



Republic of Serbia  
Ministry of Environmental Protection  
ENVIRONMENTAL PROTECTION AGENCY



## Monitoring in Serbia: state-of-art and plans for improvement - lessons learned



TAIEX Workshop on Capacity  
Building on Monitoring Programme

Belgrade, Serbia

23 – 24 October 2017

## Monitoring of surface water status in the Republic of Serbia

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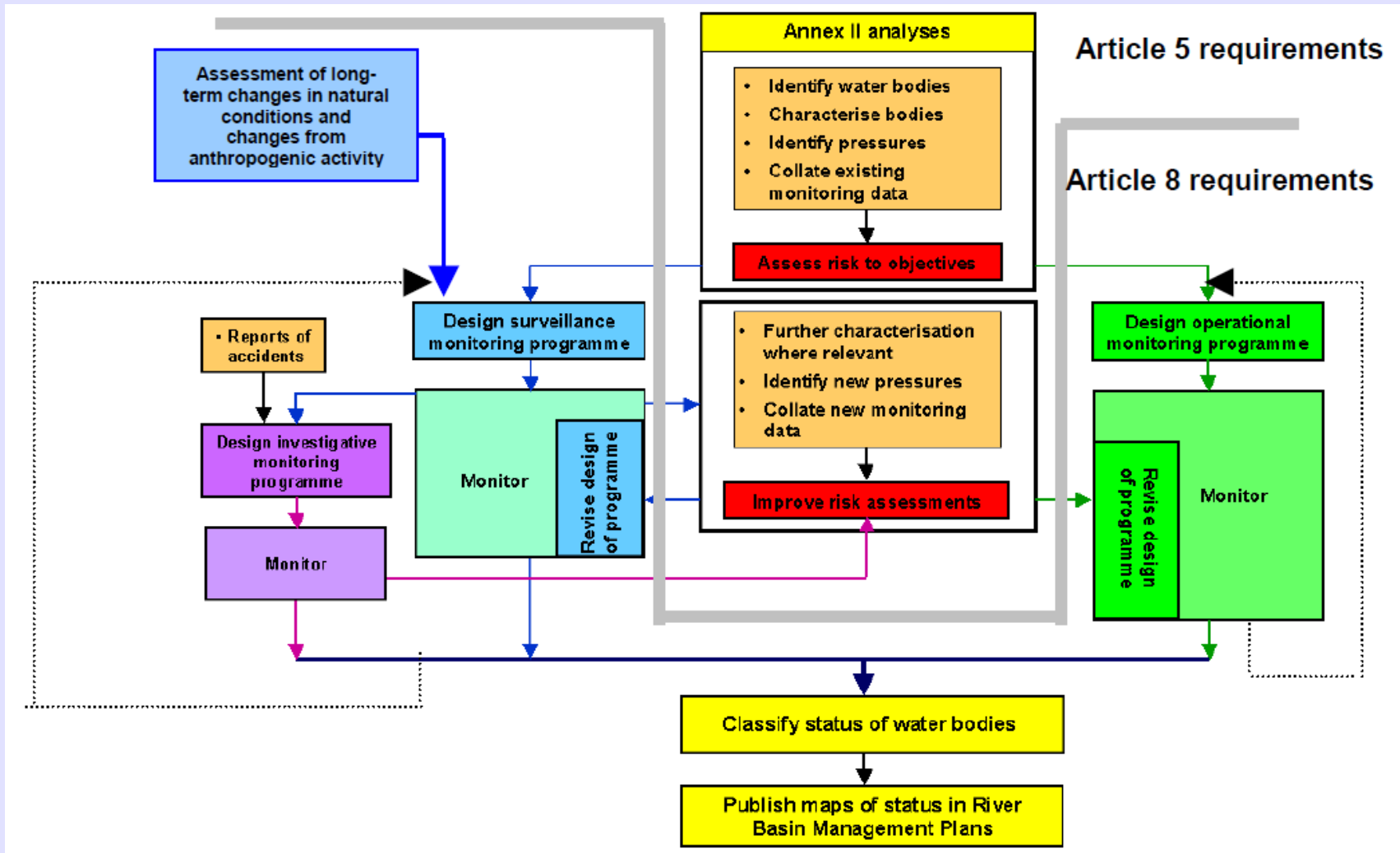
- The Water Framework Directive (WFD) of the European Parliament and the Council (2000/60 / EC) establishes a framework for community action in the field of water policy
- The WFD is a basic legislation in the water domain and its implementation represents a major challenge even for the EU Member States due to the scope of tasks but also due to strict deadlines
- Although the Republic of Serbia is still not a formal EU member, the RS had committed itself to follow the conceptual approaches of the WFD within the Danube Basin through active membership in the International Commission for the Protection of the Danube River (ICPDR)

- One key purpose of the Directive is to prevent further deterioration of, and protect and enhance the status of aquatic ecosystems
- “The status of surface water“ is a general term of the status of a surface water body assessed by the worst one than the ecological and chemical status

**The good status of a surface water body is achieved when both its statuses, ecological and chemical, are assessed at least as "good"**

- The success of the Directive in achieving this purpose and its related objectives will be mainly measured by the status of “water bodies”. “Water bodies” are therefore the units that will be used for reporting and assessing compliance with the Directive’s principal environmental objectives
- Monitoring is a cross-cutting activity within the Directive and as such there are important interrelationships with other Articles and Annexes of the Directive. A key Article in relation to monitoring and the design of appropriate programmes for surface waters is Article 5

# The relationship between Article 5 and Article 8 in the design of surface water monitoring programmes



**The objective of monitoring is to establish a coherent and comprehensive overview of water status within each River Basin District and must permit the classification of all surface water bodies into one of five classes**

This does not mean that monitoring stations will be needed in each and every water body. Member States will have to ensure that enough individual water bodies of each water body type are monitored

Three types of monitoring for surface waters are described in Annex V:

- surveillance,
- operational and
- investigative monitoring

# Surveillance monitoring of surface waters

The objectives of surveillance monitoring of surface waters are to provide information for:

- supplementing and validating the impact assessment procedure detailed in Annex II
- the efficient and effective design of future monitoring programmes
- the assessment of long term changes in natural conditions, and
- the assessment of long term changes resulting from widespread anthropogenic activity

**Surveillance monitoring has to be undertaken for at least a period of one year during the period of a RBMP**

# Operational monitoring of surface waters

- The objectives of operational monitoring are to:
  - establish the status of those bodies identified as being at risk of failing to meet their environmental objectives; and
  - assess any changes in the status of such bodies resulting from the programmes of measures



# Investigative monitoring

Investigative monitoring may also be required in specified cases. These are given as:

- where the reason for any exceedences (of Environmental Objectives) is unknown;
- where surveillance monitoring indicates that the objectives set under Article 4 for a body of water are not likely to be achieved and operational monitoring has not already been established, in order to ascertain the causes of a water body or water bodies failing to achieve the environmental objectives; or
- to ascertain the magnitude and impacts of accidental pollution.

- **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:**
  - **Regulation on establishment of surface and groundwater bodies (Official Gazette of the RS 96/2010)**
  - **Regulation on reference conditions of surface water types (Official Gazette of the RS 67/2011)**
  - **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)**
  - **Regulation on emission limit values of polluting substances in surface and groundwaters and deadlines for their achievement (Official Gazette of the RS 50/2012)**
  - **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

- 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)
- 50 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)

# The criteria for selection of surveillance monitoring stations

- The rate of water flow is significant within the river basin district as a whole; including points on large rivers where the catchment is greater than 2 500 km<sup>2</sup>;
- The volume of water present is significant within the river basin district, including large lakes and reservoirs;
- Significant bodies of water cross a Member State boundary;
- Sites are identified under the Information Exchange Decision 77/795/EEC;
- At such other sites as are required to estimate the pollutant load which is transferred across Member States boundaries, and which is transferred into the marine environment.

