NAT. CROAT. | VOL. 19 | No 2 | 389–406 | ZAGREB | December 31, 2010

original scientific paper / izvorni znanstveni rad

SAPROBIC STATUS OF RUNNING WATERS IN CROATIA BASED ON BENTHIC MACROINVERTEBRATES

RENATA ĆUK*[1], IVAN VUČKOVIĆ[1], MARIJA ŠIKORONJA[2], DAGMAR ŠURMANOVIĆ[3], SINIŠA ŠIRAC[4], MLADEN KEROVEC[5] & ZLATKO MIHALJEVIĆ[5]

[1]Hrvatske vode, Central Water Management Laboratory, Ulica grada Vukovara 220, HR-10000 Zagreb

[2]Hrvatske vode, WMD Rijeka, Water Protection Division, Đure Šporera 3, HR-51000 Rijeka

[3]Hrvatske vode, Department of Development, Ulica grada Vukovara 220, HR-10000 Zagreb

[4]Hrvatske vode, General Managers' Office, Deputy of General Manager, Ulica grada Vukovara 220, HR-10000 Zagreb

[5]Department of Zoology, Faculty of Science, University of Zagreb, Rooseveltov trg 6, HR-10000 Zagreb

Ćuk, R., Vučković, I., Šikoronja, M., Šurmanović, D., Širac, S., Kerovec, M. & Mihaljević, Z.: Saprobic status of running waters in Croatia based on benthic macroinvertebrates. Nat. Croat., Vol. 19, No. 2, 389–406, 2010, Zagreb.

In the period 1999–2010 biological investigations were conducted at 369 sampling stations all over Croatia, which included water-quality assessment according to benthic macroinvertebrates, involving 10 institutions. Water quality is assessed according to a type-specific approach which is demanded by the EU Water Framework Directive. From all the investigated sampling stations, 264 sampling stations (71.54%) indicate high or good water quality and therefore meet the requirements of WFD EU. 105 sampling stations (28.46%) indicate moderate or poor water quality, and thus do not meet the requirements of WFD EU.

Key words: saprobic status, running waters, macroinvertebrates, Croatia, WFD

Ćuk, R., Vučković, I., Šikoronja, M., Šurmanović, D., Širac, S., Kerovec, M. & Mihaljević, Z.: Saprobni status tekućica u Hrvatskoj na temelju bentičkih beskralježnjaka. Nat. Croat., Vol. 19, No. 2, 389–406, 2010, Zagreb.

U razdoblju od 1999.-2010. godine provedena su istraživanja koja su obuhvatila i određivanje kakvoće vode na osnovu bentičkih beskralježnjaka na 369 mjernih postaja na području Republike

* Author for correspondence (renata.cuk@voda.hr)

Hrvatske, a u čemu je sudjelovalo 10 institucija. Kakvoća vode je procijenjena prema tip-specifičnoj klasifikaciji graničnih vrijednosti indeksa saprobnosti za bentičke beskralježnjake, koju zahtijeva Okvirna direktiva o vodama (ODV). Od ukupnog broja mjernih postaja, 264 mjerne postaje (71,54%) ukazuju na vrlo dobru ili dobru kakvoću i time zadovoljavaju zahtjeve ODV, dok 105 mjernih postaja (28,46%) ukazuju na umjereno dobru ili slabu kakvoću vode te ne zadovoljavaju zahtjeve ODV.

Ključne riječi: saprobni status, tekućice, bentički beskralješnjaci, Hrvatska, ODV

INTRODUCTION

One of the most important biological and ecological assessment systems for the classification of water quality is the saprobic system which is based on the intensity of decomposition of organic matter in running waters (CASPER & KARBE, 1966). The main sources of organic pollution are municipal and partly industrial waste water (food industry), as well as waste water from agriculture (COPPER, 1993). Organic pollution can be looked at as a significant pressure on aquatic ecosystems (NEDEAU *et al.*, 2003).

The monitoring of water quality by using saprobic indicators (phytoplankton, periphyton and macroinvertebrates) has been applied for more than 30 years in Croatia and has been used for a long period in the entire Danube catchment area (PRIMC-HABDIJA & KEROVEC, 2005). At the beginning, LIEBMANN'S (1962) system was the official one for the purpose of biological assessment of waters in Croatia (NARODNE NOVINE, 15/81). SLADEČEK's (1973) and WEGL's (1983) indicator systems led to a considerable improvement. In the Regulation on Water Classification (NARODNE NOVINE, 77/98) for assessing the water quality according to biological parameters, a Saprobic Index (PANTLE & BUCK, 1955) (SI) is used that is based on the Liebmann or Wegl indicator system, as well as the Biotic Index (WOODIWISS, 1964). In 2008 in the Regulation on Amendments to the Regulation on Water Classification (NARODNE NOVINE, 137/08) the Saprobic Index based on the Wegl indicator system forms the method for water quality assessment, while the Biotic Index was excluded.

The method is based on the presence of indicator species. Different organisms have different tolerance to organic pollution e.g. less sensitive (more tolerant) species inhabit more organically polluted waters. From all the five biological quality elements which are monitored in freshwaters according to WATER FRAMEWORK DIRECTIVE (2000) (WFD EU), macroinvertebrates respond the best to organic pollution. Because of that and some other advantages (ROSENBERG & RESH, 1993) benthic macroinvertebrates are most frequently used in monitoring of freshwaters.

Since the Republic of Croatia, in the process of its accession to the EU, is obliged to implement European standards regarding water management it is necessery to harmonize the system of water quality assessment with the demands of the WFD EU. In order to establish a water quality assessment system harmonized with WFD EU, it is necessary to adjust the existing system to the type-specific approach of WFD EU. Before the implementation of this new European legislation in the field of water policy, surface water types were not taken into consideration either in Europe or in Croatia.

In 2006 Hrvatske vode (Croatian Waters) started the project »Ecological Research into Freshwater in Croatia regarding the criteria of the Water Framework Directive of EU« with the aim of developing a type-specific approach for the assessment of the ecological status including the type-specific class boundaries for every biologi-

cal quality element (macroinvertebrates, periphyton, phytoplankton, macrophytes, fish). The first draft of this project regarding type-specific class boundaries regarding macroinvertebrates (HABDIJA *et al.*, 2008) forms the base of this publication.

The first step in the development of type-specific assessment systems is the definition of type-specific reference conditions for the different types of surface waters. The reference conditions represent the basis for the classification of the ecological status of surface waters. In cooperation with the University of Zagreb, Hrvatske vode has presented the first draft of surface water types in Croatia, based on zoogeographic features according to Illies in which the Republic of Croatia is divided into 2 eco-regions: Dinaric West Balkans (below referred to as the Dinaric eco-region) and the Hungarian lowland (below referred to as the Pannonian eco-region) (ILLIES, 1977). The typology relies on the obligatory abiotic factors (catchment area, altitude, lithology) of the WFD EU and uses also some of the optional factors (flow quantity and permanence, travertine formations, characteristics of running waters in karstic fields). Thus, 52 different abiotic types of running waters have been defined, 20 of which are situated in Pannonian, 11 in the continental sub-eco-region and 21 in the littoral sub-eco-region of the Dinaric eco-region.

For all these types, type-specific reference conditions and class boundaries for the Saprobic Index have been defined.

The aim of this paper is to present the degree of organic pollution of Croatian watercourses expressed by the type-specific Saprobic Index (SI) (PANTLE & BUCK, 1955) as a map based on benthic macroinvertebrates (in the following named 'saprobic map'). Every stretch of a watercourse in Croatia will be assigned a colour representing the type-specific class of water quality regarding organic pollution.

