and weeds
Nature of the anthropic influence										
Influence type	Surface catchments	N/A	Surface catchments	Regulating works Banks protection Sewage waters	Forest exploitations	Forest exploitations	N/A	Pit Dam Banks protection Sewage waters	Regulating works Banks protection Sewage waters	Regulating works Banks protection Sewage waters
Physical-Chemical Parameters										
Smell	None	None	None	Metals	None	None	None	Metals	Metals	Metals
Color	Blue	Green	Blue-green	Dark green	Green	Green	Blue-green	Beige	Beige	Beige
Transparence	High	Medium	High	Low	High	High	Elevated	Low	Low	Low
pH	7.4	7.6	7.5	7.8	7.6	7.4	8.2	6.0	7.1	7.1
OD (mg/l)	9.13	11.25	9.20	11.00	7.83	6.21	11.00	11.20	10.90	10.70
CBO_5 (mg/l)	2.4	2.9	2.8	2.5	2,9	1.3	2.9	4.3	3.1	3.3
Nitrates (mg N/l)	0.63	0.41	0.30	0.60	1.80	3.00	0.40	0.60	2.62	3.40
Soluble Orto-phosphates (mg P/l)	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.3	0.3

7 campaigns of sampling were carried out during the period of 2003-2006 with a frequency of 2 times per annum, in May and September.

The investigated region is mostly included within the Baia Mare industrial perimeter. Thus, the main pollutant economic branches are represented by the mining and metallurgical industry.

Table 1 synthetically presents the abiotic parameters (hydrologic and physical-chemical elements) which characterize the analyzed stations. The physical-chemical parameters are represented by the annual average values and they are provided by the Waters Maintenance System for 2006.

MATERIALS AND METHODS

The taxonomic abundance and the marker faunistic group are used for the calculation of the NGBI [1], thus obtaining a NGBI grade that can vary between 0-20 [16]. The numerical values comprised within the mentioned interval signify waters of very low, low, medium and excellent quality, according to the following table (Table 2):

Table 2. The interpretation of the results

Quality class	Excellent	Good	Medium	Low	Very low
IBGN	20-17	16-13	12-9	8-5	4-0

The sampling was carried out using the Surber type device of a sampling surface of 1/20 m². Considering that the samplings were carried out in 8 different habitats / station, we could consider a yield of 95% of the total amount of taxons comprised in each station, respectively [16]. For the specific provided evidence of every station the recommended taxonomic unit is the family and sometimes the gene [10].

The diversity indices better detect the instability of the environment factors with the effect on the invertebrate communities, mostly in case of some perturbations of anthropic nature [15], so it was used the most utilized diversity index, Shannon-Wiener (H).

The data statistical processing was carried out using the standard statistical methods, using the SPSS (Statistical Package for the Social Science) application [4].

The physical-chemical analyses of water were carried out in the Laboratory of Chemistry within the Maramures Waters Maintenance System.

RESULTS

According to the physical-chemical analyses carried out in the chemistry laboratory within the Maramures Waters Maintenance System, the analyzed watercourses of the Sasar River basin (Fig. 1) was included within the I-II quality class for the regimen of oxygen and nutrients. Outstanding problems have been recorded for zinc, cadmium, manganese and lead in the Săsar şi Firiza rivers, downstream of the industrialized areas of Baia Sprie, Baia Mare şi Ferneziu, these indicators being situated in the III-V quality classes.

To asses the ecological state of the analyzed stations of the Sasar river basin, the zoobenthic communities were monitored for 4 years (2003-2006). Totally, 7 sampling campaigns were carried out, as 8 saplings/station were carried out in each campaign.

The analyzed watercourses for 2006 belong to the 1^{st}–2^{nd} quality classes for the oxygen and nutrient regimen. Outstanding problems have been recorded for the toxic pollutants (zinc, cadmium, manganese and lead) in the Sasar and Firiza rivers, downstream of the industrial areas of Baia Sprie, Baia Mare, these belonging to the 3^{rd}-4^{th} quality classes.

Table 3 shows the average values of the NGBI, which were determined based on the specific composition during the 4 research years, also keeping the indicator faunistic group.

Although the physical-chemical and hydrologic conditions of the studied biotypes did not vary within very large limits (Table 1), the water quality which was determined according to the NGBI significantly modified from one station to another (for example NGBI 9 for the station upstream of Baia Sprie, NGBI = 11 for Valea Limpedea, NGBI = 12 for the station Valea Morii, NGBI =7 for Valea Gordanului).

According to the Shannon-Wiener (H) index, low specific diversity is found for the Sasar river basin, the recorded values varying between 0.1-1.35.

