Water Quality in the Danube River Basin - 2018

ICPDR IKSD

International Commission for the Protection of the Danube River
Internationale Kommission zum Schutz der Donau

TNMN – Yearbook 2018

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1. Introduction

1.1 History of the TNMN

In June 1994, the Convention on Cooperation for the Protection and Sustainable Use of the Danube River (DRPC) was signed in Sofia, coming into force in October 1998 with the main objectives of achieving sustainable and equitable water management, including the conservation, improvement and the rational use of surface and ground waters in the Danube catchment area. The DRPC also emphasizes that the Contracting Parties shall cooperate in the field of monitoring and assessment. In this respect, the operation of the Trans-National Monitoring Network (TNMN) in the Danube River Basin aims to contribute to the implementation of the DRPC. This Yearbook reports on results of the basin-wide monitoring programme and presents TNMN evaluated data for 2018.

The TNMN has been in operation since 1996, although the first steps towards its creation were taken about ten years earlier. In December 1985 the governments of the Danube riparian countries signed the Bucharest Declaration. The Declaration had as one of its objectives to observe the development of the water quality of the Danube, and in order to comply with this objective, a monitoring programme containing 11 cross-sections of the Danube River was established.

1.2 Revision of the TNMN to meet the objectives of EU WFD

The original objective of the TNMN was to strengthen the existing network set up by the Bucharest Declaration, to enable a reliable and consistent trend analysis for concentrations and loads of priority pollutants, to support the assessment of water quality for water use and to assist in the identification of major pollution sources.

In 2000, having the experience of the TNMN operation, the main objective of the TNMN was reformulated: to provide a structured and well-balanced overall view of the status and long-term development of quality and loads in terms of relevant constituents in the major rivers of the Danube Basin in an international context.

Implementation of the EU Water Framework Directive (2000/60/EC, short WFD) after 2000 necessitated the revision of the TNMN in the Danube River Basin District. In line with the WFD implementation timeline, the revision process has been completed in 2007.

The major objective of the revised TNMN is to provide an overview of the overall status and long-term changes of surface water and – where necessary – groundwater status in a basin-wide context with a particular attention paid to the transboundary pollution load. In view of the link between the nutrient loads of the Danube and the eutrophication of the Black Sea, it is necessary to monitor the sources and pathways of nutrients in the Danube River Basin District and the effects of measures taken to reduce the nutrient loads into the Black Sea.

To meet the requirements of both EU WFD and the Danube River Protection Convention the revised TNMN for surface waters consists of following elements:

Surveillance monitoring 1: Monitoring of surface water status

Surveillance monitoring 2: Monitoring of specific pressures

Operational monitoring

Investigative monitoring

Surveillance monitoring 2 is a joint monitoring activity of all ICPDR Contracting Parties that produces annual data on concentrations and loads of selected parameters in the Danube and major tributaries (Figure 1).

Surveillance monitoring 1 and the operational monitoring is based on collection of the data on the status of surface water and groundwater bodies in the DRB District to be published in the DRBM Plan once in six years.

Investigative monitoring is primarily a national task but at the basin-wide level the concept of Joint Danube Surveys was developed to carry out investigative monitoring as needed, e.g. for harmonization of the existing monitoring methodologies, filling the information gaps in the monitoring networks operating in the DRB, testing new methods or checking the impact of "new" chemical substances in different matrices. Joint Danube Surveys are carried out every 6 years.

A new element of the revised TNMN is monitoring of groundwater bodies of basin-wide importance. More information on this issue is provided in the respective chapter in this Yearbook.

Detailed description of the revised TNMN is given in the Summary Report to EU on monitoring programmes in the Danube River Basin District designed under WFD Article 8.

This Yearbook presents the results of the Surveillance monitoring 2: Monitoring of specific pressures.

2. Description of the TNMN Surveillance Monitoring 2: Monitoring of specific pressures

2.1 Objectives

Surveillance Monitoring 2 aims at long-term monitoring of specific pressures of basin-wide importance. Selected quality elements are monitored annually. Such denser monitoring programme is needed to identify the specific pressures in the Danube River Basin District in order to allow a sound and reliable long-term trend assessment of specific quality elements and to achieve a sound estimation of pollutant loads being transferred across states of Contracting Parties and into the Black Sea.

Surveillance Monitoring 2 is based on the set-up of the original TNMN and is fitted to respond to pressures of basin-wide importance. The monitoring network is based on the national monitoring networks and the operating conditions are harmonized between the national and basin-wide levels to minimise the efforts and maximise the benefits (Table 1).

2.2 Selection of monitoring sites

The selection of monitoring sites is based on the following criteria:

Monitoring sites that have been monitored in the past and are therefore suitable for long-term trend analysis; these include sites

located just upstream/downstream of an international border,

located upstream of confluences between Danube and main tributaries or main tributaries and larger sub-tributaries (to enable estimation of mass balances),

located downstream of the major point sources,

located to control important water uses.

Sites required to estimate pollutant loads (e.g. of nutrients or priority pollutants) which are transferred across boundaries of Contracting Parties, and which are transferred into the marine environment.

The sites are located on the Danube river and its major primary or secondary tributaries near crossing boundaries of the Contracting Parties. List of all monitoring stations is in the Table 1, presented with differentiation of monitoring sites located on the Danube River (bold raws) and tributaries. Informations about monitoring sites monitored in 2018 is included in the Table 3 - Chapter 3.

Table 1: List of stations included in TNMN SM2

N°	Country code	TNMN code	River	Monitoring station name	Locations	x-coord	y-coord	River-km	Alti-tude	Catchment area
1	**DE**	**DE2**	**Danube**	**Jochenstein**	**M**	**13.703**	**48.520**	**2 204**	**290**	**77 086**
2	**DE**	**DE5**	**Danube**	**Dillingen**	**L**	**10.499**	**48.568**	**2 538**	**420**	**11 315**
3	DE	DE3	/Inn	Kirchdorf	M	12.126	47.782	195	452	9 905
4	DE	DE4	/Inn/Salzach	Laufen	L	12.933	47.940	47	390	6 113
5	**AT**	**AT1**	**Danube**	**Jochenstein**	**M**	**13.703**	**48.521**	**2 204**	**290**	**77 086**
6	**AT**	**AT5**	**Danube**	**Enghagen**	**R**	**14.512**	**48.240**	**2 113**	**241**	**84 869**
7	**AT**	**AT3**	**Danube**	**Wien-Nussdorf**	**R**	**16.371**	**48.262**	**1 935**	**159**	**101 700**
8	**AT**	**AT6**	**Danube**	**Hainburg**	**R**	**16.993**	**48.164**	**1 879**	**136**	**130 759**
9	CZ	CZ1	/Morava	Lanžhot	M	16.989	48.687	79	150	9 725
10	CZ	CZ2	/Morava/Dyje	Pohansko	M	16.885	48.723	17	155	12 540
11	**SK**	**SK1**	**Danube**	**Bratislava**	**LMR**	**17.107**	**48.138**	**1 869**	**128**	**131 329**
12	**SK**	**SK2**	**Danube**	**Medveďov**	**MR**	**17.652**	**47.794**	**1 806**	**108**	**132 168**
13	SK	SK4	/Váh	Komárno	MR	18.142	47.761	1.5	106	19 661
14	**SK**	**SK5**	**Danube**	**Szob**	**LMR**	**18.890**	**47.805**	**1 707**	**100**	**183 350**
15	SK	SK6	/Morava	Devín	M	16.976	48.188	1	145	26 575
16	SK	SK7	/Hron	Kamenica	M	18.723	47.826	1.7	114	5 417
17	SK	SK8	/Ipeľ	Salka	M	18.763	47.886	12	110	5 060
18	**HU**	**HU1**	**Danube**	**Medvedov**	**MR**	**17.652**	**47.792**	**1 806**	**108**	**131 605**
19	**HU**	**HU2**	**Danube**	**Komarom**	**LMR**	**18.121**	**47.751**	**1 768**	**101**	**150 820**
20	**HU**	**HU3**	**Danube**	**Szob**	**LMR**	**18.860**	**47.811**	**1 708**	**100**	**183 350**
21	**HU**	**HU4**	**Danube**	**Dunafoldvar**	**LMR**	**18.934**	**46.811**	**1 560**	**89**	**188 700**
22	**HU**	**HU5**	**Danube**	**Hercegszanto**	**LMR**	**18.814**	**45.909**	**1 435**	**79**	**211 503**
23	HU	HU6	/Sio	Szekszard-Palank	LMR	18.720	46.380	13	85	14 693
24	HU	HU7	/Drava	Dravaszabolcs	LM	18.200	45.784	78	92	35 764
25	HU	HU8	/Tisza/Sajo	Sajopuspoki	LMR	20.340	48.283	124	148	3 224
26	HU	HU9	/Tisza	Tiszasziget	LMR	20.105	46.186	163	74	138 498
27	HU	HU10	/Tisza	Tiszabecs	LM	22.831	48.104	757	114	9707
28	HU	HU11	/Tisza/Szamos	Csenger	LM	22.693	47.841	45	113	15283
29	HU	HU12	/Tisza/Hármas-Körös/Sebes-Körös	Korosszakal	MR	21.657	47.020	59	92	2489
30	HU	HU13	/Tisza/Hármas-Körös/Kettõs-Körös/Fekete-Körös	Sarkad	MR	21.431	46.694	16	85	4302
31	HU	HU14	/Tisza/Hármas-Körös/Kettõs-Körös/Fehér-Körös	Gyulavari	MR	21.336	46.629	9	85	4251
32	HU	HU15	/Tisza/Maros	Nagylak	R	20.703	46.161	51	80	30149
33	SI	SI1	/Drava	Ormož most	L	16.155	46.403	300	192	15 356
34	SI	SI2	/Sava	Jesenice na Dolenjskem	R	15.692	45.861	729	135	10 878
35	**HR**	**HR1**	**Danube**	**Batina**	**MR**	**18.829**	**45.875**	**1 429**	**86**	**210 250**
36	**HR**	**HR11**	**Danube**	**Ilok**	**M**	**19.401**	**45.232**	**1 302**	**73**	**253 737**
37	HR	HR9	/Drava	Ormoz	LMR	16.155	46.403	300	192	15356
38	HR	HR4	/Drava	Botovo	MR	16.938	46.241	227	123	31 038
39	HR	HR5	/Drava	DonjiMiholjac	MR	18.201	45.783	78	92	37 142
40	HR	HR6	/Sava	Jesenice	LR	15.692	45.861	729	135	10 834
41	HR	HR7	/Sava	UpstreamUnaJasenovac	M	16.915	45.269	525	87	30 953

N°	Country code	TNMN code	River	Monitoring station name	Locations	x-coord	y-coord	River-km	Alti-tude	Catchment area
42	HR	HR12	/Sava	Račinovci	L	18.960	44.851	218	78	65 638
43	RS	RS1	Danube	Bezdan	L	18.860	45.854	1 426	83	210 250
44	RS	RS2	Danube	Bogojevo	L	19.079	45.530	1 367	80	251 593
45	RS	RS3	Danube	Novi Sad	R	19.855	45.255	1 255	74	254 085
46	RS	RS4	Danube	Zemun	R	20.412	44.849	1 173	71	412 762
47	RS	RS6	Danube	BanatskaPalanka	ML	21.339	44.826	1 077	70	568 648
48	RS	RS7	Danube	Tekija	R	22.419	44.700	954	68	574 307
49	RS	RS8	Danube	Radujevac	R	22.680	44.263	851	32	577 085
50	RS	RS10	/Tisza (Tisa)	Martonos	R	20.081	46.114	152	76	140 130
51	RS	RS11	/Tisza (Tisa)	Novi Becej	L	20.135	45.586	65	75	145 415
52	RS	RS12	/Tisza (Tisa)	Titel	M	20.312	45.198	9	73	157 174
53	RS	RS13	/Sava	Jamena	L	19.084	44.878	205	77	64 073
54	RS	RS15	/Sava	Sabac	R	19.699	44.770	106	74	89 490
55	RS	RS16	/Sava	Ostruznica	R	20.312	44.732	17	72	95 430
56	RS	RS17	/Velika Morava	Ljubicevski Most	R	21.132	44.586	22	71	37 320
57	BA	BA5	/Sava	Gradiska	M	17.255	45.141	457	86	39 150
58	BA	BA6	/Sava/Una	KozarskaDubica	M	16.836	45.188	16	94	9 130
59	BA	BA7	/Sava/Vrbas	Razboj	M	17.458	45.050	12	100	6 023
60	BA	BA8	/Sava/Bosna	Modrica	M	18.313	44.961	24	114	10 500
61	BA	BA9	/Sava/Drina	Foca	M	18.833	43.344	234	442	3 884
62	BA	BA10	/Sava/Drina	Badovinci	M	19.344	44.779	16	90	19 226
63	BA	BA11	/Sava	Raca	M	19.335	44.891	190	80	64 125
64	BA	BA12	/Sava/Una	Novi Grad	M	16.295	44.988	70	137	4 573
65	BA	BA13	/Sava/Bosna	Usora	M	18.074	44.664	78	148	7 313
66	BG	BG1	Danube	Novo Selohарbour	LMR	22.785	44.165	834	35	580 100
67	BG	BG2	Danube	Bajkal	R	24.400	43.711	641	20	608 820
68	BG	BG3	Danube	Svishtov	R	25.345	43.623	554	16	650 340
69	BG	BG4	Danube	UpstreamRusse	R	25.907	43.793	503	12	669 900
70	BG	BG5	Danube	Silistra	LMR	27.268	44.125	375	7	698 600
71	BG	BG6	/Iskar	Orechovitza	M	24.358	43.589	28	31	8 370
72	BG	BG7	/Jantra	Karantzi	M	25.669	43.389	12	32	6 860
73	BG	BG8	/Russenski Lom	Basarbovo	M	25.913	43.786	13	22	2 800
74	BG	BG12	/Iskar	mouth	M	24.456	43.706	4	27	8 646
75	BG	BG13	/Vit	Guljantzi	M	24.728	43.644	7	29	3 225
76	BG	BG14	/Jantra	mouth	M	25.579	43.609	4	25	7 869
77	BG	BG15	/Russenski Lom	mouth	M	25.936	43.813	1	17	2 974
78	RO	RO1	Danube	Bazias	LMR	21.384	44.816	1 071	70	570 896
79	RO	RO18	Danube	Gruia/Radujevac	LMR	22.684	44.270	851	32	577 085
80	RO	RO2	Danube	Pristol/Novo Selo	LMR	22.676	44.214	834	31	580 100
81	RO	RO3	Danube	Dunare - upstreamArges (Oltenita)	LMR	26.619	44.056	432	16	676 150
82	RO	RO4	Danube	Chiciu/Silistra	LMR	27.268	44.128	375	13	698 600
83	RO	RO5	Danube	Reni	LMR	28.232	45.463	132	4	805 700
84	RO	RO6	Danube	Vilkova-Chilia arm/Kilia arm	LMR	29.553	45.406	18	1	817 000
85	RO	RO7	Danube	Sulina - Sulinaarm	LMR	29.530	45.183	0	1	817 000

N°	Country code	TNMN code	River	Monitoring station name	Locations	x-coord	y-coord	River-km	Alti-tude	Catchment area
86	**RO**	**RO8**	**Danube**	**Sf. Gheorghe-Ghorghearm**	**LMR**	**29.609**	**44.885**	**0**	**1**	**817 000**
87	RO	RO9	/Arges	Conf. Danube (Clatesti)	M	26.599	44.145	0	14	12 550
88	RO	RO10	/Siret	Conf. Danube (Sendreni)	M	28.009	45.415	0	4	42 890
89	RO	RO11	/Prut	Conf. Danube (Giurgiulesti)	M	28.203	45.469	0	5	27 480
90	RO	RO12	/Tisza/Somes	Dara (frontiera)	M	22.720	47.815	3	118	15 780
91	RO	RO13	/Tisza/Hármas-Körös/Sebes-Körös/CrisulRepede	Cheresig	M	21.692	47.030	3	116	2 413
92	RO	RO14	/Tisza/Hármas-Körös/Kettõs-Körös/CrisulNegru	Zerind	M	21.517	46.627	13	86.4	3 750
93	RO	RO15	/Tisza/Hármas-Körös/Kettõs-Körös/CrisulAlb	Varsand	M	21.339	46.626	0.2	88.9	4 240
94	RO	RO16	/Tisza/Mures	Nadlac	M	20.727	46.145	21	85.6	27 818
95	RO	RO17	/Tisza/Bega	Otelec	M	20.847	45.620	7	46	2 632
96	RO	RO19	/Jiu	Zaval	M	23.845	43.842	9	30.9	10 046
97	RO	RO20	/Olt	Islaz	M	24.797	43.744	3	32	24 050
98	RO	RO21	/Ialomita	DownstreamTandarei	M	27.665	44.635	24	8.5	10 309
99	MD	MD1	/Prut	Lipcani	L	26.483	48.152	658	100	8 750
100	MD	MD3	/Prut	Conf. Danube-Giurgiulesti	LMR	28.124	45.285	0	5	27 480
101	MD	MD5	/Prut	CostestiReservoir	L	27.145	47.513	557	91	11 800
102	MD	MD6	/Prut	Braniste	L	27.145	47.475	546	63	12 000
103	MD	MD7	/Prut	Valea Mare	L	27.515	47.075	387	55	15 200
104	**UA**	**UA1**	**Danube**	**Reni**	**M**	**28.288**	**45.437**	**132**	**4**	**805 700**
105	**UA**	**UA2**	**Danube**	**Vylkove**	**M**	**29.592**	**45.394**	**18**	**1**	**817 000**
106	UA	UA4	/Tisza	Chop	M	22.184	48.416	342	92	33000
107	UA	UA5	/Tisza/Bodrog/Latoritsa	Strazh	M	22.212	48.454	144	96	4418
108	UA	UA6	/Prut	Tarasivtsi	M	26.336	48.183	262	122	9836
109	UA	UA7	/Siret	Tcherepkivtsi	M	26.030	47.981	100	303	2070
110	UA	UA8	/Uzh	Storozhnica	R	22.200	48.617	106	112	1582
111	ME	ME1	/Lim	Dobrakovo	L	19.773	43.121	112	609	2875
112	ME	ME2	/Cehotina	Gradac	L	19.154	43.396	55.5	55	809.8

Abbreviations:

River km	The distance in km from the mouth of the mentioned river
Catchment area	The area in square km, from which water drains through the station
ds.	Downstream of
us.	Upstream of
bold font	The monitoring site is located on the Danube river
Conf.	Confluence tributary/main river
/	Indicates tributary to river in front of the slash. No name in front of the slash means Danube
Locations	Location from which the sample may be taken: L-left bank of the river, M - middle of the river, R – the right bank of the river
Grey font	The station not reported in 2018

Danube Transnational Monitoring Network: Surveillance Monitoring 2 – Surface waters

* Surveillance Monitoring 2 provides an assessment of long-term trends of specific pollutants and of loads of substances transferred downstream the Danube.

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2.3 Quality elements

The background of the whole TNMN yearbook are data reported in 2018 by 11 countries. Data provided by all countries should serve for evaluation of trends, longitudinal development and to calculate and know the changes in loads status. Data imported into database consist of different group of determinands: biological quality elements physico-chemical quality elements, organic micropollutants, heavy metals...). Basic statistical characteristics are processed for all monitoring sites (including all relevant locations) individually in the Annex I (more detailed description is in the Chapter3).

2.3.1 Parameters indicative of selected biological quality elements

To cover pressures of basin-wide importance as organic pollution, nutrient pollution and general degradation of the river, following biological quality elements have been agreed for SM 2:

- Phytoplankton (chlorophyll-a)
- Benthic invertebrates (mandatory parameters: Saprobic index and number of families once yearly, both Pantle&Buck and Zelinka&Marvan SI are acceptable; optional parameters: ASPT and EPT taxa)
- Phytobenthos (benthic diatoms – an optional parameter)

2.3.2 Priority pollutants and parameters indicative of general physico-chemical quality elements

The list of parameters for assessment of trends and loads and their monitoring frequencies are given in Table 2.

Table 2: Surface water determinands list for TNMN

Determinand	Surveillance Monitoring 2	
	Water concentrations	**Water load assessment**
Flow	annually / 12 x per year	Daily
Temperature	annually / 12 x per year	
Transparency (1)	annually / 12 x per year	
Suspended Solids (5)	annually / 12 x per year	annually / 26 x per year
Dissolved Oxygen	annually / 12 x per year	
pH (5)	annually / 12 x per year	
Conductivity @ 20 °C (5)	annually / 12 x per year	
Alkalinity (5)	annually / 12 x per year	
Inorganic Nitrogen	annually / 12 x per year	annually / 26 x per year
Total Nitrogen	annually / 12 x per year	
Total Phosphorus	annually / 12 x per year	annually / 26 x per year
Dissolved Phosphorus	annually / 12 x per year	annually / 26 x per year
Ortho-Phosphate (PO_4^{3-} -P) (2)	annually / 12 x per year	annually / 26 x per year
Calcium (Ca^{2+}) (3, 4, 5)	annually / 12 x per year	
Magnesium (Mg^{2+}) (4, 5)	annually / 12 x per year	
Chloride (Cl^-)	annually / 12 x per year	annually / 26 x per year
Atrazine	annually / 12 x per year	
Cadmium (6)	annually / 12 x per year	
Lindale (7)	annually / 12 x per year	
Lead (6)	annually / 12 x per year	
Mercury (6,8)	annually / 12 x per year	
Nickel (6)	annually / 12 x per year	

Determinand	Surveillance Monitoring 2	
	Water concentrations	Water load assessment
Arsenic (6)	annually / 12 x per year	
Copper (6)	annually / 12 x per year	
Chromium (6)	annually / 12 x per year	
Zinc (6)	annually / 12 x per year	
p,p´-DDT and its derivatives (7)	see below	
COD_{Cr} (5)	annually / 12 x per year	
COD_{Mn} (5)	annually / 12 x per year	
Dissolved Silica		annually / 26 x per year
BOD_5	annually / 12 x per year	annually / 26 x per year

(1) Only in coastal waters
(2) Soluble reactive phosphorus SRP
(3) Mentioned in the tables of the CIS Guidance document but not in the related mind map
(4) Supporting parameter for hardness-dependent EQS of PS metals
(5) Not for coastal waters
(6) Measured in a dissolved form. Measurement of total concentration is optional
(7) In areas with no risk of failure to meet the environmental objectives for DDT and lindane the monitoring frequency is 12 x per a RBMP period; in case of risk the frequency is 12 x year
(8) Mercury in fish is reported in a three-year reporting cycle

2.4 Analytical Quality Control (AQC)

Parameters covered and samples distributed in the 2018 QUALCODanube programme were as follows:

real surface water samples for nutrient analysis: preserved natural surface water, spiked if necessary and adequately homogenised. Sample codes were SW-N-1 and SW-N-2. 500 cm^3 plastic bottles were provided for $NH4^+$-N, NO_3^--N, organic N, total N, PO_4^{3-} -P and total P analysis. Measurement results were asked to be reported as mg/dm^3 N and P, respectively.

spike solutions together with matrix water for NO_2^--N analysis: due to stability concerns during transport, it was decided that participants should compose the proficiency testing items themselves in situ by mixing prescribed amounts of the spike solutions (synthetic concentrates) of the measurand with the matrix water provided (simulated surface water, pre-atreated by bringing to boiling point) according to instructions. Spike solutions were put in 20 cm^3 plastic containers with sample codes SW-N/M-1 and SW-N/M-2, whereas matrix water was provided in 500 cm^3 plastic bottle labelled “WATER FOR DILUTION - NO2- N. Measurement results were asked to be reported as mg/ dm^3 N.

spike solutions for organic micropollutant analysis: methanolic spike solutions were distributed. Participants had to compose the proficiency testing samples themselves in situ by mixing prescribed amounts of the spike solutions (synthetic concentrates) of the measurand with pesticides-free laboratory water (e.g. high purity water) according to instructions. Spike solutions were put in 5 cm^3 amber capillary bottles with sample codes SW-Org-1 and SW-Org-2. Measurement results were asked to be reported as µg/ dm^3.

Evaluation of results was performed according to ISO 13528:2015. Reported results were first inspected for obviously erroneous results or blunders (e.g. results reported in measurement units other than requested, swapping samples or parameters etc.) which were excluded from the calculation of statistical characteristics in accordance with section B.2.5. of ISO/IEC 17043:2010.

Then statistical characteristics, i.e. the assigned value of the parameter (x_{pt}), the standard uncertainty of the assigned value [u(x_{pt})] and the standard deviation for proficiency assessment (σ_{pt}) was determined. Finally, performance statistics was calculated including z-scores, z’-scores and E_n numbers and performance assessment was given (section 9.4., 9.5. and 9.6. of ISO 13528:2015). Calculation of performance statistics was also performed for results excluded from calculation of statistical characteristics in order to indicate clearly that appropriate measures should be taken by Participant.

Fifty laboratories were enrolled into the scheme in 2018, which is similar to previous years' numbers. However, one laboratory did not return results, thus the actual number of participants was 49. Most of the participants were experienced laboratories who had formerly participated in and were familiar with the scheme. As previously, nutrients were measured by most participants (40 to 47 laboratories), with the exception of organic N, where only 11 results were available for evaluation. This parameter replaced Kjeldahl N analysis in 2013 at behest of participants, however, it remains unpopular with laboratories, which renders statistical evaluation difficult. Organic micropollutants were measured by 26 to 27 laboratories.

The 2018 proficiency testing scheme was highly successful overall, number and ratio of unsatisfactory results remained low, evaluation of results could be performed for all parameters in both samples. Z'-scores, indicating elevated ratio of standard uncertainty of the assigned value compared to the standard deviation of proficiency assessment, were used for performance assessment on only seven occasions (organic N and atrazine: both samples, NO_2^--N and lindane: sample SW-N/M-2, 4,4'- DDT: sample SW-M-1), which indicates an excellent overall performance in itself. Calculation of E_n numbers and their visualization on graphs as expanded uncertainty bars around reported results is an effective tool which helps participants to assess if their uncertainty budget calculation is valid. Thus affected participants may implement preventive actions to avoid ambiguous situations.

Almost all participants reported expanded uncertainties together with their measurement results, allowing for calculation of E_n numbers, thus assessment of the validity of the underlying uncertainty estimation. Graphs clearly shows which participants have precision reserves, i.e. margin for the expanded uncertainty range between upper and lower unsatisfactory limits. Number and ratio of unsatisfactory E_n numbers were similar to those seen in previous rounds. Unfortunately, some participants still reported expanded uncertainties in % instead of the unit of measurement required, despite clear instructions on data report forms. However, this practice did not necessarily lead to unsatisfactory E_n results (i.e. when numerical values of target concentrations and % uncertainties were in the same range), thus data tables should be read with caution.