# The criteria for selection of operational monitoring stations

- Operational Monitoring Programme covered all water bodies for which was assessed as at risk and could not satisfied Environmental Quality Standards (EQS) from the WFD Article 4 and water bodies where priority substances from the Priority List discharged, based on the results of National Monitoring programmes in 2009 and 2010 as well as the impact analysis conducted in accordance with the WFD Annex II
- In 2012, **90** water bodies were included in the Operational Monitoring Programme (42 water bodies are also surveillance monitoring stations)

## **Selection of quality elements (Annex V.1.1.)**

- **For surveillance monitoring, parameters indicative of all the biological, hydromorphological and all general and specific physico-chemical quality elements are required to be monitored.**
- **For operational monitoring, the parameters used should be those indicative of the biological and hydromorphological quality elements most sensitive to the pressures to which the body is subject, all priority substances discharged and other substances discharged in significant quantities.**

# In the 2012-2014 period the monitoring of surface waters covered a total of 149 water bodies in Serbia

- The results are given in the following publication:  
<https://www.sepa.gov.rs/download/VodeSrbije/StatusPovrsinskihVodaSrbije>

 Република Србија  
Министарство пољопривреде и заштите животне средине  
АГЕНЦИЈА ЗА ЗАШТИТУ ЖИВОТНЕ СРЕДИНЕ

## СТАТУС ПОВРШИНСКИХ ВОДА СРБИЈЕ

Одличан	
Добар	
Умерен	
Слаб	
Лош	

Анализе и елементи за пројектовање мониторинга

ISBN 978-86-87159-14-3

- An implementation of the Water Framework Directive has changed the criteria and methodology of assessing the status of water bodies. Thus the assessments of surface water quality from previous years, before 2012, are not comparable with the newly obtained assessments
- We would like to outline that these are the first status assessments given for one calendar year (or two, in the case of 2012/2013) and that these assessments may differ from future status assessments, when we'll have a larger set of data



# Water Monitoring Network of Surface Waters in 2012



# Quality elements used for ecological and chemical classification of rivers, lakes and reservoirs according to the WFD and national legislation of the Republic of Serbia

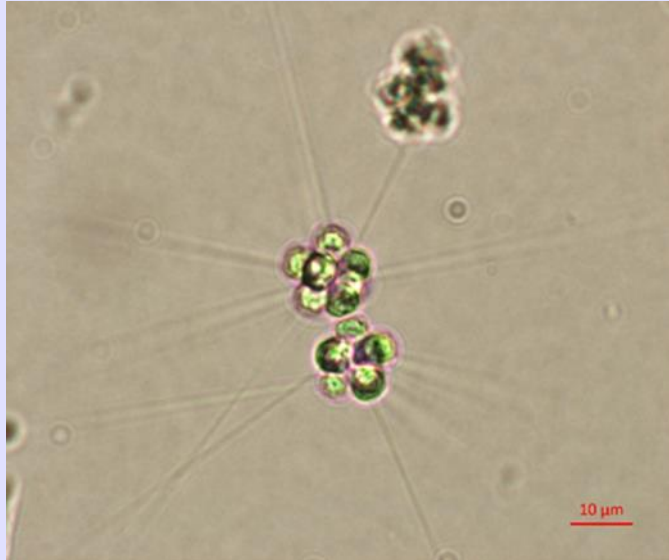
ECOLOGICAL STATUS	Biological quality elements	Rivers	Lakes and reservoirs
	• Phytoplankton	+	+
	• Phytobenthos	+	+
	• Macrophytes	-	-
	• Macroinvertebrates	+	+
	• Fish	-	-
	<b>General physico-chemical elements</b>	+	+
	<b>Specific nonpriority polluting substances</b>	+	+
	<b>Hydromorphological quality elements</b>		
	• Hydrological regime	±	±
	• River flow continuity	-	-
	• Morphological conditions	-	-
CHEMICAL STATUS	<b>Priority and priority hazardous substances</b>	+	+

## Annual frequency of water quality elements investigation

<b>Biological quality elements</b>	<b>rivers &amp; AWB</b>	<b>lakes</b>	<b>reservoirs</b>
macroinvertebrates	2	2	2
phytobenthos	2	2	2
phytoplankton	6*	4	4 (3)
macrophytes	-	-	-
fish	-	-	-
<b>General physico-chemical elements</b>	<b>12 (10-12)</b>	<b>4</b>	<b>4 (3)</b>
<b>Specific nonpriority polluting substances</b>	<b>12 (10-12)</b>	<b>4</b>	<b>4 (3)</b>
<b>Hydromorphological quality elements</b>			
hydrological regime	water level and flow		
river flow continuity	-	-	-
morphological conditions	-	-	-

\*only at large plain rivers (Type 1)

# Phytoplankton



- The following metrics are used for indicative assessment of ecological status/potential:

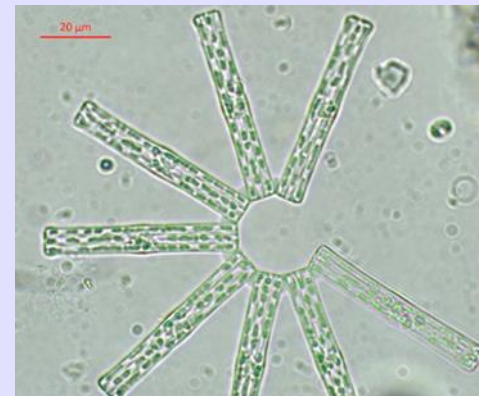
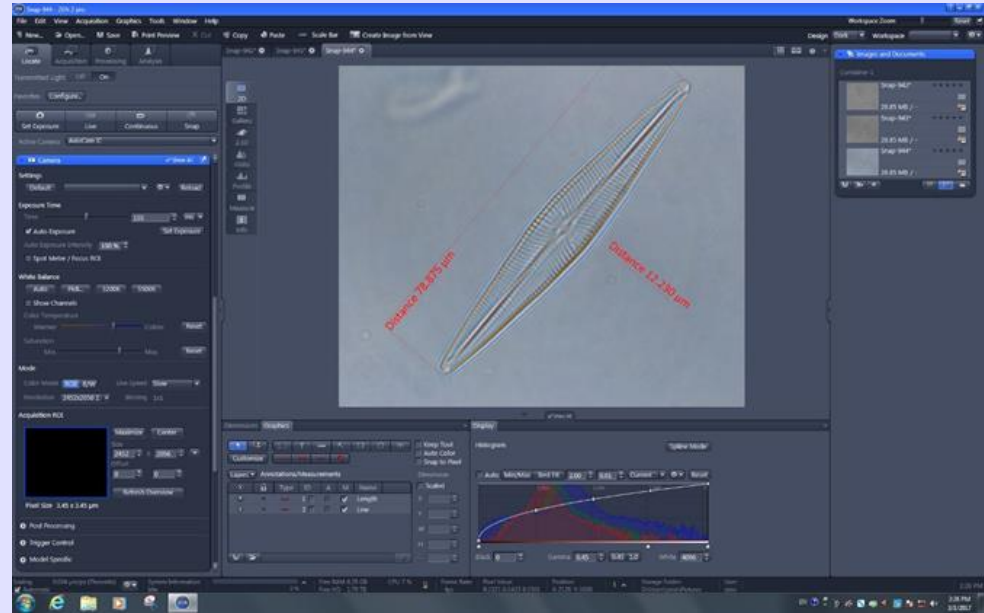
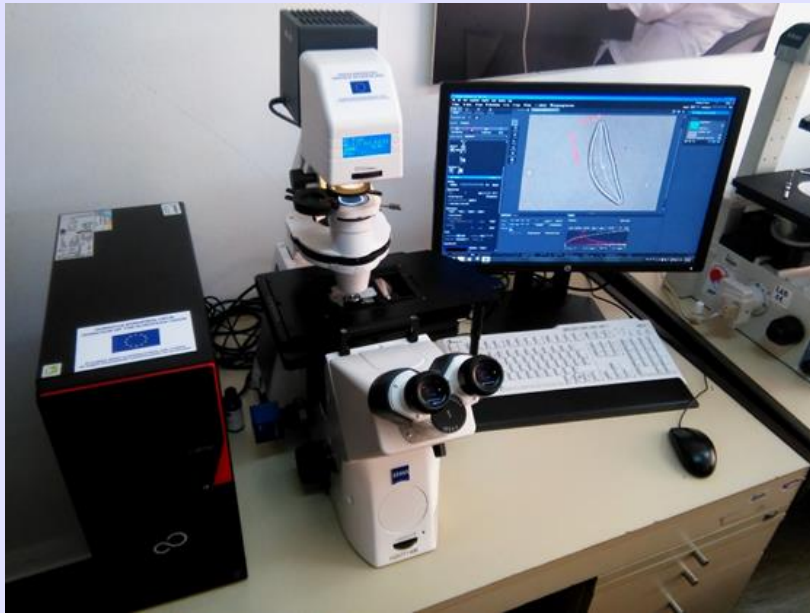
- phytoplankton abundance (cells ml<sup>-1</sup>)
- percentage participation of Cyanobacteria and Euglenophyta in the total phytoplankton community
- biomass (chlorophyll-*a* concentration)

