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New saprobic values for several macroinvertebrates

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Abstract

Numerous methods are used for water quality assessment. We investigated the applicability of the various procedures for the assessment of the biological quality of calcareous based slovenian torrential streams, Grbovic.[1] We compared the saprobic valences of several macroinvertebrate taxons in these waters to the valences given by different authors, Sladecek[2], Wegl[3,4], Moog[5]. Some differences were found for typical bioindicators. We present *some of* the saprobic valences that we propose for the type of rivers considered.

1 Introduction

Slovenia is situated in Central Europe and its area is 20252 km^2. Slovenia has three climates: Middle-European, Alpine, Mediterranean. Slovenia varies in geological and tectonical aspects; 69 % of its area are mountains and hills. 43 % of its area is influenced by erosion because of ground structure, intensity of rainfall and temperature changes. The consequences of erosion are sediment transport and turbidity of water. 23 % of Slovenia consist of karst. Annual average intensity of rainfall is from 750 mm/y to 3300 mm/y. 34 billion m^3 or 1072 m^3/s of water flows on the surface in an average rainy year. Approximately 19 billion m^3 (56 %) of water flow from within the slovene area, and 15 billion m^3 (44 %) of water are transit water originating from outside Slovenia.

2 Biological assessment/monitoring

Biological methods can only indirectly detect causes for a given change. Biological monitoring has become established as an integral part of water quality monitoring. Biological assessments of water quality have proved very successful and even mild, intermittent pollution, frequently missed by routine chemical sampling, has been detected. Physical and chemical properties give a limited picture of water quality at a particular *point in time*, while the living organisms act as continuous monitors of water quality over a *period of time,* Cairns[6]. The trend of quality improvement is first evident in physicochemical analyses and only with some delay in saprobiological analyses. On the contrary, the trend of quality deterioration is usually first shown by saprobiological analyses and only later by physicochemical analyses. Biological monitoring thus not only has a signaling and predictive function but also a controlling function.

For the evaluation of the quality of surface waters from the biological point of view, two methods are being used: the *physiological* and the *ecological* method. The ecological method uses several techniques, one of which is the ***saprobic system***, based on the fact that bioindicators and their quantitative interrelations in any biocoenosis are a clear presentation of the conditions at the examined sampling point.

2. 1 Bioindicators

Bioindicators are species, families or in general taxa whose biology and ecological role (tolerance/sensitivity to charge, pollution) is known and well understood. In ***saprobic system*** a bioindicators is assigned a *saprobic value*, which specifies the water quality class where its most frequently found, and a *weighting factor*, which depends on how spread across different quality classes the presence of the bioindicator is. The *abundance level* of the taxon as found in the sample is also taken into account. A *saprobic value* and a *weighting factor* for many organisms may differ in different biogeographycal regions.

3 Biological monitoring in Slovenia

Slovenian water authorities use the *saprobic index method* (Pantle & Buck[7], Zelinka & Marvan[8]) for biomonitoring. Our classifications based on an examination of periphyton and macroinvertebrates present in water at location, ISO[9], ISO[10], Friedrich[11], DIN[12], Zupan[13]. A basis for our biological evaluation of the water quality of running waters are the ***as complete as possible*** species determination of organisms composing the communities, their semiquantitative determination (abundance scale 1-3-5) as well as the knowledge of their autecology.

The saprobic index is calculated as a weighted average of the densities of all bioindicators from sampling sites. The frequency of occurrence of each taxon at the sampling point, as well as the saprobic value of that bioindicators are expressed numerically. The final frequency estimate of individual bioindicators is determined on the basis of the frequency estimate at the sampling point and the laboratory estimate. The frequency abundance are: 1-rare, 3-frequent and, 5-massive. The preferred trophic degree of the bioindicators by the numerical values as follows: 1-oligosaprobic, 2-betamesosaprobic, 3-alphamesosaprobic and, 4-polysaprobic.

$$SI = \frac{\sum_{i=1}^{n} s_i * h_i * g_i}{\sum_{i=1}^{n} h_i * g_i}$$

s_i - saprobic index of taxon *i*
h_i - abundance level of taxon *i* (1,3,5)
g_i - indicative weight of taxon *i* (1-5)

Results presents in single number (SI value) which reflects the quality of the water. The value of the saprobic index (SI) increases with the deterioration of the living conditions from 1 to 4. Water can be classified into 4 basic classes and 3 intermediate classes (from uncharged to excessively polluted), Table 1.

