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BIOTIC INDEX AT SECONDARY EDUCATION LEVEL AND ITS ADAPTATION IN THE SUSTAINABLE DEVELOPMENT (HUNGARY)

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ABSTRACT. During our work we are going to introduce the following methods: using bioindication for high school education, popularizing an effective method for environmental education, providing exercise focused professional knowledge. The Belgian Ministry of Public Health started to use the Belgian Biotic Index method in 1978, which was tested by several laboratories, and used as the official biological water labeling method since 1984. BBI's simplified version, which can be used also for secondary school education, is the BISEL, which is fast, does not require huge investment, and integrates the taxonomy, the ecology and chemistry. We use zoological taxonomy to determinate macroinvertebrate taxa. Familiarizing the program for wider audience should be a good opportunity to educate natural science in a more effective, exercise focused way. Our most important result is that these can be executed by high school students, who should gain routine on field work and water quality monitoring; therefore we can help their environmentally aware development. One of the most important tasks of these schools is to create the chance for the new generation, so they will be able to operate local communities in a sustainable way.

Keywords: BISEL, macroinvertebrate, Belgian Biotic Index, Bódva River, water qualification, environmental education, sustainable development

INTRODUCTION

Nearly 70 high schools, and several non-governmental organizations and education centers (operated by national parks) participated in the BISEL (Biotic Index at Secondary Education Level) national wide environmental action program. Such student groups work in these institutes that do systemic ecological assessments of state on near water flows and rivers with the guidance of teachers and instructors. In the period of ecological crisis the new challenge, the environmental education waiting for educators and general education is being appraised worldwide and even in Hungary. Its aim is to promote and form the environmentally conscientious behavior and the life style which is responsible for the environment for the wider sake of the cause to maintain and improve the quality of human life (Havas, 1993).

There are two main types of biological-method based water labeling studies. One of them is the method, which comes from Europe, and based on the presence of the microscopic indicator species. The other type is the biotic-method, which come from the US, and based on the presence or absence of the macroscopic invertebrate species - living in the water-course (Gabriels et al., 2005). These macro-invertebrate species can be well used to define the water quality, as they can be collected pretty easily, their territory is a small area, and their age is high enough for the concentrated contamination (Kotroczó et al., 2009). The bottom line of these methods is the existence and prevalence of the macro-invertebrates, and the number of identified taxa (De Pauw and Vanhooren, 1983).

The results can be rated on the basis of two things. The first method is the biological and chemical evaluation of the collected data. The second is the importance of the BISEL in the environmental education in high schools. This program has a significant advantage compared to other water labeling studies used in Europe: BISEL is fast, easy to use does not require special expertise, nor huge investment (Borián, 2002), but at the same time it has a solid place in the environmental education. One of the analyses of the results of pedagogic researches (Hines, 1986) shows that those students, who have an environmentally conscientious lifestyle, are familiar with the more important environmental concepts and the actual environmental problems and tasks. They are committed to actions and they also have practice in independent work.

During our work we tried to highlight the possibilities of using the bioindication in high-school education, the popularization of a cheap but extremely efficient method, and a way of providing practice based professional knowledge. We would like to attract attention in Hungary, to talk about the importance of this programme, and to highlight how much these simple inspections can help when students and teachers work together on environmental activities. Introducing this program to wider audience is a good opportunity to make the natural science education more effective, and practice based, and can provide useful information to the environmental activists.

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MATERIALS AND METHODS

Sampling area

The assays were performed around River Bódva, close to Edelény (Hungary). The most remarkable river in this area is the Bódva, which reaches Hungary at Hidvégardó. It's the left bayou of River Sajó, the left tributary of River Sajó can be found in the North Hungarian Mountains and it is 100 km long, approximately. Its' lowest water level is 14cm, the highest is 249cm, which was measured at Komjáth. We started the assay at the end of 2003, and took around 30 samples in 8 different locations during the 5 years.