As previously, determination of nutrients was highly successful, with few unsatisfactory or questionable results if at all: in case of nitrate and total nitrogen, all reported results were in the satisfactory range. Similarly to 2017, determination of nitrite nitrogen proved to be more challenging: reported results scatter along the diagonal axis of the Youden-plot, meaning laboratories typically under- or overestimate the assigned values in both samples. Number of laboratories with results exceeding critical limits in the same direction (z/z' > 2,0 or z/z' < -2,0 for both samples), formerly called systematic errors, is nine, which relatively high. However, all these results are just slightly above critical limits. Ammonium nitrogen proficiency testing was somewhat poorer than previously, especially with regards to the number of questionable results. Organic nitrogen, which debuted in the scheme in 2013, was measured by only 11 participants. Low participation and poor agreement between reported results did not allow statistical evaluation to be performed the last two years. This year, however, standard uncertainty of the assigned value compared to the standard deviation of proficiency assessment remained below the critical limit of 120% for both samples, thus evaluation could be performed. Organic micropollutants results cluster well around assigned values, number and ratio of unsatisfactory results is low. Results of one participant were excluded from the statistical evaluation due to being higher than the majority of results by an order of magnitude (possibly attributable to reporting in the wrong unit of measurement). Higher uncertainties of assigned values necessitated the use of z'-scores for assessment in case of both samples for atrazine and one of the samples for 4,4'-DDT and lindane.

In summary, the 2018 QualcoDanube proficiency testing scheme was successful, the scheme remains a useful and relevant tool in the quality framework of the Danube region.

2.5 TNMN Data Management

The procedure of TNMN data collection is organized at a national level. The National Data Managers (NDMs) are responsible for data acquisition from TNMN laboratories as well as for data checking, conversion into an agreed data exchange file format (DEFF) and sending it to the TNMN data management centre in the Slovak Hydrometeorological Institute in Bratislava. This centre performs a secondary check of the data and uploads them into the central TNMN database. In cooperation with the ICPDR Secretariat, the TNMN data are uploaded into the ICPDR website (www.icpdr.org).

3. Results of basic statistical processing

There in the whole Danube River Basin district in 2018 were monitored 148 sites at 101 TNMN monitoring stations (some monitoring station could contain two or three sampling sites – depending on where the sampling site is located, whether on the right or left bank of the river, or in its middle. This information is given in the Table 3, in the column „Location“). There on the Danube River directly were collected 73 sampling sites at 39 stations. Tributaries were monitored at 62 stations representing 75 sampling sites at all. These 148 reported sites presented in the Table 3 are included in the list of all TNMN SM2 sites.

Table 3 List of TNMN stations reported in 2018

N°	TNMN code	TNMN old code	Location	River	Monitoring station	River km
1	**DE5**	**L2141**	**L**	**Danube**	**Dillingen**	**2538**
2	**DE2**	**L2130**	**M**	**Danube**	**Jochenstein**	**2204**
3	DE3	L2150	M	Inn	Kirchdorf	195
4	DE4	L2160	L	Inn/Salzach	Laufen	47
5	**AT1**	**L2220**	**M**	**Danube**	**Jochenstein**	**2204**
6	**AT5**	**L2201**	**R**	**Danube**	**Enghagen**	**2113**
7	**AT3**	**L2180**	**R**	**Danube**	**Wien-Nussdorf**	**1935**
8	**AT6**	**L2171**	**R**	**Danube**	**Hainburg**	**1879**
9	CZ1	L2100	M	Morava	Lanžhot	79
10	CZ2	L2120	M	Morava/Dyje	Pohansko	17
11	**SK1**	**L1840**	**L, M, R**	**Danube**	**Bratislava**	**1869**
12	**SK2**	**L1860**	**M, R**	**Danube**	**Medveďov**	**1806**
13	SK4	L1960	M, R	Vah	Komárno	1,5
14	**SK5**	**L1871**	**L, M, R**	**Danube**	**Szob**	**1707**
15	SK6	L1872	M	Morava	Devín	1
16	SK7	L1873	M	Danube/Hron	Kamenica	1,7
17	SK8	L1874	M	Danube/Ipeľ	Salka	12
18	**HU1**	**L1470**	**M, R**	**Danube**	**Medve/Medvedov**	**1806**
19	**HU2**	**L1475**	**M, R**	**Danube**	**Komarom/Kedvedov**	**1768**
20	**HU3**	**L1490**	**L, M, R**	**Danube**	**Szob**	**1708**
21	**HU4**	**L1520**	**L, M, R**	**Danube**	**Dunafoldvar**	**1560**
22	**HU5**	**L1540**	**M**	**Danube**	**Hercegszanto**	**1435**
23	HU6	L1604	L, M	Sio	Szekszard-Palank	13
24	HU7	L1610	L, M	Drava	Dravaszabolcs	78
25	HU8	L1770	M, R	Tisza/Sajo	Sajopuspoki	124
26	HU9	L1700	L, M, R	Tisza	Tiszasziget	163
27	HU10	L1710	L, M	Tisza	Tiszabecs	757
28	HU11	L1711	L, M	Tisza/Szamos	Csenger	45
29	HU12	L1712	M, R	Tisza/Hármas-Körös/Sebes-Körös	Korosszakal	9
30	HU13	L1713	M, R	Tisza/Hármas-Körös/Kettõs-Körös/Fekete-Körös	Sarkad	16

N°	TNMN code	TNMN old code	Location	River	Monitoring station	River km
31	HU14	L1714	M, R	Tisza/Hármas-Körös/Kettõs-Körös/Fehér-Körös	Gyulavari	59
32	HU15	L1715	R	Tisza/Maros	Nagylak	51
33	SI1	L1390	L	Drava	Ormož most	300
34	SI2	L1330	R	Sava	Jesenice na Dolenjskem	729
35	**HR1**	**L1315**	**M, R**	**Danube**	**Batina**	**1429**
36	**HR11**	**L1302**	**M**	**Danube**	**Ilok**	**1301,5**
37	HR9	L1300	M	Drava	Ormož	300
38	HR4	L1240	M, R	Drava	Botovo	227
39	HR5	L1250	M, R	Drava	D. Miholjac	78
40	HR6	L1220	R	Sava	Jesenice	729
41	HR7	L1150	M	Sava	Upstream Una Jasenovac	525
42	HR12	L1303	L	Sava	Račinovci	218
43	**RS1**	**L2350**	**L**	**Danube**	**Bezdan**	**1426**
44	**RS2**	**L2360**	**L**	**Danube**	**Bogojevo**	**1367**
45	**RS3**	**L2370**	**R**	**Danube**	**Novi Sad**	**1255**
46	**RS4**	**L2380**	**R**	**Danube**	**Zemun**	**1173**
47	**RS6**	**L2400**	**L**	**Danube**	**Banatska Palanka**	**1077**
48	**RS7**	**L2410**	**R**	**Danube**	**Tekija**	**954**
49	**RS8**	**L2420**	**R**	**Danube**	**Radujevac**	**851**
50	RS10	L2440	R	Tisa	Martonos	152
51	RS11	L2450	L	Tisa	Novi Becej	65
52	RS12	L2460	M	Tisa	Titel	8,7
53	RS13	L2470	L	Sava	Jamena	205
54	RS15	L2490	R	Sava	Sabac	106
55	RS16	L2500	R	Sava	Ostruznica	17
56	RS17	L2510	R	Velika Morava	Ljubicevski Most	21,8
57	**BG1**	**L0730**	**L, M, R**	**Danube**	**Novo Selo Harbour/Pristol**	**834**
58	**BG2**	**L0780**	**R**	**Danube**	**us. Iskar-Bajkal**	**641**
59	**BG3**	**L0810**	**R**	**Danube**	**Downstream Svishtov**	**554**
60	**BG4**	**L0820**	**R**	**Danube**	**us. Russe**	**503**
61	**BG5**	**L0850**	**L, M, R**	**Danube**	**Silistra/Chiciu**	**375**
62	BG6	L0930	M	Iskar	Orechovitza	28
63	BG7	L0990	M	Jantra	Karantzi	12
64	BG8	L1010	M	Russenski Lom	Basarbovo	13
65	BG12	L0931	M	Iskar	Gigen mouth	4
66	BG13	L0940	M	Vit	Guljantzi	7
67	BG14	L0991	M	Jantra	Novgrad mouth	4
68	BG15	L1011	M	Russenski Lom	mouth	1
69	**RO1**	**L0020**	**L, M, R**	**Danube**	**Bazias**	**1071**
70	**RO18**	**L0030**	**L, M, R**	**Danube**	**Gruia/Radujevac**	**851**
71	**RO2**	**L0090**	**L, M, R**	**Danube**	**Pristol/Novo Selo**	**834**
72	**RO3**	**L0240**	**L, M, R**	**Danube**	**Dunare - upstream Arges (Oltenita)**	**432**
73	**RO4**	**L0280**	**L, M, R**	**Danube**	**Chiciu/Silistra**	**375**

N°	TNMN code	TNMN old code	Location	River	Monitoring station	River km
74	**RO5**	**L0430**	**L, M, R**	**Danube**	**Reni-Chilia/Kilia arm**	**132**
75	**RO6**	**L0450**	**L, M, R**	**Danube**	**Vilkova-Chilia arm/Kilia arm**	**18**
76	**RO7**	**L0480**	**L, M, R**	**Danube**	**Sulina - Sulina arm**	**0**
77	**RO8**	**L0490**	**L, M, R**	**Danube**	**Sf. Gheorghe-Ghorghe arm**	**0**
78	RO9	L0250	M	Arges	Conf. Danube (Clatesti)	0
79	RO10	L0380	M	Siret	Conf. Danube (Sendreni)	0
80	RO11	L0420	M	Prut	Conf. Danube (Giurgiulesti)	0
81	RO12	L0421	M	Somes	Dara (frontiera)	3
82	RO13	L0422	M	Crisul Repede	Cheresig	3
83	RO14	L0423	M	Crisul Negru	Zerind	13
84	RO15	L0424	M	Crisul Alb	Varsand	0
85	RO16	L0425	M	Mures	Nadlac	21
86	RO17	L0426	M	Bega	Otelec	7
87	RO19	L0427	M	Jiu	Zaval	9
88	RO20	L0428	M	Olt	Islaz	3
89	RO21	L0429	M	Lalomita	Downstream Tandarei	24
90	MD1	L2230	L	Prut	Lipcani	658
91	MD3	L2270	L	Prut	Conf. Danube-Giurgiulesti	0
92	MD5	L2235	L	Prut	Costesti Reservoir	254
93	MD6	L2236	L	Prut	Braniste	254
94	MD7	L2237	L	Prut	Valea Mare	525
95	**UA1**	**L0630**	**M**	**Danube**	**Reni**	**132**
96	**UA2**	**L0690**	**M**	**Danube**	**Vylkove**	**18**
97	UA4	L0692	M	Tisza	Chop	342
98	UA5	L0693	M	Tisza/Bodrog/Latoritsa	Strazh	144
99	UA6	L0694	M	Prut	Tarasivtsi	262
100	UA7	L0695	M	Siret	Tcherepkivtsi	100
101	UA8	L0696	R	Uzh	Storozhnytsya	106

Explanations:
Bold font – for the Danube River sites
Not bold font – tributaries

The basic processing of the TNMN data includes in the first step - calculation of selected statistical characteristics for each determinand/monitoring site. Thereafter the results are presented in tables, in the Annex I and some of them are presented also graphically in form of long-term trends (Figures 4.1-4.25) or on the annually basis (Figures 4.26-4.40).

ANNEX I - data format:

Term used	Explanation
Determinand name	name of the determinand measured according to the agreed method
Unit	unit of the measured determinand
N	number of measurements
Min	minimum value of the measurements done in the year 2018
Mean	arithmetical mean of the measurements done in the year 2018
Max	maximum value of the measurements done in the year 2018
C50	50 percentiles of the measurements done in the year 2018
C90	90 percentiles of the measurements done in the year 2018 (C10 for dissolved oxygen)

When processing the TNMN data and presenting them in the tables of the Annex, the following rules have been applied:

- *If "less than the quantification limit" values were present in the dataset for a given determinand, then the ½ value of the limit of quantification was used in statistical processing of the data.*
- *If the number of measurements for a particular determinand was lower than four, then only the minimum, maximum and mean are reported in the tables of the Annex.*
- *The statistic value "C90" is equal to 90 percentile (10 percentile for dissolved oxygen and lower limit of pH value) if the number of measurements in a year was at least eleven. If the number of measurements in a year was lower than eleven, then the "C90" value is represented by a maximum value from a data set (a minimum value for dissolved oxygen and lower limit of pH value).*

In year 2009 the analytical data method according to Directive 2009/90/EC with limit of quantification (LOQ) has been applied. In this case if values were less than limit of quantification in statistic processing of data was used ½ limit of quantification (LOQ).

The Problem is the reduced monitoring frequency for certain determinands such as dissolved phosphorus, biological determinands, heavy metals and specific organic micropollutants, primarily in the lower part of the Danube River Basin.

Table 4, based on data in in the Annex I processed, shows in an aggregated way the concentration ranges (minimum, maximum) and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2018. These include indicators of the oxygen regime, nutrients, heavy metals, biological determinands and organic micropollutants. The table 4 also includes information about total number of monitoring locations/sites actually measured in 2018.

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2018 (Part 1)

Determinand name	Unit	Danube					Tributaries				
		No. of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean		No. of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean	
			Min	Max	Min avg	Max avg		Min	Max	Min avg	Max avg
Temperature	°C	62/32	0.5	29	11.867	17.847	57/55	< 0.000	71	8.054	20.263
Suspended solids	mg/l	60/32	< 0.25	428	7	64	55/53	< 1	1802	6	281
Dissolved oxygen	mg/l	62/32	4.6	15.7	7.2	11.85	57/55	3.2	16.2	5.65	11.65
Oxygen saturation	%	35/15	72.8	131	88.92	105.73	24/24	47.93	134	74.67	102.27
BOD (5)	mg/l	68/38	< 0.25	8.4	1.01	4.14	64/62	< 0.25	8.1	0.78	4.57
COD (Cr)	mg/l	55/25	< 2.00	40.4	< 5.00	16.93	51/49	< 0.05	134.5	2.82	49.97
COD (Mn)	mg/l	61/31	0.86	12.06	2.23	7.45	45/43	0.92	29.3	2.16	9.24
TOC	mg/l	45/25	1.3	10.5	2.15	5.13	36/34	1	39.8	1.55	14.73
DOC	mg/l	33/15	1.2	7.44	1.992	6.02	17/17	< 0.250	11.15	1.208	6.918
pH	-	62/32	6.9	12.69	7.78	8.65	53/53	6.53	19.4	7.44	9.64
Alkalinity - total	mmol/l	69/39	1.229	8.1	1.525	4.382	54/52	< 0.025	231	1.185	189.833
Ammonium (NH4-N)	mg/l	69/39	< 0.001	0.973	0.016	0.212	64/62	< 0.001	5.391	0.017	2.049
Nitrite (NO2-N)	mg/l	69/39	< 0.0005	0.161	0.0085	0.0295	64/62	< 0.0005	0.218	0.0053	0.0848
Nitrate (NO3-N)	mg/l	69/39	0.07	4.09	0.797	2.646	64/62	< 0.003	8.27	0.488	6.709
Total nitrogen	mg/l	61/31	0.5	4.51	1.262	2.675	54/52	< 0.150	11.7	0.817	8.865
Organic nitrogen	mg/l	29/19	< 0.025	1.78	0.029	0.881	23/21	< 0.050	4.27	< 0.100	1.135
Inorganic nitrogen	mg/l	69/39	0.082	4.462	0.881	2.702	64/62	< 0.000	8.598	0.517	7.265
Orthophosphate (PO4-P)	mg/l	69/39	< 0.0025	0.14	0.0125	0.0731	64/62	< 0.0010	1.002	0.0044	0.3013
Total phosphorus	mg/l	67/37	0.0121	0.457	0.0367	0.1771	62/60	< 0.0035	1.366	0.0183	0.509
Total phosphorus, dissolved	mg/l	40/18	0.01	0.36	0.0311	0.1076	13/13	0.018	1.17	0.0369	0.3198
Conductivity	µS/cm	65/37	270	1811	368.583	540.083	62/60	34.2	1346	50.567	1199.417
Calcium (Ca++)	mg/l	69/39	17.6	90.4	35.42	80.45	64/62	2	116	22.09	89.95
Sulphate (SO4--)	mg/l	46/24	12.5	74.6	18.85	54.55	46/44	7.88	475	11.23	113.83
Magnesium (Mg++)	mg/l	69/39	1.8	35.5	10.78	25.38	63/61	< 0.25	75.6	2.64	57.58
Potassium (K+)	mg/l	26/16	< 0.50	5.71	1.66	3.31	36/34	0.74	12.2	1.17	10
Sodium (Na+)	mg/l	26/16	7.87	29	12.05	21.42	36/34	2.36	325.38	4.82	169.67
Manganese (Mn)	mg/l	12/8	< 0.0050	0.235	0.0141	0.1429	19/17	< 0.0003	0.78	0.0307	0.285
Manganese (Mn), dissolved	mg/l	23/17	< 0.0001	35.8	0.0015	14.7583	25/23	0.0006	0.43	0.0039	0.1283
Iron (Fe)	mg/l	8/6	< 0.001	2.9	0.388	0.725	24/22	< 0.010	24.5	0.032	5.356
Iron (Fe), dissolved	mg/l	16/12	0.003	0.74	0.008	0.181	18/16	< 0.005	0.41	0.01	0.097
Chloride (Cl-)	mg/l	69/39	11	84.1	17.99	34.24	64/62	< 2.50	266.75	6.12	170.68
Silicates (SiO2)	mg/l	16/8	1	23	2.3017	10.2333	17/15	0.821	28.6	1.8714	23.1917
Silicates(SiO2), dissolved	mg/l	13/11	< 0.200	8.7	3.433	5.985	15/15	2.2	22.6	4.455	9.771
Macrozoobenthos sapr. index	-	23/17	1.951	3.095	1.978	3.095	34/33	1.69	3.17	1.69	3.17

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2018 (Part 2)

Determinand name	Unit	Danube					Tributaries				
		No. of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean		No. of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean	
			Min	Max	Min avg	Max avg		Min	Max	Min avg	Max avg
Zinc (Zn)	µg/l	22/18	< 0.50	671.7	5.05	199.8	28/26	2.1	655	3.06	229.38
Zinc (Zn), dissolved	µg/l	69/39	< 0.500	375.6	1.174	152.222	58/56	< 0.500	498	0.968	167.5
Copper (Cu)	µg/l	20/16	< 0.250	98.6	1.789	31.525	29/27	< 0.500	294	1.967	48.408
Copper (Cu), dissolved	µg/l	69/39	< 0.250	61.4	0.767	18.675	64/62	< 0.250	80.3	< 0.500	20.217
Chromium (Cr) - total	µg/l	20/16	< 0.1000	58	0.4708	9.011	31/29	< 0.2500	61.3	0.8394	14.95
Chromium (Cr), total dissolved	µg/l	60/34	< 0.10	5.96	0.17	2	51/49	< 0.02	56.2	0.11	7.32
Lead (Pb)	µg/l	20/16	< 0.0500	30.1	< 0.5000	4.4927	32/30	< 0.0500	125	0.3363	15.1842
Lead (Pb), dissolved	µg/l	58/32	< 0.025	8.639	< 0.025	2.94	57/55	< 0.025	21.5	0.037	6.496
Cadmium (Cd)	µg/l	20/16	< 0.00250	0.7	0.0225	0.11909	32/30	< 0.00250	89.6786	0.02271	18.50755
Cadmium (Cd), dissolved	µg/l	67/37	< 0.003	0.821	< 0.007	0.23	61/59	< 0.003	0.66	0.005	< 0.250
Mercury (Hg)	µg/l	20/16	< 0.0100	0.3	< 0.0100	0.0708	30/28	< 0.0050	0.5496	0.0079	0.2003
Mercury (Hg), dissolved	µg/l	66/36	< 0.0010	0.196	0.0017	< 0.0350	57/55	< 0.0010	< 0.1500	0.0012	< 0.1500
Nickel (Ni)	µg/l	20/16	< 0.250	58.6	0.754	10.764	32/30	< 0.500	60.9	1.208	15.483
Nickel (Ni), dissolved	µg/l	67/37	< 0.250	16	0.404	5.37	58/56	< 0.250	47.2	0.373	12.233
Arsenic (As)	µg/l	20/16	< 0.250	8.5	0.755	2.925	24/22	< 0.250	43.4	0.876	8.25
Arsenic (As), dissolved	µg/l	67/37	< 0.250	9.653	< 0.500	2.965	56/54	< 0.050	13.8	< 0.050	7.212
Aluminium (Al)	µg/l	11/7	< 4.000	1455	139.25	458.083	8/6	37.5	23000	182.658	5302.5
Aluminium (Al), dissolved	µg/l	25/15	< 0.01	296.8	< 0.01	66.47	16/14	< 1.50	224	3.4	59.04
Phenol index	mg/l	34/12	< 0.0025	0.01	< 0.0025	0.0031	18/18	< 0.0004	0.017	< 0.0004	0.0049
Anionic active surfactants (PAL-A)	mg/l	40/16	< 0.0050	0.14	< 0.0100	0.1165	28/28	< 0.0025	0.5	< 0.0025	0.2
AOX	µg/l	14/8	2.7	97	5.75	26	14/14	< 5.0000	148	11.7143	59.0583
Petroleum hydrocarbons	mg/l	29/14	< 0.0025	0.433	< 0.0025	0.1648	25/25	< 0.0000	0.851	< 0.0100	0.3434
Lindane (gama-HCH)	µg/l	59/29	< 0.0003	< 0.0250	< 0.0003	< 0.0250	57/55	< 0.0003	< 0.0400	< 0.0003	< 0.0400
p,p'-DDT	µg/l	54/28	< 0.0002	< 0.0250	< 0.0002	< 0.0250	52/50	< 0.0002	< 0.0500	< 0.0002	< 0.0500
Atrazine	µg/l	57/27	< 0.0005	< 0.0900	< 0.0005	< 0.0900	45/43	< 0.0005	0.112	< 0.0005	< 0.0900
Chloroform	µg/l	19/11	< 0.003	0.5	< 0.003	0.5	22/20	< 0.015	0.75	< 0.015	0.75
Carbon tetrachloride	µg/l	12/8	< 0.050	0.5	< 0.050	0.5	23/21	< 0.050	< 0.250	< 0.050	< 0.250
Trichloroethylene	µg/l	12/8	< 0.050	0.5	< 0.050	0.5	23/21	< 0.050	< 0.250	< 0.050	< 0.250
Tetrachloroethylene	µg/l	12/8	< 0.050	0.5	< 0.050	0.5	23/21	< 0.050	0.62	< 0.050	0.281

4. Profiles and trend assessment of selected determinands

There in this part of this chapter in Figures 4.1-4.16 is presented **the development of selected determinands** (dissolved oxygen (DO), BOD_5, COD_{Cr}, N-NH_4, N-NO_3, P-PO_4, P_{total} and Cd) **in time** (11 years period) in the Danube River and also in tributaries by 90 percentile (c90) or 10 percentile (c10-DO).

Due to revision of the TNMN in 2006 following monitoring points on the Danube were replaced: AT2 rkm 2120 to AT5 rkm 2113, AT4 rkm 1874 to AT6 rkm 1879, DE1 rkm 2581 to DE5 rkm 2538. Among tributaries, the site HR3 rkm 288 was replaced by HR9 rkm 300 BG8 rkm 54 to BG14 rkm 4 and BG8 rkm 13 to BG15 rkm 1. In 2009 SK3 was replaced with SK5, this monitoring point is also in graphs illustrated as Hungarian point HU3. For trend graphs was used illustration of SK5 and HU3.

The long-term trends in the upper, middle and lower Danube and more detailed example of analysis for selected parameters (BOD_5, N-NO_3, P_{total}) are individually provided for the sites SK1 Bratislava, HU5 Hercegszanto and RO5 Reni (Figures 4.17-4.25).

As regards a general spatial distribution of key water quality parameters along the Danube River in 2018 the **highest concentrations of biodegradable organic matter** were observed in the middle and lower parts of the Danube River with the maximum 8.4 $mg.l^{-1}$ (HU3 Danube – Szob) near the maximum value 8.1 $mg.l^{-1}$ in tributaries (CZ1 Morava – Lanžhot) .

Taking into account the entire period of TNMN operations positive changes in water quality can be seen at several TNMN stations. Decreasing tendencies of biodegradable organic matter in 2018 were observed in the middle and lower Danube, at the monitoring sites HU2, and RO3 (see Figure4.3).

The decrease of the BOD5 has been observed in some tributaries: Drava, Tisza, Russenski Lom and Arges (Figure 4.4). In 2018 concentration of BOD5 has increased in German (DE3-Inn, DE4-Inn/Salzach), Czech (CZ1-Morava, CT2-Morava/Dyje), Croatian (HR9-Drava), Bulgarian (BG14-Jantra) and Moldovan (MD1-Prut) tributaries.

The highest (maximum) values of **dissolved oxygen** (DO) in the Danube River were observed in its upper part (DE5 Danube – Dillingen 15.7 $mg.l^{-1}$), in the lower Danube dissolved oxygen levels decreased to 9.2 $mg.l^{-1}$ at the monitoring point BG1 Danube – Novo Selo harbour. Maximum c_{90} value reached up to 10 $mg.l^{-1}$, e.g. in the HR1 monitoring point (Danube-Batina 9.88 $mg.l^{-1}$, Figure 4.1).

The range of DO maximum values in tributaries was 6.87-16.2 $mg.l^{-1}$ (BG12/HU6). The maximum concentrations in Danube and also in tributaries slightly increased in comparison with maximum values of previous year (14.88 $mg.l^{-1}$ in Danube/15.4 $mg.l^{-1}$ in tributaries). The c_{90} values in tributaries slightly exceeded level 10 $mg.l^{-1}$

Positive finding of c_{90} values decrease in 2018 for nitrate-nitrogen (NO3_N), from the group of **nutrients**, presented in the Figure 4.9 was indicated in the most Danube River monitoring sites (20 sites from 33). The maximum from these c_{90} values was 3.2 $mg.l^{-1}$ in DE5 (Danube – Dillingen). The lowest c_{90}values during the last 11 years, are in Serbian sites (RS7 Danube-Tekija, RS8 Danube-Radujevac). The maximum increase of 0.6 $mg.l^{-1}$ in c_{90} values was in AT3 site (Danube – Wien Nussdorf).

The range of maximum values of nitrate-nitrogen in the Danube River sites were up to 4.09 $mg.l^{-1}$ and in the tributaries up to 8.27 $mg.l^{-1}$ in BG8 (Russenski Lom). In comparison with the previous year in this site the increase has achieved 0.5 $mg.l^{-1}$. The maximum decrease in c_{90} values was in SK5 monitoring point (Danube-Szob, 0.66 $mg.l^{-1}$). The increase of maximum concentrations was detected in the Russenski Lom River (BG15 – 6.76 $mg.l^{-1}$), Morava River CZ2 (Morava/Dyje-5.1 $mg.l^{-1}$), CZ1 (Morava -3.8 $mg.l^{-1}$). The c_{90} statistical characteristics was lowest in RS16 (Sava-Otruznica, 0.8 $mg.l^{-1}$, together with 2 German monitoring sites DE3 and DE4.

Temporal changes of nitrate-nitrogen (c_{90} during last 11 years, presented in the Figures 4.20 – 4.22 for the Danube River in Bratislava (Slovakia), Hercegszanto (Hungary) and Reni (Romania) indicate decrease in Romanian territory (Reni). The lowest concentration was in Reni in 2018 (1.42 $mg.l^{-1}$ (c_{90})).

