Development of master curricula in ecological monitoring and aquatic bioassessment for Western Balkans HEIs / ECOBIAS

Task 1.1 REPORT

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Task 1.1 Analysis of Programme Countries Knowledge/Skills/Practice in ecological monitoring and freshwater bioassessment

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As the aim of this task was to investigate and analyze knowledge, skills, and practice in ecological monitoring and bioassessment in Partner Countries, Bosnia and Herzegovina and Montenegro to select priority subject areas for strengthening within the ECOBIAS curricula and LLL trainings, the following report was made.

The EU WFD establishes a legal framework to protect and enhance the ecological status of all waters and protected areas including water-dependent ecosystems, prevent their deterioration, and ensure long-term, sustainable use of water resources. According to the WFDEcological status is an assessment of the quality of the structure and functioning of surface water ecosystems. It shows the influence of pressures (e.g. pollution and habitat degradation) on the identified quality elements. Ecological status is determined for each of the surface water bodies of rivers, lakes, transitional waters, and coastal waters, based on biological quality elements and supported by physico-chemical and hydromorphological quality elements. The overall ecological status classification for a water body is determined, according to the 'one out, all out' principle, by the element with the worst status out of all the biological and supporting quality elements (Table 1).

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Table 1 Surface water bodies, water body category and ecological status of potential

	River						Lake					
RBMP	High	Good	Unknown	Moderate	Poor	Bad	High	Good	Unknown	Moderate	Poor	Bad
2nd	11 767	34 730	5 174	40 854	13 654	5 779	3 957	9 663	1 129	7 904	1 960	790

	River						Lake					
NUTS0	High	Good	Unknown	Moderate	Poor	Bad	High	Good	Unknown	Moderate	Poor	Bad
AT	1 593	2 137	107	3 038	942	248	10	45		6	1	
BE	14	131	14	102	140	126				6	7	5
BG	43	375	78	273	69	35	6	7	6	11	5	2
CY	7	90		73	3	1			3	5		
CZ	4	202	2	560	218	58		9	17	16	20	15
DE	9	598	249	3 257	3 093	1 792	17	174	21	249	192	77
DK	494	1 810	1 918	1 617	844	1 093	50	114	169	189	129	205
EE	4	385	1	205	47	3	4	56		26	3	
ES	591	1 837	81	1 325	402	154	24	132	5	90	32	43
FI	312	914	17	477	153	40	1 122	2 604	80	641	144	26
FR	908	3 886	7	4 199	1 318	388	10	118	31	209	51	16
HR	288	330		290	233	343	11	6		5	3	12
HU	4	71	91	408	279	110	2	12	54	29	15	3
IE	245	1 085	847	597	412	6	293	184	168	112	30	25
IT	369	2 827	1 235	1 934	899	229	10	60	143	124	8	2
LU		3		70	27	10						
LV	1	41		117	37	7	6	51		172	21	9
MT			3						2			
NL		2		80	124	40			3	179	208	61
NO	4 694	7 848	421	4 555	1 585	429	1 160	2 956	421	1 451	369	69
PL	23	1 383	2	2 754	334	90	55	304		553	70	62
PT	52	941	92	543	207	64	1	10		6	6	
RO	1	1 907		976	2	5		94	6	30		
SE	1 846	2 949	1	9 121	947	228	1 071	2 555		3 207	504	85
SI	6	77	3	42	8	1		4		5	3	
SK	55	793		526	126	10						
UK	204	2 108	5	3 715	1 205	269	105	168		583	139	73

1) River basin districts and sub-units as reported in the 2nd RBMPs.
2) For river water bodies, the size value is the length (km). For other water body categories, the size value is the area (km^2).
3) 'Unchanged' water bodies are water bodies that have not been redelineated between the 1st and 2nd RBMP.
4) Percentages per row can only be calculated by number of water bodies.

Bioindication and biomonitoring as a young science have a great tradition in using freshwater biota as reliable indicators of the aquatic ecosystem health. Different groups at a different level of organization (individual, population, community, and ecosystem) have been used worldwide by national water authorities in defining the regional specific routine monitoring programs. Until the early nineties of the last century, the routine monitoring of surface waters in the major part of Europe has mainly comprised the chemical and physical parameters. However, some European countries were using biological parameters as a part of their routine monitoring programs for assessing and classifying the water quality of rivers.

Since then, a wide variety of biologically based stream assessment methods, often using benthic macroinvertebrates, have been developed in many European countries. In general, macroinvertebrates algae and fish are commonly used for constructing routine monitoring programs. However, of all the freshwater organisms that have been considered for use in biological monitoring, benthic macroinvertebrates (mainly consisting of aquatic insects, mites, mollusks, crustaceans, and annelids) are most often recommended (Hellawell 1986, Bonada et al). There are many advantages to using macroinvertebrates in water quality assessment: 1) being ubiquitous, they are affected by perturbations in all types of waters and habitats, 2) Large numbers of species offer a spectrum of responses to perturbations, 3) The sedentary nature of many species allows spatial analysis of disturbance effects, 4) Their long life cycles allow effects of regular or intermittent perturbations, variable concentrations, etc., to be examined temporally 5) Qualitative sampling and analysis are well developed, and can be done using simple, inexpensive equipment, 6.) Taxonomy of many groups is well known and identification keys are available, 7) Many methods of data analysis have been developed for macroinvertebrate assemblages 8) Responses of many common species to different types of pollution have been established, 9) Macroinvertebrates are well suited to experimental studies of perturbation, and 10) Biochemical and physiological measures of the response of individual organisms to perturbations are being developed. Beside all these advantages there are some difficulties which have to be considered: 1)Quantitative sampling requires large numbers of samples, which can be costly, 2) Factors other than water quality can affect distribution and abundance of organisms, 3) Seasonal variation may complicate interpretations or comparisons, 4) Propensity of some macroinvertebrates to drift may offset the advantage gained by the sedentary nature of many species, 5) Perhaps too many methods for analysis available, 6) Certain groups are not well known taxonomically, 7) Benthic macroinvertebrates may not be sensitive to some perturbations, such as human pathogens and trace amounts of some pollutants, and 8) Poorly established relationships between specific stressors and most commonly used metrics (Hauer and Lamberti 2007).

Nixon et al. (1996) analyzed all routine monitoring programs in European countries until 1996. and most of these methods indicate are constructed to detect organic pollution in rivers and streams, indicating eutrophication, acidification, and salinization. In addition, most bioassessment approaches are, however, limited to a single impact factor and are only applicable in a restricted geographic range or for a certain stream type. Therefore, there was a strong need for constructing more complex systems which would consider different impact factors, to enable an integrated assessment of streams. This was important due to diversification of anthropogenic impact on aquatic ecosystems, where organic pollution, once the main anthropogenic factor on streams in past decades, was declining in most European countries and other impact factors, such as deterioration of stream morphology, are becoming increasingly important. Changes in land use, direct exploitation of organisms, climate change, and invasion of alien species are the direct drivers of change in nature which have accelerated with an enormous rate during the past 50 years.

A big breakthrough in the bioassessment research of aquatic ecosystems was the multimetric approach. RBP ((Barbour et al., 1999), AQEM/STAR protocol (AQEM, 2002); www.eu-star.at) are some of the largest projects which had an output in multimetric indices. This type of indices have been commonly used in routine monitoring programs for freshwater and brackish water ecosystems in Europe (Hering et al., 2006, Hering et al., 2004)) and the United States ((Barbour et al., 1999, Davis and Simon, 1995, Hughes et al., 1998, Karr and Chu, 1998, Stoddard et al., 2008)). Multimetric indices simplify complex biological data in the form of individual metrics but keeping a sufficient amount of information regarding the ecosystem's health. One of the first approaches in Europe for water bodies monitoring, based on macroinvertebrates has been the Dutch EBEOSWA (PEETERS et al., 1994), which is now implemented into the Dutch national water quality control system. This approach has metrics related to current velocity, saprobity, trophy and substrate types. However, for some regions of Europe, e.g. Greece and Poland, due to regional specificity, there were no any indices adjusted to the regional specificity. Also, there were some attempts to harmonise and intercalibrate assessment and indication methods within Europe, e.g. between Austria and Germany.

The EU Water Framework Directive (WFD), requires advanced multimeric assessment systems. To determine the ecological status of streams and rivers, aquatic biota, including macrophytes, benthic algae, and phytoplankton, benthic invertebrates and fish were recommended to be used as biological indicators. According to WFD, the detection of the ecological status must have been based on reference conditions, pristine aquatic ecosystems. A major challenge has been, how to obtain a quality score by means of a measure that calculates the distance of the ecosystem towards the reference ecosystem.

