Stanislava Bačíková, Katarína Kučárová, Magdaléna Valúchová

DANUBE SURFACE WATER AND RIVERBED SEDIMENT QUALITY

Danube Monitoring Scientific Conference Publication, Slovak Section, chapter:

V.1.10. Monitoring of surface waters and sediment quality in the area influenced by the Gabčíkovo hydraulic structures

Magdaléna Valúchová, Katarína Kučárová

V.1.11. Impact of the Gabčíkovo hydraulic structures on the Danube water quality

Stanislava Bačíková

THE MONITORING OF ENVIRONMENTAL COMPONENTS IN THE SURROUNDINGS OF THE GABČÍKOVO HYDRAULIC STRUCTURES

The aim of monitoring:

is documenting the development of water quality in the Danube between Bratislava and Komárno, water quality in the Čunovo reservoir, in the arm system, in the Mosoni Danube and in the seepage canals.

Runs in accordance with:

- The Decision of the administrative authority
- The “Agreement” between Slovakia and Hungary from 1995

- The investor and operator of the Gabčíkovo project, the water-management constructions, state enterprise, is responsible for monitoring.
- The complete list of monitored parameters, frequency and sites of sampling are defined in an Annex of the “Decision”.
- Methods of sampling, applied analytical methods, and the annual evaluation of the development of surface water quality in the affected territory are presented in the National reports, Joint reports and relevant publications are available on the web side

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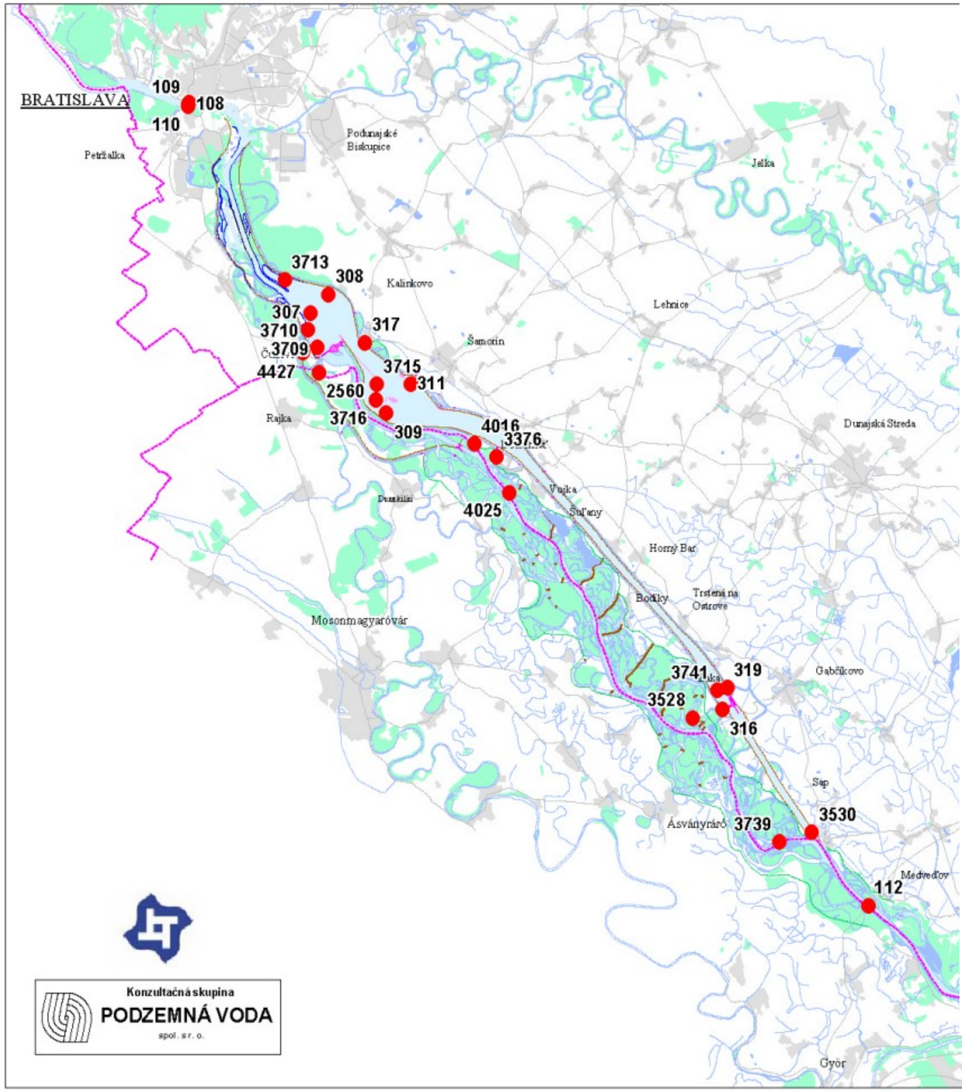
CONTROL SITES OF SURFACE WATER QUALITY IN THE AREA OF THE GABČÍKOVO HYDRAULIC STRUCTURES

