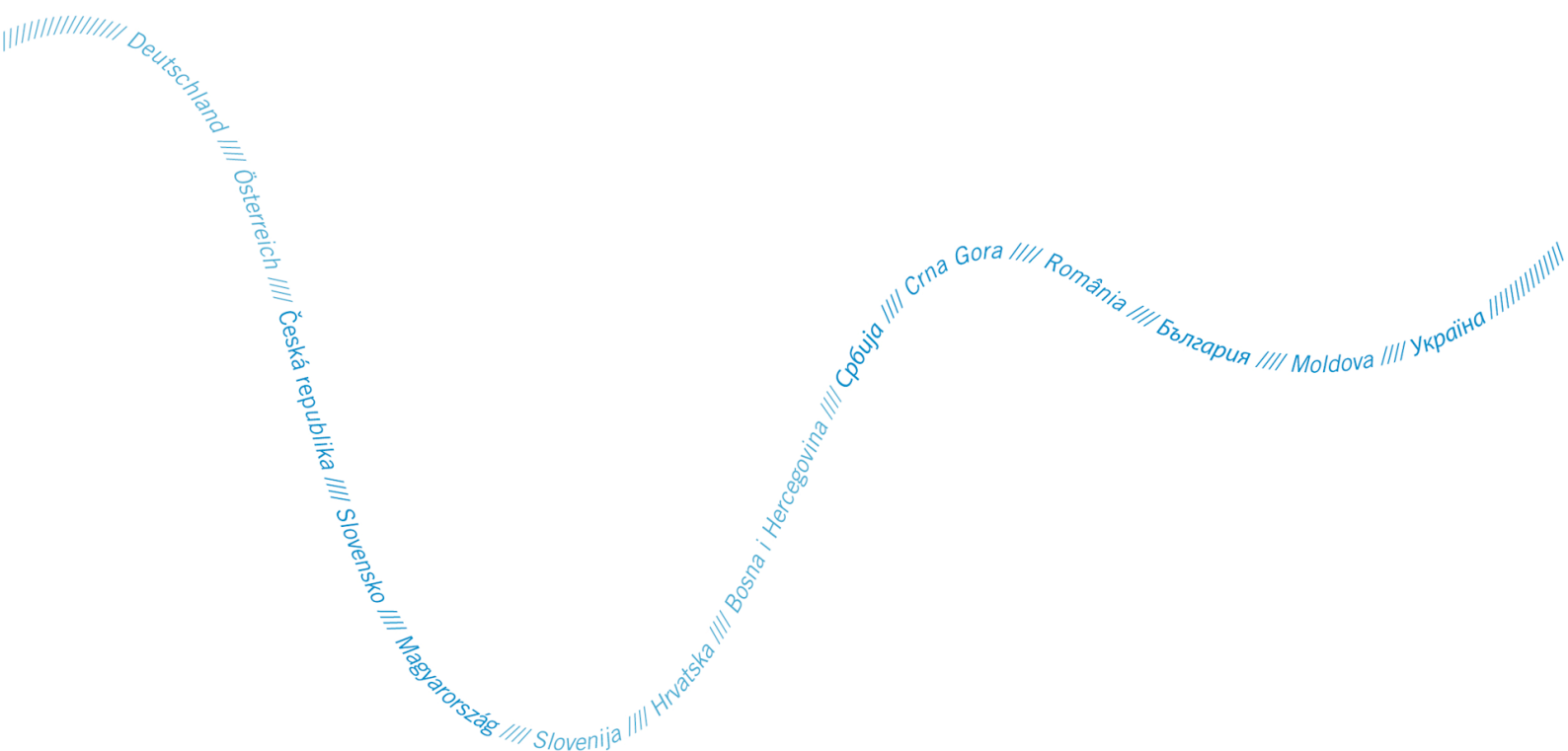

Water Quality in the Danube River Basin – 2019



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for the Protection
of the Danube River

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zum Schutz der Donau

TNMN – Yearbook 2019



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Table of content

1. Introduction	4
1.1 History of the TNMN	4
1.2 Revision of the TNMN to meet the objectives of EU WFD	4
2. Description of the TNMN Surveillance Monitoring 2: Monitoring of specific pressures	6
2.1 Objectives	6
2.2 Selection of monitoring sites	6
2.3 Quality elements	11
2.3.1 Parameters indicative of selected biological quality elements	11
2.3.2 Priority pollutants and parameters indicative of general physico-chemical quality elements	11
2.4 Analytical Quality Control (AQC)	12
2.5 TNMN Data Management	13
3. Results of basic statistical processing	14
4. Profiles and trend assessment of selected determinands	20
4.1 Saprobic index based on macrozoobenthos	37
4.2 The Sava and Tisza Rivers	38
5. Load Assessment	40
5.1 Introduction	40
5.2 Description of load assessment procedure	40
5.3 Monitoring Data in 2019	40
5.4 Calculation Procedure	41
5.5 Results	42
6. Groundwater monitoring	58
6.1 GW bodies of basin-wide importance	58
6.2 Reporting on groundwater quality	59
7. Abbreviations	60

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 2019.

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 (see map on page).

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 rows) and tributaries. Information about monitoring sites monitored in 2019 is included in the Table 3 - Chapter 3.

Table 1: List of stations included in TNMN SM2

No.	Country code	TNMN code	River	Monitoring station name	Locations	x- coord	y- coord	River- km	Alti- tude	Catch- ment 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	Medved'ov	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	18.715	45.984	1 435	79	211 503
23	HU	HU6	/Sio	Szekszard-Palank	LMR	18.720	46.380	13	85	14 693
24	HU	HU7	/Drava	Dravasabolcs	LM	18.200	45.784	78	92	35 764
25	HU	HU8	/Tisza/Sajo	Sajopuszoki	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/Kettös- Körös/Fekete-Körös	Sarkad	MR	21.431	46.694	16	85	4302
31	HU	HU14	/Tisza/Hármas- Körös/Kettös- 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	Jesenicena 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	Donji Miholjac	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	Upstream Una Jasenovac	M	16.915	45.269	525	87	30 953
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	19.842	45.225	1 255	74	254 085
46	RS	RS4	Danube	Zemun	R	20.412	44.849	1 173	71	412 762
47	RS	RS6	Danube	Banatska Palanka	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

No.	Country code	TNMN code	River	Monitoring station name	Locations	x- coord	y-coord	River-km	Altitude	Catchment area
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 Selo	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	Orechovitz	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	29.671	45.158	0	1	817 000
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	27.934	45.403	0	4	42 890
89	RO	RO11	/Pрут	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/Kettös-Körös/CrisulNegru	Zerind	M	21.517	46.627	13	86.4	3 750
93	RO	RO15	/Tisza/Hármas-Körös/Kettös-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	24.778	43.764	3	32	24 050
98	RO	RO21	/Ialomita	DownstreamTandarei	M	27.828	44.655	24	8.5	10 309
99	MD	MD1	/Pрут	Lipcani	L	26.483	48.152	658	100	8 750
100	MD	MD3	/Pрут	Conf. Danube-Giurgiulesti	LMR	28.124	45.285	0	5	27 480
101	MD	MD5	/Pрут	CostestiReservoir	L	27.145	47.513	557	91	11 800
102	MD	MD6	/Pрут	Braniste	L	27.145	47.475	546	63	12 000

No.	Country code	TNMN code	River	Monitoring station name	Locations	x- coord	y-coord	River-km	Altitude	Catchment area
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

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 2019

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.

2.3 Quality elements

The background of the whole TNMN yearbook are data reported in 2019 by 13 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 Chapter 3).

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 SM2:

- Phytoplankton (chlorophyll-a)
- Benthic invertebrates (macrozoobenthos) (mandatory parameters: Saprobic index SI 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
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	
Arsenic (6)	annually / 12 x per year	
Copper (6)	annually / 12 x per year	

Determinand	Surveillance Monitoring 2	
	Water concentrations	Water load assessment
	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 2019 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 cm³ plastic bottles were provided for NH₄⁺-N, NO₃⁻-N, organic N, total N, PO₄³⁻-P and total P analysis. Measurement results were asked to be reported as mg/dm³ N and P, respectively.
- spike solutions together with matrix water for NO₂⁻-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-treated by bringing to boiling point) according to instructions. Spike solutions were put in 20 cm³ plastic containers with sample codes SW-N/M-1 and SW-N/M-2, whereas matrix water was provided in 500 cm³ plastic bottle labelled "WATER FOR DILUTION - NO₂- N. Measurement results were asked to be reported as mg/ dm³ N.

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.

Forty-six laboratories were enrolled into the scheme in 2019, which is similar to previous years' numbers. However, two laboratories did not return results, consequently the actual number of participants was 44. 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 (37 to 44 laboratories per parameter), with the exception of organic N, where only 10 and 11 results were available for evaluation of the two samples, respectively. This parameter replaced

Kjeldahl N analysis in 2013 at behest of participants, however, it remains unpopular with laboratories, which renders statistical evaluation difficult.

The 2019 proficiency testing scheme was successful overall, number and ratio of unsatisfactory results remained low. Some of the unsatisfactory results are probably attributable to non-analytical errors (e.g. reporting in units of measurement other than prescribed, concentrations at 2 or 10 times higher than expected), while high negative errors in N-form determinations might be caused by inadequate pH adjustment before analysis. Evaluation of results could not be performed in only one case, namely organic N in sample SW-N-2, where high spread of results led to the standard uncertainty of the assigned value (i.e. robust average) exceeding the critical limit of 120% of standard deviation of proficiency assessment. In case of total P, all reported results were in the satisfactory range. Total N analysis is equally successful with no questionable and only one unsatisfactory result. Proficiency testing of nitrite nitrogen is traditionally less successful; however, this year's reported values show a marked improvement with sharp decline in both questionable and unsatisfactory result. Similarly to 2018, determination of ammonium nitrogen proved to be challenging: 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 relatively high (7). More of the non-satisfactory results were in the unsatisfactory range, as opposed to last year, where questionable results were more numerous. This, together with the fact that agreement between results was much better before 2018, presents a negative trend for NH_4^+ -N analysis.

In summary, the 2019 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 2019 were monitored 153 sites at 110 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 80 stations representing 71 sampling sites at all. These 153 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 2019

N°	TNMN code	Location	River	Monitoring station	River km
1	DE5	L	Danube	Dillingen	2538
2	DE2	M	Danube	Jochenstein	2204
3	DE3	M	Inn	Kirchdorf	195
4	DE4	L	Inn/Salzach	Laufen	47
5	AT1	M	Danube	Jochenstein	2204
6	AT5	R	Danube	Enghagen	2113
7	AT3	R	Danube	Wien-Nussdorf	1935
8	AT6	R	Danube	Hainburg	1879
9	CZ1	M	Morava	Lanzhot	79
10	CZ2	M	Morava/Dyje	Pohansko	17
11	SK1	L, M, R	Danube	Bratislava	1869
12	SK2	M, R	Danube	Medved'ov	1806
13	SK4	M, R	Vah	Komárno	1,5
14	SK5	L, M, R	Danube	Szob	1707
15	SK6	M	Morava	Devín	1
16	SK7	M	Danube/Hron	Kamenica	1,7
17	SK8	M	Danube/Ipeľ	Salka	12
18	HU1	M, R	Danube	Medve/Medvedov	1806
19	HU2	M, R	Danube	Komarom/Kedvedov	1768
20	HU3	L, M, R	Danube	Szob	1708
21	HU4	L, M, R	Danube	Dunafoldvar	1560
22	HU5	M	Danube	Hercegszanto	1435
23	HU6	L, M	Sio	Szekszard-Palank	13
24	HU7	M	Drava	Dravasabolcs	78
25	HU8	M	Tisza/Sajo	Sajopuspoki	124
26	HU9	L, M, R	Tisza	Tiszasziget	163
27	HU10	M	Tisza	Tiszabecs	757
28	HU11	M	Tisza/Szamos	Csenger	45
29	HU12	M, R	Tisza/Hármas-Körös/Sebes-Körös	Korosszakal	9
30	HU13	M, R	Tisza/Hármas-Körös/Kettős-Körös/Fekete-Körös	Sarkad	16
31	HU14	M, R	Tisza/Hármas-Körös/Kettős-Körös/Fehér-Körös	Gyulavari	59
32	HU15	R	Tisza/Maros	Nagylak	51
33	SI1	L	Drava	Ormož most	300

N°	TNMN code	Location	River	Monitoring station	River km
34	SI2	R	Sava	JesenicenaDolenjskem	729
35	HR1	M, R	Danube	Batina	1429
36	HR11	M	Danube	Ilok	1301,5
37	HR9	M	Drava	Ormož	300
38	HR4	M, R	Drava	Botovo	227
39	HR5	M, R	Drava	D. Miholjac	78
40	HR6	R	Sava	Jesenice	729
41	HR7	M	Sava	Upstream Una.Jasenovac	525
42	HR12	L	Sava	Račinovci	218
43	RS1	L	Danube	Bezdan	1426
44	RS2	L	Danube	Bogojevo	1367
45	RS3	R	Danube	Novi Sad	1255
46	RS4	R	Danube	Zemun	1173
47	RS6	L	Danube	BanatskaPalanka	1077
48	RS7	R	Danube	Tekija	954
49	RS8	R	Danube	Radujevac	851
50	RS10	R	Tisa	Martonos	152
51	RS11	L	Tisa	Novi Becej	65
52	RS12	M	Tisa	Titel	8,7
53	RS13	L	Sava	Jamena	205
54	RS15	R	Sava	Sabac	106
55	RS16	R	Sava	Ostruznica	17
56	RS17	R	Velika Morava	Ljubicevski Most	21,8
57	BA5	M	Sava	Gradiska	457
58	BA6	M	Sava/Una	KozarskaDubica	16
59	BA7	M	Sava/Vrbas	Razboj	12
60	BA8	M	Sava/Bosna	Modrica	24
61	BA9	M	Sava/Drina	Foca	234
62	BA10	M	Sava/Drina	Badovinci	16
63	BA11	M	Sava	Raca	190
64	BA12	M	Sava/Una	Novi Grad	70
65	BA13	M	Sava/Bosna	Usora	78
66	BG1	L, M, R	Danube	Novo Selo Harbour/Pristol	834
67	BG2	R	Danube	us. Iskar-Bajkal	641
68	BG3	R	Danube	Downstream Svishtov	554
69	BG4	R	Danube	us. Russe	503
70	BG5	L, M, R	Danube	Silistra/Chiciu	375
71	BG6	M	Iskar	Orechovitza	28
72	BG7	M	Jantra	Karantzi	12
73	BG8	M	Russenski Lom	Basarbovo	13
74	BG12	M	Iskar	Gigen mouth	4
75	BG13	M	Vit	Guljantzi	7
76	BG14	M	Jantra	Novgrad mouth	4
77	BG15	M	Russenski Lom	mouth	1
78	RO1	L, M, R	Danube	Bazias	1071

N°	TNMN code	Location	River	Monitoring station	River km
79	RO18	L, M, R	Danube	Gruia/Radujevac	851
80	RO2	L, M, R	Danube	Pristol/Novo Selo	834
81	RO3	L, M, R	Danube	Dunare - upstream Arges (Oltenita)	432
82	RO4	L, M, R	Danube	Chiciu/Silistra	375
83	RO5	L, M, R	Danube	Reni-Chilia/Kilia arm	132
84	RO6	L, M, R	Danube	Vilkova-Chilia arm/Kilia arm	18
85	RO7	L, M, R	Danube	Sulina - Sulina arm	0
86	RO8	L, M, R	Danube	Sf. Gheorghe-Ghorghe arm	0
87	RO9	M	Arges	Conf. Danube (Clatesti)	0
88	RO10	M	Siret	Conf. Danube (Sendreni)	0
89	RO11	M	Prut	Conf. Danube (Giurgiuilesti)	0
90	RO12	M	Somes	Dara (frontiera)	3
91	RO13	M	CrisulRepede	Cheresig	3
92	RO14	M	CrisulNegru	Zerind	13
93	RO15	M	Crisul Alb	Varsand	0
94	RO16	M	Mures	Nadlac	21
95	RO17	M	Bega	Otelec	7
96	RO19	M	Jiu	Zaval	9
97	RO20	M	Olt	Islaz	3
98	RO21	M	Lalomita	Downstream Tandarei	24
99	MD1	L	Prut	Lipcani	658
100	MD3	L	Prut	Conf. Danube-Giurgiuilesti	0
101	MD5	L	Prut	Costesti Reservoir	254
102	MD6	L	Prut	Braniste	254
103	MD7	L	Prut	Valea Mare	525
104	UA1	M	Danube	Reni	132
105	UA2	M	Danube	Vylkove	18
106	UA4	M	Tisza	Chop	342
107	UA5	M	Tisza/Bodrog/Latoritsa	Strazh	144
108	UA6	M	Prut	Tarasivtsi	262
109	UA7	M	Siret	Tcherepkivtsi	100
110	UA8	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. There after 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 2019
Mean	arithmetical mean of the measurements done in the year 2019
Max	maximum value of the measurements done in the year 2019
C50	50 percentiles of the measurements done in the year 2019
C90	90 percentiles of the measurements done in the year 2019 (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 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 2019. 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 2019.

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2019 (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	69/39	1.2	29	10.95	17.2	73/71	-0.1	29.6	< 0	19.725
Suspended solids	mg/l	67/37	< 0.25	710	4	77	71/69	< 1	2702	< 1	538
Dissolved oxygen	mg/l	69/39	4.3	19.33	6.39	11.31	73/71	< 0.1	15	< 0.1	11.75
BOD (5)	mg/l	69/39	< 0.25	13.2	0.93	4.26	73/71	< 0.1	17.3	< 0.25	4.44
COD (Mn)	mg/l	63/33	0.74	19.7	2.08	7.53	42/40	< 0.35	26.7	2.16	8.5
COD (Cr)	mg/l	58/28	< 2.0	41.7	3.39	18.72	61/59	< 2.0	76.2	< 2.0	37.6
TOC	mg/l	36/20	1.1	8.7	2.12	4.24	28/26	1.0	52	1.59	8.83
DOC	mg/l	33/15	1.07	6.86	2.033	5.811	17/17	0.6	8.94	1.333	7.141
pH	-	69/39	6.8	9.17	7.65	8.72	69/69	< 1.0	8.9	< 1.0	8.39
Alkalinity - total	mmol/l	69/39	1.27	9.43	1.534	4.326	60/58	0.92	8.6	1.235	7.173
Ammonium (NH ₄ -N)	mg/l	69/39	< 0.002	0.44	0.013	0.167	73/71	< 0.004	4.334	< 0.005	1.928
Nitrite (NO ₂ -N)	mg/l	69/39	< 0.0005	0.099	0.0068	0.0226	72/70	< 0.0005	0.33	< 0.0005	0.1003
Nitrate (NO ₃ -N)	mg/l	69/39	< 0.025	4.1	0.833	2.708	73/71	< 0.035	8.11	< 0.035	6.145
Total nitrogen	mg/l	61/31	0.66	5.61	1.509	2.875	64/62	< 0.05	11.4	< 0.05	7.439
Organic nitrogen	mg/l	29/19	< 0.025	4.51	0.061	1.885	28/26	< 0.05	5.1	< 0.25	2.547
Orthophosphate (PO ₄ -P)	mg/l	69/39	< 0.0015	0.326	0.0123	0.0901	73/71	< 0.0015	0.669	< 0.0015	0.3372
Total phosphorus	mg/l	67/37	< 0.01	0.72	0.0359	0.2158	73/71	< 0.0025	1.61	< 0.01	0.5641
Total phosphorus, dissolved	mg/l	40/18	< 0.005	0.161	0.0271	0.114	20/20	< 0.0035	0.3815	0.023	0.2493
Phytoplankton (biomass - chlorophyll-a)	µg/l	41/19	< 0.0015	86.82	2.25	86.82	36/34	< 0.0015	242.8	0.19	85.82
Conductivity	µS/cm	67/37	28.8	1203	38.308	547.83	72/70	< 0.25	1904	< 0.25	1171.33
Calcium (Ca ⁺⁺)	mg/l	69/39	16	105	35.99	79.78	73/71	< 0.45	249	< 0.45	139.83
Sulphate (SO ₄ ⁻⁻)	mg/l	46/24	14	65.84	18.69	50.44	45/43	2.4	268	10.46	118.07
Magnesium (Mg ⁺⁺)	mg/l	69/39	3.5	87.9	11.13	30.33	72/70	< 0.3	252.93	< 0.3	96.42
Potassium (K ⁺)	mg/l	29/17	1.1	5.8	1.8	3.37	28/26	< 0.3	10.8	1.15	9.06
Sodium (Na ⁺)	mg/l	29/17	5	32.3	11.23	22.43	28/26	2	235	5.67	189.75
Manganese (Mn)	mg/l	9/7	< 0.005	0.339	0.0283	0.1298	19/17	< 0.0003	0.558	0.0133	0.173
Iron (Fe)	mg/l	8/6	< 0.005	3.23	0.403	0.619	14/12	0.013	12.5	0.107	3.506
Chloride (Cl ⁻)	mg/l	60/34	7.1	256	15.74	64.28	66/64	1.69	825	3.48	260.42
Silicates (SiO ₂)	mg/l	16/8	1.0	11.7	1.9067	7.3917	16/14	0.7	34	4.9571	19.61
Silicates(SiO ₂), dissolved	mg/l	12/10	< 0.5	8.1	3.188	6.008	15/15	1.29	11.4	3.386	8.9
Macrozoobenthos- saprobic index		26/20	0.43	2.348	0.43	2.328	37/36	0.36	3.234	0.36	2.717

