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# Water Quality in the Danube River Basin – 2023

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International Commission  
for the Protection  
of the Danube River

Internationale Kommission  
zum Schutz der Donau

## TNMN – Yearbook 2023



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Overall coordination and preparation of the TNMN Yearbook and database: Lea Mrafková, Slovak Hydrometeorological Institute, Bratislava, in cooperation with the Monitoring and Assessment Expert Group of the ICPDR.

Editor: Igor Liska, ICPDR Secretariat

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### Contact

ICPDR Secretariat

Vienna International Centre / D0412

P.O. Box 500 / 1400 Vienna / Austria

T: +43 (1) 26060-5738 / F: +43 (1) 26060-5895

[secretariat@icpdr.org](mailto:secretariat@icpdr.org) / [www.icpdr.org](http://www.icpdr.org)

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# 1. Introduction

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## 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 (DRB) 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 2023.

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 10).

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 Danube River Basin Management Plan (DRBMP) 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.

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## 2. Description of the TNMN Surveillance Monitoring 2: Monitoring of Specific Pressures

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### 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. All monitoring stations are listed in the Table 1, presented with differentiation of monitoring sites located on the Danube River (in bold) and tributaries. Information about monitoring sites reporting data in 2023 is included in the Table 3 - Chapter 3.

Table 1: List of stations included in TNMN SM2

N°	Country code	Station code	River	Monitoring station name	Locations	x-coord	y-coord	River-km	Altitude	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	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	18.853	47.813	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	47.813	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	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	9 707
28	HU	HU11	/Tisza/Szamos	Csenger	LM	22.693	47.841	45	113	15 283
29	HU	HU12	/Tisza/Hármas-Körös/Sebes-Körös	Korosszakal	MR	21.657	47.020	59	92	2 489
30	HU	HU13	/Tisza/Hármas-Körös/Kettős-Körös/Fekete-Körös	Sarkad	MR	21.431	46.694	16	85	4 302
31	HU	HU14	/Tisza/Hármas-Körös/Kettős-Körös/Fehér-Körös	Gyulavari	MR	21.336	46.629	9	85	4 251
32	HU	HU15	/Tisza/Maros	Nagylak	R	20.703	46.161	51	80	30 149
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	15 356
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

N°	Country code	Station code	River	Monitoring station name	Locations	x-coord	y-coord	River-km	Altitude	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	19.842	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	RS9	Danube	Backa Palanka	R	19.382	45.234	1,299	76.5	253,737
51	RS	RS10	/Tisza (Tisa)	Martonos	R	20.081	46.114	152	76	140 130
52	RS	RS11	/Tisza (Tisa)	Novi Becej	L	20.135	45.586	65	75	145 415
53	RS	RS12	/Tisza (Tisa)	Titel	M	20.312	45.198	9	73	157 174
54	RS	RS13	/Sava	Jamena	L	19.084	44.878	205	77	64 073
55	RS	RS15	/Sava	Sabac	R	19.699	44.770	106	74	89 490
56	RS	RS16	/Sava	Ostruznica	R	20.312	44.732	17	72	95 430
57	RS	RS17	/Velika Morava	Ljubicevski Most	R	21.132	44.586	22	71	37 320
58	BA	BA5	/Sava	Gradiska	M	17.255	45.141	457	86	39 150
59	BA	BA6	/Sava/Una	Kozarska Dubica	M	16.836	45.188	16	94	9 130
60	BA	BA7	/Sava/Vrbas	Razboj	M	17.458	45.050	12	100	6 023
61	BA	BA8	/Sava/Bosna	Modrica	M	18.313	44.961	24	114	10 500
62	BA	BA9	/Sava/Drina	Foca	M	18.833	43.344	234	442	3 884
63	BA	BA10	/Sava/Drina	Badovinci	M	19.344	44.779	16	90	19 226
64	BA	BA11	/Sava	Raca	M	19.335	44.891	190	80	64 125
65	BA	BA12	/Sava/Una	Novi Grad	M	16.295	44.988	70	137	4 573
66	BA	BA13	/Sava/Bosna	Usora	M	18.074	44.664	78	148	7 313
67	BG	BG1	Danube	Novo Selo harbour	LMR	22.785	44.165	834	35	580 100
68	BG	BG2	Danube	Bajkal	R	24.400	43.711	641	20	608 820
69	BG	BG3	Danube	Svishtov	LMR	25.345	43.623	554	16	650 340
70	BG	BG4	Danube	Upstream Russe	MR	25.907	43.793	503	12	669 900
71	BG	BG5	Danube	Silistra	LMR	27.268	44.125	375	7	698 600
72	BG	BG6	/Iskar	Orechovitza	M	24.358	43.589	28	31	8 370
73	BG	BG7	/Jantra	Karantzi	M	25.669	43.389	12	32	6 860
74	BG	BG8	/Russenski Lom	Basarbovo	M	25.913	43.786	13	22	2 800
75	BG	BG12	/Iskar	Gigen mouth	M	24.456	43.706	4	27	8 646
76	BG	BG13	/it	Guljantzi	M	24.728	43.644	7	29	3 225
77	BG	BG14	/Jantra	Novgrad mouth	M	25.579	43.609	4	25	7,869
78	BG	BG15	/Russenski Lom	mouth	M	25.936	43.813	1	17	2,974
79	RO	RO1	Danube	Bazias	LMR	21.384	44.816	1 071	70	570 896
80	RO	RO18	Danube	Gruia/Radujevac	LMR	22.684	44.270	851	32	577 085
81	RO	RO2	Danube	Pristol/Novo Selo	LMR	22.676	44.214	834	31	580 100
82	RO	RO3	Danube	Dunare – upstream Arges (Oltenita)	LMR	26.619	44.056	432	16	676 150
83	RO	RO4	Danube	Chiciu/Silistra	LMR	27.268	44.128	375	13	698 600
84	RO	RO5	Danube	Reni	LMR	28.232	45.463	132	4	805 700