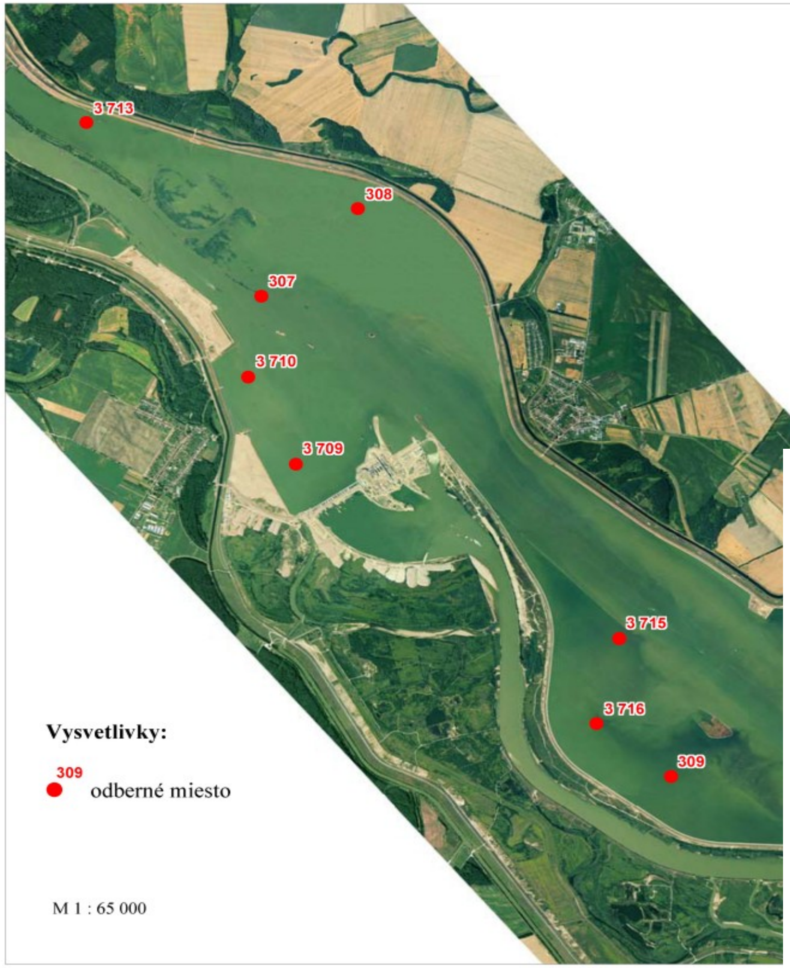


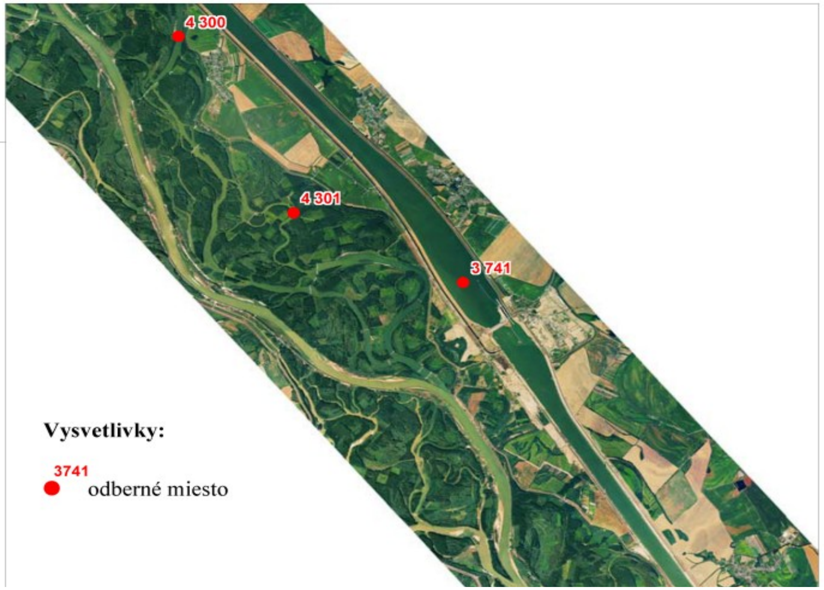
Tab. 1. Control sites of surface water quality in the area of the Gabčíkovo hydraulic structures.

Id. No.	Number of profile	Locality	Water-right decision		Agreement 95	
			WD	Org.	A95	Org.
109	110490	Danube, Bratislava – New bridge, M, rkm 1868.75	✓	SVP-BA	✓*	VÚVH
108	110390	Danube, Bratislava - New bridge, LS, rkm 1868.75	✓	SVP-BA		
110	110590	Danube, Bratislava - New bridge, RS, rkm 1868.75	✓	SVP-BA		
1203	110790	Danube, Rajka – RS, r km 1848			*	VÚVH
112	110890	Danube, Medveďov - bridge, M, rkm 1806.30	✓	SVP-BA	✓*	VÚVH
307	8012	Danube – reservoir, Kalinkovo, SL, km 2.8	✓	SVP-BA	✓	SVP-BA
3709	2001	Danube – reservoir, Kalinkovo, RS, km 1	✓	SVP-BA		
3710	2002	Danube – reservoir, Kalinkovo, RS, km 2.2	✓	SVP-BA		
308	8013	Danube – reservoir, Kalinkovo, LS, km 15	✓	SVP-BA	✓	SVP-BA
3713	2004	Danube – reservoir, Kalinkovo, LS, km 16.5	✓	SVP-BA		
309	8014	Danube – reservoir, Šamorín, RS, km 5	✓	SVP-BA	✓	SVP-BA
3715	2007	Danube – reservoir, Šamorín, RS, km 2.5	✓	SVP-BA		
3716	2008	Danube – reservoir, Šamorín, RS, km 3.5	✓	SVP-BA		
311	8016	Danube – reservoir, Šamorín, LS, km 8	✓	SVP-BA	✓	SVP-BA
4016	0002	Danube, Dunakiliti, SL, weir, rkm 1843.1	✓	SVP-BA	✓	SVP-BA
4025	1106	Danube, Dobrohošť, LS, rkm 1838.6	✓	SVP-BA	✓	SVP-BA
3739	8028	Danube, Sap, M, upstream of mouthing, rkm 1812.5	✓	SVP-BA	✓	SVP-BA
1205	111090	Danube, Komárno - bridge, SL, rkm 1767	✓	SVP-BA	✓	VÚVH
2560	115090	Mošonský Danube, Čunovo, RS, rkm 96	✓	SVP-BA		
3529	115090	Mošonský Danube, Čunovo			✓*	VÚVH
3741	S16	Bypass canal, Gabčíkovo, SL, upper roadstead	✓	SVP-BA		
3530	8018	Tail-race canal, Sap, LS	✓	SVP-BA	✓	SVP-BA
3376	8026	Arm system, Dobrohošť	✓	SVP-BA	✓	SVP-BA
3528	8027	Arm system, Bačianske rameno arm	✓	SVP-BA		
4427	8019	Right-side seepage canal, Čunovo, km 0.0 LS	✓	SVP-BA		
3531	115290	Right-side seepage canal, Čunovo			✓*	VÚVH
316	8021	Right-side seepage canal, Gabčíkovo, km 16.5	✓	SVP-BA		
317	8022	Left-side seepage canal, Hamuliakovo, km 11.5	✓	SVP-BA	✓	SVP-BA
319	8024	Left-side seepage canal, Gabčíkovo, km 16	✓	SVP-BA		

* monitoring of "Border waters" between Hungary and Slovakia,
M – middle of river; LS – left side; RS – right side; SL – stream line

