

“Towards the assessment of ecological status of water bodies in the Sava River Basin”

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Jožef Stefan Institute

Ljubljana, Slovenia

Monitoring of surface water status in the Republic of Serbia

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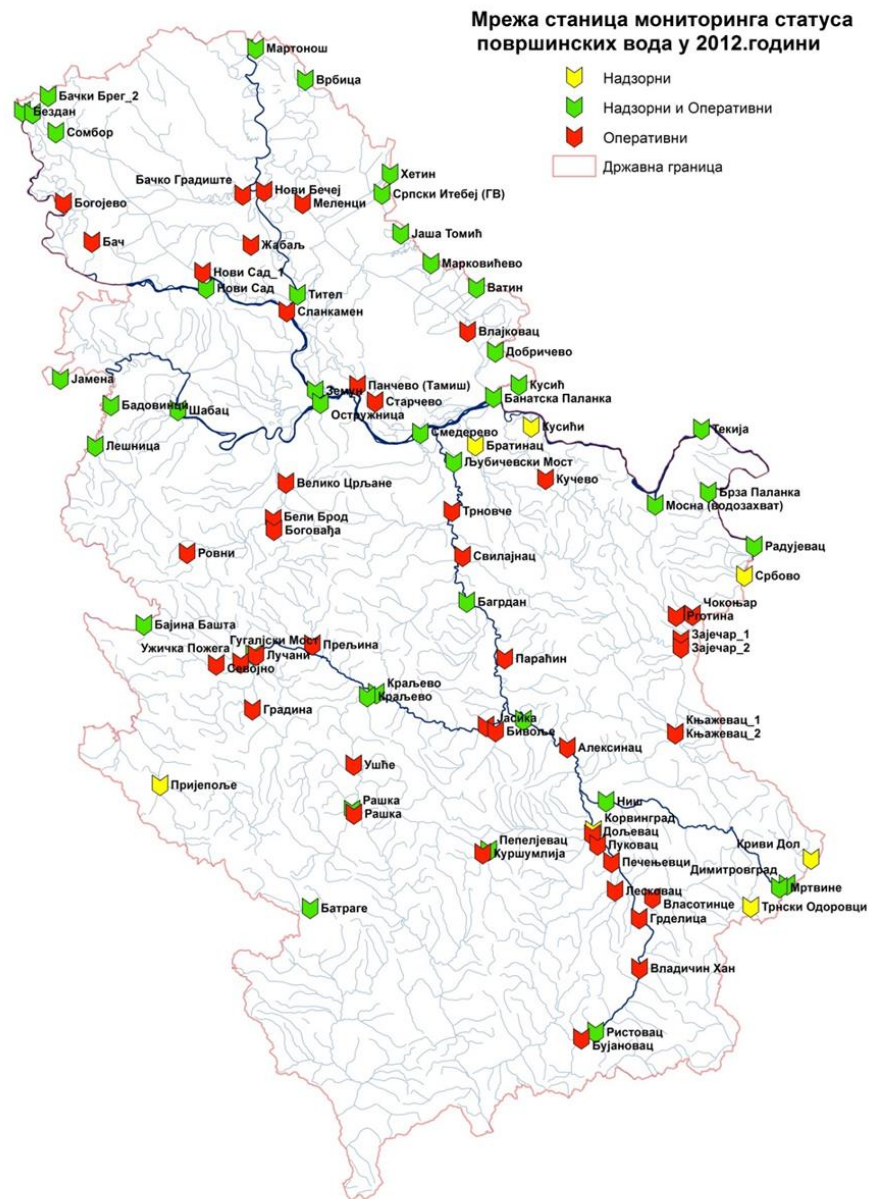


- **Adoption of Water Law in 2010 (Official Gazette of the Republic of Serbia 30/2010) and following bylaws acquired adequate conditions on harmonization of monitoring of surface water status in the Republic of Serbia with the Water Framework Directive (2000/60/EC) requirements**
- **National Water Bylaws 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 that represent the “basis” of water monitoring network with main goal to provide the whole water status survey within the catchment areas (the Morava, the Sava and the Danube River Catchment Area)**

- **Based on the results of water quality assessment in the National Water Network in 2009 and 2010, the water bodies at risk were identified and operational monitoring was established at these stations**
- **In 2012, 90 water bodies were included in the Operational Monitoring Programme (42 water bodies are also surveillance monitoring stations)**
- **In the 2012-2014 period, monitoring of surface water status covered a total of 149 water bodies in the territory of Serbia**

Water Monitoring Network of Surface Waters in 2012



Ecological status assessment

- **The following water quality elements are used for the indicative ecological status/potential assessment:**
 - **biological elements (phytoplankton, phytobenthos, macroinvertebrates, macrophytes and fishes)**
 - **general physico-chemical elements**
 - **specific nonpriority polluting substances discharged in significant quantity in water body**

Annual frequency of water quality elements investigation

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

* only at large plain rivers (Type 1)

Macroinvertebrates



Theodoxus fluviatilis



Sinanodonta woodiana

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

Macroinvertebrates



Hemimysis anomala



Dinocras cephalotes

- 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)

Macroinvertebrates



Ephemera danica

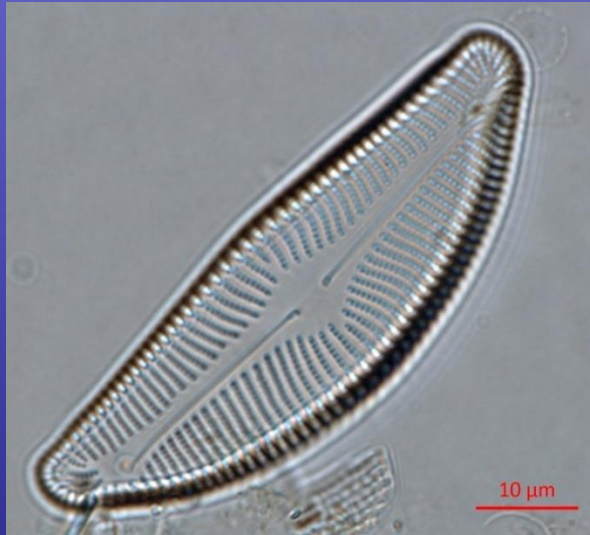


Pomatinus substriatus

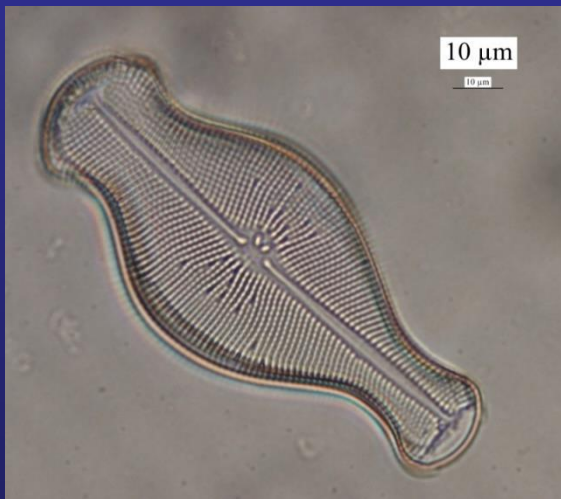
- **Identification of pressures:**
 - organic pollution
 - hydromorphological degradation