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2019 (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 - Dissolved *	µg/l	68/38	< 0.5	423.00	< 1.0	119.16	73/71	0.29	261.70	< 0.5	77.38
Copper - Dissolved	µg/l	69/39	< 0.25	148.60	0.84	25.90	73/71	< 0.15	45.70	< 0.5	17.28
Chromium - Dissolved	µg/l	69/39	< 0.02	12.8	< 0.03	2.92	69/67	< 0.03	42.30	< 0.03	10.89
Lead - Dissolved	µg/l	67/37	< 0.025	13	0.028	4.488	61/59	< 0.005	7.98	0.07	4.63
Cadmium - Dissolved	µg/l	67/37	< 0.005	5.07	0.01	0.57	62/60	< 0.005	0.46	0.01	0.21
Mercury - Dissolved	µg/l	63/35	< 0.0025	1.36	< 0.0025	0.13	55/53	< 0.0025	0.44	< 0.0025	0.08
Nickel - Dissolved	µg/l	67/37	< 0.25	31.70	0.49	9.74	60/58	0.17	56.90	0.47	15.23
Arsenic - Dissolved	µg/l	67/37	0.46	12.58	0.63	2.95	65/63	0.24	11.43	0.37	7.64
Aluminium - Dissolved	µg/l	19/13	< 1.5	65.30	2.79	23.39	19/17	< 0.25	254.00	< 1.5	41.50
Zinc *	µg/l	23/19	< 0.5	479.00	2.61	159.52	32/30	< 0.5	361.32	3.98	115.68
Copper	µg/l	20/16	< 0.5	153.20	1.00	39.06	28/26	< 0.5	529.00	1.82	74.73
Chromium - total	µg/l	20/16	< 0.25	26.60	0.55	3.69	31/29	0.2284	66.00	0.96	16.43
Lead	µg/l	20/16	< 0.1	21.70	0.54	2.43	26/24	< 0.15	37.70	< 0.5	7.73
Cadmium	µg/l	20/16	< 0.005	1.46	0.01	0.25	32/30	< 0.01	93.06	0.03	7.83
Mercury	µg/l	16/14	< 0.01	0.15	< 0.01	0.05	35/33	< 0.005	2.42	< 0.005	0.60
Nickel	µg/l	20/16	< 0.5	127.10	1.07	20.45	33/31	< 0.25	92.80	1.01	22.34
Arsenic	µg/l	20/16	< 0.5	10.20	0.87	2.56	24/22	< 0.25	29.90	0.82	6.00
Aluminium	µg/l	8/6	< 5.0	3290.0	242.0	448.0	8/6	20.0	15500.0	175.8	3332.5
Phenol index	mg/l	34/12	< 0.0015	0.0044	< 0.0015	0.0036	17/17	< 0.0004	0.0154	< 0.0004	0.0069
Anionic active surfactants	mg/l	40/16	< 0.005	0.16	< 0.01	0.12	22/22	< 0.0025	0.05	< 0.0025	< 0.05
AOX	µg/l	14/8	2.8	67.00	5.64	17.20	14/14	< 3.0	122.00	4.30	24.67
Petroleum hydrocarbons	mg/l	33/15	< 0.0025	0.23	< 0.0025	0.10	24/24	< 0.0065	0.45	0.01	0.12
Lindane	µg/l	61/31	< 0.0003	0.06	< 0.0003	0.06	49/47	< 0.0003	5.0	< 0.0003	4.0
pp'DDT	µg/l	58/30	< 0.0002	< 0.025	< 0.0002	< 0.025	48/46	< 0.0002	5	< 0.0002	4.5
Atrazine	µg/l	57/27	< 0.0005	< 0.09	< 0.0005	< 0.09	43/41	< 0.0005	< 0.0900	< 0.0005	< 0.09
Chloroform	µg/l	12/8	< 0.081	0.5	< 0.081	0.5	22/20	< 0.015	0.75	< 0.015	0.55
Carbon tetrachloride	µg/l	12/8	< 0.05	0.5	< 0.050	0.5	22/20	< 0.05	0.50	< 0.05	0.2
Trichloroethylene	µg/l	12/8	< 0.05	0.500	< 0.050	0.5	22/20	< 0.05	0.50	< 0.05	< 0.25
Tetrachloroethylene	µg/l	12/8	< 0.05	0.50	< 0.050	0.500	22/20	< 0.05	0.50	< 0.05	< 0.25

4. Profiles and trend assessment of selected determinands

Figures 4.1-4.16 show **the development of selected determinands** (dissolved oxygen (DO), BOD₅, COD_{Cr}, N-NH₄, N-NO₃, P-PO₄, P_{total} and Cd) over last 10 years in the Danube River and also in the major tributaries by 90 percentile (c90) or 10 percentile (c10-DO).

Due to revision of the TNMN in 2006 the following monitoring points on the Danube were replaced: AT2 rkm 2120 to AT5 rkm 2113, AT4 rkm 1874 to AT6 rkm 1879 and 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 in graphs also illustrated as Hungarian site HU3. For trend graphs illustration of SK5 and HU3 was used.

The long-term trends in the upper, middle and lower Danube and more detailed example of analysis for selected parameters (BOD₅, N-NO₃, 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 2019 the **highest concentrations of biodegradable organic matter** were observed in the middle and lower parts of the Danube River with the maximum 12.7 mg.l⁻¹ (BG2 Danube – us. Iskar-Bajkal).

Taking into account the entire period of TNMN monitoring positive changes in water quality can be seen at several TNMN stations. Decreasing tendencies of biodegradable organic matter in 2019 were observed in the middle Danube, at the monitoring sites HU5, HR1, RS1, and RS2 (see Figure 4.3).

The decrease of the BOD₅ has been observed in some tributaries: Morava, Dyje, Russenski Lom and Jantra (Figure 4.4). In 2019 concentration of BOD₅ has increased in Germany (DE3-Inn, DE4-Inn/Salzach), Hungarian Sajo (HU8) and Croatian Drava (HR9). Maximal concentration was in Sajo (HU8, 17.3 mg.l⁻¹).

At selected monitoring point SK1 BOD₅ level was the same as in 2018. In HU5 decreased and RO5 BOD₅ increased slightly in 2019 (Figure 4.17-4.19).

The highest values of **dissolved oxygen (DO)** in the Danube River were observed in its upper part (maximum: DE5 Danube – Dillingen 9.6 mg.l⁻¹), in the lower Danube dissolved oxygen levels decreased, minimum was 4.5 mg.l⁻¹ in BG2 Danube – us. Iskar-Bajkal (Figure 4.1).

Maximum value of dissolved oxygen in tributaries was in DE4 (10.5 mg.l⁻¹). The minimal concentration in was in HU6 Sio - 5.4 mg.l⁻¹. The concentrations have a stable character (Figure 4.2).

Concentrations of **chemical oxygen demand (COD_{Cr})** (Figure 4.5 and Figure 4.6) show the difference in pollution between the Danube River and tributaries. The concentrations in tributaries are higher (range of c90 values 5 - 63.9 - mg.l⁻¹ with maximum in BG15 (Russenski Lom-mouth), than in the Danube River sites (range of c90 values 2.6 - 39.7 mg.l⁻¹), maximum in BG2 Danube – us. Iskar-Bajkal.

The almost stable level of **ammonium-nitrogen** concentrations (c90) was recorded in the whole Danube River. In the lower part of Danube concentrations decrease in monitoring points BG5, RO5, RO6, RO7, RO8 (Figure 4.7).

In 2019, compared to previous year, concentrations of ammonium- nitrogen increased in tributaries Morava, Sio and Sava (see Figure 4.8, CZ1, HU8, RS13, and RS15). The concentration of ammonium-nitrogen decreased in 2019 in Russenski Lom and Arges (Figure 4.8).

The level of **nitrate-nitrogen** concentrations is rather stable during recent years. In comparison with the previous year, nitrate-nitrogen concentrations increased in the upper part of the Danube River at monitoring points DE5, DE2, AT1, AT5, AT6 (see Figure 4.9). A slight increase of nitrate-nitrogen concentrations was also observed at few stations in the middle and lower Danube. Maximal concentration was detected at DE5 3.8 mg.l⁻¹.

As for the tributaries, in Russenski Lom and Jantra the nitrate-nitrogen concentration slightly decreased in 2019. An increase was observed in Dyje, Prut, Tisza, Vah and Sio (Figure 4.10).

Temporal changes of nitrate-nitrogen (presented in the Figures 4.20 – 4.22 for the Danube River at Bratislava (Slovakia), Hercegszanto (Hungary) and Reni (Romania) indicate increase at all monitoring points. The lowest value of c90 (in 2019) was 1.62 mg.l⁻¹ in Reni.

The data for **ortho-phosphate-phosphorus** concentrations in the Danube River presented in Figure 4.11 show a stable situation in 2019. An increase of ortho-phosphate-phosphorus was observed in the RS8 (Danube-Radujevac) which is the highest value in 2019 (0.12 mg.l⁻¹).

The increase of ortho-phosphate-phosphorus concentrations was observed in the tributaries Dyje, Sio, Russenski Lom, Prut and Jantra. Maximum ortho-phosphate-phosphorus concentration of 0.66 mg.l⁻¹ was observed in MD1 being an exceptional increase since the last year (Figure 4.12).

In 2019, most of the monitoring sites on the upper and middle Danube River show a stable situation concerning **total phosphorus** levels (Figure 4.13), certain increase was observed in HU1, HU2, HU3, HU4, RS1 and RS2.

The values of total phosphorus c90 in tributaries in 2019 show an increase at DE4, CZ2, HU6, HU7, BG15 and MD1 (Figure 4.14). The highest total phosphorus (c90) concentration among all tributaries in 2019 was detected at DE4 Salzach River (1.27 mg.l⁻¹). This was caused by high water conditions.

The temporal changes of total phosphorus (c90) at selected monitoring sites in Figures 4.23-4.25, show a decreasing tendency over 2018 and 2019.

The **cadmium** concentration (Figure 4.15) is constant or slightly decreasing along the Danube River. The maximum value of c90 was 0.22 mg.l⁻¹ at HU5 Hercegszanto in 2019. Higher concentrations were detected in tributaries, with the maximum c90 2.4 mg.l⁻¹ in Prut river (MD3). The extreme cadmium c90 concentration of 89.2 mg.l⁻¹ observed at HU9 (Tisza-Tiszasziget) in 2018 decreased to 0.21 mg.l⁻¹ in 2019.

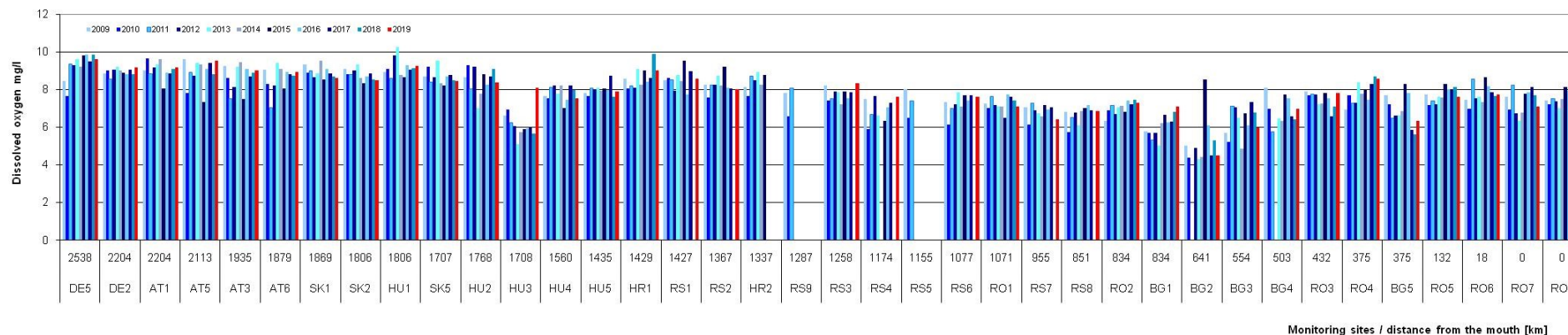
The comparison of statistical characteristics 90 and 10 percentiles (C90, c10) in 2019 for selected determinands (N-NH₄, P-PO₄, COD_{Cr}, BOD₅) are displayed in the Figures 4.26-4.33. These charts indicate the ranges of annual concentrations for a given parameter and monitoring site. In graphs for the tributaries the rkm of the Danube are indicated, at which the respective tributary enters the Danube River.

The annual differences between C90 and C10 have an insignificant variation for COD_{Cr}, P-PO₄, N-NH₄ and BOD₅ in the in upper and middle Danube. The visible differences were observed N-NH₄ and P-PO₄ in the middle and lower part of the Danube. The highest difference was observed for COD_{Cr} and BOD₅ at BG2.

The 10 and 90 percentile values fluctuate for COD_{Cr} and BOD₅ in all tributaries. The significant differences for the COD_{Cr} were observed in the lower tributaries Mures, Ialomita, Somes, and Siret. For the BOD₅ differences were visible also in the upper and middle tributaries Salzach, Sajo, Szamos, Sava, Una and at RO12 and RO15.

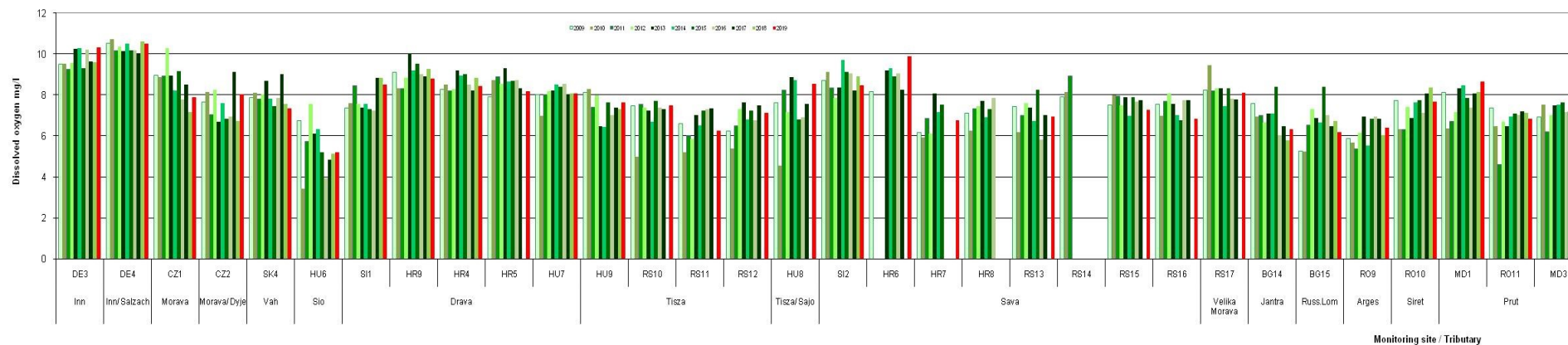
The differences in concentrations for ammonium-nitrogen are visible in the tributaries Somes, Arges, Ialomita, and Prut. For the ortho-phosphate-phosphorus the more significant differences were observed in the tributaries Dyje, Sio and Prut.

Figure 4.1.: Temporal changes (2009-2019) of dissolved oxygen (c10) in the Danube River



Monitoring sites / distance from the mouth [km]

Figure 4.2.: Temporal changes (2009-2019) of dissolved oxygen (c10) in tributaries



Monitoring site / Tributary

Figure 4.3.: Temporal changes (2009-2019) of BOD₅ (c90) in the Danube River.

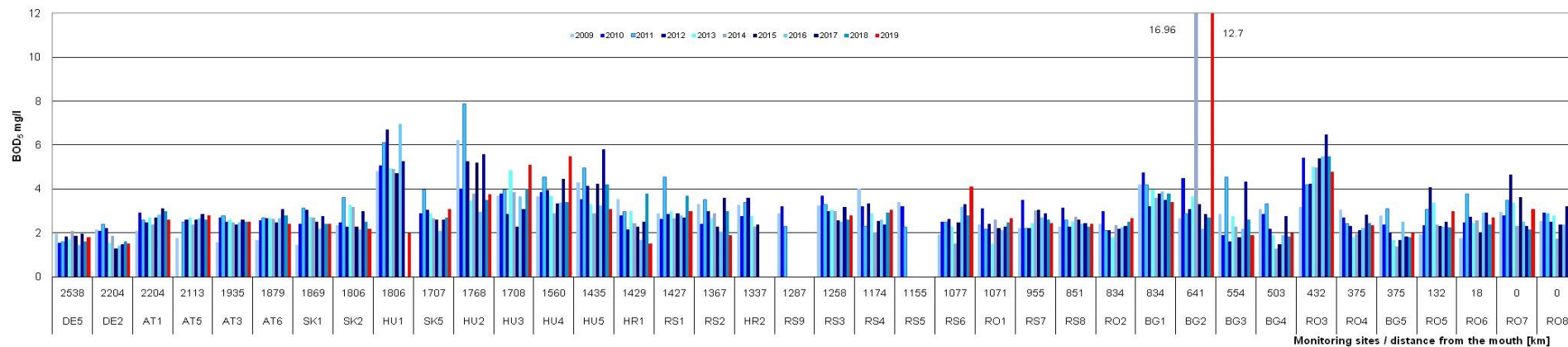


Figure 4.4.: Temporal changes (2009-2019) of BOD₅ (c90) in tributaries.

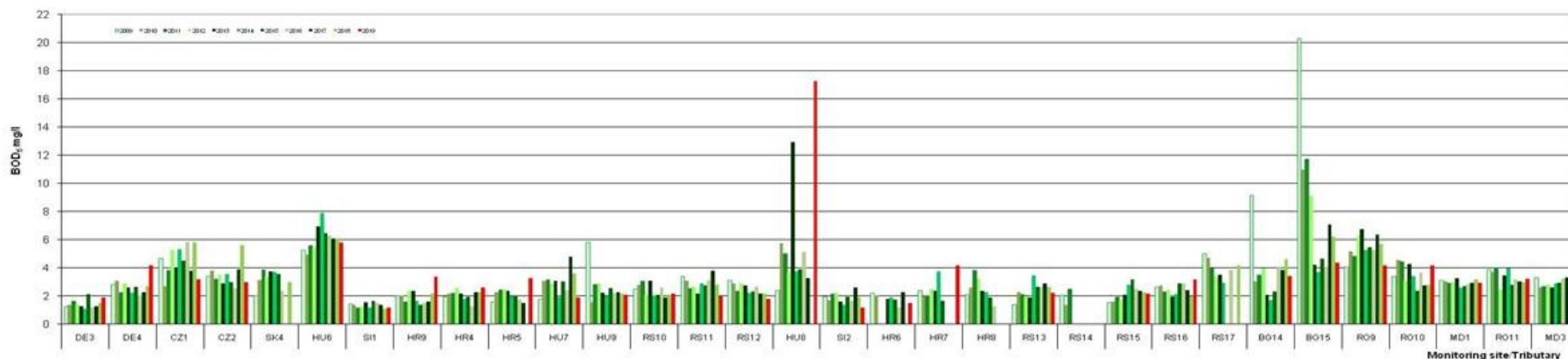


Figure 4.5.: Temporal changes (2009-2019) of COD_{Cr}(c90) in the Danube River.

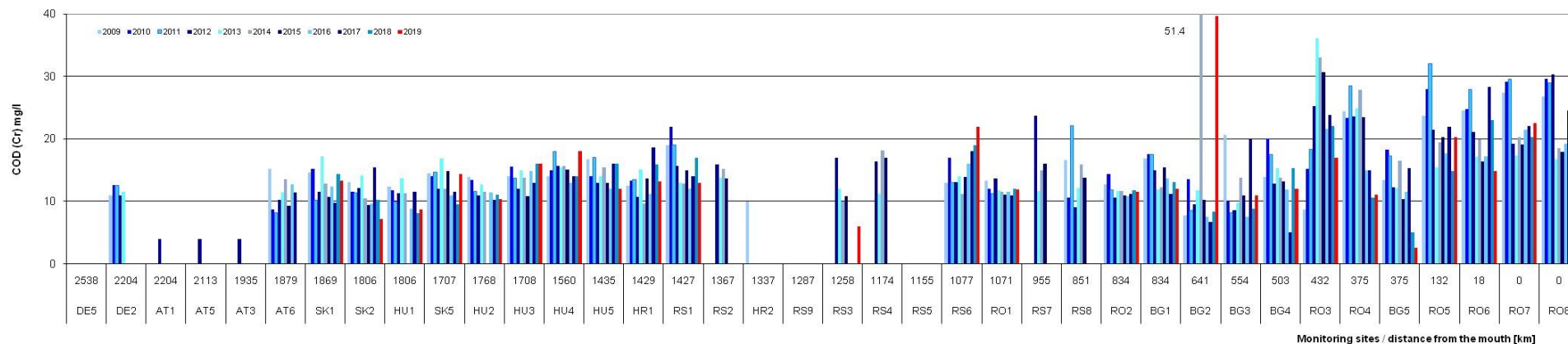


Figure 4.6.: Temporal changes (2009-2019) of COD_{Cr}(c90) in tributaries.

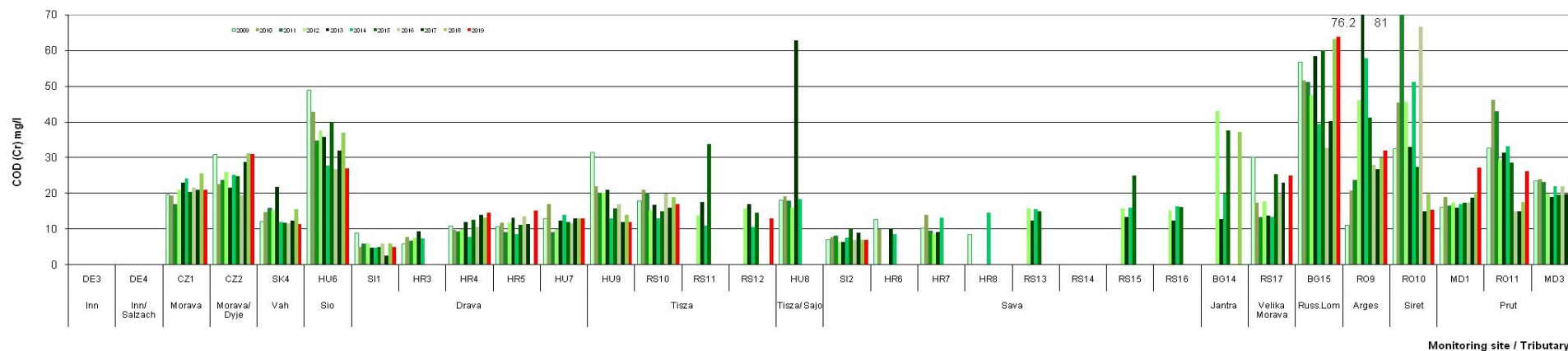


Figure 4.7.: Temporal changes (2009-2019) of NH₄-N (c90) in the Danube River.