N°	Country code	Station code	River	Monitoring station name	Locations	x-coord	y-coord	River-km	Altitude	Catchment area
85	RO	RO6	Danube	Vilkova-Chilia arm/Kilia arm	LMR	29.553	45.406	18	1	817 000
86	RO	RO7	Danube	Sulina - Sulina arm	LMR	29.671	45.158	0	1	817 000
87	RO	RO8	Danube	Sf. Gheorghe-Ghorghe arm	LMR	29.609	44.885	0	1	817 000
88	RO	RO9	/Arges	Conf. Danube (Clatesti)	M	26.599	44.145	0	14	12 550
89	RO	RO10	/Siret	Conf. Danube (Sendreni)	M	27.934	45.403	0	4	42 890
90	RO	RO11	/Prut	Conf. Danube (Giurgiulesti)	M	28.203	45.469	0	5	27 480
91	RO	RO12	/Tisza/Somes	Dara (frontiera)	M	22.720	47.815	3	118	15 780
92	RO	RO13	/Tisza/Hármas-Körös/Sebes-Körös/Crisul Repede	Cheresig	M	21.692	47.030	3	116	2 413
93	RO	RO14	/Tisza/Hármas-Körös/Kettős-Körös/Crisul Negru	Zerind	M	21.517	46.627	13	86.4	3 750
94	RO	RO15	/Tisza/Hármas-Körös/Kettős-Körös/Crisul Alb	Varsand	M	21.339	46.626	0.2	88.9	4 240
95	RO	RO16	/Tisza/Mures	Nadlac	M	20.727	46.145	21	85.6	27 818
96	RO	RO17	/Tisza/Bega	Otelec	M	20.847	45.620	7	46	2 632
97	RO	RO19	/Jiu	Zaval	M	23.845	43.842	9	30.9	10 046
98	RO	RO20	/Olt	Islaz	M	24.778	43.764	3	32	24 050
99	RO	RO21	/Ialomita	Downstream Tandarei	M	27.828	44.655	24	8.5	10 309
100	MD	MD1	/Prut	Lipcani	L	26.804	48.254	658	100	8 750
101	MD	MD3	/Prut	Conf. Danube-Giurgiulesti	LMR	28.198	45.472	0	5	27 480
102	MD	MD5	/Prut	Costesti Reservoir	L	27.229	47.842	557	91	11 800
103	MD	MD6	/Prut	Braniste	L	27.250	47.794	546	63	12 000
104	MD	MD7	/Prut	Valea Mare	L	27.875	47.108	387	55	15 200
105	UA	UA1	Danube	Reni	M	28.288	45.437	132	4	805 700
106	UA	UA2	Danube	Vylkove	M	29.592	45.394	18	1	817 000
107	UA	UA4	/Tisza	Chop	M	22.184	48.416	342	92	33 000
108	UA	UA5	/Tisza/Bodrog/Latoritsa	Strazh	M	22.212	48.454	144	96	4,418
109	UA	UA6	/Prut	Tarasivtsi	M	26.336	48.183	262	122	9 836
110	UA	UA7	/Siret	Tcherepkivtsi	M	26.030	47.981	100	303	2 070
111	UA	UA8	/Uzh	Storozhnica	R	22.200	48.617	106	112	1 582
112	ME	ME1	/Lim	Dobrakovo	L	19.773	43.121	112	609	2,875
113	ME	ME2	/Cehotina	Gradac	L	19.154	43.396	55.5	55	809.8

**Explanations:**

River km	The distance in kilometres from the mouth of the mentioned river
Catchment area	The area in square kilometres, from which water drains through the station
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 - right bank of the river
Bold font	The monitoring site is located on the Danube river
Grey font	The station was not reported in 2023