- **indicative ecological status/potential assessment**
 - meritory (obtained or mean value)

Phytobenthos (diatoms)



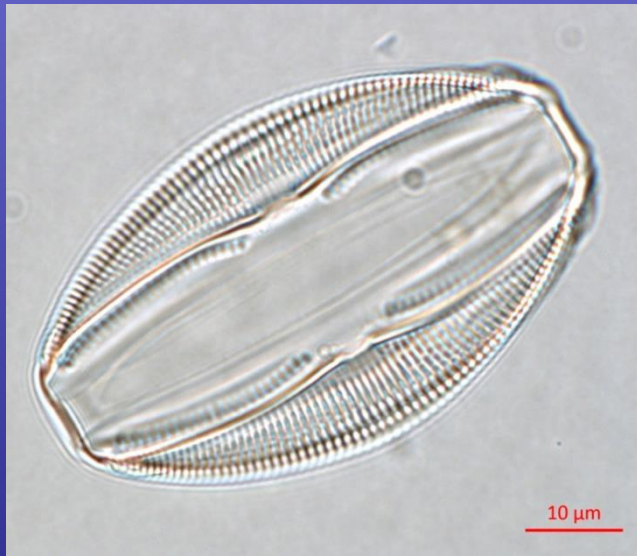
Encyonema prostratum



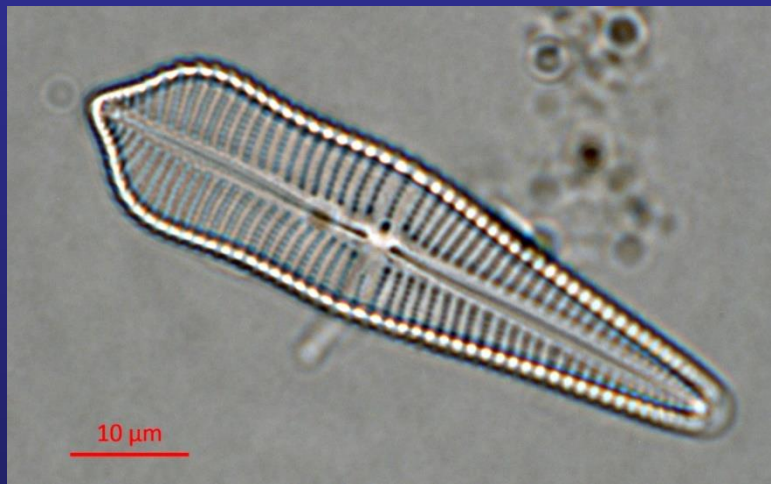
Didymosphaenia geminata

- 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

Phytobenthos (diatoms)



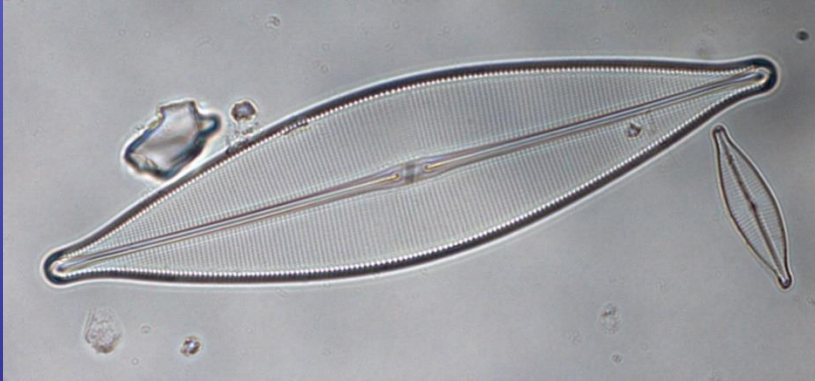
Amphora ovalis



Gomphonema augur

- in rivers diatoms are collected mostly from cobble-sized substrate and emergent or submerged aquatic macrophytes
- in reservoirs “artificial” substrates are introduced (5 large-sized stones) and attached to the mobile “platform” (or similar object) using polypropylene rope
- the stones have to be in water constantly at a depth of 50 to 80 cm
- after a two-month period diatoms are collected from the substrates

Phytobenthos (diatoms)



Craticula cuspidata



Hippodonta capitata

- The following diatom indices are used for indicative assessment of ecological status/potential:
 - **IPS** (Coste in Cemagref, 1982) "Indice de pollu-sensibilite"
 - **CEE** (Descy & Coste, 1990)
 - **EPI-D** (Dell'Uomo, 1999) "Diatom-based Eutrophication/Pollution Index"
- **Identification of pressures:**
 - eutrophication
 - organic pollution
- **indicative ecological status/potential assessment - meritory (obtained or mean value)**

Phytoplankton



Schroederia setigera



Desmodesmus denticulatus

- Sampling and sample preserving in accordance with the following standards: SRPS EN ISO 5667-1:2008, SRPS EN ISO 5667-3:2007, SRPS ISO 5667-6:1997 and 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
- Quantitative 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

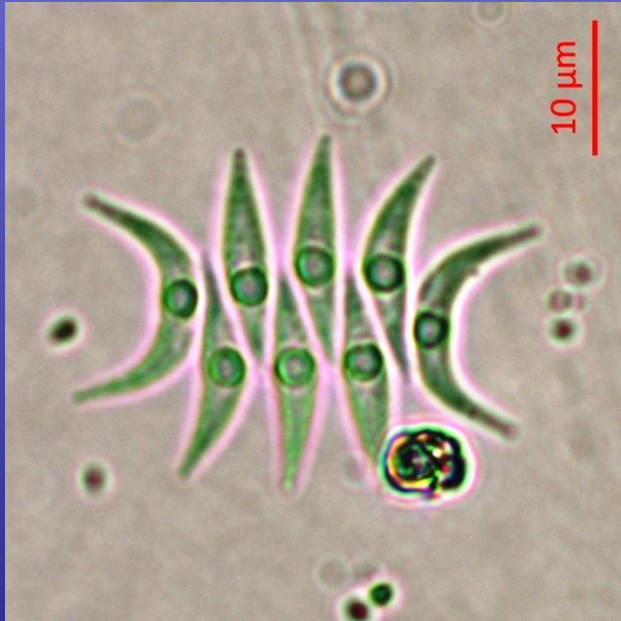
Methodology of reservoir investigation

- Reservoirs are investigated at 3 to 4 sampling sites by depth of the water column
- in the period of thermal stratification the metalimnion (thermocline) is determined by measuring temperature in the steps of 0.5 m to the bottom
- samples for general physico-chemical parameters, nutrients and chlorophyll-*a* are taken using hydrobiological bottle or pump every 1.5 m in depth in epilimnion, each 0.5m in metalimnion, then every 1.5 m in hypolimnion, down to 15 m in depth and thereafter at every 5m, including a point situated at 10% of the depth of the bottom-surface of reservoir
- in the period of circulation sampling is carried out every 1.5 to 3 m to a depth of 15 m, and then every 5 m, including a point situated at 10 % of the depth of the bottom-surface of reservoir
- samples for quantitative analysis of phytoplankton are taken using hydrobiological bottle at 3 to 4 sampling sites by depth of the water column in the layers of epilimnion, metalimnion and hypolimnion