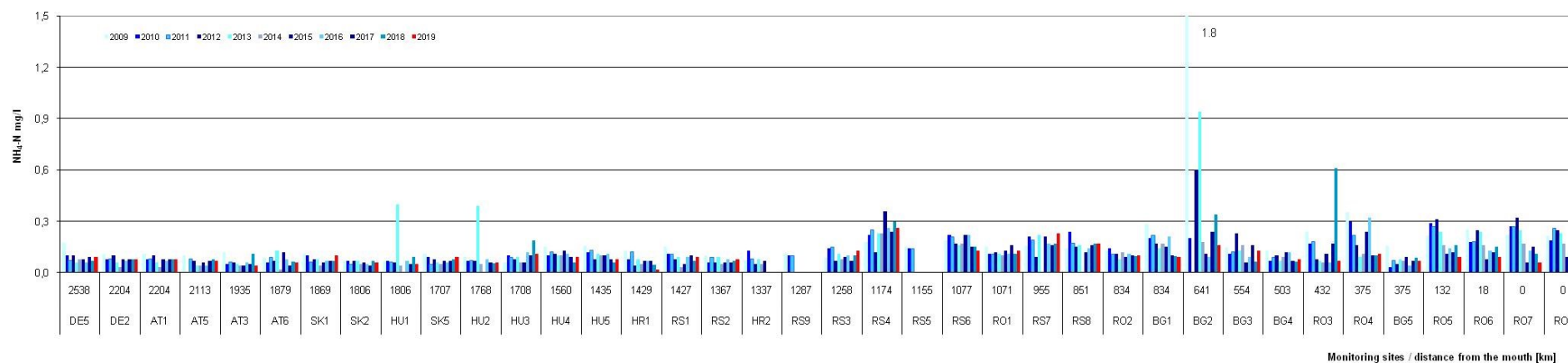


Figure 4.8.: Temporal changes (2009-2019) of NH₄-N (c90) in tributaries.



Figure 4.9.: Temporal changes (2009-2019) of NO₃-N (c90) in the Danube River.

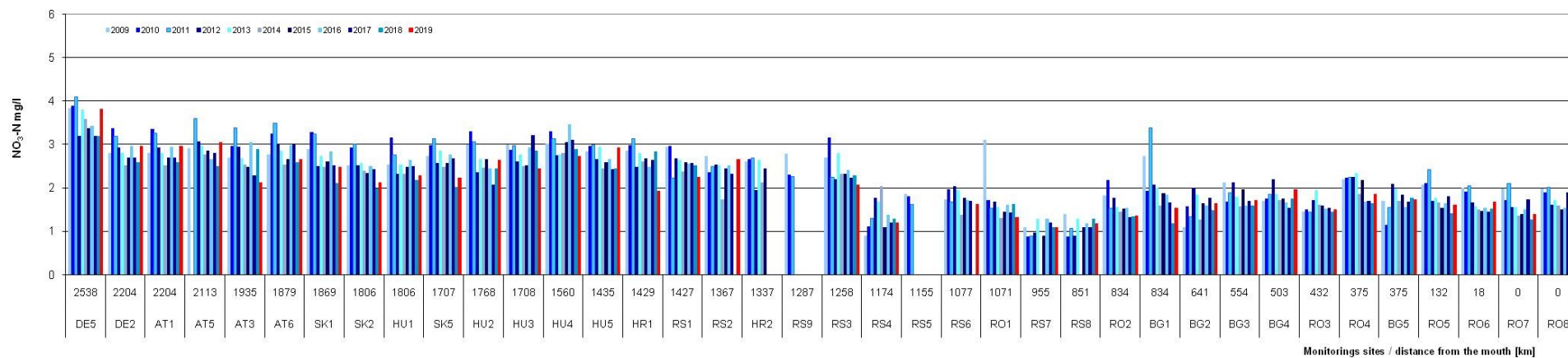


Figure 4.10.: Temporal changes (2009-2019) of NO₃-N (c90) in tributaries.

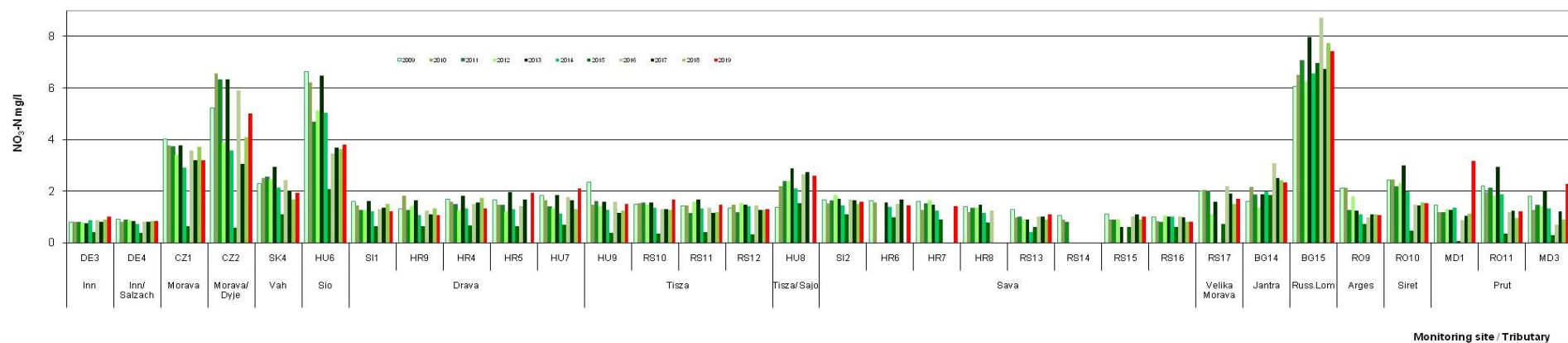


Figure 4.11.: Temporal changes (2009-2019) of o-PO₄-P (c90) in the Danube River.

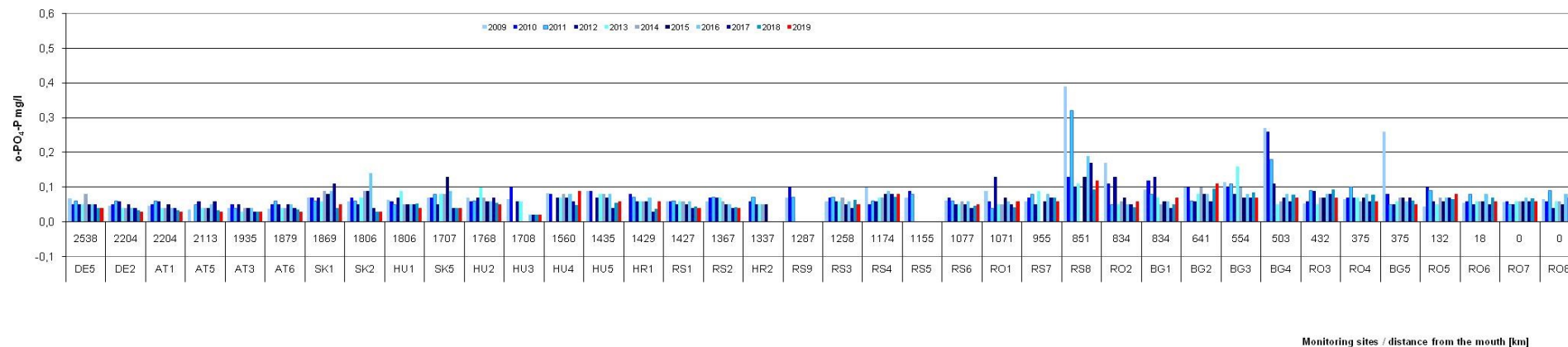


Figure 4.12.: Temporal changes (2009-2019) of o-PO₄-P (c90) in tributaries

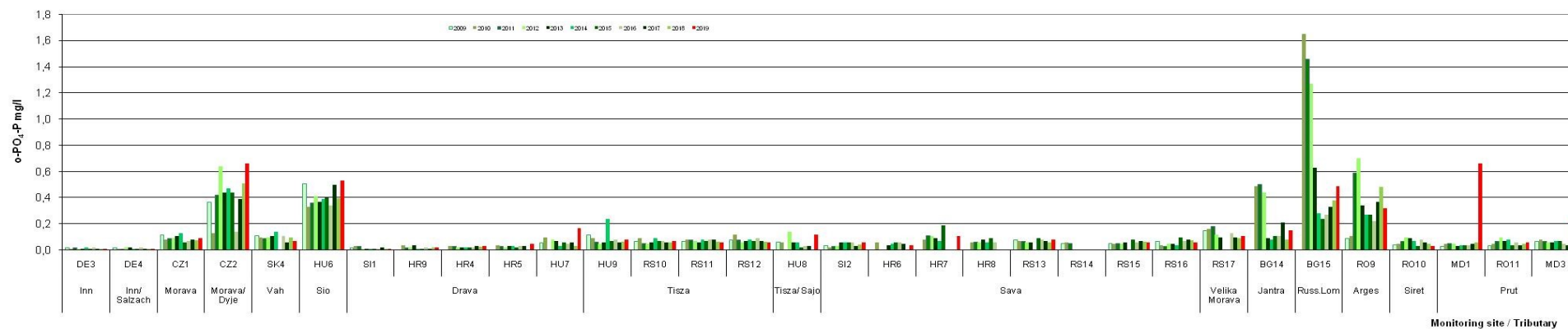


Figure 4.13.: Temporal changes (2009-2019) of total phosphorus (c90) in the Danube River.

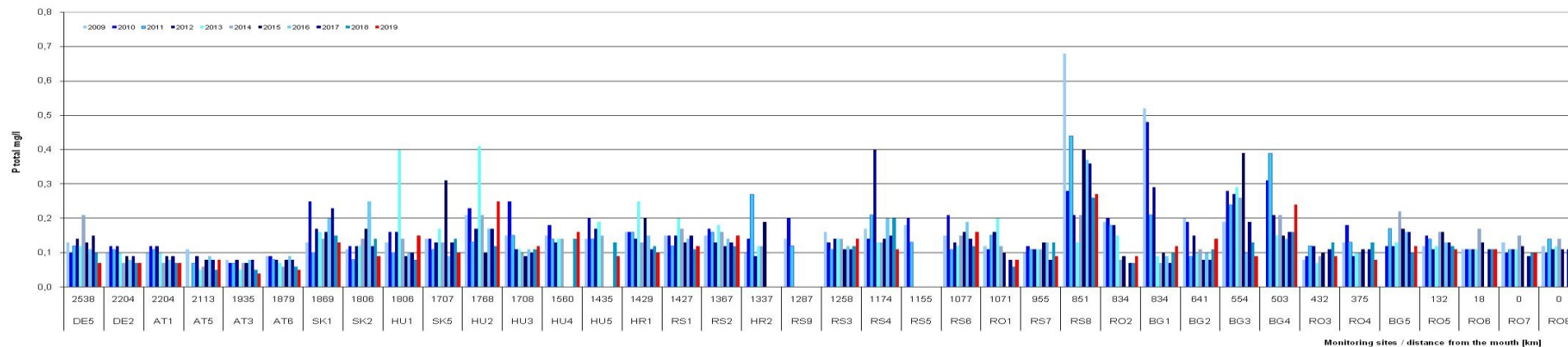


Figure 4.14.: Temporal changes (2009-2019) of total phosphorus (c90) in tributaries.

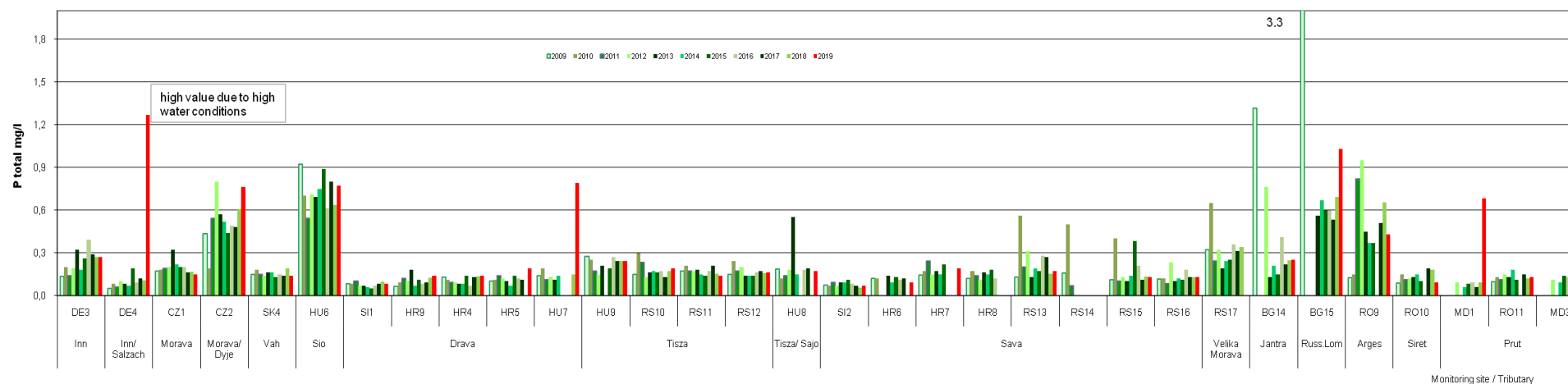


Figure 4.15.: Temporal changes (2009-2019) of cadmium (c90) in the Danube River.

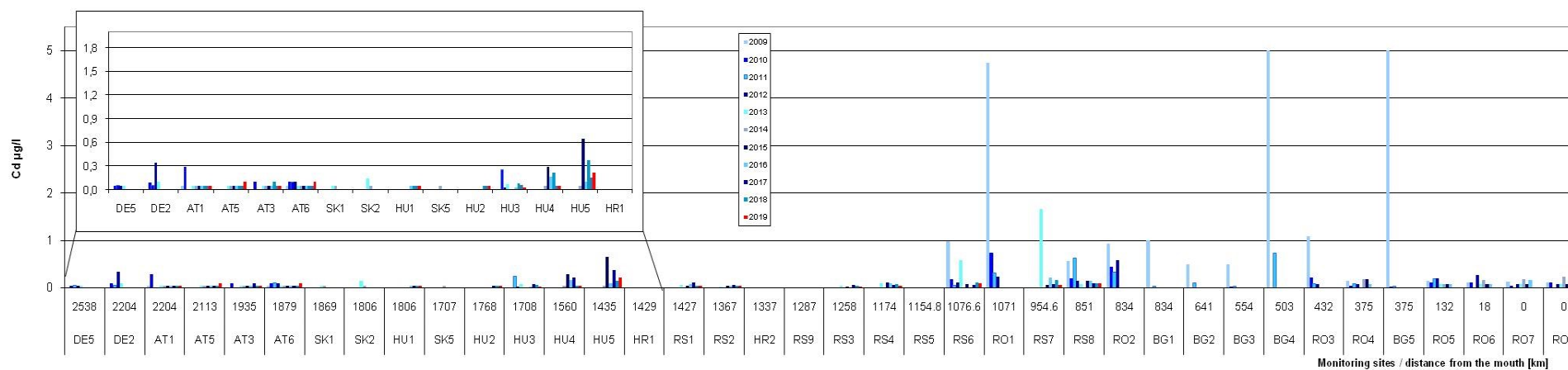


Figure 4.16.: Temporal changes (2009-2019) of cadmium (c90) in tributaries.

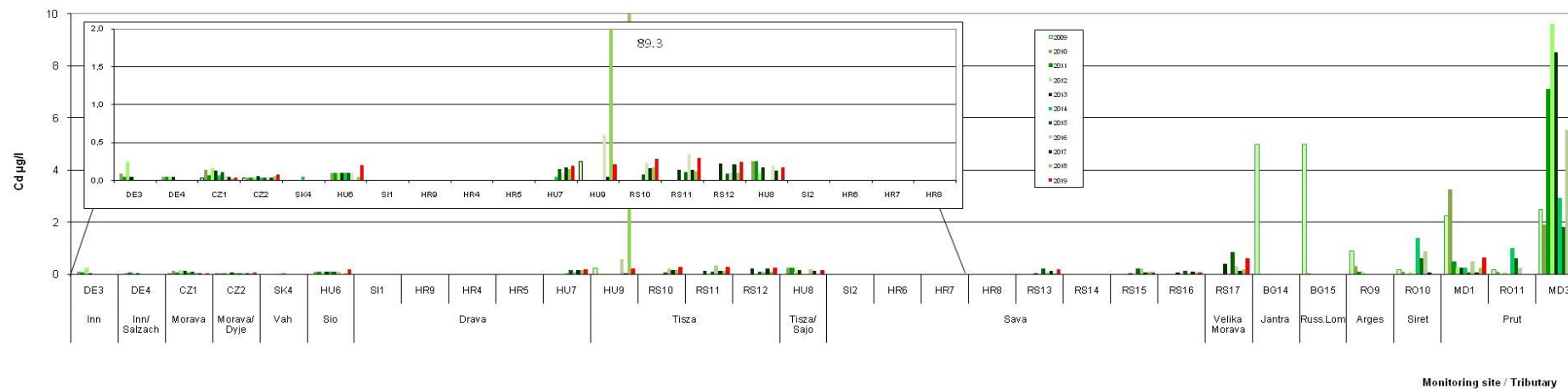


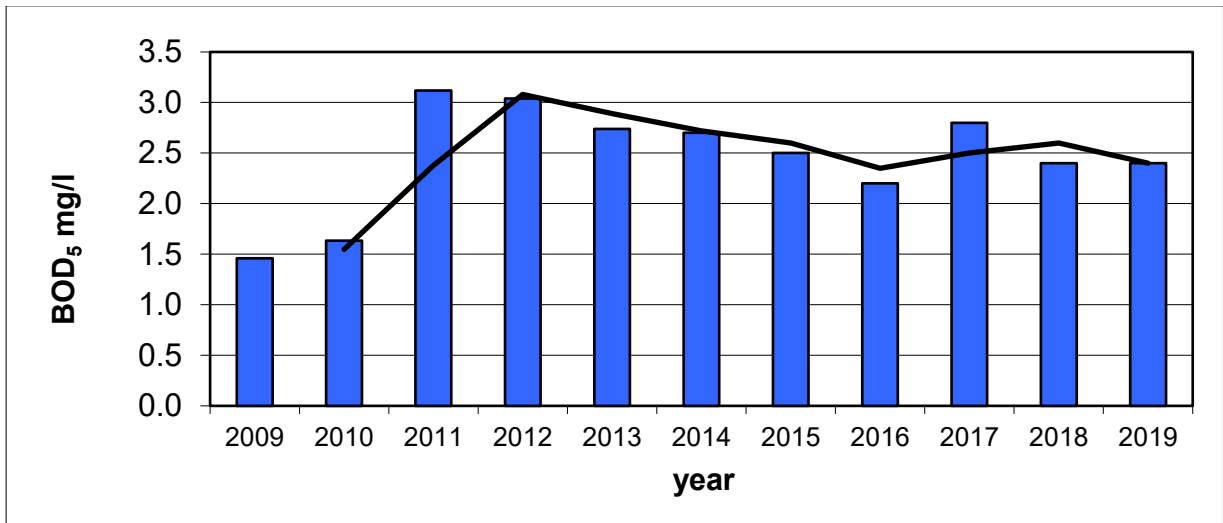
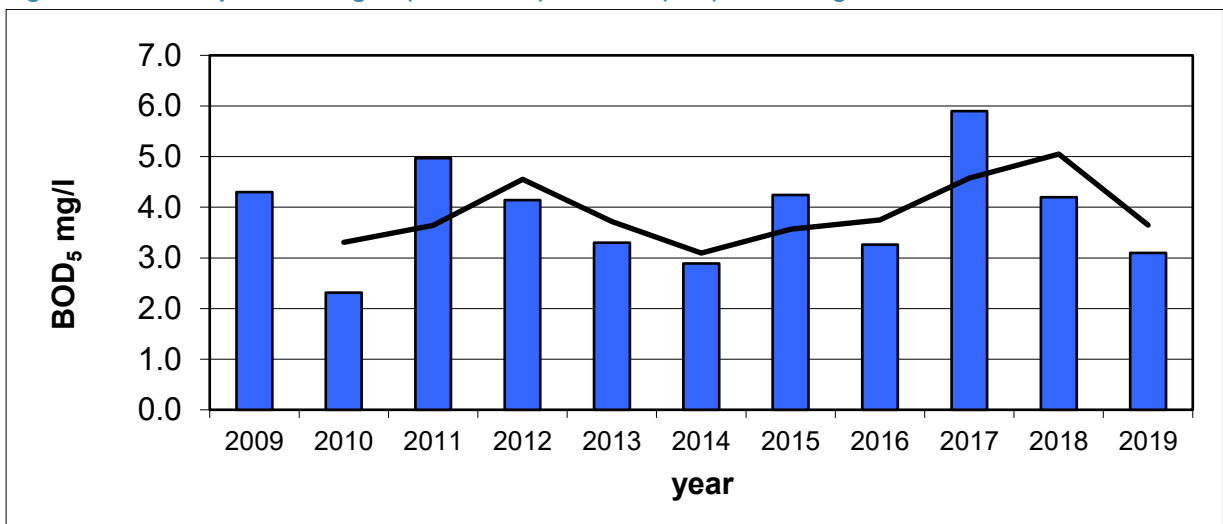
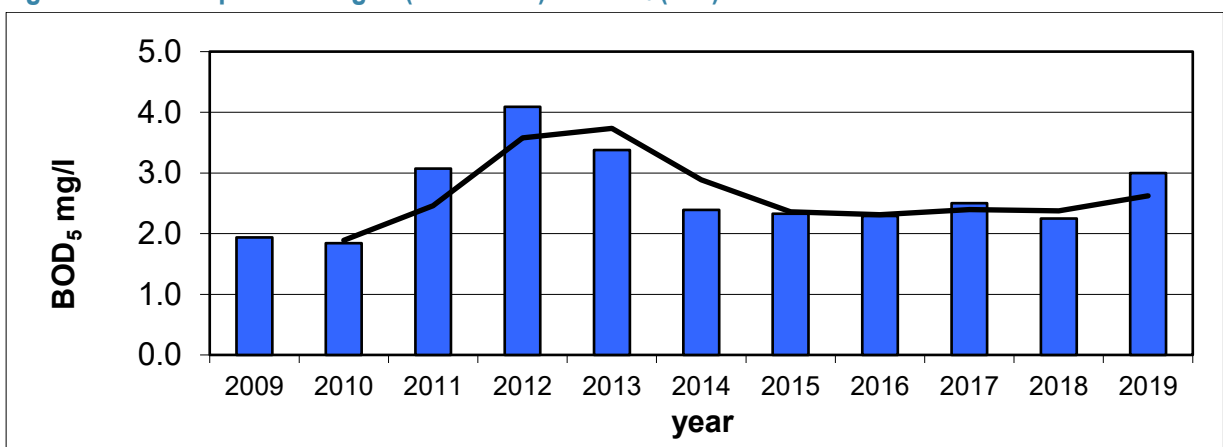
Figure 4.17.: Temporal changes (2009-2019) of BOD₅ (c90) in BratislavaFigure 4.18.: Temporal changes (2009-2019) of BOD₅ (c90) in HercegszantoFigure 4.19.: Temporal changes (2009-2019) of BOD₅ (c90) in Reni