## Identification of pressures:

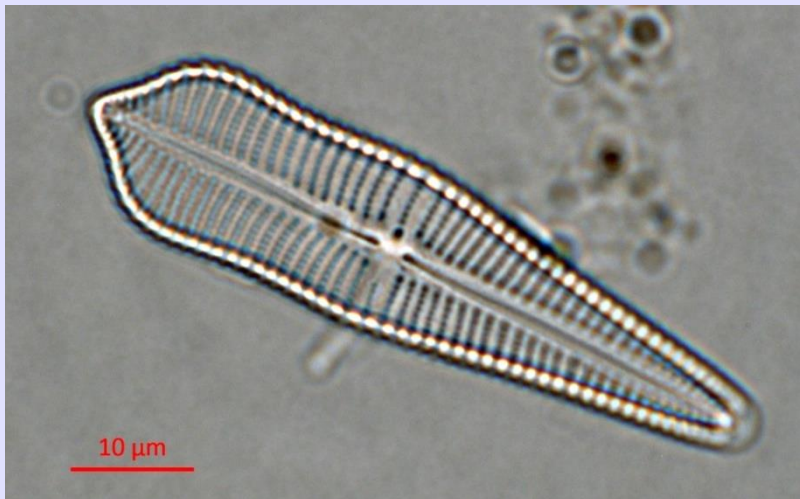
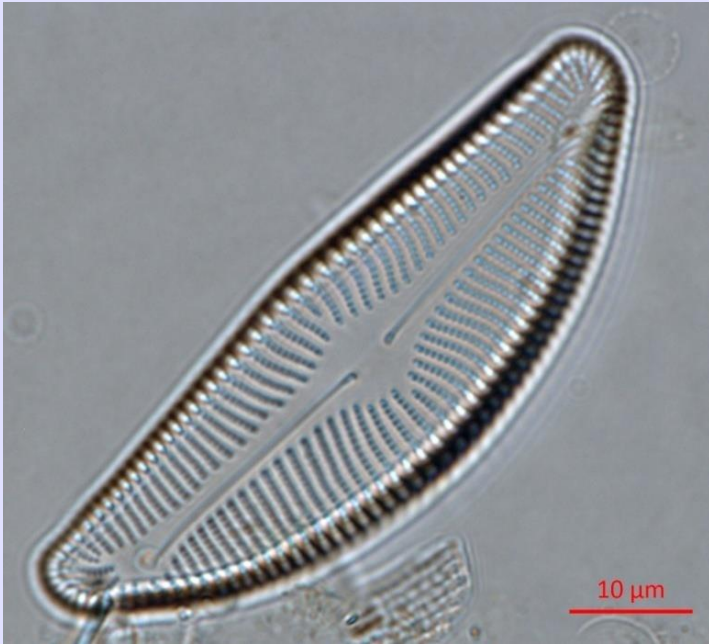
- eutrophication and organic pollution

meritory - mean value

# Inverted microscope with dark and light field and phase contrast with camera and image analysis for phytoplankton analysis, Carl Zeiss GmbH, Axio Observer D1



# Phytobenthos



- The following diatom indices are used for indicative assessment of ecological status/potential:
  - **IPS** (Coste in Cemagref, 1982)  
"Indice de pollutio-sensibilite"
  - **CEE** (Descy & Coste, 1990)
  - **EPI-D** (Dell'Uomo, 1999)  
"Diatom-based Eutrophication/Pollution Index"

## Identification of pressures:

- eutrophication
- organic pollution

meritory (obtained or mean value)

# Diatom indices calculation (OMNIDIA v. 5.5)



OMNIDIA 5.5 (GB)

File Edit Utilities Commands Reports Menu Help Inventories Window Help

INVENTORIES

Help IBD Graph Print Add up Duplicate Delete Modify Insert List Research

Analysis 35  Validated

SLIDE N° 171983437

Date 07/09/2016

Basin DUNAV

River BAJSKI KANAL

Site BACKI BREG

Hydrologic code 92111

Distance/source

Temperature 23.0

Sampling code 437

Particularities

Other labels...

NB of species 43

Population 420

Diversity 4.27

Evenness 0.79

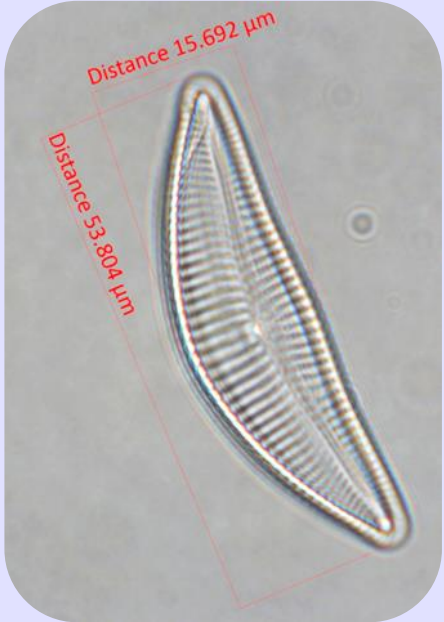
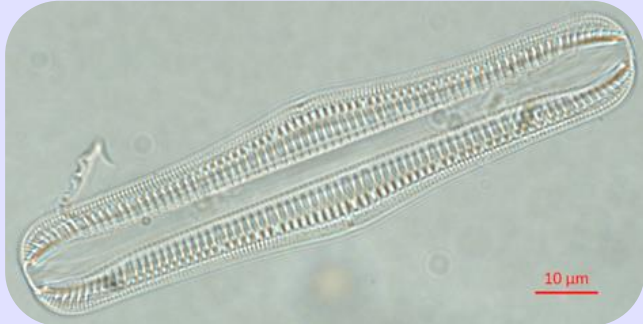
No genera 20

Detailed list

Species	Abundance
FRAC	1
FULN	1
GOLI	1
GPAR	1
GTRU	1
GYAT	1
HNOR	3
HVEN	4
MVAR	1
NCPR	5
NCTE	19
NCTO	17
NFON	1
NIGR	2
NINI	1
NRAD	14
NVIR	1
NZLT	2
PTLA	1
RGIB	44
SHAN	2

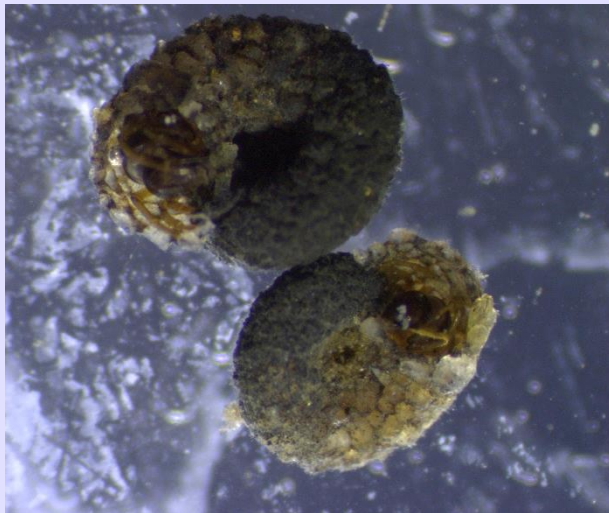
Quality notes/20	DAP	SHE	IPS	OSE/5	TDV20	IDP	I
INDICES	14.6	15.4	15.3	3.83	13.5	13.7	
	EPI-D 15.0	DI-CH 15.9	SIN 13.2	IDG 15.5	%PT 1.7	ROTT troph. 10.1	
	W 16.1	WAT 9.8	D 18.8	CEP 16.2	LOBO 11.4	ROTT sap. 17.5	