The EU funded project AQEM (The Development and Testing of an Integrated Assessment System for the Ecological Quality of Streams and Rivers throughout Europe using Benthic Macroinvertebrates) had the main objective to develop a framework for a future European stream assessment system based on benthic macroinvertebrates. To realized this goal the following tasks were set: to develop and test an assessment procedure for streams and rivers using benthic macroinvertebrates, according to the EU Water Framework Directive; – to outline a European stream typology; – to adapt the assessment method to regional conditions to allow comparable application in all EU member states; – to define quality targets for the ecological status of streams and rivers; – to combine this new assessment method with the methods presently used in the EU member states; – to test the method to applied water management.

The AQEM assessment system currently covers 29 European stream types. It was designed to classify a sampling site into an Ecological Quality Class ranging from 5 (high) to 1 (bad) based on a macroinvertebrate taxa list, which has been obtained from sampling the site using the multihabitat sampling method (Figure 1); To develop the multimetric index a large number of metrics was tested for each of 29 stream types. Metrics were selected according to the extent of their correlation with the degradation gradient. Only metrics that were able to make a difference between reference sites and one or more stress classes were selected as suitable for the multimetric systems.

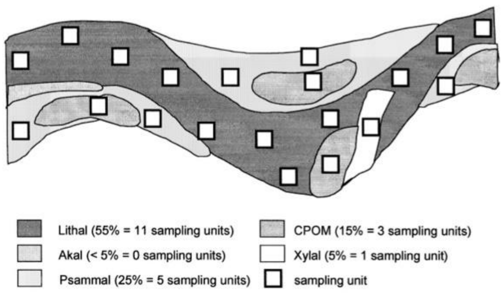

Figure 1 The multihabitat sampling method (Hering et al 2004)

Table 2. Part of the metrics used for the construction of AQEM multimetric system. (Hering et al 2004).

AQEM code	Stream type	Metrics used to assess the ecological quality	Predicted response to increasing perturbation
A01	Mid-sized streams in the Hungarian Plains	organic pollution	
		• Saprobic Index Zelinka & Marvan	increase
		• Number of Ephemeroptera+Plecoptera-taxa	decrease
		• (%) Ephemeroptera+Plecoptera-taxa/total taxa (sp)	decrease
		• (%) Ephemeroptera+Plecoptera individuals / total individuals	decrease
		• Total number of families	decrease
		• Number of sensitive taxa	decrease
		• (%) Littoral+profundal	increase
		• Abundance of Plecoptera	decrease
		• (%) Shredder	decrease
		• Diversity (Margalef)	decrease
A02	Mid-sized calcareous pre-alpine streams	organic pollution	
		• Saprobic Index Zelinka & Marvan	increase
		degradation in stream morphology	
		• Number of EPT-taxa	decrease
		• Total number of taxa	decrease
		• (%) EPT-taxa/total taxa	decrease
		• Number of sensitive taxa	decrease
		• Abundance of Plecoptera	decrease
		• Abundance of Trichoptera	decrease
		• Diversity (Margalef)	decrease
A03	Small non-glaciated crystalline alpine streams	organic pollution	
		• Saprobic Index Zelinka & Marvan	increase
		degradation in stream morphology	
		• Number of EPT-taxa	decrease
		• Total number of taxa	decrease
		• Number of sensitive taxa	decrease
		• Abundance of Plecoptera	decrease
		• Ratio Oligochaeta and Diptera/total-taxa	increase
		• Abundance of Oligochaeta	increase
		• RETI	decrease
		• Diversity (Margalef)	decrease
		• (%) Littoral and Profundal preferences	increase
A04	Mid-sized streams in the Bohemian Massif	organic pollution	
		• Saprobic Index Zelinka & Marvan	increase
		degradation in stream morphology	
		• Number of EPT-taxa	decrease
		• Abundance of all taxa	variable
		• Index of Biocoenotic Region	variable
		• (%)Oligochaeta and Diptera taxa	increase
		• (%) Littoral preferences	increase
		• (%) Gatherers/collectors	increase
		• Total number of taxa	decrease
		• Abundance of Trichoptera	decrease

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The general architecture of a multimetric approach (Figure 2), as applied in the AQEM consists of the following steps: 1. The starting point is the taxa list obtained from the sampling site, which is to be assessed. 2. Based on this taxa list some metrics are ca calculated. 3. Generally, the metric results are individually converted into scores by comparing their values with the values of the same metrics in the stream-type specific referencecondition. 4. Thescoresorresultsofthemetricsarecombinedin a simple multimetric index (usually the average of all scores). This procedure enables the user to view both the final assessment result (Ecological Quality Class) and the individual metric results, allowing further interpretation of the data for future management procedures (Hering et al., 2004)

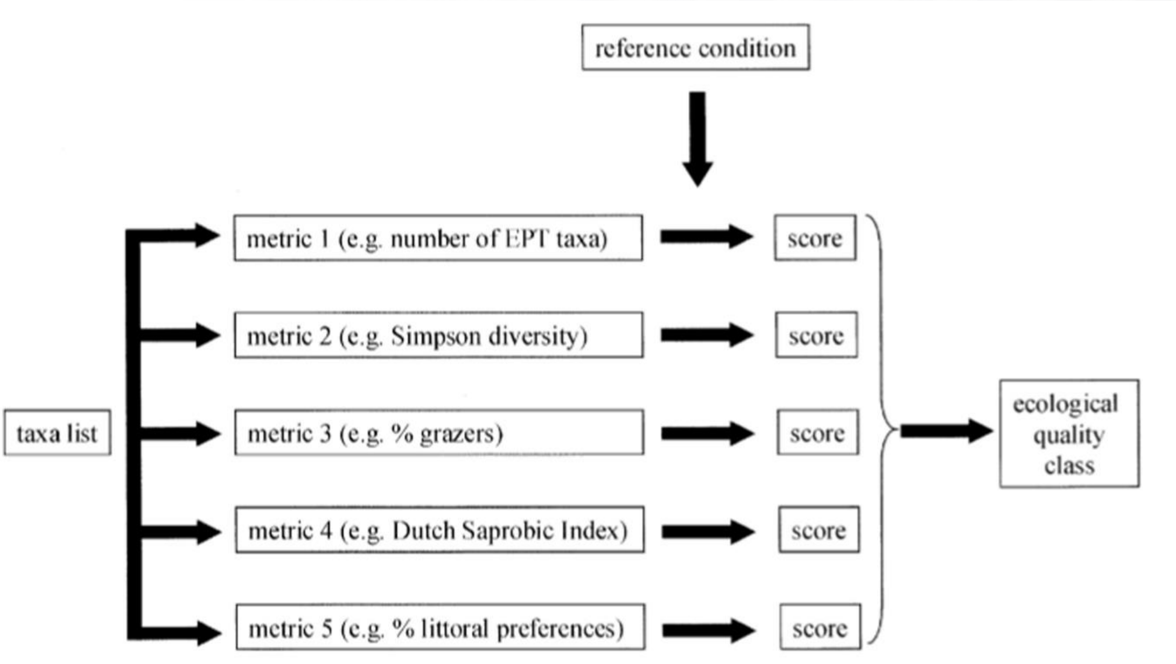

Figure 2 General scheme of a multimetric calculation (Hering et al 2004)

Analysis of Programme Countries knowledge, skills and Practice in, they have exceptional expertise and long tradition in the area of ecological monitoring and freshwater bioassessment. All programme countries perform biomonitoring programmes in accordance with actual EU legislation. This is especially true for Germany, but also Croatia and Serbia who have been successfully implemented methodology proposed by the EU Water Framework Directive (WFD) in the last decade. Moreover, Programme countries have numerous of experts able to access ecological status of water bodies using different biological quality elements.

Thus, Program countries seem to be completely suitable to perform a professional education of future professionals in Bosnia and Herzegovina and Montenegro as Partner countries. Bearing all this qualities of Program countries in mind, ECOBIAS project will undoubtedly improve knowledge, skills and practise in ecological monitoring and bioassessment in Partner countries meeting the WFD criteria.

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Content

ANALYSIS OF EXISTING CURRICULA RELATED TO EMAB IN PROGRAMME COUNTRIES

1. 1. RESULTS OF QUESTIONNAIRES RELATE CROATIAN KNOWLEDGE / SKILLS / PRACTICE IN EMAB

1.1. Hrvatske Vode

Hrvatske Vode conducts the monitoring of macrophytes every year in case of surveillance monitoring and every three year as a part of operational monitoring. Over 400 stations are included in monitoring scheme (natural and modified water bodies, lotic and lentic) so they conduct monitoring continuously, every year during the vegetation season conducts an annual monitoring program where biological components in rivers are sampled once a year, and phytoplankton in some heavily modified water bodies is sampled 3-4 times per year. They monitor phytobenthos and macroinvertebrates, Phytoplankton (including chlorophyll-a) and Zooplankton, also Macrophytes and Ichthyofauna.