\* 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 is data reported in 2023 by 14 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 the database consist of different groups 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 once yearly, both Pantle&Buck and Zelinka&Marvan SI are acceptable; optional parameters: ASPT and EPT taxa)
- Phyto-benthos (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	Water
	concentrations	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 (P-PO <sub>4</sub> <sup>3-</sup> ) (2)	annually / 12 x per year	annually / 26 x per year
Calcium (Ca <sup>2+</sup> ) (3, 4, 5)	annually / 12 x per year	
Magnesium (Mg <sup>2+</sup> ) (4, 5)	annually / 12 x per year	
Chloride (Cl <sup>-</sup> )	annually / 12 x per year	annually / 26 x per year
Atrazine	annually / 12 x per year	
Cadmium (6)	annually / 12 x per year	
Lindane (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	
Chromium (6)	annually / 12 x per year	

Determinand	Surveillance Monitoring 2	
	Water	Water
	concentrations	load assessment
Zinc (6)	annually / 12 x per year	
p,p'-DDT and its derivatives (7)	see below	
COD <sub>Cr</sub> (5)	annually / 12 x per year	
COD <sub>Mn</sub> (5)	annually / 12 x per year	
Dissolved Silica		annually / 26 x per year
BOD <sub>5</sub>	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 times per RBMP period; in case of risk the frequency is 12 times per 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 2023 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<sup>3</sup> plastic bottles were provided for NH<sub>4</sub><sup>+</sup>-N, NO<sub>3</sub><sup>-</sup>-N, organic N, total N, PO<sub>4</sub><sup>3-</sup>-P and total P analysis. Measurement results were asked to be reported as mg/dm<sup>3</sup> N and P, respectively.
- real surface water samples for heavy metal analysis: preserved natural surface water, spiked and adequately homogenised. Sample codes were SW-M-1 and SW-M-2. 250 cm<sup>3</sup> plastic bottles were provided for Cd, Ni and Pb analysis. Measurement results were asked to be reported as µg/dm<sup>3</sup>.
- spike solutions together with matrix water for NO<sub>2</sub><sup>-</sup>-N and Hg 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, pretreated by bringing to boiling point) according to instructions. Spike solutions were put in 20 cm<sup>3</sup> plastic containers with sample codes SW-N/M-1 and SW-N/M-2, whereas matrix water was provided in 500 cm<sup>3</sup> plastic bottle labelled “WATER FOR DILUTION - NO<sub>2</sub>- N” and “WATER FOR DILUTION - Hg”. Measurement results were asked to be reported as mg/dm<sup>3</sup> N and µg/dm<sup>3</sup> Hg, respectively.
- fish muscle samples for Hg analysis: freeze-dried samples with a particle size of < 0,5 mm in 30 cm<sup>3</sup> amber glass bottles. Sample codes were FISH-M-1 and FISH-M-2. Samples were prepared from freshwater fish muscle and spiked with inorganic mercury. Results were to be reported to the material provided “as is” in mg/kg, i.e. no separate determination of and correction with dry matter content was required.

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 ( $\sigma_{pt}$ ) was determined. Finally, performance statistics was calculated including z-scores, z'-scores and E<sub>n</sub> numbers and performance assessment was given (section 9.4., 9.5. and 9.7. of ISO 13528:2015). Calculation of performance statistics was also performed for results excluded from calculation of statistical characteristics in order to clearly indicate when appropriate measures should be taken by participants.

Sixty-two laboratories were enrolled into the scheme in 2023, which is similar to previous years' numbers. All of the appointed laboratories reported results. Most of the participants were experienced laboratories who had formerly participated in and were familiar with the AQC scheme. As previously, nutrients were measured by the majority of participants (50 to 56 laboratories per parameter), with the exception of organic N, where only 5 results were available for evaluation, which is below the minimum where assessment can be performed. Organic N replaced Kjeldahl N analysis in 2013 at behest of participants, however, it remains unpopular with laboratories. In case of simulated concentrates, correlation between theoretical values calculated and actual assigned values (robust averages) is good, recovery was between 92 and 108%. In case of natural samples, the surface water batches serving as basis for preparation of proficiency testing samples normally contain non-negligible amounts of parameters to be determined, thus expected concentration differences between sample pairs, calculated from spiking, were compared to actual differences of assigned values (robust averages). Recovery was excellent for most parameters (between 98% and 105%, except for phosphate phosphorous (142%) and cadmium (82%). Lower phosphate phosphorous recovery is in accordance with previous experience and is probably due to the small target concentration difference between the two samples. In case of mercury in fish measurements, expected values based on predistribution analysis were compared to assigned values, where recoveries were remarkably good (102% and 104% for the two samples). Performance assessment was predominantly based on z-scores, due to the general good agreement among participants. Higher spread of results necessitated use of z'-scores in case of Pb in surface water (both samples), Hg in fish (both samples) and Hg in surface water (sample SW-N/M-1).