Fig. 1 Sampling point at River Bódva in Edelény region (Source: Google Earth)

Table 1

Taxonomical groups and its levels to use for identification of BISEL Indexes (Borián, 2002)

Taxonomy groups	Identification levels of the taxonomy groups
Plathelminthes	genus
Oligochaeta	family
Hirudinea	genus
Mollusca	genus
Crustacea	family
Plecoptera	genus
Ephemeroptera	genus
Trichoptera	family
Odonata	genus
Megaloptera	genus
Hemiptera	genus
Coleoptera	family
Diptera	family
Hydracarina	occurence

Collecting macro-invertebrate taxa

The collection of macro-invertebrates was made by standard, metal-framed, cone-shaped, hand-operated net (Borián et al., 2001; Borián, 2002) which had a 300 µm hole-wideness. After selection the identification was made by a stereo-microscope with a magnifying from tenfold to fifty fold. The purpose of the identification is to determine the number of taxonomic units and the presence of the most sensitive fauna groups in the sample. When BBI is used the taxonomic groups are suitable for the taxonomic units designated earlier, on the level of species or family or with the presence of orders and suborders. In consequence the identification of taxonomic units is made in certain practical depths (Table 1).

Use of the BISEL (Biotic Index at Secondary Education Level)

The highest Biotic Index (10) means good water quality and lack of contamination (min. 2 *Plecoptera*- or *Heptogeniidea* species from taxon genus, and min. 16 taxonomic unit). The decrease in the Biotic Index

from 10 to 7 in a river means, that some contamination exists, however it can happen that the absolute value remains pretty low. If the Biotic Index is 5 or less, it not only means polluted water, but the level of contamination is critical. The 10 index can be categorized into 5 water quality classes (I.-V.), which marked with different colors (blue, green, yellow, orange and red). (Class=Biotic Index, color: contamination level; I=10-9, blue, no contamination; II=8-7, green, moderate contamination, III=6-5, yellow, mild contamination /critical/; IV=4-3, orange, heavy contamination; V=2-1, red, very heavy contamination). 0 values show the total lack of bioindicatiors, and shall be marked with black. The index value follows the quality of the water (Rácz et al., 2009b).

In the course of water sampling we need to collect as many creatures as possible. During the processing we identified and counted the collected macroinvertebrate and grouped them based on their responsiveness to different environmental factors. The factors were identified from a standard table defined in BISEL program (Table 2). We examined all the accessible habitats and micro-biotopes on the investigated reach; the subsoil of the water-bottom (sand, silt and stone), the macro vegetation (floating-, underwater- and emerging plants), the inundated roots of trees stretching over the water and every other natural and artificial, floating or submerged object in the water.

Table 2

The standard table used in BISEL Program. The horizontal graduation is corresponded to the observed faunistic groups, ordered from 1 to 7 for the decreasing environmental demands, or according to the increase of tolerance against the contamination (1st column). The most sensitive groups like *Plecoptera*, or *Trichoptera* and *Ephemeroptera* with exosceleton are found in the upper level of the chart. Species with the greatest tolerance are in the bottom of the table, for example *Tubificidae*, *Syrphidae* (*Eristalinae*). The middle groups are *Gammaridae*, *Asselidae*, *Sphaeridae* and *Odonata.*

BISEL
Biotic Index at Secondary Education Level
Comenius 3.1. Socrates educational programme (1995-1999)

I. Indicator groups	II. Sensibility	III. Number of taxa	IV. Total number of taxa 0-1	2-5	6-10	11-15	>16
			Biotic Index				
 (Plecoptera) (Heptageniidae)	1	≥ 2	-	7	8	9	10
		1	5	6	7	8	9
 (Trichoptera)	2	≥ 2	-	6	7	8	9
		1	5	5	6	7	8
 (Ancylidae) (Ephemeroptera) except the Heptageniidae	3	≥ 2	-	5	6	7	8
		1	3	4	5	6	7
 Aphelocherius (Odonata Gammaridae Mollusca except Sphaeridae and Ancylidae	4	≥ 1	3	4	5	6	7
 Asellus Hirudinea Sphaeridae Hemiptera except the Aphelocheirus	5	≥ 1	2	3	4	5	-
 Tubificidae Chironomus thummi-plumosus	6	≥ 1	1	2	3	-	-
 Syrphidae	7	≥ 1	0	1	1	-	-

RESULTS AND DISCUSSIONS

The results can be evaluated based on two aspects: the first method is based on the collected data. In B1 sampling point (Table 3) the BBI value was between 4 and 7, so the water quality was between class II and IV. Class II should be ascribed to the fact, that the sampling happed in late-winter/early-spring time, so there was no high temperature coupling with low oxigen concentration, and the low amount of moisture did not wash impurities into the ground from the nearby dump. At B2 sampling point (Table 4) the BBI values and the water quality classes were pretty similar compared to B1. At B3 (Table 5), where there are no direct pollutant sources, the water quality was pretty good and reached class I and II. The Biotic Index was 7 and 8. We took the biggest number of samples from Point B4 (Table 6), where the water quality was in class III in most of the time. Only a few samples were taken from B6 (Table 7), but the water quality was also around class III, based on the classification of the macroinvertate taxa. We only have samples from B8 (Table 8) in the past few years. At the end of summer, the quality in the heavily polluted category based on the low-level BBI. The other sampling points had balanced and moderate contamination.