SURVEY OF SAMPLING PLACES OF SEDIMENTS





Tab. 2. Survey of sampling places of sediments

Id. No.	Number of profiles	Locality	Water-right decision		Agreement 95	
			WI	Org.	D95	Org.
307	8012	Danube – reservoir, Kalinkovo, SL, km 2.8	✓	SVP-BA	✓	SVP-BA
3709	2001	Danube – reservoir, Kalinkovo, RS, km 1	✓	SVP-BA		
3710	2002	Danube – reservoir, Kalinkovo, RS, km 2.2	✓	SVP-BA		
308	8013	Danube – reservoir, Kalinovo, LS, km 15	✓	SVP-BA	✓	SVP-BA
3713	2004	Danube – reservoir, Kalinkovo, LS, km 16.5	✓	SVP-BA		
309	8014	Danube – reservoir, Šamorín, RS, km 5	✓	SVP-BA	✓	SVP-BA
3715	2007	Danube – reservoir, Šamorín, RS, km 2.5	✓	SVP-BA		
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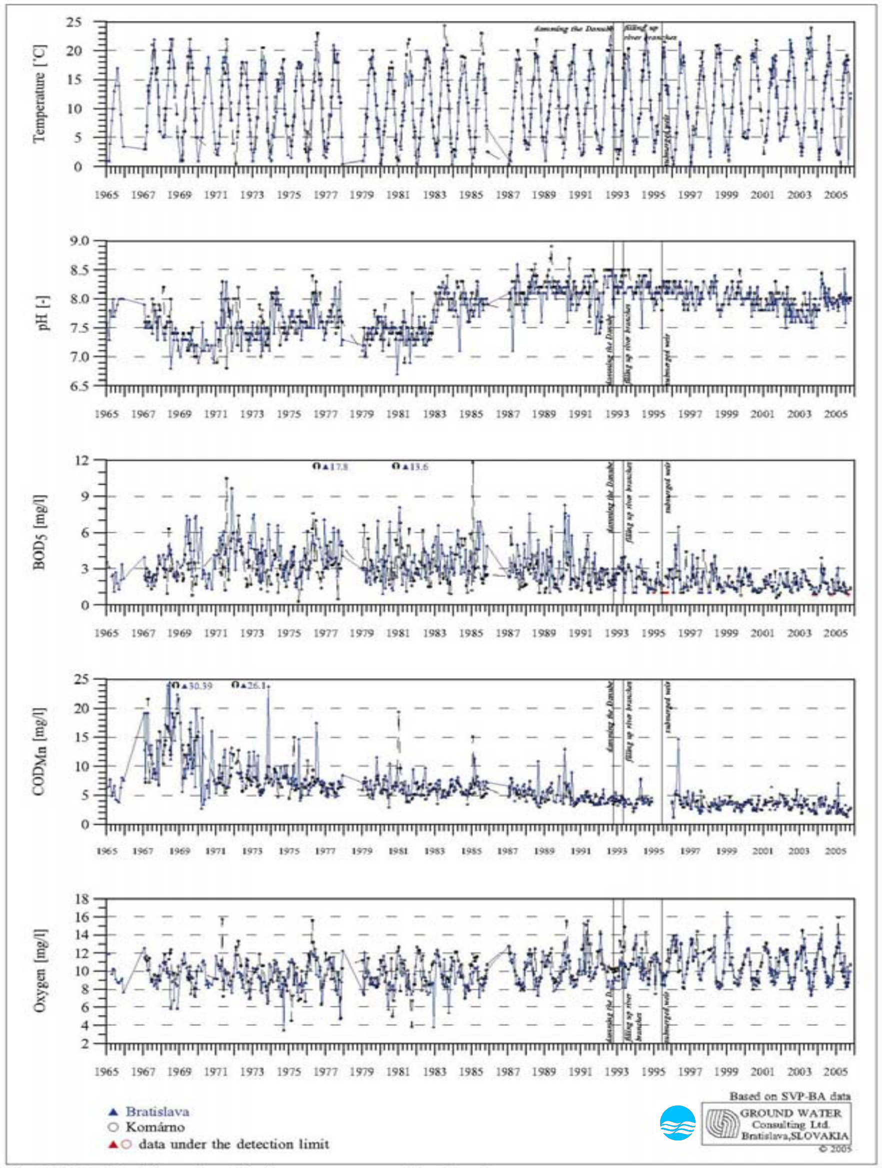
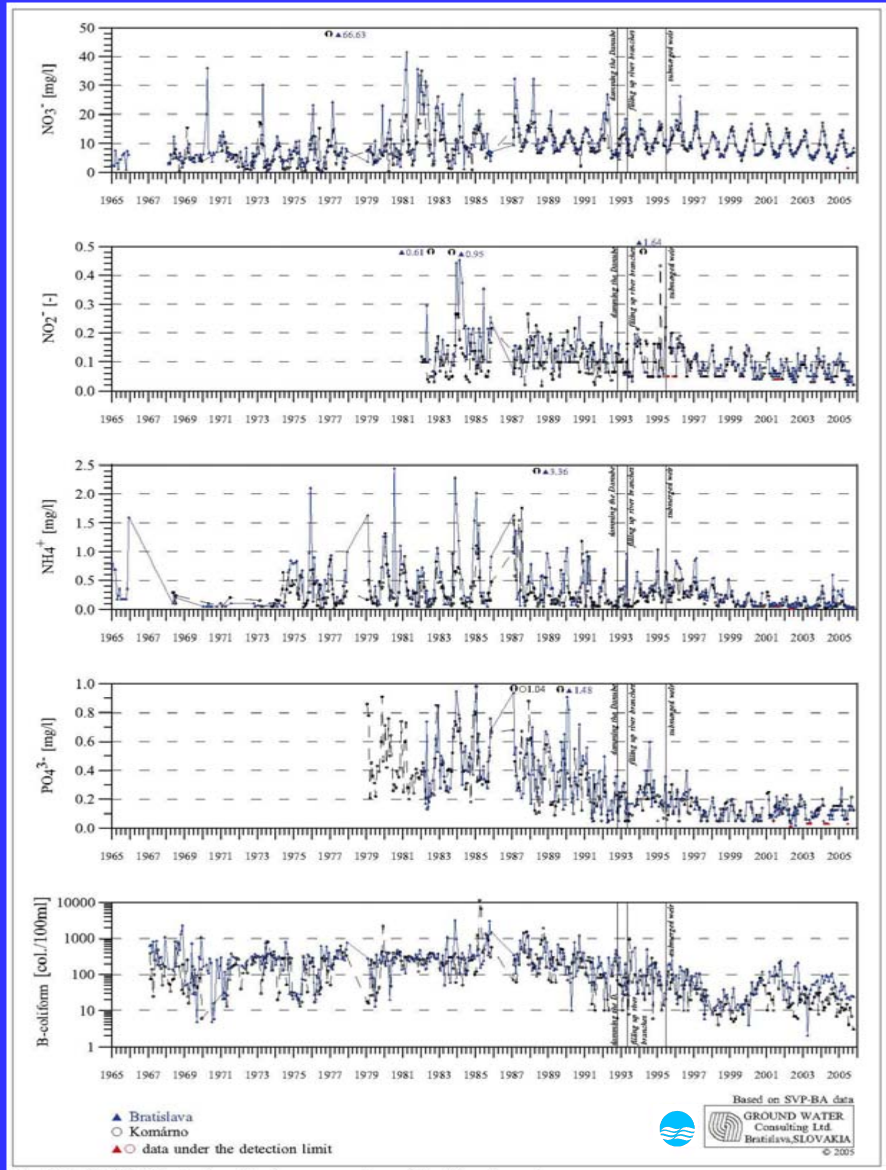
3741	S16	Bypass canal, Gabčíkovo, SL, upper roadstead	✓	SVP-BA		
4016	0002	Danube, Dunakiliti, SL, weir, rkm 1843.1	✓	SVP-BA	✓	SVP-BA
3739	8028	Danube, Sap, SL, upstream of confluence, rkm 1812	✓	SVP-BA	✓	SVP-BA

EVALUATION OF SURFACE WATER QUALITY





RESULTS OF MONITORING SURFACE WATER QUALITY

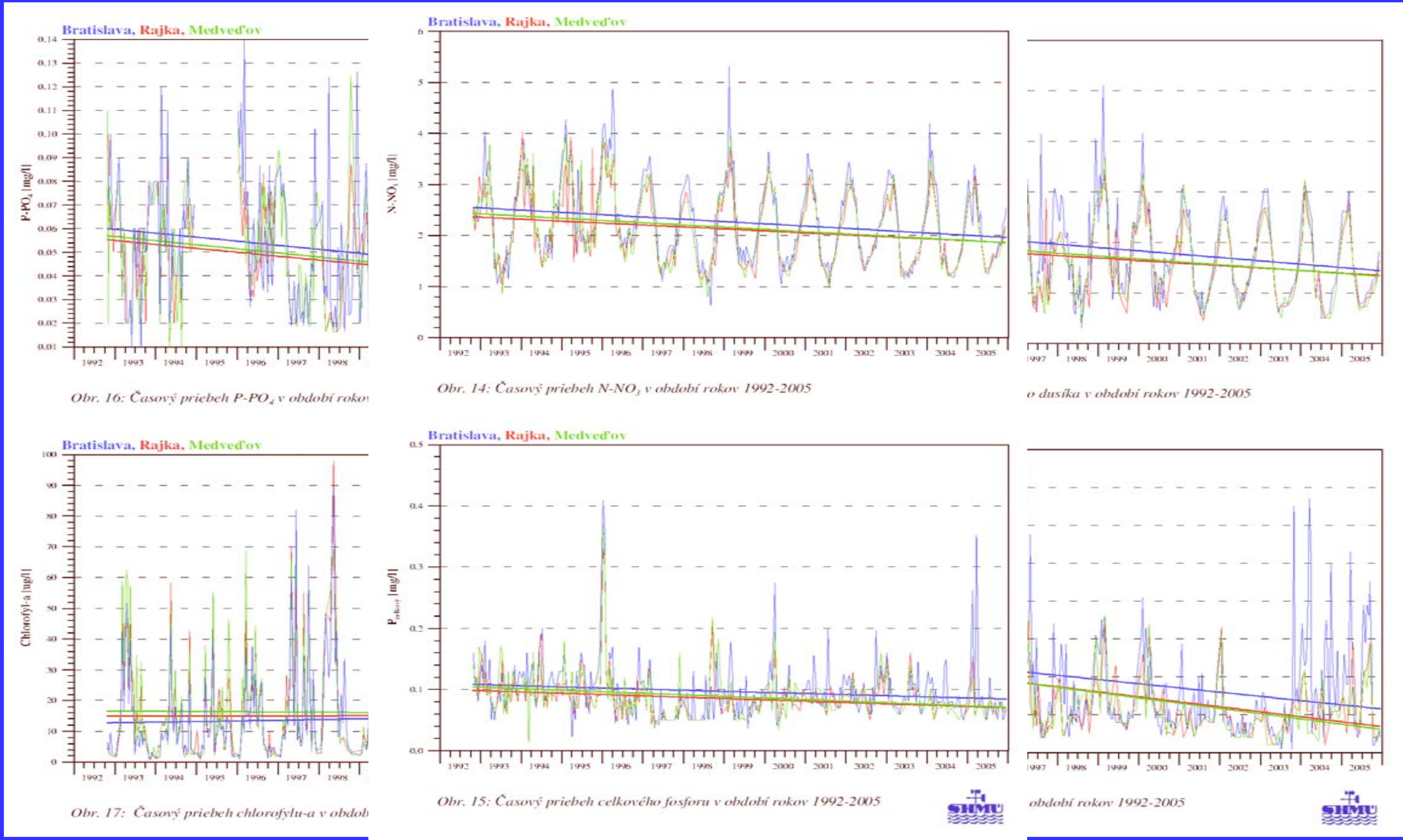
Long-term development of water quality at the profiles Danube – Bratislava and Medveďov (Komárno):