MATERIAL AND METHODS

Macroinvertebrate samples are collected by using a hand net with a mesh size of 500 µm. The sample is preserved with 70% ethanol. Separation and determination are done in the laboratory using a binocular stereomicroscope and adequate keys in order to determine the organisms to the lowest possible taxonomic level. The value of the SI is calculated according to the following formula (PANTLE & BUCK, 1955):

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

s_i – saprobic value (WEGL, 1983)

h_i – relative abundance (h = 1, 3 or 5 if organisms of the taxon are found incidentally, frequently or abundantly, respectively).

The final value of SI is between 1 and 4, where higher numbers reflect greater organic pollution. The type-specific approach is of a great importance since for example a saprobic index with a value of 2.00 in a large lowland river indicates relatively unpolluted water while the same results in a mountain stream indicate significant organic pollution.

All results are depicted in a Saprobic map, made with a geographic information system (GIS). The SI value at a certain sampling station is transferred (extrapolated) to the nearest upstream sampling station or a significant pressure.

In total 369 sites have been sampled (Tab. 2). The majority of the results presented in the saprobic map are obtained from the Central Water Management Laboratory of Hrvatske vode, as a part of the national monitoring programme. Also, the results of some other institutions like public health institutes (Pula, Rijeka, Zadar, Split, Karlovac, Sisak and Osijek) and Bioinstitut Čakovec, which have participated in the national monitoring of biological quality elements, are used in the saprobic map. The values from the sampling stations included in the national monitoring programme are calculated as the mean value of four samplings during two years (2007 and 2008). Furthermore, the saprobic map is completed with the data from various scientific projects conducted by the University of Zagreb between 1999–2007. Finally, the saprobic map also presents the results of a one-time sampling campaign at additional sites never previously investigated.

RESULTS AND DISCUSSION

As part of the Croatian water quality monitoring the first saprobic map was presented in the National Water Management Strategy (Narodne Novine, 91/08). In this map all calculated SI values from the years 2000-2002 including both macroinvertebrate and periphyton communities are presented, using the class-boundaries of SI defined in the Regulation on Water Classification (NARODNE NOVINE, 77/98). At that time, a type-specific approach was not required in a water quality assessment.

With regard to the implementation of the WFD EU, the first draft of a type-specific classification of class boundaries for benthic macroinvertebrates was designed within the project Ecological Research of Freshwater in Croatia regarding criteria of the Water Framework Directive of EU (HABDIJA *et al.*, 2008). For each running water type the reference values of the Saprobic Index have been defined as the base for the saprobiological classification. For the analysis of saprobic reference conditions, dataset analysis of reference sites distributed all over the Croatia and covering nearly all basic stream types was performed. According to the deviation from the reference values, class-boundaries for five classes have being established. Approximations to the next »quarter« of a class are defined with respect to the needs of water management. Stream types that react similarly to organic pollution were grouped together to assign a common value. Stream types with no reference conditions (lowland streams in Istria and in the Panonnian eco-region) were classified according to expert knowledge.

Each class is marked by a certain colour and by short description, in the following way:

Class	Colour and description
I	High
II	Good
III	Moderate
IV	Poor
V	Bad

Tab. 1. Type-specific saprobic index values for five water quality classes for rivers and streams in Croatia, based on benthic macroinvertebrates (Saprobic Index acc. to Pantle-Buck)

	Pannonian eco-region	REF	HIGH	GOOD	MODERATE	POOR	BAD	TYPES
1.	Mountainous streams	1,1	1,3	1,9	2,65	3,2	>3,2	1A
2.	Sub-mountainous small and medium streams	1,4	1,55	2,05	2,75	3,3	>3,3	2A, 2B
3.	Lowland small, medium, large and very large rivers, including Mura and upper part of Sava and Drava	1,75	1,85	2,3	2,9	3,45	>3,45	3A, 3B, 3C, 4A, 4B, 4C, 5A, 5B, 5C, 6A, 7A, 7B, 8A
4.	Lowland large and very large rivers (Danube, lower part of Sava and Drava)	1,85	1,95	2,4	2,9	3,5	>3,5	8B, 9A, 9B, 10
	Dinaric eco-region							
1.	Crenal section of mountainous and sub-mountainous streams	1,1	1,25	1,85	2,6	3,15	>3,15	11A, 11B, 12B, 15A, 15B, 17A
2.	Sub-mountainous and lowland small, medium and large streams	1,4	1,55	2,05	2,75	3,3	>3,30	12A, 12C, 12D, 13A, 13B, 14A, 14B, 14C, 16A, 16B, 18A, 20A, 20B, 21A, 21B, 22A, 23A, 23B, 24A, 26A, 27A, 28A
3.	Lowland small streams	1,5	1,6	2,1	2,75	3,35	>3,35	19A, 25A
4.	Lowland small and medium streams in Istria	1,6	1,7	2,2	2,8	3,4	>3,4	28B, 28C

The 52 described abiotic types of rivers in Croatia are grouped into 8 types, 4 in the Pannonian and 4 in the Dinaric eco-region according to the macroinvertebrate communities (Tab. 1). Fig. 2 shows the saprobic map of running waters in Croatia, in which the SI values are shown as a coloured segments of the rivers and streams.

All available biological data regarding macroinvertebrates suitable for the calculation of the Saprobic Index are represented in the saprobic map. The saprobic values were calculated according to the type-specific classification of SI regarding macroinvertebrates (HABDIJA *et al.*, 2008).

It is also important to point out that Hrvatske vode has arranged continuation of cooperation with the University of Zagreb in December 2008 via the project Testing of biological methods of ecological status assessment (WATER FRAMEWORK DIRECTIVE 2000/60/EC) in representative River basins of the Pannonian and Dinaric eco-regions, which will test suggested indices and methods of assessing the ecological status from the previous project. That means that the first type-specific class-boundaries will be verified, and possibly revised in the second complex research of running waters in Croatia conducted during 2009/2010. Thus, the results presented in this saprobic map are considered to be preliminary. It is important to notice that the investigation of rivers and streams is continuous process. A certain number of rivers and streams have never been investigated and no data on their water quality exist; consequently the saprobic map will be updated with all new data.

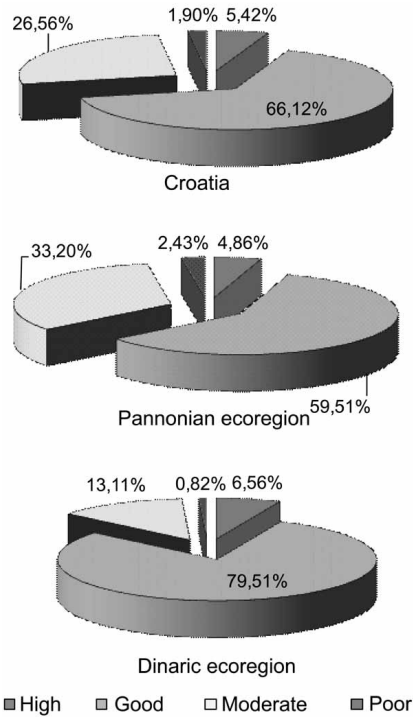

Fig. 1. The share of river water quality classes in Croatia and in Pannonian and Dinaric eco-regions regarding organic pollution

Tab. 2. List of sampling stations in alphabetic order, with the eco-region (abbreviation: D – Dinaric or P – Pannonian) – water type, year of sampling, value of saprobic index and the institution involved (abbreviation: CWML – Central Water Management Laboratory; PHI – Public Health Institute; BIČ – Bioinstitut Čakovec; University – Department of Zoology).