The increasing or almost stable level of **ammonium-nitrogen** concentrations (c_{90}) was recorded in the whole Danube River. The highest increase in Danube was 0.44 $mg.l^{-1}$ (c_{90}) in comparison with previous year in RO3 (Danube – Dunare upstream Arges (Oltenita)) and 1,27 $mg.l^{-1}$ (c_{90}) in RO9 (Arges – Confluence Danube (Clatesti)). In 2018 increased concentrations of ammonium- nitrogen in tributaries Morava, Russenski Lom, Arges and Prut (see Figure 4.8, RO9, BG15, MD1, MD3, CZ2). The concentration of ammonium- nitrogen in 2018 decreased in 11 presented sites.

There in the Figure 4.11 in which the data of **ortho-phosphate-phosphorus** in the Danube River are presented, is seen that in 2018 are results of c_{90} only up to 0.096 $mg.l^{-1}$, compared to 0.5 $mg.l^{-1}$ of c_{90} in 2017. There in the RS8 (Danube-Radujevac) is the highest decrease, 0.077 $mg.l^{-1}$ after eleven years and so the concentration reached the range of others monitoring sites (bellow 0.1 $mg.l^{-1}$). In general, the maximum c_{90} values in tributaries are higher than in the Danube River, in 2015 reached c90 value 0.51 $mg.l^{-1}$ in CZ2 (Morava/Dyje-Pohansko - Figure 4.12). The sites other than RO9, HU6 and BG15 reached also up to 0.1 $mg.l^{-1}$. The decrease of ortho-phosphate-phosphorus concentrations was observed in 15 from 26 monitoring sites presented in Figure 4.12.

Most of the Danube River monitoring sites presented for the **phosphorus-total** (Figure 4.13) in 2018 show decrease in c_{90} values (20 sites from 33). Although the monitoring site RS8 (Danube-Radujevac) achieved the highest c_{90} concentration 0.26 $mg.l^{-1}$ in 2018, there is also the highest decrease of 0.1 $mg.l^{-1}$. The values of c_{90} in tributaries in 2018 show an increase in most places (17 sites from presented 26 (Figure 4.14)), only up to 0.162 $mg.l^{-1}$ in BG15 (Russenski Lom). The highest decrease of 0.17 $mg.l^{-1}$ in (c_{90}) from all tributaries was detected in HU6 (Sio-Szekszard-Palank).

The temporal changes of **total phosphorus** (c_{90}) in Figures 4.23-4.25 at selected monitoring sites**,** in the Danube River - Bratislava, Hercegszanto and Reni during the last 11 years appear decreasing.

There in the development of **chemical oxygen demand (COD_{Cr})** (Figure 5 and Figure 6) is seen the difference in pollution between the Danube River and tributaries. The concentrations in tributaries are higher (range of c_{90} values 6-63.2 $mg.l^{-1}$ with maximum in BG15 (Russenski Lom-mouth), than in the Danube River sites (range of c_{90} values 5 - 23 $mg.l^{-1}$) in RO6 Danube-Vilkova Chilia arm/Kilia arm).

The **cadmium** concentration (Figure 4.15) is constant or slightly decreasing in Danube River, with maximum of c90 values 0.16 $mg.l^{-1}$ in RS7 (Danube-Tekija). Higher concentrations are detected in tributaries, with the maximum c_{90} 89.2 $mg.l^{-1}$ in HU9 (Tisza-Tiszasziget).

The comparison of statistical characteristics 90 and 10 percentiles (C_{90}, c_{10}) in 2018 for selected determinands (N-NH_4, P-PO_4, COD_{Cr}, BOD_5) assessed in 2018 are displayed in the Figures 4.26-4.33. The pictures indicate the ranges of annual concentrations for a given parameter and monitoring site. In graphs for tributaries there are rkm of Danube, where tributary discharge to the Danube River.

Insignificant differences were observed for N-NH_4, P-PO_4 and BOD_5 in the upper part of the Danube River.

The 10 and 90 percentile values fluctuate for COD_{Cr} and BOD_5 in all tributaries. The differences were observed in slightly lower c_{90} values for BOD_5 (RO12, BG13, RO9) and slightly higher for COD_{Cr} (RO12, BG15). The higher concentrations for ammonium nitrogen are visible in the middle and lower part of Danube, but only for some of the monitoring sites located on the Danube River (RO3, BG2, RS4), or on tributaries (RO9, RO21,BG15).

Figure 4.1.: Temporal changes (2008-2018) of dissolved oxygen (c10) in the Danube River

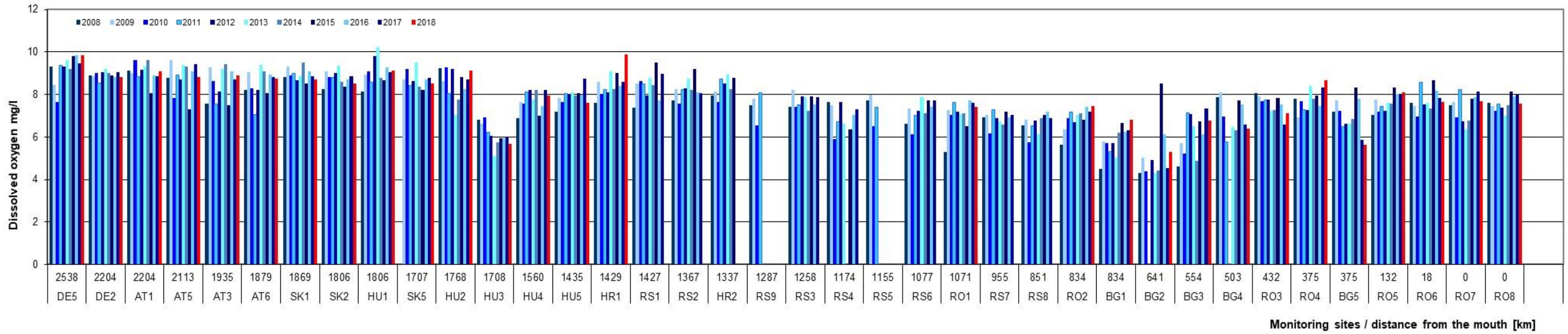


Figure 4.2.: Temporal changes (2008-2018) of dissolved oxygen (c10) in tributaries

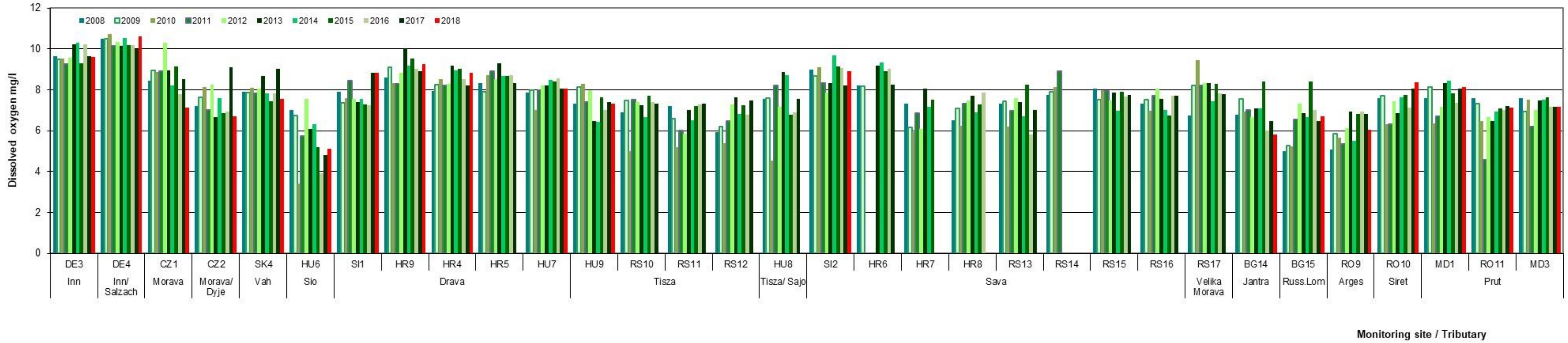


Figure 4.3.: Temporal changes (2008-2018) of BOD_5 (c90) in the Danube River.

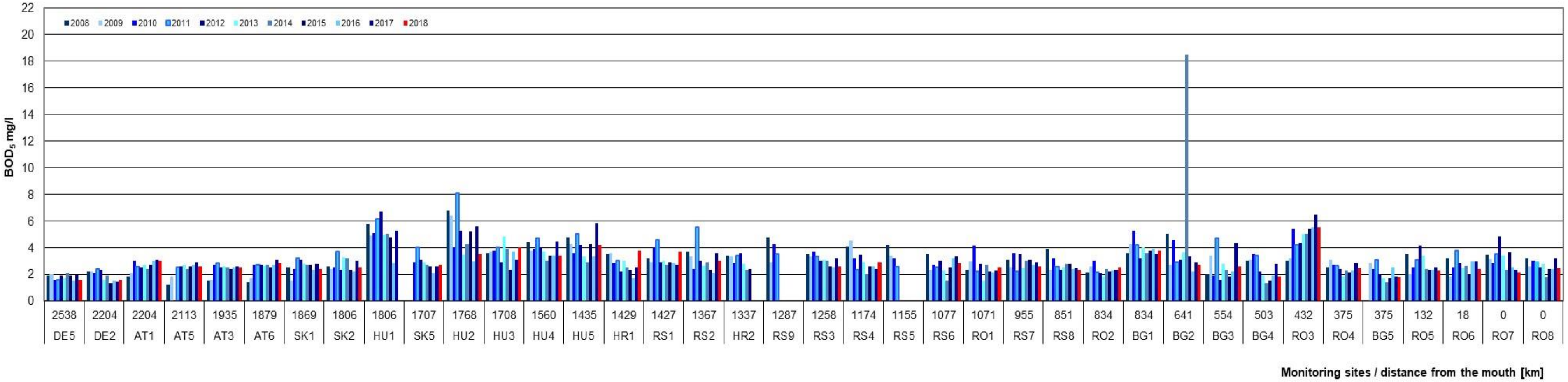


Figure 4.4.: Temporal changes (2008-2018) of BOD_5 (c90) in tributaries.

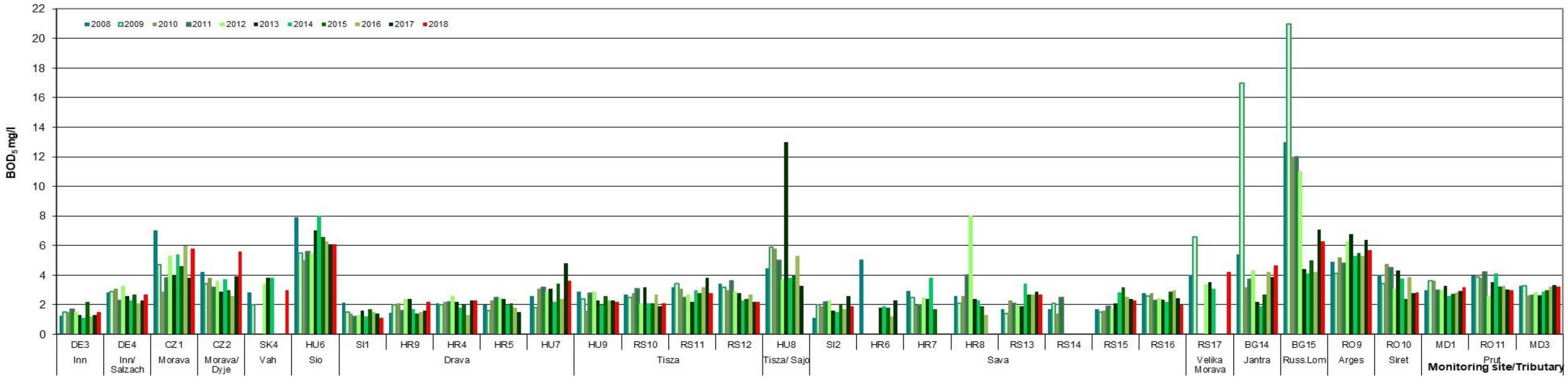


Figure 4.5.: Temporal changes (2008-2018) of COD_{Cr} (c90) in the Danube River.

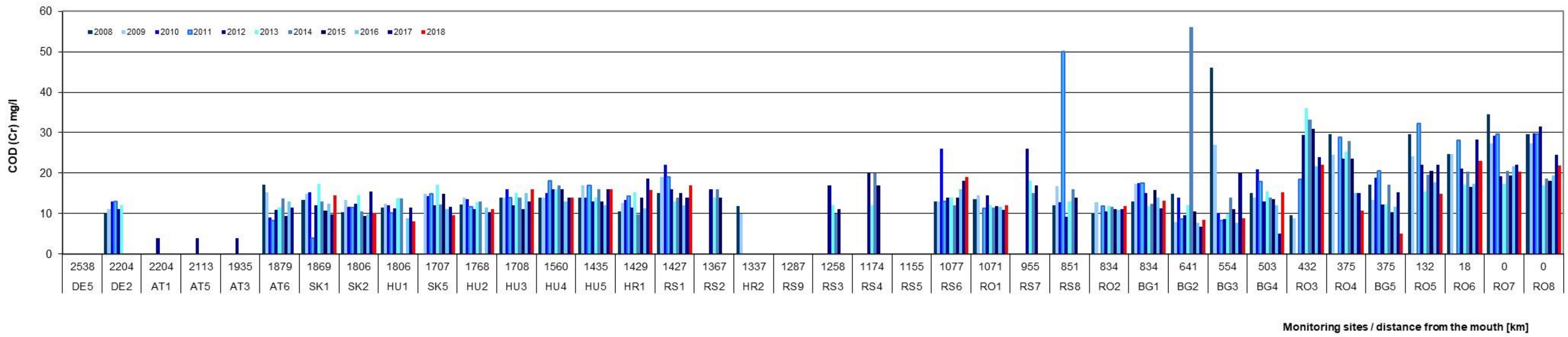


Figure 4.6.: Temporal changes (2008-2018) of COD_{Cr} (c90) in tributaries.

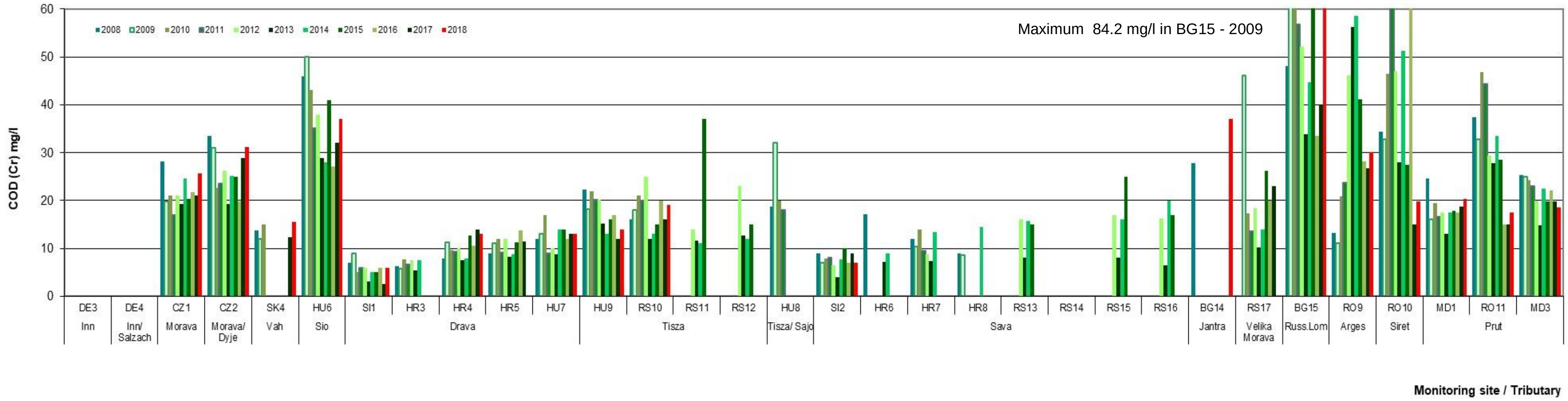


Figure 4.7.: Temporal changes (2008-2018) of NH_4-N (c90) in the Danube River.

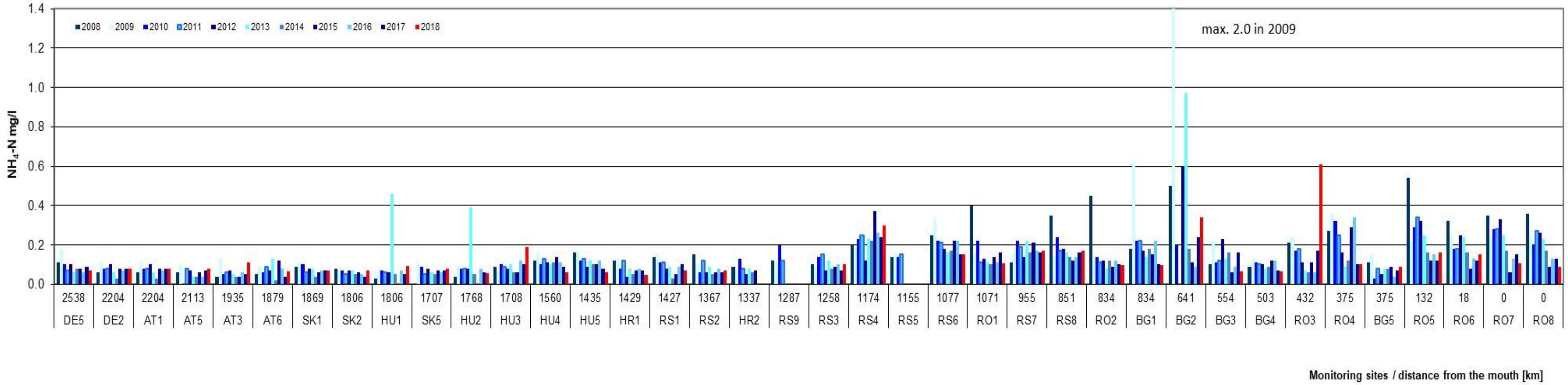


Figure 4.8.: Temporal changes (2008-2018) of NH_4-N (c90) in tributaries.

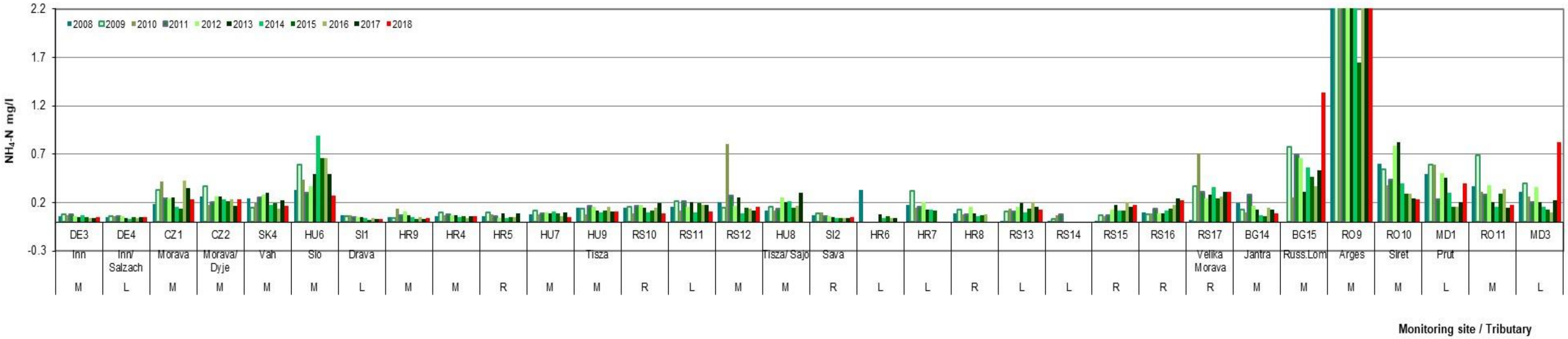


Figure 4.9.: Temporal changes (2008-2018) of NO_3-N (c90) in the Danube River.

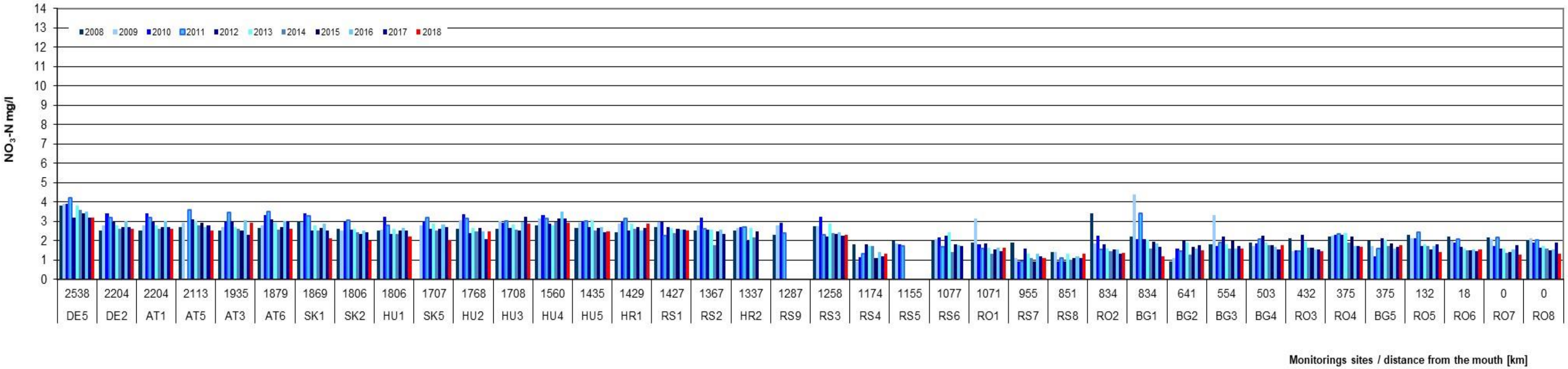


Figure 4.10.: Temporal changes (2008-2018) of NO_3-N (c90) in tributaries.

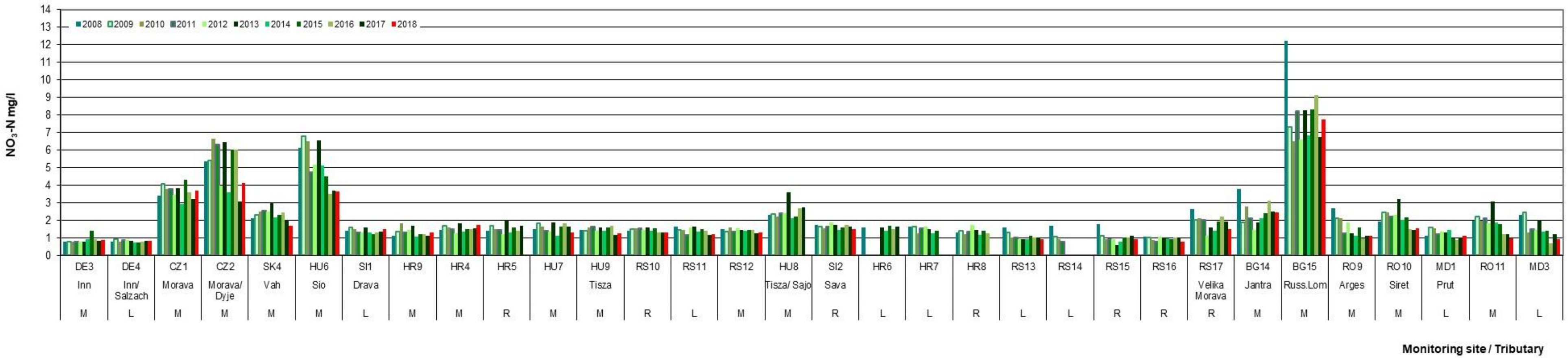


Figure 4.11.: Temporal changes (2008-2018) of o PO_4-P (c90) in the Danube River.

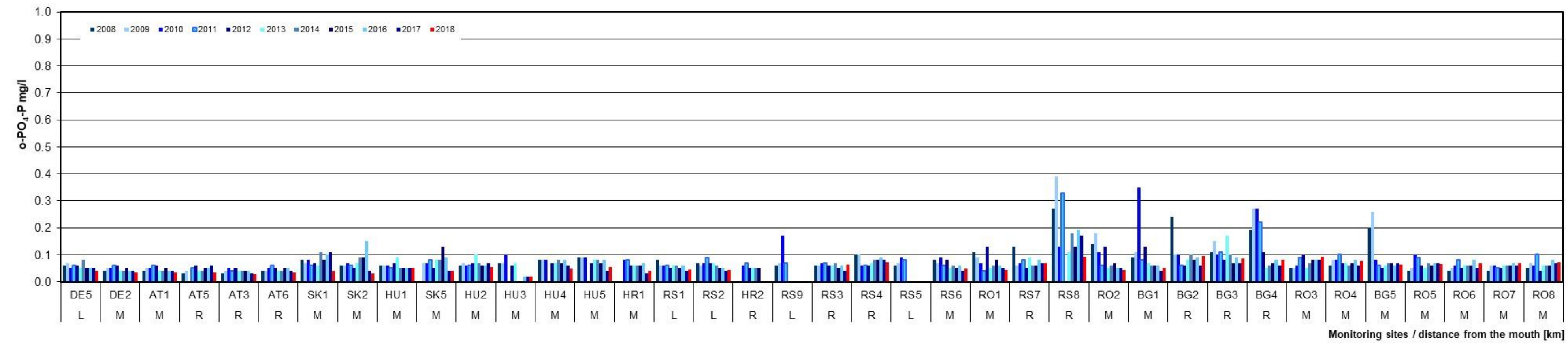


Figure 4.12.: Temporal changes (2008-2018) of o PO_4-P (c90) in tributaries

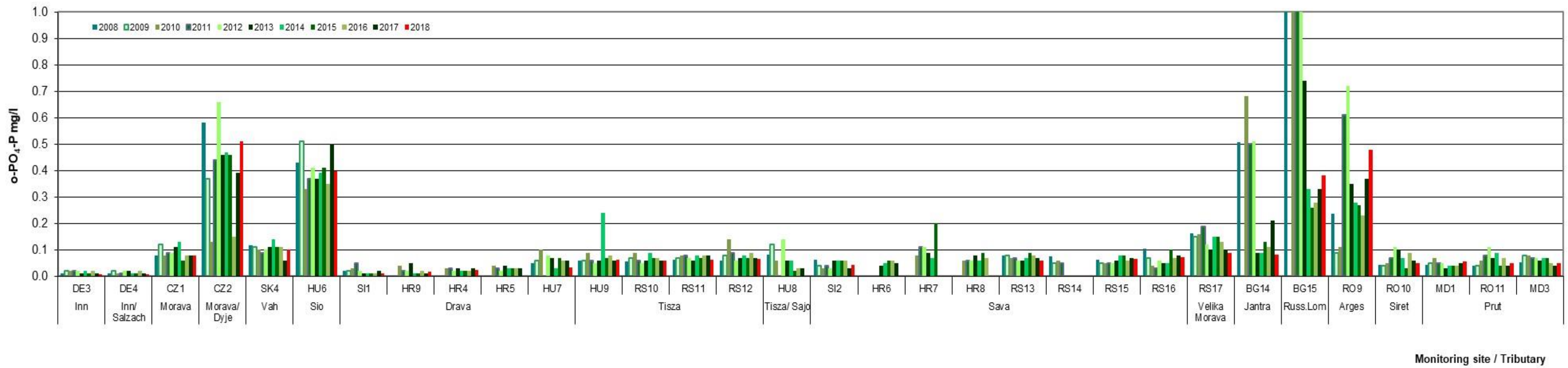


Figure 4.13.: Temporal changes (2008-2018) of total phosphorus (c90) in the Danube River.