Ecologic values Complement compute indices Find Exit



Diatom indices used in ecological status/potential assessment according to the National Monitoring Programme

# Macroinvertebrates



- The following metrics are used for indicative assessment of ecological status/potential (depending on the type of water body):

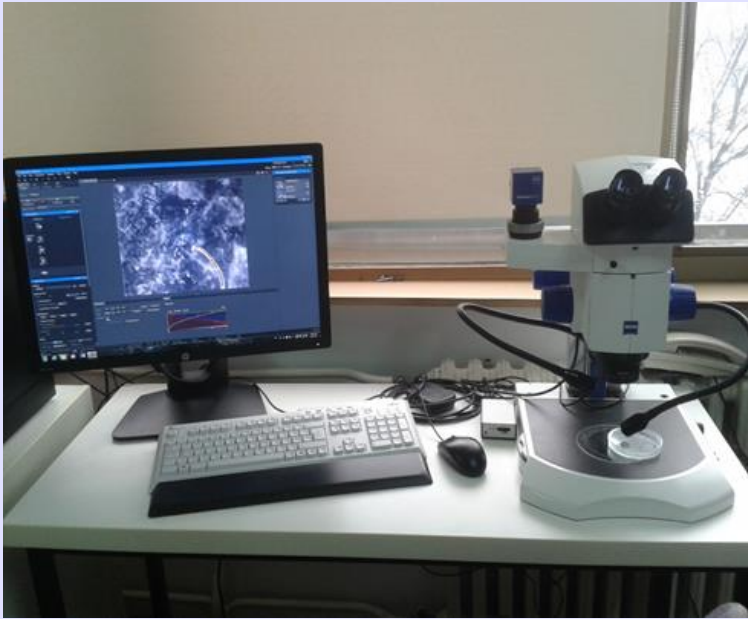
- Zelinka & Marvan Saprobic Index
- BMWP Score
- ASPT Score
- Shannon-Weaver Diversity Index
- EPT Taxa
- number of families
- total number of taxa
- percentage participation of Oligochaeta/Tubificidae
- number of bivalve species
- number of gastropod species
- number of sensitive taxa (Austrian list)

## Identification of pressures:

- general degradation
- organic pollution



# Stereomicroscope with gooseneck type cold light with camera and image analysis for analysis of benthic invertebrates, Carl Zeiss GmbH, SteREO Discovery V8



ZEN 2 Microscope and Imaging Software

Country: Europe

ASTERICS

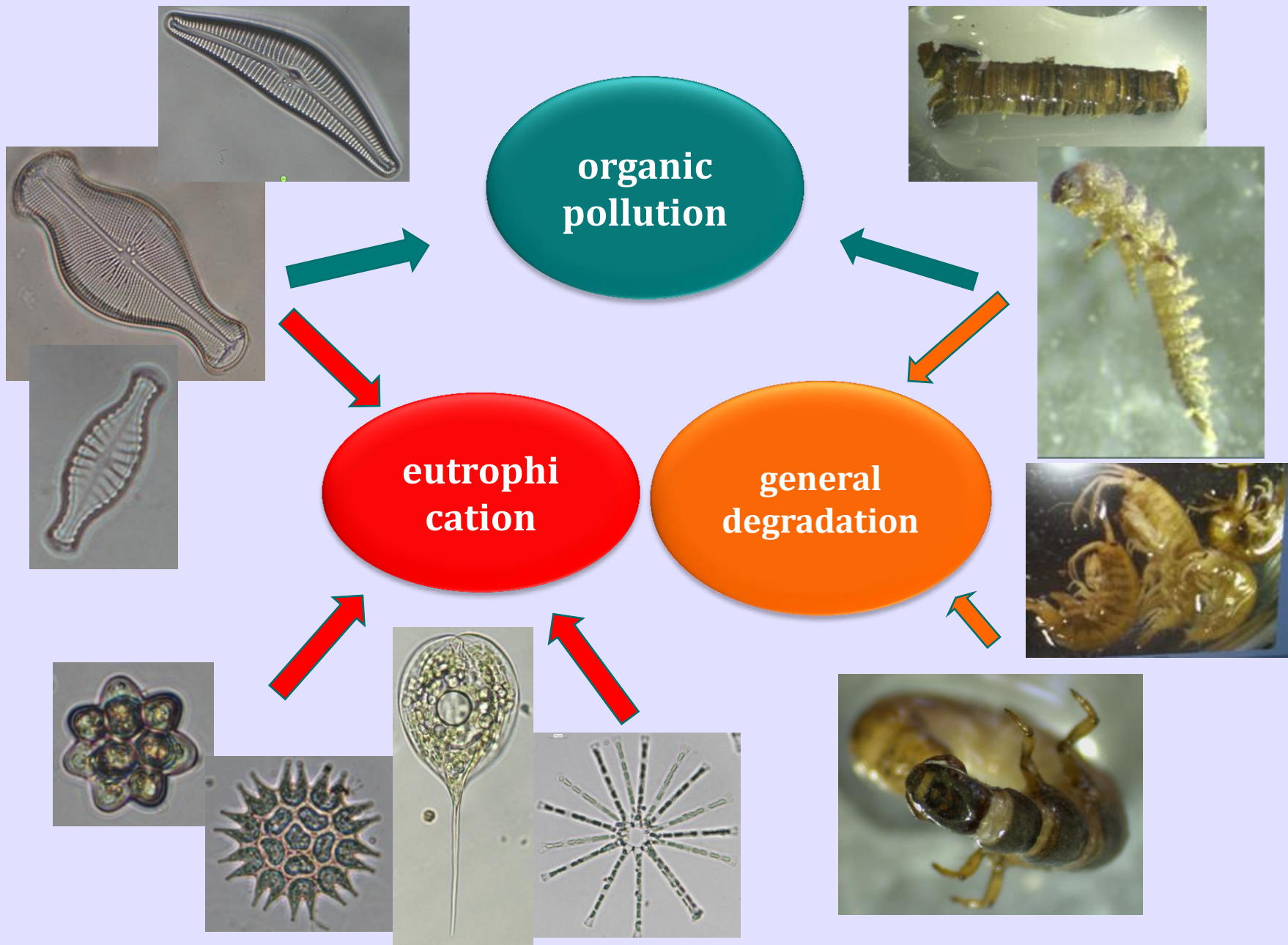
Taxa list (28)

Import Save... Save as... Samples Char. Calculate

ID_Art	Taxon name	ShortCode	No.
4552	Capnia sp.	capnisp	1
4639	Cheumatopsyche lepidia	cheulepi	4
4642	Chironomidae Gen. sp.	chidaege	4
7726	Culicidae Gen. sp.	culigen.	1
8037	Ecdyonurus aurantifascus	ecdyaura	1
12550	Epeorus assimilis	epeoassi	2
9810	Gordius aquaticus	gordaqua	3
5456	Heptagenia sp.	heptisp.	1
5531	Hydraena sp. Ad.	hydnepad	1
8142	Hydropsyche incognita	hydnico	30
13023	Hydropsyche pellucidula-Gr.	hydnpegr	6
4364	Ibisia marginata	ibismarg	3
5726	Leptoceridae Gen. sp.	leserige	10
5790	Leuctra sp.	leuctrsp	2
5809	Limnephilidae Gen. sp.	lphidge	3
11623	Ponania substriata Ad.	ponsubad	2
18982	Radix labiata	radlabi	3
7753	Rhytrogenia daphana-Gr.	rhtdig	1
19298	Rhyacophila dorsalis ssp.	rhydorso	1

ASTERICS v. 4.0.4 Software for benthic invertebrate metrics





# General physico-chemical parameters used in ecological status assessment

Parameter	Unit
Water temperature	°C
<b>Transparency</b>	m
Turbidity	NTU
Suspended Solids	mg/l
<b>Dissolved Oxygen</b>	mgO <sub>2</sub> /l
Oxygen Saturation	%
Alkalinity	mmol/l
Total Hardness (CaCO <sub>3</sub> )	mg/l
Free Carbon Dioxide CO <sub>2</sub>	mg/l
Carbonates - CO <sub>3</sub> <sup>2-</sup>	mg/l
Bicarbonates - HCO <sub>3</sub> <sup>-</sup>	mg/l
Total Alkalinity (CaCO <sub>3</sub> )	mg/l
<b>pH</b>	-
Conductivity	μS/cm
Total Dissolved Solids (TDS)	mg/l
<b>Ammonium (NH<sub>4</sub>-N)</b>	mg/l