*Planktothrix
rubescens*

Phytoplankton



Acutodesmus acuminatus



Micractinium pusillum

- **The following metrics are used for indicative assessment of ecological status/potential:**
 - phytoplankton abundance (cells ml⁻¹)
 - 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**

General physico-chemical elements in ecological status/potential assessment



- Water sampling in rivers, reservoirs and lakes according to the following standards: SRPS EN ISO 5667-1:2008, SRPS EN ISO 5667-3:2007, SRPS ISO 5667-4:1997 and SRPS ISO 5667-6:1997
- Parameters:
 - pH
 - Dissolved Oxygen (DO)
 - BOD₅
 - Total Organic Carbon (TOC)
 - Ammonium (NH₄⁺-N)
 - Nitrate (NO₃⁻-N)
 - Orthophosphate (PO₄³⁻-P)
 - Total Phosphorus (P)
 - Chloride (Cl⁻)

Statistical analysis results

- general physico-chemical parameters and specific nonpriority substance in ecological status/potential assessment
- priority and nonpriority hazardous substances in chemical status assessment

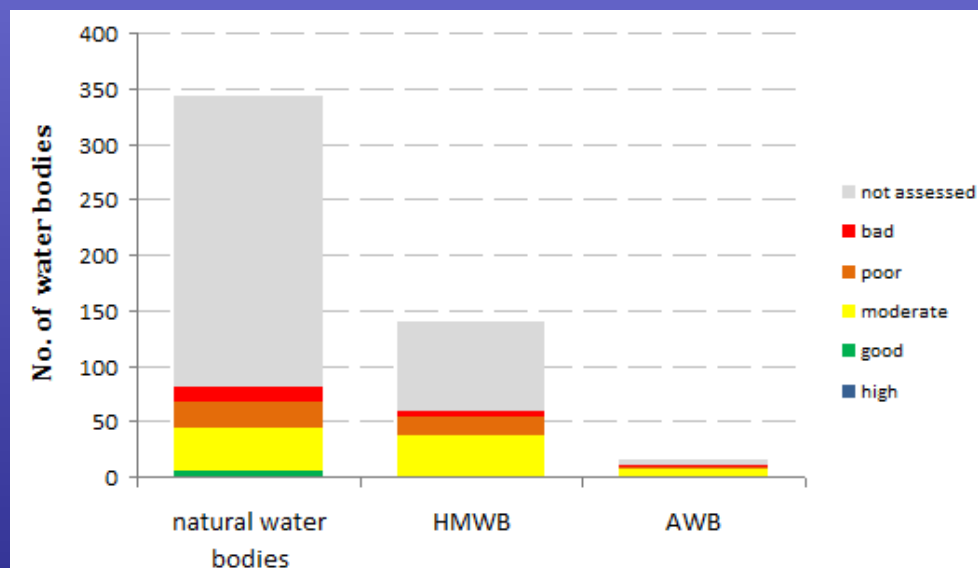
rivers - parameter value is calculated as 80th percentile, except for the parameter Dissolved Oxygen (10th percentile)

lakes and reservoirs - parameter value is calculated as mean value in a water column, except for the parameter Dissolved Oxygen (10th percentile)

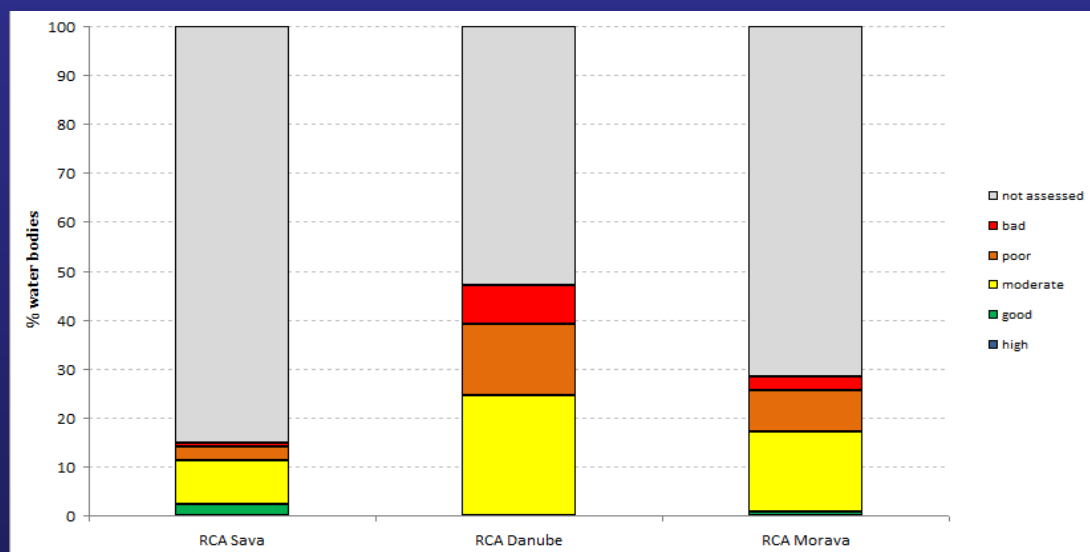
Specific nonpriority polluting substances

No.	Specific polluting substance	Analytical method
1	Цинк (Zn)	EPA 6020A:2007
2	Бакар (Cu)	EPA 6020A:2007
3	Алуминијум (Al)	EPA 6020A:2007
4	Гвожђе (Fe)	EPA 6020A:2007
5	Манган (Mn)	EPA 6020A:2007
6	Хром укупни (Cr)	EPA 8270D:2007
7	Арсен (As)	EPA 6020A:2007
8	Бор (B)	EPA 6020A:2007
9	Површински анјон активне супстанце	EPA 425.1
10	Нафтни угљоводоници	MSz 12750/23-76
11	Фенолни индекс	EPA 8270D:2007
12	Укупна бета радиоактивност	SRPS ISO 9697:2008
13	Полихлоровани бифенили (PCB):28,52,101,118,138,153,180 и 194	EPA 8270D:2007
14	Пропазин (Propazin)	SRPS ISO EN 11369:2008
15	Линурон (Linuron)	SRPS ISO EN 11369:2008
16	Тербутилазин (Terbutilazin)	SRPS ISO EN 11369:2008