- During the whole monitoring the concentrations measured at Bratislava are usually higher than those measured at Komárno in all evaluated parameters of water quality.
- Content of organic matter (pollution) expressed by the index BOD5 and CODMn shows a long-term decrease,
- Content of dissolved oxygen shows a long-term increase by ca. 2 mg/l. The maximum and minimum concentrations of dissolved oxygen increase at both profiles. The increase in Bratislava is stronger.
- Content of nitrates is often higher at Bratislava. Its content is a function of vegetation period. It has a slowly decreasing general tendency.
- Content of nitrites and ammonia is decreasing, especially at Bratislava.
- Very positive is the strong long-term drop of concentration of phosphates in the Danube water since 1979. The maximum values dropped from 0.8-1.0 mg/l to values less than 0.2 mg/l at present.
- Bacterial pollution has also strongly decreased, especially after 1991-1992.

IMPACT OF THE GABČÍKOVO HYDRAULIC STRUCTURES ON QUALITY OF THROUGH-FLOWING WATER

- The hydraulic structures themselves do not produce pollutants. They can modify water quality only by the impact of a changed water regime on the chemical and biological processes.
- A comparison of the “uninfluenced” water flowing through the profile at Bratislava into the project area with the “influenced” water flowing out from this area through the profile at Medveďov
- The quality is permanently balanced and in the course of a year it depends mainly on discharges and water temperature in the Danube under the influence of meteorological factors.
- **The physical and chemical composition** of the Danube water does not change after passing through the Gabčíkovo hydraulic structures.

IMPACT OF THE GABČÍKOVO HYDRAULIC STRUCTURES ON QUALITY OF THROUGH-FLOWING WATER



ECOTOXICITY OF WATERS AND SEDIMENTS

Ecotoxicity tests detect certain a synergistic effect of a mixture of substances, which are not detectable by chemical analysis

These tests include:

- Test of acute lethal toxicity on fish *Poecilia reticulata*,
- Test of acute toxicity and inhibition of mobility of *Daphnia magna*,
- Test of inhibition of light emission of luminescence bacteria *Photobacterium phosphoreum* or *Vibrio fisheri*,
- Test of chronic toxicity on Cladocers *Daphnia magna*,
- Test of inhibition of root growth of the culture plant *Sinapis alba* (semi-chronic test),
- Test of inhibition of growth of the green alga *Scenedesmus quadricauda* (semi-chronic test),
- Test of germinate capacity of seeds (semi-chronic test).

ECOTOXICITY OF WATERS AND SEDIMENTS

- A bioluminescent activity of selected microorganisms shows that samples from Medveďov have *stronger* stimulation effect than those from Bratislava.
- A comparison of tests made on green algae from profiles in Bratislava and Medveďov shows *very similar values at both profiles*.
- Samples of water and sediments are not actually toxic for the test organisms in a great majority of cases.
- Samples of surface water or sediment pore water have *a strong stimulation effect* on more test organisms.
- Since putting the Gabčíkovo project in operation there were recorded only three cases of acute toxicity for water organisms. In all cases, the probable cause of toxic effect on cladocera was an increased level of **petroleumhydrocarbons** in the samples.
- Tests of chronic and semi-chronic ecotoxicity on samples of surface water do not bring results with significant ecotoxicity exceeding +30% in any organism

EUTROPHICATION AND GABČÍKOVO HYDRAULIC STRUCTURES

• Manifestation of eutrophication, i.e. algae biomass overproduction visible with the naked eye

Ľavá strana zdrže Kalinkovo
profil č. 2005 (3713)

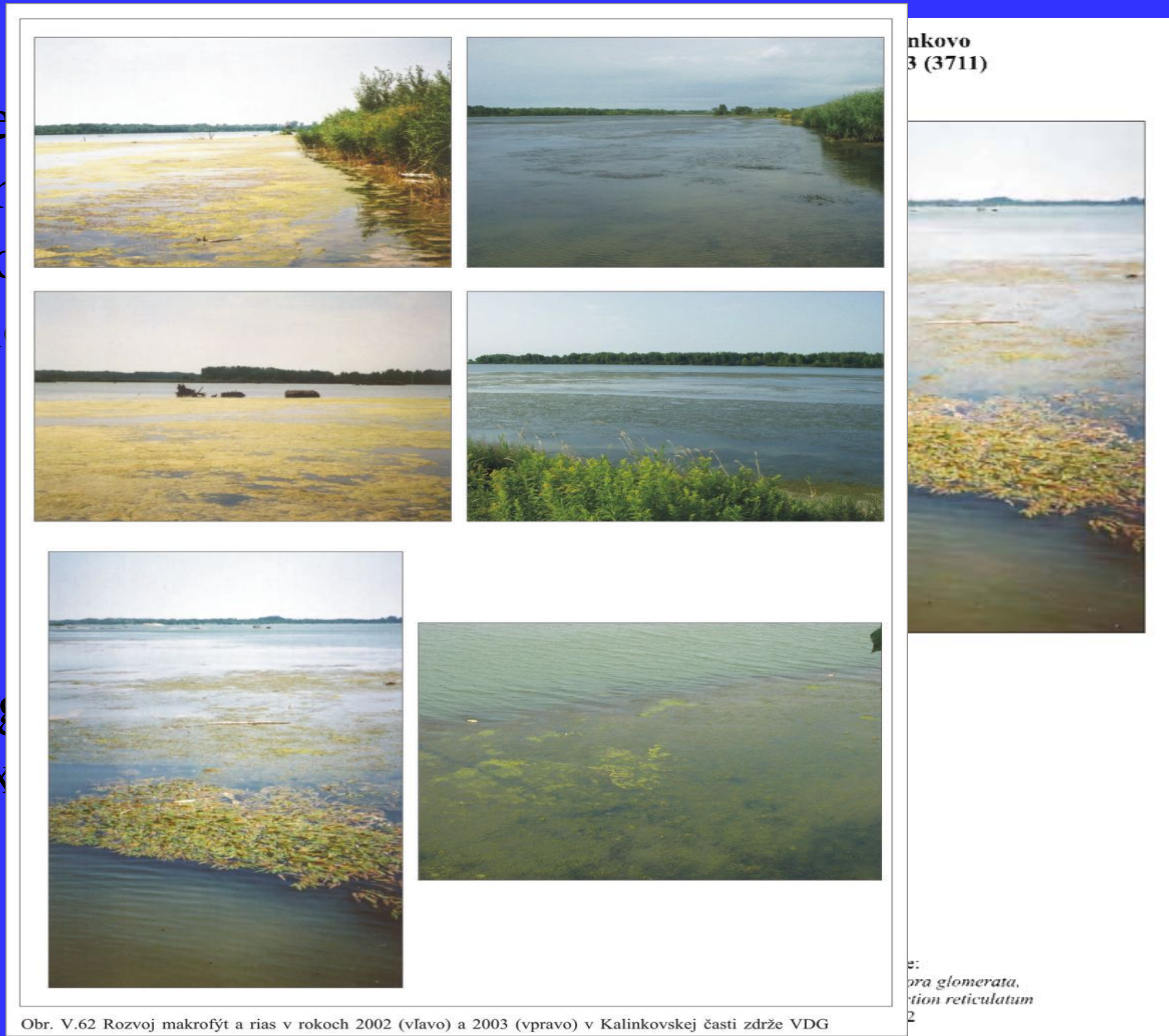
od profilu 2005 - smer koniec zátoky, prevláda *Hydrodiction reticulatum*, 12.7.2002