Nr.	sampling station	eco-region – water type	year	IS MZB	institution
1	Baranjska Karašica – Branjin Vrh	P – 4C	2007/2008	**2.31**	PHI (Osijek)
2	Baranjska Karašica – Draž	P – 4B	2006	**2.85**	University
3	Barna – V. Jasenovača	P – 3A	2009	**1.87**	CWML
4	Bedenica – after confluence with the Orešćak	P – 3A	2010	**2.48**	CWML
5	Bednja – Stažnjevec	P – 4A	2007/2008	**2.17**	PHI (Osijek)
6	Bednja – Tuhovec	P – 4B	2007/2008	**2.29**	PHI (Osijek)
7	Bednja – Mali Bukovec	P – 4B	2007/2008	**2.34**	PHI (Osijek)
8	Bednja – Lepoglava	P – 4B	2007/2008	**2.23**	PHI (Osijek)
9	Bić – on the road Velika Kopanica – Vrpolje	P – 4B	2007/2008	**2.31**	PHI (Osijek)
10	Bijela Rijeka – upstream of Sirača quarry	P – 2A	2009	**1.67**	CWML
11	Bijela Rijeka – downstream of sluice	D – 11B	2006	**1.18**	University
12	Bistra Koprivnička – bridge in Molve	P – 4B	2007/2008	**2.12**	PHI (Osijek)
13	Bistra Koprivnička – bridge in Koprivnica	P – 4B	2007/2008	**2.14**	PHI (Osijek)
14	Bistrica – Podgađe Bistričko	P – 3A	2007/2008	**2.29**	CWML
15	Bistrica (Dobra) – upper part	D – 12A	2007	**1.64**	University
16	Bjelovacka – downstream of V. Trojstvo	D – 3A	2010	**1.94**	CWML
17	Bliznec – near the police academy	P – 3A	2007/2008	**2.33**	CWML
18	Bliznec – upstream of Jazbina	P – 3A	2003	**2.26**	University
19	Bokana – Prgomelje	P – 3A	2010	**2**	CWML
20	Boljunčica – mouth	D – 28C	2007/2008	**1.70**	PHI (Pula)
21	Boljunčica – Boljun	D – 28B	2007	**3.22**	University
22	Bosut – upstream of Vinkovci	P – 5C	2007/2008	**2.32**	PHI (Osijek)
23	Bosut – downstream of Vinkovci	P – 5C	2007/2008	**2.22**	PHI (Osijek)
24	Bosut – on the road Rokovci – Andrijaševci	P – 5C	2007/2008	**2.25**	PHI (Osijek)
25	Bosut – Nijemci	P – 5C	2006	**3.32**	University
26	Boščak – on the road Belica – M. Subotica	P – 3A	2007/2008	**2.01**	BIČ
27	Boščak – on the road Domašinec – Kvitrovec	P – 3A	2007/2008	**1.96**	BIČ
28	Bregana – Bregana (lower part)	D – 12A	2007/2008	**1.78**	CWML
29	Bregana – upper part	D – 12A	2008	**1.64**	CWML
30	Bregana – middle part	D – 12A	2008	**1.61**	CWML
31	Breznica – Našička Breznica	P – 3A	2009	**2.02**	CWML
32	Bribišnica – Medare – Žažvić	D – 25A	2007	**1.74**	University
33	Brodec – Peklenica	P – 3A	2007/2008	**2.45**	BIČ
34	Brusovača – upper part	P – 3A	2009	**1.83**	CWML
35	Brzaja – Vučjak Kamenski	P – 2A	2006	**1.72**	University
36	Bukovik – before confluence into Vučica	P – 4B/3A	2009	**2.33**	CWML
37	Butina – spring	D – 15B	2007/2008	**1.82**	PHI (Split)
38	Butišnica – Strmica	D – 15A	2006	**1.66**	University
39	Butišnica – upstream of Golubić	D – 26A	2006	**1.47**	University
40	Butonega – Kršikla	D – 28B	2007	**2.13**	University
41	Cetina – Vinalić	D – 20A	2007/2008	**1.60**	CWML
42	Cetina – Trilj	D – 27A	2007/2008	**2.20**	CWML
43	Cetina – Radmanove Mlinice	D – 23A	2007/2008	**1.83**	CWML

44	Cetina – Čikotina Lađa	D – 27A	2007/2008	**1.83**	CWML
45	Cetina – Obrovac Sinjski	D – 22A	2007/2008	**1.70**	CWML
46	Crna rijeka – 200 m downstream of spring	D – 11B	2006	**1.13**	University
47	Čabranka – mouth	D – 11A	2007/2008	**1.64**	PHI (Rijeka)
48	Čabranka – after Čabar	D – 11A	2007/2008	**1.77**	PHI (Rijeka)
49	Čabranka – spring	D – 11A	2007/2008	**1.55**	PHI (Rijeka)
50	Česma – Obedišće	P – 5B	2007/2008	**2.20**	CWML
51	Česma – Čazma	P – 5B	2007/2008	**2.23**	CWML
52	Česma – Narta	P – 4B	2007/2008	**2.18**	CWML
53	Česma – Siščani	P – 5B	2007/2008	**2.27**	CWML
54	Česma – Pavlovac	P – 4B	2010	**1.99**	CWML
55	Čikola – downstream of Drniš	D – 19A	2007	**1.85**	University
56	Črnec – Miholec	P – 3A	2010	**2.38**	CWML
57	Črnec – Pavlovec Ravenski	P – 3A	2010	**2.1**	CWML
58	Črnec – before confluence with Glogovnica	P – 4B	2010	**2.16**	CWML
59	Dobra – Novigrad na Dobri	D – 14C	2007/2008	**1.71**	PHI (Karlovac)
60	Dobra – Gornje Pokuplje	D – 14C	2007/2008	**1.98**	PHI (Karlovac)
61	Dobra – Lešće	D – 14B	2007/2008	**1.83**	PHI (Karlovac)
62	Dobra – Luke	D – 14A	2007/2008	**1.76**	PHI (Karlovac)
63	Dobra – spring at Bukov vrh	D – 12A	2006	**1.13**	University
64	Dobra – Erdelj – Lešće	D – 14B	2006	**1.58**	University
65	Dobra – Jaškovo	D – 14C	2006	**1.70**	University
66	Dobra – Jarče Polje	D – 14C	2006	**2.11**	University
67	Dragonja – mouth, Kaštel	D – 28B	2007/2008	**1.74**	CWML
68	Drava – biol. min. ak. ČA	P – 3A	2006	**2.81**	University
69	Drava – biol. min. ak. DUB	P – 3A	2006	**2.42**	University
70	Drava – biol. min. ak. VŽ	P – 7A	2006	**2.67**	University
71	Drava – Bistrinci	P – 9A	2007/2008	**2.43**	PHI (Osijek)
72	Drava – Višnjevac (at hippodrome)	P – 9A	2007/2008	**2.85**	PHI (Osijek)
73	Drava – Nemetin (at Tranzit)	P – 9A	2007/2008	**2.75**	PHI (Osijek)
74	Drava – Varaždin	P – 7A	2007/2008	**2.18**	CWML
75	Drava – Donja Dubrava	P – 7A	2007/2008	**2.28**	CWML
76	Drava – Terezino Polje	P – 9A	2007/2008	**2.23**	CWML
77	Drava – Botovo	P – 9A	2007/2008	**2.02**	CWML
78	Drava – Ormož	P – 7A	2007/2008	**2.27**	CWML
79	Drava – Belišće	P – 9A	2007/2008	**2.05**	PHI (Osijek)
80	Drava – odv.knl ak.ČA	P – 3A	2006	**2.43**	University
81	Drava – odv.knl ak.VŽ	P – 7A	2006	**2.56**	University
82	Drava – Donji Miholjac	P – 9A	2007/2008	**2.09**	CWML
83	Dretulja – upstream of Plaški	D – 12A	2007/2008	**1.67**	PHI (Karlovac)
84	Dubočanka – below Tisovac	P – 2A	2006	**1.47**	University
85	Dubočanka – upstream of Velika	P – 2A	2009	**1.61**	University
86	Duboka rijeka – spring	P – 1A	2009	**1.67**	University
87	Dulepski potok – Luka Vrbovečka	P – 3A	2010	**2.04**	CWML
88	Dunav – Borovo	P – 10A	2007/2008	**2.48**	PHI (Osijek)
89	Dunav – border (Cro-Hu)	P – 10A	2007/2008	**2.15**	PHI (Osijek)
90	Dunav – Ilok (bridge)	P – 10A	2007/2008	**2.30**	PHI (Osijek)
91	Dunav – Aljmaš	P – 10A	2004	**2.26**	University
92	Dunjara – downstream of Ivančan	P – 3A	2010	**2.15**	CWML
93	Đedovica – upstream of Voćin	P – 2A	2006	**1.67**	CWML