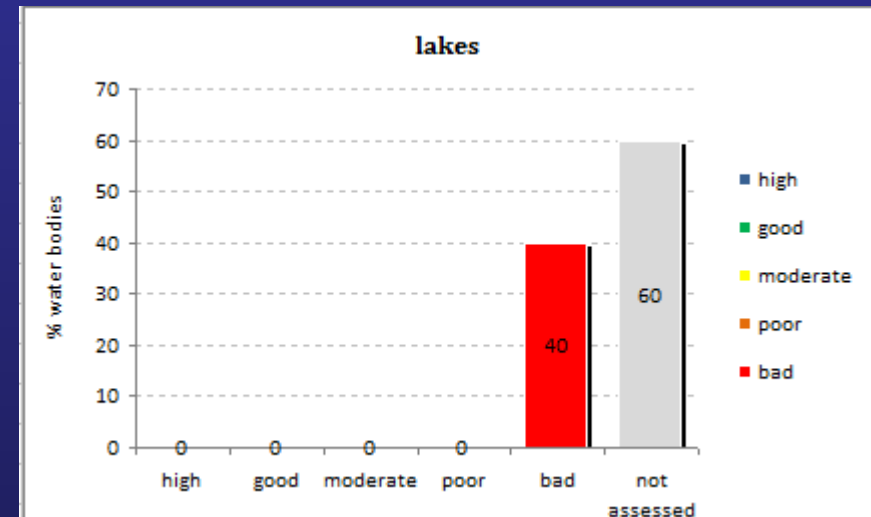
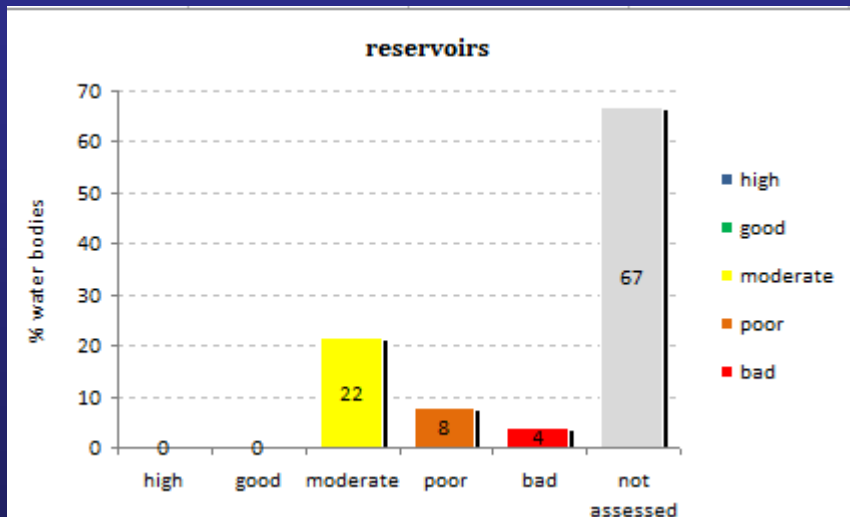
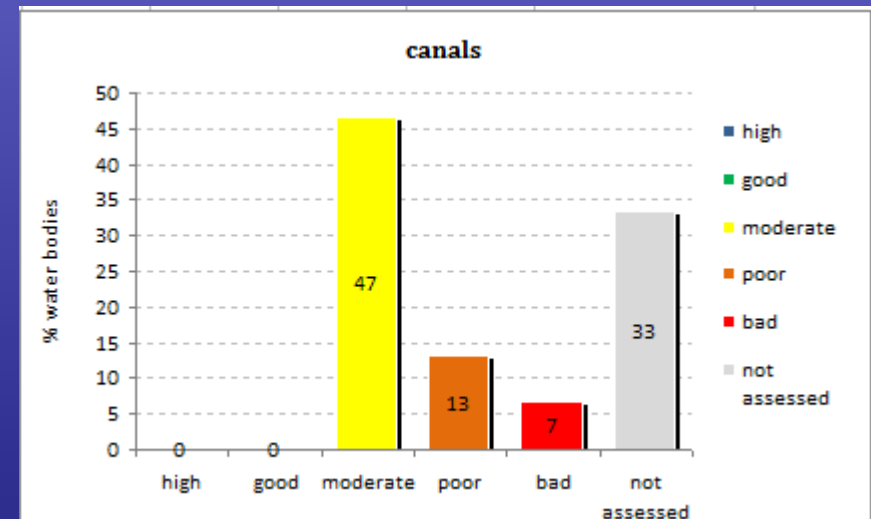
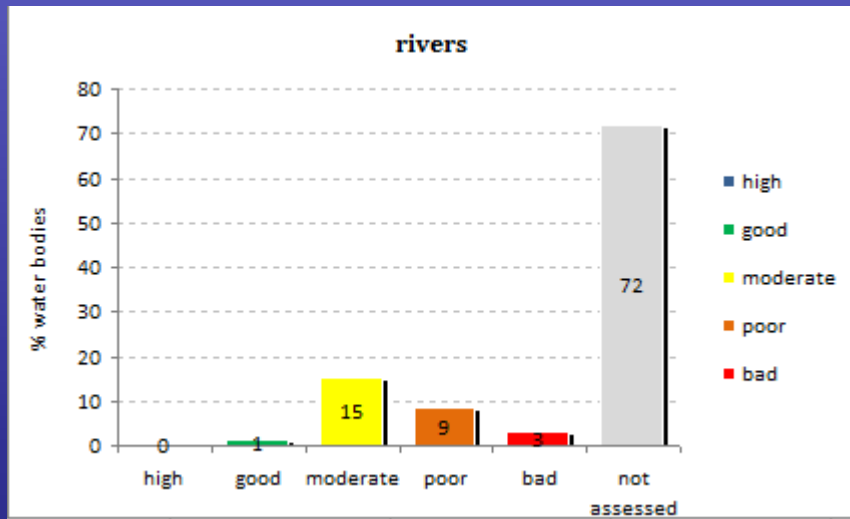
Percentage participation of natural water bodies, HMWB and AWB with respect to ecological status classes in the 2012-2014 period