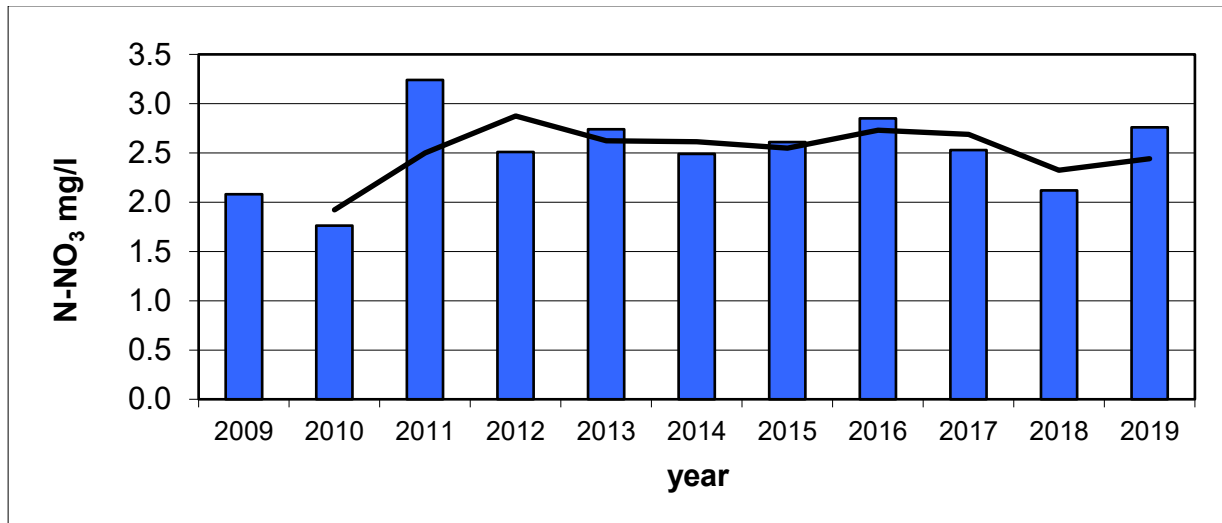
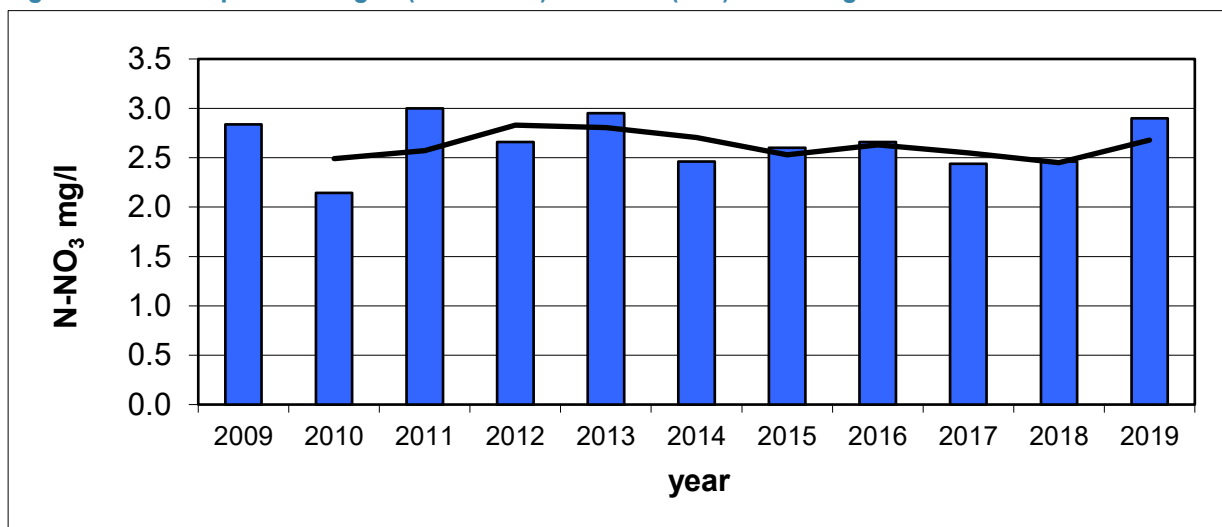
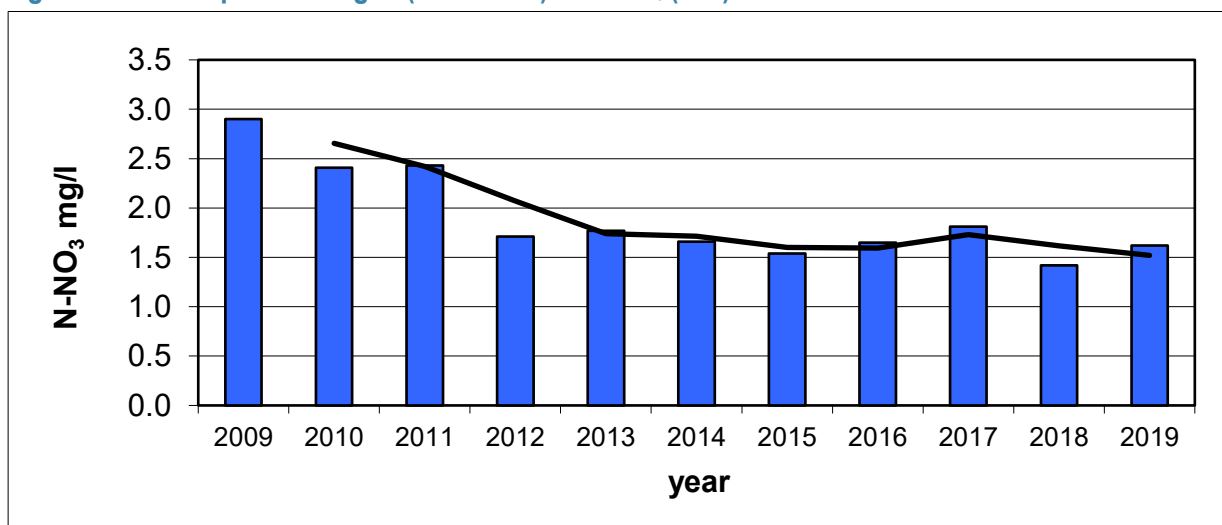
Figure 4.20.: Temporal changes (2009-2019) of N-NO₃ (c90) in BratislavaFigure 4.21.: Temporal changes (2009-2019) of N-NO₃ (c90) in HercegszantoFigure 4.22.: Temporal changes (2009-2019) of N-NO₃ (c90) in Reni

Figure 4.23.: Temporal changes (2009-2019) of total phosphorus (c90) in Bratislava

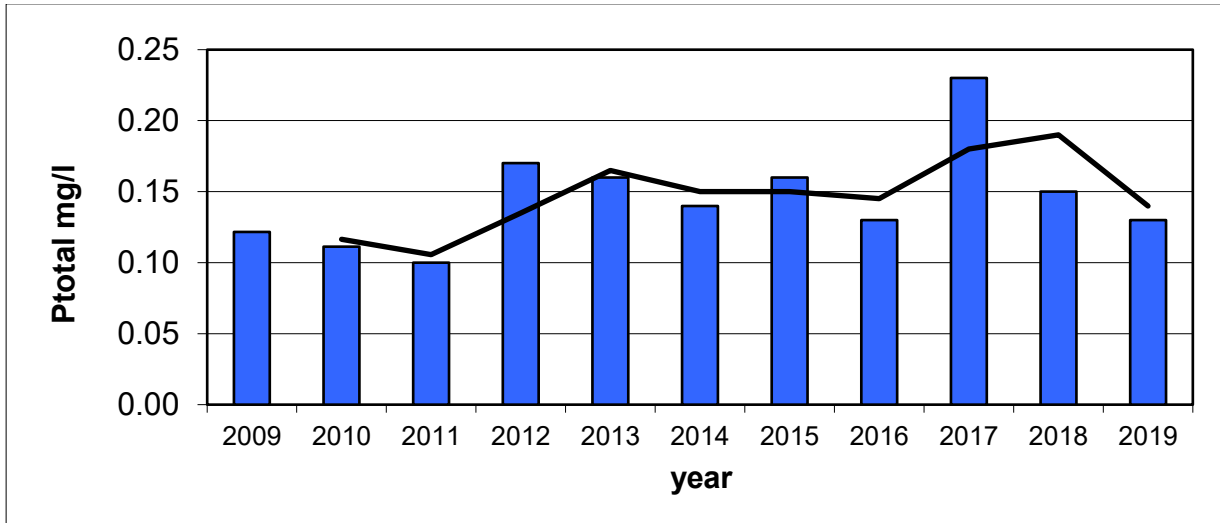


Figure 4.24.: Temporal changes (2009-2019) of total phosphorus (c90) in Hercegszanto

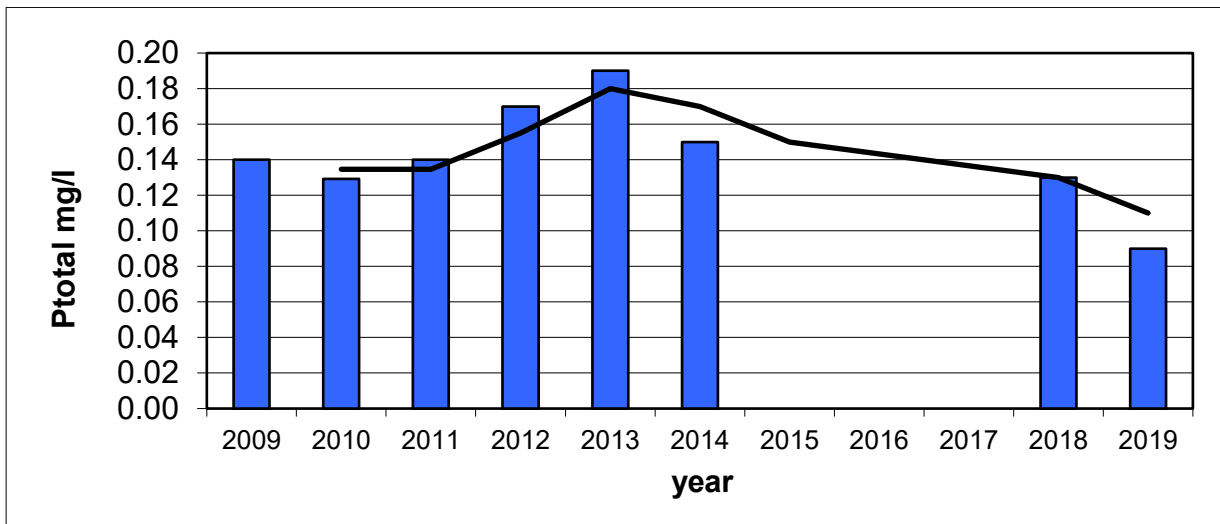


Figure 4.25.: Temporal changes (2009-2019) of total phosphorus (c90) in Reni

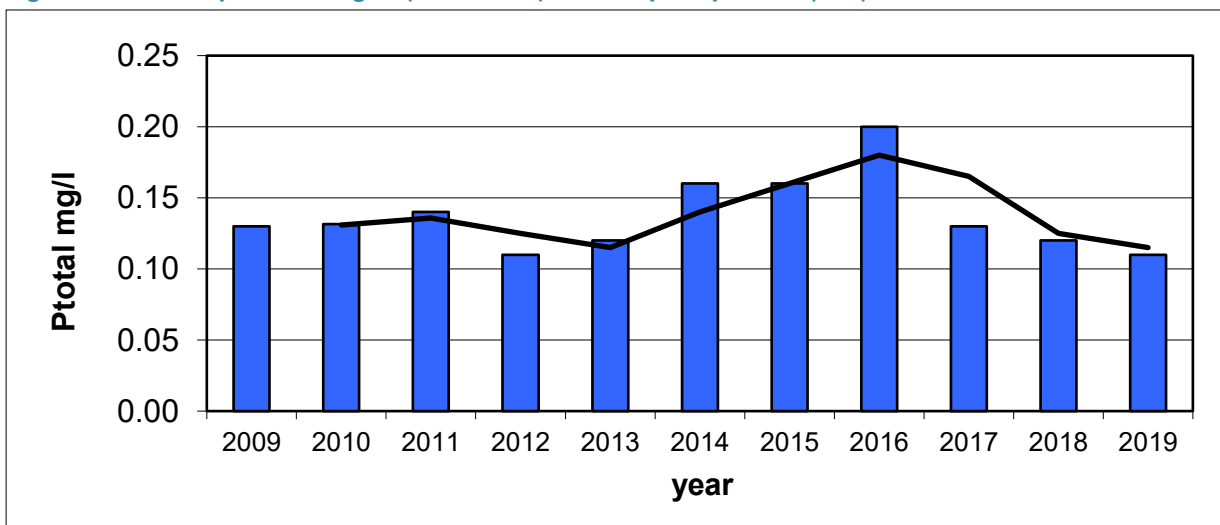


Figure 4.26.: The percentile (90, 10) of N-NH₄ concentration along the Danube River in 2019

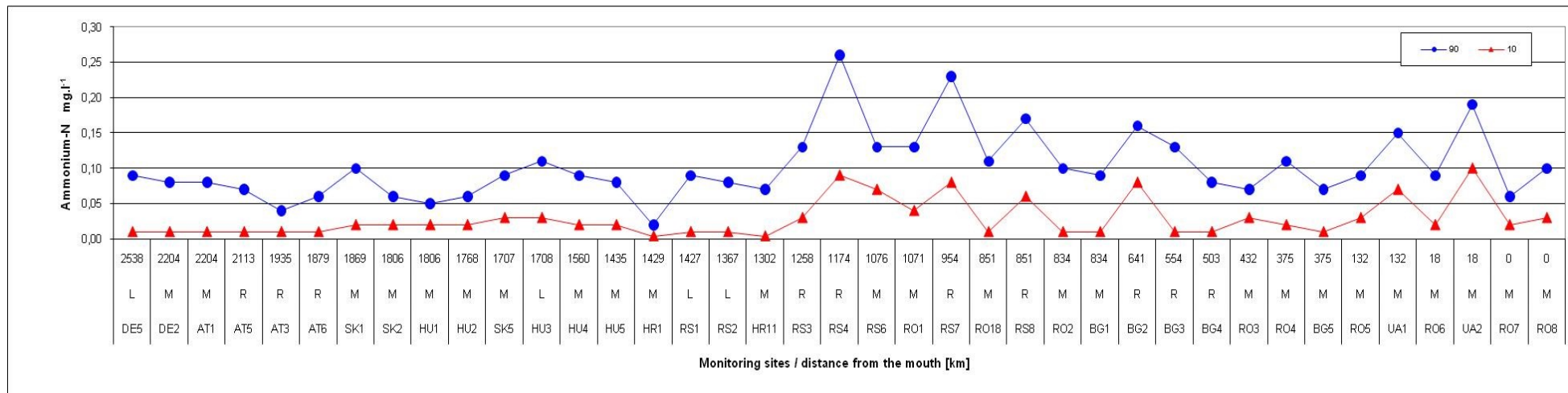


Figure 4.27.: The percentile (90, 10) of N-NH₄ concentration in the tributaries in 2019

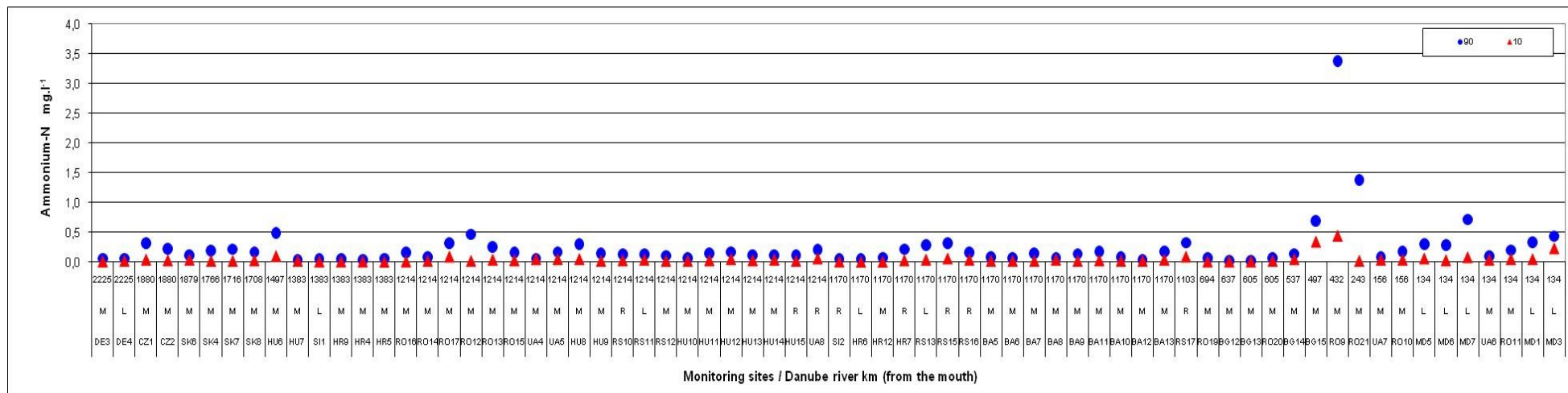


Figure 4.28.: The percentile (90, 10) of o P-PO₄ concentration along the Danube River in 2019

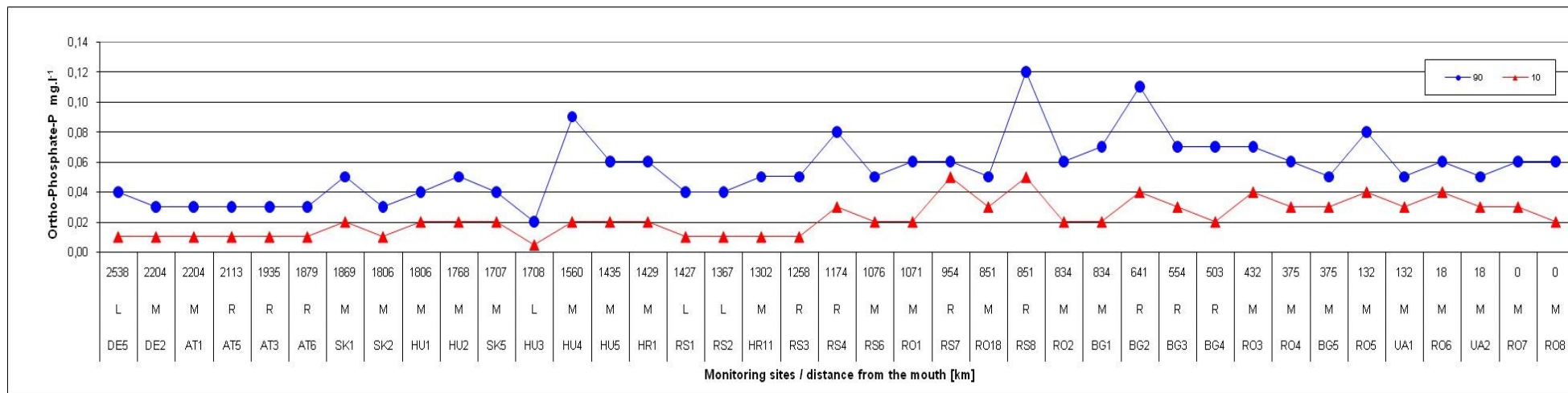


Figure 4.29.: The percentile (90, 10) of P-PO₄ concentration in the tributaries in 2019

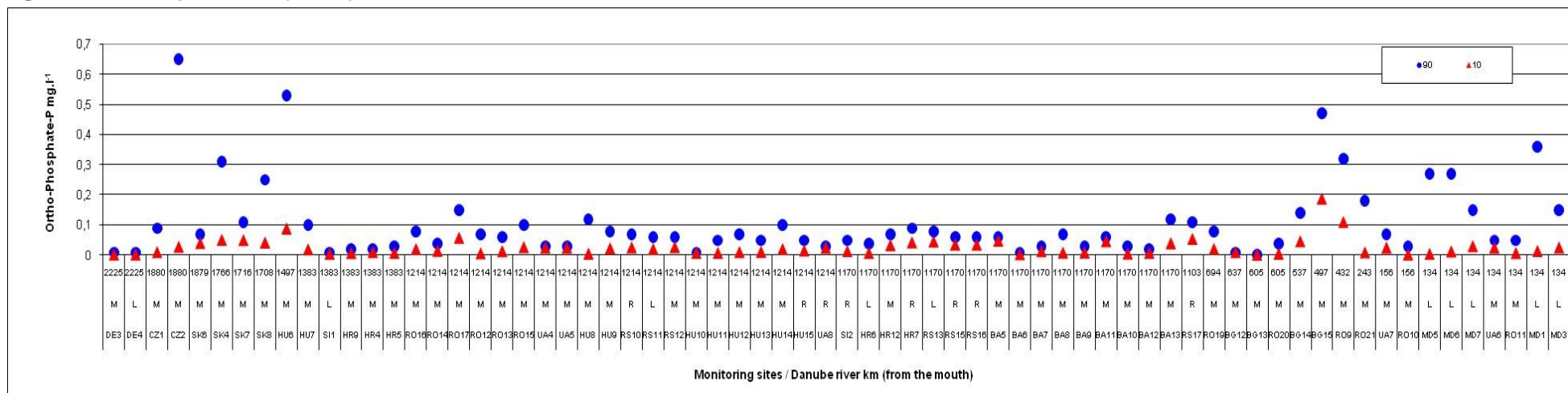


Figure 4.30.: The percentile (90, 10) of COD_{Cr} concentration along the Danube River in 2019