Sampling, data collecting and processing is conducted according to the national methodology (Methodology of sampling, laboratory analysis and ecological quality ratio of biological quality elements), which meets the requirements and normative guidelines of the WFD and is in accordance with Regulation on the Water Quality Standard (Official Gazette 96/19).

Monitoring includes natural, artificial or heavily modified lotic waterbodies with catchment area larger than 10 km2, as well as natural, artificial or heavily modified lentic waterbodies larger than 0,5 km2 situated both in Pannonian and Dinaric ecoregion of Croatia. Number and spatial distribution of the sampling points is designated by the State Institution for Water Management "Hrvatske vode" based on the results of the pressure and impact analysis carried out as part of the River Basin Management Plan preparation.

As for macrophytes, at each is necessary to select a representative section of the river or channel, 50 - 100 m long with no visible external disturbances (e.g. bridges and other structures, estuaries, disturbed banks, etc.). Selected section should represents general watercourse characteristics in the studied section. Here, the length of the section depends on the general ecological conditions of the watercourse. If the conditions are uniform, monitored sections can be longer and if the conditions change more frequently along the watercourse (e.g. waterfalls, changes in slope, substrate, surrounding vegetation and shade, etc.), shorter sections are monitored. In case when conditions change frequently along the watercourse, several smaller sections can be sampled. Monitoring of large rivers includes sampling along the 500 m long sections and one to three km long sections in case of very large rivers. Generally, sampling should start at one point and continue 50 m upstream. After that, sampling is considered finished when no new species can be recorded 25 m upstream from the already sampled section. Natural and artificial lakes are monitored using 100 m long and 2-6 m wide transects. Transects are perpendicular on the waterbody margin and expand to the depth where macrophytes are no longer present. If the whole waterbody bottom is covered with, aquatic vegetation transects need to be made across the whole waterbody.

Monitoring shall be carried out regularly unless the monitoring carried out earlier has shown that the water body concerned has been in good condition and that there is no indication from the impact assessment of human activities that this impact has changed. (In such cases, monitoring is carried out during every third river basin management plan.)

According to the last report, the ecological status of surface water in Croatia was determine within the survey, conducted from 2016 to 2018. where all sampling stations were sampled at least ones Table 2. Out of all sampling stations, the ecological status was determined for 83% samples.

Table 2 Sampling network for monitoring of surface waters in Croatia (Barbalić et al., 2019)

Sampling stations	Republic of Croatia		Adriatic river basin district		Daube basin district		Sava basin district		Drava and Danube sub-basin district	
	No	%	No	%	No	%	No	%	No	%
Sampling stations without data	92	17	13	12	79	18	68	21	11	10
Sampling stations with data	452	83	97	88	355	82	259	79	96	90
Total number of sampling stations	544	100	110	100	434	100	327	100	107	100

In comparison to the results of previous campaign in 2015, number of sampling stations in the campaign within the period 2016-2018) was substantially increased (83%).

The results of monitoring, based on biological elements to assess the ecological status where the following (Fig 3):

1. good ecological state was confirmed for 15 % of sampling stations, included in the campaigns from 2015. to 2018.

2. The ecological state was improved for 8% of surveyed sampling stations. Biological metrices which indicated bad poor and moderate state were based on

macroinvertebrates and macrophytes. Decrease of ecological state was caused by habitat degradation and organic pollution.

3. Bad, poor and moderate state were recorded in 55% of surveyed sampling sites which indicated that applied measures did not reach expected impact.

4. High ecological state was determined in only 2 surveyed sampling stations.

5. 15% of sampling stations were not included in the monitoring campaign (Barbalić et al., 2019)

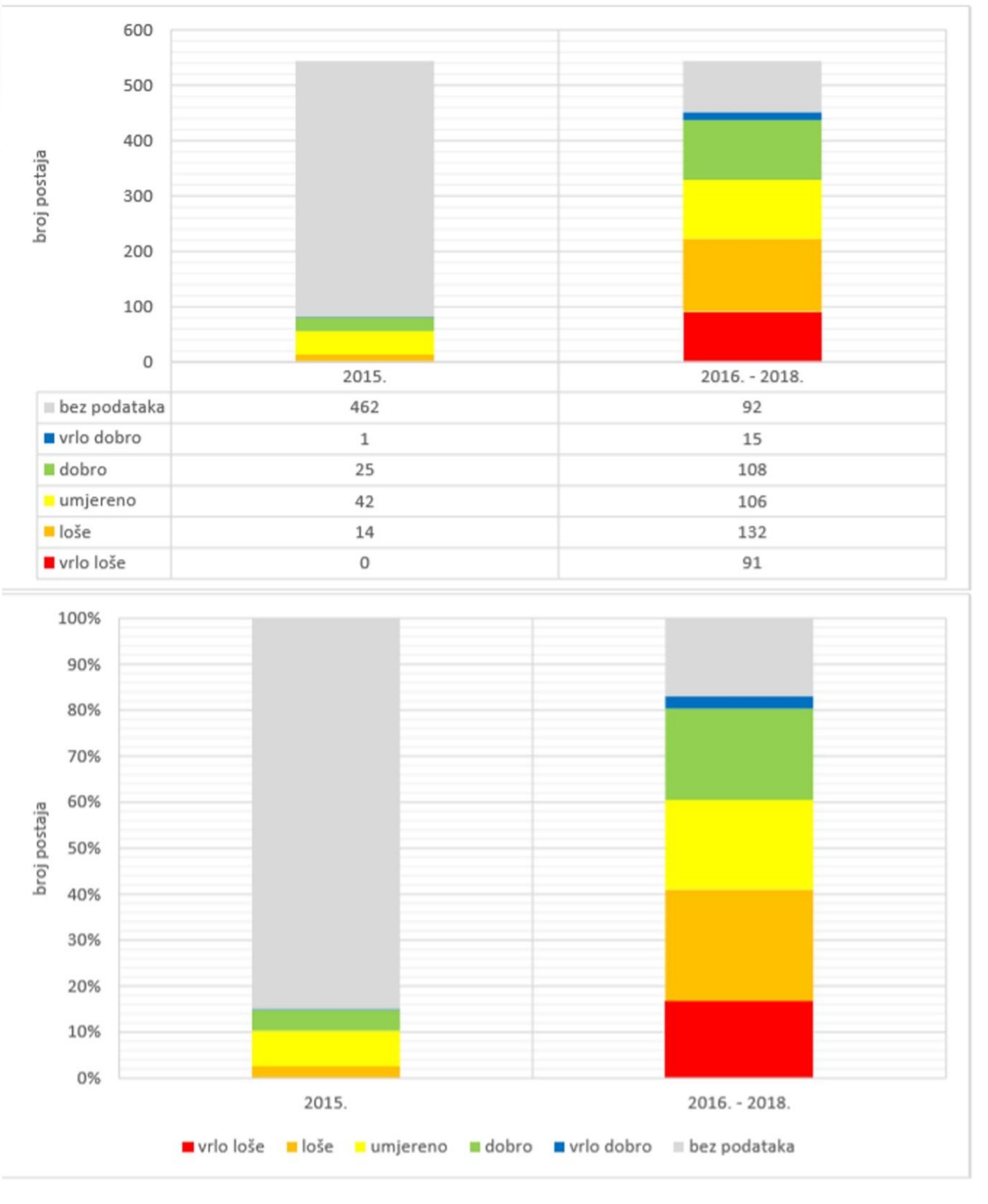

Figure 3. Ecological status calculated from the biological metrices in rivers from 2015 to 2018 (Barbalić et al., 2019).

2 RESULTS OF QUESTIONNAIRES RELATE SERBIAN NOWLEDGE / SKILLS / PRACTICE IN EMAB

2.1 THE SERBIAN ENVIRONMENTAL PROTECTION AGENCY

Adoption of Water Law in 2010 (Official Gazette of the Republic of Serbia 30/2010) and following bylaws acquired adequate conditions on harmonization of monitoring of surface water status in the Republic of Serbia with the Water Framework Directive (2000/60/EC) requirements

National Water Bylaws adopted in the 2010-2014 period:

1.Regulation on establishment of surface and groundwater bodies (Official Gazette of the RS 96/2010)

2.Regulation on reference conditions of surface water types (Official Gazette of the RS 67/2011)

3.Regulation on the parameters of ecological and chemical status of surface waters and parameters of chemical status and quantitative status of groundwaters (Official Gazette of the RS 74/2011)

4.Regulation on emission limit values of polluting substances in surface and groundwaters and deadlines for their achievement (Official Gazette of the RS 50/2012)

5.Regulation on emission limit values of priority and priority hazardous substances which pollute surface waters and deadlines for their achievement (Official Gazette of the RS 24/2014)

The first Programme of surface water monitoring status in Serbia harmonized with the WFD requirements was carried out in 2012.