Table 1: Quality classes according to the value of saprobic index (SI)

Trophic degree	**SI Value**	**Quality class**	**Color**	**Significance**
oligosaprobic	1.0 - 1.5	I	blue	uncharged-very little charged
oligo-betamesosapro	1.51- 1.8	I-II		little charged
betamesosaprobic	1.81- 2.3	II	green	moderately charged
beta-alphmesosapro	2.31- 2.7	II-III		critically charged
alphamesosaprobic	2.71- 3.2	III	yellow	heavily polluted
alpha-polysaprobic	3.21- 3.5	III-IV		very heavily polluted
polysaprobic	3.51- 4.0	IV	red	excessively polluted

Beside the above stated methods for determining the quality of the surface waters, our experience in this field was considered, too, Grbovic[1], Zupan[13]. This method has certain disadvantages which become particularly evident with fast flowing streams, such as the majority od Slovene rivers are. Fast water flow makes for relatively favourable oxygen conditions, even if the waters highly charged with waste matter. In some cases it may become appropriate to complement the saprobic index with a ***personal evaluation*** of specific conditions of the water and the bottom at a particular sampling point. In that case the following factors are considered: increased turbidity, drift, eutrophication, presence of filamentous organisms (heterotrophic:autotrophic), anaerobic conditions on the bottom, formation of ferro-sulphide (FeS) etc.

3.1 Example

Bioindicators identified mostly at the species level. The species or taxa devided into following groups: organisms characteristic of unpolluted water, species dominating in polluted water, pollution indicators and indifferent species. Certain taxa were evaluated on the basis of our own experience while the others that also proved relevant were taken areas that resembled ours. In Slovenia we have only a few our own specific determination keys for aquatic macroinvertebrates (Gastropoda, Lamellibranchiata) so, we must use another

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Table 2: Saprobiological evaluation for several macroinvertebrate taxons