94	Erpenjščica – Jalšje	P – 3A	2010	**2.07**	CWML
95	Gacka – before merging with Lika	D – 13B	2007/2008	**1.91**	PHI (Rijeka)
96	Gacka – Tonkovićevo vrelo	D – 13B	2007/2008	**2.16**	PHI (Rijeka)
97	Gacka – Čovići – L. lešće	D – 13B	2007	**1.88**	University
98	Gliboki – on the road Koprivnica – Varaždin	P – 3A	2007/2008	**2.62**	PHI (Osijek)
99	Glina – Glina	P – 5B	2007/2008	**2.04**	PHI (Karlovac)
100	Glina – Slana	P – 5B	2007/2008	**1.74**	PHI (Karlovac)
101	Globornica – Generalski Stol	D – 12D	2006	**1.76**	University
102	Globornica – upper part	D – 12D	2007/2008	**1.57**	CWML
103	Glogovnica – Mostari	P – 5B	2007/2008	**2.31**	CWML
104	Glogovnica – on the road Križevci – Sv. Ivan Žabno	P – 3A	2007/2008	**2.32**	CWML
105	Glogovnica – Gradec	P – 4B	2007/2008	**2.54**	CWML
106	Glogovnica – spring, upstream of D. Glogovnice	P – 3A	2006	**2.54**	University
107	Glogovica. Obodni kanal – Slavonski Brod	P – 4B	2007/2008	**2.47**	PHI (Osijek)
108	Gornja Branjinska – Bukovački Antunovac	P – 3A	2009	**1.88**	CWML
109	Gornji potok – on the road Selnica – Praporčan	P – 3A	2007/2008	**2.20**	BIČ
110	Gradiščak – Brezovac	P – 3A	2007/2008	**2.10**	BIČ
111	Gradna – Samobor	D – 12A	2007/2008	**1.92**	CWML
112	Gradna – Savršćak	P – 3C	2007/2008	**2.63**	CWML
113	Grđevica – after V. Grđevac	P – 3A	2010	**2.12**	CWML
114	Horvatska – Veliko Trgovišće (Zabok)	P – 4B	2007/2008	**2.30**	CWML
115	Horvatska – Tuhelj	P – 3A	2010	**2.42**	CWML
116	Ilova – Veliko Vukovje	P – 5B	2007/2008	**2.28**	CWML
117	Ilova – Ilova	P – 5B	2007	**2.35**	University
118	Ilova – downstream of the confluence with the Tomašica	P – 4B	2007/2008	**2.09**	CWML
119	Jalšovečki potok – on the road Bukovje – Štrigova	P – 3A	2007/2008	**2.58**	BIČ
120	Jalšovnica – Ferketinac	P – 3A	2007/2008	**2.05**	BIČ
121	Jankovački potok – Papuk	P – 2A	2006	**1.62**	University
122	Jošava – downstream of Đakovo	P – 4D	2007/2008	**2.88**	PHI (Osijek)
123	Jošava – upstream of Đakovo	P – 3C	2007/2008	**2.76**	PHI (Osijek)
124	Joševica – spring	D – 12A	2007/2008	**1.80**	PHI (Zadar)
125	Jovanovica – upstream of Voćin	P – 2A	2009	**1.55**	CWML
126	Kamešnica – Gregurevec	P – 3A	2010	**2.13**	CWML
127	kanal Bistrec – Rakovnica – on the road Hemuševec – Goričan	P – 3A	2007/2008	**2.07**	BIČ
128	kanal Bistrec – Rakovnica – on the road Donja Dubrava – Kotoriba	P – 4B	2007/2008	**2.05**	BIČ
129	kanal Črnec III – before Sesvetska Sela	P – 3A	2007/2008	**2.43**	CWML
130	Kanal Karašica – Baranja kod Popovca	P – 4C	2007/2008	**2.75**	PHI (Osijek)
131	kanal Komarnica – Molve (bridge)	P – 3C	2007/2008	**2.21**	PHI (Osijek)
132	Karašica – Črnkovci	P – 4B	2007/2008	**2.21**	PHI (Osijek)
133	Kašina – upper course	P – 2A/3A	2009	**1.63**	CWML
134	Kašina – on the road Drenčec – Glavničica	P – 3A	2007/2008	**2.27**	CWML
135	Kopanjek – Kloštar Podravski	P – 4D	2007/2008	**2.32**	PHI (Osijek)
136	Korana – on the road Selišće – Ladvenjak	D – 14C	2007/2008	**2.13**	PHI (Karlovac)
137	Korana – Gaza	D – 14C	2007/2008	**2.09**	PHI (Karlovac)