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

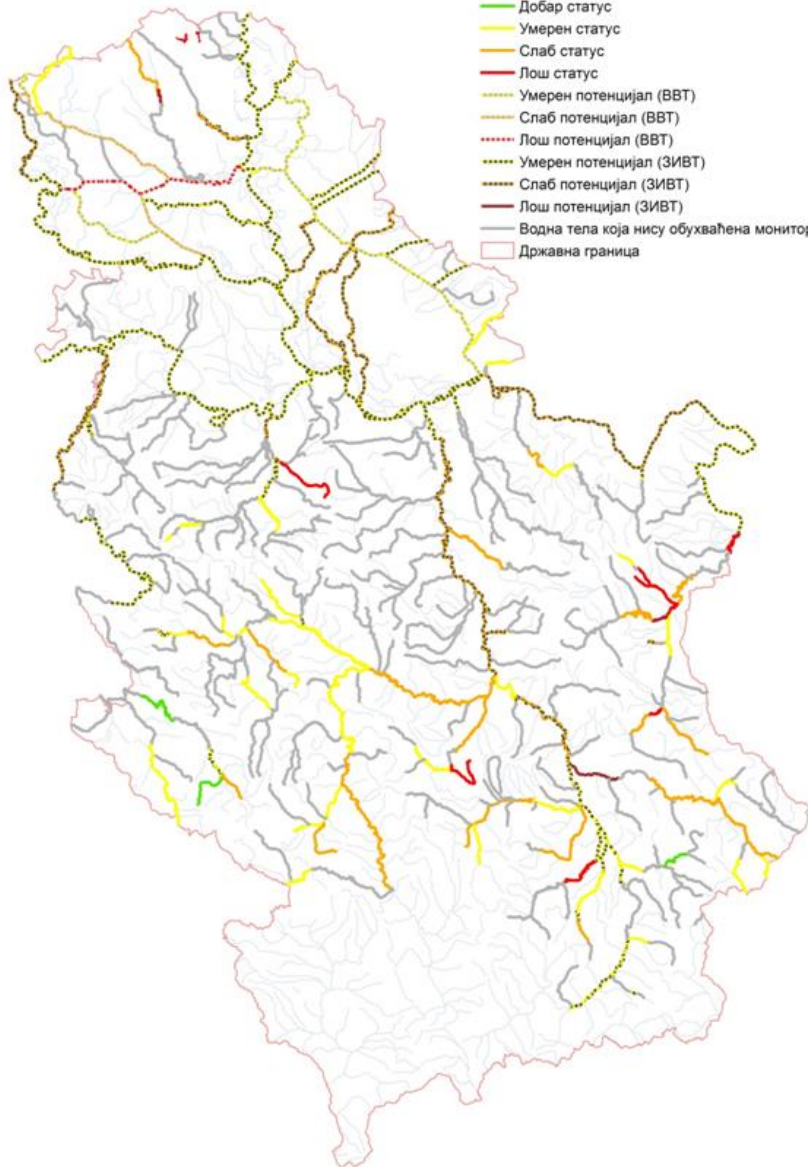


Percentage participation of different water body types with regard to ecological status classes in the 2012-2014 period



ЕКОЛОШКИ СТАТУС/ПОТЕНЦИЈАЛ (2012.-2013.)

- Добар статус
- Умерен статус
- Слаб статус
- Лош статус
- Умерен потенцијал (BBT)
- Слаб потенцијал (BBT)
- Лош потенцијал (BBT)
- 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 (BBT)
- Слаб потенцијал (BBT)
- Добар и бољи потенцијал (ЗИВТ)
- Умерен потенцијал (ЗИВТ)
- Слаб потенцијал (ЗИВТ)
- Лош потенцијал (ЗИВТ)
- Водна тела која нису обухваћена мониторингом
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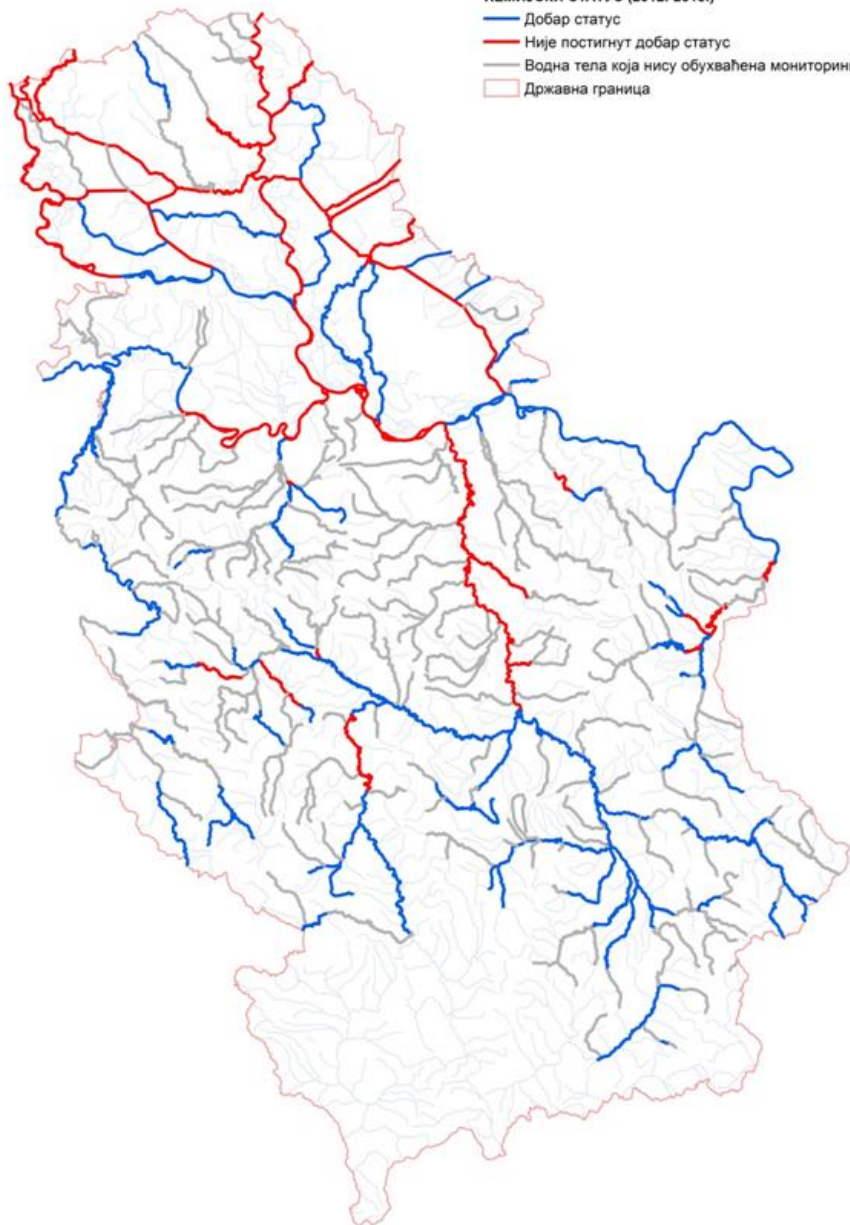
Chemical status assessment - priority and priority hazardous substances

No.	CAS Number 1	Priority substance	Analytical method
1	15972-60-8	Алахлор (Alachlor)	EPA 8270D:2007
2	120-12-7	Антрацен (Anthracene)	EPA 8270D:2007
3	1912-24-9	Атразин (Atrazine)	SRPS ISO EN 11369:2008
4	7440-43-9	Кадмијум (Cd) и његова једињења	EPA 6020A:2007
5	470-90-6	Хлорфенвинфос (Chlorfenvinphos)	EPA 8270D:2007
6	2921-88-2	Хлорпирифос (Chlorpyrifos)	EPA 8270D:2007
7-10	Циклодиенски пестициди		
	309-00-02	Алдрин (Aldrin)	EPA 8270D:2007
	60-57-1	Диелдрин (Dieldrin)	EPA 8270D:2007
	72-20-8	Ендрин (Endrin)	EPA 8270D:2007
	465-73-6	Изордин (Izodrin)	EPA 8270D:2007
11	/	Укупан ДДТ	EPA 8270D:2007
12	50-29-3	Пара-пара-ДДТ	EPA 8270D:2007
13	330-54-1	Диурон (Diuron)	SRPS ISO EN 11369:2008
14	115-29-7	Ендосуфлан (endosulfan)	EPA 8270D:2007
15	206-44-0	Флуорантен (Fluoranthene)	EPA 8270D:2007
16	118-74-1	Хексахлорбензен (Hexachlorobenzene)	EPA 8270D:2007
17	87-68-3	ХексахлорбутADIЕН (Hexachlorobutadiene)	EPA 8270D:2007