Author/Editor		**Sladecek, 1973**						**Wegl, 1983, 1985**					**Fauna Austriaca, 1995**						**Our experience**
Taxon		**x**	**o**	**b**	**a**	**p**	**S_i**	**o**	**b**	**a**	**p**	**S_i**	**x**	**o**	**b**	**a**	**p**	**S_i**	**S_i**
Ameletus	inopinatus	10	-	-	-	-	**0,1**	10	-	-	-	**1,0**	5	5	-	-	-	**0,5**	**1,0**
Baetis	alpinus	-	8	2	-	-	**0,2**	6	4	-	-	**1,4**	2	4	4	-	-	**1,2**	**1,2**
Baetis	fuscatus	-	-	-	-	-		1	7	2	-	**2,1**	-	+	8	2	-	**2,2**	**2,1**
Baetis	muticus	-	-	-	-	-		-	6	4	-	**1,4**	1	4	5	-	-	**1,4**	**1,4**
Baetis	rhodani	3	3	3	1	-	**1,05**	5	4	1	-	**1,6**	-	2	5	3	-	**2,1**	**2,3**
Baetis	scambus	-	5	5	-	-	**1,5**	2	7	1	-	**1,9**	-	3	7	-	-	**1,7**	**1,5**
Baetis	sp.	-	-	-	-	-		4	5	1	-	**1,7**	-	-	-	-	-		**1,7**
Caenis	macrura	4	4	2	-	-	**0,75**	4	5	1	-	**1,7**	+	3	5	2	-	**1,9**	**1,7**
Caenis	sp.	-	-	-	-	-		3	5	2	-	**1,9**	-	-	-	-	-		**1,9**
Centroptilum	luteolum		2	7	1		**1,85**	2	7	1	-	**1,9**	-	1	7	2	-	**2,1**	**1,9**
Centroptilum	pennulatum	-	-	-	-	-		6	4	-	-	**1,4**	-	1	5	4	-	**2,3**	**1,4**
Cleon	dipterum	-	3	4	3	-	**2,0**	2	5	3	-	**2,1**	+	5	4	1	-	**2,3**	**2,2**
Cleon	simile	-	-	-	-	-		3	6	1	-	**1,8**	+	1	5	4	-	**2,3**	**2,2**
Cleon	sp.	-	-	-	-	-		3	4	3	-	**2,0**	-	-	-	-	-		**2,0**
Ecdyonurus	aurantiacus	-	-	-	-	-		1	7	2	-	**2,1**	-	-	-	-	-		**2,1**
Ecdyonurus	dispar	-	1	7	2	-	**2,15**	2	7	1	-	**1,9**	-	1	7	2	-	**2,2**	**1,9**
Ecdyonurus	forcipula	-	4	5	1	-	**1,65**	5	5	-	-	**1,5**	-	-	-	-	-		**1,7**
Ecdyonurus	helveticus+	-	-	-	-	-		-	-	-	-		3	5	2	-	-	**0,9**	**1,5**
Ecdyonurus	insignis	-	2	6	2	-	**2,0**	3	6	1	-	**1,8**	-	1	6	3	-	**2,2**	**1,8**
Ecdyonurus	sp.	-	-	-	-	-		5	4	1	-	**1,6**	-	-	-	-	-		**1,6**
Ecdyonurus	venosus+	2	5	3	+	-	**1,15**	6	3	1	-	**1,5**	2	4	4	-	-	**1,2**	**1,7**
Epeorus	assimilis	5	4	1	-	-	**0,55**	8	2	-	-	**1,2**	-	-	-	-	-		**1,2**
Epeorus	sylvicola	-	-	-	-	-		9	1	-	-	**1,1**	+	6	4	-	-	**1,4**	**1,4**
Ephemera	danica	1	4	4	1	-	**1,5**	5	4	1	-	**1,6**	+	3	6	1	-	**1,8**	**1,8**
Ephemera	sp.	-	-	-	-	-		2	6	2	-	**2,0**	-	-	-	-	-		**2,0**
Ephemerella	ignita	1	3	3	3	-	**1,95**	2	5	3	-	**2,1**	+	2	5	3	-	**2,1**	**1,9**
Ephemerella	mucronata	-	-	-	-	-		7	3	-	-	**1,3**	+	6	4	+	-	**1,4**	**1,4**