138	Korana – Velemerić	D – 14C	2007/2008	**1.88**	PHI (Karlovac)
139	Korana – Veljun	D – 14B	2007/2008	**1.86**	PHI (Karlovac)
140	Korana – Slunj	D – 14A	2007/2008	**1.91**	PHI (Karlovac)
141	Korana – Bogovolja	D – 14A	2007/2008	**1.82**	PHI (Karlovac)
142	Korana – Korana (bridge)	D – 14A	2007/2008	**1.91**	PHI (Karlovac)
143	Koruška – upstream of Križevci	P – 3C	2009	**2.3**	CWML
144	Koruška – downstream of Križevci	P – 3A	2009	**2.81**	CWML
145	Kosovčica – spring	D – 15A	2007	**2.35**	University
146	Kosovčica – before Knauf	D – 15A	2007	**1.78**	University
147	Kosteljina – Jalšje	P – 3A	2007/2008	**2.35**	CWML
148	Kosteljina – Lovreća Selo	P – 3A	2010	**2.04**	CWML
149	Kosteljina – upstream of Pregrada	P – 2A	2010	**1.61**	CWML
150	Kotarka (Ličina) – mouth into Vransko jezero	D – 27A	2007/2008	**1.90**	PHI (Zadar)
151	Kraljevečki potok – lower part	P – 2A	2002	**2.5**	University
152	Kraljevečki potok (Medveščak) – Kraljičin Zdenac	P – 2A	2006	**1.37**	University
153	Krapina – Zaprešić	P – 5B	2007/2008	**2.25**	CWML
154	Krapina – downstream of the confluence with the Krapinica	P – 5B	2007/2008	**2.40**	CWML
155	Krapina – Bedekovčina	P – 5B	2007/2008	**2.48**	CWML
156	Krapina – Krapina Selo	P – 5B	2007/2008	**1.95**	CWML
157	Krapina – upstream of Zaprešić, Pojatno	P – 5B	2006	**2.17**	University
158	Krapinica – Zabok	P – 4B	2007/2008	**2.67**	CWML
159	Krapinica – Krapina	P – 3A	2007/2008	**2.59**	CWML
160	Krapinica – upstream of Đurmanec	P – 3A	2007/2008	**2.25**	CWML
161	Krapinjčica – Kamena Gorica	P – 3A	2006	**1.73**	University
162	Krbavica – Krbavica, Krasulja spring	D – 11A	2007/2008	**1.45**	PHI (Zadar)
163	Križ potok – Lazac Lokvarski	D – 11A	2006	**1.83**	University
164	Krka – downstream of Knin	D – 26A	2007/2008	**2.22**	CWML
165	Krka – downstream of HPP Miljacka	D – 23B	2007/2008	**1.60**	CWML
166	Krka – downstream of Skradinski Buk	D – 23B	2007/2008	**2.00**	CWML
167	Krka – spring, Krčić	D – 26A	2007/2008	**1.52**	CWML
168	Krka – Roški slap	D – 23B	2007	**1.59**	University
169	Krupa – Manastir	D – 15B	2007/2008	**1.67**	CWML
170	Krupa – spring	D – 15B	2007/2008	**1.06**	PHI (Karlovac)
171	Kupa – Sisak	P – 6A	2007/2008	**2.10**	PHI (Karlovac)
172	Kupa – Brest	P – 6A	2007/2008	**2.27**	PHI (Karlovac)
173	Kupa – Šišinec	P – 6A	2007/2008	**2.10**	PHI (Karlovac)
174	Kupa – Jamnička Kiselica	P – 6A	2007/2008	**2.05**	PHI (Karlovac)
175	Kupa – Rečica	P – 6A	2007/2008	**2.12**	CWML
176	Kupa – Gornje Pokuplje	D – 14C	2007/2008	**1.96**	PHI (Karlovac)
177	Kupa – Kamanje	D – 14A	2007/2008	**1.89**	CWML
178	Kupa – Bubnjarci	D – 14A	2007/2008	**1.87**	CWML
179	Kupa – Pribanjci	D – 14A	2007/2008	**1.98**	PHI (Karlovac)
180	Kupa – Vodostaj	D – 14C	2007/2008	**2.41**	PHI (Karlovac)
181	Kupa – after confluence with the Kupica	D – 14A	2007/2008	**1.69**	PHI (Rijeka)
182	Kupa – spring (Kupari)	D – 14A	2007/2008	**1.80**	PHI (Rijeka)
183	Kupa – Ozalj-Mahično	D – 14C	2006	**2.66**	University
184	Kupčina – Lazina	P – 4D	2007/2008	**2.55**	PHI (Karlovac)
185	Kupčina – Donja Kupčina	P – 4B	2007/2008	**2.13**	PHI (Karlovac)

186	Kupica – spring	D – 14C	2009	**1.54**	CWML
187	Kutjevačka rijeka – upstream of Kutjevo	P – 2A	2006	**1.83**	University
188	Kutjevačka rijeka – mouth	P – 3A	2009	**2.7**	CWML
189	Lateralni kanal – on the road Čakovec-Mihovljan	P – 3A	2007/2008	**2.31**	BIČ
190	Lateralni kanal Sava-Odra – 3 km from Vukovina	P – 4B	2007/2008	**2.44**	CWML
191	Lendava – Brestić	P – 4B	2007/2008	**2.42**	PHI (Osijek)
192	Lika – before merging with Gacka	D – 13B	2007/2008	**2.10**	PHI (Zadar)
193	Lika – Budak	D – 13B	2007/2008	**1.98**	PHI (Zadar)
194	Lika – Bilaj	D – 13B	2007/2008	**2.21**	PHI (Zadar)
195	Lipovačka Gradna – upstream of Gregurić Breg	D – 12A	2006	**1.59**	University
196	Lisičina – lower part	P – 3A	2009	**2.31**	CWML
197	Lomnica – near the bridge	P – 3A	2007/2008	**2.43**	CWML
198	Lonđa – before the confluence into Orljava	P – 4B	2007/2008	**2.22**	PHI (Osijek)
199	Lonja – upstream of Zelina	P – 4B	2009	**2.3**	CWML
200	Lonja – Lonjica	P – 4B	2009	**2.18**	CWML
201	Lonja – Dubovec Bisaški	P – 4B	2009	**2.26**	CWML
202	Lučelnica – Hruševec Kupljenski	P – 3A	2009	**1.96**	CWML
203	Ljuta – spring. Konavle	D – 15B	2007/2008	**1.70**	PHI (Split)
204	Mala Belica – spring	D – 12A	2007/2008	**1.63**	PHI (Rijeka)
205	Matica – Rastok. Brza Voda	D – 19A	2007/2008	**1.99**	PHI (Split)
206	Matica – Staševica	D – 19A	2007/2008	**2.03**	PHI (Split)
207	Matica (Vrgorska) – Luka	D – 27A	2006	**2.01**	University
208	Milinska rijeka (Česma) – upstream of D. Mikleuš	P – 3A	2007	**2.34**	University
209	Milinski potok – Čukur	P – 3A	2007	**2.29**	University
210	Mirna – Portonski Most	D – 28C	2007/2008	**1.90**	PHI (Pula)
211	Mirna – Kamenita vrata	D – 28C	2007/2008	**1.98**	PHI (Pula)
212	Mirna – spring (Rečica)	D – 28B	2007/2008	**1.83**	PHI (Pula)
213	Mirna – Kotli	D – 28B	2007	**1.95**	University
214	Mirna – Istarske Toplice	D – 28C	2007	**2.18**	University
215	Mislina – bridge	D – 15B	2007/2008	**2.07**	PHI (Split)
216	Mrežnica – Mostanje	D – 14C	2007/2008	**2.20**	CWML
217	Mrežnica – Juzbašići	D – 14A	2007/2008	**1.91**	PHI (Karlovac)
218	Mrežnica – on the road Generalski Stol – Perjasica	D – 14B	2007/2008	**1.89**	PHI (Karlovac)
219	Mrežnica – Zvečaj	D – 14B	2006	**1.92**	University
220	Mrežnica – Belavići	D – 14B	2006	**1.92**	University
221	Mrsunja – on the road Oriovac – Sl. Kobaš	P – 3B	2007/2008	**2.41**	PHI (Osijek)
222	Mura – Goričan	P – 7A	2007/2008	**2.04**	CWML
223	Mura – Peklenica	P – 7A	2007	**1.91**	University
224	Murščak – on the road Domašinec – St. Straža	P – 3A	2007/2008	**2.27**	BIČ
225	Našička rijeka – mouth. at Velimirovac	P – 3A	2009	**3.1**	CWML
226	Norin – spring at Prud	D – 19A	2007/2008	**1.76**	PHI (Split)
227	Odra – Sisak	P – 4B	2007/2008	**2.19**	PHI (Karlovac)
228	Odra – Čička Poljana. bridge	P – 4D	2007/2008	**2.20**	CWML
229	Odra – 500 m after the confluence with the Buna	P – 4B	2007/2008	**2.13**	CWML