The Serbian Environmental Protection Agency conducts monitoring once time per year (Table 3).

Table 3. Annual frequency of water quality elements investigation (Veljković, 2018)

Biological quality elements	Rivers & AWB	Lakes	Reservoirs
Macroinvertebrates	**2**	**2**	**2**
Phytobenthos	**2**	**2**	**2**
Phytoplankton	**6***	**4**	**4 (3)**
Macrophytes	**-**	**-**	**-**
Ichtyofauna	**-**	**-**	**-**
General physico-chemical elements	**12 (10-12)**	**4**	**4 (3)**
Specific non-priority polluting substances	**12 (10-12)**	**4**	**4 (3)**
Hydromorphological quality elements			
hydrological regime	water level and flow		
river flow continuity	**-** **-**		
morphological conditions	**-** **-** **-** **-**		

The Serbian Environmental Protection Agency (SEPA) monitors following biological quality elements: phytoplankton, phytobenthos and benthic invertebrates. For sampling and data processing they used the following standard and calibrated methods:

1.SRPS EN 15204:2008

2.SRPS EN 14407:2008

3.SRPS EN 16695:2016

4.SRPS EN 16698:2016

5.SRPS EN 13946:2008

6.SRPS EN 27828:2009

7.SRPS EN 16150:2013

Macroinvertebrates sampling is conducted according to the SRPS EN 27828:2009, using hand nets (25x25cm, 500µm mesh size) and following AQEM protocol (AQEM Consortium, 2002) and MHS "multi-habitat" sampling procedure. Taxa identification is performed using binocular magnifiers Leica MS 5 and Carl Zeiss SteREO Discovery.V8 with camera and applying ZEN 2 Pro Microsope and Imaging Software. Data processing is conducted using ASTERICS v. 4.0.4 software.

Only diatom communities are used for indicative ecological status/potential assessment. Sampling and pretreatment of benthic diatoms are performed according to the SRPS EN 13946: 2008. Identification, enumeration and interpretation of benthic diatom samples are carried out according to the SRPS EN 14407: 2008. Taxa identification is performed mostly to the species level. For diatom indices calculation OMNIDIA v 5.3 software is used.

Finally, phytoplankton sampling and preserving are done in accordance with the following standards: SRPS EN ISO 5667-1:2008, SRPS EN ISO 5667-3:2007, SRPS ISO 5667-6:1997 и SRPS ISO 5667-4:1997. Samples for qualitative analysis: using plankton nets, 25 µm mesh size. Samples for quantitative analysis: by taking of 250 ml of water from surface layer of river. Quanitative analysis is performed according to the Utermöhl method (1958) and the SRPS EN 15204:2008. measurement of chlorophyll-a according to the SRPS ISO 10260. After two-month period diatoms are collected from the substrates.

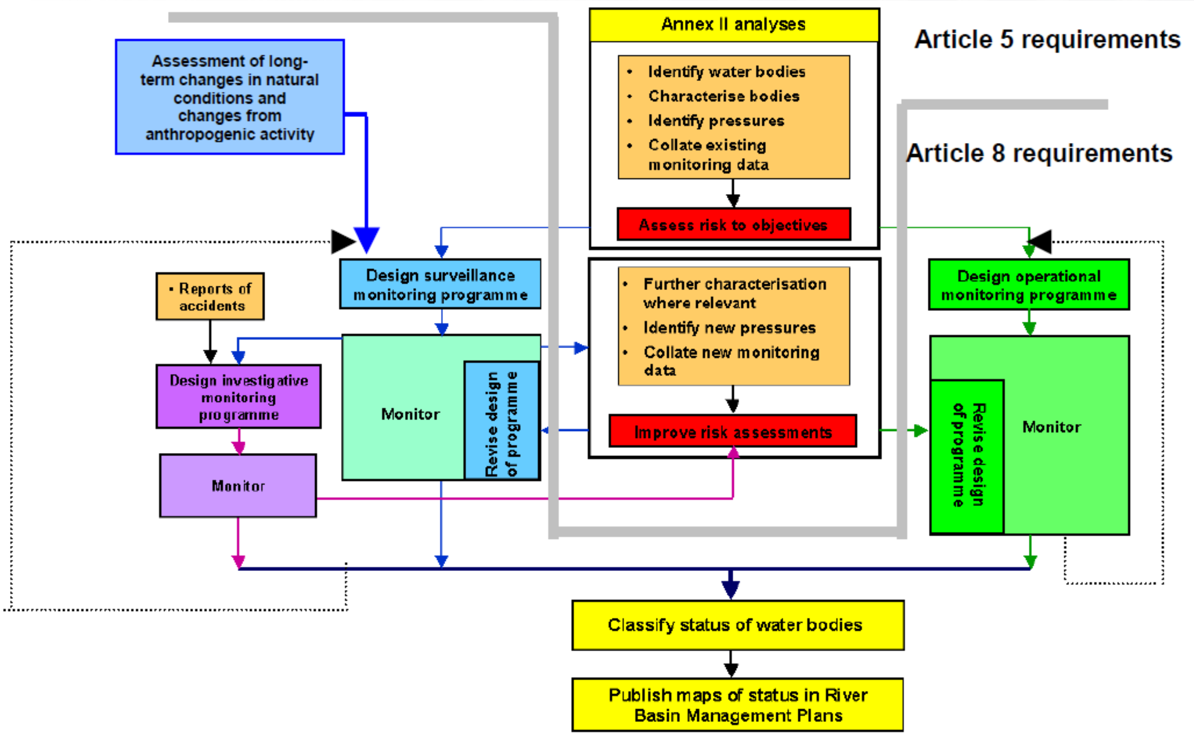

Figure 4. The design of surgae water monitoring programmes in Serbia (Veljković, 2018)

Table 4. The standard and calibrated methods for collecting and processing the data used.(Veljković, 2018)

BQE	Parameter	Unit	Waterbody type
Phytoplankton	Cyanobacteria	%	Type 1; lakes; reservoirs; AWB
	Chrysophyta	%	lakes; reservoirs; AWB
	Bacillariophyta	%	Type 1; lakes; reservoirs; AWB
	Xanthophyta	%	lakes; reservoirs; AWB
	Cryptophyta	%	
	Dinophyta	%	
	Euglenophyta	%	Type 1; lakes; reservoirs; AWB
	Chlorophyta	%	
	abundance	cell mL^{-1}	Type 1; lakes; reservoirs; AWB
	phytoplankton biomass, chlorophyll *a*	µg L^{-1}	
Phytobenthos	[1]IPS		All waterbody types; lakes; reservoirs; AWB
	[2]CEE		
	[3]EPI-D		
Benthic invertebrates	Zelinka&Marvan Saprobic Index		All waterbody types; lakes; reservoirs; AWB
	BMWP Score		Type 1, 2, 3, 4, 5; lakes; reservoirs; AWB
	ASPT		Type 1, 2, 3, 4, 5; lakes above 200 m a.s.l.
	Shannon-Weaver Diversity Index		Type 1, 2, 3, 4, 5; lakes; reservoirs; AWB

	Oligochaeta-Tubificidae	%	All waterbody types; lakes; reservoirs and AWB
	EPT Taxa		Type 2, 3, 4, 6; lakes above 200 m a.s.l.; reservoirs formed on waterbody Types 2, 3, 4
	No. of sensitive taxa (Austrian list)		Type 1, 2, 3, 4, 5, 6; lakes above 200 m a.s.l.
	Total no. of taxa		All waterbody types; lakes; reservoirs and AWB
	No. of families		Type 3
	No. of bivalve species		Type 1; lakes below 200 m a.s.l.; reservoirs formed on waterbody Type 1
	No. of Gastropoda species		Type 1, 5; lakes below 200 m a.s.l.; reservoirs formed on waterbody Type 1
Additional parameter for lakes and reservoirs	Trophic State Index (Carslon's)		Lakes and reservoirs

The first Programme of surface water monitoring status in Serbia harmonized with the WFD requirements was carried out in 2012. A total of 498 surface water bodies were determined in the territory of the Republic of Serbia, of these 493 surface water bodies were grouped into the following categories: rivers, heavily modified water bodies (HMWB), artificial water bodies (AWB) and 5 lakes. The selection of operational and surveillance monitoring stations was done based on the WFD requirements (Annex V, 1.3.1; 1.3.2). Fifty surveillance monitoring stations were selected which represent the "basis" of water monitoring network as well as should provide the whole water status survey within the catchment areas (the Morava, the Sava and the Danube River Catchment Area).