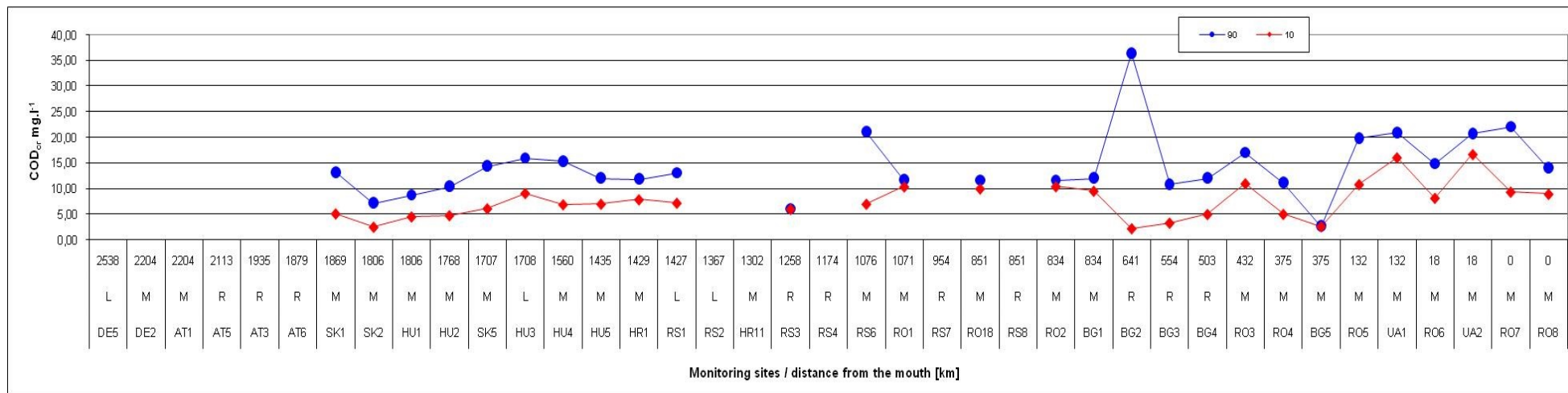


Figure 4.31.: The percentile (90, 10) of COD_{Cr} concentration in the tributaries in 2019

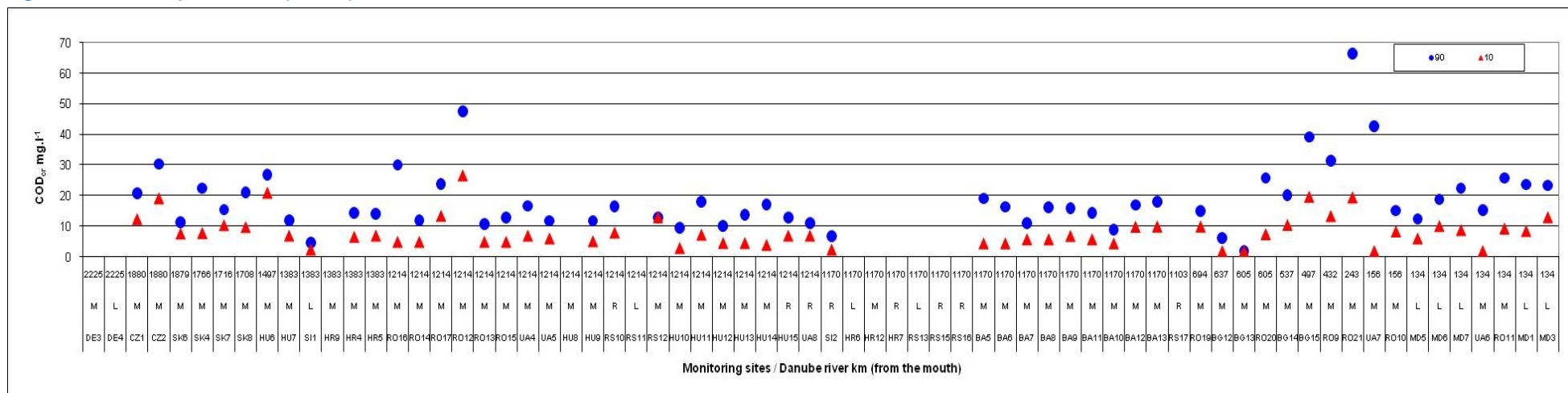


Figure 4.32.: The percentile (90, 10) of BOD₅ concentration along the Danube River in 2019

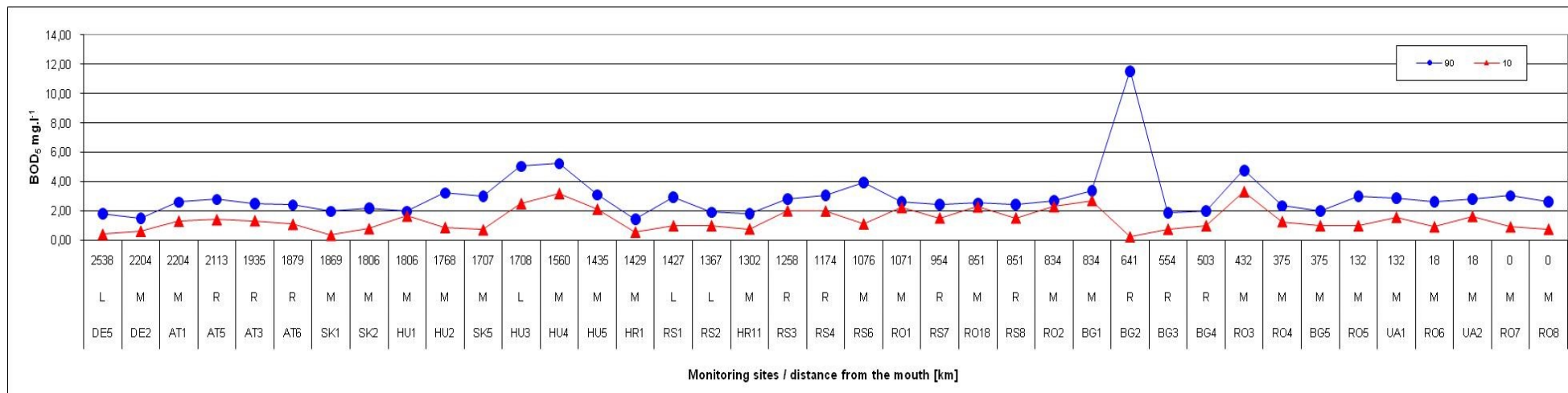
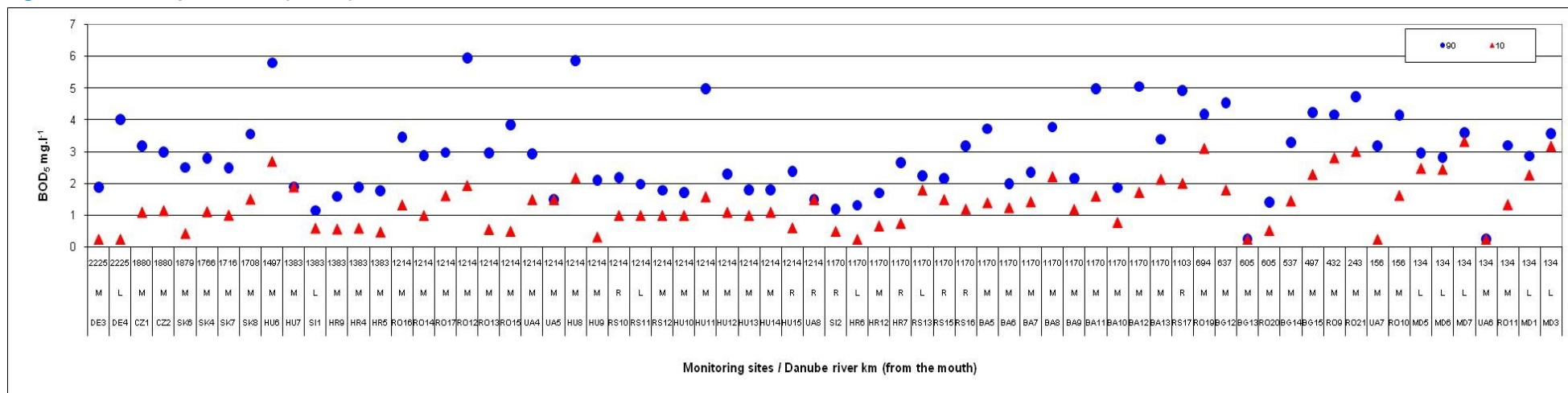


Figure 4.33.: The percentile (90, 10) of BOD₅ concentration in the tributaries in 2019--



4.1 Saprobic index based on macrozoobenthos

The maximum values of saprobic index based on macrozoobenthos 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 2019 for 19 monitoring points located in the Danube River and for 36 monitoring points in tributaries. The maximal value of saprobic index was determined in RO6 Vilkova-Chilia arm and in RO16 Mures tributary.

Figure 4.34.: The maximum values of saprobic index based on macrozoobenthos along the Danube River in 2019

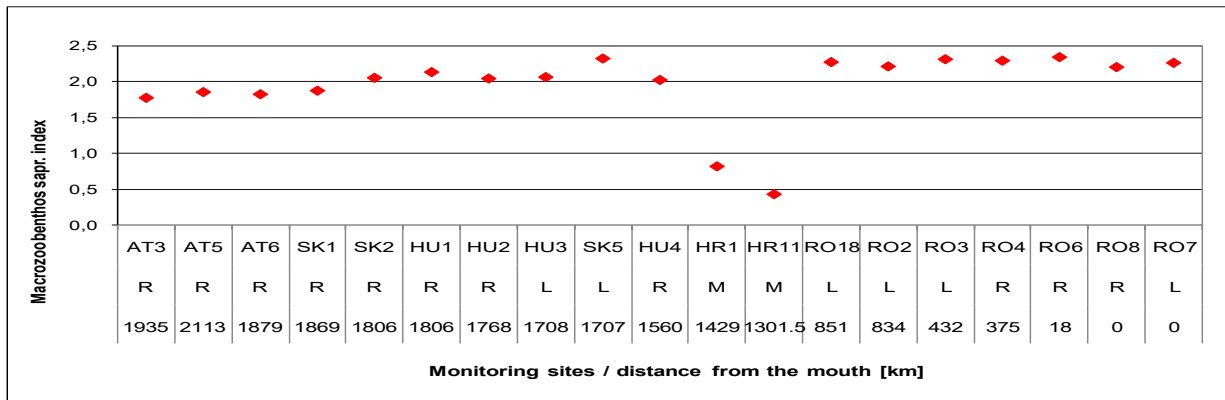


Figure 4.35.: The maximum values of saprobic index based on macrozoobenthos in the tributaries in 2019

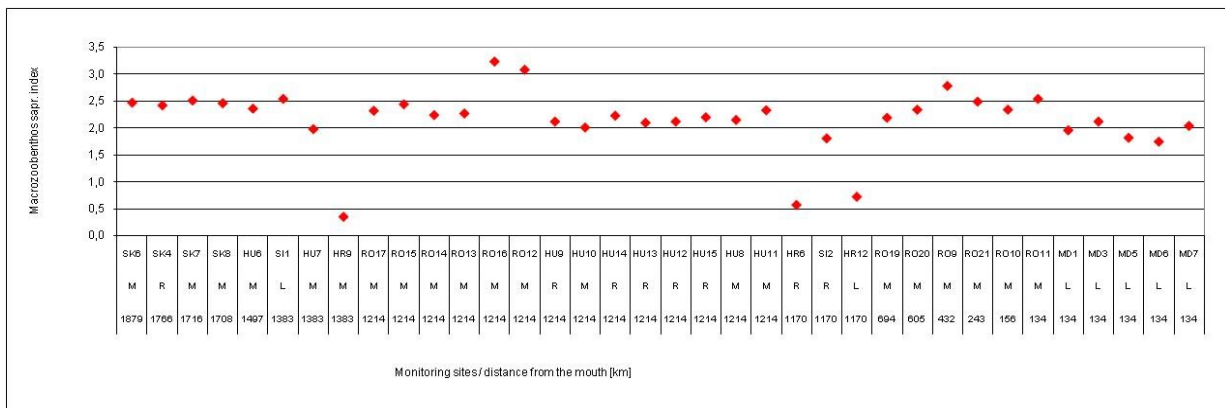
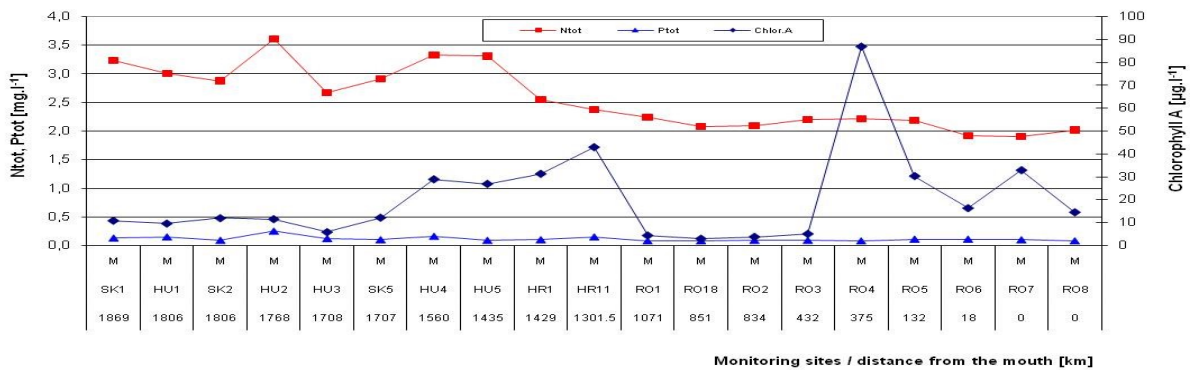


Figure 4.36.: The percentile (90) of total nitrogen, total phosphorus and chlorophyll-a concentration along the Danube River in 2019.



The concentrations of nutrients (N_{tot} , P_{tot}) and the **chlorophyll-a** are presented in the Figure 4.36 (indicating only monitoring points where all three determinands were measured). The maximal

concentration of **chlorophyll-a** ($86.82 \mu\text{g.l}^{-1}$) was observed in RO4 Chiciu. The highest concentration of N_{total} and P_{total} was observed at HU2 Komarom ($\text{N}_{\text{total}} 3.6 \text{ mg.l}^{-1}$ and $\text{P}_{\text{total}} 0.25 \text{ mg.l}^{-1}$).

4.2 The Sava and Tisza Rivers

The 90 percentiles of nutrients, and BOD_5 measured in 2019 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 RS15 (0.31 mg.l^{-1}). The maximum concentration of N-NO_3 was observed in SI2 (Jesenice, 1.57 mg.l^{-1}) and the highest value of N_{total} was measured in RS13 (Jamena, 4.19 mg.l^{-1}).

The highest value of BOD_5 in the Sava River was measured in monitoring point BA11 Raca (4.99 mg.l^{-1}). The maximum value of COD 19.2 mg.l^{-1} was measured in BA5 Gradiska.

Figure 4.37.: The percentile (90) of total nitrogen, N-NH_4 and N-NO_3 concentration along the Sava River in 2019

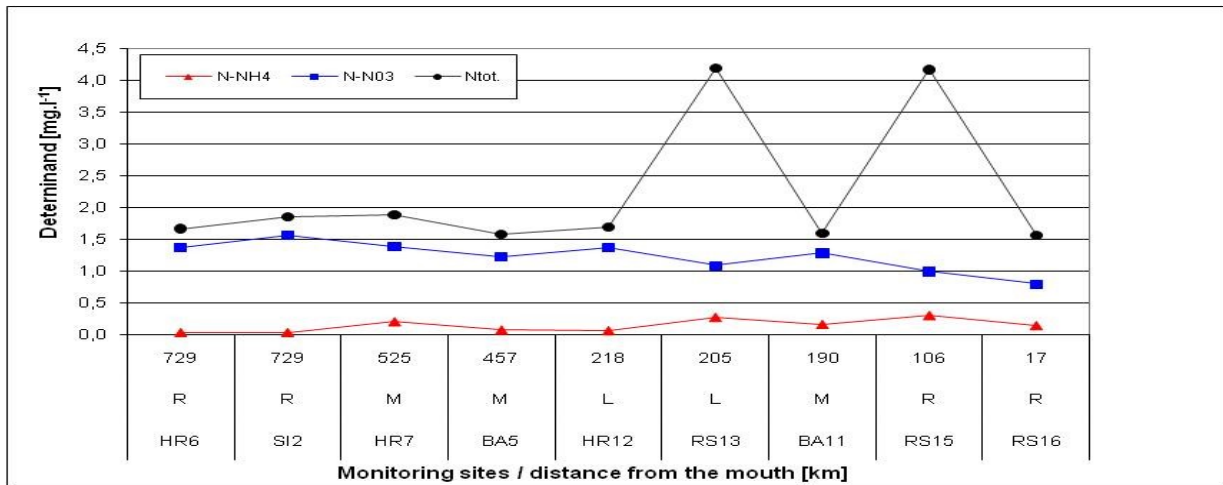


Figure 4.38.: The percentile (90) of BOD_5 concentration along the Sava River in 2019

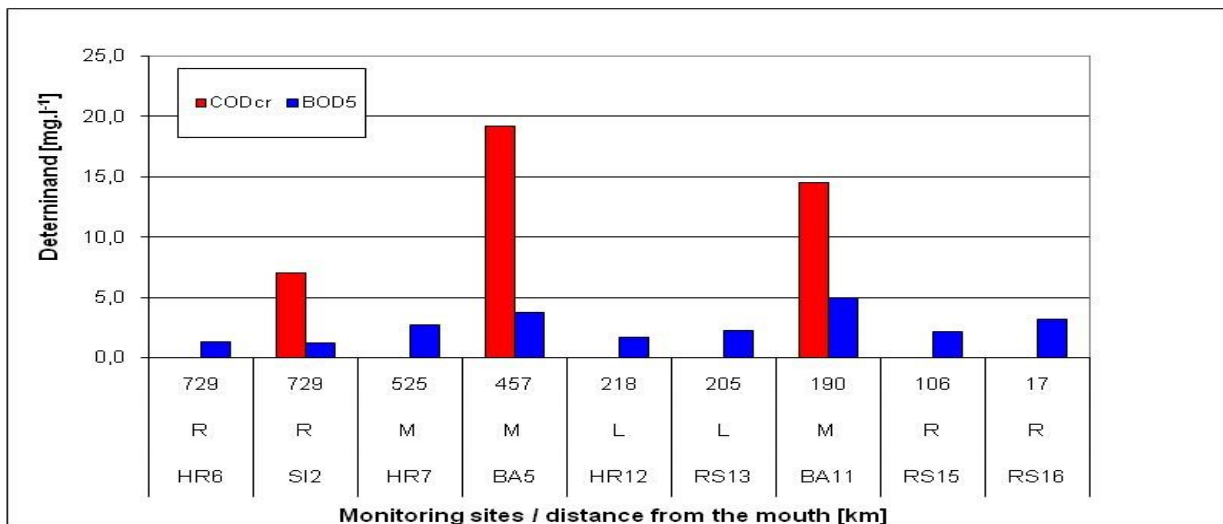


Figure 4.39.: The percentile (90) of total nitrogen, N-NH₄ and N-NO₃ concentration along the Tisza River in 2019

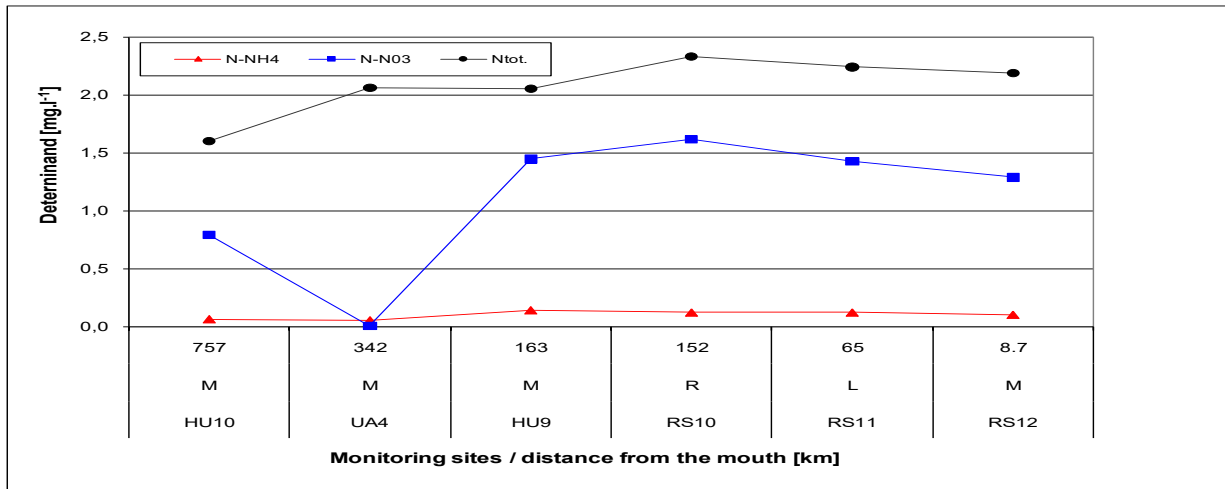
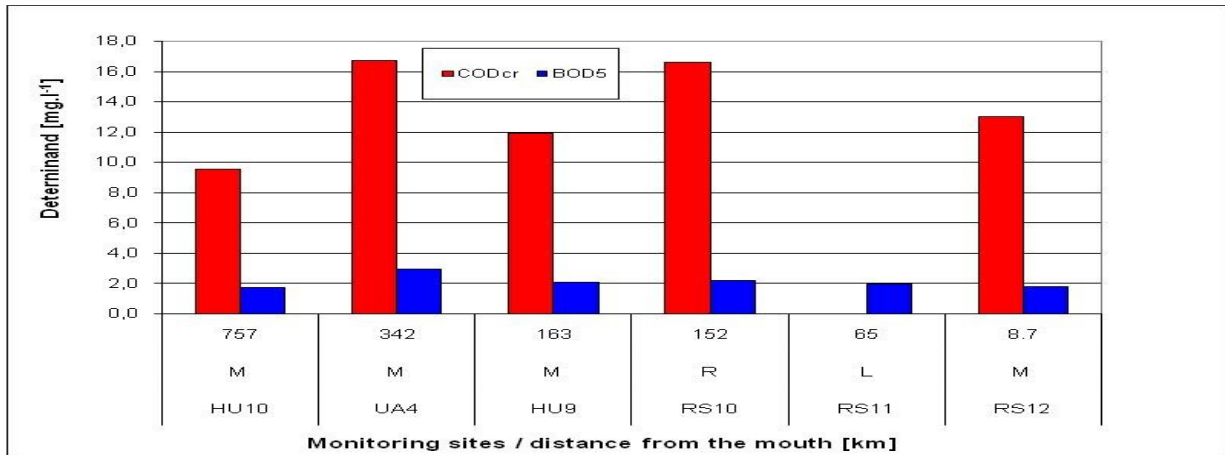


Figure 4.40.: The percentile (90) of BOD₅ and COD_{Cr} concentration along the Tisza River in 2019



The maximum value of N-NH₄ in the Tisza River was in HU9 Tiszasziget (0.14 mg.l⁻¹). The highest value of N-NO₃ and N_{total} were measured in RS10 Martonos (1.62 mg.l⁻¹ and for total nitrogen 2.33 mg.l⁻¹).