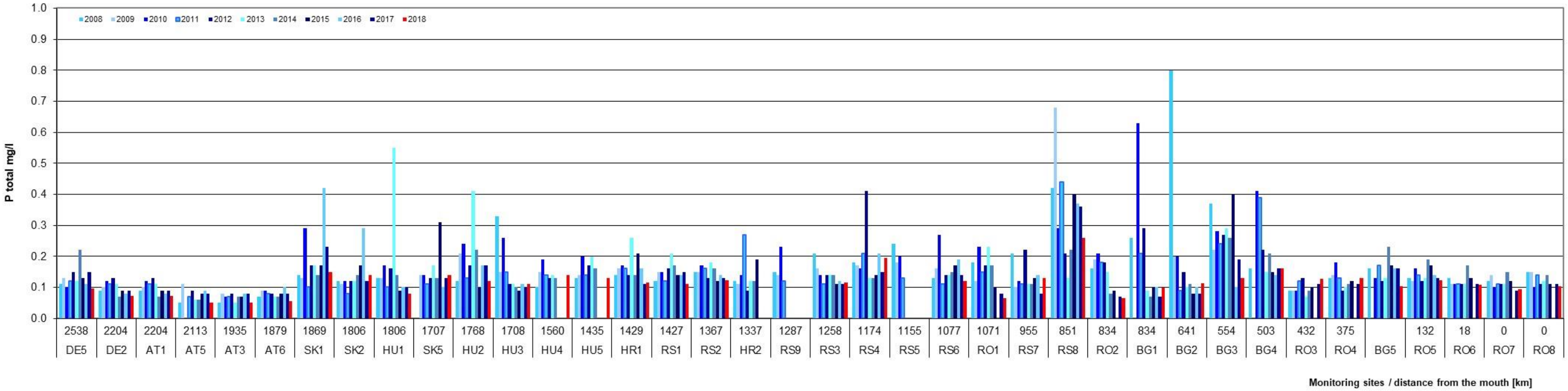


Figure 4.14.: Temporal changes (2008-2018) of total phosphorus (c90) in tributaries.

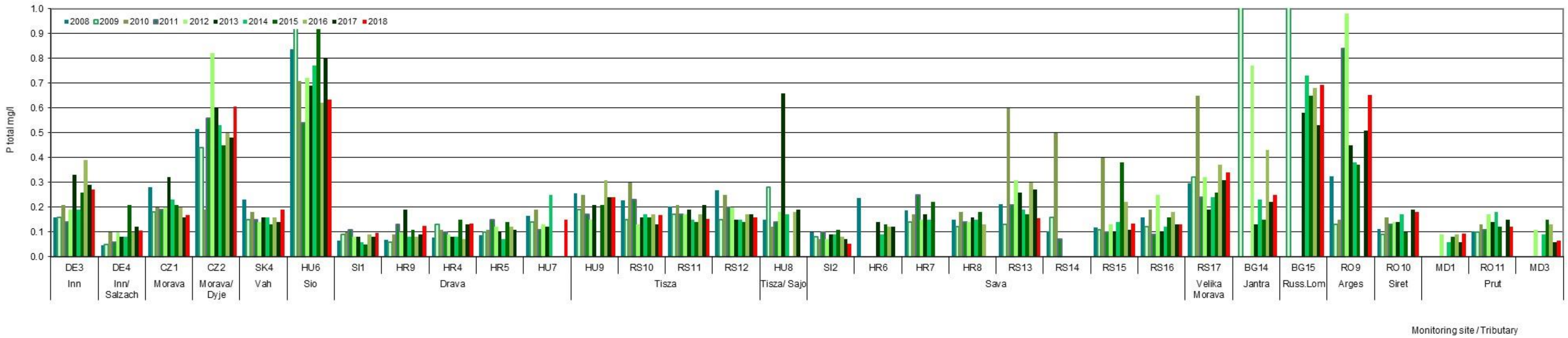


Figure 4.15.: Temporal changes (2008-2018) of cadmium (c90) in the Danube River.

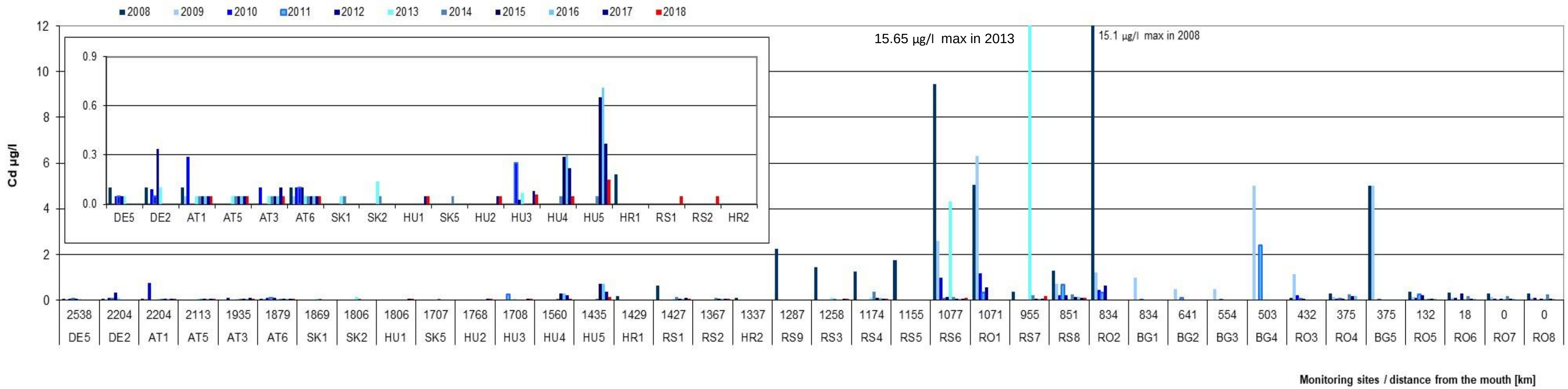


Figure 4.16.: Temporal changes (2008-2018) of cadmium (c90) in tributaries.

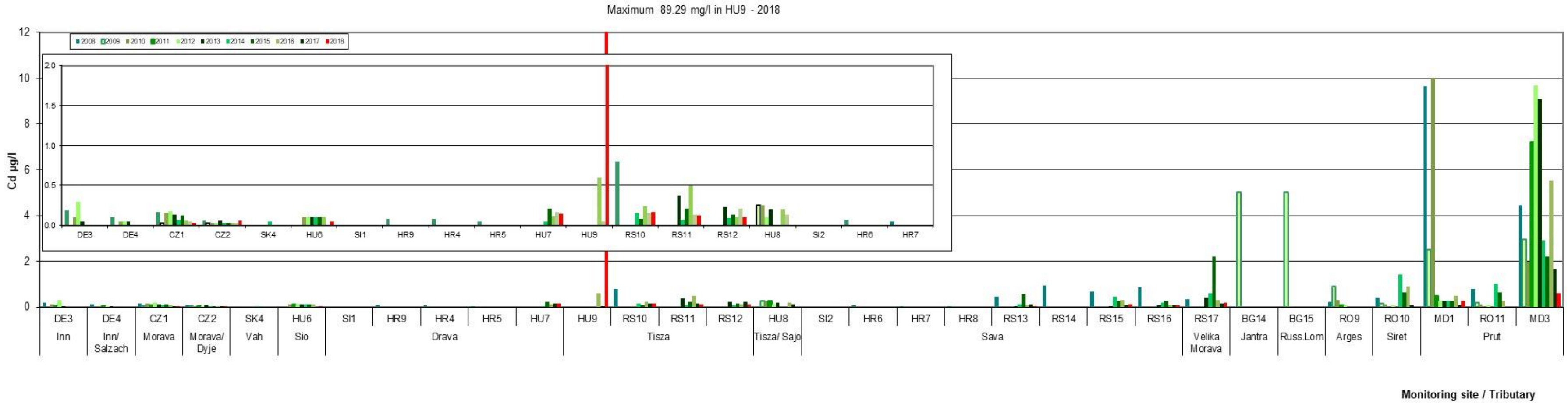


Figure 4.17.: Temporal changes (2008-2018) of BOD_5 (c90) in Bratislava

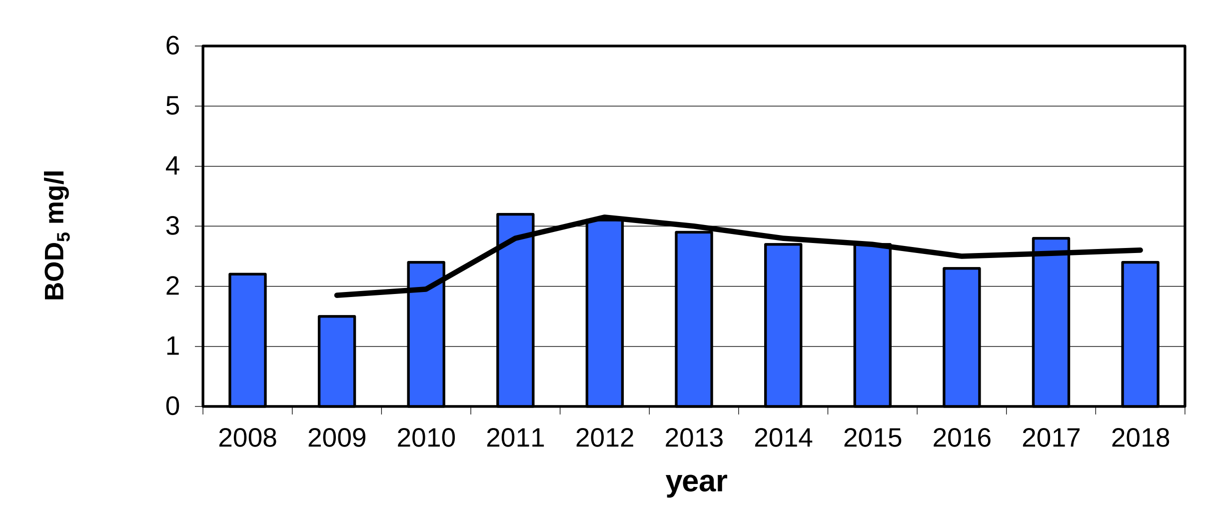


Figure 4.18.: Temporal changes (2008-2018) of BOD_5 (c90) in Hercegszanto

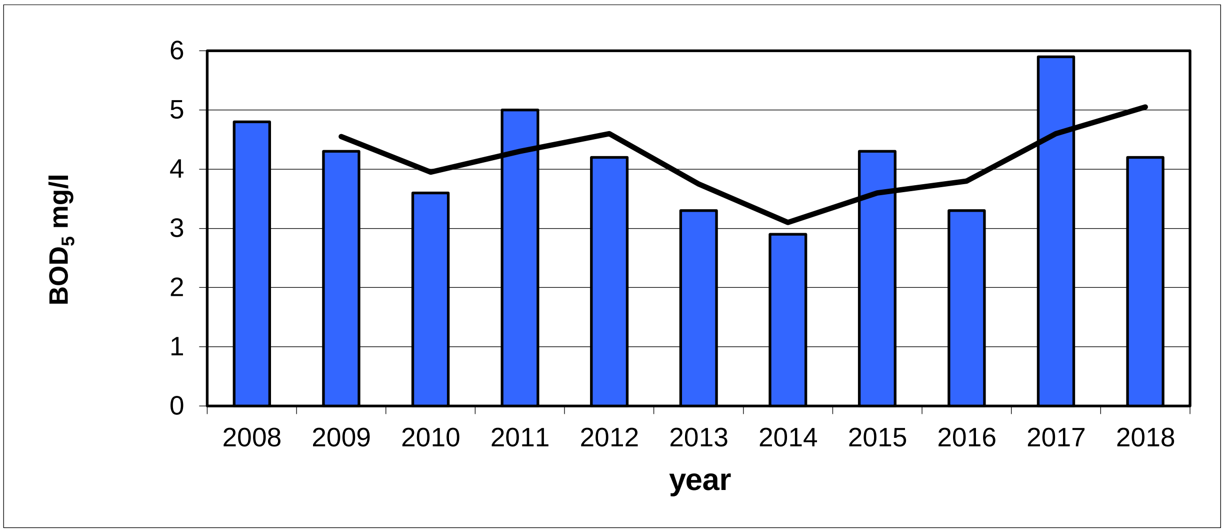


Figure 4.19.: Temporal changes (2008-2018) of BOD_5 (c90) in Reni

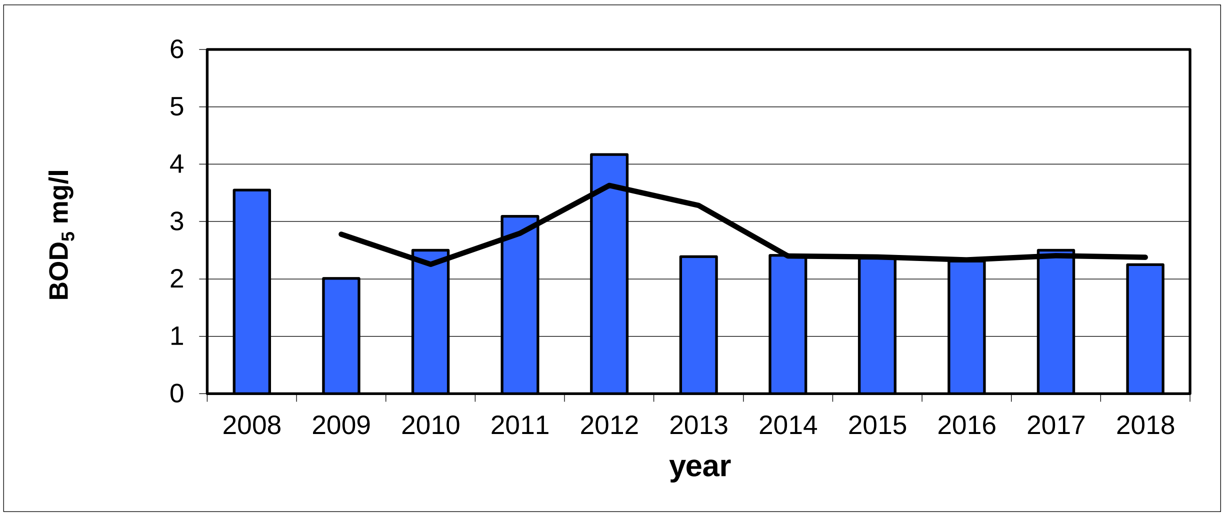


Figure 4.20.: Temporal changes (2008-2018) of N-NO$_3$ (c90) in Bratislava

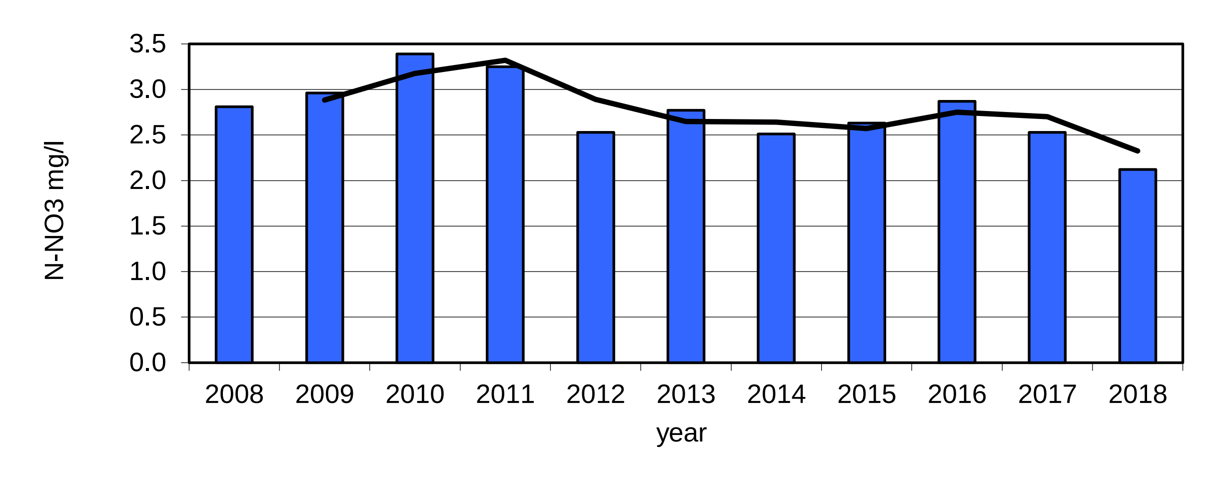


Figure 4.21.: Temporal changes (2008-2018) of N-NO$_3$ (c90) in Hercegszanto

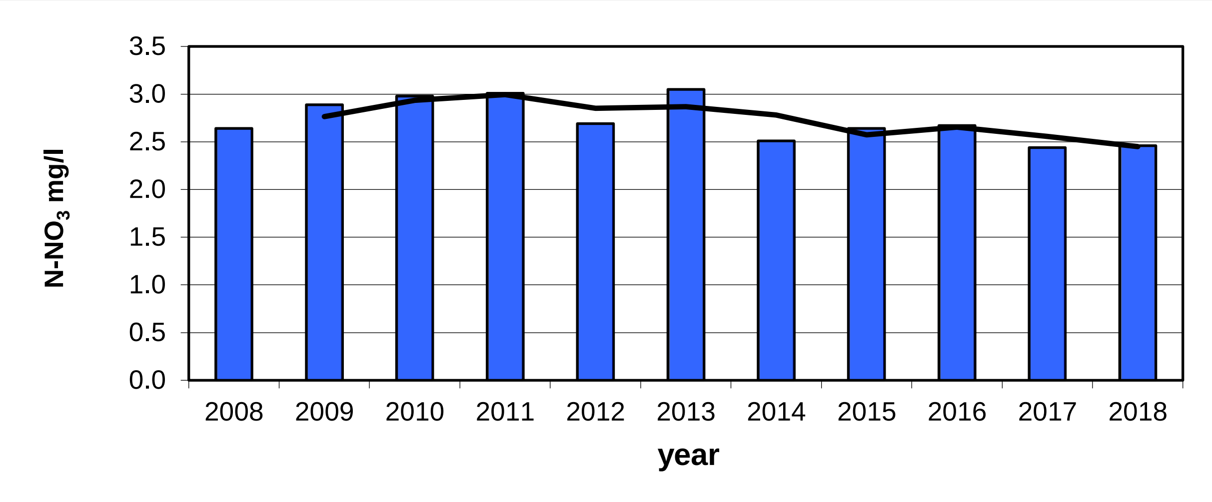


Figure 4.22.: Temporal changes (2008-2018) of N-NO$_3$ (c90) in Reni

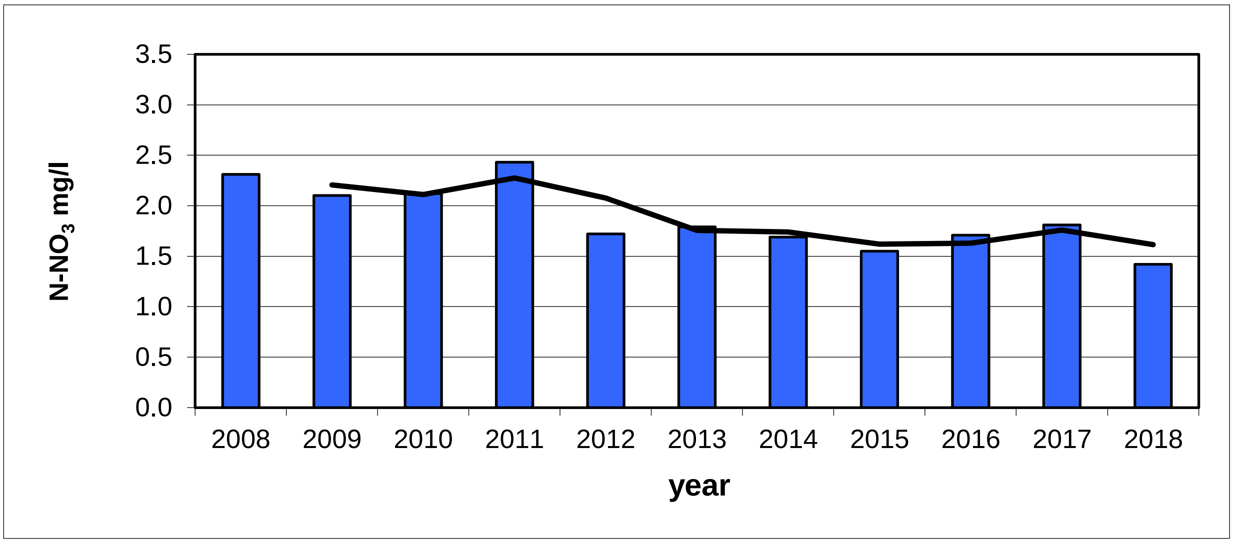


Figure 4.23.: Temporal changes (2008-2018) of total phosphorus (c90) in Bratislava

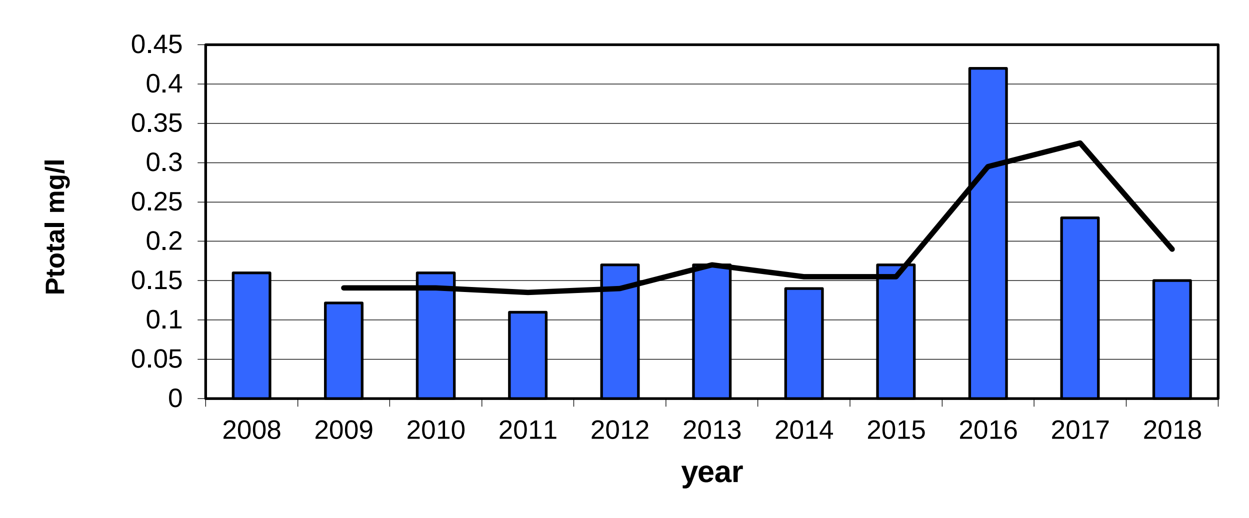


Figure 4.24.: Temporal changes (2008-2018) of total phosphorus (c90) in Hercegszanto

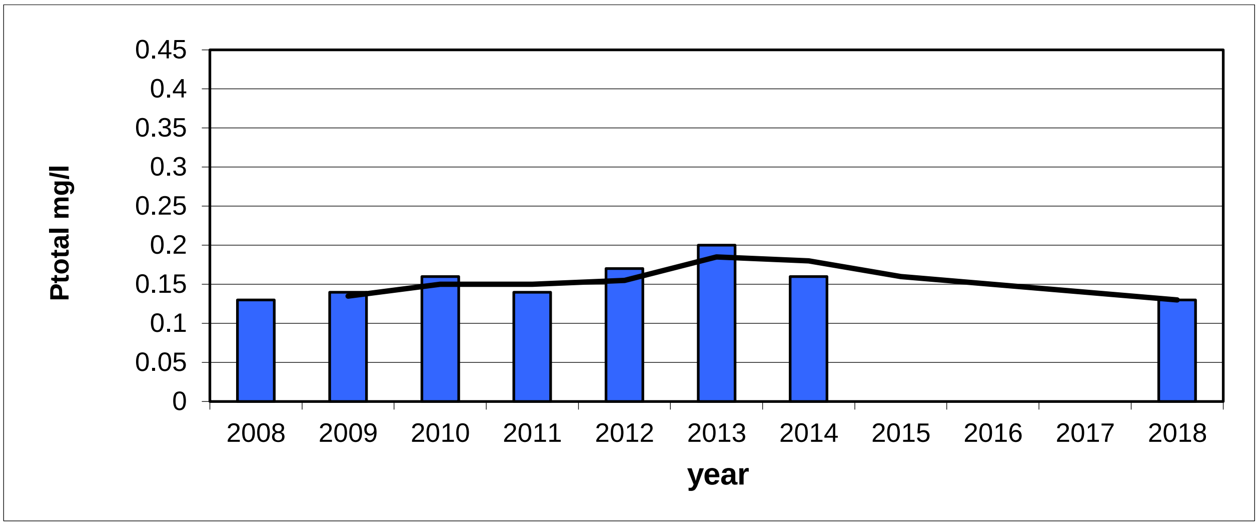


Figure 4.25.: Temporal changes (2008-2018) of total phosphorus (c90) in Reni

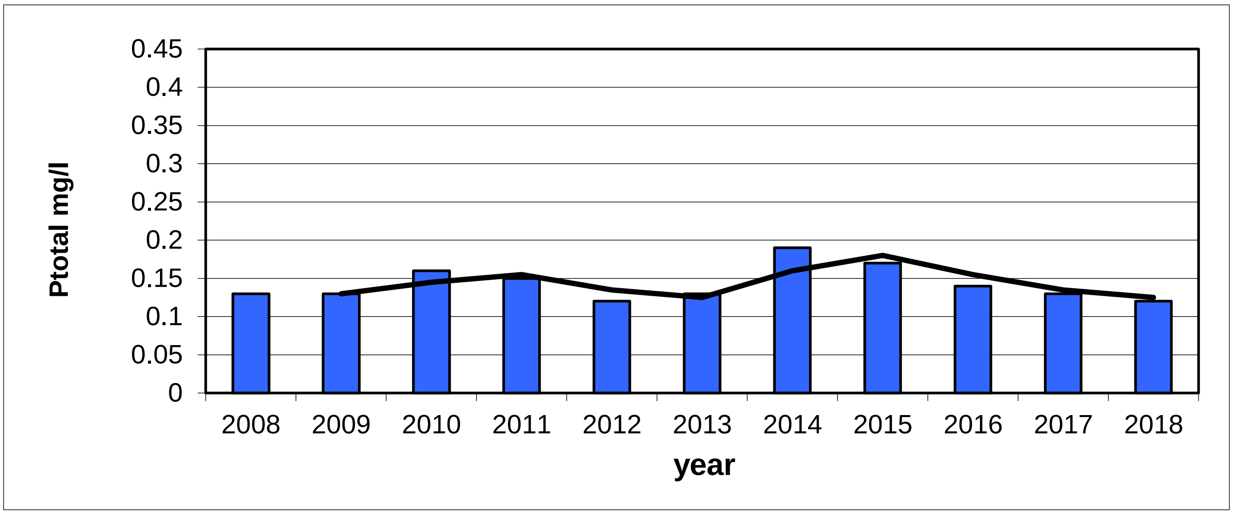


Figure 4.26.: The percentile (90, 10) of N-NH4 concentration along the Danube River in 2018