In 2012, 90 water bodies were included in the Operational Monitoring Programme (42 water bodies are also surveillance monitoring stations) (Figure 7). In the 2012-2014 period, monitoring of surface water status was carried out in total of 149 water bodies in Serbia. The results are given in the following publication: https://www.sepa.gov.rs/download/VodeSrbije/StatusPovrsinskihVodaSrbije/ The sampling stations were distributed throughout the whole country. In 2019 a total of 77 samplings stations within 52 river basins were covered in Serbia. It depends from year to year. For large rivers and reservoirs usually 3, up to 10 sampling stations at the Danube River. For small and medium streams and rivers usually one sampling station per river.

Although the conducted monitoring programmes in 2012, 2013 and 2014 covered only 30% of water bodies, selection of surveillance and operational monitoring stations of each river catchment areas fulfills the criteria for water body classification in order to obtain representative review of ecological and chemical status in Serbia. The obtained results were presented for the type of large rivers (Danube, Sava, Tisza, Tamiš and Drina), Danube-Tisza-Danube (DTD) Canal System, basins of large rivers (Velika Morava, Južna and Zapadna Morava, Kolubara, and the tributaries of Danube in the Iron Gates stretch with Timok River), reservoirs and lakes.

Quantitative analysis of monitoring realization showed that 57% of river water bodies have not yet covered by previous monitoring programmes, whilst for the canals (AWB) this percentage is somewhat lower (38%). The results of ecological status/potential assessment of lakes and reservoirs in Serbia also indicates high percentage of water bodies which are not covered by previous monitoring programmes (66% of the reservoirs and 60% of the lakes respectively). In the investigated period (2012-2016), 40% of lake water bodies are characterized by poor ecological status, whilst for the reservoir water bodies the water quality is somewhat higher (moderate-18%, poor-11% and bad-9%). Generally, only 3% of stream and river water bodies in the 2012-2016 period covered by monitoring programmes are characterized by good ecological status.

The ecological status/potential assessment data analysis provides that large rivers and large river basin areas situated in the Danube River Catchment Area (the Danube RCA) had unsatisfied water quality with domination of moderate and poor ecological status/potential. Water quality of the Danube-Tisza-Danube (DTD) Canal System was unsatisfied, too, due to, besides moderate and poor ecological status, bad ecological status was determined at 17% of water bodies. Similar water quality had water bodies of the right Đerdap tributaries with the Timok River (high percentage of water bodies in bad ecological status (22%)). In the Drina and the Kolubara River Basin (the Sava RCA) as well as the Južna Morava, the Zapadna Morava and the Velika Morava River Basin (the Morava RCA) the streams and rivers are characterized by higher water quality due to the assessed ecological status/potential (besides moderate and poor ecological status/potential, 29% of water bodies in the Drina River Basin, 3% in the Kolubara, 6% in the Velika Morava, 6% in the Zapadna Morava and 7% in the Južna Morava River Basin are characterized by good ecological status/potential (Figure 5, 6)(Veljković, 2018).

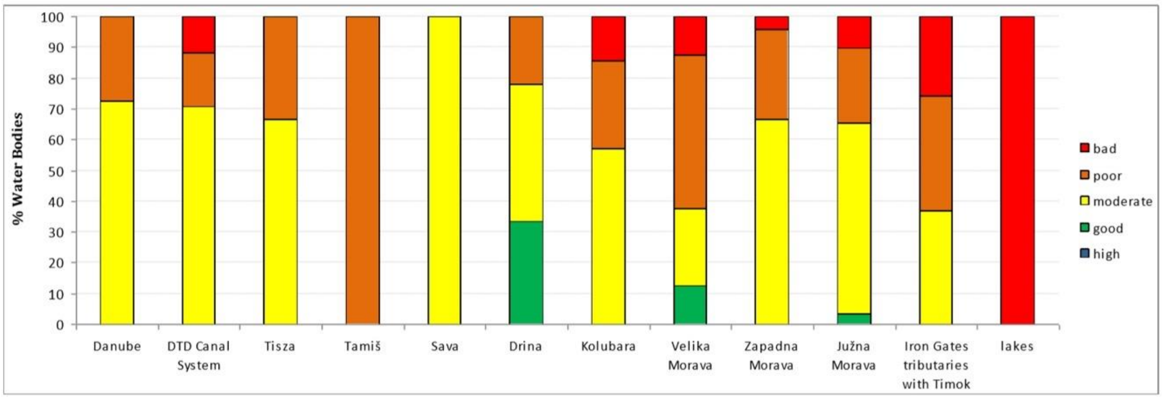

Figure 5. Percentage participation of water bodies with respect to ecological status assessment in large rivers, river basins and lakes in the 2012-2014 period (Veljković, 2018)

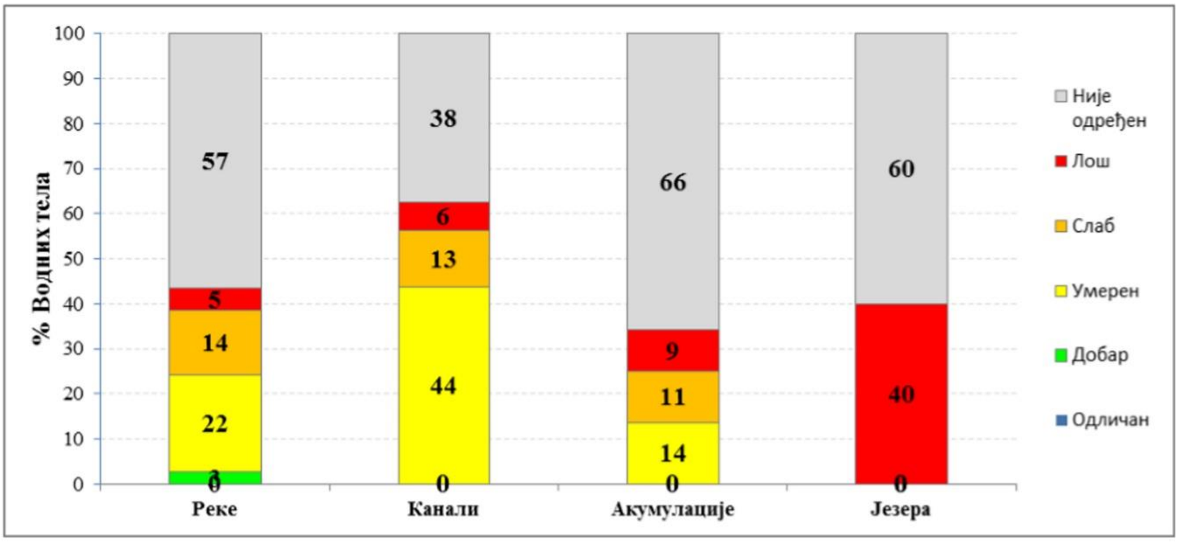

Figure 6. Ecological status/potential assessment of rivers, canals, reservoirs and lakes (2012-2016 period) (Veljković, 2018)

Figure 7. Sampling network for monitoring of surface waters in Serbia in 2012.(Veljković, 2018)