The highest value of COD_{Cr} and maximum of BOD₅ was measured in UA4 Chop (COD_{Cr} 16.75 mg.l⁻¹ and BOD₅ 2.94 mg.l⁻¹ see figure 4.40).

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: BOD₅, 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 2019

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. Table 6 summarizes information about number of samples taken in 2019. The differences are presented by different colour. The majority of determinands were measured 11 and more times in 2019.

For Croatian monitoring points frequency was 8-10 times and for HU5 for suspended solids, chlorides and silicates 7-8 times. For this monitoring point BOD₅ was measured only 3 times and for that reason the load was not calculated. In 2010, load calculation for Slovakian monitoring points on tributaries Morava, Hron and Ipel' was added, at a monitoring frequency of 12 times a year.

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 11 locations only. Also, the load for silicates / silicates dissolved was calculated at 9/5 monitoring points.

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

Country	River	Water quality monitoring location		Hydrological station		
		Station 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	Lanzhot	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:

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

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:

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

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:

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

5.5 Results

The above described procedure allows calculation of loads separately for Danube River monitoring sites (Table 9) and for sites located on the tributaries (Table 10), connected with hydrological stations for agreed determinands: suspended solids, inorganic nitrogen, ortho-phosphate-phosphorus, total phosphorus, BOD₅, chlorides and – where available – dissolved phosphorus and silicates, or silicates dissolved. These results are supported by some statistical outputs and basic information. Table 6 informs about number of measurements for selected monitoring sites and determinands (the ranges of measurements are distinguished by different colour). Due to the low number of measurements in 2019, there was no load calculation for BOD₅ at HU5.

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 2019
C_{mean}	arithmetical mean of the concentrations in the year 2019
Annual Load	annual load of given determinand in the year 2019

The calculated **loads for 2019**, 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 decreases, increases or is stable against previous year 2018 (distinguished by different font and/or colour; explanations are below the tables).

Based on the Table 9 the Danube River sites it is seen that the ortho-phosphate phosphorus in most of assessed monitoring points increased. For suspended solids, inorganic nitrogen and chlorides in four monitoring points load increased. Total phosphorus and BOD₅ increased in tree monitoring points and silicates in two monitoring points. In the monitoring site RO5 (Reni) it is seen that for 3 of 8 assessed determinands were loads higher in 2018.

In tributaries load values increased in several monitoring points in case of suspended solids, ortho-phosphate phosphorus, inorganic nitrogen and total phosphorus. In six monitoring points load of BOD₅ and chlorides increased. Maximal load of suspended solids was in Salzach, the maximum of inorganic

nitrogen, ortho-phosphate-phosphorus and BOD₅ as well as silicates-dissolved was in HR7. The highest load of total phosphorus and silicates was in HU9 and maximum of total dissolved phosphorus was in Vah.

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). In the lower part of the Danube River, the highest loads for all determinands were obtained in monitoring sites RO2, RO4 and RO5.

Table 11 shows information about the number of measurements for determinands used for calculation of loads at the Reni monitoring site. Based on the agreement with the Black Sea Commission, the profile Reni is monitored since 2005 and is focused on nutrients and heavy metals. 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 over 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, total phosphorus, phosphorus dissolved, BOD₅, chlorides, silicates) slightly decreased in 2019, only the load of ortho phosphate-phosphorus increased.

Table 6: Number of measurements at TNMN locations selected for assessment of pollution load in 2019

Country Code	River	Location	Location in profile	River Km	Number of measurements in 2019								
					Qr (2019)	SS	N _{inorg}	P-PO ₄	P _{total}	BOD ₅	Cl	P _{diss}	SiO ₂
DE2	Danube	Jochenstein	M	2204	365	14	26	26	26	14	14		
DE3	Inn	Kirchdorf	M	195	365	12	12	12	12	12	12		
DE4	Inn/Salzach	Laufen	L	47	365	13	13	13	13	13	13		
AT1	Danube	Jochenstein	M	2204	365	12	25	26	26	12	12	12	
AT6	Danube	Hainburg	R	1879	365	24	24	24	24	24	24	24	
CZ1	Morava	Lanzhot	M	79	365	12	12	12	12	12	12		12
CZ2	Morava/Dyje	Pohansko	M	17	365	12	12	12	12	12	12		12
SK1	Danube	Bratislava	L	1869	365	26	26	26	26	26	12	26	26
SK1	Danube	Bratislava	M	1869	365	26	26	26	26	26	12	26	26
SK1	Danube	Bratislava	R	1869	365	26	26	26	26	26	12	26	26
SK4	Váh	Komárno	M	1	365	12	12	12	12	12	12	12	12
SK6	Morava	Devín	M	1	365	12	12	12	12	12	12	12	12
SK7	Hron	Kamenica	M	2	365	12	12	12	12	12	12	12	12
SK8	Ipoly	Salka	M	12	365	12	12	12	12	12	12	12	12
HU3	Danube	Szob	L	1708		17	25	25	25	17	12		11
			M	1708	365	17	25	25	25	17	12		11
			R	1708		15	24	24	24	16	12		11
HU5	Danube	Hercegszántó	M	1435	365	7	20	20	19	3	8		7
HU9	Tisza	Tiszasziget	L	163		11	12	12	12	12	12		12
			M	163	365	11	26	26	26	12	12		12
			R	163		11	12	12	12	12	12		12
HR11	Danube	Ilok	M	1302		10	10	10	10	10	10		10*
HR6	Sava	Jesenice	R	729	365	10	10	10	10	10	10		10*
HR7	Sava	us Una Jesenovac	M	525	365	10	10	10	10	10	10		10*
HR12	Sava	Račinovci	L	218	365	8	8	8	8	8	8		8*
SI1	Drava	Ormoz	L	300	365	26	26	26	26	26	12		
SI2	Sava	Jesenice	R	729	365	25	25	25	25	25	12		
RO2	Danube	Pristol-Novo Selo	L	834		26	26	26	26	26	12	26	
			M	834	365	25	25	25	25	25	11	25	
			R	834		25	25	25	25	25	11	25	
RO4	Danube	Chiciu-Silistra	L	375	365	26	26	26	26	12	12	12	
			M	375		26	26	26	26	12	12	12	
			R	375		26	26	26	26	12	12	12	
RO5	Danube	Reni	L	132		26	26	26	26	13	12	12	26
			M	132	365	26	26	26	26	13	12	12	26
			R	132		26	26	26	26	13	12	12	26
RO10	M	Siret	M	0	365	25	26	26	26	12	12	10	
RO11	M	Prut	M	0	365	26	26	26	26	12	12	12	
UA2	Danube	Vylkove	M	18	365	12	12	12		12	12	12	12

*Silicates (SiO₂) in dissolved form

11 and more samples

less than 11 and more than 4 samples

< 4 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 2019

Station Code	Profile	River Name	Location	River km	Q _a	C _{mean}							
					(m ³ .s ⁻¹)	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD ₅	Chlorides	Phosphorus - dissolved	Silicates
						(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	1446	47.21	1.61	0.02	0.05	1.47	17.05	0.03	
AT6	R	Danube	Hainburg	1879	1966	16.15	1.63	0.02	0.04	2.00	16.96	0.03	
SK1	M	Danube	Bratislava	1869	1962	49.15	1.66	0.04	0.09	1.09	17.88	0.05	5.12
HU3	LMR	Danube	Szob	1708	2114	14.09	1.60	0.02	0.08	3.76	20.07		4.65
HU5	M	Danube	Hercegszántó	1435	2253	13.43	1.78	0.04	0.06	2.67	19.75		4.19
HR11	M	Danube	Ilok	1302	2822	16.81	1.32	0.03	0.09	1.24	16.04		3.92*
RO2	LMR	Danube	Pristol-Novo Selo	834	4593	37.46	1.15	0.05	0.07	2.56	23.06	0.06	
RO4	LMR	Danube	Chiciu-Silistra	375	5168	14.79	1.24	0.05	0.08	1.77	26.25	0.05	
RO5	LMR	Danube	Reni	132	5579	37.93	1.10	0.06	0.09	1.85	29.38	0.07	3.22*
UA2	M	Danube	Vylkove	18	2768	27.92	1.25	0.04		2.27	32.96	0.11	1.91

*Silicates (SiO₂) in dissolved form

Table 8: Mean annual concentrations in monitoring locations selected for load assessment on tributaries in 2019

Station Code	Profile	River Name	Location	River km	Q _r (2019)	C _{mean}							
					(m ³ .s ⁻¹)	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD ₅	Chlorides	Phosphorus - dissolved	Silicates
						(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	355	118.28	0.74	0.01	0.11	1.09	9.00		
DE4	L	Inn/Salzach	Laufen	47	266	348.65	0.66	0.01	0.25	1.70	7.92		
CZ1	M	Morava	Lanzhot	79	39	25.29	2.18	0.05	0.12	1.99	31.49		7.90
CZ2	L	Morava/Dyje	Pohansko	17.00	22	12.92	2.38	0.27	0.35	2.13	69.58		10.66
SK4	M	Váh	Komárno	1	175	10.92	1.55	0.05	0.11	1.41	21.33	0.07	5.48
SK6	M	Morava	Devín	1	65	22.42	2.25	0.15	0.24	2.08	41.98	0.17	9.48
SK7	M	Hron	Kamenica	2	38	16.50	1.92	0.08	0.15	1.77	22.02		
SK8	M	Ipoly	Salka	12	9	17.67	1.85	0.15	0.24	2.27	30.78		
HU9	LMR	Tisza	Tiszasziget	163	598	35.76	0.89	0.05	0.15	1.27	39.78		10.63
SI1	L	Drava	Ormoz	300	316	12.25	1.13	0.02	0.06	0.92	7.78		
SI2	R	Sava	Jesenice	729	284	5.82	1.38	0.03	0.04	0.89	7.66		
HR6	R	Sava	Jesenice	729	284	6.00	1.23	0.03	0.05	0.94	7.34		3.39*
HR7	L	Sava	us. Una Jasenovac	525	710	13.06	1.33	0.07	0.11	1.72	8.35		3.89*
HR12	M	Sava	Račinovci	218	1056	13.68	1.18	0.05	0.10	1.08	28.88		3.69*
RO10	M	Siret	Conf. Danube (Sendreni)	729	207	89.36	1.25	0.02	0.05	2.66	64.52	0.03	
RO11	M	Prut	Conf. Danube (Giurgiuilesti)	729	88	36.58	0.80	0.03	0.08	2.28	36.36	0.04	

*Silicates (SiO₂) in dissolved form

Table 9: Annual load in selected monitoring locations on Danube River in 2019

Station Code	Profile	River Name	Location	River km	Annual Load in 2019							
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD ₅	Chlorides	Phosphorus - dissolved	Silicates
					(x10 ⁶ tonns)	(x10 ³ tonns)	(x10 ³ tonns)	(x10 ³ tonns)	(x10 ³ tonns)	(x10 ⁶ tonns)	(x10 ³ tonns)	(x10 ⁶ tonns)
DE2+AT1	M	Danube	Jochenstein	2204	1.71	73.97	0.93	2.27	65.54	0.78	1.39	
AT6	R	Danube	Hainburg	1879	1.14	100.31	1.29	2.25	128.37	1.00	1.70	
SK1	LMR	Danube	Bratislava	1869	4.00	104.65	2.04	6.35	77.76	1.07	2.69	0.32
HU3	LMR	Danube	Szob	1708	0.96	108.78	1.05	5.85	279.78	1.30		0.31
HU5	M	Danube	Hercegszántó	1435	0.66	112.15	2.31	3.98		1.04		0.20
HR11	M	Danube	Ilok	1302	1.25	102.40	2.21	7.09	95.50	1.19		0.31*
RO2	LMR	Danube	Pristol-Novo Selo	834	5.63	169.76	6.63	9.92	371.04	3.17	8.09	
RO4	LMR	Danube	Chiciu-Silistra	375	2.85	207.67	7.68	11.60	284.92	4.34	8.91	
RO5	LMR	Danube	Reni	132	8.07	193.60	10.09	16.16	330.03	5.03	12.82	0.61*
UA2	M	Danube	Vylkove	18	2.91	109.62	3.64		200.77	2.76	9.97	0.18

*Silicates (SiO₂) in dissolved form

Explanations for comparison of values:

Bold font increased value in comparison with 2018

10.09 maximum value of determinand in 2019 and also increased value in comparison with 2018

8.07 maximum value of determinand in 2019, but decreased value in comparison with 2018

missing value in 2019 - not assessed

Table 10: Annual load in selected monitoring locations on tributaries in 2019

Station Code	Profile	River Name	Location	River km	Annual Load in 2019							
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD ₅	Chlorides	Phosphorus - dissolved	Silicates
					(x10 ⁶ tonns)	(x10 ³ tonns)	(x10 ³ tonns)	(x10 ³ tonns)	(x10 ³ tonns)	(x10 ⁶ tonns)	(x10 ³ tonns)	(x10 ⁶ tonns)
DE3	M	Inn	Kirchdorf	195	2.02	6.42	0.06	1.75	10.55	0.07		
DE4	L	Inn/Salzach	Laufen	47	2.70	5.36	0.06	1.97	14.29	0.06		
CZ1	M	Morava	Lanzhot	79	0.05	3.01	0.04	0.15	2.52	0.03		0.010
CZ2	L	Morava/Dyje	Pohansko	17	0.01	2.00	0.12	0.16	1.40	0.04		0.006
SK4	M	Váh	Komárno	1	0.06	8.94	0.29	0.55	8.29	0.12	0.35	0.030
SK6	M	Morava	Devín	1	0.05	5.58	0.24	0.42	4.50	0.08	0.28	0.019
SK7	M	Hron	Kamenica	2	0.02	2.31	0.08	0.17	2.08	0.02	0.10	0.016
SK8	M	Ipoly	Salka	12	0.01	0.57	0.03	0.06	0.61	0.01	0.05	0.006
HU9	LMR	Tisza	Tiszasziget	163	0.78	18.19	0.88	3.43	24.15	0.57		0.221
SI1	L	Drava	Ormoz	300	0.17	10.09	0.18	0.68	8.91	0.07		
SI2	R	Sava	Jesenice	729	0.07	12.23	0.24	0.32	6.87	0.06		
HR6	R	Sava	Jesenice	729	0.05	9.47	0.21	0.37	7.02	0.05		0.027*
HR7	M	Sava	us. Una Jasenovac	525	0.24	23.73	1.16	1.88	31.58	0.14		0.077*
HR12	L	Sava	Račinovci	218	0.23	20.95	0.89	1.72	22.74	0.44		0.061*
RO10	M	Siret	Conf. Danube (Sendreni)	0	1.00	7.94	0.17	0.35	19.87	0.39	0.22	
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	0.09	1.79	0.11	0.22	7.16	0.09	0.13	

*Silicates (SiO₂) in dissolved form

Explanations for comparison of values:

Bold font increased value in comparison with 2018

2.70 maximum value of determinand in 2019 and also increased value in comparison with 2018

3.43 maximum value of determinand in 2019, but decreased value in comparison with 2018

23.73 maximum value of determinand in 2019, but not assessed in 2018

0.13 stability

missing value in 2019 - not assessed

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

Country Code	River	Location	Location in profile	River km	Number of measurements in 2019																				
					Qr 2019	SS	Ni	oPO4_P	P _{total}	BOD ₅	Cl	P _{diss.}	SiO _{2diss.}	N-NH ₄	N-NO ₂	N-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	13	12	12	26	26	26	26	26	12	12				12		12

Country Code	River	Location	Location in profile	River km	C _{mean}																				
					Qr 2019	SS	Ni	oPO4_P	P _{total}	BOD ₅	Cl	P _{diss.}	SiO _{2diss.}	N-NH ₄	N-NO ₂	N-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)	(mg.l ⁻¹)	(mg.l ⁻¹)	(mg.l ⁻¹)	(mg.l ⁻¹)	(mg.l ⁻¹)	(mg.l ⁻¹)	(mg.l ⁻¹)	(mg.l ⁻¹)
RO5	Danube	Reni	LMR	132	5579	37.93	1.10	0.055	0.088	1.85	29.38	0.07	3.22	0.05	0.02	1.03	1.56		6.37		2.61		0.15		0.011

Country Code	River	Location	Location in profile	River km	Annual Load in 2019 in tonnes (t)																				
					SS	Ni	oPO4_P	P _{total}	BOD ₅	Cl	P _{diss.}	SiO _{2diss.}	N-NH ₄	N-NO ₂	N-NO ₃	N _{total}	Cu	Cu _{diss.}	Pb	Pb _{diss.}	Cd	Cd _{diss.}	Hg	Hg _{diss.}	
					(x10 ⁶ t)	(x10 ³ t)	(x10 ³ t)	(x10 ³ t)	(x10 ³ t)	(x10 ⁶ t)	(x10 ³ t)	(x10 ³ t)	(x10 ³ t)	(x10 ³ t)	(x10 ³ t)	(x10 ³ t)	(x10 ³ t)	t	t	t	t	t	t	t	t
RO5	Danube	Reni	LMR	132	8.07	193.60	10.09	16.16	330.03	5.03	12.82	0.61	9.41	3.23	180.93	270.25		1141.33		408.37		22.78		2.23	

Figure 5.1.: Annual load of suspended solids along the Danube River in 2019

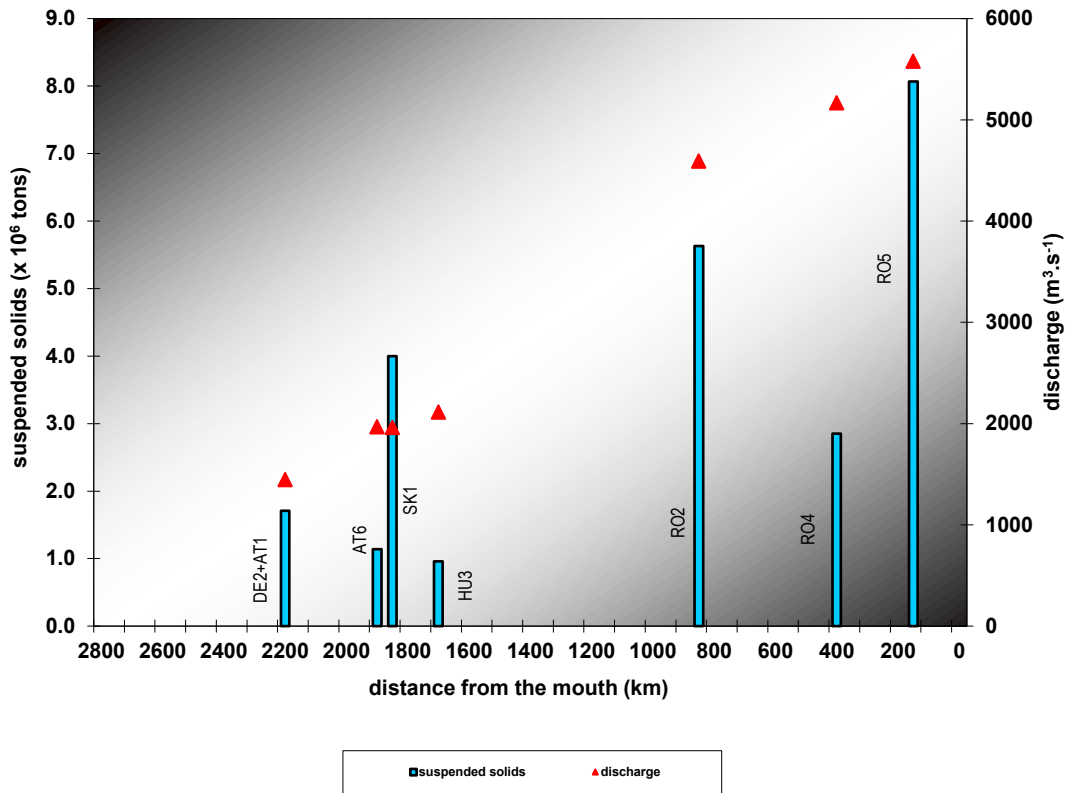


Figure 5.2.: Annual load of suspended solids at monitoring locations on tributaries in 2019