Parameter	Unit
Nitrites (NO <sub>2</sub> -N)	mg/l
<b>Nitrates (NO<sub>3</sub>-N)</b>	mg/l
Organic Nitrogen (N)	mg/l
Total Nitrogen (N)	mg/l
<b>Ortophosphates (PO<sub>4</sub>-P)</b>	mg/l
<b>Total Phosphorus (P)</b>	mg/l
Dissolved Silicates (SiO <sub>2</sub> )	mg/l
Calcium (Ca <sup>++</sup> )	mg/l
Magnesium (Mg <sup>+</sup> )	mg/l
<b>Chloride (Cl<sup>-</sup>)</b>	mg/l
Sulphate (SO <sub>4</sub> <sup>2-</sup> )	mg/l
<b>BOD5</b>	mg/l
COD <sub>Mn</sub>	mg/l
COD <sub>Cr</sub>	mg/l
<b>Total Organic Carbon (TOC)</b>	mg/l

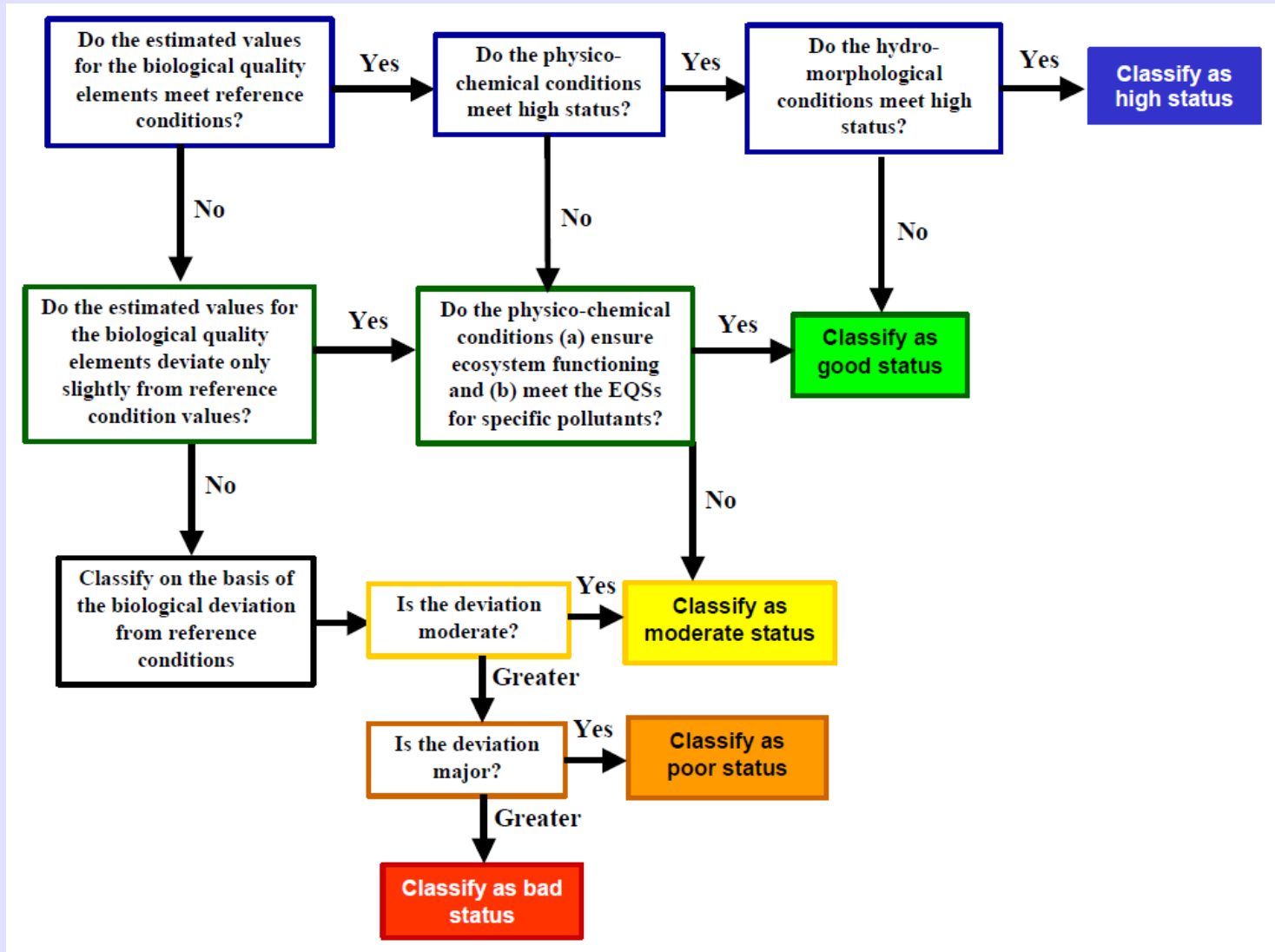
# Specific nonpriority polluting substances

No.	Specific polluting substance	Analytical method
1	Zinc (Zn)	EPA 6020A:2007
2	Copper (Cu)	EPA 6020A:2007
3	Aluminium (Al)	EPA 6020A:2007
4	Iron (Fe)	EPA 6020A:2007
5	Manganese (Mn)	EPA 6020A:2007
6	Total Chromium (Cr)	EPA 8270D:2007
7	Arsenic (As)	EPA 6020A:2007
8	Boron (B)	EPA 6020A:2007
9	Non-ionogenic surface-active agents	EPA 425.1
10	Petroleum Hydrocarbons	MSz 12750/23-76
11	Phenol Index	EPA 8270D:2007
12	Gross beta-radioactivity	SRPS ISO 9697:2008
13	Polychlorinated biphenyls (PCB):28,52,101,118,138,153,180 и 194	EPA 8270D:2007
14	Propazine	SRPS ISO EN 11369:2008
15	Linuron	SRPS ISO EN 11369:2008
16	Terbuthylazine	SRPS ISO EN 11369:2008