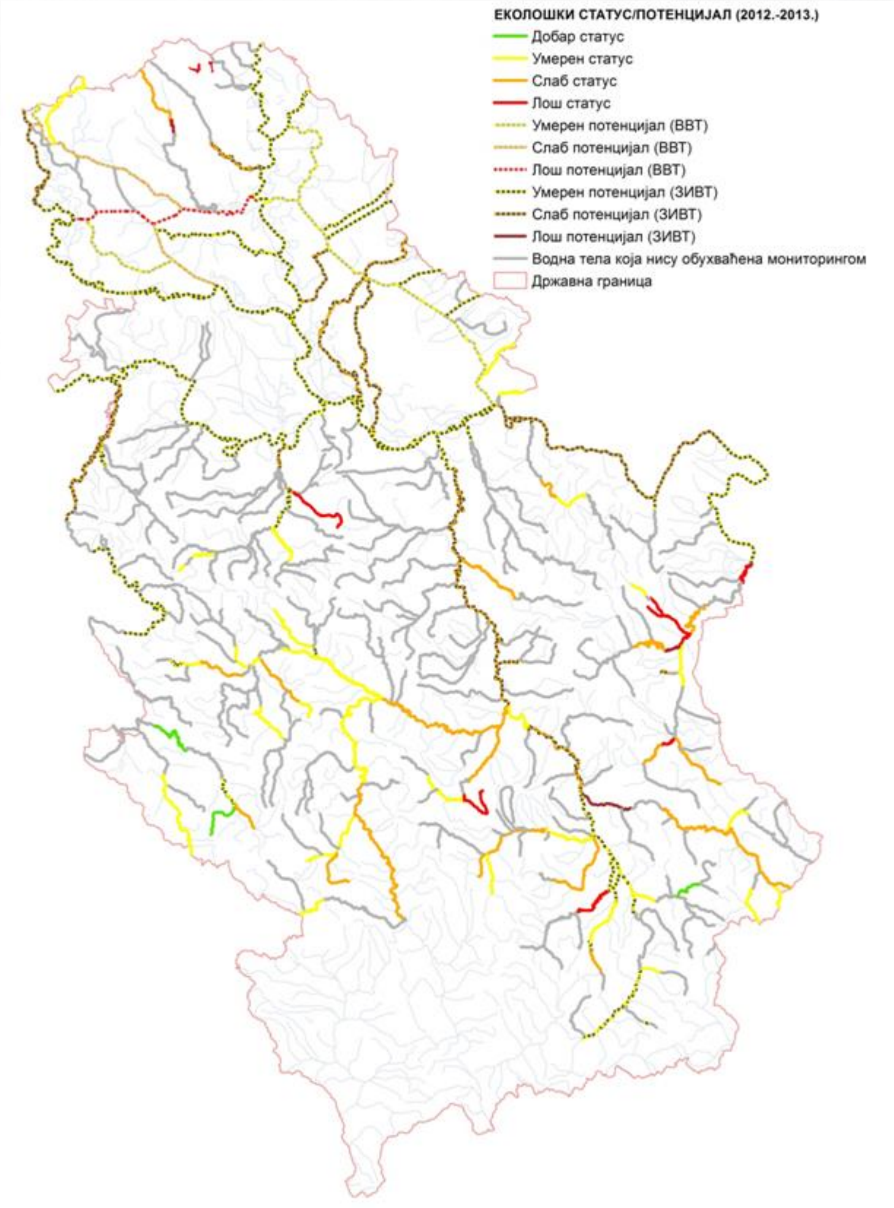

Figure 8. Ecological status of surface waters in Serbia in 2012-2013 (Veljković, 2018)

Figure 9. Ecological status of surface waters in Serbia in 2014 (Veljković, 2018)

3 RESULTS OF QUESTIONNAIRES RELATE GERMAN KNOWLEDGE / SKILLS / PRACTICE IN EMAB

3.1 THE GERMAN ENVIRONMENT AGENCY (UMWELTBUNDESAMT – UBA

In Germany rivers, lakes (water bodies > 50 ha), transitional waters and coastal waters are continuously monitored following the demands of the EU-Water Framework Directive (WFD).

Monitoring frequencies vary between biological quality elements and water body categories. Monitoring frequencies are legally fixed in the Ordinance for the Protection of Surface Waters (German term: Ober flächen gewässer verordnung, OGewV). You may find a summary of these values in Arle et al. 2016 (page 5 table 2, see https://www.mdpi.com/2073-4441/8/6/217) The elements of biological quality that are monitored by the Water Resources of Srpska are: Phytoplankton (chlorophylle a), Phytobenthos, Macroinvertebrates and Ichthyofauna.

In Germany five biological quality elements (BQEs) are monitored in German waters as demanded by the EU-Water Framework Directive: Ichthyofauna, benthic invertebrates, macroalgae, phytobenthos and phytoplankton.

Additionally, priority pollutants are measured in various biota (etc. in fish and mussels).

Further biota monitoring activities exist under other EU-Directives like the Habitats-Directive (FFH), Birds - Directive or the Marine Strategy Framework Directive (MSFD). Most of these monitoring activities focus on specific species.

Many sampling and analysis methods for physical and chemical quality elements in aquatic systems were standardized long before the entry into force of the WFD. Most biological assessment methods became standard in Germany and all over Europe in the course of the implementation of the WFD.

The WFD contains many CEN/ ISO Standards which are legally binding.

Furthermore, all biological assessment methods used under the WFD need to be “intercalibrated”. This "intercalibration" procedure aims at the harmonization of biological assessment methods in Europe and is a legal demand of the Water Framework Directive (Annex V, 1.4.1).

Its purpose is the establishment of consistent ecological status thresholds for the good-moderate and very good-good boundaries of the biological assessment systems by harmonizing the strengths of the different national approaches to biological assessment, rendering the assessment results comparable.

The biological assessment methods within the framework of the WFD have been intercalibrated by means of comprehensive statistical and numerical approaches. The results of the intercalibration are fixed in the so called "Intercalibration decision" which is a legally binding document (see https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018D0229).

All (or better nearly all) biological assessment methods officially used in Germany for the implementation of the WFD are part of this intercalibration decision.

In 2014 Germany had delineated nearly 10,000 water bodies out of its rivers, lakes, transitional and coastal waters and more than 13,000 monitoring stations for the operational monitoring of surface waters have been specified (compare Arle et al. 2016 (page 4 table 1, seehttps://www.mdpi.com/2073-4441/8/6/217)

Along German rivers and streams, an average of one monitoring site is to be found every 10–15 kilometers and the averagesize of the delineated stream and river water bodies is 15.2 km (median = 8.7 km; min < 1 km;max = 242 km).

Present state of lotic systems in Germany

The share of streams and rivers in at least good ecological status or with at least good ecological potential remained almost constant between 2010 and 2015. This share was just under 7 % when last measured. The most important reason for this is that species communities which have been disturbed on the long term require time to recover. This was initially underestimated. However, the share of running waters in a bad or poor status declined between 2010 and 2015. At the same time the proportion of running waters in a moderate ecological status increased significantly.

The European Water Framework Directive (WFD, EU Directive 2000/60/EC) was agreed in 2000. This set a target for all water bodies in Europe of a good or very good status by 2015. The Federal States drew up management plans defining measures for improving water quality. Germany was not the only country that missed the 2015 target for most streams and rivers by a large margin. The two subsequent management cycles under the WFD now need to be used to reach the ambitious targets by 2027 at the latest.

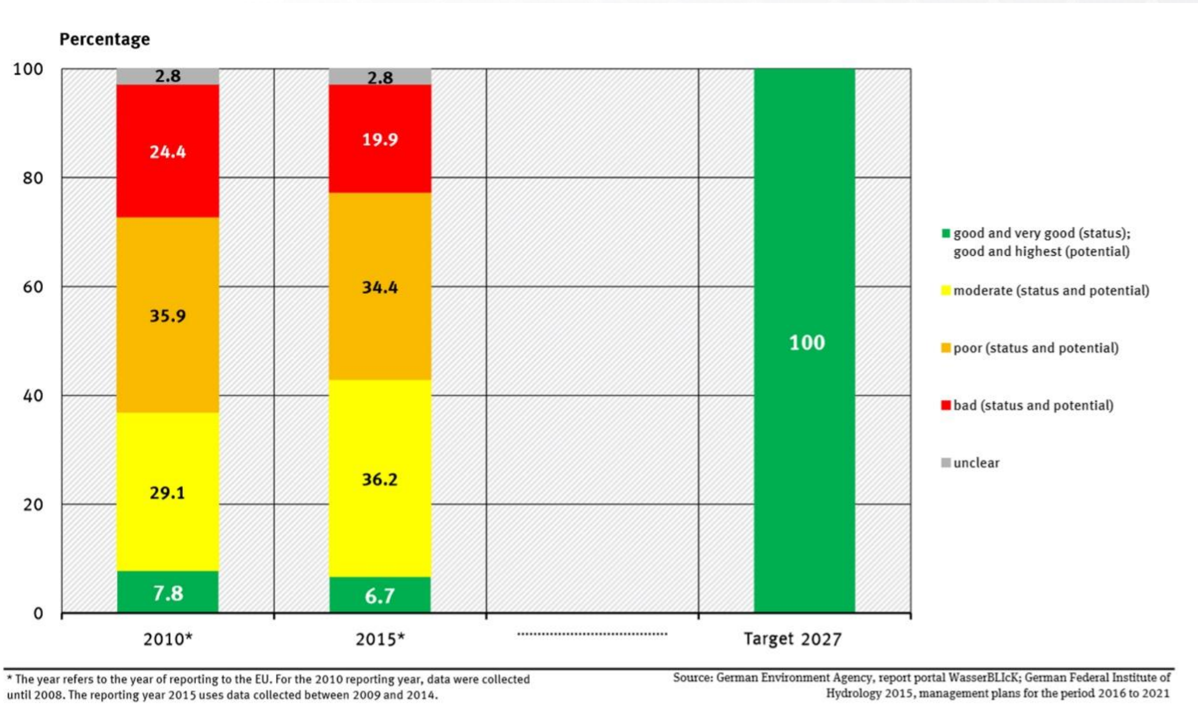

Figure 10. Percentage of running waters in at least goo status or with at least good potential in Germany (https://www.umweltbundesamt.de/en/indicator-ecological-status-of-rivers#at-a-glance)