No.	CAS Number 1	Priority substance	Analytical method
18	Хексахлорциклохексани (Hexachlorocyclohexane)		
	319-84-16	α- НСН	EPA 8270D:2007
	319-85-7	β- НСН	EPA 8270D:2007
	58-89-9	γ- НСН(Линдан)	EPA 8270D:2007
	608-73-1	δ- НСН	EPA 8270D:2007
19	34123-59-6	Изопротурон (Isoproturon)	SRPS ISO EN 11369:2008
20	140-66-9	Октифеноли 4 - (1,1,3,3 -tetrametilbutil) фенол	EPA 8270D:2007
21	7439-92-1	Олово (Pb) и његова једињења	EPA 6020A:2007
22	91-20-3	Нафтален (Naphthalene)	EPA 8270D:2007
23	7440-02-0	Никл (Ni) и његова једињења	EPA 6020A:2007
24	104-40-5	4-(пара)нонилфенол-(4-(para)nonylphenol)	EPA 8270D:2007
25	608-93-5	Пентахлоробензен (Pentachlorobenzene)	EPA 8270D:2007
26	87-86-5	Пентахлорофенол (Pentachlorophenol)	EPA 8270D:2007
27-31	Полиароматични угљоводоници (ПАН)		
	50-32-8	Бензо(а)пирен (Benzo(a)pyrene)	EPA 8270D:2007
	205-99-2	Бензо(б)флуорантен (Benzo(b)fluoranthene)	EPA 8270D:2007
	191-24-2	Бензо(г,х,и)перилен (Benzo(g,h,i)perylene)	EPA 8270D:2007
	207-08-9	Бензо(к)флуорантен (Benzo(k)fluoranthene)	EPA 8270D:2007
	193-39-5	Индено(1,2,3ц,д)пирен (Indeno(1,2,3-cd)pyrene)	EPA 8270D:2007
33	122-34-9	Симазин (Simazine)	SRPS ISO EN 11369:2008
34	1582-09-8	Трифлуралин (Trifluralin)	EPA 8270D:2007
35	886-50-0	Тербутрин (Terbutrin)	SRPS ISO EN 11369:2008
36	7439-97-6	Жива (Hg) и њена једињења	EPA 245.1:1978
37	76-44-8	Хептахлор (Heptahlor)	EPA 8270D:2007
38	1024-57-3	Хептахлор-епоксид(Heptahlor-epoksid)	EPA 8270D:2007

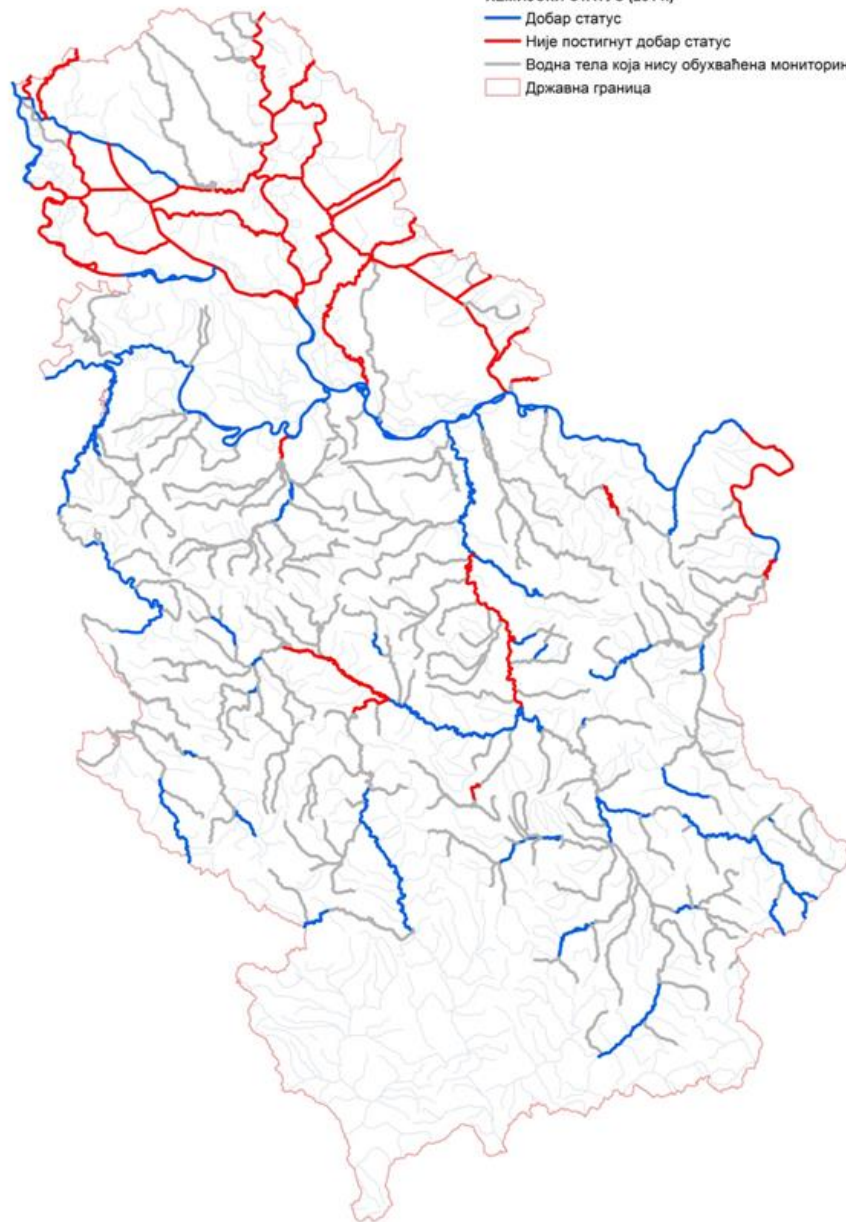
ХЕМИЈСКИ СТАТУС (2012.-2013.)

- Дobar статус
- Није постигнут добар статус
- Водна тела која нису обухваћена мониторингом
- Државна граница



ХЕМИЈСКИ СТАТУС (2014.)