230	Ođenica – upstream of Virovitica	P – 3A	2009	**1.9**	CWML
231	Opsenica – Jurjević	D – 12A	2007/2008	**1.84**	PHI (Zadar)
232	Orljava – below highway	P – 5B	2007/2008	**2.47**	PHI (Osijek)
233	Orljava – Pleternica. bridge	P – 5B	2007/2008	**2.68**	PHI (Osijek)
234	Orljava – downstream of Požega	P – 4B	2007/2008	**3.11**	PHI (Osijek)
235	Orljava – upstream of Požega	P – 4B	2007/2008	**2.49**	PHI (Osijek)
236	Orljava – upstream of Požega	P – 4B	2006	**1.91**	University
237	Lonja-Strug – Stružec relief channel	P – 5B	2007/2008	**2.19**	PHI (Karlovac)
238	Lonja-Strug – Trebež relief channel	P – 5B	2007/2008	**2.61**	PHI (Karlovac)
239	Otuča – downstream of Gračac	D – 12A	2007/2008	**2.20**	CWML
240	Pačetina – Začretje	P – 3A	2010	**2.51**	CWML
241	Pakra – Lipik	P – 4B	2007/2008	**2.36**	PHI (Osijek)
242	Pakra – near Lipik	P – 4B	1999	**2.44**	University
243	Pakra – Kusonje	P – 4B	2009	**1.85**	CWML
244	Pazinčica – Dubravica	D – 28A	2007/2008	**1.68**	PHI (Pula)
245	Pazinčica – upper part	D – 28A	2009	**1.96**	CWML
246	Petrinjčica – lower part	P – 4B	2008	**1.86**	CWML
247	Petrinjčica – upper part	P – 2B	2008	**1.71**	CWML
248	Pištanica – Papuk	P – 3A	2006	**1.74**	University
249	Plavnica – upstream of Gugovac	P – 3A	2010	**2**	CWML
250	Plavnica – G. Plavnice	P – 3A	2007	**2.97**	University
251	Plitvica – Kučan Gornji	P – 4B	2007/2008	**2.10**	PHI (Osijek)
252	Plitvica – Veliki Bukovac, bridge	P – 4B	2007/2008	**2.25**	PHI (Osijek)
253	Plitvica – upper part	P – 3A	2009	**1.86**	University
254	Počiteljica – Ornice	D – 13A	2006	**1.62**	University
255	potok Burnjak – Medvednica	P – 2A	1999	**1.75**	University
256	Kraljevečki potok – middle part	P – 2A	2002	**1.92**	University
257	potok Pronjak – Medvednica	P – 2A	1999	**1.75**	University
258	potok Vidak – Medvednica	P – 2A	1999	**1.83**	University
259	Račačka – Stara Rača	P – 3A/4B	2010	**1.99**	CWML
260	Radlovačka rijeka – Papuk	P – 2A	2006	**1.61**	University
261	Radljevac – Radljevac	D – 16B	2006	**1.68**	University
262	Radonja – Tušilović	P – 4B	2007/2008	**2.35**	PHI (Karlovac)
263	Radonja – upstream of Vojnić	P – 2A	2006	**1.77**	University
264	Rakova noga – Medvednica	P – 2A	1999	**1.67**	University
265	Rakovica – Strmec, bridge	P – 3C	2007/2008	**2.74**	CWML
266	Raša – Potpičan, bridge	D – 28B	2007/2008	**2.08**	PHI (Pula)
267	Raša – mouth, at Mutvica	D – 28C	2007/2008	**2.03**	PHI (Pula)
268	Raša (Krbunski potok) – Lukačići	D – 28B	2009	**1.7**	CWML
269	Reka – Lovrečan	P – 3A	2007/2008	**2.28**	CWML
270	Reka – upper part	P – 2B	2007	**1.59**	CWML
271	Ričica – Josetin Most	D – 12A	2007/2008	**1.83**	PHI (Zadar)
272	Rječina – Drastin	D – 20B	2007/2008	**1.57**	PHI (Rijeka)
273	Rječina – spring	D – 16A	2007/2008	**1.59**	PHI (Rijeka)
274	Rječina – Kukuljani, Rijeka	D – 21A	2006	**1.82**	University
275	Rječica (Plitvice)	D – 11A	2002	**1.55**	University
276	Rogoljica potok – Donji Rogolji	P – 2A	2007	**1.61**	University
277	Ruda – upper part	D – 15A	2009	**1.54**	CWML
278	Ruda – mouth into Cetina	D – 22A	2007/2008	**1.82**	CWML
279	Sartuk – Plitvice	D – 11A	2009	**1.61**	CWML

280	Sava – Gunja	P – 9B	2007/2008	**2.19**	CWML
281	Sava – downstream of Županja	P – 9B	2007/2008	**2.24**	CWML
282	Sava – downstream of the confluence with the Bosna	P – 9B	2007/2008	**2.37**	CWML
283	Sava – upstream of the confluence with the Bosna	P – 9B	2007/2008	**2.12**	CWML
284	Sava – downstream of Slavonski Brod	P – 9B	2007/2008	**2.26**	CWML
285	Sava – upstream of Slavonski Brod	P – 8B	2007/2008	**2.18**	CWML
286	Sava – downstream of the confluence with the Vrbas	P – 8B	2007/2008	**2.18**	CWML
287	Sava – upstream of the confluence with the Vrbas	P – 8B	2007/2008	**2.34**	CWML
288	Sava – Košutarica, downstream of the confluence with the Una	P – 8B	2007/2008	**2.35**	CWML
289	Sava – Jasenovac, upstream of the confluence with the Una	P – 8B	2007/2008	**2.27**	CWML
290	Sava – Lukavec, downstream of the confluence with the Kupa	P – 8B	2007/2008	**2.29**	CWML
291	Sava – Galdovo	P – 8B	2007/2008	**2.44**	CWML
292	Sava – Martinska Ves	P – 8B	2007/2008	**2.45**	CWML
293	Sava – Oborovo	P – 8B	2007/2008	**2.36**	CWML
294	Sava – Petruševac	P – 7B	2007/2008	**2.11**	CWML
295	Sava – Jankomir	P – 7B	2007/2008	**2.15**	CWML
296	Sava – Jesenice/D	P – 7B	2007/2008	**2.09**	CWML
297	Sava – upstream of Županja	P – 9B	2007/2008	**2.18**	CWML
298	Severinska – upstream of Nevinac	P – 4B	2010	**1.95**	CWML
299	Sičica. Gornja (Skradska) Dobra – G. Dobra	D – 12A	1999	**1.65**	University
300	Slunjčica – Slunj-Rastoke	D – 14A	2007/2008	**1.88**	PHI (Karlovac)
301	Slunjčica – spring	D – 14A	2007	**1.58**	CWML
302	Sopotnica – Marinići	P – 3A	2010	**1.95**	CWML
303	Spačva – Apševci	P – 4C	2007/2008	**2.35**	PHI (Osijek)
304	Spojni kanal Z-L-G-Č – Poljanski Lug	P – 4B	2007/2008	**2.53**	CWML
305	Srebrnjak – Kerestinec	P – 3A	2007/2008	**2.54**	CWML
306	Sredska – D. Kraj	P – 4B	20010	**1.78**	CWML
307	Stara Drava – Čingi Lingi, left side	P – 3A	2007/2008	**2.30**	PHI (Osijek)
308	Stara Drava – Kopačevo	P – 4B	2007/2008	**2.33**	PHI (Osijek)
309	Starča – Stupnik	P – 3A	2007/2008	**2.35**	CWML
310	Stari Trebež (Pakra) – Trebež	P – 4B	2007/2008	**2.97**	PHI (Karlovac)
311	Stupnica – G. Stupnica	P – 2A	2006	**1.59**	University
312	Sunja – Strmen	P – 4B	2007/2008	**2.25**	PHI (Karlovac)
313	Sunja – Sunja	P – 4B	2009	**2.04**	CWML
314	Sutla – Harmica	P – 4B	2007/2008	**1.98**	CWML
315	Sutla – Zelenjak	P – 4B	2007/2008	**1.87**	CWML
316	Sutla – Prišlin	P – 2A	2007/2008	**2.08**	CWML
317	Sutla – Lupinjak	P – 2A	2007/2008	**1.79**	CWML
318	Suvaja (Brušanka) – Brušane	D – 11A	2007	**1.84**	University
319	Šemnica – downstream of Začretje	P – 3A	2010	**2.37**	CWML
320	Štefanovec – near Nova Bolnica	P – 3A	2007/2008	**2.33**	CWML
321	Štrigovski potok – on the road Čakovec – Štrigova	P – 3A	2007/2008	**2.64**	BIČ
322	Šumetlica – downstream of Nova Gradiška	P – 3A	2009	**2.48**	CWML