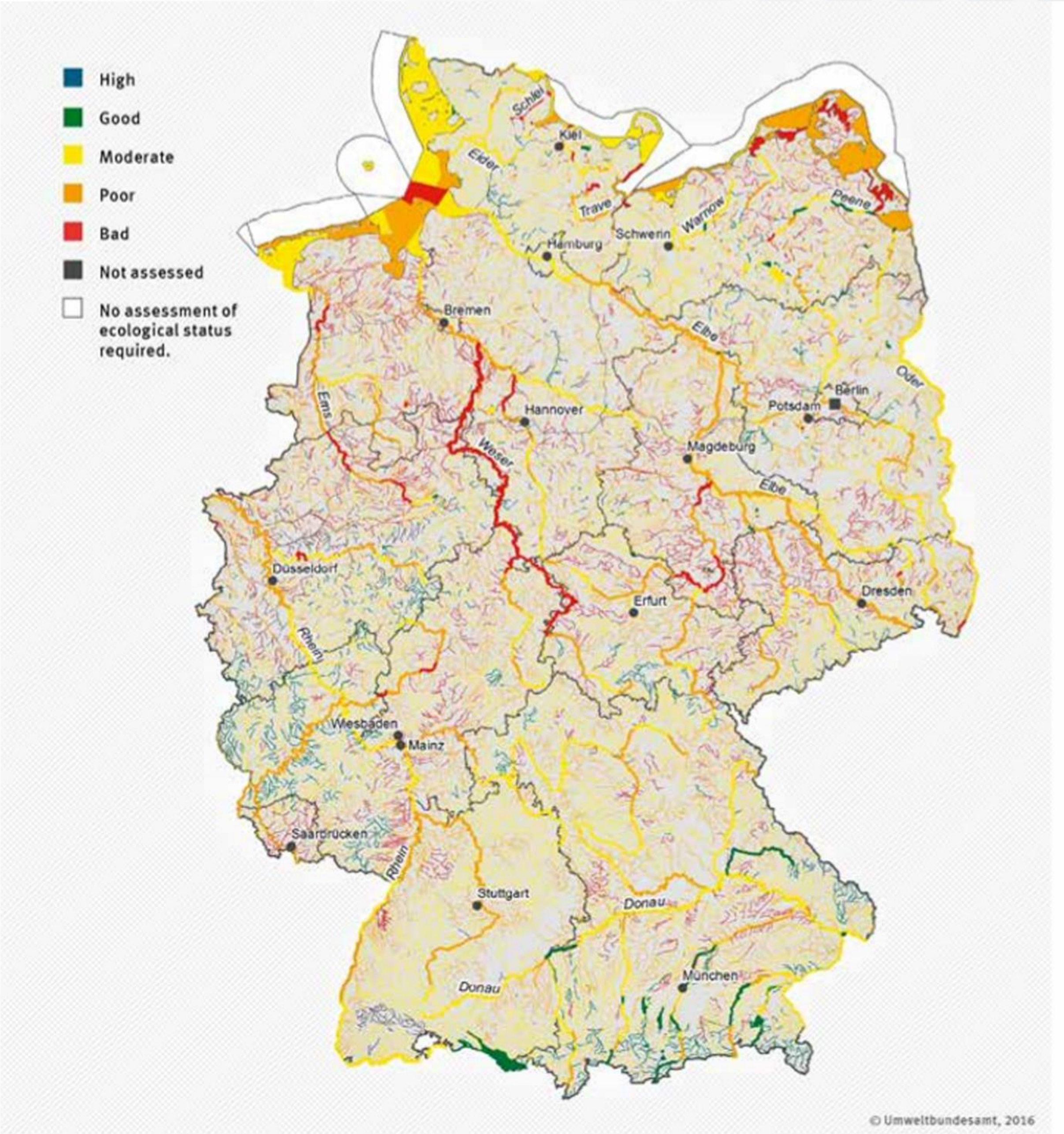

Figure 11. Ecological status/ecological potential of surface water bodies in Germany

Present state of lentic systems in Germany (https://www.umweltbundesamt.de/en/indicator-ecological-status-of-rivers#at-a-glance)

The share of water bodies in a good or very good ecological status is considerably higher in the case of lakes than in other types of water bodies. In 2015 24.0 % of lakes were in a good ecological status and 2.3 % in a very good status. The fact that the values have deteriorated in comparison to 2010 is mainly due to better measurement methods. The real status of the lakes has remained roughly constant overall.

Germany is still far away from achieving the targets laid down in the European Water Framework Directive (WFD, EU Directive 2000/60/EC). According to it all water bodies should be in at least a good status by 2015. As this target has been missed, the two subsequent management cycles under the WFD now need to be used to reach the ambitious targets by 2027 at the latest. The Federal States drew up management plans defining measures for improving water quality.

A major problem for the status of many lakes is the use of too large amounts of agricultural fertilisers (cf. 'Agricultural nitrogen surplus'). To reduce this surplus the Fertiliser Ordinance was comprehensively revised and adopted in spring 2017. It is already foreseeable now that additional measures are necessary to reduce the input of nutrients into surface waters to an acceptable level.

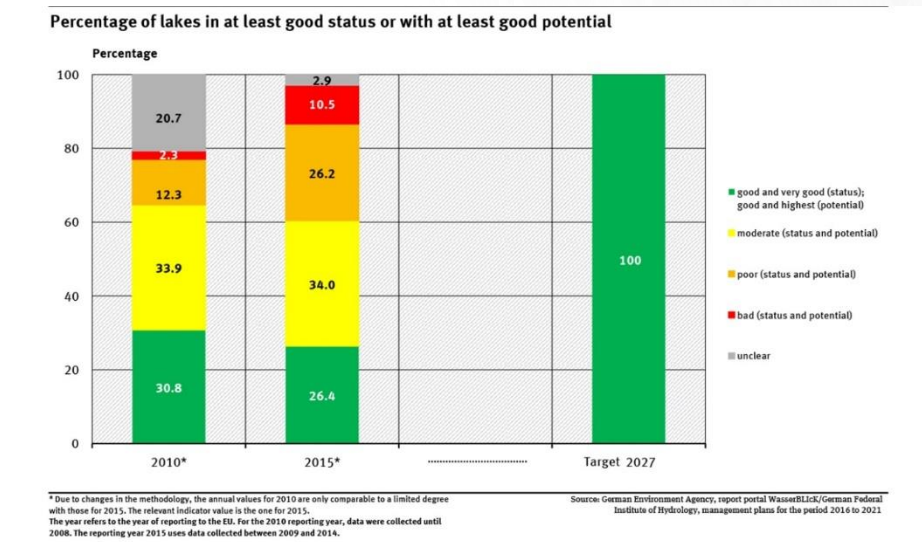

Figure 12. Percentage of lakes in at least good status or with at least good potential in Germany (https://www.umweltbundesamt.de/en/indicator-ecological-status-of-lakes)

Table 5.Trophic assessment of selected lakes in Germany (https://www.umweltbundesamt.de/en/indicator-ecological-status-of-lakes)

Trophic assessment of selected lakes in Germany

Trophic level *									
Lake	Reference	1990	1995	1996	1997	1998	1999	2000	2001
Ammersee	Oligotrophic	m	m	m	m	m	m	m	m
Arendsee	Oligotrophic	–	–	e1	e1	e1	e1	e1	e1
Lake Constanze	Oligotrophic	m	m	m	m	m	m	m	m
Brombachsee	Oligotrophic	–	–	–	–	–	–	m	m
Chiemsee	Oligotrophic	e1	m	m	m	m	m	m	o
Dobersdorfer See	Mesotrophic	e2	–	–	–	–	p1	e2	e2
Edersee Reservoir	Oligotrophic	–	–	–	–	–	–	m	m
Goitzschesee	Oligotrophic	–	–	–	–	–	–	–	–
Großer Müggelsee	Mesotrophic	p1	e1	e1	e1	e2	e2	e1	e2
Großer Plöner See	Oligotrophic	–	–	–	–	e1	e1	m	e1
Kochelsee	Oligotrophic	–	–	–	–	–	–	o	m
Königssee	Oligotrophic	–	–	–	–	–	–	o	–
Kummerower See	Mesotrophic	–	–	–	–	e1	e2	e2	e1
Laacher See	Oligotrophic	e1	e1	e1	e1	e1	e1	–	–
Langbürgner See	Oligotrophic	–	–	–	–	–	–	–	–
Muldestausee	Mesotrophic	–	–	–	–	–	–	–	–
Müritz (Outer Müritz)	Mesotrophic	–	–	–	m	e1	m	m	m
Müritz (Inner Müritz)	Mesotrophic	–	–	–	m	e1	m	m	m
Upper Havel	Weakly eutrophic	–	–	–	–	–	–	–	–
Ostersee	Oligotrophic	–	–	–	–	–	–	–	m
Plauer See	Mesotrophic	–	–	–	e1	m	m	m	m
Rappbode Reservoir	Oligotrophic	–	–	–	–	–	–	–	–
Sacrower See	Mesotrophic	–	e1	e1	e1	e1	e1	e2	e1
Scharmützelsee	Mesotrophic	–	e2	e2	e2	e2	e1	m	e1
Schweriner See (Outer Lake)	Mesotrophic	–	–	–	–	e1	e1	p1	e1
Schweriner See (Inner Lake)	Mesotrophic	–	–	–	–	e1	e1	e1	e1
Staffelsee	Oligotrophic	–	–	–	–	–	–	m	m
Starnberger See	Oligotrophic	m	m	m	m	m	m	m	o
Stechlinsee	Oligotrophic			o	o	o	o	o	o
Steinhuder Meer	Weakly eutrophic	p2	p2	p2	p2	p2	e2	e2	e1
Tegernsee	Oligotrophic	–	–	–	–	–	–	o	–
Unterbacher See	Mesotrophic	–	–	–	e1	e1	e1	e1	e1
Walchensee	Oligotrophic	–	–	–	–	–	–	o	o
Wörthsee	Oligotrophic	–	–	–	–	–	–	o	m
Zeuthener See	Weakly eutrophic	–	–	–	–	–	–	e2	e2