- Дobar статус
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Priority and priority hazardous substances

- The obtained concentrations of Dissolved Nickel (Ni) and Ni-compounds were found to be the most frequent above the concentration limits in chemical status assessment
- Natural background level of Ni is not defined
- Comparing concentration levels of Ni to the neighbouring countries regulations, it is concluded that our annual mean concentrations of Ni are very low, therefore it is necessary to revise valid National Regulation

Parameter	National Regulation of Serbia		National Regulation of Slovenia*		National Regulation of Croatia**	
	PGK [µg/l]	MDK [µg/l]	PGK [µg/l]	MDK [µg/l]	PGK [µg/l]	MDK [µg/l]
Nickel (Ni) and its compounds	4	34	20	-	20	-

* Uredba o spremembah in dopolnitvah Uredbe o stanju površinskih voda, Ur. l. RS št. 98/10

** Uredba o standardu kakavoće vode, Narodne novine br. 073/2013

Guidelines on further harmonization of surface water monitoring to the WFD

- **Future surveillance monitoring programmes should include:**
 - the stations situated at large lakes and reservoirs
 - other biological quality elements - macrophytes and fishes
 - 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
- **Strengthening of staff capacity in the SEPA to achieve WFD requirements, current is not sufficient**
- **Forming and equipping Regional Monitoring Centers within the SEPA**

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 in Serbia to the WFD

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

International cooperation

- The Serbian Environmental Protection Agency (SEPA) as a part of its competency reports on state of the environment on national and international level
- The SEPA submits data to the:
 - European Environment Information and Observation Network (EIONET)
 - International Commission for the Protection of the Danube River (ICPDR)
- Participation in the Joint Danube Surveys (JDS 1, 2001; JDS 2, 2007)
- Bilateral cooperation (Hungary, Romania)
 - in cooperation between Serbia and Hungary, the methodology is harmonized to the WFD requirements
 - in cooperation between Serbia and Romania these activities will be forthcoming

Cooperation with national institutions

- **Republic Hydrometeorological Service of Serbia (RHMS)**
- **Water Directorate of Serbia, Belgrade**
- **Institute for Biological Research “Siniša Stanković” (IBRSS), University of Belgrade**
- **Faculty of Biology, University of Belgrade**
- **Faculty of Sciences, Department of Biology and Ecology, University of Novi Sad**
- **Jaroslav Černi Institute for the Development of Water Resources (JCI)**
- **Serbian Water Pollution Control Society**
- **Other ministries and public water management companies**