323	Šušulić (Vir) – Pitomača	P – 3A	2007/2008	**2.73**	PHI (Osijek)
324	Toplica – upstream of Daruvar	P – 3C	2007/2008	**1.79**	CWML
325	Toplica – Sokolovac	P – 4B	2007/2008	**2.35**	CWML
326	Topličina – Mokrice	P – 3A	2007/2008	**2.63**	CWML
327	Trnava – downstream of the confluence with the Lateralni kanal	P – 3A	2007/2008	**2.77**	BIČ
328	Trnava – on the road Čakovec – state border crossing	P – 4B	2007/2008	**2.20**	BIČ
329	Trnava – on the road M. Subotica – Belica	P – 4B	2007/2008	**2.91**	BIČ
330	Trupinjska Reka – upper part	D – 12A	2007	**1.75**	CWML
331	Trupinjska rijeka – Grabovac Krnjački	D – 12D	2006	**1.91**	University
332	Una – Hrvatska Kostajnica	P – 5B	2007/2008	**2.22**	PHI (Karlovac)
333	Una – Struga	P – 5B	2007/2008	**2.16**	PHI (Karlovac)
334	Una – spring. at Donja Suvaja	D – 12A	2007/2008	**1.64**	PHI (Zadar)
335	Una – Hrvatska Dubica	P – 5B	2009	**1.91**	CWML
336	Veličanka – Požega, bridge	P – 4B	2007/2008	**2.18**	PHI (Osijek)
337	Veličanka – upstream of the quarry	P – 2A	2007/2008	**1.75**	PHI (Osijek)
338	Velika – Mače	P – 3A	2007/2008	**2.03**	CWML
339	Velika – Rajić	P – 4B/4D	2009	**1.5**	CWML
340	Velika – mouth, upstream of the with the Črnec	P – 3A	2009	**2**	CWML
341	Velika Belica – Kužnjak	D – 12A	2009	**1.51**	CWML
342	Vera – Vera (Plaški)	D – 12B	2009	**1.87**	CWML
343	Voćinska rijeka – downstream of Voćin	P – 4B	2009	**1.99**	CWML
344	Vodostaj – spring at Španovica	P – 2A	2006	**1.59**	University
345	Vojlovica – upstream of Đuričić	P – 2A/3A	2007	**1.58**	CWML
346	Vrapčak – downstream of the confluence with the Črnomerec	P – 3A	2007/2008	**2.32**	CWML
347	Vrapčak – on the Vrapčanska road	P – 3A	2007/2008	**2.17**	CWML
348	Vrba – Vrba	D – 16A	2007	**1.94**	University
349	Vrelo Koreničko – Vrelo Koreničko	D – 11A	2007/2008	**1.90**	PHI (Zadar)
350	Vrljika (Matica) – Kamenmost	D – 27A	2007/2008	**1.78**	PHI (Split)
351	Vrljika (Opačac) – spring	D – 24A	2007/2008	**1.92**	PHI (Split)
352	Vučica – Petrijevci	P – 5B	2007/2008	**2.30**	PHI (Osijek)
353	Vučica (Pistanac I) – Klokočevci	P – 4B	2009	**2.21**	CWML
354	Vuka – Tordinci	P – 4B	2007/2008	**2.74**	PHI (Osijek)
355	Vuka – Lipovac Hrastinski	P – 4B	2006	**2.69**	University
356	Vukšenac – upstream of Stubičke Toplice	P – 3A	2010	**1.71**	CWML
357	Zbel – spring	P – 3A	2007/2008	**2.22**	PHI (Osijek)
358	Zbel – on the road Zbelava – Trnovec	P – 3A	2007/2008	**2.05**	PHI (Osijek)
359	Zbel – mouth into Plitvica	P – 3A	2007/2008	**2.08**	PHI (Osijek)
360	Zdela – Molve, bridge	P – 3C	2007/2008	**2.28**	PHI (Osijek)
361	Zelina – Božjakovina	P – 4B	2009	**2.33**	CWML
362	Zrmanja – Vrelo	D – 15A	2007/2008	**1.50**	CWML
363	Zrmanja – Žegar	D – 21A	2007/2008	**1.72**	CWML
364	Zrmanja – upstream of Palanka	D – 20A	2006	**1.78**	University
365	Zrmanja – Radova Draga	D – 20A	2006	**1.93**	University
366	Žbiljski potok – downstream of Žbilj	P – 3A	2010	**1.58**	CWML
367	Žirovnica – Dvor, mouth into Una	P – 4B	2007/2008	**1.89**	PHI (Karlovac)
368	Žumberačka reka – upper part	P – 2B	2007	**1.5**	CWML
369	Županijski kanal – Vaška	P – 4B	2007/2008	**2.21**	PHI (Osijek)

Fig. 2. Cartographic overview of saprobic status of running waters in Croatia based on benthic macroinvertebrates (five classes, acc. to WFD EU).

The objective of the WFD EU for the member states, but also for the Republic of Croatia is the attainment of at least good water status on every water body.

At the moment, the saprobic map is based on 369 sampling stations where macroinvertebrates were sampled and analyzed. From all sampling station, 20 sites (5.42%) indicate high water quality with regard to organic pollution, while 244 sites (66.12%) indicate good water quality. In total, 264 sampling stations (71.54%) meet the requirements of WFD EU. 98 sampling station (26.56%) indicate moderate water quality, while 7 sampling stations (1.90%) indicate poor water quality, which makes a total of 105 sampling stations (28.46%) that do not meet the requirements of WFD EU (Fig. 1).

From all examined sampling stations, 247 (66,94%) are situated in the Pannonian eco-region. 12 sampling stations (4.86%) indicate high water quality while 147 sam-

pling stations (59.51%) indicate good water quality. This means, in total, 159 (64.37%) sampling stations meet the requirements of WFD EU. 82 sampling stations (33.20%) indicate moderate and 6 sampling stations (2,43%) indicate poor water quality which sums up a total of 88 sampling stations (35.63%) in the Pannonian eco-region that do not meet the requirements WFD EU (Fig. 1).

In comparison, 122 (33.06%) of the sampling sites are located in the Dinaric eco-region where 8 sampling stations (6.56%) indicate high and 97 sampling stations (79,51%) good water quality which leads to a total of 105 (86,07%) sampling stations which meet the requirements of WFD EU. On the other hand, 16 sampling stations (13.11%) indicate moderate water quality while only 1 sampling station (0.82%) indicates poor water quality. This means, that only 17 sampling stations (13,93%) in the Dinaric eco-region do not meet the requirements WFD EU (Fig. 1).

The water quality of large lowland rivers like Sava, Drava and Danube is mostly in a good status. Nevertheless, some parts of these rivers are exposed to higher organic pressure due to waste water outlets. The water quality of medium sized inland rivers is mostly also in a good status. Small inland rivers, especially in the Pannonian eco-region mostly deviate from the good quality class regarding SI. Such rivers are characterized by a low water flow over a longer period, thus even a slight organic input causes certain pollution, unlike large rivers.

Unfortunately, in some parts of the country it is still not possible to sample due to mine fields in the investigation area.