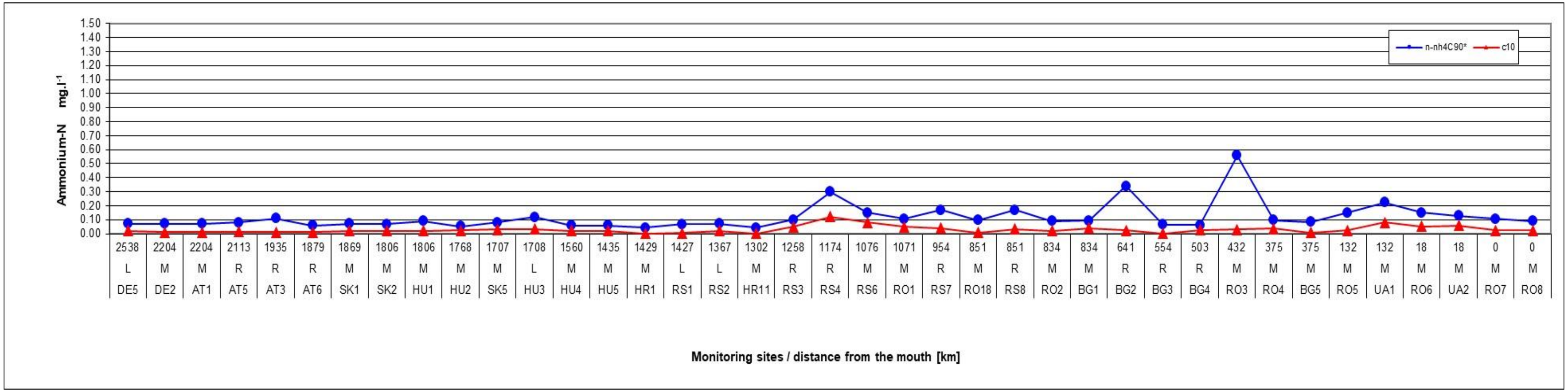


Figure 4.27.: The percentile (90, 10) of N-NH4 concentration in the tributaries in 2018

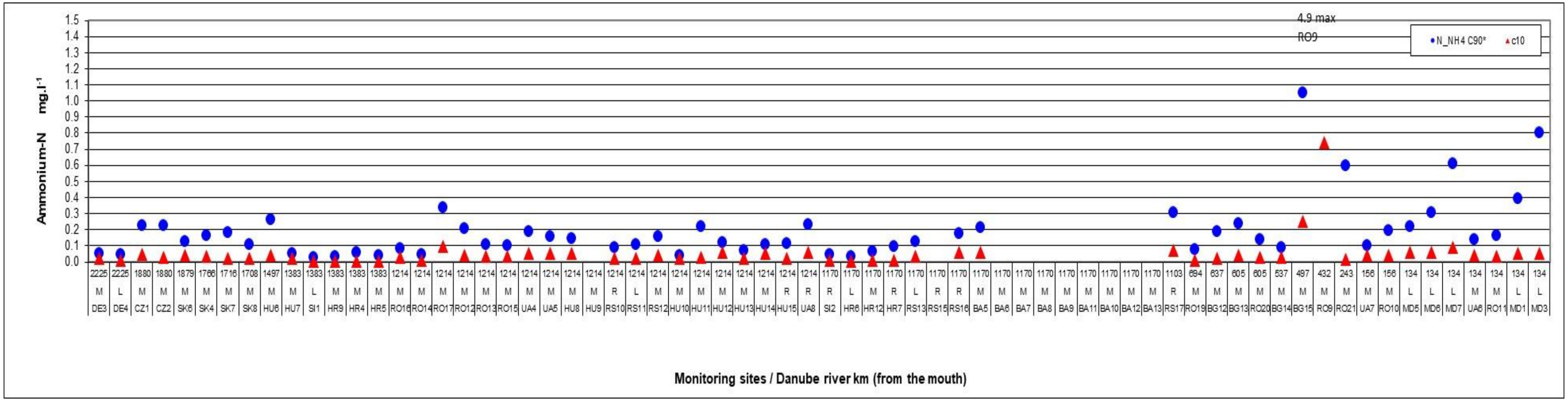


Figure 4.28.: The percentile (90, 10) of $P\text{-}PO_4$ concentration along the Danube River in 2018

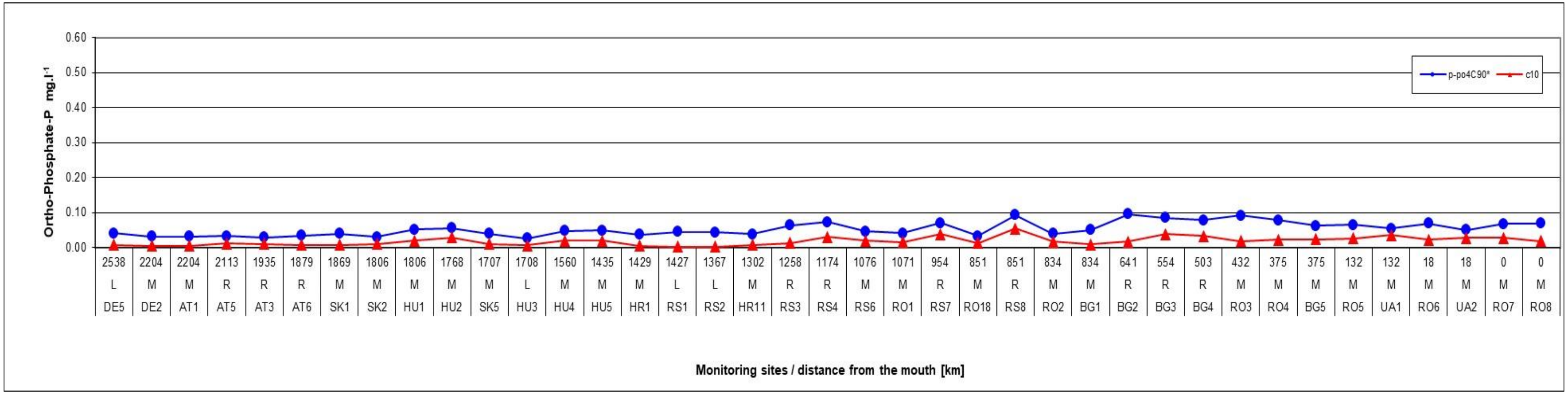


Figure 4.29.: The percentile (90, 10) of $P\text{-}PO_4$ concentration in the tributaries in 2018

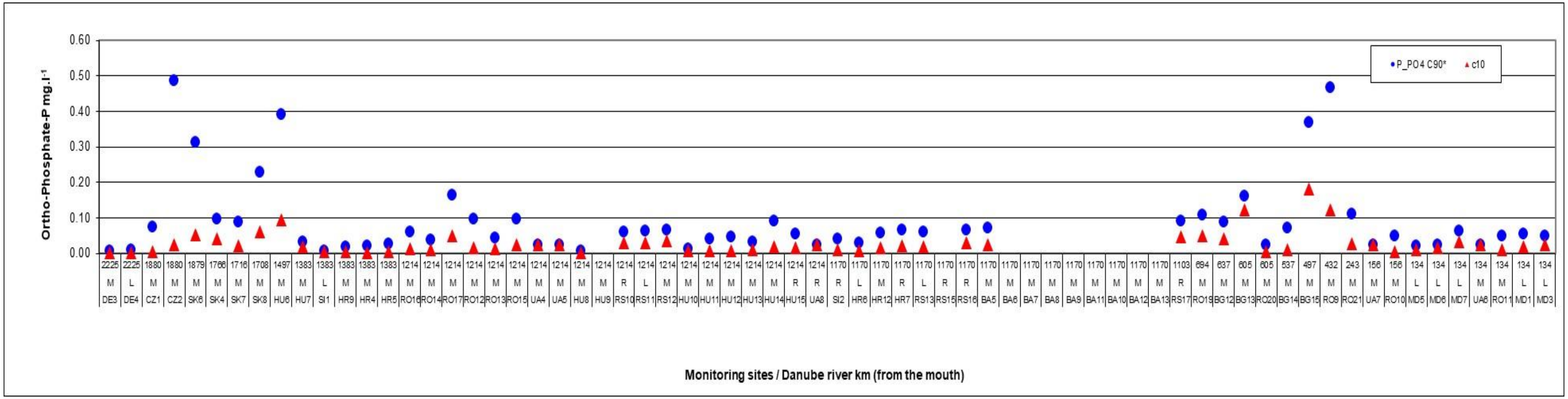


Figure 4.30.: The percentile (90, 10) of COD_{Cr} concentration along the Danube River in 2018

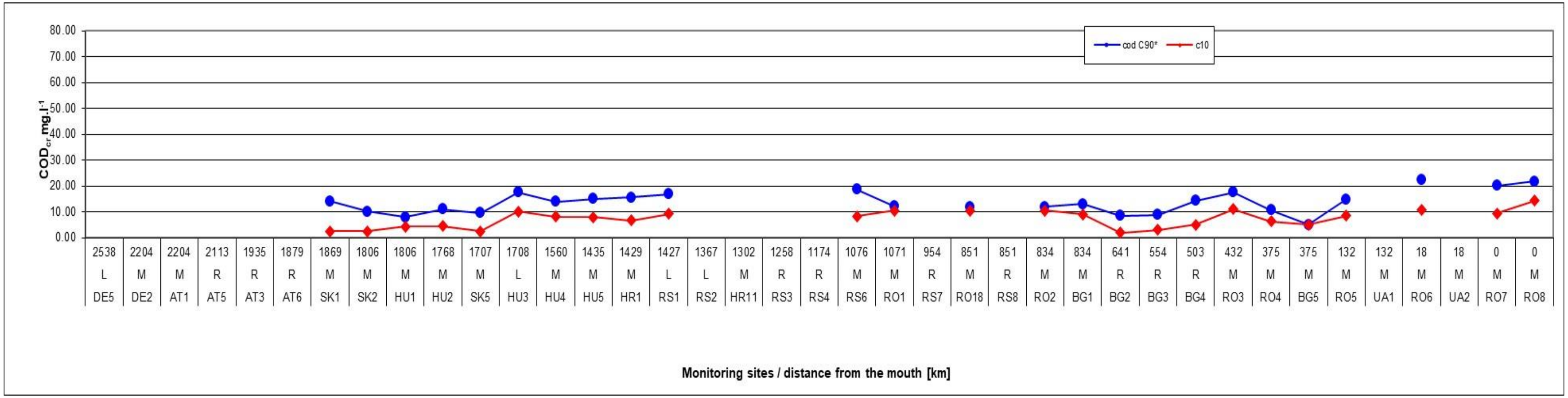


Figure 4.31.: The percentile (90, 10) of COD_{Cr} concentration in the tributaries in 2018

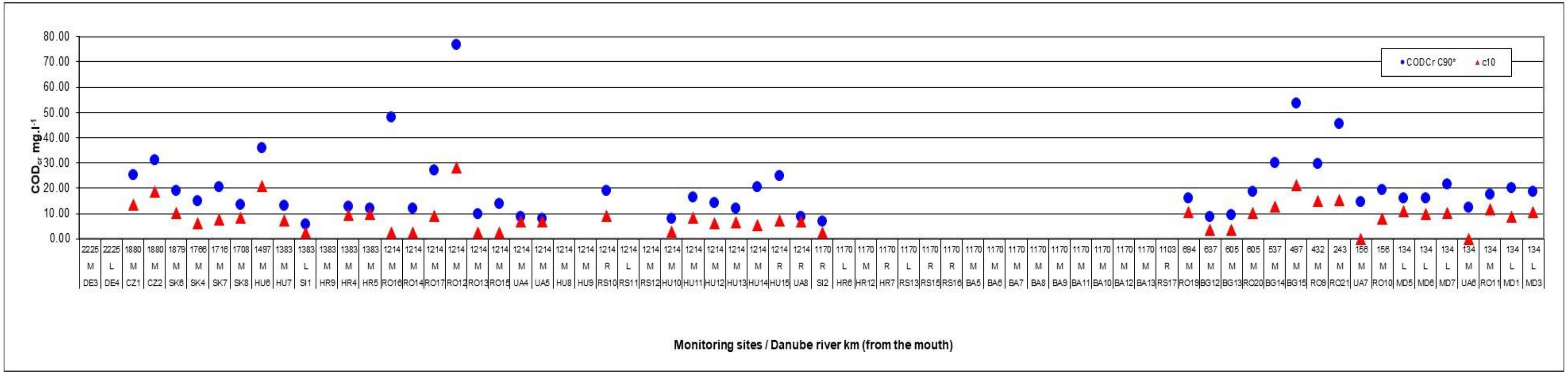


Figure 4.32.: The percentile (90, 10) of BOD_5 concentration along the Danube River in 2018

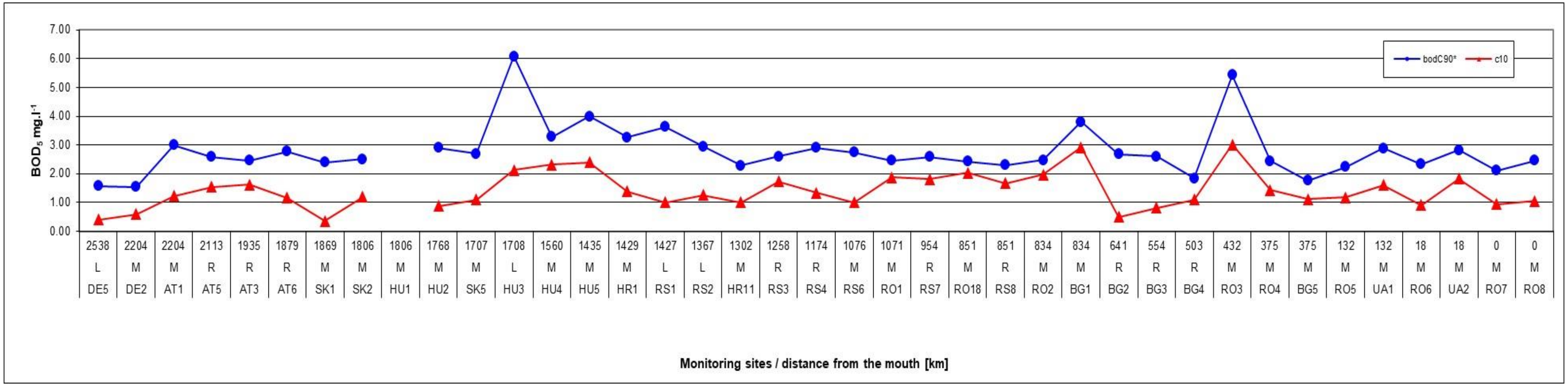
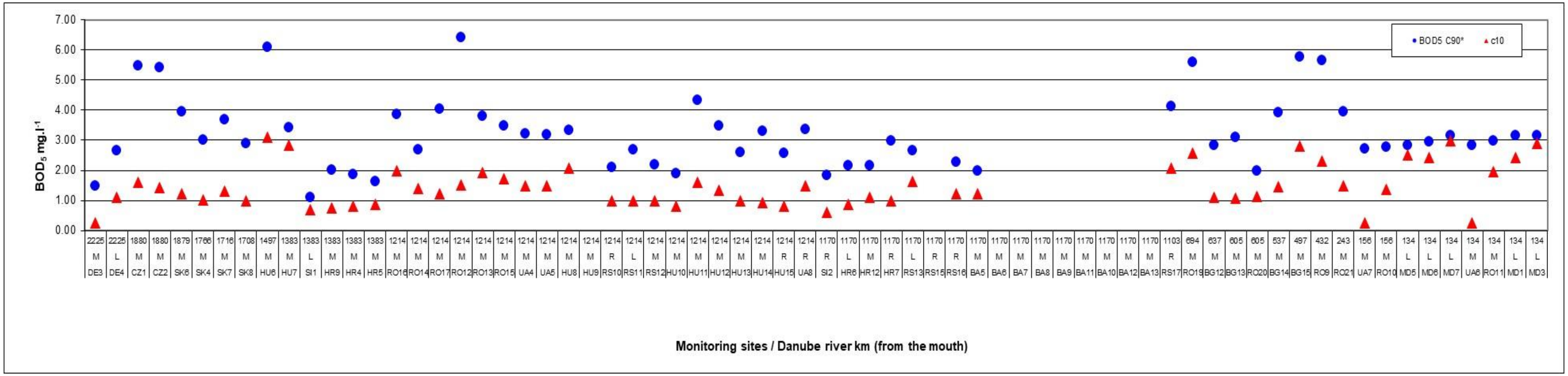


Figure 4.33.: The percentile (90, 10) of BOD_5 concentration in the tributaries in 2018



4.1 Saprobic index based on macrozoobentos

The maximum values of Saprobic index based on macrozoobentos in the Danube River and its tributaries are presented in the Figures 4.34 and 4.35. The data of macrozoobenthos were delivered during the year 2018 for 22 monitoring points located in the Danube River and for 23 monitoring points in tributaries. The maximal value of saprobic index was determined in SK 1 (Danube-Bratislava) and in RO20 (Olt - Islaz) tributary.

Figure 4.34.: The maximum values of Saprobic index based on macrozoobentos along the Danube River in 2018

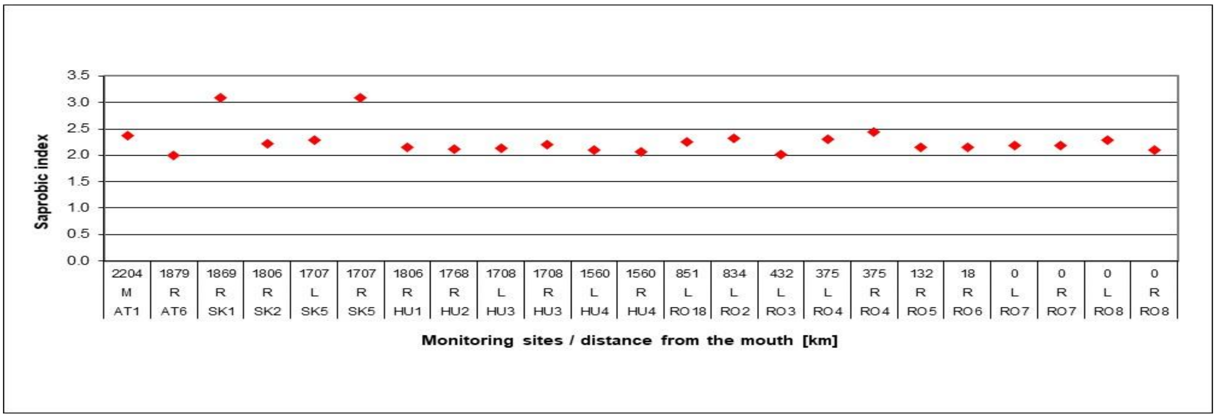


Figure 4.35.: The maximum values of Saprobic index based on macrozoobentos in the tributaries in 2018

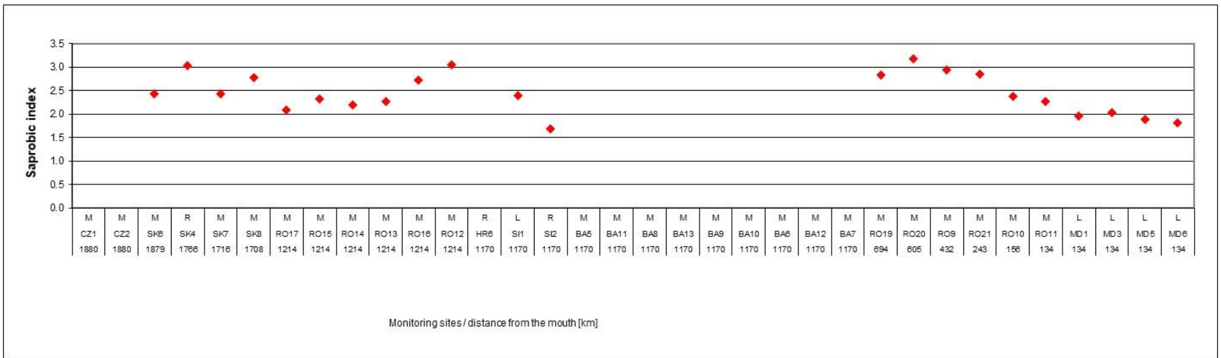
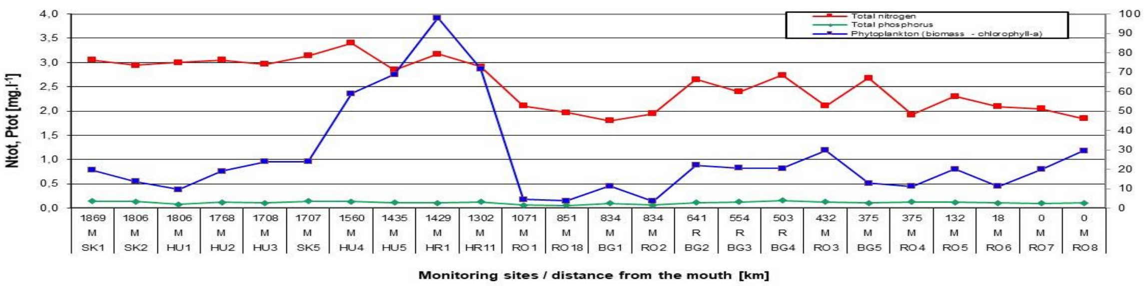


Figure 4.36.: The percentile (90) of total nitrogen, phosphorus and chlorophyll-a concentration along the Danube River in 2018.



The concentration of nutrients (N_{tot}, P_{tot}) and the **chlorophyll-a** are presented in the Figure 4.36 (there in the chart are described only monitoring points where all three determinands were measured). The maximal concentration of **chlorophyll-a** was observed in HR1 (98.01 $\mu g.l^{-1}$ Danube-Batina). The highest concentration of N_{total} was observed in HU4 (Danube-Dunafoldvar, 3.4 $mg.l^{-1}$) and maximal concentration of P_{total} was in BG4 (Danube-Upstream Russe, 0.16 $mg.l^{-1}$).

4.2 The Sava and Tisza Rivers

The 90 percentiles of nutrients, and BOD_5 measured in 2018 in the Sava and Tisza rivers are presented in the Figures 4.37-4.38. The highest value of N-NH_4 in the Sava River (Figure 4.37) was found in monitoring point is still RS16 (0.216 $mg.l^{-1}$). The maximum concentration of N-NO_3 was again observed in HR6 (Sava-Jesenice, 1.49 $mg.l^{-1}$) and the highest value of N_{total} was measured in RS13 (Sava-Jamena, 2.12 $mg.l^{-1}$). Very positive is finding that content of total nitrogen decreased (from 3.23 $mg.l^{-1}$ in 2017).

The highest values of BOD_5 in the Sava River was measured in monitoring point HR7 (Sava-Upstream Una Jasenovac, 2.98 $mg.l^{-1}$). The maximum value is almost identical with 2017 value 2.9 $mg.l^{-1}$, but this values was measured in 2017 in RS13.

Figure 4.37.: The percentile (90) of $N_{tot.}$, N-NH_4 and N-NO_3 concentration along the Sava River in 2018

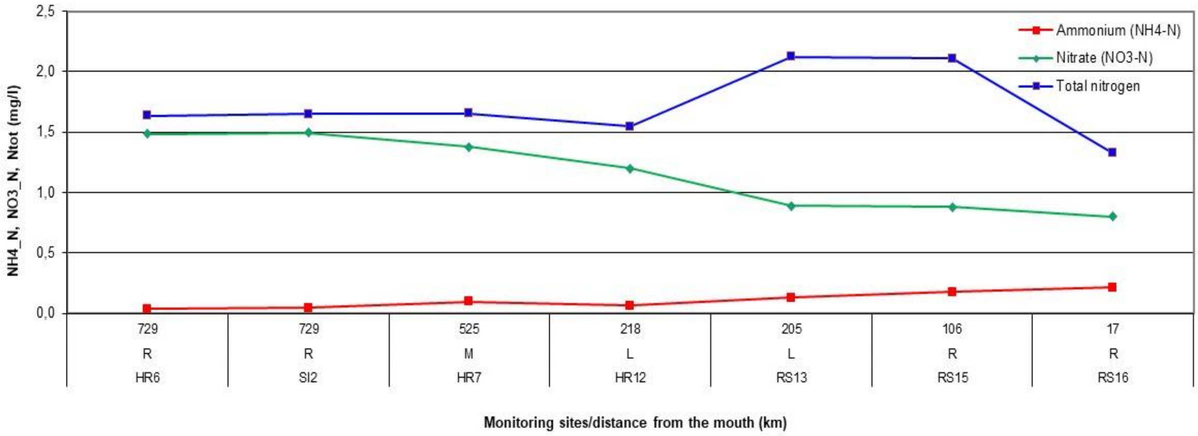


Figure 4.38.: The percentile (90) of BOD_5 concentration along the Sava River in 2018

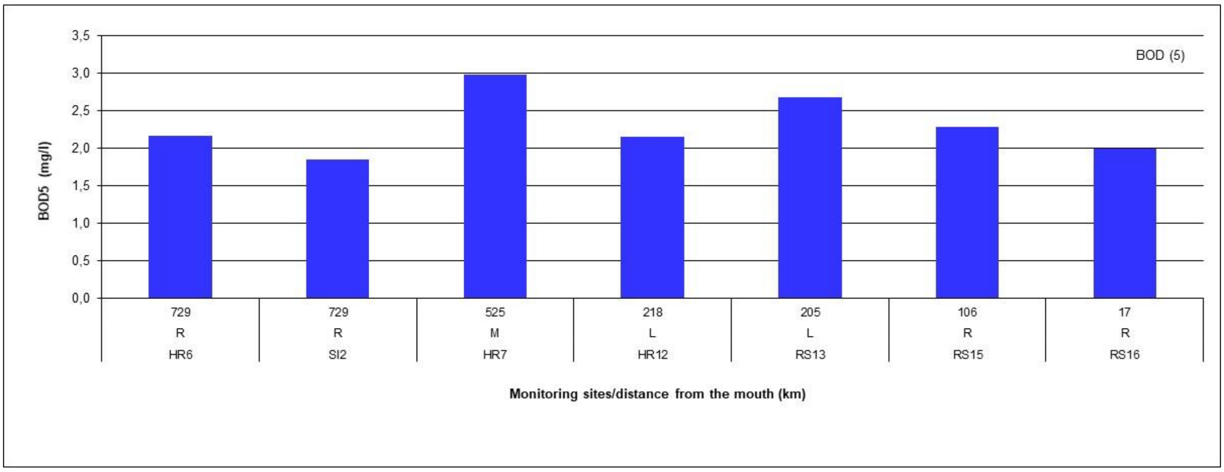


Figure 4.39.: The percentile (90) of total nitrogen, N-NH$_4$ and N-NO$_3$ concentration along the Tisza River in 2018

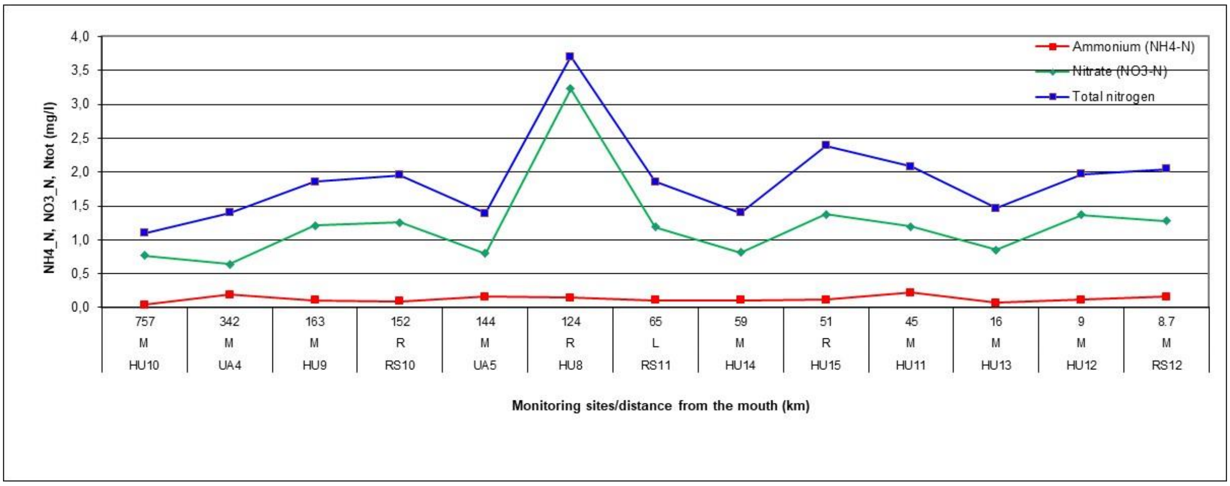
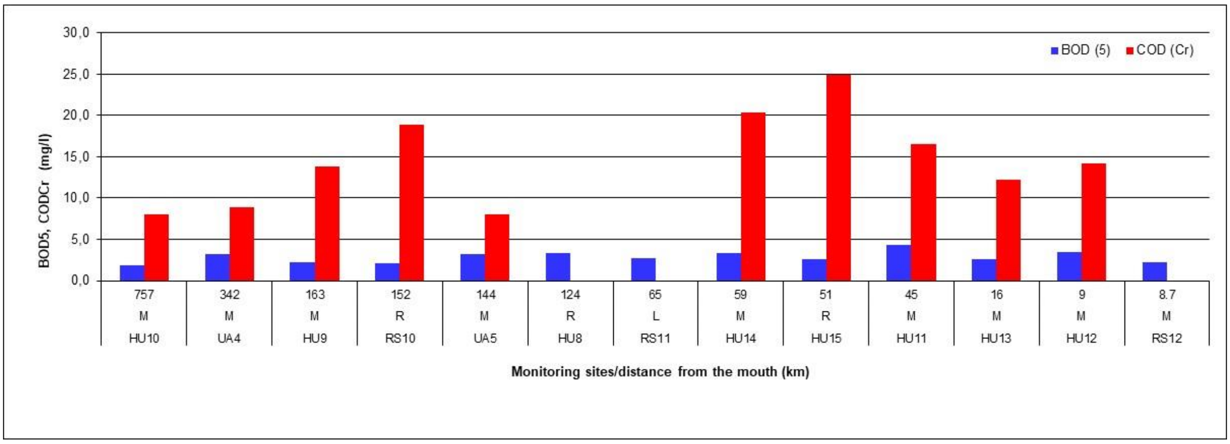


Figure 4.40.: The percentile (90) of BOD$_5$ and COD$_{Cr}$ concentration along the Tisza River in 2018.