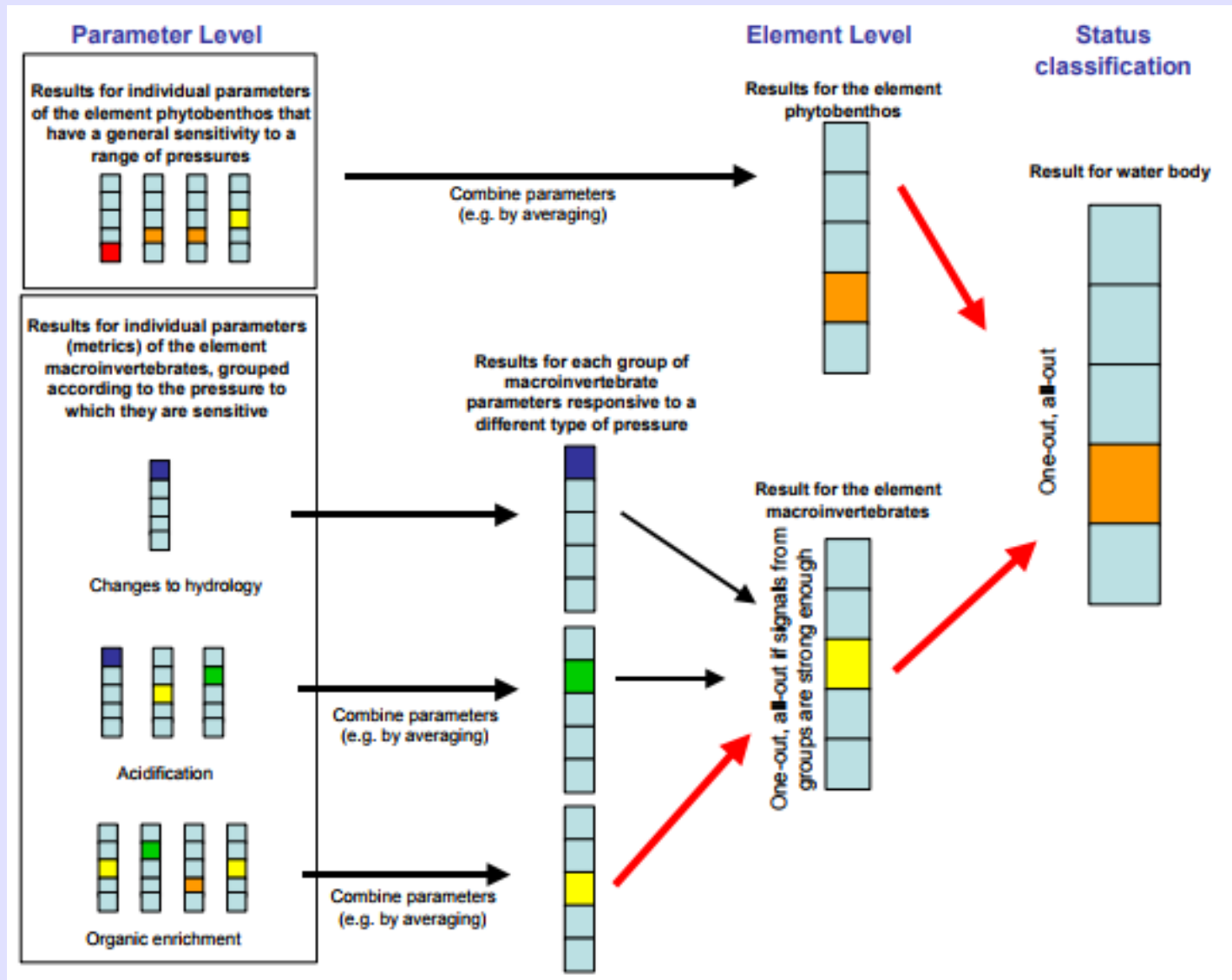
# Statistical analysis results

- **general physico-chemical parameters and specific nonpriority substances in ecological status/potential assessment**
  - **rivers - parameter value is calculated as 80th percentile, except for the parameter Dissolved Oxygen (10th percentile)**
  - **lakes and reservoirs - parameter value is calculated as mean value in a water column, except for the parameter Dissolved Oxygen (10th percentile)**

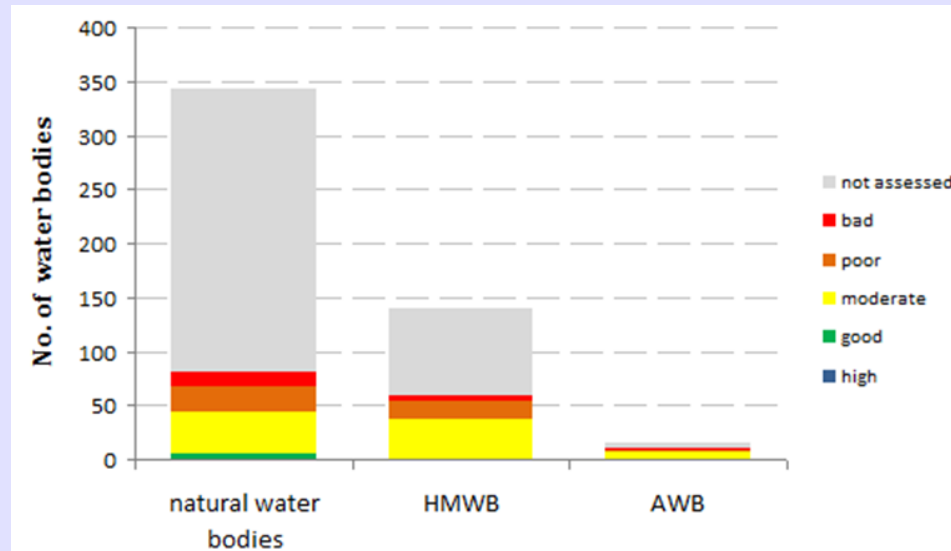
# The relationships between the biological, hydromorphological and physico-chemical quality elements in status classification



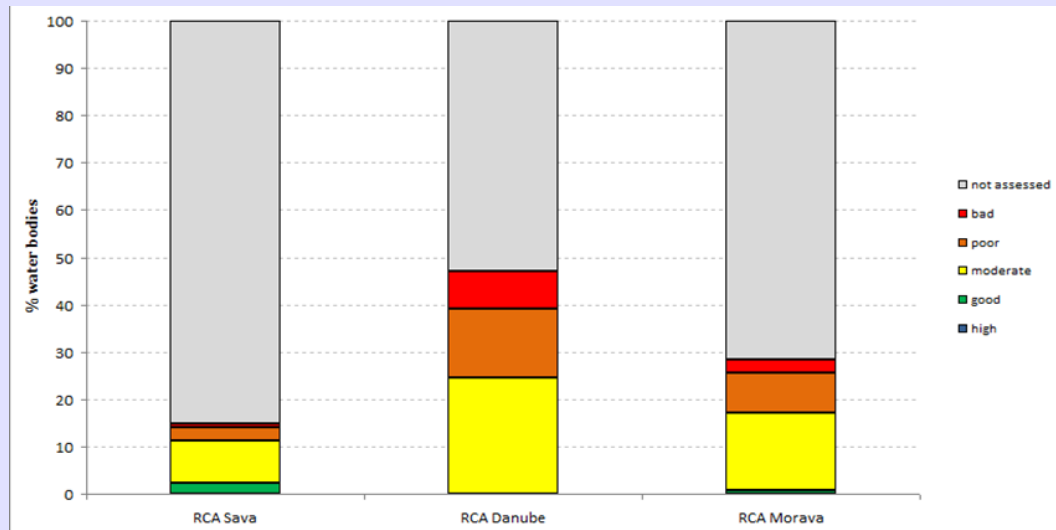
# Combining parameters to indicate the status of a biological quality element and applying the “one out all out” principle to overall ecological classification



## Percentage participation of natural water bodies, HMWB and AWB with respect to ecological status classes in the 2012-2014 period