• Caused by presence of nutrients in the surface water and supported by suitable meteorological conditions and other factors

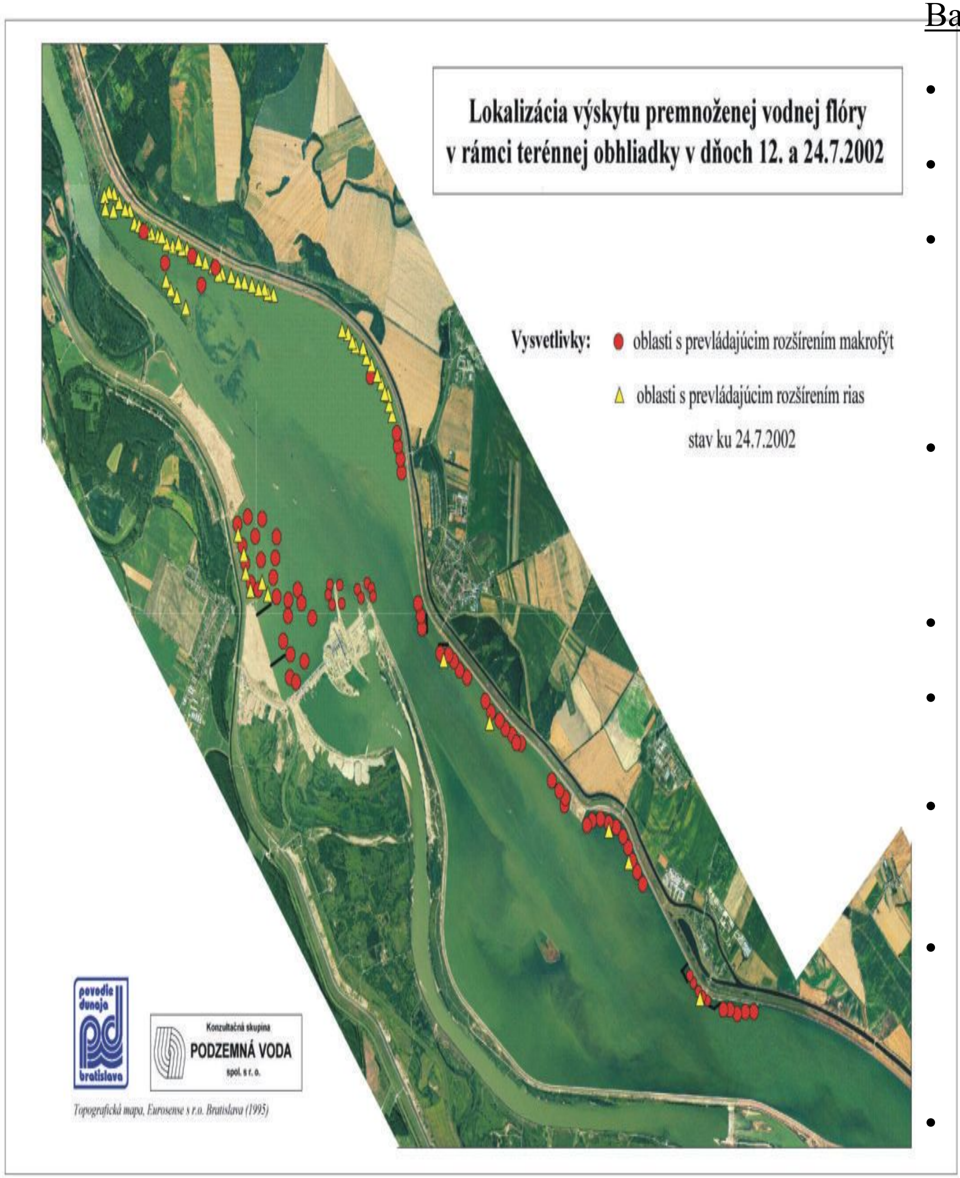
EUTROPHICATION AND GABČÍKOVO HYDRAULIC STRUCTURES

- Occurred in the reservoir for the 1993, in 2001 i extent (only in c and very signifi 2002 and 2003.

- The years 2002 were extremely dry and dischar Danube were ex in 2003



EUTROPHICATION AND GABČÍKOVO HYDRAULIC STRUCTURES

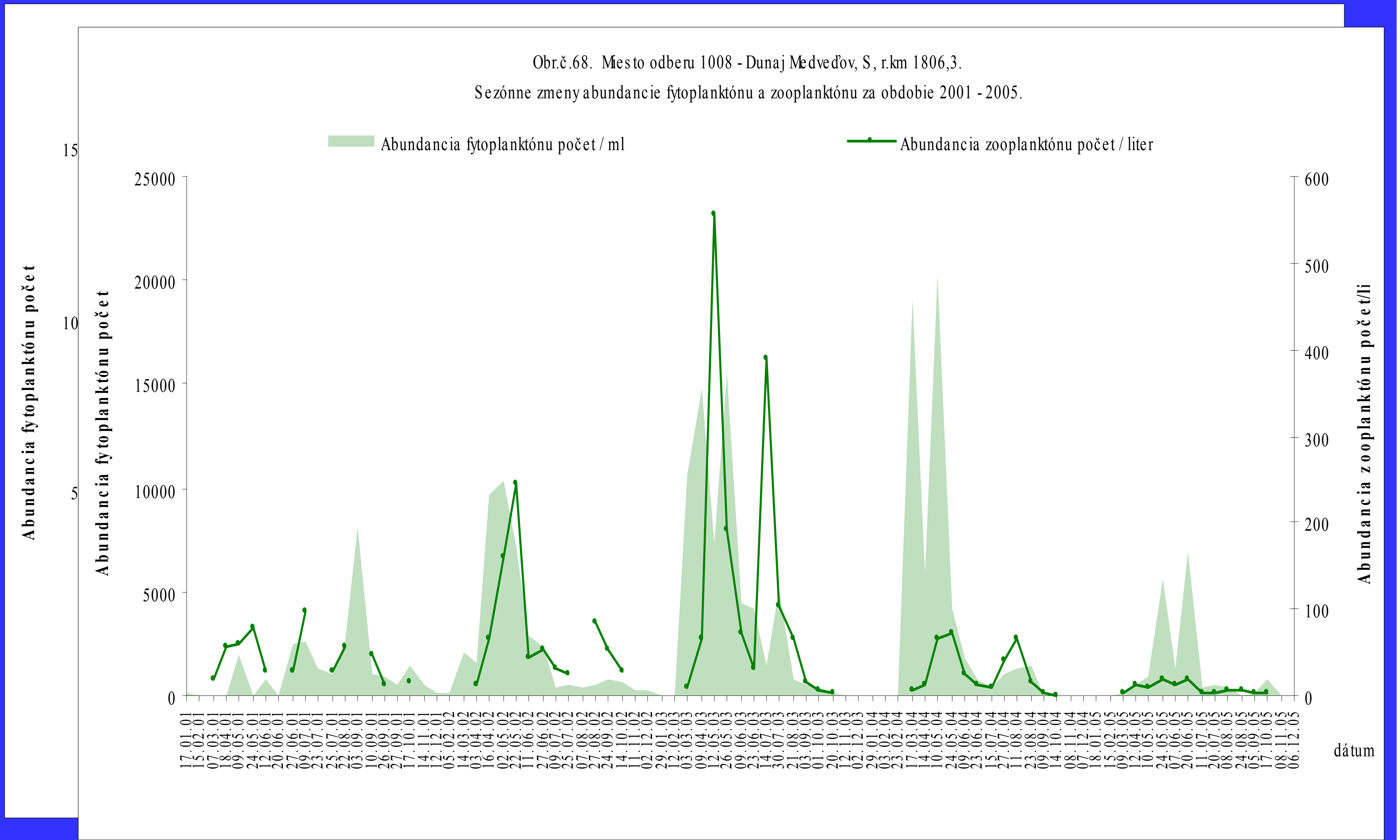


Obr. V.63 Prípad výskytu premnoženej vodnej flóry (podľa Valúchová M., a kol., júl 2002)