The maximum value of N-NH$_4$ in the Tisza River and its tributaries was HU11 (Tisza/Szamos-Csenger, 0.223 mg.l^{-1}). The highest value of N-NO$_3$ was measured in HU8 (Tisza/Sajo-Sajopuspoki, 3.2 mg.l^{-1} and also for total nitrogen (3.7 mg.l^{-1}).

The highest value of COD$_{Cr}$ (Figure 4.40) in monitoring sites situated directly on the Tisza River and its tributaries was detected in HU15 (Tisza/Maros-24.9 mg.l^{-1}) and maximum of BOD$_5$ was measured in HU11 (Tisza/Samos, 4.54 mg.l^{-1}).

5. Load Assessment

5.1 Introduction

The long-term development of loads of agreed determinands (Table 2) in the important rivers of the Danube Basin is one of the main objectives of the TNMN. This is the reason why the load assessment programme in the Danube River Basin started in 2000. For the calculation of loads, a commonly agreed standard operational procedure is used.

5.2 Description of load assessment procedure

The following principles have been agreed for the load assessment procedure:

- *Load is calculated for the following determinands: BOD_5, inorganic nitrogen, ortho-phosphate-phosphorus, dissolved phosphorus, total phosphorus, suspended solids and - on a voluntary basis – chlorides and dissolved silica; based on the agreement with the Black Sea Commission, silicates are measured at the Romanian load assessment sites since 2004;*
- *The minimum sampling frequency is 24 times a year at sampling site selected for load calculation;*
- *The load calculation is processed according to the procedure recommended by the Project "Transboundary assessment of pollution loads and trends" and described in Chapter 6.4. Additionally, countries can calculate annual load by using their national calculation methods, results of which would be presented together with data prepared on the basis of the agreed method;*
- *Countries should select for load assessment those TNMN monitoring sites for which valid flow data is available (see Table 4).*

Table 4 shows TNMN monitoring locations selected for the load assessment program. It also provides information about hydrological stations collecting flow data for load assessment. Altogether 27 monitoring locations from nine countries are included in the list. One location – Danube-Jochenstein has been included by two neighbouring countries, therefore the actual number of locations is 26, with ten locations on the Danube River itself and 16 locations on the tributaries. The Rivers Prut and Siret were added in the year 2010.

The second location that could potentially be processed by using combined data from two countries is Sava-Jesenice.

5.3 Monitoring Data in 2018

The Table 5 provides an overview where monitoring sites for water quality and flow are measured in selected countries for TNMN load assessment. The monitoring frequency is an important factor for the assessment of pollution loads in watercourses.

Data are shown in the tables 6 - 11. The Table 6 summarizes information about number of samples taken in 2018. The differences are presented by different colour: The majority of determinands were measured in frequency 11 and more times. The low number of analyses could bring the uncertainty in the interpretation of the load results, therefore all data from Croatia (due to force majeure - the laboratory burned down) and one site from Hungary (HU5-M) were excluded (based on agreement with representatives responsible for data reporting from Croatia and Hungary). The lower frequency was detected also in RO4 site for dissolved phosphorus (10x). In 2010, load calculation for Slovakian monitoring points on tributaries Morava, Hron and Ipeľ was added, at a monitoring frequency of 12.

The loads in the Danube at Jochenstein are being assessed based on data from Germany and Austria together; there is no issue with insufficient frequency there.

There is still a lack of data on dissolved phosphorus, measured at 21 locations only. Also, the silicate /dissolved silica load was calculated at 16/7 monitoring points.

Table 5: List of TNMN locations selected for load assessment program

Country	River	Water quality monitoring location			Hydrological station	
		Country Code	Location	Distance from mouth (Km)	Location	Distance from mouth (Km)
Germany	Danube	DE2	Jochenstein	2204	Achleiten	2223
Germany	Inn	DE3	Kirchdorf	195	Oberaudorf	211
Germany	Inn/Salzach	DE4	Laufen	47	Laufen	47
Austria	Danube	AT1	Jochenstein	2204	Aschach	2163
Austria	Danube	AT6	Hainburg	1879	Hainburg (Danube) Angern (March)	1884 32
Czech Republic	Morava	CZ1	Lanžhot	79	Lanzhot	79
Czech Republic	Morava/Dyje	CZ2	Pohansko	17	Breclav-Ladná	32,3
Slovak Republic	Danube	SK1	Bratislava	1869	Bratislava	1869
Slovak Republic	Váh	SK4	Komárno	1.5	Sum of: Maly Dunaj -Trstice Vah- Sala Nitra -Nove Zamky	22,5 58,8 12,3
Slovak Republic	Morava	SK6	Devín	1	Zahorska Ves	32,5
Slovak Republic	Hron	SK7	Kamenica	1.7	Kamenin	10,9
Slovak Republic	Ipeľ	SK8	Salka	12.0	Salka	12,2
Hungary	Danube	HU3	Szob	1708	Nagymaros	1695
Hungary	Danube	HU5	Hercegszántó	1435	Mohács	1447
Hungary	Tisza	HU9	Tiszasziget	163	Szeged	174
Croatia	Danube	HR11	Ilok	1302	Ilok	1302
Croatia	Sava	HR06	Jesenice	729	Jesenice	729
Croatia	Sava	HR7	Una Jesenovac	525	Una Jesenovac	525
Croatia	Sava	HR8	Zupanja	254	Zupanja	254
Slovenia	Drava	SI1	Ormoz	300	Borl HE Formin Pesnica-Zamusani	325 311 10.1(to the Drava)
Slovenia	Sava	SI2	Jesenice	729	Catez Sotla -Rakovec	737 8.1 (to the Sava)
Romania	Danube	RO2	Pristol-Novo Selo	834	Gruia	858
Romania	Danube	RO4	Chiciu-Silistra	375	Chiciu	379
Romania	Danube	RO5	Reni	132	Isaccea	101
Romania	Siret	RO10	Sendreni	0	Sendreni	0
Romania	Prut	RO11	Giurgiulesti	0	Giurgiulesti	0
Ukraine	Danube	UA2	Vylkove	18		

5.4 Calculation Procedure

Regarding several sampling sites in the profile, the average concentration at a site is calculated for each sampling day. In case of values “below the limit of quantification”, the ½ of the limit of quantification is used in the further calculation. The average monthly concentrations are calculated according to the formula:

$$C_m\,[\mathrm{mg.l^{-1}}] = \frac{\sum_{i\in m} C_i\,[\mathrm{mg.l^{-1}}]\,.\,Q_i\,[\mathrm{m^3.s^{-1}}]}{\sum_{i\in m} Q_i\,[\mathrm{m^3.s^{-1}}]}$$

where C_m average monthly concentrations
C_i concentrations in the sampling days of each month
Q_i discharges in the sampling days of each month

The monthly load is calculated by using the formula:

$$L_m\,[\text{tones}] = C_m\,[\text{mg.l}^{-1}]\;.\;Q_m\,[\text{m}^3.\text{s}^{-1}]\;.\;\text{days (m)}\;.\;0{,}0864$$

where L_m monthly load
Q_m average monthly discharge

- *If discharges are available only for the sampling days, then Q_m is calculated from those discharges.*
- *For months without measured values, the average of the products $C_m.Q_m$ in the months with sampling days is used.*

The annual load is calculated as the sum of the monthly loads:

$$L_a\,[\text{tones}] = \sum_{m=1}^{12} L_m\,[\text{tones}]$$

5.5 Results

The above described procedure allows calculation of loads, separately for selected group of Danube River monitoring sites (Tables 9) and sites located on tributaries (Tables 10), connected with hydrological stations for agreed determinands: suspended solids, inorganic nitrogen, ortho-phosphate-phosphorus, total phosphorus, BOD_5, chlorides and – where available – dissolved phosphorus and silicates, or silicates dissolved. These results are supported by some statistical outputs and basic information. The Table 6 inform about number of measurements for selected monitoring sites and determinands (the ranges of measurements are distinguished by different colour).

The mean annual concentrations for the Danube River are presented in the Table 7 and for tributaries in the Table 8. The used abbreviations for these Tables are as follows:

Term used	Explanation
Station Code	TNMN monitoring location code
Profile	location of sampling site in profile (L-left, M-middle, R-right)
River Name	name of river
Location	name of monitoring location
River km	distance to mouth of the river
Qr	mean annual discharge in the year 2018
C_{mean}	arithmetical mean of the concentrations in the year 2018
Annual Load	annual load of given determinand in the year 2018

The calculated **loads for 2018**, for Danube monitoring sites and tributaries are presented in the Table 9 and for tributaries sites in the Table 10. In addition, these two tables provide also information about load development, if the load for a given determinand decrease, increase or is stable against previous year 2017 (distinguished by different font and/ or colour, explanation are below the tables).

There from the Table 9 for the Danube River sites is seen favourable development for ortho-phosphate phosphorus and total phosphorus, when loads values for most of assessed monitoring sites decreased, for other determinands the loads were increased. In case of tributaries (16 assessed sites), the decrease in load values was detected for ortho-phosphate phosphorus, total phosphorus and already for chlorides, silicates. There in the monitoring site RO5 (Reni) is seen that for 6 of 8 assessed determinands were loads higher in 2018.

The longitudinal development of the annual load is presented along the Danube River for suspended solids (Figure 5.1), inorganic nitrogen (Figure 5.3), ortho-phosphate-phosphorus (Figure 5.5), total phosphorus (Figure 5.7), BOD5 (Figure 5.9) and chlorides (Figure 5.11). There in the lower part of the Danube River, in monitoring sites RO4 and RO5 are seen the highest loads for all determinands except for suspended solids.

From the spatial distribution of load in tributaries (Figures 5.2, 5.4, 5.6, 5.8, 5.10, 5.12) is seen that the maximum loads for all 6 determinands are from the Tisza River.

There in the next **Table 11**, divided into 3 parts, are information about number of measurements for determinands used for calculation of loads at the Reni monitoring site. Based on the Black Sea Commission agreement the profile Reni is monitored since 2005 and is focused on nitrogen forms and heavy metals determinands. Mean annual concentrations are presented in the second part of the Table 11 and the calculated annual loads are in its third part.

Trends for **load development during the last 10 years** for selected determinands **at Reni** monitoring site are shown in the Figures 5.13 -5.18. In general, the loads of all presented determinands (suspended solids, inorganic nitrogen, ortho phosphate-phosphorus, total phosphorus, phosphorus dissolved, BOD5, chlorides, silicates) slightly increased in 2018.

The loads of all nitrogen forms are higher in 2018, as well as loads of $Cu_{dissolved}$ that were doubled and for $Pb_{dissolved}$ even tripled.

The mean annual discharges were in 2018 in Danube River sites higher only in Romanian (Danube-pristol/Novo Selo, Chiciu/Silistra, Reni) and Ukrainian areas (Vylkove). In tributaries were mean annual discharges higher in Hungary (Tisza), Slovenia (Drava, Sava), Croatia (Sava) and Romania Siret, Prut).

Table 6: Number of measurements at TNMN locations selected for assessment of pollution load in 2018

Country Code	River	Location	Location in profile	Number of measurements in 2018									
				Flow	Suspended solids	$N_{inorganic}$	Ortho-phosphate phosphorus	P_{total}	$P_{dissolved}$	Silicates	Silicates dissolved	Chlorides	BOD_5
DE2	Danube	Jochenstein	M	365	13	25	25	25				13	13
DE3	/Inn	Kirchdorf	M	365	13	13	13	13				13	13
DE4	/Inn/Salzach	Laufen	L	365	13	13	13	13				13	13
AT1	Danube	Jochenstein	M	365	12	25	25	25	12			12	12
AT6	Danube	Hainburg	R	365	24	24	24	24	24			24	24
CZ1	/Morava	Lanzhot	M	365	12	12	12	12		12		12	12
CZ2	/Morava/Dyje	Pohansko	M	365	12	12	12	12		12		12	12
SK1	Danube	Bratislava	L		26	26	26	26	26	26		12	26
SK1	Danube	Bratislava	M	365	26	24	26	26	26	26		12	26
SK1	Danube	Bratislava	R		26	24	26	26	26	26		12	26
SK4	/Váh	Komárno	M	365	12	12	12	12	12	12		12	12
SK6	/Morava	Devín	M	365	12	12	12	12	12	12		12	12
SK7	/Hron	Kamenica	M	365	12	12	12	12	12	12		12	12
SK8	/Ipeľ	Salka	M	365	12	12	12	12	12	12		12	12
HU3	Danube	Szob	L		12	26	26	26		12		12	12
HU3	Danube	Szob	M	365	12	26	26	26		11		12	12
HU3	Danube	Szob	R		12	26	26	26		11		12	12
HU5	Danube	Hercegszanto	M	365	13	26	26	25		12		13	2*
HU9	/Tisza	Tiszasziget	L		12	12	12	12		12		12	12
HU9	/Tisza	Tiszasziget	M	365	12	25	25	25		12		12	12
HU9	/Tisza	Tiszasziget	R		12	12	12	12		12		12	12
SI1	/Drava	Ormož most	L	365	26	26	26	26				12	26
SI2	/Sava	Jesenice na Dolenjskem	R	365	26	26	26	26				12	26
RO2	Danube	Pristol/Novo Selo	L	365	26	26	26	26	26			12	26
RO2	Danube	Pristol/Novo Selo	M	365	26	26	26	26	26			12	26
RO2	Danube	Pristol/Novo Selo	R	365	26	26	26	26	26			12	26
RO4	Danube	Chiciu/Silistra	L	365	27	27	27	27	12			12	12
RO4	Danube	Chiciu/Silistra	M	365	27	27	27	26	11			12	12
RO4	Danube	Chiciu/Silistra	R	365	27	27	27	27	10			12	12
RO5	Danube	Reni	L	365	26	26	26	26	11		26	12	12
RO5	Danube	Reni	M	365	26	26	26	26	12		26	12	12
RO5	Danube	Reni	R	365	26	26	26	26	12		26	12	12
RO10	/Siret	Conf. Danube (Sendreni)	M	365	26	26	26	26	12			12	12
RO11	/Prut	Conf. Danube	M	365	26	26	26	26	12			12	12
UA2	Danube	Vylkove	M	365	12	12	12		12	12		12	12

DE2 - blue font used for stations (only 1 location), SK1 – black font used for sites (more locations for 1 station)

11 and more samples	less than 11 and more than 4 samples	2*-data were not used for calculation of loads - to little data to calculate reliable load data

Table 7: Mean annual concentrations in monitoring locations selected for load assessment on Danube River in 2018

Country Code	Location in profile	River name	Location	River km	Qr (2018)	Cmean								
						Suspended solids	Inorganic nitrogen	Ortho-phosphate Phosphorus	Total phosphorus	BOD_5	Chlorides	Total phosphorus dissolved	Silicates	Silicates dissolved
					($m^3.s^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)
DE2 + AT1	M	Danube	Jochenstein	2204	1,227.8	15.1	1.81	0.019	0.049	1.59	20.59	0.034		
AT6	R	Danube	Hainburg	1879	1,630.3	7.55	1.77	0.022	0.04	2.25	19.12	0.034		
SK1	M	Danube	Bratislava	1869	1,644.1	22.46	1.64	0.029	0.094	1.45	18.73	0.066	5.58	
HU3	LMR	Danube	Szob	1708	1,808.1	18.03	1.84	0.014	0.084	3.05	21.68		6.13	
HU5	M	Danube	Hercegszanto	1435	1,906.3	13.04	1.61	0.029	0.072		22.23		3.86	
RO2	LMR	Danube	Pristol/Novo Selo	834	4,891.0	37.88	1.08	0.035	0.055	2.3	20.34	0.043		
RO4	LMR	Danube	Chiciu/Silistra	375	5,875.5	17.19	1.17	0.05	0.086	1.95	23.65	0.071		
RO5	LMR	Danube	Reni	132	6,487.8	45.53	1.1	0.045	0.088	1.7	27.47	0.071		3.5
UA2	M	Danube	Vylkove	18	3,197.7	63.33	1.28	0.04		2.34	32.16	0.108	2.39	

Table 8: Mean annual concentrations in monitoring locations selected for load assessment on tributaries in 2018

Country Code	Location in profile	River name	Location	River km	Qr (2018)	C_{mean}								
						Suspended solids	Inorganic nitrogen	Ortho-phosphate Phosphorus	Total phosphorus	BOD_5	Chlorides	Total phosphorus dissolved	Silicates	Silicates dissolved
					$(m^3.s^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$
DE3	M	/Inn	Kirchdorf	195	292	71.85	0.62	0.0053	0.092	0.89	7.19			
DE4	L	/Inn/Salzach	Laufen	47	217.9	36.92	0.63	0.008	0.046	1.80	8.06			
CZ1	M	/Morava	Lanzhot	79	27.3	14.09	1.95	0.023	0.124	2.79	35.83		7.17	
CZ2	L	/Morava/Dyje	Pohansko	17	12.9	12.22	1.96	0.193	0.305	2.87	67.42		11.62	
SK4	M	/Váh	Komárno	1	143.8	10.67	1.50	0.063	0.133	2.06	23.13	0.092	5.92	
SK6	M	/Morava	Devín	1	44.26	17.17	1.81	0.153	0.248	2.58	50.23	0.193	10.11	
SK7	M	/Hron	Kamenica	2	33.6	30.58	1.56	0.063	0.163	2.44	21.11	0.095	13.85	
SK8	M	/Ipeľ	Salka	12	12.2	34.00	2.03	0.148	0.270	1.87	29.08	0.183	23.19	
HU9	LMR	/Tisza	Tiszasziget	163	668.9	49.81	0.83	0.048	0.170	1.32	34.51		9.78	
SI1	L	/Drava	Ormož most	300	344.6	12.29	1.19	0.006	0.049	0.94	12.50			
SI2	R	/Sava	Jesenice na Dolenjskem	729	287.9	5.62	1.30	0.024	0.038	1.06	8.95			
RO10	M	/Siret	Conf. Danube (Sendreni)	729	227.7	162.19	1.31	0.018	0.067	2.35	75.47	0.051		
RO11	M	/Prut	Conf. Danube (Giurgiulesti)	729	78.1	46.65	0.76	0.026	0.067	2.48	36.52	0.051		

Table 9: Annual load in selected monitoring locations on Danube River in 2018

Station Code	Profile	River Name	Location	River km	Annual Loads in 2018							
					Suspended solids	Inorganic nitrogen	Ortho-phosphate phosphorus	Total phosphorus	Total phosphorus dissolved	Silicates / Silicates dissolved*	Chloride	BOD5
					(10^6tonns)	(10^3tonns)	(10^3tonns)	(10^3tonns)	(10^3tonns)	(10^6tonns)	(10^6 tonns)	(10^3tonns)
AT1, DE2	M	Danube	Jochenstein	2204	0.66	**75.44**	0.78	1.91	**1.37**		**0.82**	65.17
AT6	R	Danube	Hainburg	1879	0.45	93.97	1.16	2.8	1.77		0.97	117.02
SK1	LMR	Danube	Bratislava	1869	1.66	85.98	1.58	6.4	**4.11**	0.30	0.99	80.97
HU3	LMR	Danube	Szob	1708	**1.39**	114.11	0.84	4.93		**0.30**	**1.22**	**188.56**
HU5	LMR	Danube	Hercegszanto	1435	**0.85**	103.63	1.79	4.81		0.24	**1.38**	44.04
RO2	LMR	Danube	Pristol/Novo Selo	834	**5.98**	**176.41**	4.7	7.66	5.91		**3.2**	**347.13**
RO4	LMR	Danube	Chiciu/Silistra	375	**4.05**	**227**	**8.32**	**15.45**	**11.98**		**4.28**	**377.16**
RO5	LMR	Danube	Reni-Chilia/Kilia arm	132	**11.43**	**223.8**	**8.34**	**17.53**	**14.7**	**0.78***	**5.37**	**362.49**
UA2	M	Danube	Vylkove	18	**7.88**	**132.54**	**4.2**		**10.6**	**0.26**	**3.21**	**250.45**

Explanations for comparison of values:

Bold font -	**increased value in comparison with 2017**
11.430	**maximum value of determinand in 2018 and also increased value in comparison with 2017**
0.30	stability
	missing value in 2017 or in 2018 - not assessed

Table 10: Annual load in selected monitoring locations on tributaries in 2018

Station Code	Profile	River Name	Location	River km	Annual Load in 2018							
					Suspended solids	Inorganic nitrogen	Ortho-phosphate phosphorus	Total phosphorus	BOD (5)	Chloride	Total phosphorusdissolved	Silicates/ Silicates dissolved*
					(10^6 tonns)	(10^3 tonns)	(10^3 tonns)	(10^3 tonns)	(10^3 tonns)	(10^6 tonns)	(10^3 tonns)	(10^3 tonns)
DE3	M	Inn	Kirchdorf	195	0.990	5.17	0.05	1.22	**8.64**	0.05		
DE4	L	Inn/Salzach	Laufen	47	0.267	4.15	0.05	0.34	**12.85**	0.05		
CZ1	MR	Morava	Lanzhot	79	0.014	2.31	0.01	0.09	1.96	0.02		0.007
CZ2	LM	Morava/Dyje	Pohansko	17	**0.004**	**1.01**	0.05	0.09	**1.09**	0.02		0.004
SK4	LMR	Vah	Komárno	2	0.051	6.93	0.27	0.62	10.19	0.10	**0.44**	0.028
SK6	M	Morava	Bratislava	1	0.032	3.51	0.15	0.3	**4.13**	0.06	0.24	0.015
SK7	M	Danube/Hron	Kamenica	2	**0.053**	**1.85**	0.06	**0.2**	**3.06**	<u>0.02</u>	0.11	**0.017**
SK8	M	Danube/Ipeľ	Salka	12	**0.021**	**0.89**	<u>**0.04**</u>	**0.09**	**0.99**	<u>0.01</u>	<u>0.06</u>	**0.009**
HU9	LMR	Tisza	Tiszasziget	163	**1.679**	**21.28**	**0.98**	**4.54**	**31.28**	**0.55**		0.22
SI1	L	Drava	Ormož most	300	**0.148**	**12.6**	<u>**0.06**</u>	**0.58**	**10.08**	**0.14**		
SI2	R	Sava	Jesenice na Dolenjskem	729	**0.053**	**11.55**	**0.22**	0.35	**8.1**	**0.08**		
RO10	M	Siret	Conf. Danube (Sendreni)	0	**1.717**	**7.99**	**0.16**	**0.53**	**16.82**	**0.45**	**0.38**	0
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	**0.156**	1.51	**0.07**	0.19	**5.8**	0.09	**0.13**	

Explanations for comparison of values:

Bold font	**increased value in comparison with 2017**
1.717	**maximum value of determinand in 2018 and also increased value in comparison with 2017**
23.86	**maximum value of determinand in 2018, but decreased value in comparison with 2017**
<u>0.02</u>	stability
	missing value in 2017 or in 2018 - not assessed

Table 11: Additional annual load data at Reni for reporting to the Black Sea Commission

					Number of measurements in 2018																				
Country Code	River	Location	Location in profile	River km	Q_r	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	Phosphorus - dissolved	BOD_5	Chlorides	Silicates diss.	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
RO5	Danube	Reni	LMR	132	365	26	26	26	26	12	12	11	26	26	26	26	23		12		12		12		12

Location in profile	River km	Q_r	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	Phosphorus - dissolved	BOD_5	Chlorides	Silicates diss.	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
		$(m^3.s^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$
LMR	132	6488	45,53	1,09	0,045	0,088	0,07	1,70	27,47	3,50	0,08	0,02	0,99	1,52		5,58		2,48		0,09		0,013