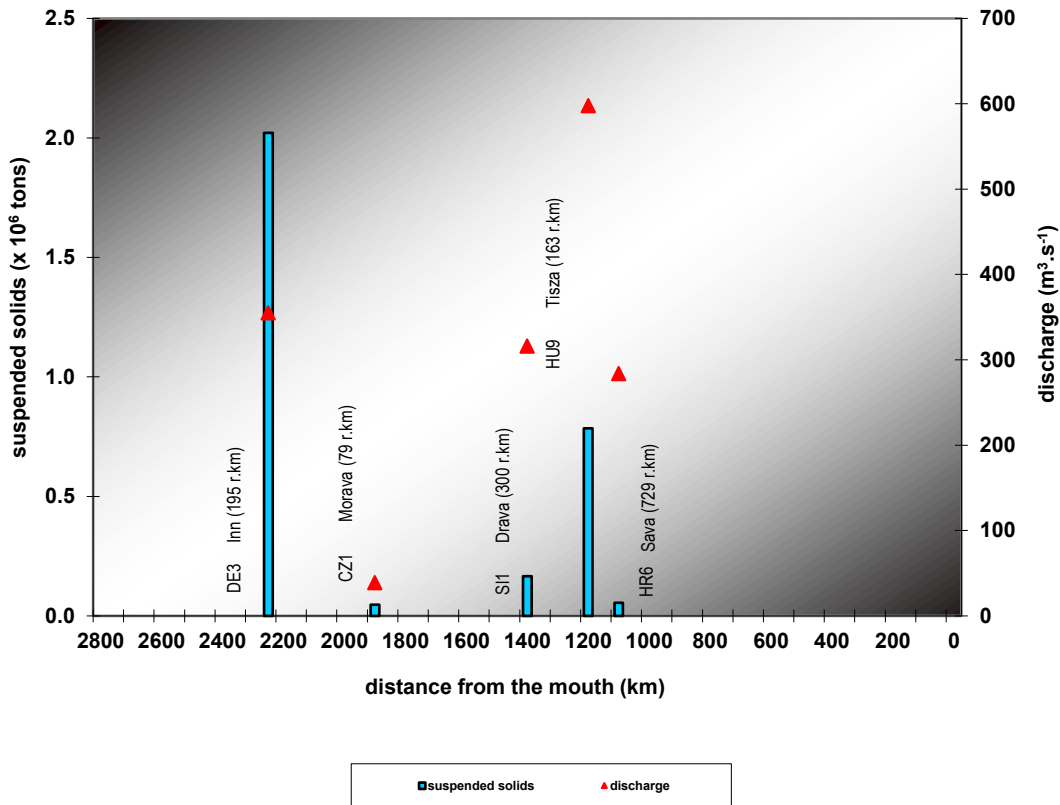


Figure 5.3.: Annual loads of inorganic nitrogen along the Danube River in 2019

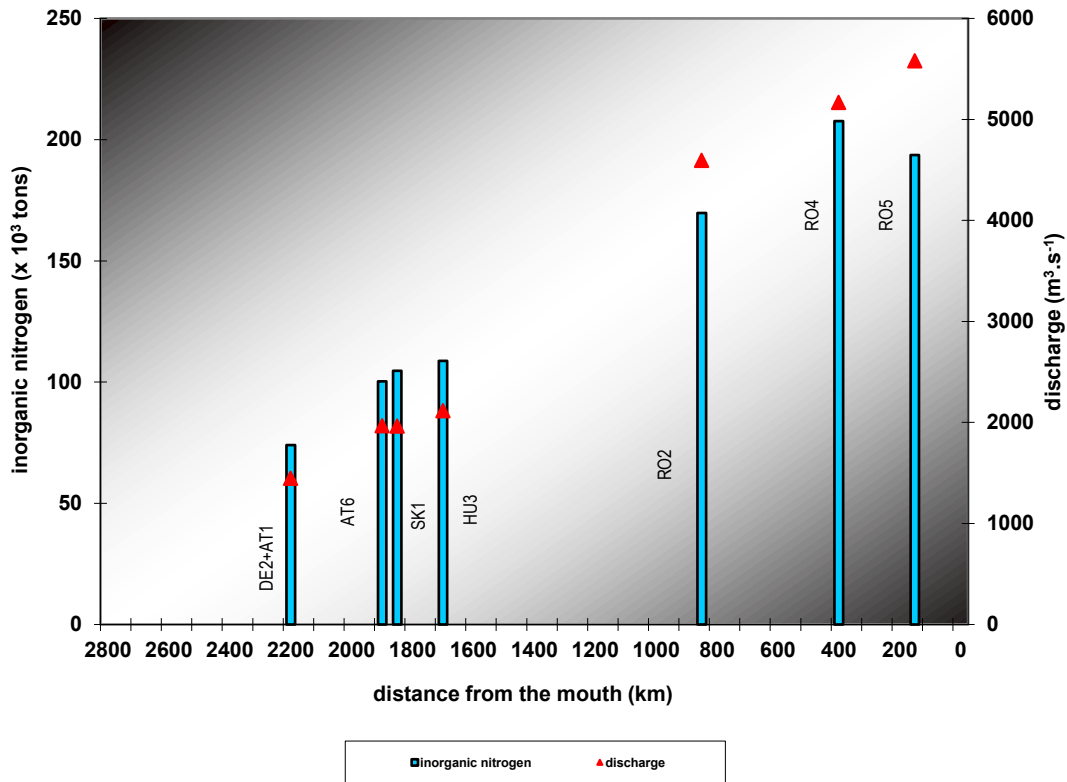


Figure 5.4.: Annual loads of inorganic nitrogen at monitoring locations on tributaries in 2019

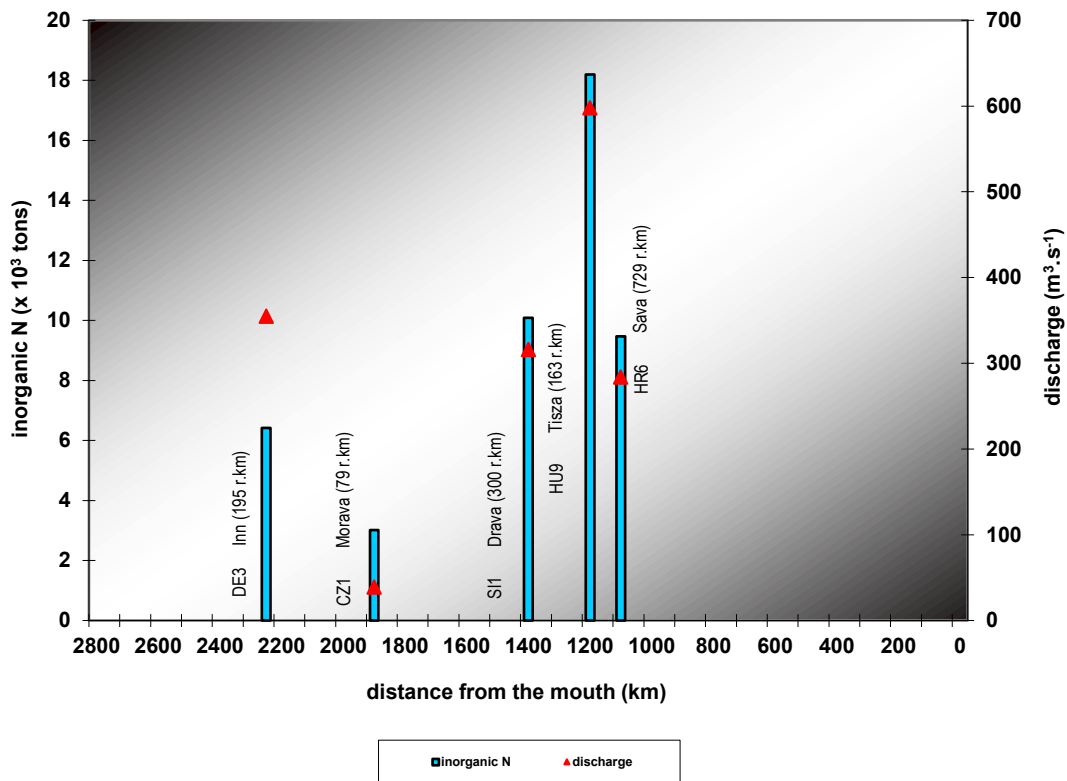


Figure 5.5.: Annual loads of o P-PO₄ at monitoring locations along the Danube River in 2019

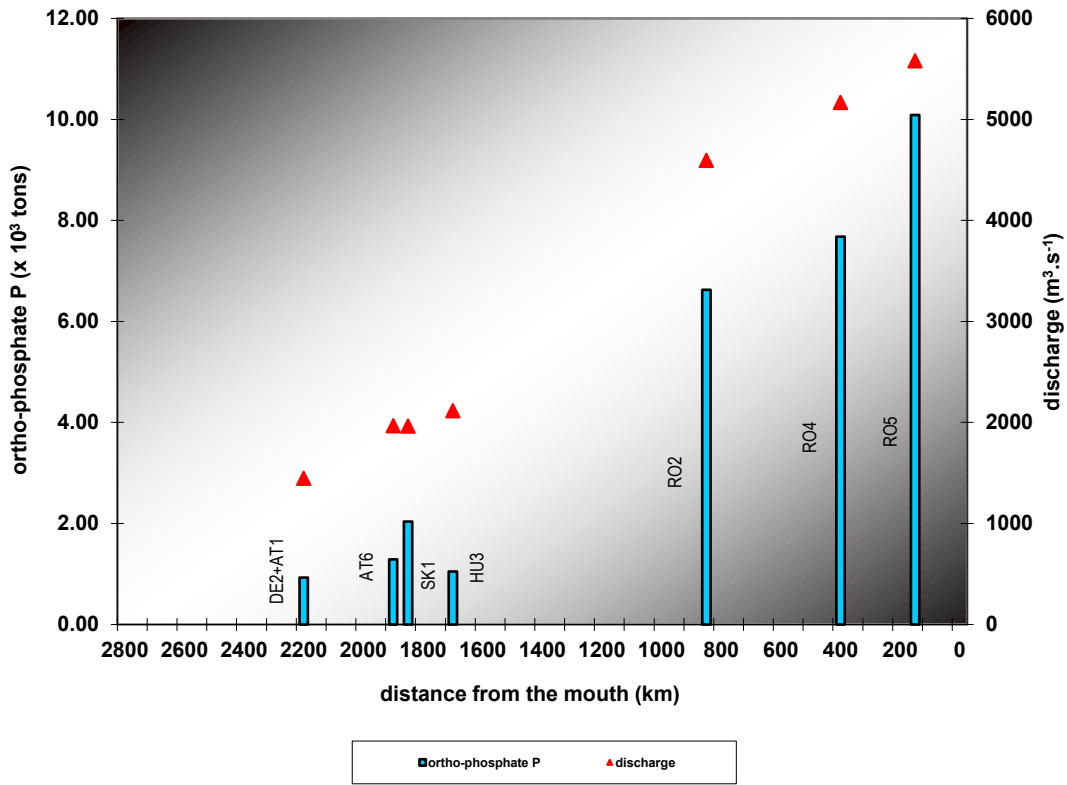


Figure 5.6.: Annual loads of o P-PO₄ at monitoring locations on tributaries in 2019

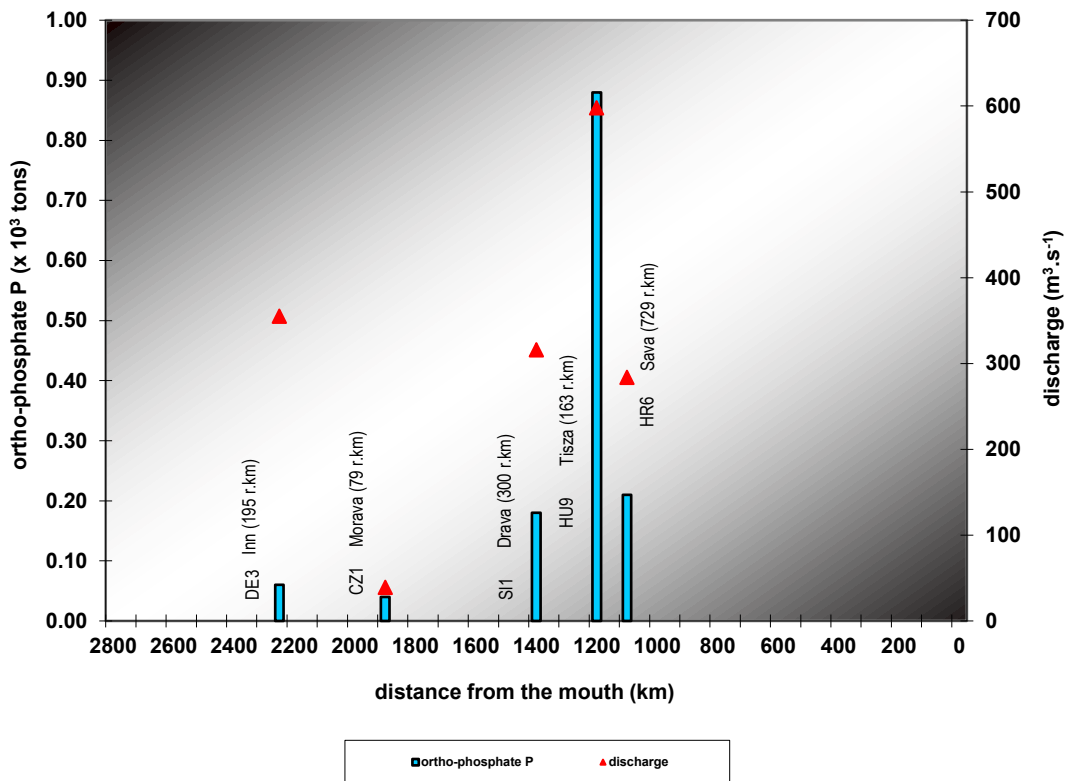


Figure 5.7.: Annual loads of total phosphorus along the Danube River in 2019

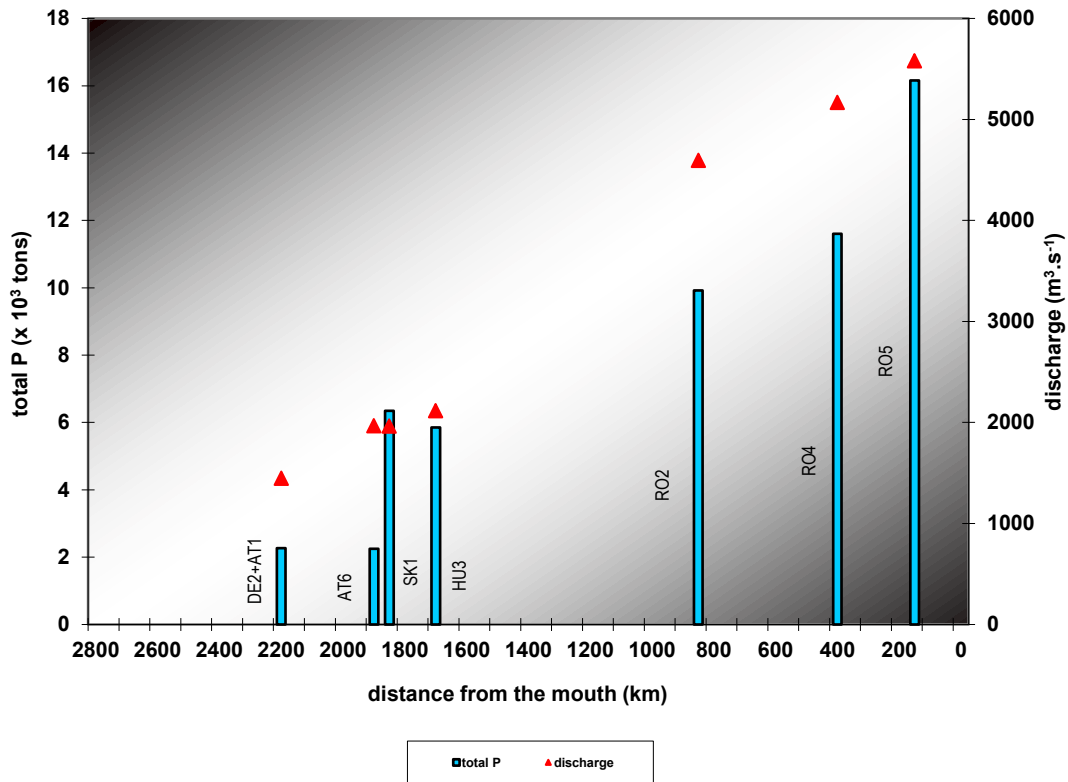


Figure 5.8.: Annual loads of total phosphorus at monitoring locations on tributaries in 2019

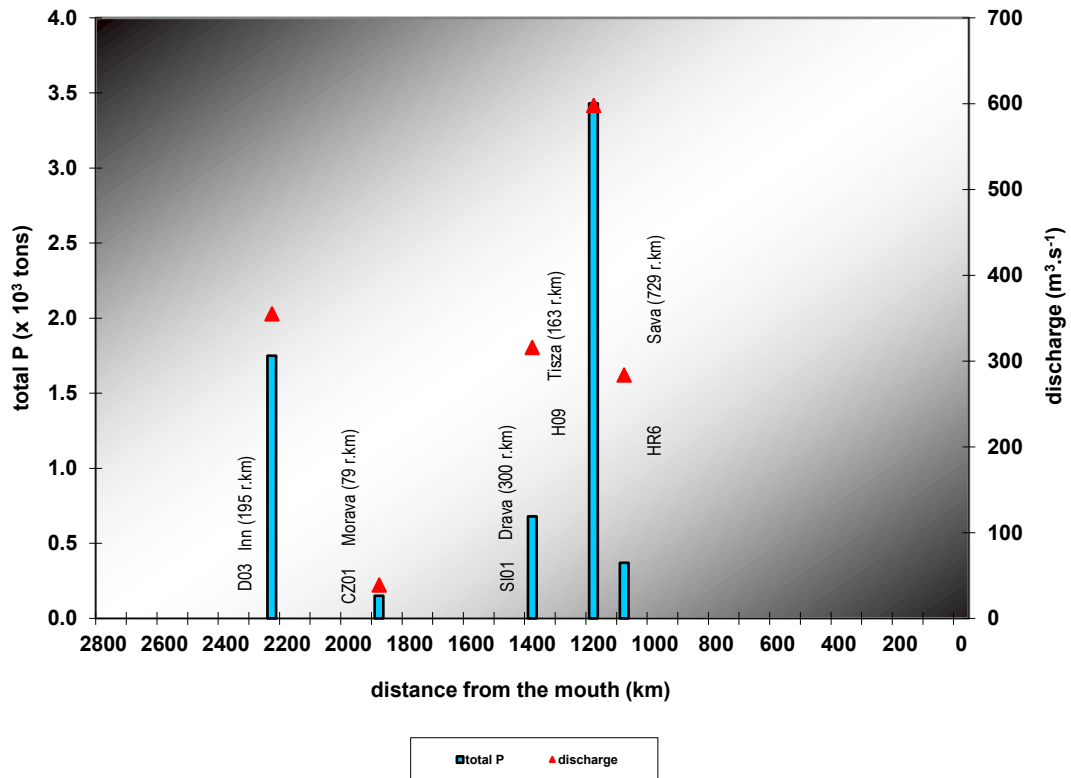


Figure 5.9.: Annual loads of BOD₅ along the Danube River in 2019

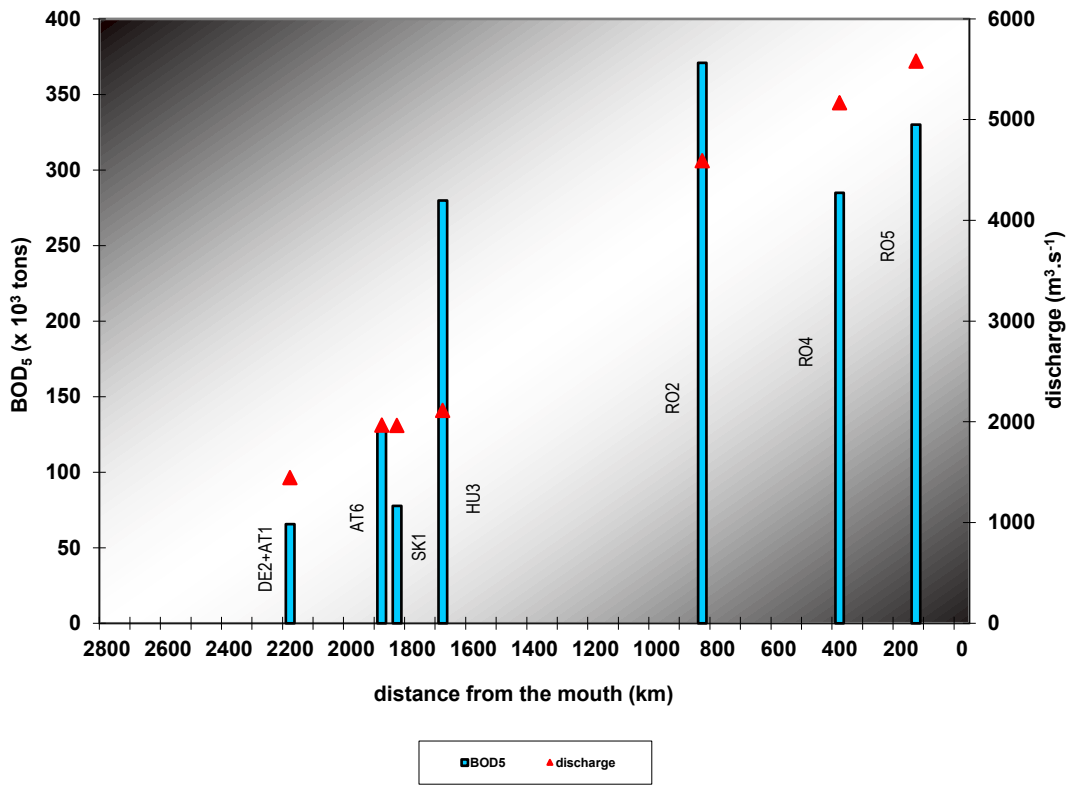


Figure 5.10.: Annual loads of BOD₅ at monitoring locations on tributaries in 2019