The 2023 proficiency testing scheme was successful overall, number and ratio of unsatisfactory results is lower or similar to previous years' values. Some of the unsatisfactory results are attributable to non-analytical errors e.g. probable switching of parameters or reporting in a different unit of measurement (these results were excluded from calculation of statistical characteristics). However, unrealistically low results caused by inadequate pH adjustment before analysis in N-form determinations, prevalent source of errors in the past, was absent this year. Evaluation of results could not be performed for organic nitrogen in either samples, as the ratio of the standard uncertainty of the assigned value (i.e. robust average) and the standard deviation of proficiency assessment was well above the critical limit of 120%. Diminishing number of interested laboratories (only 5 this year, compared to the equally low value of 11 in 2018) questions the long-term feasibility of inclusion of this parameter in the AQC scheme. All reported results were in the satisfactory range for total nitrogen and Hg in fish. Determination of total phosphorous was equally successful, with only one questionable reported value. In summary, the 2023 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 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 made available on the ICPDR website ([www.icpdr.org](http://www.icpdr.org)).

### 3. Results of Basic Statistical Processing

In the whole Danube River Basin District in 2023, 148 sites at 111 TNMN monitoring stations were monitored (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 Table 1, in the column „Location“. Samples from 69 sampling sites at 40 stations were collected directly on the Danube river. Tributaries were monitored at 79 sampling sites representing 71 stations.

**Table 3: List of TNMN stations reported in 2023**

N°	Station 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	Lanžhot	79
10	CZ2	M	Morava/Dyje	Pohansko	17
11	SK1	L, M, R	Danube	Bratislava	1869
12	SK2	M,R	Danube	Medveďov	1806
13	SK5	L, M, R	Danube	Szob	1707
14	SK4	M,R	Vah	Komárno	1,5
15	SK6	M	Morava	Devín	1
16	SK7	M	Danube/Hron	Kamenica	1,7
17	SK8	M	Danube/Ipeľ	Salka	12
18	HU1	M	Danube	Medve/Medvedov	1806
19	HU2	M	Danube	Komarom/Medvedov	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	Dravaszabolcs	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	Tisza/Hármas-Körös/Sebes-Körös	Korosszakal	9
30	HU13	M	Tisza/Hármas-Körös/Kettős-Körös/Fekete-Körös	Sarkad	16
31	HU14	M	Tisza/Hármas-Körös/Kettős-Körös/Fehér-Körös	Gyulavari	59
32	HU15	R	Tisza/Maros	Nagylak	51
33	SI1	L	Drava	Ormož most	300
34	SI2	R	Sava	JesenicenaDolenjskem	729
35	HR1	M, R	Danube	Batina	1429
36	HR11	M	Danube	Ilok	1301,5
37	HR9	M,R	Drava	Ormož	300

N°	Station code	Location	River	Monitoring station	River km
38	HR4	M, R	Drava	Botovo	227
39	HR5	M, R	Drava	D. Miholjac	78
40	HR6	L,R	Sava	Jesenice	729
41	HR7	M	Sava	Upstream UnaJasenovac	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	Banatska Palanka	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	BG15	M	Russenski Lom	mouth	1
77	RO1	L, M, R	Danube	Bazias	1071
78	RO18	L, M, R	Danube	Gruia/Radujevac	851
79	RO2	L, M, R	Danube	Pristol/Novo Selo	834
80	RO3	L, M, R	Danube	Dunare - upstream Arges (Oltenita)	432
81	RO4	L, M, R	Danube	Chiciu/Silistra	375
82	RO5	M, R	Danube	Reni-Chilia/Kilia arm	132
83	RO6	R	Danube	Vilkova-Chilia arm/Kilia arm	18
84	RO7	L, M, R	Danube	Sulina - Sulina arm	0
85	RO8	L, M, R	Danube	Sf. Gheorghe-Ghorghe arm	0
86	RO9	M	Arges	Conf. Danube (Clatesti)	0
87	RO10	M	Siret	Conf. Danube (Sendreni)	0

N°	Station code	Location	River	Monitoring station	River km
88	RO11	M	Prut	Conf. Danube (Giurgiulesti)	0
89	RO12	M	Somes	Dara (frontiera)	3
90	RO13	M	CrisulRepede	Cheresig	3
91	RO14	M	CrisulNegru	Zerind	13
92	RO15	M	Crisul Alb	Varsand	0
93	RO16	M	Mures	Nadlac	21
94	RO17	M	Bega	Otelec	7
95	RO19	M	Jiu	Zaval	9
96	RO20	M	Olt	Islaz	3
97	RO21	M	Ialomitita	Downstream Tandarei	24
98	MD1	L	Prut	Lipcani	658
99	MD3	L	Prut	Conf. Danube-Giurgiulesti	0
100	MD5	L	Prut	Costesti Reservoir	254
101	MD6	L	Prut	Braniste	254
102	MD7	L	Prut	Valea Mare	525
103	<b>UA1</b>	<b>M</b>	<b>Danube</b>	<b>Reni</b>	<b>132</b>
104	<b>UA2</b>	<b>M</b>	<b>Danube</b>	<b>Vylkove</b>	<b>18</b>
105	UA4	M	Tisza	Chop	342
106	UA5	M	Tisza/Bodrog/Latoritsa	Strazh	144
107	UA6	M	Prut	Tarasivtsi	262
108	UA7	M	Siret	Tcherepkivtsi	100
109	UA8	R	Uzh	Storozhnytsya	106
110	ME1	L	/Lim	Dobrakovo	112
111	ME2	L	/Cehotina	Gradac	55.5