Based on the long-term results evaluated in the reports it is possible to state generally that:

- Revival of water in the Čunovo reservoir is influenced mainly by water flowing into the reservoir;
- Limiting factors of the mass development of algae are flow velocity and content of phosphate phosphor;
- Development of phytoplankton, zooplankton and content of chlorophyll "a" in the water of the reservoir is connected, along with the suspended nutrients (first of all compounds of phosphor), also with the hydrologic condition in the reservoir, flow velocity, water depth, amount of sunshine and penetration of sun light into water column;
- Local differences in the abundance of phytoplankton depend on discharge, flow velocity, length of water delay, depth and transparency of water and on the abundance of macrophytes; content of biogenic elements is approximately equal in the whole reservoir;
- Water temperature does not have a determining influence on the development of phytoplankton and zooplankton;
- During vegetation period the content of nutrients drops to a minimum and the content of suspended oxygen during the day time increases and water over saturates;
- Content of silicates varies seasonally: it decreases with development of phytoplankton, especially if phytoplankton contains diatoms with a high content of silicon in cell membranes;
- Development of zooplankton in relationships to phytoplankton can be characterized by the Lotka-Voltera´s model, i.e. The culminations of zooplankton occur with a delay after the culmination of phytoplankton (about 15-30 days);
- sediments, birds