The Pearson correlation coefficient was used in order to substantiate the association degree among the stations, based on the structure of the benthic invertebrate communities. The interval of the values belongs to -1.00 to +1.00. The "+" sign shows a positive correlation, and the "-" sign shows a negative correlation. Thus, applying the Pearson correlation coefficient, it was remarked that the highest degree of resemblance regarding the structuring mode of the benthic invertebrate communities was between the stations downstream of Baia Mare and Valea Firiza ($r=0.97$; $p<0.001$), followed by the couple of the stations downstream of Baia Mare- upstream of Baia Mare ($r=0.91$; $p<0.001$); then: Valea Limpedea - Valea Gordanului ($r=0.89$; $p<0.001$), Valea Gordanului - Valea Morii ($r=0.89$; $p<0.001$), upstream of Baia Mare-downstream of Baia Sprie ($r=0,82$; $p<0.001$), Valea Limpedea - Valea Mărițiii ($r=0.79$; $p<0.001$), Valea Firiza- upstream of Baia Mare ($r=0.79$; $p<0.001$), upstream of Baia Sprie - down of Baia Sprie ($r=0.75$; $p<0.001$), Valea Limpedea - upstream of Baia Mare ($r=0.73$; $p<0.001$), upstream of Baia Mare - upstream of Baia Sprie ($r=0.73$; $p<0.001$), upstream of Baia Sprie - Valea Firiza ($r=0.68$; $p<0.001$), upstream of Baia Sprie - downstream of Baia Mare ($r=0.66$; $p<0.001$), downstream of Baia Mare - downstream of Baia Sprie ($r=0.52$; $p<0.001$). The highest differences were recorded between the stations downstream of Blidari – upstream of Baia Sprie ($r=-0.42$; $p<0.001$).

Table 3. The NGBI value relative to the nature and taxonomical variety of the benthic macrofauna

Taxon \ Stations	Valea Măriuţii	Upstream Baia Sprie	Valea Limpedea	Downstream Baia Sprie	Valea Morii	Valea Gorda-nului	Upstream Blidari	Valea Firiza	Upstream Baia Mare	Downstream Baia Mare
Chloroperlidae	N/A	N/A	1	N/A	N/A	N/A	1	N/A	N/A	N/A
Perlidae	23	1	11	N/A	15	N/A	8	N/A	N/A	N/A
Taeniopterygidae	4	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Philopotamidae	4	N/A	1	N/A	11	1	N/A	N/A	N/A	N/A
Leuctridae	N/A	N/A	1	N/A	N/A	N/A	2	N/A	N/A	N/A
Glossosomatidae	1	N/A	3	N/A	N/A	N/A	2	N/A	N/A	N/A
Goeridae	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A
Leptophlebiidae	N/A	N/A	1	N/A	N/A	22	4	N/A	N/A	N/A
Nemouridae	11	3	6	N/A	N/A	N/A	1	N/A	N/A	N/A
Sericostomatidae	3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Ephemeridae	9	4	2	N/A	3	N/A	N/A	N/A	N/A	N/A
Heptageniidae	18	15	12	N/A	9	22	6	N/A	N/A	N/A
Polycentropodidae	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A
Rhyacophilidae	9	5	11	N/A	8	2	N/A	N/A	N/A	N/A
Limnephilidae	4	1	8	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hydropsychidae	41	20	29	N/A	28	28	1	N/A	N/A	N/A
Ephemerellidae	N/A	8	12	5	N/A	N/A	N/A	N/A	N/A	N/A
Bäetidae	17	61	16	38	4	9	N/A	2	26	4
Caenidae	N/A	N/A	N/A	N/A	-	4	N/A	N/A	N/A	N/A
Gammaridae	14	17	N/A	N/A	10	76	N/A	N/A	N/A	N/A
Mollusca	N/A	N/A	3	N/A	1	N/A	N/A	N/A	N/A	N/A
Chironomidae	19	43	15	99	9	15	1	25	116	226
Asellidae	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Hirudinea	3	N/A	31	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Oligochaeta	N/A	N/A	N/A	89	N/A	18	N/A	N/A	73	50
Total variety	17	17	14	7	8	13	18	2	3	3
Indicator Group	9	4	7	2	10	3	9	2	2	2
NGBI	14	9	11	4	12	7	14	1	2	2
Quality	Good	Medium	Medium	Very low	Medium	Low	Good	Very low	Very low	Very low

Table 3. Shannon-Wiener (H) diversity index for macroinevertebrate communites from hydrographic basin of the

Station	Average number of taxons	Average number of individuals	Shannon-Wiener (H) diversity index
Valea Măriuţii	17	56	1.35
Upstream Baia Sprie	17	53	1.12
Valea Limpedea	14	48	1.27
Downstream Baia Sprie	7	60	0.47
Valea Morii	8	41	1.01
Valea Gordanului	13	50	0.87
Upstream of Blidari	18	46	1.00
Valea Firiza	2	7	0.10
Upstream Baia Mare	3	47	0.40
Downstream Baia Mare	3	70	0.20