Explanations:

Bold font – for the Danube River sites

Normal font – tributaries

## 4. Profiles and Trend Assessment of Selected Determinands

The basic processing of the TNMN data includes in the first step a calculation of selected statistical characteristics for each determinand/monitoring site. 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 annual basis (Figures 4.26-4.40).

**ANNEX I** - data format:

Term used	Explanation
<b>Determinand name</b>	name of the determinand measured according to the agreed method
<b>Unit</b>	unit of the measured determinand
<b>N</b>	number of measurements
<b>Min</b>	minimum value of the measurements done in the year 2023
<b>Mean</b>	arithmetical mean of the measurements done in the year 2023
<b>Max</b>	maximum value of the measurements done in the year 2023
<b>C50</b>	50 percentiles of the measurements done in the year 2023
<b>C90</b>	90 percentiles of the measurements done in the year 2023 (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).*

Since 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 the limit of quantification, in statistic processing of data ½ limit of quantification (LOQ) was used.

A 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 2023. These include indicators of the oxygen regime, nutrients, heavy metals, biological determinands and organic micropollutants. Table 4 also includes information about the total number of monitoring locations/sites actually measured in 2023.

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2023 (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 <sub>avg</sub>	Max <sub>avg</sub>		Min	Max	Min <sub>avg</sub>	Max <sub>avg</sub>
Temperature	°C	67/40	1	32.5	11	17	73/71	0.2	31.1	0.2	23.4
Suspended solids	mg/l	67/40	< 1	410	5	69	73/71	< 1	641	< 1	227
Dissolved oxygen	mg/l	67/40	0.5	14.6	6.16	10.77	73/71	1.8	15.49	6.08	11.71
BOD (5)	mg/l	67/40	< 0.25	15.3	0.72	5.73	73/71	< 0.25	43.0	0.82	10.24
COD (Mn)	mg/l	60/33	0.96	17.5	2.1	6.16	40/38	1.12	28	2.41	7.23
COD (Cr)	mg/l	54/27	< 2.5	58	6.2	19.55	58/56	<2.5	150.0	3.92	43.3
TOC	mg/l	33/21	< 0.25	19.4	2.79	5.91	30/28	0.99	22.0	1.68	8.06
DOC	mg/l	30/15	< 0.25	9.70	2.27	5.43	17/17	< 0.25	9.59	1.29	7.18
pH	-	64/39	7.1	9.73	7.62	8.44	69/69	6.53	8.9	7.19	8.29
Alkalinity	mmol/l	66/39	1.199	7.48	1.614	4.344	59/57	0.9	8.70	1.27	7.67
Ammonium nitrogen (NH4-N)	mg/l	67/40	< 0.004	0.876	0.021	0.256	68/66	< 0.004	4.053	0.014	2.268
Nitrite-Nitrogen (NO2-N)	mg/l	67/40	< 0.001	0.255	0.0087	0.0361	73/71	< 0.001	0.2113	< 0.0025	0.1172
Nitrate-Nitrogen (NO3-N)	mg/l	67/40	0.02	3.3	0.841	2.408	73/71	0.02	5.24	0.044	3.859
Total nitrogen	mg/l	59/32	< 0.5	9.73	1.35	2.656	64/62	0.4	6.9	0.73	5.024
Organic nitrogen	mg/l	27/15	< 0.06	8.56	0.219	1.078	25/23	< 0.007	2.5	0.102	1.833
Orthophosphate (PO4-P)	mg/l	67/40	< 0.0011	1.22	0.01	0.43	73/71	< 0.001	0.91	< 0.0035	0.34
Total phosphorus	mg/l	65/38	0.02	1.39	0.05	0.48	73/71	< 0.003	1.03	0.02	0.66
Total phosphorus, dissolved	mg/l	36/17	0.01	1.34	0.03	0.46	18/18	< 0.0035	0.79	0.01	0.30
Phytoplankton (biomass - chlorophyll-a)	µg/l	41/21	< 0.0015	33.00	2.22	10.37	34/32	< 0.0015	223.00	0.25	46.84
Conductivity	µS/cm	65/38	48	1339	355	487	68/66	135	1715	202	1463
Calcium (Ca++)	mg/l	67/40	16.52	103	39.94	78.48	73/71	20.6	202	29.57	165
Sulphate (SO4--)	mg/l	42/23	9.8	59.6	14.73	33.92	45/43	4.1	178	5.7	99.13
Magnesium (Mg++)	mg/l	66/39	< 2.00	77.72	10.22	26.66	68/66	1.68	83.4	4.53	60
Potassium (K+)	mg/l	29/17	< 0.10	6.6	< 0.10	3.4	35/33	0.7	12	0.88	11
Sodium (Na+)	mg/l	29/17	5.8	24.3	11.2	16.2	35/33	1.8	238.18	2.63	88.54
Manganese (Mn)	mg/l	16/10	< 0.0005	0.677	< 0.0005	0.1012	19/17	< 0.0003	0.399	< 0.0005	0.1196
Iron (Fe)	mg/l	12/10	< 0.001	10.1	< 0.001	0.843	21/19	< 0.001	5.24	< 0.001	0.662
Chloride (Cl-)	mg/l	66/39	8.1	300.28	16.1	46.29	73/71	1.24	389.00	3.00	339.75
Silicates (SiO2)	mg/l	16/8	2.13	26.7	2.6625	10.0167	17/15	1.2	30.4	6.08	22.74
Silicates(SiO2), dissolved	mg/l	10/8	< 0.054	10	3.015	6.2	9/9	0.234	11.7	3.46	9.22
Macrozoobenthos- saprobic index		17/14	0.4	2.466	0.4	2.404	30/30	3.36	0.46	3.07	6.61