We can say that the water quality of Bódva River in the Edelény region was between heavily (IV.) and moderately (II.) contaminated, with an average of III. Among the collected species, we have found several sensitive ones (eg. *Plecoptera*, *Heptageniidea*). During our research in one case we found that the quality of the water wasn't polluted (1st water-quality section) which is due to that we found several individuals from the groups of the most sensitive species in the course of identification and classification.

The second - also important - aspect is the importance of the BISEL in the environmental-focused education in high schools. This program has a great advantage compared to other European water quality studies: BISEL is fast, easy to use, does not require special expertise, nor huge investment, but at the same time it has a solid place in the environmental education. One of the most important lessons of the results is that sustainability can be explained and accomplished most easily in the level of local communities. It is basic that to be active participants in forming their community to sustainable and in its operation in a sustainable way, future generations have to be prepared for this task in schools. The water quality inspections can be started in freshman year of high school. After the motivation – and basic theoretical discussions the students will keenly attend on the area – and laboratory projects during the following years. After collecting and evaluating the data, they can prepare their own project reports, which should be submitted to the national database.

Table 3

Representative macroinvertebrate fauna of River Bódva (Point B1) by taxa-list of BBI

		Point B1						
BISEL list of taxa	**T**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Trichoptera	2		x	x		x			
Asellus	5		x			x			
Amphipoda			x	x			x	x	
Emphemeroptera	2		x	x	x			x	
Tubificidae	6								
Chrysapa perla				x					
Gastropoda	6			x					
*Chironomus**	6			x					
Dytiscidae				x					
Hirudinae				x					
Odonata	4				x				
Hemiptera	5				x				
Chironomidae					x		x		
Diptera					x				
Plecoptera	1					x			
Heptageniidae	1					x	x		
Aphelocherus	4					x			
Gammaridae	4					x			
Nematoda						x			
Hidrachnellae								x	
Planariidea								x	
Heteroptera									
Syrphidae	7								
Total taxa			4	8	5	7	3	4	
BBI:			4	6	6	7	7	5	
Water qual. cl.			IV.	III.	III.	II.	II.	III.	

Table 4

Representative macroinvertebrate fauna of River Bódva (Point B2) by taxa-list of BBI

		Point B2						
BISEL list of taxa	**T**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Tubifcidae	6		x	x					
Odonata	4		x						
Amphipoda			x				x		
Chironomidae	6		x				x		x
Bivalvia	4		x						
Emphemeroptera	3		x						
Culicidae			x						
Heteroptera			x						
Plecoptera	1			x			x		
Hyrophilidae				x					
*Chironomus**	6			x					
Hemiptera	5			x					
Heptageniidae	1						x		
Trichoptera	2						x		
Gastropoda	4						x		
Gammaridae	4								x
Nematoda									x
Syuspetrum vulg.									
Coleoptera									
Total taxa			8	4			6		3
BBI:			5	5			7	4	4
Water qual. cl.			III.	III.			II.	IV.	IV.

Table 5

Representative macroinvertebrate fauna of River Bódva (Point B3) by taxa-list of BBI

		Point B3							
BISEL list of taxa	**T**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Tubificidae	6	x		x	x				
Molluska	4	x							
Odonata	4	x		x	x				
Syrphidea	7	x							
Ephemeroptera	2			x	x				
Plecoptera	1			x	x				
Amphipoda				x	x				
Hirudinea	5			x					
Daphnia				x					
Chironomidae				x					
Gammaridae	4				x				
Trichoptera	2				x				
Heptageniidae	1								
Gastropoda	4								
Heteroptera									
Total taxa		4		8	7				
BBI:		4		8	7				
Water qual. cl.		IV.		I.	II.				