CONCLUSIONS AND OUTLOOK

1. The saprobic map is based on 369 sampling stations where macroinvertebrates were sampled and the Saprobic Index was calculated. 10 institutions participated in this process.
2. From all the examined sampling stations in Croatia, 20 sampling stations (5.42%) indicate high water quality, while 244 sampling stations (66.12%) indicate good water quality, which makes a total of 264 sampling stations (71,54%) that meet the requirements of WFD EU.
3. From all the examined sampling stations in Croatia, 98 sampling stations (26.56%) indicate moderate water quality, while 7 sampling stations (1.90%) indicate poor water quality, which makes a total of 105 sampling stations (28.46%) that do not meet the requirements of WFD EU.
4. In the Pannonian eco-region 64.37% from the examined sampling stations meet the requirements of WFD EU, while this number is much higher in Dinaric eco-region and counts 86.07%.
5. Most of the sampling stations that do not meet the requirements of WFD EU are small rivers and streams in the continental part of Croatia.
6. A great number of rivers and streams in Croatia have never been examined, which means that there are no data available about their water quality. Therefore, it is of great importance to investigate as many of these rivers and streams as possible in order to gather valuable faunistic information in general and, in the next step, to allow for a sound assessment of the water quality of these surface waters.

7. With regard to dangerous mine fields in the surrounding area of the sites, a certain number of rivers and streams especially in Slavonia can not yet be investigated.

ACKNOWLEDGEMENT:

We are very grateful to our valued colleague Igor Stanković from Hrvatske vode for his great help regarding working in GIS. Furthermore, we are sincerely grateful to our colleague Predrag Koren, MSc, from Hrvatske vode for helping in the selection new sampling stations in order to complete the saprobic map. Finally, we are very grateful to our German colleagues Dr Stephan von Keitz, Senta Berner and Dr Mario Sommerhäuser for all the valuable advice and opinions that we have received from them over the last few years.

Received October 10, 2010

REFERENCES

CASPER, H. & KARBE, L., 1966: Trophie und Saprobität als stoffwechseldyamischer Koplex. Gesichtspunkt für die Definitio dder Saprobitätsstufen. Archiv für Hydrobiologie. **61**, 453–470.

COOPER, C. M., 1993: Biological effects of agroculturally derived surface –water pollutants on aquatic systems-a review. Journal Environmental Quality **22**, 402–408.

HABDIJA, I., KEROVEC, M., MRAKOVČIĆ, M., PLENKOVIĆ-MORAJ, A. & PRIMC-HABDIJA, B., 2008: Ekološko istraživanje površinskih kopnenih voda u Hrvatskoj prema kriterijima Okvirne direktive o vodama. Prirodoslovno matematički fakultet, Sveučilišta u Zagrebu.

ILLIES, J., 1978: Limnofauna Europaea, Stuttgart: Gustav Fischer Verlag.

LIEBMANN, H., 1962: Handbuch der Frishwasser- und Abwasserbiologie, Band I.-R. Oldenbourg, München, pp. 588.

NARODNE NOVINE, 1981: Uredba o kategorizaciji vodotoka (Ordinance on Categorization of Watercourses). Br. 15/81.

NARODNE NOVINE, 1998: Uredba o klasifikaciji voda (Regulation on Water Classification). Br. 77/98.

NARODNE NOVINE, 1998: Uredba o izmjenama i dopunama Uredbe o klasifikaciji voda (Regulation on Amendments to the Regulation on Water Classification). Br. 137/08.

NARODNE NOVINE, 2008: Strategija upravljanja vodama (Water Management Strategy). Br. 91/08.

NEDEAU, E. J., MERIT, R. W. & KAUFMAN, M. G., 2003: The effect of an industrial effluent on an urban stream benthic community: water quality vs. habitat quality. Enviromental Pollution **23**, 1–13.

PANTLE, R. & BUCK, H., 1955: Die biologische Überwachung der Gewasser die Darstellung der Ergebnisse.-Gas-und-Wasserfach **96**, pp. 604.

PRIMC-HABDIJA, B. & KEROVEC. M., 2005: Biološka valorizacija voda, Primjena Hrvatskog indikatorskog sustava, Prirodoslovno matematički fakultet, Sveučilišta u Zagrebu.

ROSENBERG, D. M. & RESH, V. H. (ed.), 1993: Freshwater biomonitoring and bentic macroinvertebrates. Chapman and Hall, New York, pp 488.

SLADEČEK, V., 1973: System of water quality from the biological point of view. – Archiv für Hydrobiologie **7**, 1–218.

WATER FRAMEWORK DIRECTIVE, 2000: Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy, Brussels.

WEGL, R., 1983: Index für die Limnosaprobität, Wasser und Abwasser, Band 26, Wien, 175 p.

WOODIWISS, F. S., 1964: The biological system of stream classification used by the Trent River Bord. Chemistry and Industry, 443–447.

SAŽETAK

Saprobni status tekućica u Hrvatskoj na temelju bentičkih beskralježnjaka

R. Ćuk, I. Vučković, M. Šikoronja, D. Šurmanović, S. Širac, M. Kerovec & Z. Mihaljević

Indeks saprobnosti je metoda kojom se određuje količina organskog opterećenja u tekućicama. Od svih bioloških elemenata kakvoće, na organsko opterećenje najbolje reagiraju bentički beskralježnjaci (makrozoobentos). Stupanj organskog onečišćenja u vodotocima izražen je vrijednostima P-B indeksa saprobnosti, pri čemu su indikatorske vrijednosti preuzete od Wegla.

Kako je Republika Hrvatska u svom procesu pridruživanja Europskoj uniji dužna preuzeti europske norme i načela u području gospodarenja vodama, potrebno je i sustav ocjenjivanja kakvoće voda i metode biološke valorizacije voda uskladiti sa zahtjevima Okvirne direktive o vodama EU, odnosno, potrebno je metode biološke valorizacije voda prilagoditi tip-specifičnom pristupu, jer do sada postojanje različitih tipova voda na području Europe, pa tako niti u Hrvatskoj, nije bilo uzeto u obzir. Glavna svrha određivanja tipova površinskih voda je omogućavanje definiranja referentnih, prirodnih uvjeta specifičnih za određene tipove površinskih voda. Definiranje referentnih uvjeta predstavlja temelj klasifikacije ekološkog stanja voda. U Hrvatskoj su definirana ukupno 52 različita abiotička tipa naših tekućica, koja su obzirom na specifičnosti makrozoobentoskih zajednica, grupirana u 8 tipova, 4 u Panonskoj i 4 u Dinaridskoj ekoregiji.

Dobivene vrijednosti indeksa saprobnosti makrozoobentosa prenesene su na određene odsječke vodotoka obojene odgovarajućom bojom koja predstavlja određenu tip-specifičnu klasu kakvoće vode s obzirom na stupanj organskog onečišćenja..

Ispitivanje kakvoće vode na osnovu bentičkih beskralježnjaka provedeno je na 369 mjernih postaja, od čega 264 mjerne postaje (71,54%) ukazuju na vrlo dobru ili dobru kakvoću i time zadovoljavaju zahtjeve ODV, dok 105 mjernih postaja (28,46%) ukazuju na umjereno dobru ili slabu kakvoću vode te ne zadovoljavaju zahtjeve ODV.

U Panonskoj regiji nalazi se 247 (66,94%) ispitanih mjernih postaja, od čega 159 (64,37%) zadovoljava uvjete dobre kakvoće vode s obzirom na organsko onečišćenje prema ODV, dok 88 (35,63%) mjernih postaja ne zadovoljava te uvjete. Od 122 (33,06%) mjernih postaja koje se nalaze u Dinaridskoj regiji njih 105 (86,07%) zadovoljava uvjete dobre kakvoće vode s obzirom na organsko onečišćenje, dok 17 (13,93%) mjernih postaja ne zadovoljava te uvjete.

Najveći broj vodotoka koji ne zadovoljavaju uvjete dobre kakvoće vode su manji vodotoci u kontinentalnom dijelu Hrvatske (Panonska ekoregija). Velik broj vodotoka, posebno manjih, nikada nije bio istraživan te ne postoje podaci o kakvoći tih voda.