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2023 (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 <sub>avg</sub>	Max <sub>avg</sub>		Min	Max	Min <sub>avg</sub>	Max <sub>avg</sub>
Zinc - Dissolved *	µg/l	65/38	0.259	63	0.795	13.703	73/71	0.232	94	0.557	44.28
Copper - Dissolved	µg/l	65/38	< 0.25	36.9	0.948	6.16	73/71	< 0.25	34.7	0.5	7.242
Chromium - Dissolved	µg/l	65/38	0.08	3.8	< 0.10	1.18	68/66	0.06	18.3	0.02	4.86
Lead - Dissolved	µg/l	61/36	0.022	10.7	0.046	1.697	58/56	0.015	32.6	< 0.025	6.348
Cadmium - Dissolved	µg/l	61/36	< 0.005	0.875	< 0.005	0.165	57/55	< 0.005	0.585	< 0.005	0.5
Mercury - Dissolved	µg/l	61/36	< 0.0025	0.08	< 0.0025	0.044	58/56	< 0.0025	0.23	< 0.0025	0.30
Nickel - Dissolved	µg/l	65/38	< 0.250	8.6	0.499	3.099	58/56	< 0.1	12.5	< 0.15	10.82
Arsenic - Dissolved	µg/l	61/36	0.448	5.01	< 0.500	2.723	65/63	0.201	8	< 0.25	5.567
Aluminium - Dissolved	µg/l	19/13	< 1.00	62.6	7.76	24.82	23/21	< 2.25	605	3.86	149.91
Zinc *	µg/l	23/19	< 0.5	230	2.7	34.74	30/28	0.5	290.7	3.36	101.36
Copper	µg/l	19/15	< 0.5	69.4	1.816	9.167	26/24	< 0.5	60.5	2.072	20.358
Chromium - total	µg/l	20/16	0.177	15.8	0.6825	3.33	33/31	0.02	41.8	0.4621	15.4083
Lead	µg/l	15/13	< 0.15	72.5	0.6417	7.1833	27/25	< 0.15	192.8	0.423	22.13
Cadmium	µg/l	15/13	< 0.01	2.1	0.01833	0.261	27/25	< 0.01	1.07	< 0.01	0.5
Mercury	µg/l	15/13	< 0.01	0.4	0.0175	0.1	26/24	0.005	0.9	< 0.01	0.3
Nickel	µg/l	21/17	< 0.5	29.2	0.9	5.6	28/26	< 0.15	108	1.714	31.35
Arsenic	µg/l	15/13	< 0.5	8.3	0.938	2.67	22/20	< 0.25	16.8	0.88	14
Aluminium	µg/l	8/6	< 5.0	15300	240.333	2102.25	13/11	17.3	25500	123.992	4988.417
Phenol index	mg/l	32/13	< 0.0001	0.016	0.0001	0.004	20/20	< 0.0001	0.009	0.0001	< 0.003
Anionic active surfactants	mg/l	36/15	0.01	< 0.0500	< 0.0150	< 0.0500	26/26	< 0.0025	0.19	< 0.0025	0.0715
AOX	µg/l	13/7	< 5.0	30	5.5833	12.75	14/14	< 3.0	42	< 7.5	27.25
Petroleum hydrocarbons	mg/l	29/14	< 0.01	0.176	0.01	0.0803	19/19	< 0.01	1.635	< 0.0025	0.182
Lindane	µg/l	57/30	< 0.00005	< 0.0015	< 0.00005	< 0.0015	48/46	< 0.00005	< 0.025	< 0.00005	< 0.0250
pp'DDT	µg/l	55/30	< 0.00003	< 0.0025	< 0.00003	< 0.0015	50/48	< 0.00003	6.9	< 0.00003	5.08
Atrazine	µg/l	56/29	< 0.0005	0.183	< 0.0005	< 0.025	47/45	< 0.0005	< 0.5	< 0.0005	< 0.5
Chloroform	µg/l	14/8	< 0.052	0.5	< 0.064	0.5	19/19	< 0.015	< 0.5	0.03	< 0.5
Carbon tetrachloride	µg/l	14/8	< 0.063	0.5	< 0.069	< 0.500	20/20	< 0.05	< 1.0	< 0.05	< 1.0
Trichloroethylene	µg/l	5/3	< 0.073	0.5	< 0.073	0.5	16/16	< 0.05	< 1.0	< 0.05	< 1.0
Tetrachloroethylene	µg/l	5/3	< 0.075	0.5	< 0.077	0.5	16/16	< 0.05	< 1.0	< 0.05	< 1.0