CONCLUSIONS

During our work we are going to introduce the following methods: using bioindication for high school education, popularizing an effective method for environmental education, providing exercise focused professional knowledge. The Belgian Ministry of Public Health started to use the Belgian Biotic Index method in 1978, which was tested by several laboratories, and used as the official biological water labeling method since 1984. With only minimal adaption, it proved to be useful in whole Europe. BBI's simplified version, which can be used also for secondary school education, is the BISEL. The examination of the surface-water contaminations with the application of bio-indicators began with the recognition that there are different species in polluted water and clean water. BISEL is fast, easy, it doesn't need great investments and it integrates taxonomy,

ecology and chemistry. The identification of macro-invertebrates is made by taxonomy and the valuation of water-quality is in connection with the changed environment, completed with chemical researches, so we get exact picture of the condition of our surface waters. Introducing this program to wider audience is a good opportunity to make the natural science education more effective, and practice based, and can provide useful information to the environmental activists.

Table 6

Representative macroinvertebrate fauna of River Bódva (Point B4) by taxa-list of BBI

		Point B4							
BISEL list of taxa	**T**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Odonata	4	x	x			x	x		
Plecoptera	1	x	x		x	x	x		
Gastropoda	4	x	x			x	x	x	x
Trichoptera	2	x	x	x	x	x	x	x	x
*Chironomus**	6	x					x		x
Tubificiade	6	x	x	x	x	x		x	x
Bivalvia			x		x				
Planariidae			x			x			
Amphipoda				x		x		x	x
Hirudinea	5			x					
Chryropa perla				x					
Molluska	4				x				
Heptageniidea	1					x	x		
Aphelocherius						x			
Syuspetrum vulg.						x		x	
Hiteroptera									x
Ephemeroptera	3								x
Hydrachnellae									
Trichoptera	2								x
Total taxa		6	7	5	5	10	6	5	8
BBI:		6	6	6	5	7	5	5	8
Water qual. cl.		III	III	III	III	II.	III	III	III

Table 7

Representative macroinvertebrate fauna of River Bódva (Point B6) by taxa-list of BBI

		Point B6							
BISEL list of taxa	**T**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Heptageniidea	1					x			
Tubificidae	6					x			
Asellus	5					x			
Planariidae						x			
Syuspetrum vulg.						x			
Trichoptera	2					x			
Amphipoda						x			
Asellus aquaticus						x			
Chironomidae									
Bivalvia									
Ephemeroptera	3								
Odonata									
Bivalvia									
Total taxa						8			
BBI:						6			
Water qual. cl.						III.			

Table 8

Representative macroinvertebrate fauna of River Bódva (Point B8) by taxa-list of BBI

	Point B8								
BISEL list of taxa	**T**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Amphipoda								x	x
Ephemeroptera	3							x	
Hydrachnellae								x	
Planariidae								x	
Heteroptrea								x	x
Trichoptera	2							x	
Gastropoda	4								x
Chironomidae									x
Hirudinea	5								x
Plecoptera	1								x
Tubificidea	6								x
Nematoda									
Gammaridae	4								
Hemenoptera	5								
Odonata	4								
Bivalvia									
Total taxa								6	7
BBI:								4	7
Water qual. cl.								IV.	II.

According to our results, in sum we can say that in the examined period considerable water-quality changes weren't typical on the Edelény reach of the river, instead local contaminations occur. Local and temporal pollution cause strongly contaminated water-quality from time to time, which disappears in a short distance. Briefly, we can state that spring rises determine the quality of water and influence the frequency of living beings. On the occasion of floods contaminants leak into the river water from the nearby illegal landfill or from the acutely deposited waste which is also illegal and the circulation on the city reach of the river.

We do not consider the observation of the water-quality through many years, in three seasons as the best result of our work, but that this work was made by 14-18 year-old high school students. The common thinking and action with the experts contributes in a great extent to that students can find solutions on their own to the problems arise during their studies and researches. This cooperation contributes to youth to build a society that loves the environment and nature more. This program supports the use of internet during the biological and professional (environment, forestry and water management) education and it popularize such efficient and cheap educational manners that can be utilized well during the environmental education. BISEL arranges further, accredited educations dealing with bio-indication and it familiarizes the environmental program with teachers beyond the frontiers. It has to be one of the most important tasks of schools to create the possibility and prepare the new generation to be able in an early age to form local communities to be sustainable and to operate them in a sustainable way.

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