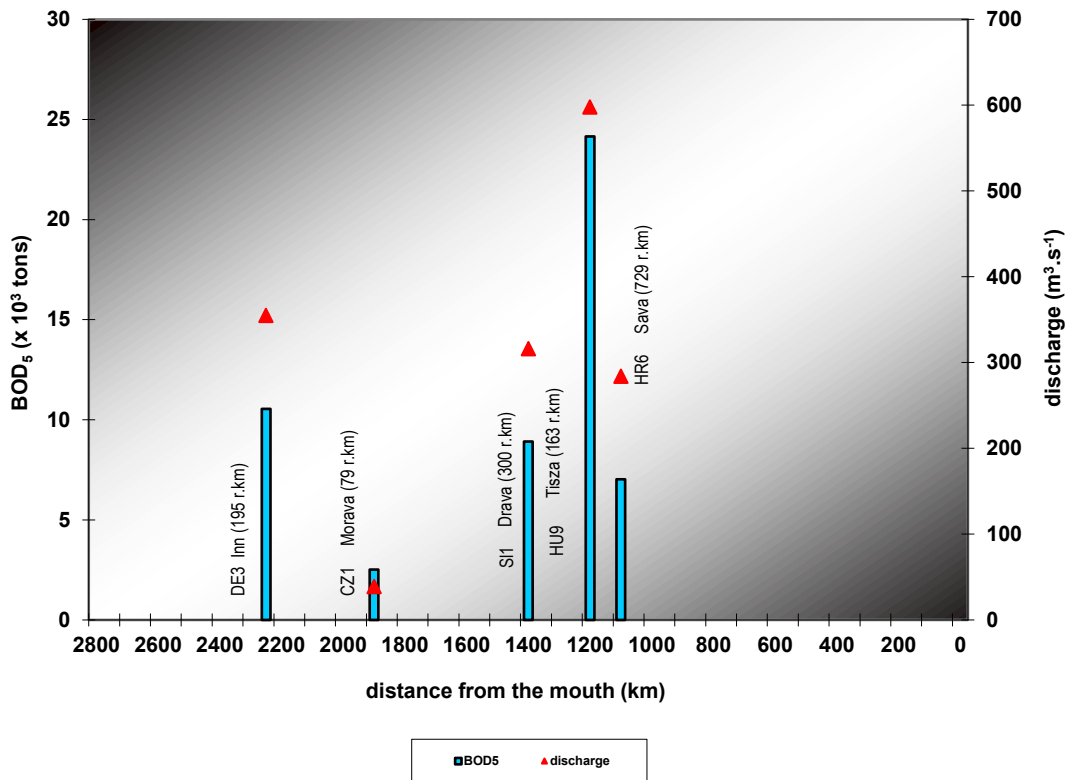


Figure 5.11.: Annual loads of chlorides along the Danube River in 2019

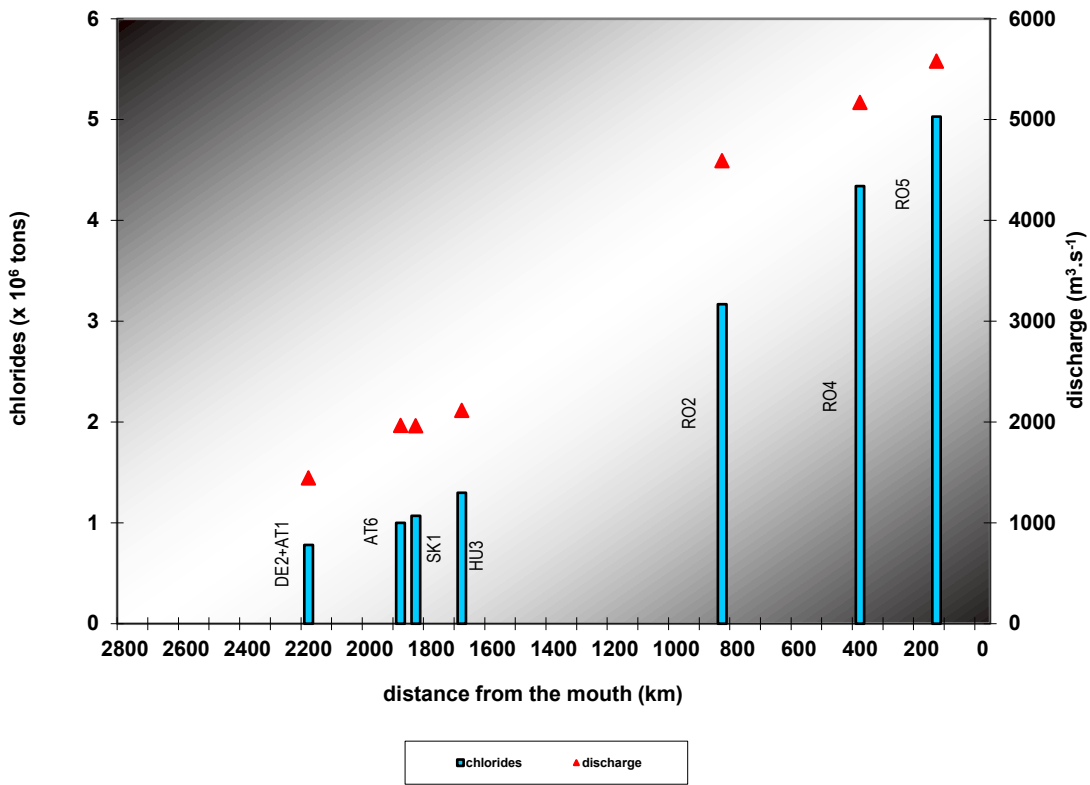


Figure 5.12.: Annual loads of chlorides at monitoring locations on tributaries in 2019

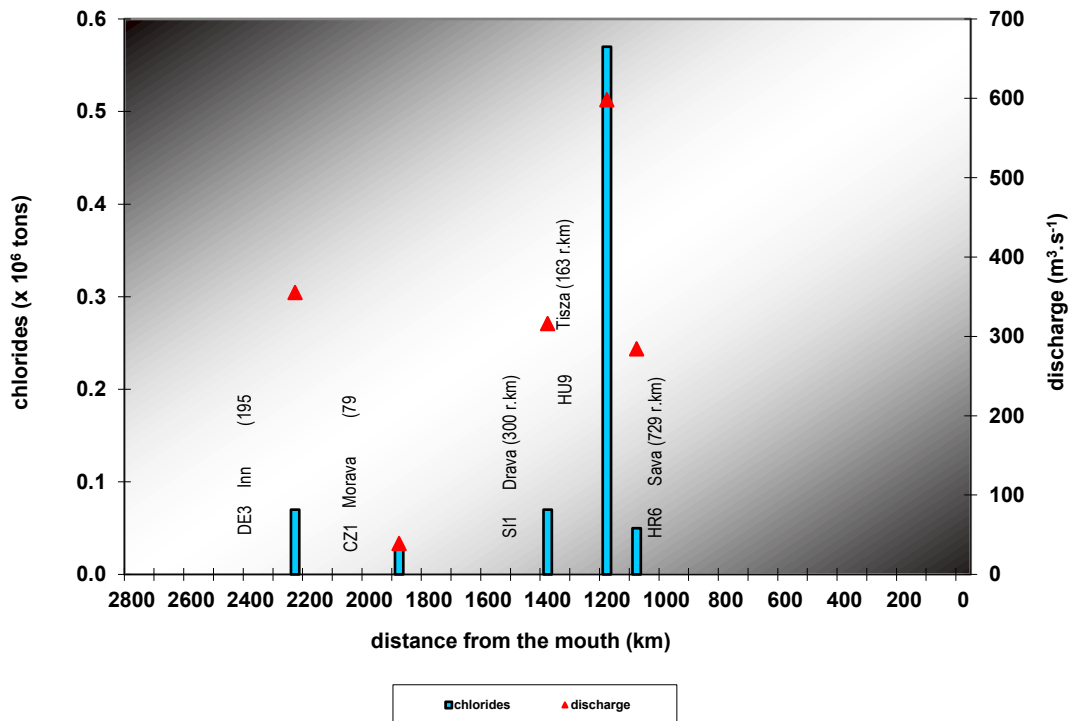


Figure 5.13.: Development trend of annual loads of suspended solids at Reni.

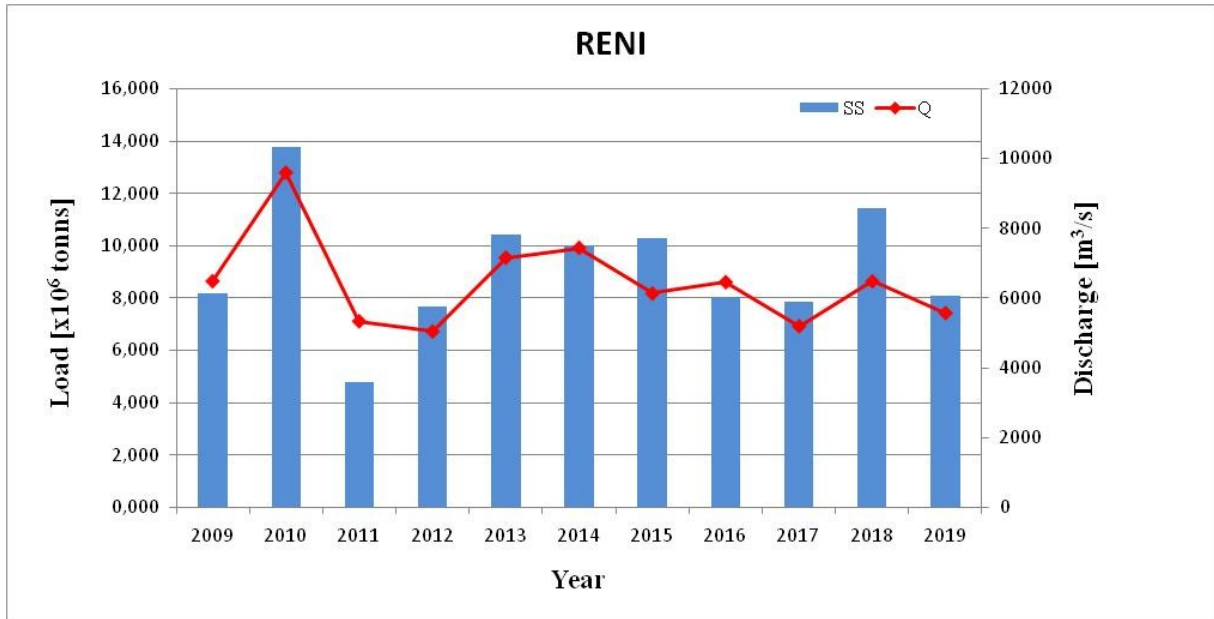


Figure 5.14.: Development trend of annual loads of inorganic nitrogen at Reni.

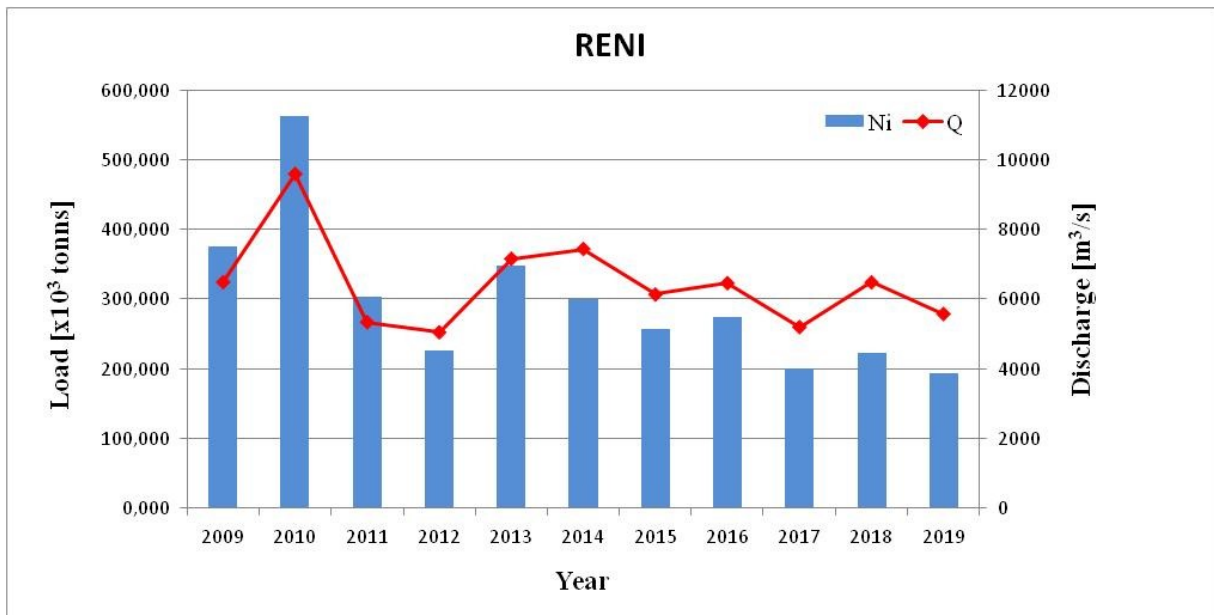


Figure 5.15.: Development trend of annual loads of ortho-phosphate phosphorus, total phosphorus and dissolved phosphorus at Reni.

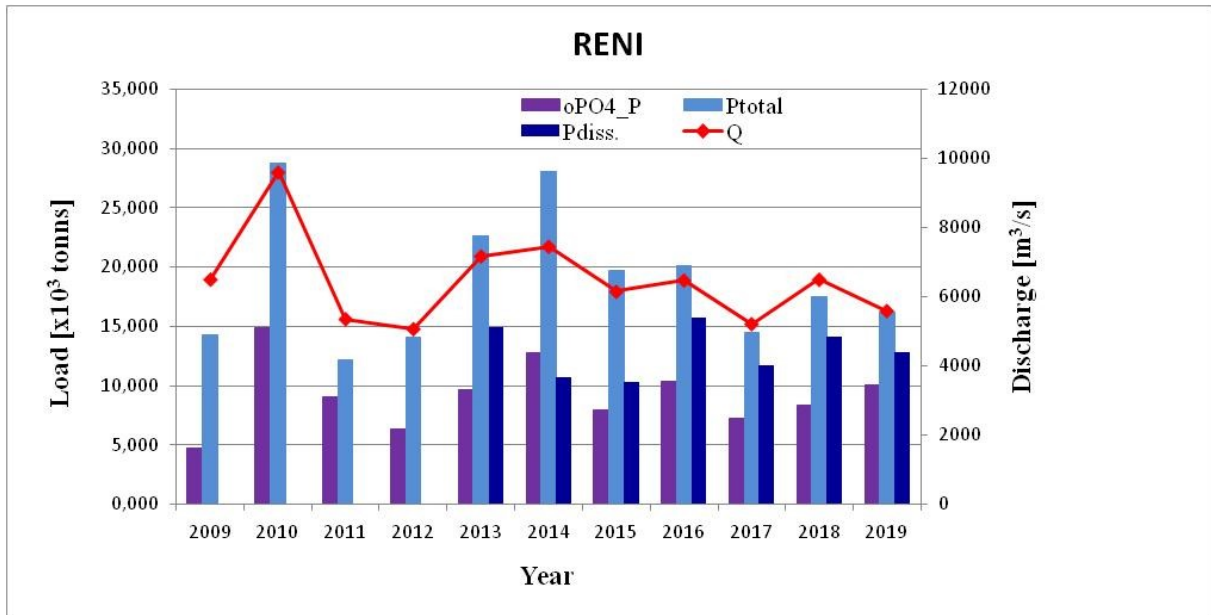


Figure 5.16.: Development trend of annual loads of BOD₅ at Reni.

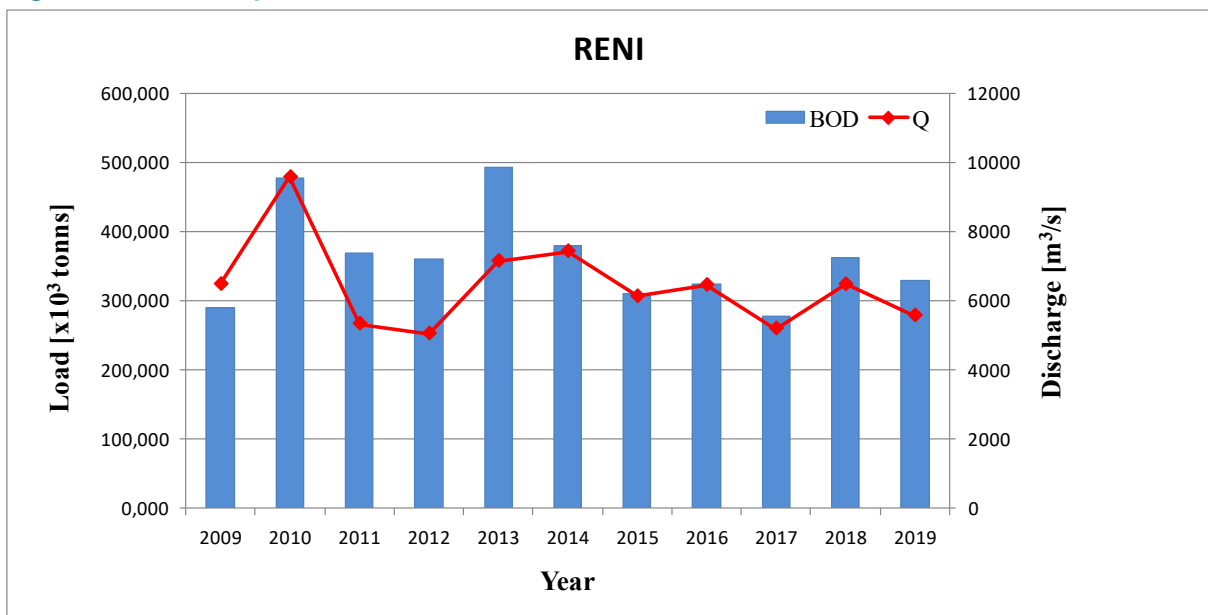


Figure 5.17.: Development trend of annual loads of chlorides at Reni.

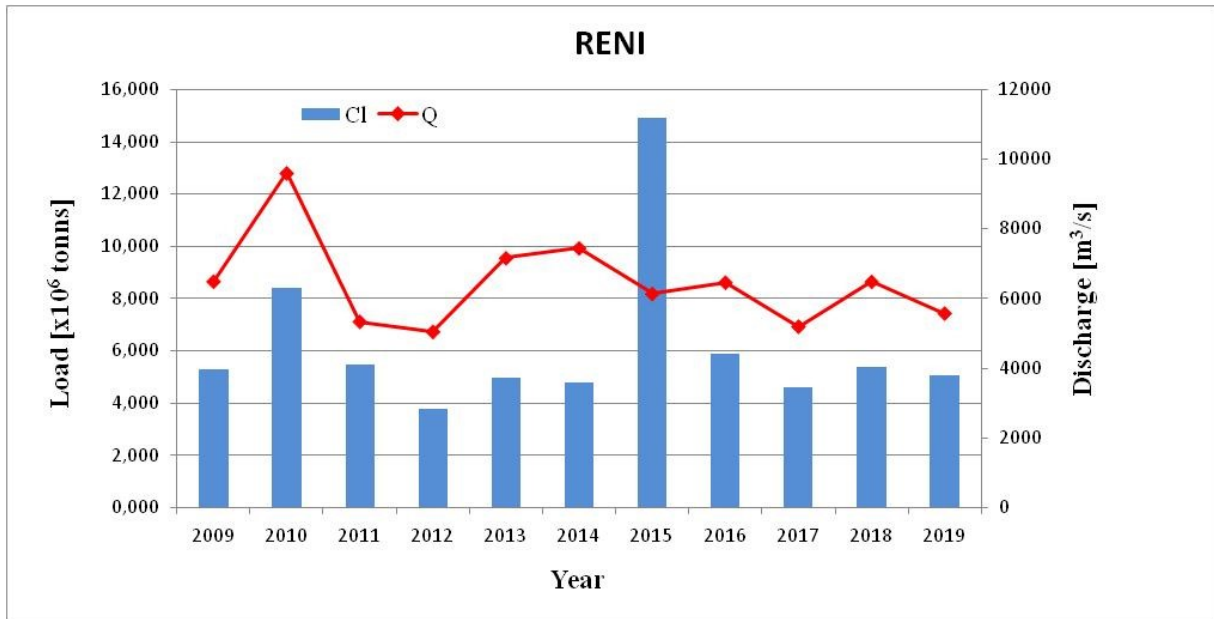
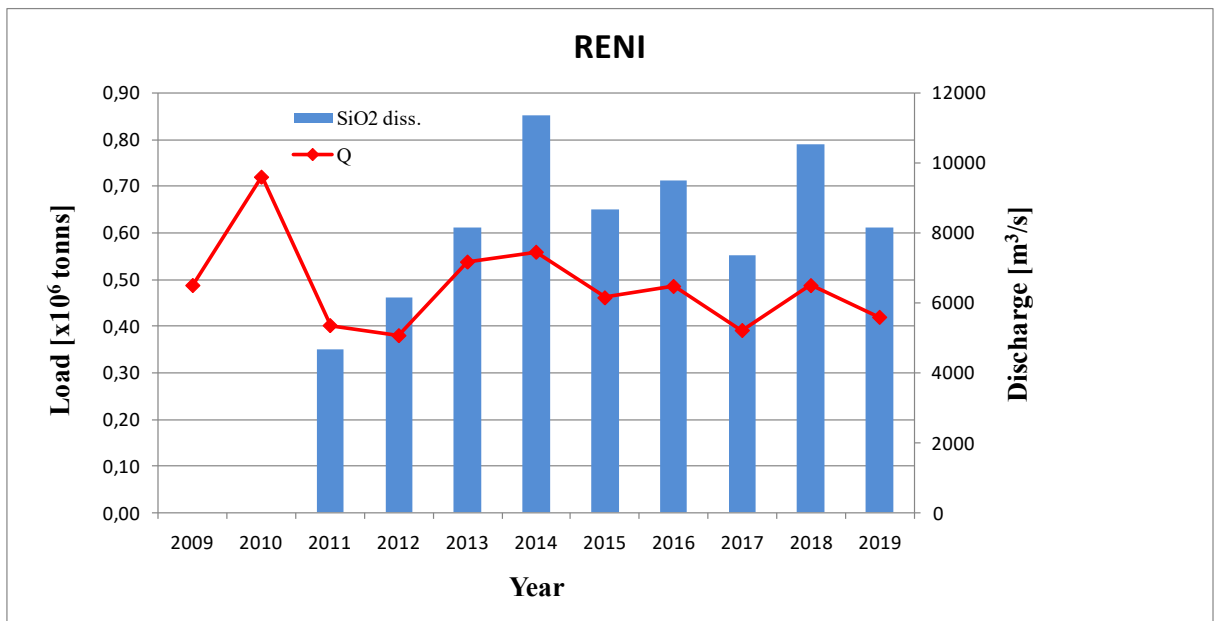


Figure 5.18.: Development trend of annual loads of silicates at Reni.



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. In 2019, SK/HU Transboundary commission agreed on a proposal of creating a new GWB-12 on Ipel/Ipoly. The ICPDR adopted GWB-12 at StWG-17 in June 2019. All 12 GW bodies of basin-wide importance are shown in Map (Figure 6.1).

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



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.

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. 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
SS	Suspended solids
Ni	Inorganic nitrogen
NO ₂ _N	Nitrite-nitrogen
NO ₃ _N	Nitrate-nitrogen
Ntot.	Total nitrogen
NRL	National Reference Laboratory
oPO ₄ _P	Orto-phosphate-phosphorus
Pdiss.	Phosphorus dissolved
Ptot.	Total phosphorus
SiO ₂	Silicates
SiO ₂ diss.	Silicates dissolved
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

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