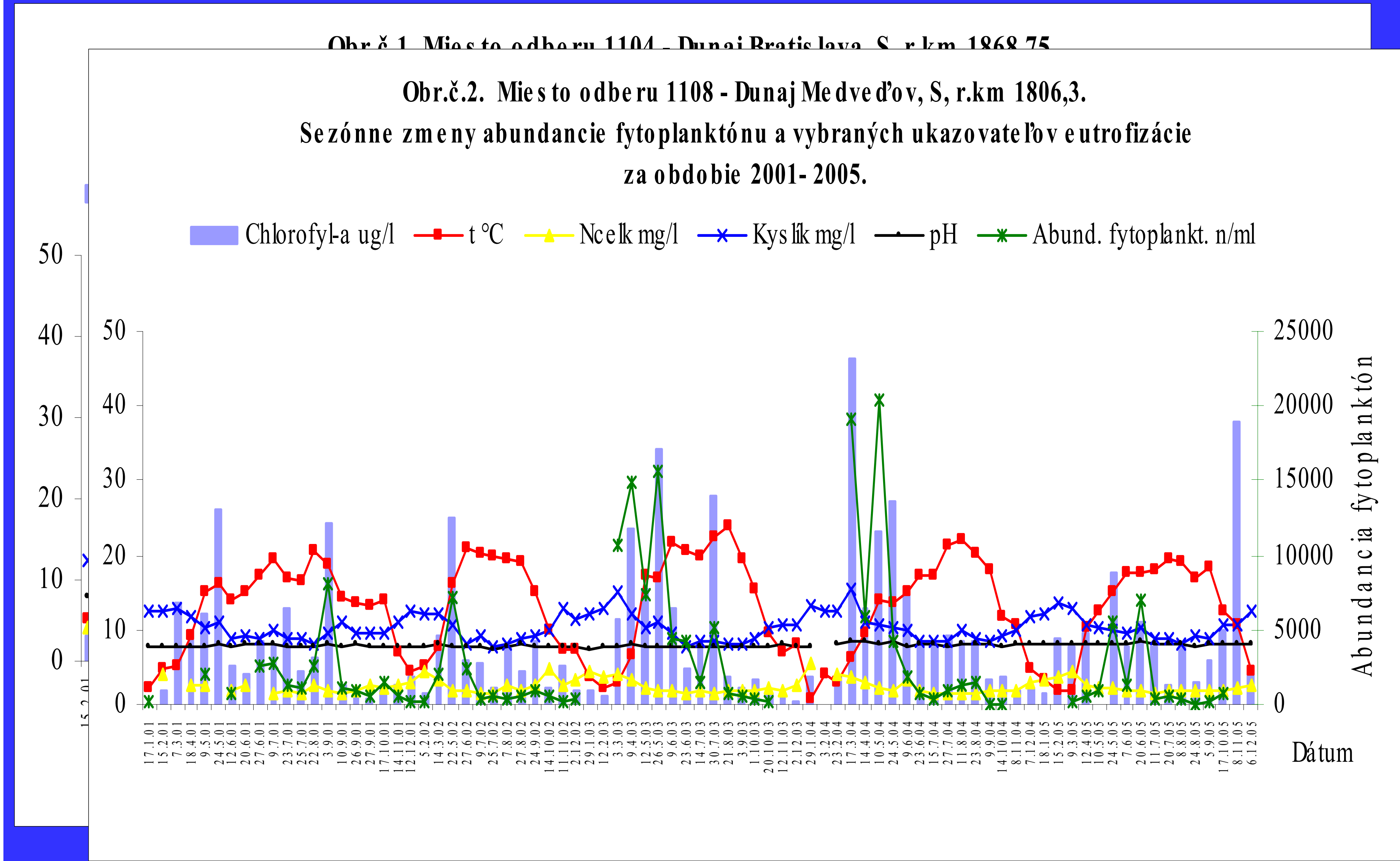
EUTROPHICATION AND GABČÍKOVO HYDRAULIC STRUCTURES



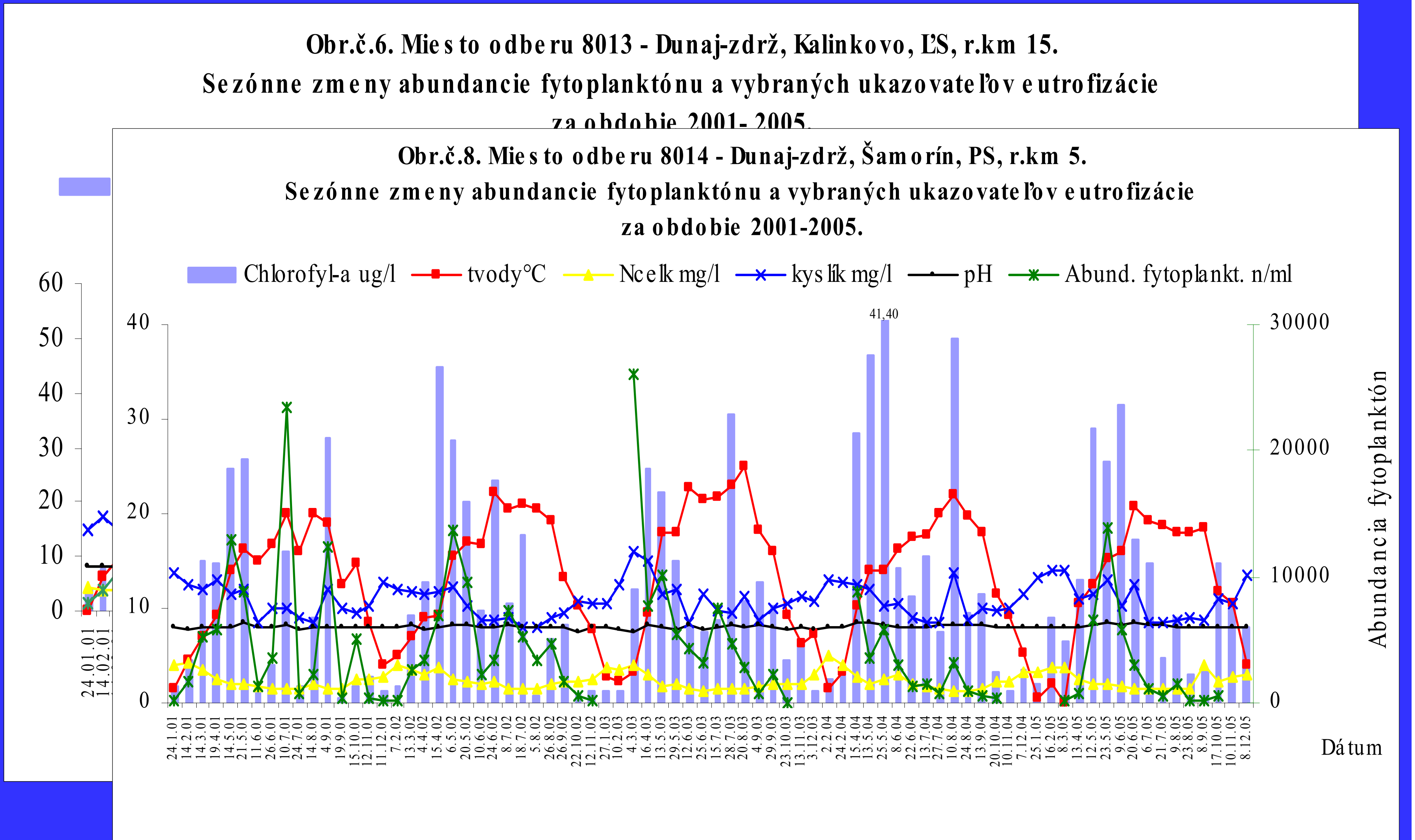
EUTROPHICATION AND GABČÍKOVO HYDRAULIC STRUCTURES

- We want to stress that the recorded eutrophication processes in the reservoir did not influence the quality of the water flowing out from the Gabčíkovo hydraulic structures area presented in the profile at Medveďov in comparison with the quality of water at the profile in Bratislava.
- Manifestations of eutrophication disappear or are strongly reduced after the passing of a high discharge, which occur in the Danube several times a year. Content of chlorophyll “a” was higher at the profile Medveďov than in Bratislava also in the pre-dam conditions.
- After the extreme years 2002 and 2003, the phytoplankton abundance was higher at Medveďov than in Bratislava and, as a rule, it was also higher in Sap than in Rajka, but the common data are available only from two last years
- Experimentally test the influence of existing possibilities of water regime regulation on the course of eutrophication is based on the fact that the conditions of eutrophication in the reservoir and arm system are very variable, changeable in time, and could be influenced. Besides this, the expected climatic changes could support the more frequent occurrence of eutrophication and some measures would be welcome.

EUTROPHICATION AND GABČÍKOVO HYDRAULIC STRUCTURES



EUTROPHICATION AND GABČÍKOVO HYDRAULIC STRUCTURES



MONITORING OF SEDIMENTS

- There were especially concerns of possible remobilisation of heavy metal or other substances from reservoir sediments into the ground waters.

- Sediments, consisting of bed loads and suspended loads, are deposited in the reservoir or are wished and transported away. Mobility of the upper layer sediments is very large and depends on the actual place and flow velocity.

- In the reservoir are not suitable for chemically releasing absorbed micro-pollutants, if they are actually absorbed. The permanent decrease of suspended classical organic pollution of the Danube water has created suitable conditions for the sediments and a decrease in content of decomposing organic substances

- However, content of organic carbon in sediments is significant because it influences the oxidation-reduction and biodegradation processes, which subsequently influence water quality, even already during infiltration through the river bottom. At transition into the reduction processes, it can determine the mobilization of toxic substances if they are adsorbed in the sediments. On the contrary, an increased content of organic carbon in sediments increases their capacity to adsorb hydrophobic organic pollution, heavy metals etc.

MONITORING OF SEDIMENTS

Evaluation of sediment in Slovak republic is carried out in accordance with:

- „Methodical directive of the ministry of environment No. 549/98-2"

- „Canadian sediment quality guideline for the protection of aquatic life" (CSQG)

Tab. 3. Basic principle of evaluation according to CSQG

Influence / Concentration:	**< TEL**	**TEL – PEL**	**> PEL**
Unfavourable influence	sporadically	occasionally	frequently
Occurrence of unfavourable influence	< 25 %	25 – 50 %	> 50 %

TEL - **T**hreshold **E**ffect **L**evel, exceeding this concentration results in an unfavourable biological impact. At lower values (< TEL) the unfavourable biological impact occurs only sporadically.

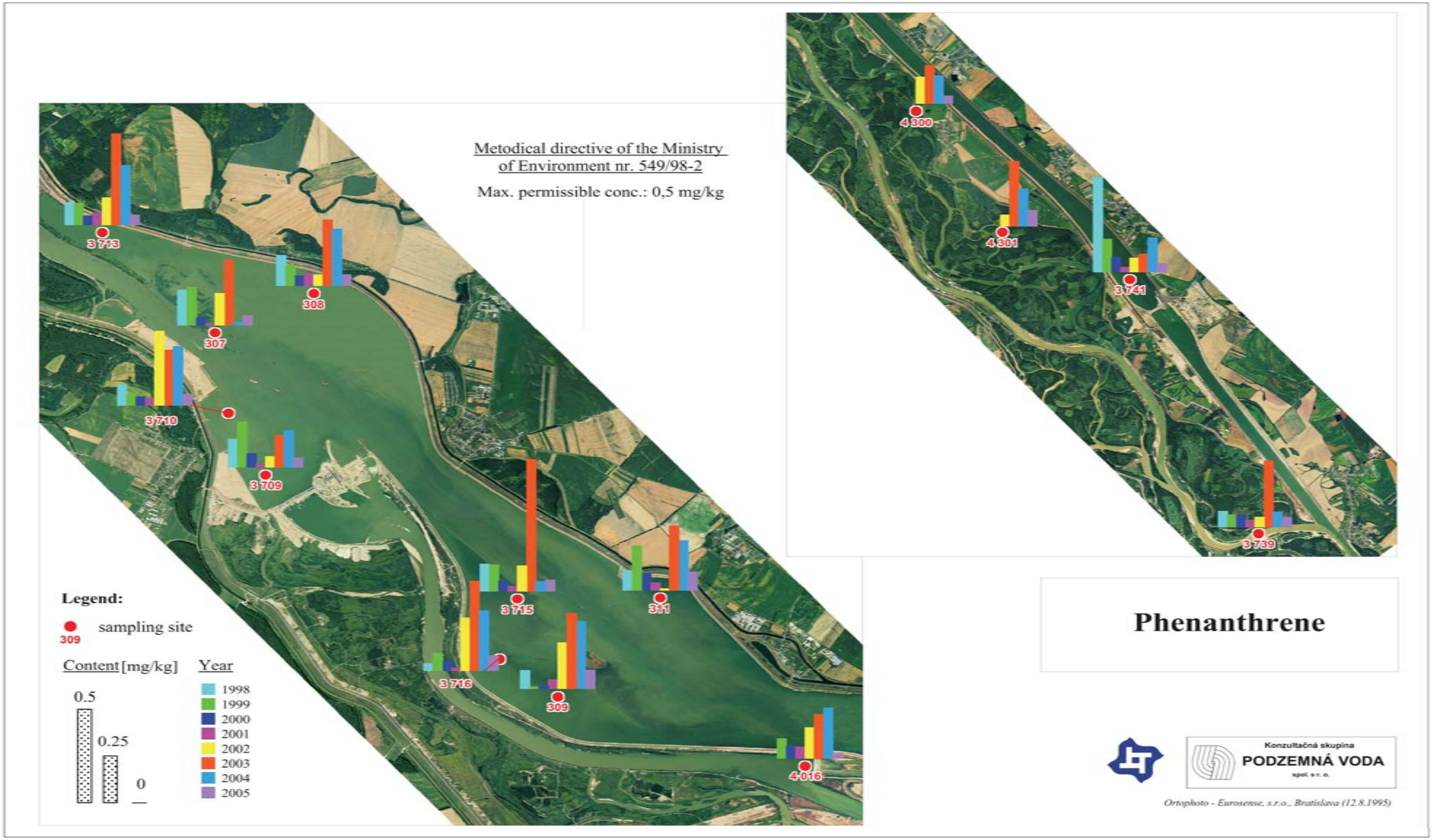
PEL – **P**robable **E**ffect **L**evel, exceeding of this concentration is presumed to result in a frequent occurrence of the unfavourable biological impact.