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Table 2, continued

Ephemerella	notata	-	-	-	-	-		2	6	2	-	**2,0**	-	2	6	2	-	**2,0**	**2,0**
Ephemerella	major/belgica	1	4	4	1	-	**1,5**	5	5	-	-	**1,5**	-	4	4	2	-	**1,8**	**1,4**
Habroleptoides	modesta/confusa	3	4	2	1	-	**1,05**	7	2	1	-	**1,4**	+	5	4	1	-	**1,6**	**1,6**
Habrophlebia	fusca	1	4	4	1	-	**1,55**	5	4	1	-	**1,6**	1	4	4	1	-	**1,5**	**1,5**
Habrophlebia	lauta	1	4	4	1	-	**1,55**	6	3	1	-	**1,5**	-	3	4	3	-	**2,0**	**1,5**
Habrophlebia	sp.	-	-	-	-	-		6	3	1	-	**1,5**	-	-	-	-	-		**1,5**
Heptagenia	flava	-	1	6	3	-	**2,25**	2	6	2	-	**2,0**	-	-	7	3	-	**2,3**	**2,0**
Heptagenia	fuscogrisea	-	3	6	1	-	**1,75**	3	6	1	-	**1,8**	-	3	6	1	-	**1,8**	**1,8**
Heptagenia	sulphurea	-	1	6	3	-	**2,25**	2	7	1	-	**1,9**	-	2	6	2	-	**2,0**	**2,0**
Oligoneuriella	rhenana	-	3	6	1	-	**1,75**	2	7	1	-	**1,9**	+	2	7	1	-	**1,9**	**1,9**
Paraleptophlebia	sp.	-	-	-	-	-		5	4	1	-	**1,6**	-	-	-	-	-		**1,6**
Paraleptophlebia	submarginata	-	5	5	-	-	**1,5**	5	4	1	-	**1,6**	-	5	4	1	-	**1,6**	**1,5**
Potamanthus	luteus	-	1	6	3	-	**2,25**	2	6	2	-	**2,0**	-	-	8	2	-	**2,2**	**2,1**
Rhithrogena	semicolorata+	7	3	-	-	-	**0,3**	8	2	-	-	**1,2**	-	3	5	2	-	**1,9**	**1,6**
Rhithrogena	sp.	-	-	-	-	-		8	2	-	-	**1,2**	-	-	-	-	-		**1,2**
Siphlonurus	aestivalis	-	-	-	-	-		2	6	2	-	**2,0**	-	2	6	2	-	**2,0**	**2,0**
Siphlonurus	lacustris	-	-	-	-	-		8	2	-	-	**1,2**	2	4	4	-	-	**1,2**	**1,2**
Siphlonurus	sp.	-	3	4	3	-	**2,0**	5	4	1	-	**1,6**	-	-	-	-	-		**1,6**
Aeschna	isosceles	-	-	-	-	-					-		-	*	-	-	-		**2,0**
Aeschna	sp.	-	-	-	-	-		2	6	2	-	**2,0**	-	-	-	-	-		**2,0**
Anax	imperator	-	-	-	-	-		2	6	2	-	**2,0**	-	2	6	2	-	**2,0**	**2,0**
Agrion/Calopteryx	splendens	-	5	5	-	-	**1,5**	1	6	3	-	**2,2**	-	1	6	3	-	**2,2**	**2,0**
Agrion/Calopteryx	virgo	-	9	1	-	-	**1,1**	3	6	1	-	**1,8**	-	3	6	1	-	**1,8**	**1,9**
Calopteryx	sp.	-	-	-	-	-		3	6	1	-	**1,8**	-	-	-	-	-		**1,8**
Cordulegaster	boltoni	-	-	-	-	-		3	6	1	-	**1,8**	-	5	5	-	-	**1,5**	**1,5**
Gomphus	sp.	-	-	-	-	-		2	6	2	-	**2,0**	-	-	-	-	-		**2,0**
Lestes	viridis	-	-	5	5	-	**2,5**	-	5	5	-	**2,5**	-	-	-	-	-		**2,1**
Onychogomphus	forcipatus	-	-	-	-	-		2	6	2	-	**2,0**	-	3	5	2	-	**1,9**	**2,0**
Platycnemis	pennipes	-	5	4	1	-	**1,55**	1	6	3	-	**2,2**	-	2	6	2	-	**2,0**	**2,1**
Pyrrhosoma	nymphula	-	3	4	3	-	**2,0**	2	5	3	-	**2,1**	-	3	4	3	-	**2,0**	**2,0**

Notes: x-xenosaprobity, o-oligosaprobity, b-betamesosaprobity, a-alphamesosaprobity, p-polysaprobity, S_i-individual saprobic index ones from another countries; from different Alpine countries including flora and fauna of Central Europe.

In this paper we given the diferencies among the saprobic valencies and the individual saprobic index for a several macroinvertebrate taxons, Table 2.

4 Conclusions

Sampling, sorting of organisms, identification and data processing for ***routine biological monitoring*** should be as simple as possible, involving the minimum of time and manpower.

Bioindicators may furthermore differ from country to country, due to biogeographical variety. Bioindicators are, in fact, organisms whose ecological role is relatively well known inside the ecosystems they inhabitate. However only few organisms out of all are thoroughly studied and have a well determinated ecological role. Little is also known about the influence of physical and chemical water properties on many organisms.

The ecology and sensitivity to pollution of many organisms (bioindicators, key-organisms) used in water quality assessments are still very ***inadequately known***, even in those countries with a long tradition of research in freshwater biology. From an ecological and water quality points of view these are important research topics for some upgrading tools, such as artificial intelligence.

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