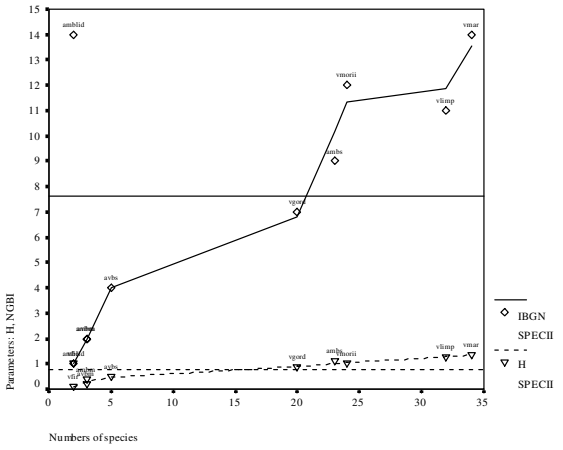

Figure 2. The variation of the parameters: H, NGBI and of the species for each monitored station

DISCUSSIONS

Subsequent to the carried out research, a graduated simplification of the zoobenthic communities was found, as these communities appear totally compromised downstream of the industrial areas of Baia Sprie and Baia Mare.

A number of 45 of pollution sources spill their residual waters into the Sasar and Firiza rivers [9].

Among them, the highest load of volume and chemical content belongs to the industrial enterprises, mainly Romplumb, the flotation plants of Baia Sprie-Tăuţii de Sus and Săsar.

Analyzing the physical-chemical parameters of water, outstanding problems were recorded for the indicators: zinc, cadmium, manganese and lead, mainly for the Valea Firiza station, where the diversity of the benthic communities is also compromised. Extremely affected are also the stations downstream of Baia Sprie, respectively upstream and downstream of Baia Mare, where the level of the benthic diversity is minimum. Most frequently the decrease of the specific component is the consequence of the decline of the water quality and the anthropic activity, implicitly [11].

Although the stations of Valea Morii, Valea Gordanului are located at altitudes which are favorable for the appearance of the majority of the benthonic groups, the diversity of the benthic communities is diminished, this being explained by the industrial noxious air that is guided by the air currents along the valleys, with consequences upon the aquatic life.

We have also to mention that the natural background of the searched area contains polymetallic accumulations, with consequences upon the specific composition, numerical abundance and spatial distribution of the communities studied in the Sasar river basin. Thus is explained the reduced number of the species for the stations with a minimum or absent anthropic impact (Valea Măriuții, upstream of Blidari, Valea Limpedea).

The Shannon-Wiener (H) diversity index shows that a high diversity of the zoobenthic fauna exists for the stations: Valea Măriuții (H=1.35) and Valea Limpedea (H=1.27), these stations being located within areas of minimum anthropic impact. Reduced values of the Shannon-Wiener (H) index were recorded in the stations: downstream of Baia Sprie (H=0.47), upstream of Baia Mare (H= 0.40), downstream of Baia Mare (H=0.20) and Valea Firiza (H=0.10), these stations being located in areas that are affected by the mining and metallurgical industries.

The NGBI grades show good quality water in 2 stations: upstream of Blidari (IBGN=14), Valea Măriuții (IBGN=14); average quality in 3 stations: Valea Morii (IBGN=12), Valea Limpedea (IBGN=11), upstream of Baia Sprie (IBGN=9); very low quality in the station of Valea Gordanului (IBGN=7); and very low quality in 4 stations: upstream of Baia Sprie (IBGN=4), upstream of Baia Mare (IBGN=2), downstream of Baia Mare (IBGN=2), Valea Firiza (IBGN=1).

We can note that the stations of Valea Firiza, upstream of Baia Mare and downstream of Baia Mare resemble very much, as the ecologic conditions resemble and the anthropic pressure has the same nature and intensity.

From the point of view of the structuring mode of the zoobenthic communities, the most stable stations are, in this order: Valea Măriuții (H=1.35), Valea Limpedea (H=1.27), upstream of Blidari (H=1.00). Significant biologic unbalances were recorded, in the decreasing order of the intensity: Valea Firiza (H=0.10), downstream of Baia Mare (H=0.20), upstream of Baia Mare (H=0.40) and downstream of Baia Sprie (H=0.47).