In this chapter, in Figures 4.1-4.16 **the temporal changes for selected determinands** (dissolved oxygen (DO), BOD<sub>5</sub>, COD<sub>Cr</sub>, N-NH<sub>4</sub>, N-NO<sub>3</sub>, P-PO<sub>4</sub>, P<sub>total</sub> and Cd) in the last 10 years in the Danube River and also in tributaries are presented 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 also in graphs shown as the Hungarian point HU3. For trend graphs the illustration of SK5 and HU3 was used. In 2016, the Danube HR2 rkm 1337 was replaced with HR11 rkm 1301.5 and in the Sava river HR8 rkm 254 was replaced with HR12 rkm 218.

The long-term trends in the upper, middle and lower Danube and more detailed examples of analysis of selected parameters (BOD<sub>5</sub>, N-NO<sub>3</sub>, P<sub>total</sub>) are 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 2023 the **highest concentrations of biodegradable organic matter** were observed in the middle and lower parts of the Danube River with a maximum of 6.65 mg.l<sup>-1</sup> in HU1.

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 2023 were observed in the middle and lower part (see Figure 4.3).

The decrease of the BOD<sub>5</sub> has been observed in some tributaries: Morava, Sio and Russenski Lom (Figure 4.4). In 2023 the concentration of BOD<sub>5</sub> has increased in Sava (HR6, HR7, BA5, BA11). The maximal concentration was found in the Russenski Lom (BG15 – 6.26 mg.l<sup>-1</sup>).

At the monitoring points SK1 and RO5 the BOD<sub>5</sub> levels decreased in 2023, while at HU5 the BOD<sub>5</sub> levels increased (Figure 4.17 - 4.19).

The highest values of **dissolved oxygen (DO)** in the Danube River were observed in its upper and middle part, in the lower Danube the dissolved oxygen levels decreased, minimum was 4.95 mg.l<sup>-1</sup> in BG5 (Figure 4.1).

The maximum value of dissolved oxygen in tributaries was in Salzach (10.26 mg.l<sup>-1</sup>) and the minimal concentration was in Sio 4.72 mg.l<sup>-1</sup>. The concentrations have a stable character (Figure 4.2).

Concentrations of **chemical oxygen demand (COD<sub>Cr</sub>)** (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 4.5 - 90 - mg.l<sup>-1</sup> with maximum in BG15 (Russenski Lom-mouth) than in the Danube River sites (range of C90 values 8.6 - 23 mg.l<sup>-1</sup>), maximum in lower part -RO6.

The almost stable level of **ammonium-nitrogen** concentrations (C90) was recorded in the whole Danube River (Figure 4.7). The concentration increased in BG2 with a maximum of 0.57 mg.l<sup>-1</sup>.

In 2023, concentrations of ammonium-nitrogen decreased in the tributaries Arges RO9 and Velika Morava RS17 (see Figure 4.8). In the upper and middle Danube tributaries the concentration of ammonium-nitrogen had a stable level in 2023 (Figure 4.8).

The level of **nitrate-nitrogen** concentrations was rather stable during the recent years. In comparison with the previous year the concentrations in upper part slightly decreased (see figure 4.9). Maximum of nitrate nitrogen concentration was in DE5 2.9 mg.l<sup>-1</sup>.

In the lower Danube tributaries the **nitrate-nitrogen** concentrations decreased. An increase was observed in the Dyje, Sio, Sajo, Jantra and Prut (RO11) (Figure 4.10).

**Temporal changes of nitrate-nitrogen** which are presented in the Figures 4.20 - 4.22 for the Danube River in Bratislava (Slovakia), Hercegszanto (Hungary) and Reni (Romania) indicate an increase in all monitoring points. The lowest value of C90 in 2023 was 1.29 mg.l<sup>-1</sup> in RO5 - Reni.

The data for **ortho-phosphate-phosphorus** in the Danube River are presented in Figure 4.11 showing that the 2023 results were stable. An decrease of the ortho-phosphate-phosphorus was observed at RS8 (Danube-Radujevac) where was the highest value detected in year 2021.