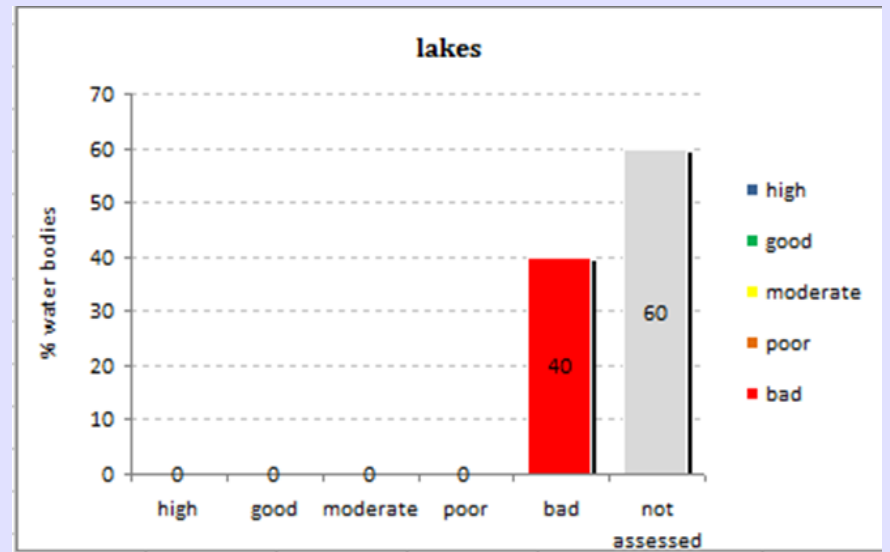
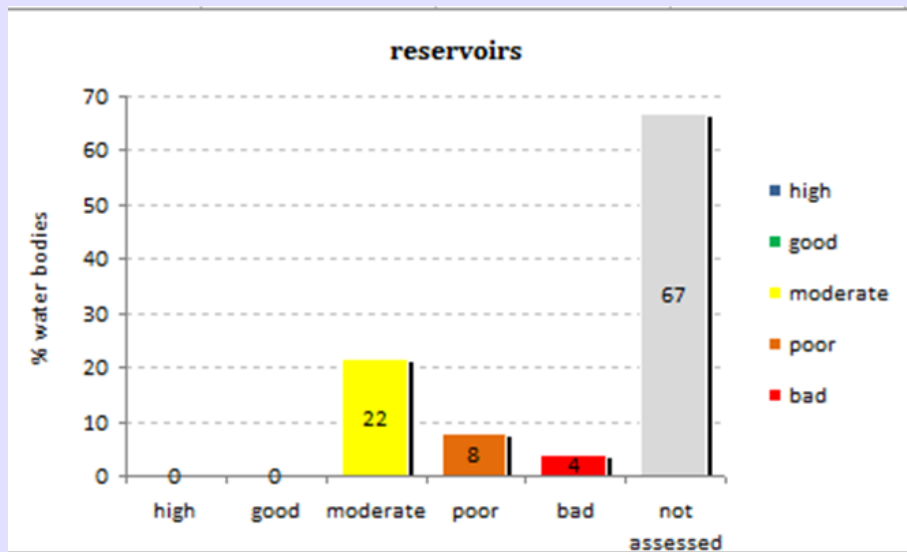
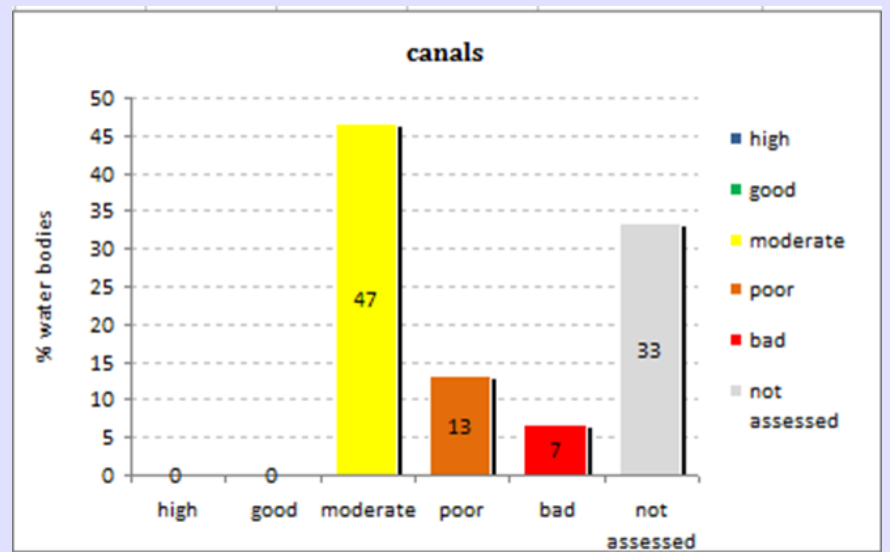
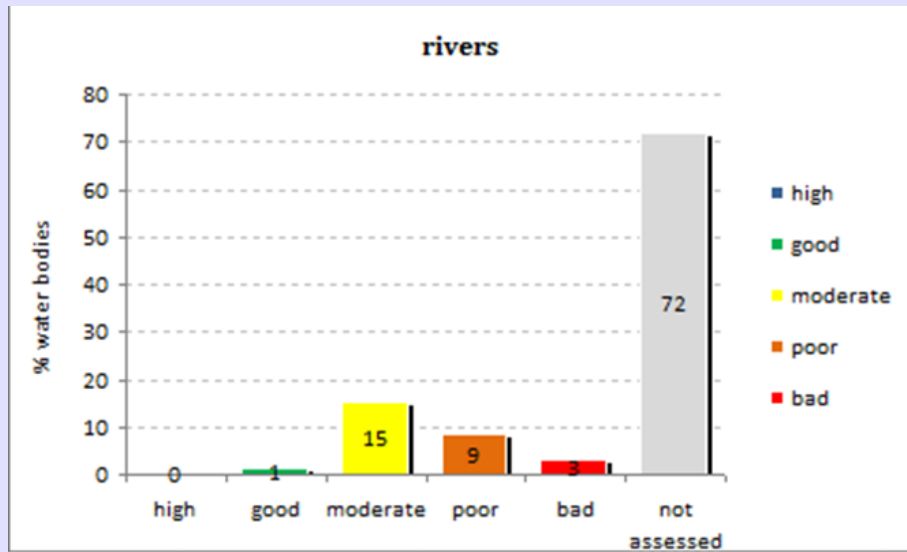


## Percentage participation of water bodies within each River Catchment Area (RCA) with respect to ecological status classes in the 2012-2014 period



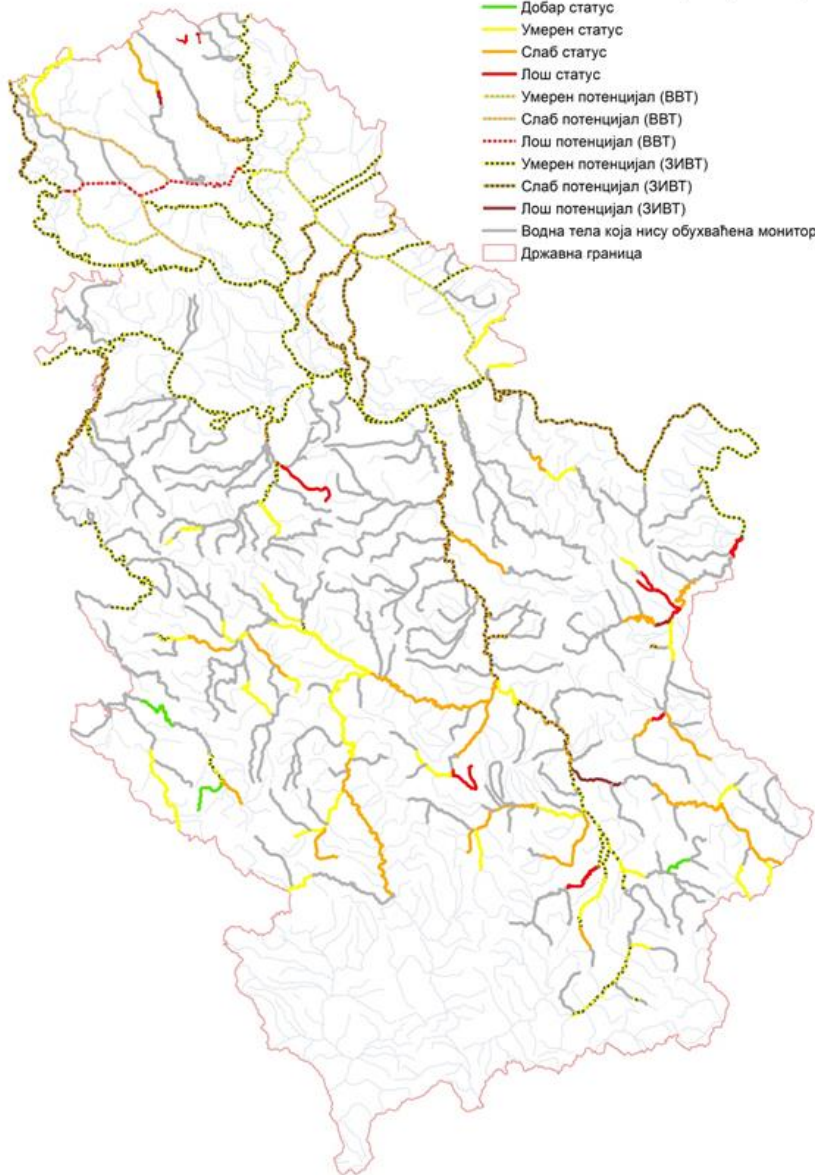
- ❖ the worst status had RCA Danube-no water bodies with satisfied status
- ❖ RCA Sava-only 3% water bodies with satisfied status
- ❖ RCA Morava - only 2% water bodies with satisfied status