Location in profile	River km		Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	Phosphorus - dissolved	BOD_5	Chlorides	Silicates diss.	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
			$(x10^6 tonns)$	$(x10^3 tonns)$	$(x10^3 tonns)$	$(x10^3 tonns)$	$(x10^3 tonns)$	$(x10^3 tonns)$	$(x10^6 tonns)$	$(x10^6 tonns)$	$(x10^3 tonns)$	$(x10^3 tonns)$	$(x10^3 tonns)$	$(x10^3 tonns)$	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)
LMR	132		11,42	223,23	8,31	17,48	14,04	361,68	5,36	0,79	16,17	3,60	203,47	293,51		1079,74		477,82		17,29		2,53

Figure 5.1.: Annual load of suspended solids along the Danube River in 2018

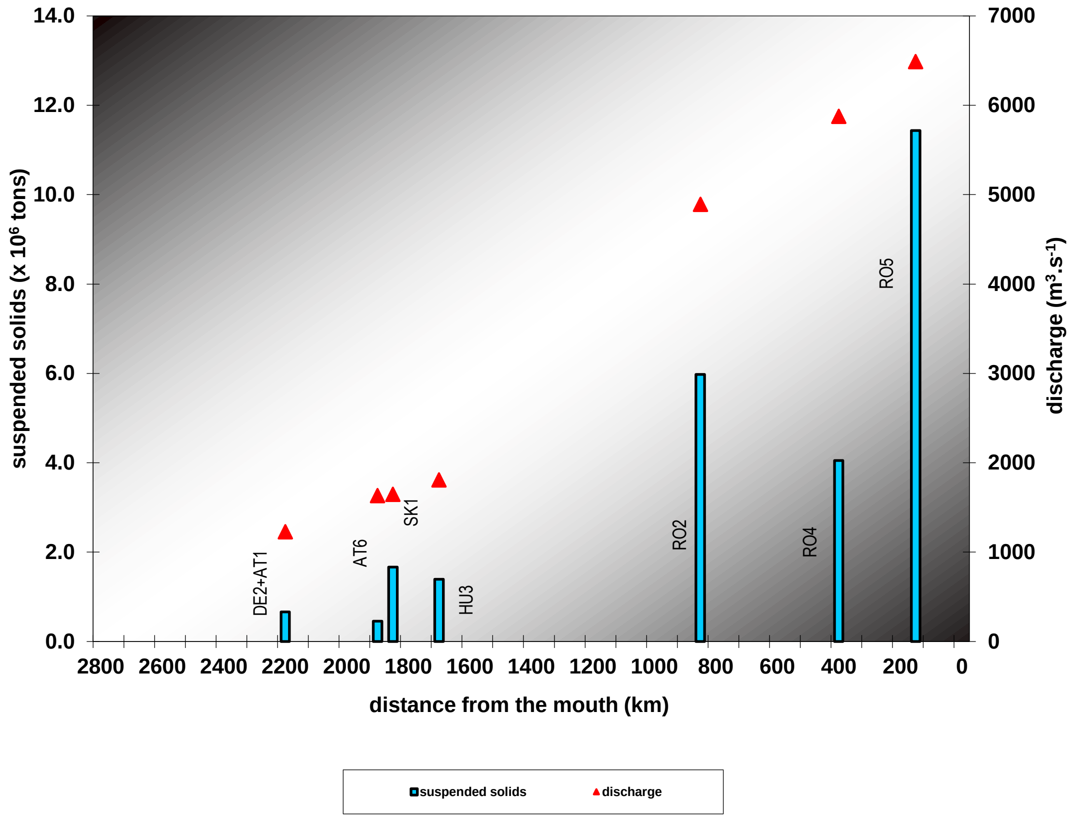


Figure 5.2.: Annual load of suspended solids at monitoring locations on tributaries in 2018

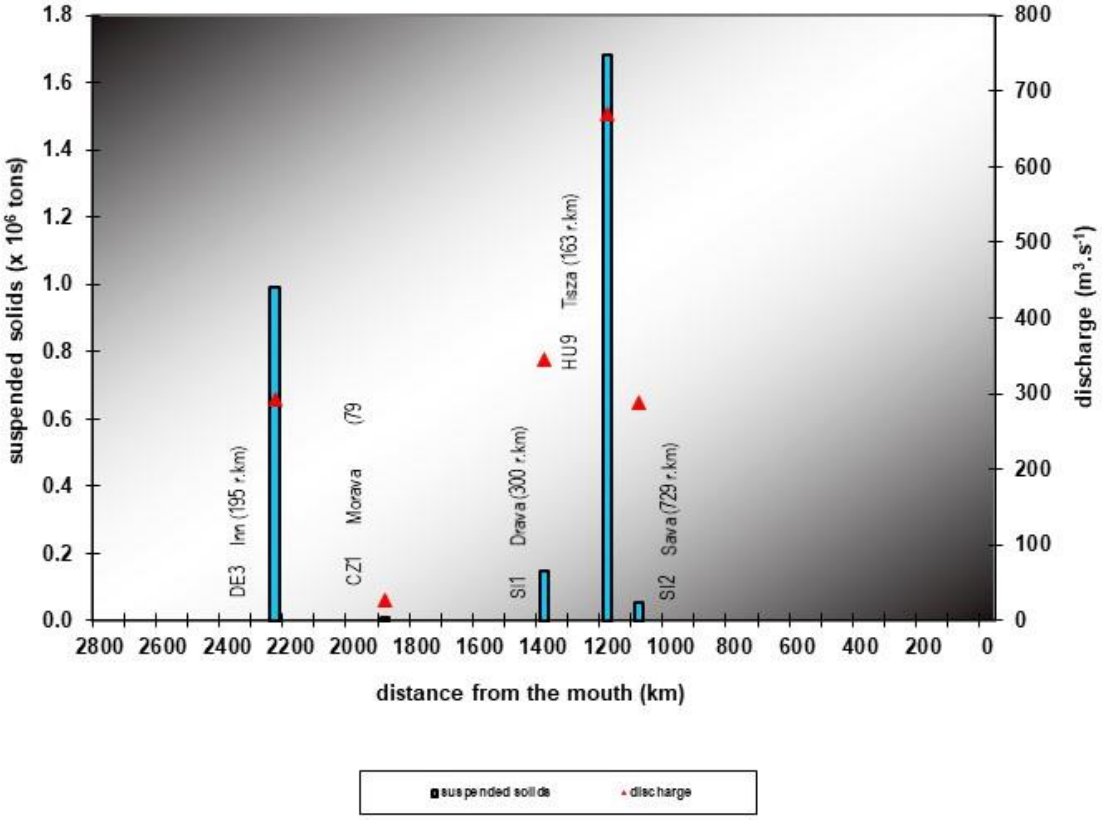


Figure 5.3.: Annual loads of inorganic nitrogen along the Danube River in 2018

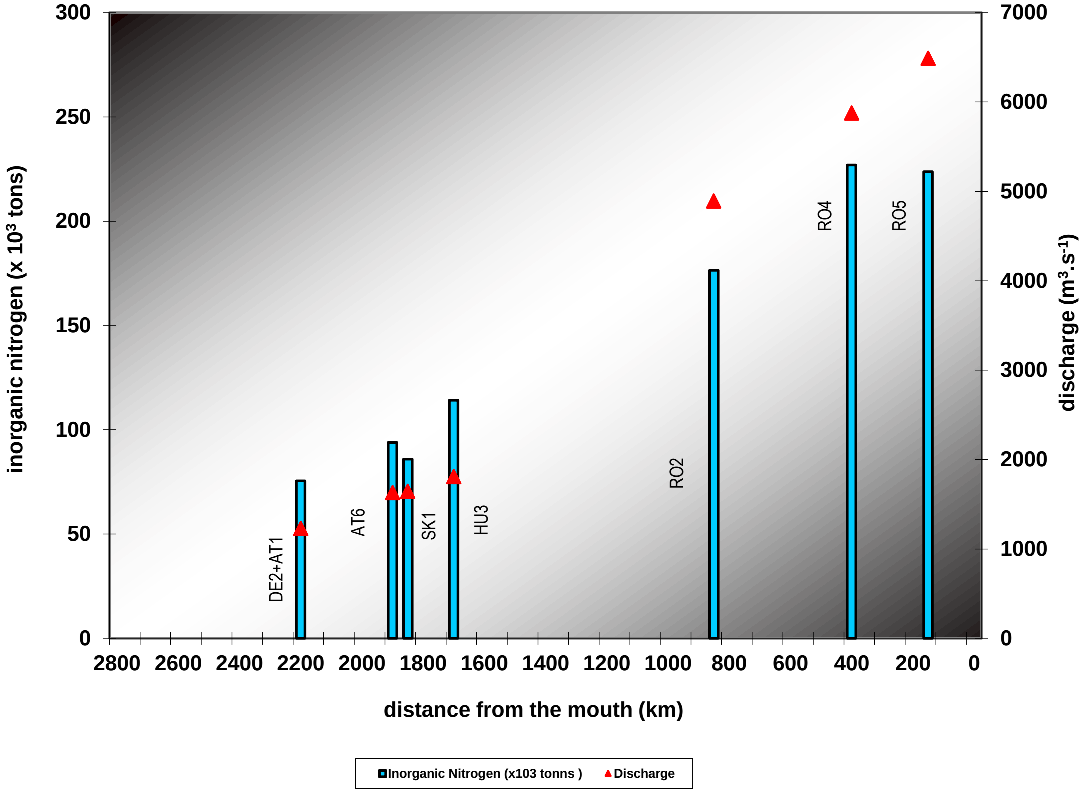


Figure 5.4.: Annual loads of inorganic nitrogen at monitoring locations on tributaries in 2018

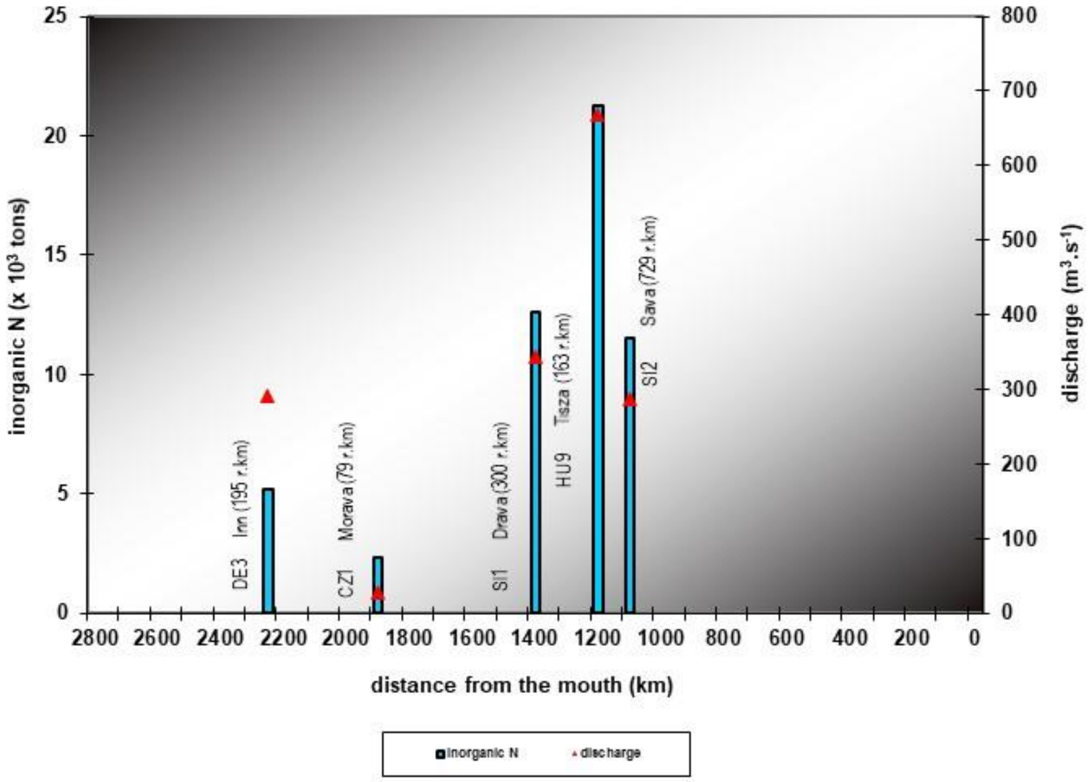


Figure 5.5.: Annual loads of P-PO₄ at monitoring locations along the Danube River in 2018

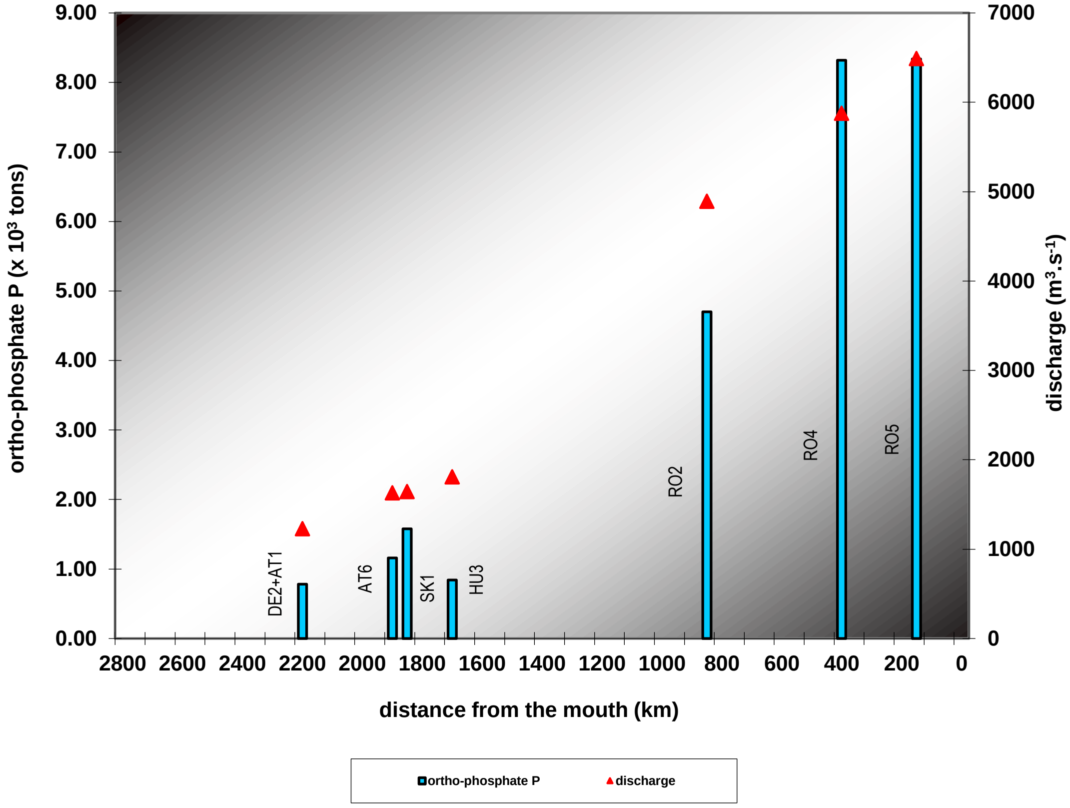


Figure 5.6.: Annual loads of P-PO₄ at monitoring locations on tributaries in 2018

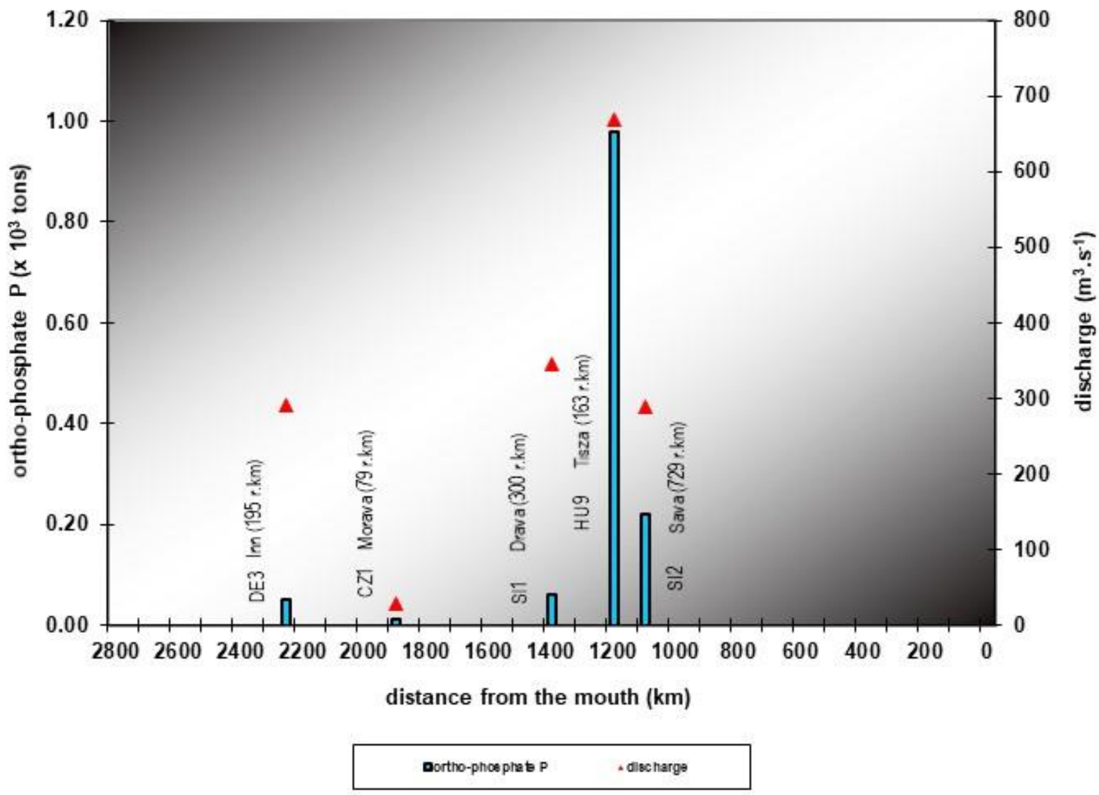


Figure 5.7.: Annual loads of total phosphorus along the Danube River in 2018

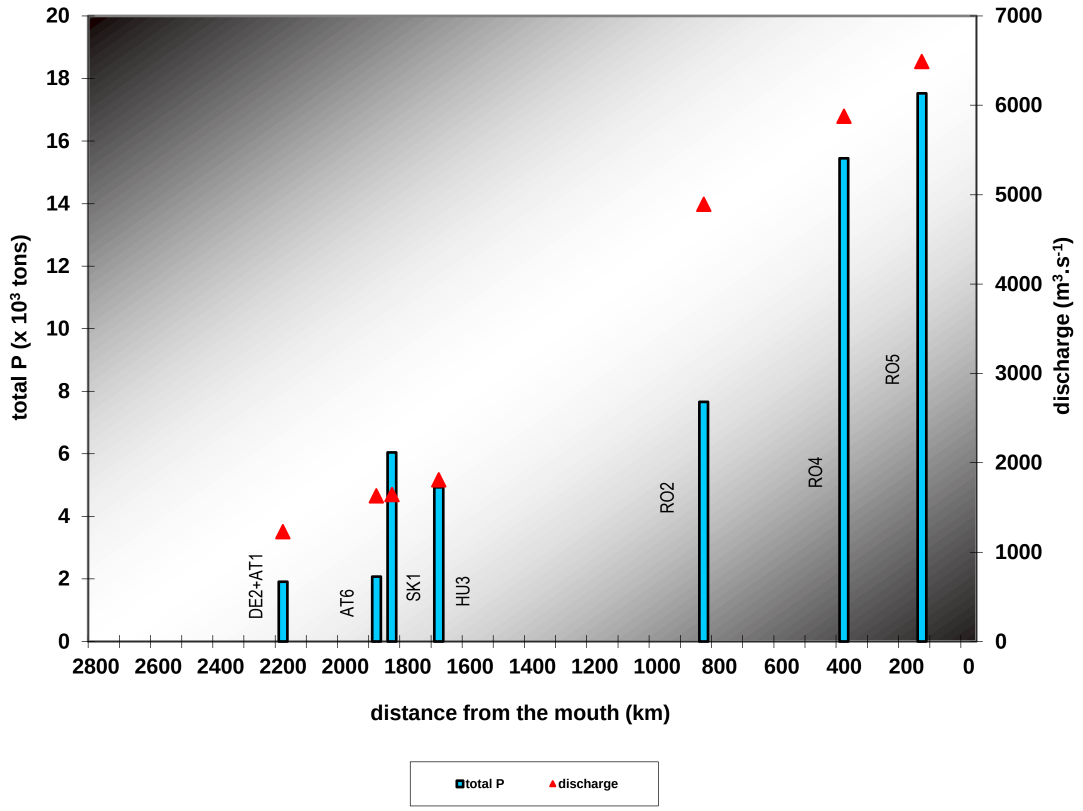


Figure 5.8.: Annual loads of total phosphorus at monitoring locations on tributaries in 2018

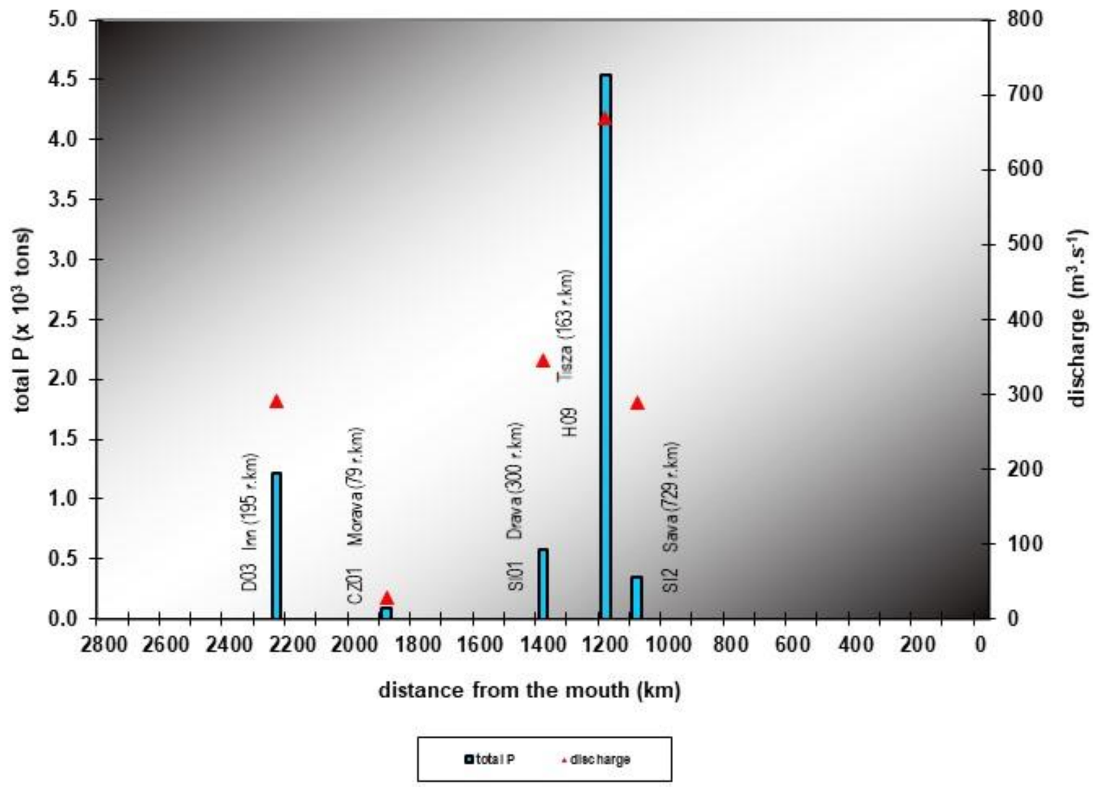


Figure 5.9.: Annual loads of BOD_5 along the Danube River in 2018

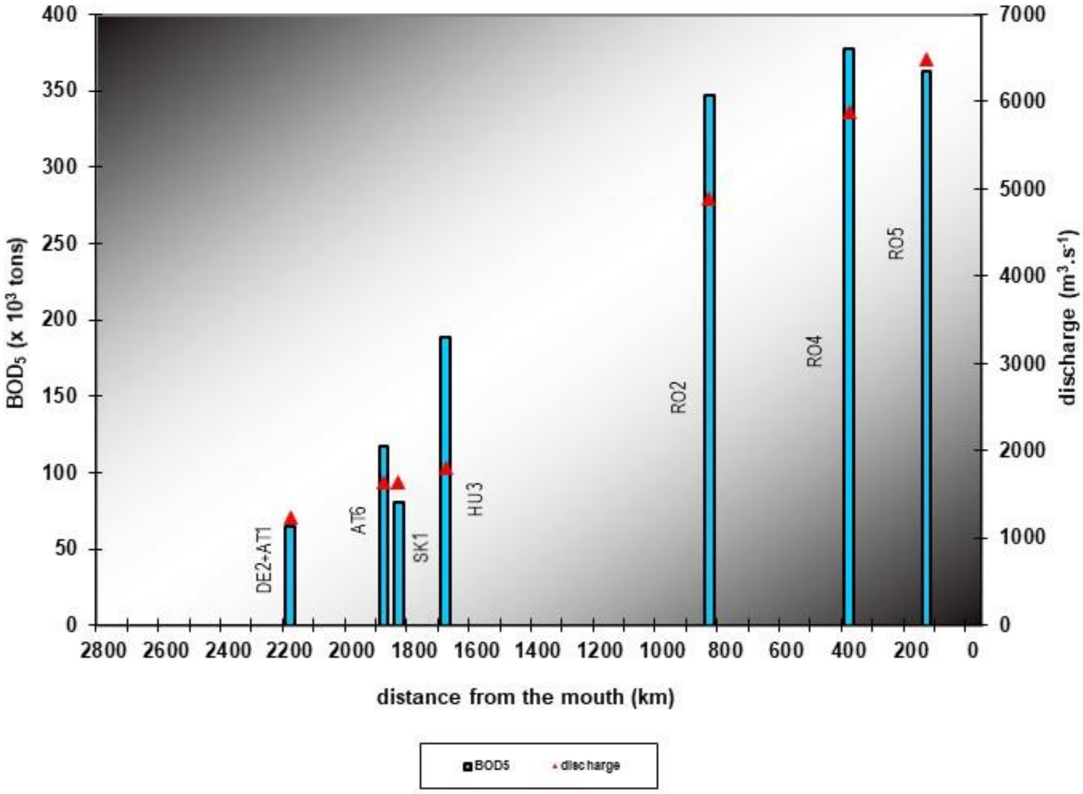


Figure 5.10.: Annual loads of BOD_5 at monitoring locations on tributaries in 2018.