Concluding, based on the obtained NBGI grades and Shannon-Wiener (H) index, the categories of the water quality of the Sasar River Basin can be stated as it follows: good ecologic quality for the stations: Valea Măriuții (H=1.35, IBGN=14) and upstream of Blidari (H=1.00, IBGN=14); mediocre ecologic quality for the stations: Valea Limpedea (H=1.27, IBGN=11), Valea Morii (H=1.01, IBGN=12) and upstream of Baia Sprie (H=1.12, IBGN=9); unsatisfactory ecologic quality for the stations: Valea Gordanului (H=0.87, IBGN=7), downstream of Baia Sprie (H=0.47, IBGN=4), upstream of Baia Mare (H=0.40, IBGN=2), downstream of Baia Mare (H=0.20, IBGN=2) and Valea Firiza (H=0.10, IBGN=1).

REFERENCES

[1] Beisel, J.N., Usseglio-Polatera, P., Thomas, S., Moreteau, J.C., (1998): Influence de l'echantilonnage des communautes macrobenthiques sur l'evaluation de la qualite biologique d'un cours d'eau, Annals Limnol., 34 (4): 445-454.

[2] Boca, M., (1972): Monografia municipiului Baia Mare, Întreprinderea Poligrafică Printing House, Baia Mare, pp. 23-50.

[3] Gheţeu, D., Neagu, A.N., Miron, I., (2005): The use of bioindicators in the assessment of water quality în the catchement area of Bicaz reservoir for the lake ecological diagnosis, Suistainability for humanity & environment in the extend connection field Science-Economy-Policy, Politehnică Printing House, Timişoara, pp. 172-176.

[4] Howitt, D., Cramer, D., (2006): Introducere în SPSS pentru psihologie, Polirom Printing House, Bucharest.

[5] Moog, O., Sharma, S.,(1996): Biological assessment of the water quality in the river Bagmati and its tributaries, Kathmandu valley, Nepal. pp. 23-24 In: Chalise, S.R., (ed.), Extended abstract, International Conference on Ecohydrology oh High Mountain Areas Kathmandu: ICIMOD.

[6] Neagu, A.N., (1999): Contribution a le determination de la qualité des eaux de la riviere Bistriţa et ses effluents par l´indice Biologique Global Normalisé (IBGN), Lacurile de acumulare din România, "Al. I. Cuza" University Press, Iaşi, II: 165-169.

[7] Neagu, A.N., (2004): The effect of sampling protocol on the IBG effect of sampling protocol on the IBGN, (Standardized Global Biological Index) notes for the assessment of running water quality, Studii şi Cecetări de Biologie, Universitatea Bacău, 9: 144-146.

[8] Pavluk, T., (1997): The trophic structure of macroinevertebrate communites as approach for estimation of river ecosystem condition, Research contract No. RI-1811 in Research contract No. RI-1811.

[9] Petrea, D., (2005): Potenţial natural, resurse şi reconversie teritorială în aria de impact a activităţilor miniere din Munţii Igniş, Gutâi şi Văratec, Research Report, Grant no.133, Babeş-Bolyai University, Cluj Napoca, Romania, pp: 14-20.

[10] Tachet, H., Richoux, P., Oournaud, M., Usseglio-Polatera, P., (2000): Invertebrates d´eau douce. Systematique, biologie, ecologie. CNRS Editions, 590 pp.

[11] Tudorancea, M.M., (2004): Ecologia unor populaţii de Chironomidae (Diptera) din râul Someşul Mic şi bazinul de drenaj al râului Crişul Repede, Doctoral thesis, "Babes-Bolyai" University Cluj Napoca, Romania [in Romanian], pp: 62-64.

[12] Verneaux, J., Tuffery, G., (1967): Une methode zoologique pratique de determination de la qualite biologique des eaux courantes, Inidices Biotique, Ann. Scientifiques de L' Universite de Besançon, Fasc. 3: 78-89.

[13] Verneaux, J., Galmiche, P., Janier, F., Monnot, A., (1982): Une nouvelle méthode pratique d'évaluation de la qualité des eaux courantes. Un indice biologique de qualité générale (I.B.G.). Ann. Sci. Univ. de Franche-Comté Besançon, Biol. anim. 4' serie, fase. 3, Note N" 2: 11-21.

[14] Verneaux, J., (1984): Methodes biologique et problemes de la determination des qualites des eaux corantes, in Bull. Ecol., t.15, 1: 47-55.

[15] Washington, H.G., (1984): Diversity, Biotic and Similarity indices. A review with special relevance to aquatic ecosystems, in water Res. Vol. V (6): 653-694.

[16] 1992, AFNOR NF T 90-350, Essai des eaux. Determination de l'Indice Biologique Global Normalise I.B.G.N., 9.

[17] 2000, Directive 2000/60/EC of The European Parliament and of the Council of 23 October 2000 establishing a famework for Community action in the field of water policy.