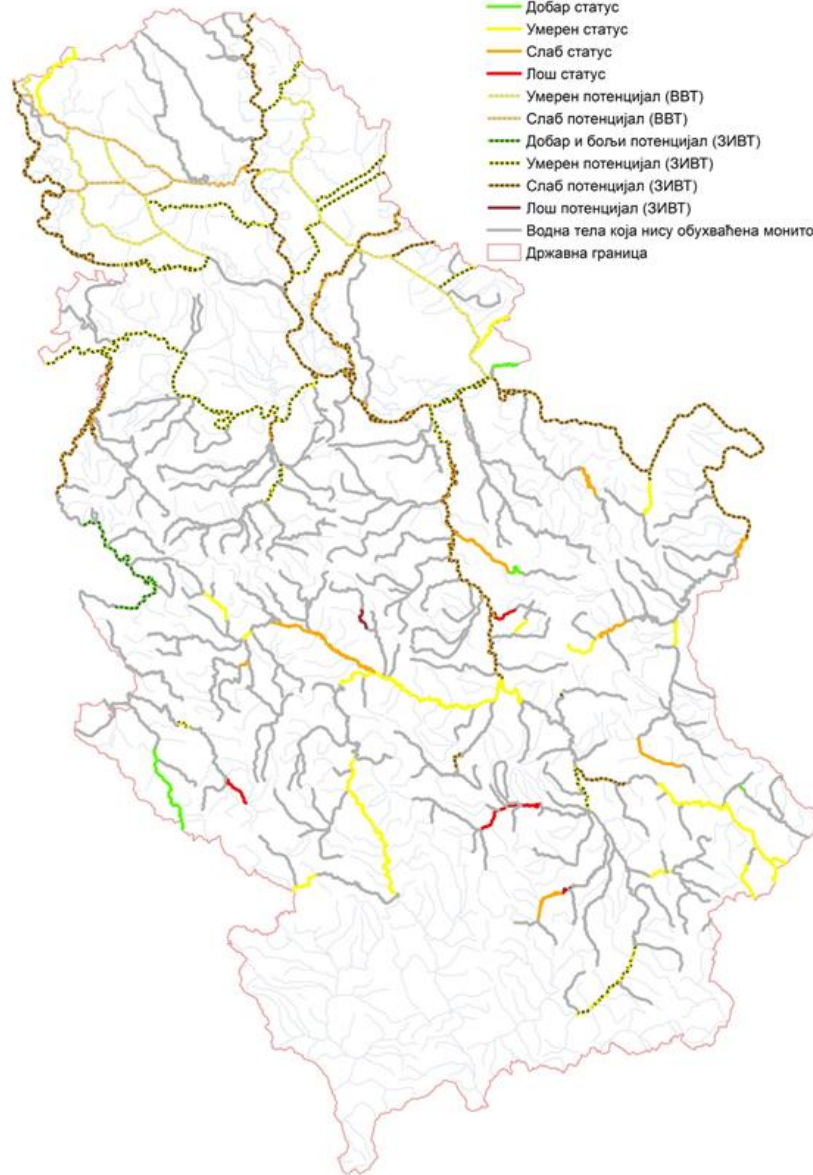
ЕКОЛОШКИ СТАТУС/ПОТЕНЦИЈАЛ (2012.-2013.)

- Добар статус
- Умерен статус
- Слаб статус
- Лош статус
- Умерен потенцијал (ВВТ)
- Слаб потенцијал (ВВТ)
- Лош потенцијал (ВВТ)
- Умерен потенцијал (ЗИВТ)
- Слаб потенцијал (ЗИВТ)
- Лош потенцијал (ЗИВТ)
- Водна тела која нису обухваћена мониторингом
- Државна граница



ЕКОЛОШКИ СТАТУС/ПОТЕНЦИЈАЛ (2014.)

- Добар статус
- Умерен статус
- Слаб статус
- Лош статус
- Умерен потенцијал (ВВТ)
- Слаб потенцијал (ВВТ)
- Добар и бољи потенцијал (ЗИВТ)
- Умерен потенцијал (ЗИВТ)
- Слаб потенцијал (ЗИВТ)
- Лош потенцијал (ЗИВТ)
- Водна тела која нису обухваћена мониторингом
- Државна граница





# Assessment of the ecological potential of reservoirs in the 2012-2014 period

Reservoir	River	Water body code	The type of river on which was formed	Locality	Biological quality elements			General physico-chemical elements	Trophic Status Parameters	Specific nonpriority polluting substances	Assessment of the ecological potential	Evaluation of levels reliability
					Phytoplankton	Phytobenthos	Macroinvertebrates					
Bela Crkva	-	-	AWB	B		-	-					medium
Radoinja	Uvac	UV_4	Type 4	A								medium
		UV_4	Type 4	B		-	-					medium
		UV_4	Type 4	C								medium
Bovan	Moravica	SOKMOR_2	Type 3	A			-					medium
		SOKMOR_2	Type 3	B		-						medium
		SOKMOR_2	Type 3	C		-	-					medium
		SOKMOR_2	Type 3	D		-	-					medium
Čelije	Rasina	RAS_2	Type 3	A		-	-					medium
		RAS_2	Type 3	B			-					medium
		RAS_2	Type 3	C		-						medium
		RAS_2	Type 3	D		-	-					medium
Gruža	Gruža	GRU_2	Type 3	A								medium
		GRU_2	Type 3	B		-	-					medium
		GRU_2	Type 3	C		-						medium
		GRU_2	Type 3	D		-	-					medium

# Assessment of the ecological status of lakes in Serbia

Lake	type of lake	Phytoplankton	General physico-chemical elements	Trophic State parameters	Assessment of the ecological status	Evaluation of reliability level
Palić	lake to 200 m a.s.l.					high
Ludaš	lake to 200 m a.s.l.					high

**Palić**



**Ludaš**

## **Guidelines on further harmonization of surface water monitoring to the WFD conducted by the SEPA**

- **Future surveillance monitoring programmes should include:**
  - **the stations situated at large lakes and reservoirs**
  - **other biological quality elements - macrophytes and fish**
  - **all hydromorphological quality elements**
- **Future operational monitoring programmes should include:**
  - **water bodies which have not yet been investigated (also grouping of water bodies with regard to type/various pressure and sensitivity to identified pressures should be carried out as well as conducting operational monitoring programme in representative water bodies in order to obtain results for the whole river catchment area)**
  - **fish and macrophyte community investigation at the water bodies in which these quality elements are the most sensitive to pressures**

## **Guidelines on further harmonization of surface water monitoring to the WFD**

- **Amendment the Regulation on the parameters of ecological and chemical status of surface waters and parameters of chemical status and quantitative status of groundwaters:**
  - **revision the list of parameters and ecological status class boundaries**
  - **in order to ensure comparability of monitoring systems, the results of the systems operated shall be expressed as Ecological Quality Ratios (EQR) for the purposes of classification of ecological status**

## **Guidelines on further harmonization of surface water monitoring to the WFD**

- **to define a clear and unambiguous methodology with main goal to determine appropriate values in ecological and chemical status assessment**
- **revising the criteria considering the level of reliability/confidence and precision in ecological status classification**
- **to define a list of the specific polluting substances and Environmental Quality Standards (EQS) with regard to these substances**
- **amendment the Regulation on reference conditions of surface water types**



## **Current activities related to the implementation of the WFD**

- The Serbian Environmental Protection Agency prepares a Report on the Status of Surface Waters in Serbia for 2015 and 2016 which will be published by the end of this year
- This report will also show the results of operational monitoring for the new 20 sampling stations on water bodies for which until now we had no monitoring data and for 6 reservoirs as well
- The Operational Monitoring Programme of surface waters for 2017 covered new 15 sampling stations on water bodies for which we had no monitoring data so fa

# Current activities related to the implementation of the WFD

- The implementation of the project "Operational monitoring of surface and groundwaters of the Republic of Serbia" is underway, financed by the Ministry of Environmental Protection of Serbia

## **Part 1 - "Operational monitoring of surface waters"**

- The aim of the project is to improve the protection of the watercourses of the Danube River Basin and to implement the Water Framework Directive by expanding the existing surface water monitoring and by introducing research of biological quality elements - macrophytes and fish that have not been systematically investigated in the territory of the RS so far
- the project was granted to a consortium headed by the Faculty of Biology, University of Belgrade
- the investigation of the macrophyte community, in order to assess the ecological status/potential, is foreseen for 27 water bodies of rivers and canals, 16 reservoirs and two lakes
- the investigation of fish community, in order to assess the ecological status/potential, is foreseen for 47 water bodies of river and canals



**Thanks for your attention !!!**