Field research



Biological laboratory

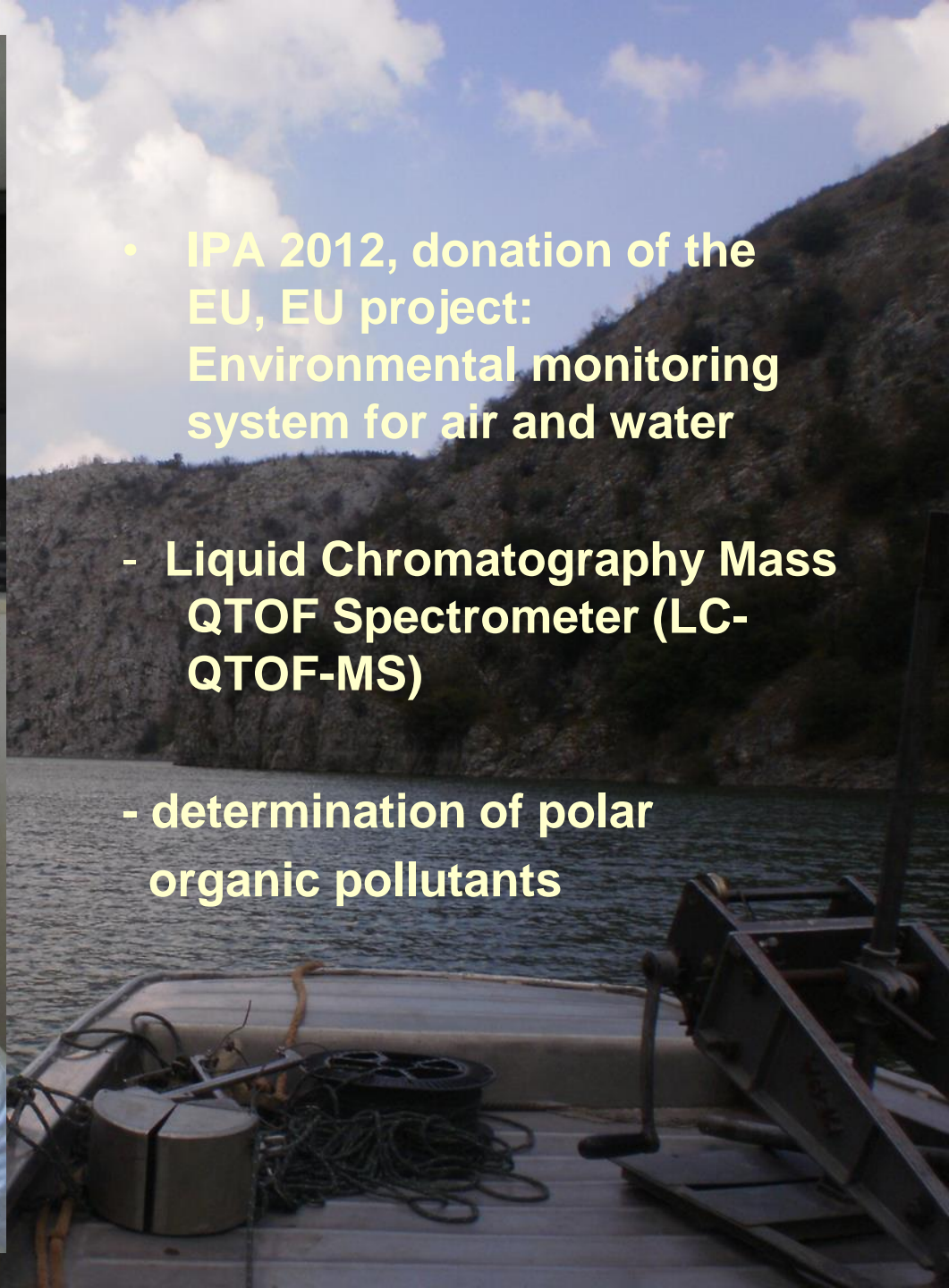


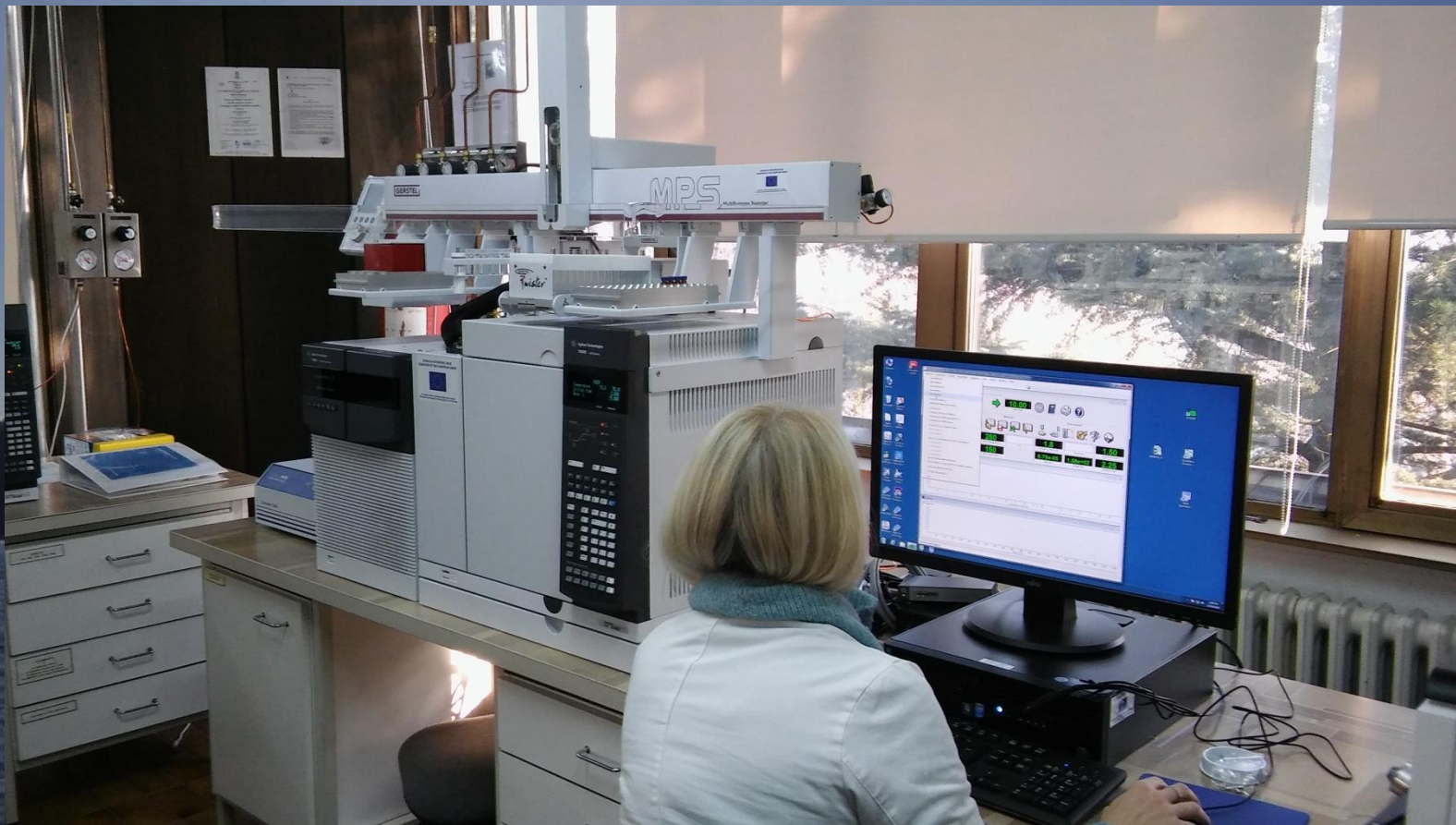
Biological laboratory





- IPA 2012, donation of the EU, EU project:
Environmental monitoring system for air and water
- Liquid Chromatography Mass QTOF Spectrometer (LC-QTOF-MS)
- determination of polar organic pollutants

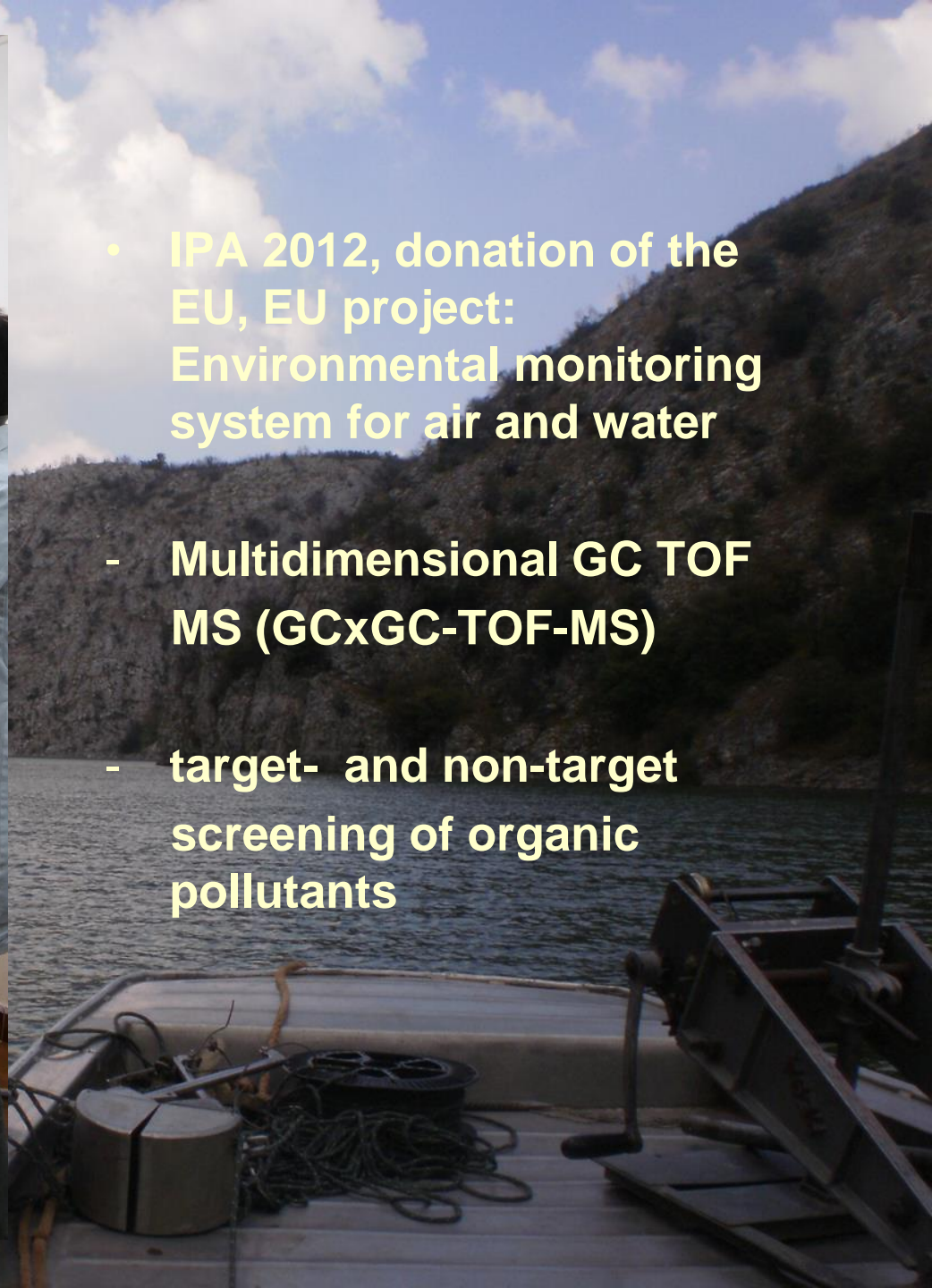




- **Triple quadrupole GC-MS-MS**
- **determination of nonpolar and semipolar organic pollutants**



- IPA 2012, donation of the EU, EU project: Environmental monitoring system for air and water
- Multidimensional GC TOF MS (GCxGC-TOF-MS)
- target- and non-target screening of organic pollutants





- **IPA 2012, donation of the EU, EU project: Environmental monitoring system for air and water**
- **Analyser for the determination of Mercury (Hg) in liquid samples using technique of cold vapours with atomic fluorescence detection**



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

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Many thanks for your attention !!!