* According to LAWA 1999

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
	m	m	m	m	m	m	m	m	m	m	o	o	o
	e1	e2	e2	e2	e2	e2	e1	e2	e1	e1	–	–	–
	m	m	m	m	m	m	m	m	m	m	o	m	m
	m	m	m	m	m	m	m	m	m	m	m	m	m
	m	o	m	m	m	m	m	m	m	m	–	o	–
	p1	e2	e2	e2	e2	e2	–	–	–	–	–	–	–
	m	m	m	m	e1	e1	e1	m	m	m	m	o	m
	–	–	–	–	–	–	m	m	o	o	–	–	–
	e1	e2	e1	e2	e1	e1	e1	e1	e1	e1	–	–	–
	e1	m	m	m	m	m	m	–	–	–	–	–	–
	–	m	–	–	–	o	–	–	–	–	–	o	–
	–	–	–	–	–	–	–	–	–	–	–	–	–
	p1	e2	e2	e2	e2	e2	–	–	–	–	e2	e2	e1
	–	–	–	m	–	–	m	–	m	m	m	–	–
	–	–	–	o	–	–	–	–	–	–	o	–	–
	e2	e2	e1	e2	e1	m	e1	m	m	m	–	–	–
	m	m	m	m	m	m	m	–	–	–	m	–	e1
	m	m	m	m	m	m	m	–	–	–	m	–	m
	–	–	–	–	e2	e2	e2	e2	e2	e2	–	–	–
	–	–	o	–	–	–	m	–	–	–	–	–	o
	m	m	m	m	m	m	m	–	–	–	m	–	m
	e1	e1	m	m	m	m	m	m	m	m	–	–	–
	e1	e2	e1	e1	e1	e1	e1	–	–	–	–	–	–
	e2	m	m	m	m	m	m	–	–	–	–	m	m
	e2	e2	e2	e1	e1	e1	e1	–	–	–	e1	e1	m
	e2	e2	e2	e1	e1	e1	e1	–	–	–	e2	e2	e2
	–	–	m	–	–	m	–	–	m	m	–	o	–
	m	m	o	o	m	o	o	o	o	o	o	o	o
	o	o	o	o	o	o	o	–	–	–	–	m	–
	e1	p2	p1	–	–	–	–	–	–	–	e2	e1	e2
	–	–	–	–	–	–	o	–	–	–	–	–	o
	e1	e1	e1	e1	e1	e1	e1	–	–	–	–	–	–
	–	o	–	–	o	–	o	–	–	–	–	–	o
	m	m	–	o	–	–	o	–	–	–	–	–	o
	e2	e2	e2	e2	e2	e2	e2	e2	e2	e2	–	–	–

ACTUAL status							
Referenzzustand *	Oligotrophic (o)	Mesotrophic (m)	Weakly eutrophic (e1)	Highly eutrophic (e2)	Weakly polytrophic (p1)	Highly polytrophic (p2)	Hyper-trophic (h)
Oligotrophic							
Mesotrophic							
Weakly eutrophic							
Highly eutrophic							
Weakly polytrophic							

* According to LAWA 1999

Source: German Environment Agency from data supplied by LAWA

References

AQEM 2002. Manual For The Application Of The Aqem System. A Comprehensive Method To Assess European Streams Using Benthic Macroinvertebrates, Developed For The Purpose Of The Water Framework Directive. Contract No: Evk1-Ct1999-00027).

Arle, J., Mohaupt, V., & Kirst, I. (2016). Monitoring of surface waters in Germany under the water framework directive—a review of approaches, methods and results. Water, 8(6), 217.

Barbalić, S., Biondić, D., Čupić. D-. Medić, D., Miholić. T., Musić, V., Šikoronja, M., Šturlan Popović, S. (2019) Plan upravljanjavodnimpodručjima 2016. – 2012. HrvatskeVode, Zagreb.248.

Barbour, M. T., Gerritsen, J., Snyder, B. D., & Stribling, J. B. (1999). Rapid Bioassessment Protocols For Use In Streams And Wadeable Rivers: Periphyton, Benthic Macroinvertebrates And Fish (Vol. 339). Washington, Dc: Us Environmental Protection Agency, Office Of Water.

Bonada, N., Prat, N., Resh, V. H., &Statzner, B. (2006). Developments In Aquatic Insect Biomonitoring: A Comparative Analysis Of Recent Approaches. Annu. Rev. Entomol., 51, 495-523.

Davis, W. S. & Simon, T. P. 1995. Biological Assessment And Criteria: Tools For Water Resource Planning And Decision Making, Crc Press.

Hauer, F. R., & Lamberti, G. A. (2007). Methods In Stream Ecology, Academic Press. City, St.

Hellawell, J. (1986). Biological Indicators Of Freshwater Pollution And Environmental Management.

Hering, D., Feld, C., Moog, O. &Ofenböck, T. 2006. Cook Book For The Development Of A Multimetric Index For Biological Condition Of Aquatic Ecosystems: Experiences From The European Aqem And Star Projects And Related Initiatives. Hydrobiologia, 566, 311-324.

Hering, D., Moog, O., Sandin, L., &Verdonschot, P. F. (2004). Overview And Application Of The Aqem Assessment System. Hydrobiologia, 516(1-3), 1-20.

Hering, D., Buffagni, A., Moog, O., Sandin, L., Sommerhäuser, M., Stubauer, I., ... &Verdonschot, P. (2003). The Development Of A System To Assess The Ecological Quality Of Streams Based On Macroinvertebrates–Design Of The Sampling Programme Within The Aqem Project. International Review Of Hydrobiology: A Journal Covering All Aspects Of Limnology And Marine Biology, 88(3-4), 345-361.

Hughes, R. M., Kaufmann, P. R., Herlihy, A. T., Kincaid, T. M., Reynolds, L. & Larsen, D. P. 1998. A Process For Developing And Evaluating Indices Of Fish Assemblage Integrity. Canadian Journal Of Fisheries And Aquatic Sciences, 55, 1618-1631.

Karr, J. R. & Chu, E. W. 1998. Restoring Life In Running Waters: Better Biological Monitoring, Island Press.

Nixon, S. C., Mainstone, C. P., Iversen, T. M., Kristensen, P., Jeppesen, E., Friberg, N., ... & Pedersen, F. (1996). The Harmonised Monitoring And Classification Of Ecological Quality Of Surface Waters In The European Union. Final Report. Wrc Ref Co, 4150, 289.

Pantle, R. (1955). Die BiologischeUberwachungDerGewasser Und Die Darstellung Der Ergebnisse. Gas-Und Wasserfach, 96, 604.

Peeters, E. T. H. M., Gardeniers, J. J. P., &Tolkamp, H. H. (1994). New Methods To Assess The Ecological Status Of Surface Waters In The Netherlands Part 1: Running Waters. Internationale VereinigungFürTheoretische Und AngewandteLimnologie: Verhandlungen, 25(3), 1914-1916.

Veljković, N. (2018) Status površinskihvodaSrbije. Razvojmonitoringa u okviruplanovaupravljanjarečnimslivovima. Agencija za zaštitužvotnesredine.Beograd.166.

Stoddard, J. L., Herlihy, A. T., Peck, D. V., Hughes, R. M., Whittier, T. R. &Tarquinio, E. 2008. A Process For Creating Multimetric Indices For Large-Scale Aquatic Surveys. Journal Of The North American Benthological Society, 27, 878-891.

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