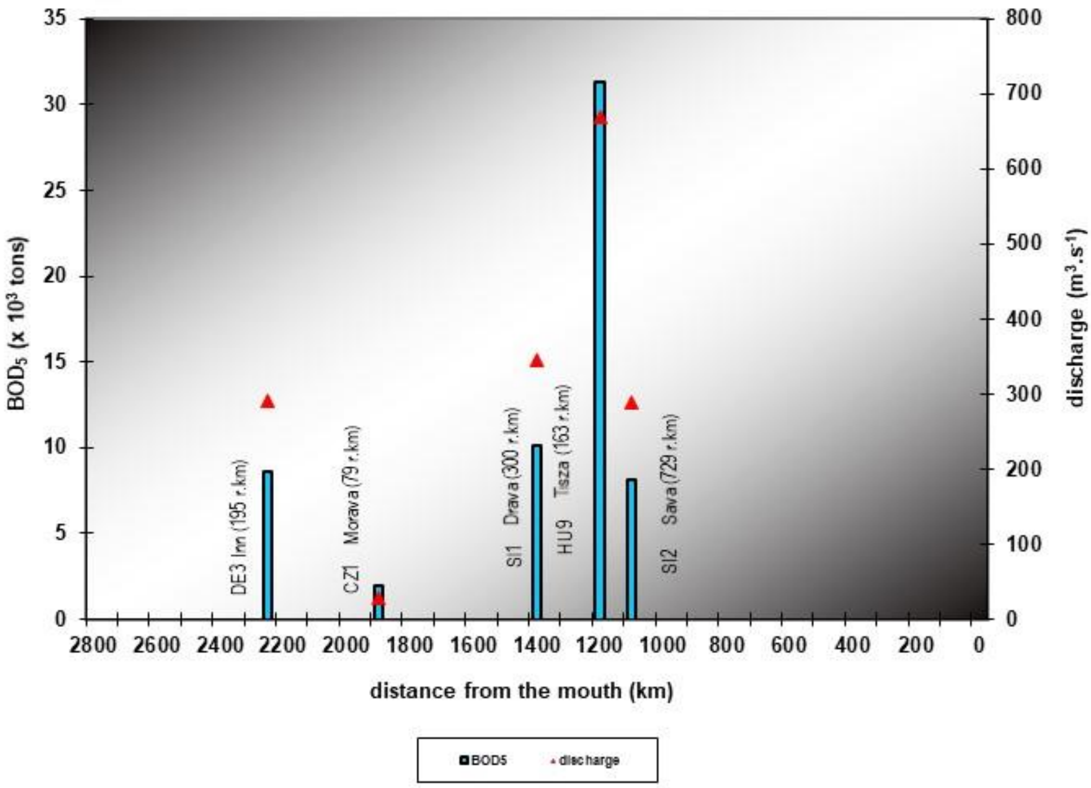


Figure 5.11.: Annual loads of chlorides along the Danube River in 2018

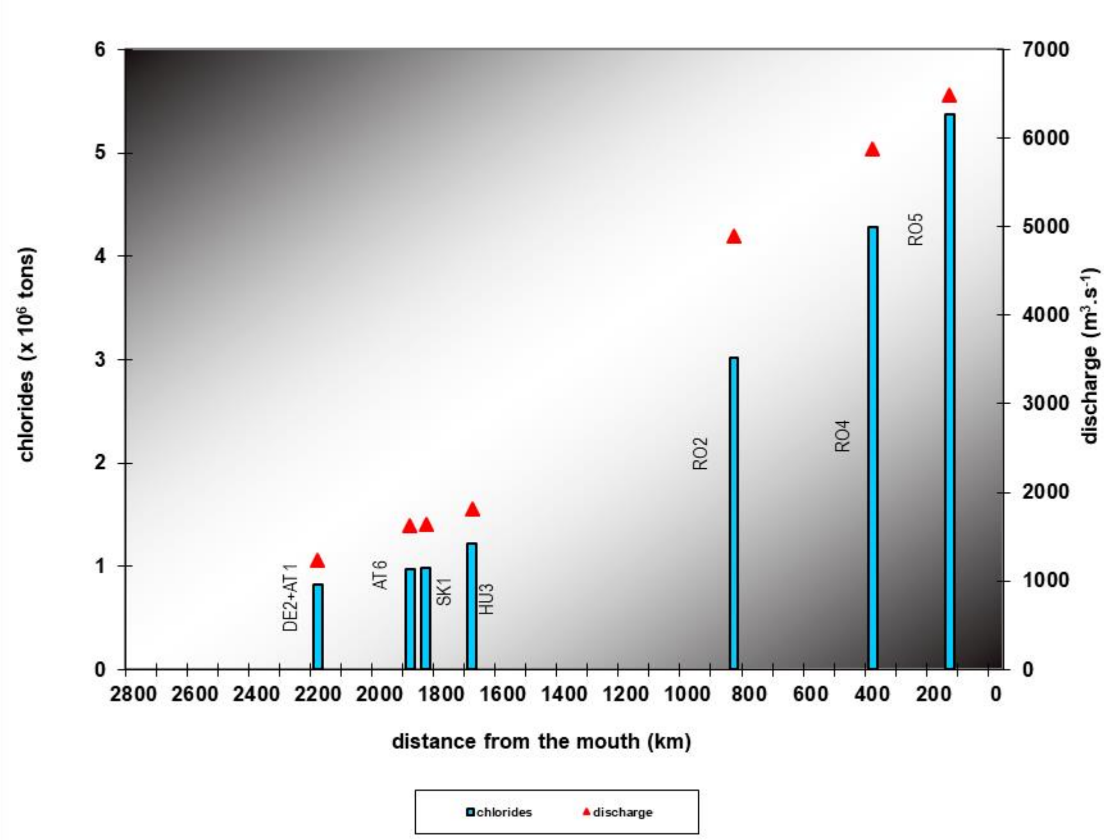


Figure 5.12.: Annual loads of chlorides at monitoring locations on tributaries in 2018

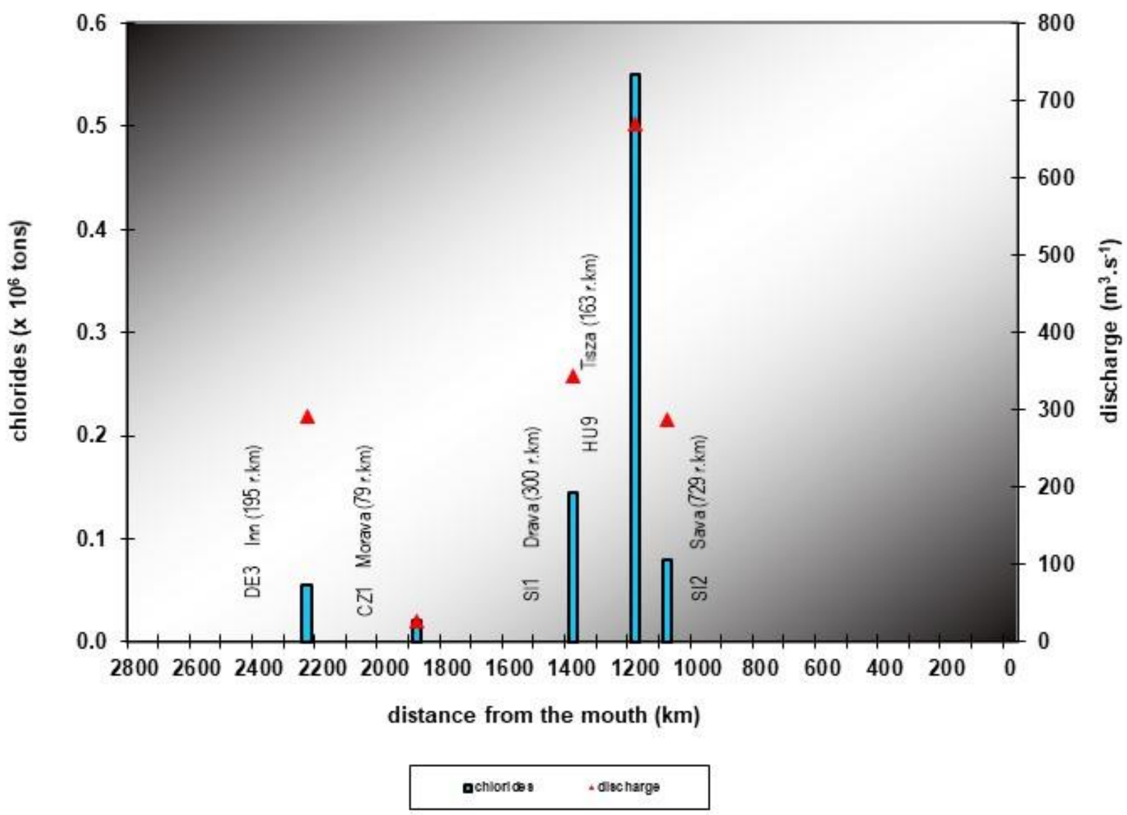


Figure 5.13.: Development trend of annual loads of suspended solids at Reni.

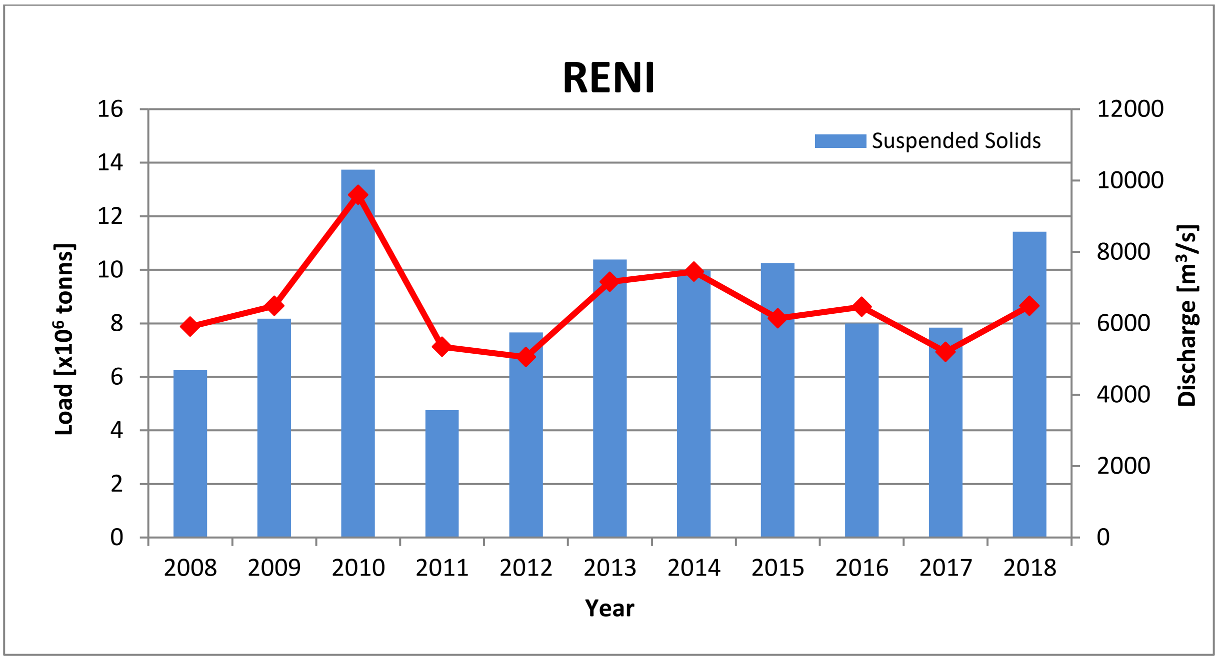


Figure 5.14.: Development trend of annual loads of inorganic nitrogen at Reni.

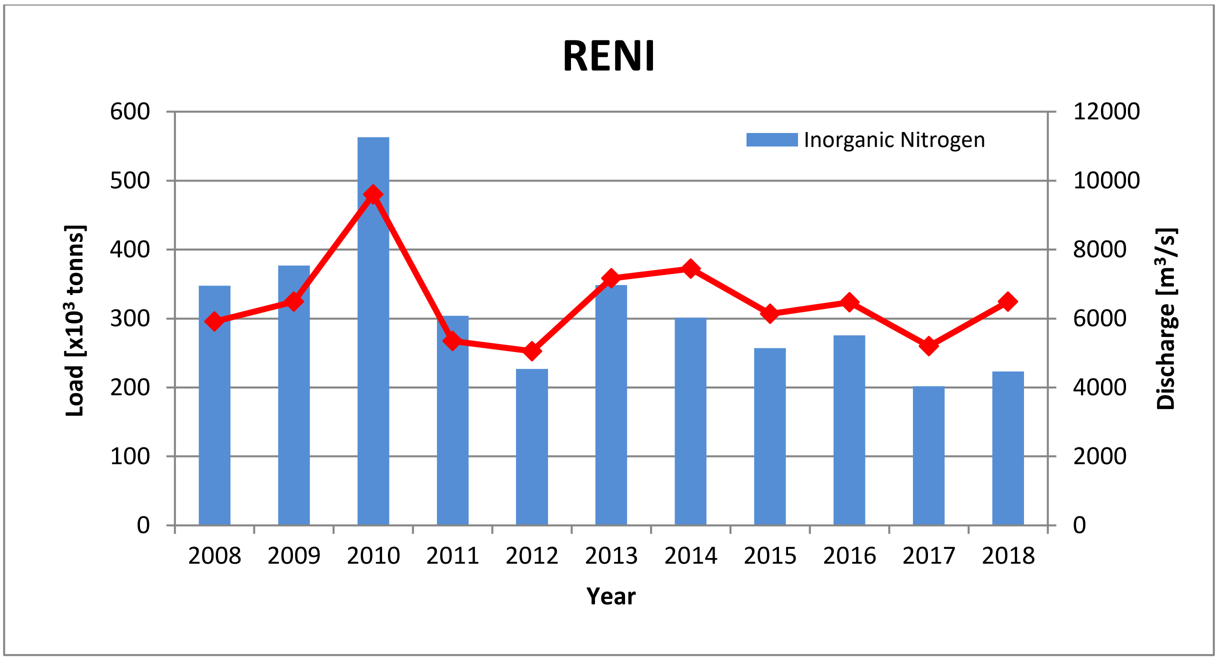


Figure 5.15.: Development trend of annual loads of ortho-phosphate phosphorus, total phosphorus and dissolved phosphorus at Reni.

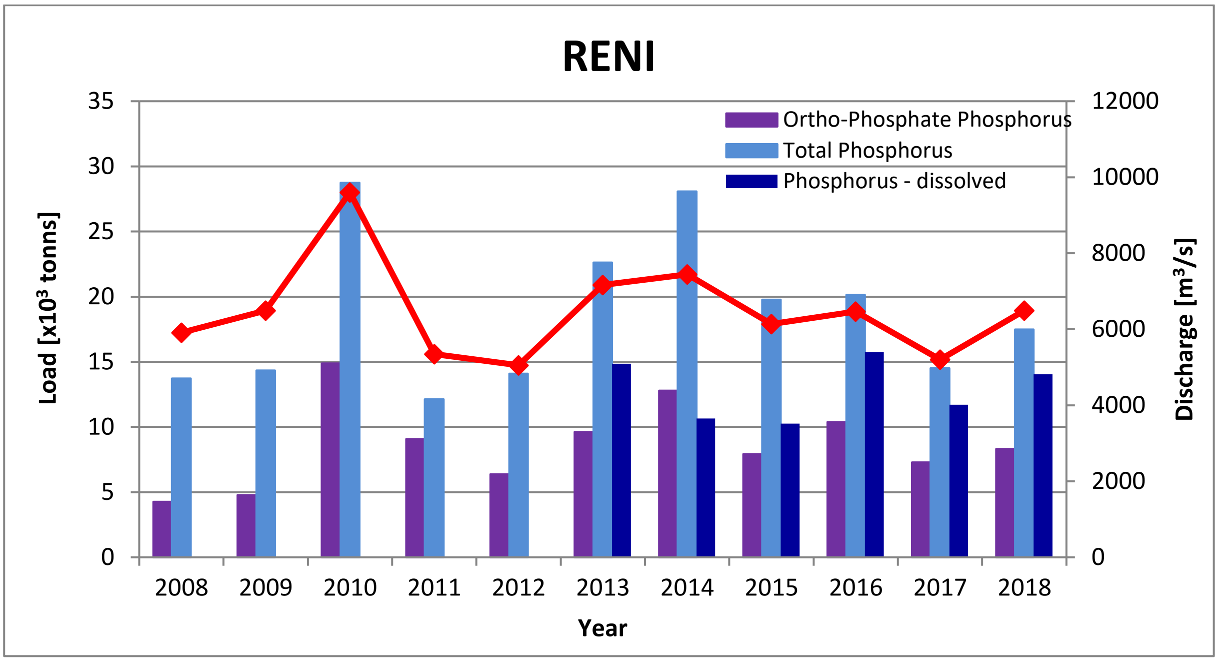


Figure 5.16.: Development trend of annual loads of BOD_5 at Reni.

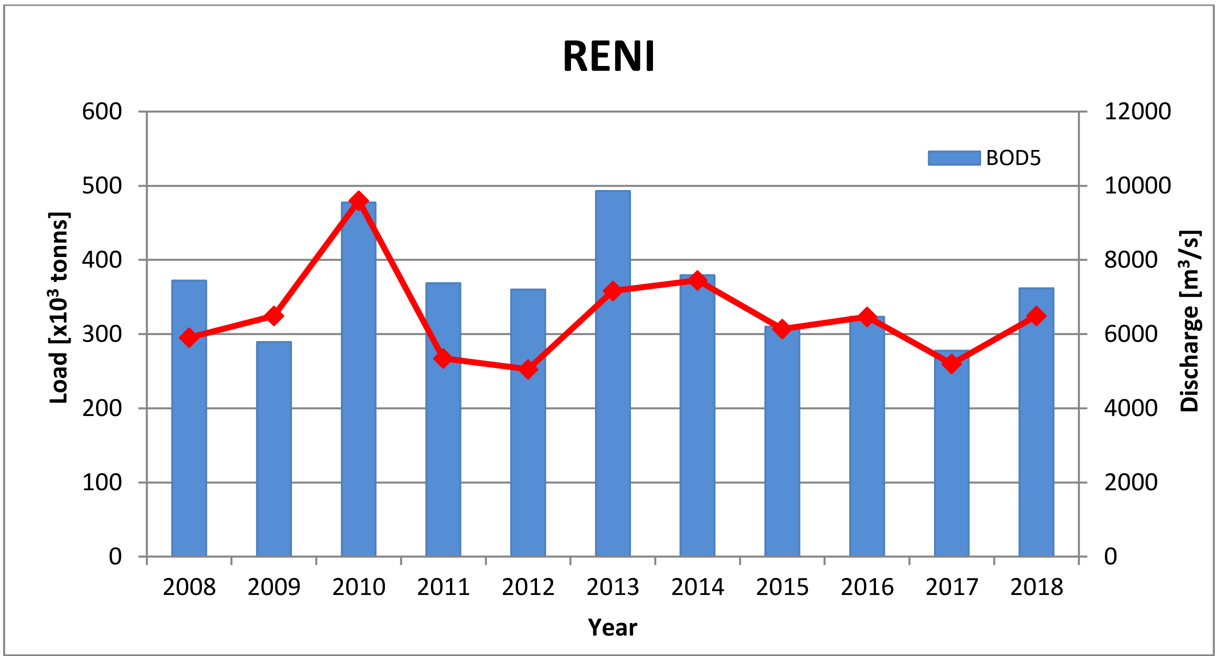


Figure 5.17.: Development trend of annual loads of chlorides at Reni.

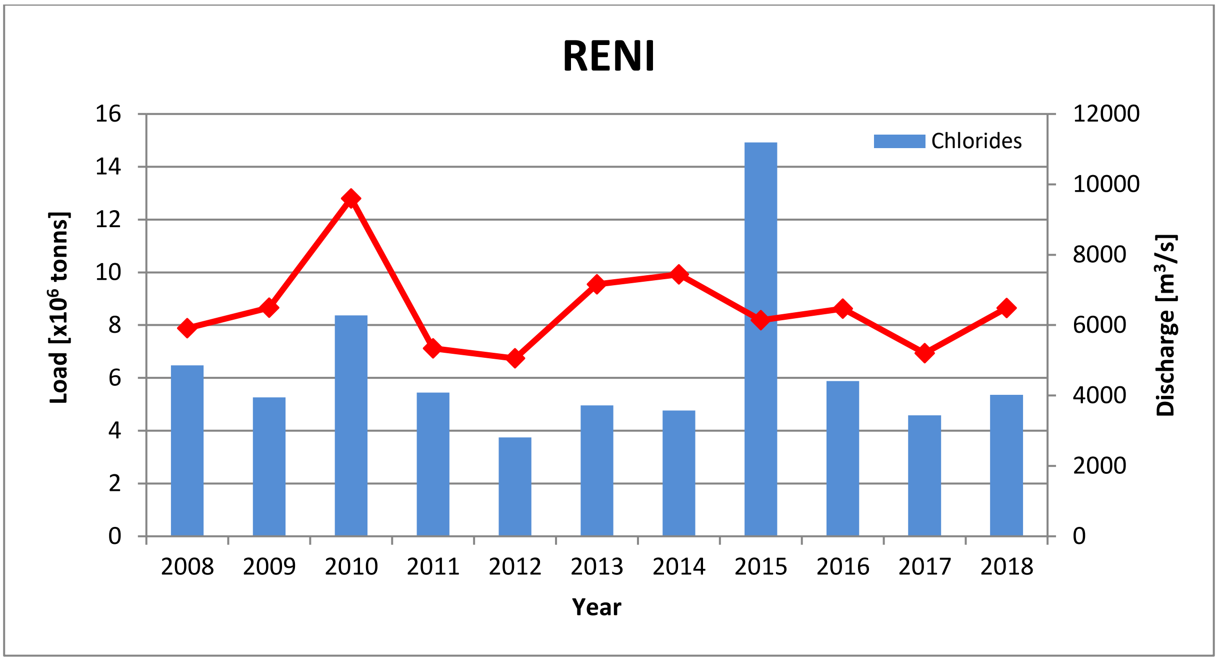
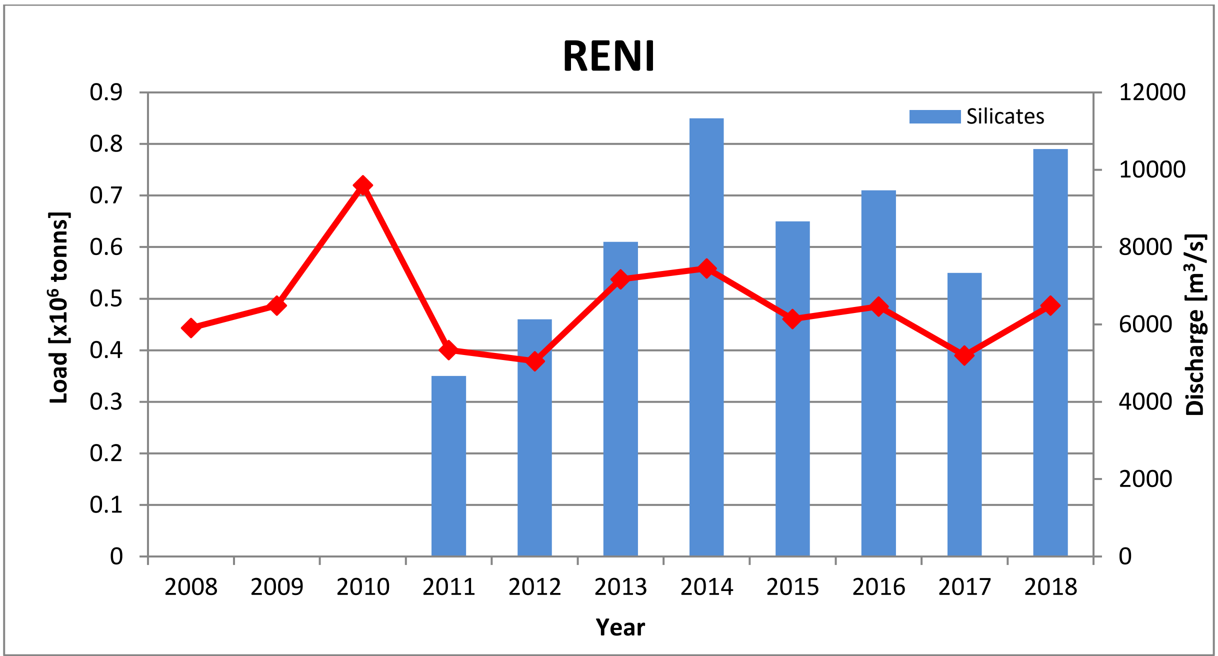


Figure 5.18.: Development trend of annual loads of silicates at Reni.



6. Groundwater monitoring

6.1 GW bodies of basin-wide importance

According to the Article 2 of the EU Water Framework Directive (2000/60/EC) ‘Groundwater’ means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. The analysis and review of the groundwater bodies in the Danube River Basin as required under Article 5 and Annex II of the WFD was performed in 2004 and it identified 11 GW-bodies or groups of GW-bodies of basin-wide importance, which are shown in Map (Figure 6.1).

GW-bodies of basin-wide importance were defined as follows:

important due to the size of the groundwater body which means an area larger than 4000 km² or

important due to various criteria e.g. socio-economic importance, uses, impacts, pressures interaction with aquatic eco-system. The criteria need to be agreed bilaterally.

This means that the other groundwater bodies even those with an area larger than 4000 km², which are fully situated within one country of the DRB are dealt with at the national level. A link between the content of the DRBMP and the national plans is given by the national codes of the groundwater bodies.

Figure 6.1: Transboundary GW-bodies of basin-wide importance and their transnational monitoring network

6.2 Reporting on groundwater quality

According to the WFD groundwater is an integral part of the river basin management district and therefore monitoring of groundwater of basin-wide importance was introduced into the TNMN in the Danube River Basin. The detailed description of the current status in development of the groundwater monitoring network in the Danube River Basin District is given in the TNMN Groundwater monitoring report (Part II of the Summary Report to EU on monitoring programs in the Danube River Basin District designed under Article 8).

Groundwater monitoring under TNMN is based on a six-year reporting cycle in line with the WFD reporting requirements. Information on status of the groundwater bodies of basin-wide importance is provided in the DRBM Plans published every six years. This sufficiently allows for making any relevant statement on significant changes of groundwater status for the GW-bodies of basin-wide importance.

7. Abbreviations

Abbreviation	Explanation
AQC	Analytical Quality Control
AOX	Adsorbable organic halogens
BOD_5	Biochemical oxygen demand (5 days)
BSC	Black Sea Commission
COD_{Cr}	Chemical oxygen demand (Potassium dichromate)
COD_{Mn}	Chemical oxygen demand (Potassium permanganate)
DEFF	Data Exchange File Format
DOC	Dissolved organic carbon
DRB	Danube River Basin
DRBMP	Danube River Basin Management Plan
DRPC	Convention on Cooperation for the Protection and Sustainable Use of the Danube River (short: Danube River Protection Convention)
GW	Groundwater
ICPDR	International Commission for the Protection of the Danube River
LOQ	Limit of Quantification
MA EG	Monitoring and Assessment Expert Group (former MLIM EG)
MLIM EG	Monitoring, Laboratory and Information Management Expert Group
NO2_N	Nitrite-nitrogen
NO3_N	Nitrate-nitrogen
Ntot.	Total nitrogen
NRL	National Reference Laboratory
oPO4_P	Orto-phosphate-phosphorus
Pdiss.	Phosphorus dissolved
Ptot.	Total phosphorus
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
Qr	Mean annual discharge
SOP	Standard Operational Procedure
TNMN	Trans National Monitoring Network
TOC	Total organic carbon
WFD	EU Water Framework Directive

Deutschland //// Österreich //// Česká republika //// Slovensko //// Magyarország //// Slovenija //// Hrvatska //// Bosna i Hercegovina //// Србија //// Crna Gora //// România //// България //// Moldova //// Україна

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