RESULTS OF SEDIMENTS MONITORING

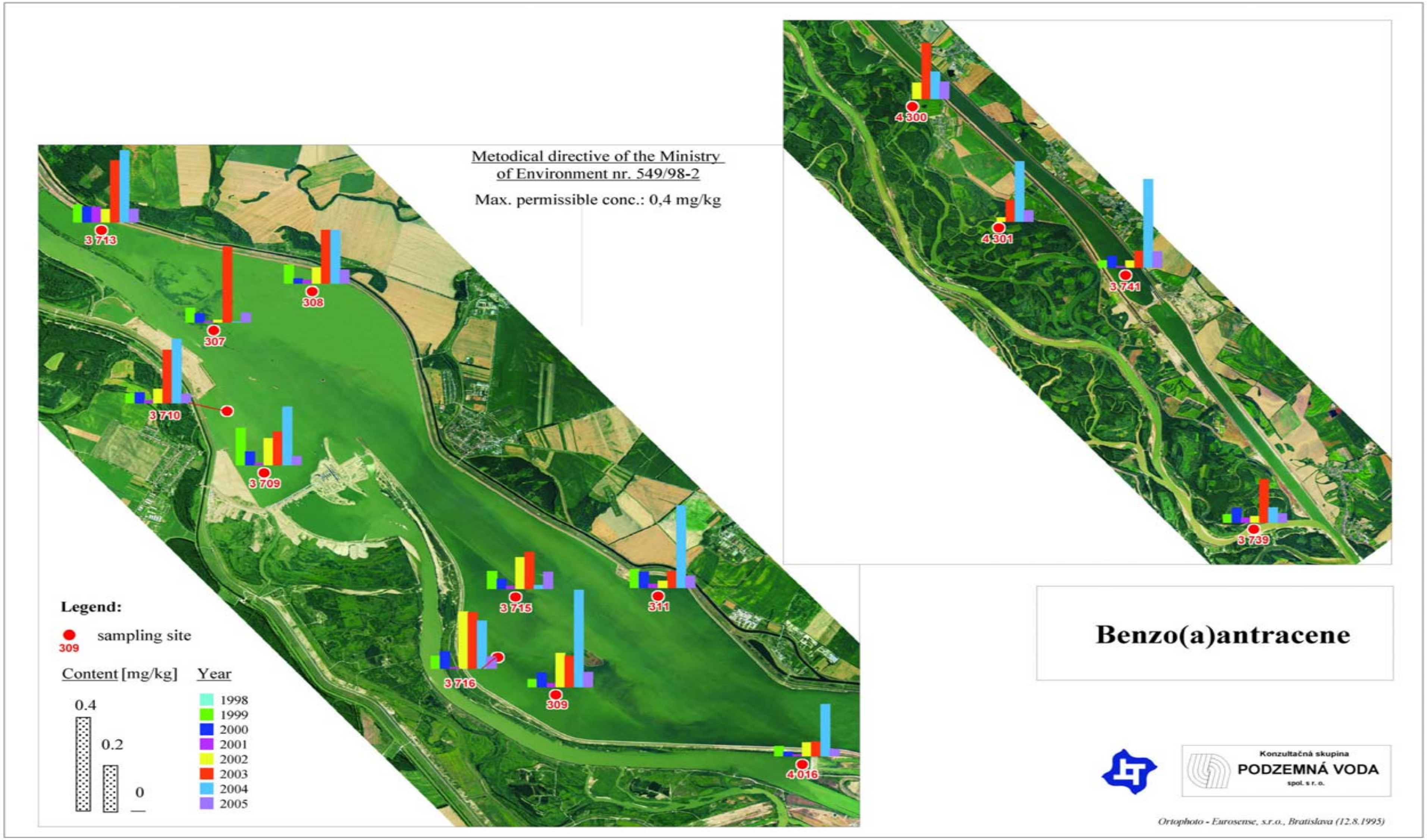
Among these parameters, the following exceeded the PEL values in the monitored period:

- As – in most profiles monitored in 1996-1999,
- Lindane – in most profiles monitored in 1996-2003,
- Heptachlor – in most profiles monitored in 1996-2003,
- Acenaphthene – in most profiles monitored in 1998,
- Phenanthrene – in 1998 at profile 3741 and in 2003 at profile 3715,
- Fluoranthene – in 1998 at profiles 307, 308, 309, 3713, 3715, 3716 and 3741, in 2002 at profile 3710 and in 2003 at profiles 3713 and 3715,
- Benzo(a)anthracene – in 2004 at profiles 309, 3741 and 311.

RESULTS OF SEDIMENTS MONITORING



RESULTS OF SEDIMENTS MONITORING



MONITORING THE GABČÍKOVO HYDRAULIC STRUCTURES AND WATER FRAME DIRECTIVE

33 priority substances listed in Annex no. X. WFD Water act of Slovak republic	List of priority substances relevant for the Slovak republic
anthracene	arsenic and its compounds
atrazine	DDT and its isomers
benzene	phenanthrene
cadmium and its compounds	chrome and its composites
hexachlorobenzene	cyanides
lindane (gama hexachlorocyclohexan)	copper and its compounds
lead and its compounds	MCPA (2-methyl-4-chlorophenoxyacetic acid)
mercury and its compounds	PCB and its congeners (28, 52, 101, 118, 138, 153, 180)
naphthalene	toluene
nickel and its compounds	xylens (isomers o-, m-, p-)
Benzo (a) pyrene	zinc and its compound
Benzo (b) fluoranthene	
Benzo (g,h,i) perylene	
Benzo (k) fluoranthene	
Indeno (1,2,3-cd) pyrene	

MONITORING THE GABČÍKOVO HYDRAULIC STRUCTURES AND WATER FRAME DIRECTIVE

Biological monitoring

According to the Water Frame Directive, among the biological parameters the following should be monitored:

- Phytoplankton – taxonomic composition, abundance, frequency and intensity of occurrence of water bloom,
- Macrophytes and phytobenthos – taxonomic composition and average composition,
- Benthic invertebrates – taxonomic composition and abundance,
- Fish fauna - species composition, abundance and age structure

MONITORING THE GABČÍKOVO HYDRAULIC STRUCTURES AND WATER FRAME DIRECTIVE

Monitoring to evaluate the chemical state of the waters

monitoring to evaluate the general conditions of the chemical state of the waters is provided at present monitoring specific polluting substances also is gradually being done as shown above

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