A decrease of ortho-phosphate-phosphorus concentrations was observed in Dyje, Arges and Velika Morava with a maximum of  $0.78 \text{ mg.l}^{-1}$  in CZ2 Dyje (Figure 4.12).

Concentrations of **total phosphorus** (Figure 4.13) in the upper and middle Danube were stable. The **total phosphorus** values in 2023 showed a stable situation in the Danube tributaries (Figure 4.14). The highest concentration in 2023 of  $0.99 \text{ mg.l}^{-1}$  was found in the Sio.

**The temporal changes of total phosphorus (C90)** are shown in Figures 4.23-4.25 at selected monitoring sites. In 2023 the concentrations increased in SK1 and HU5 slightly increased and in RO5 was the same as in 2022.

The **cadmium** dissolved concentration (Figure 4.15) was constant in the whole part of the Danube. The maximum value was  $0.49 \text{ mg.l}^{-1}$  in RO7 Sulina – Sulina arm.

The concentrations of  $\text{Cd}_{\text{diss}}$  was stable in the upper part tributaries with the maximum of  $0.5 \text{ mg.l}^{-1}$  in Prut (MD3). The concentration has increased in Tisza- RS 11.

**The comparison of statistical characteristics of 90 and 10 percentiles (C90, C10) in 2023** for selected determinands ( $\text{N-NH}_4$ ,  $\text{P-PO}_4$ ,  $\text{COD}_{\text{Cr}}$ ,  $\text{BOD}_5$ ) is 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 the Danube, where tributary discharges into the Danube River.

The annual differences between P90 and P10 have an insignificant variation for  $\text{COD}_{\text{Cr}}$ ,  $\text{P-PO}_4$ ,  $\text{N-NH}_4$  in the in upper and middle Danube. Some differences were observed for  $\text{BOD}_5$  in the middle and lower part of the Danube. The highest difference was observed for  $\text{COD}_{\text{Cr}}$  in SK2 and for  $\text{BOD}_5$  in RO8.

The differences for percentiles 10 and 90 percentile values was observed for  $\text{COD}_{\text{Cr}}$  and  $\text{BOD}_5$  in lower tributaries. The significant differences for the  $\text{COD}_{\text{Cr}}$  were observed in the lower tributaries Ialomita, Russenski Lom, Crisul Negru. For the  $\text{BOD}_5$  significant differences was also in the lower part in Ialomita, Sava and Una.

The reason of rather high P90-value for  $\text{BOD}_5$  in DE5 (Danube/Dillingen) is the low water in summer and flood in winter (Figure 4.32).

The differences in concentrations for ammonium-nitrogen are visible in the tributaries Vit, Siret and Ialomita. For ortho-phosphate-phosphorus the more significant differences were observed in upper Danube tributaries Dyje, Morava, Sio and in lower tributaries Arges, Vit, Jantra.

Figure 4.1: Temporal changes (2013-2023) of dissolved oxygen (C10) in the Danube River

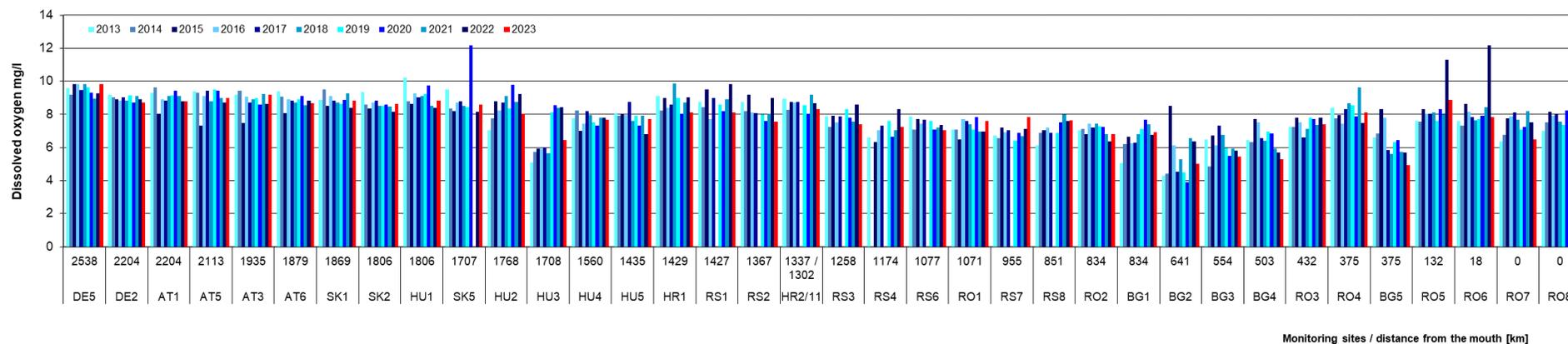


Figure 4.2: Temporal changes (2013-2023) of dissolved oxygen (C10) in tributaries

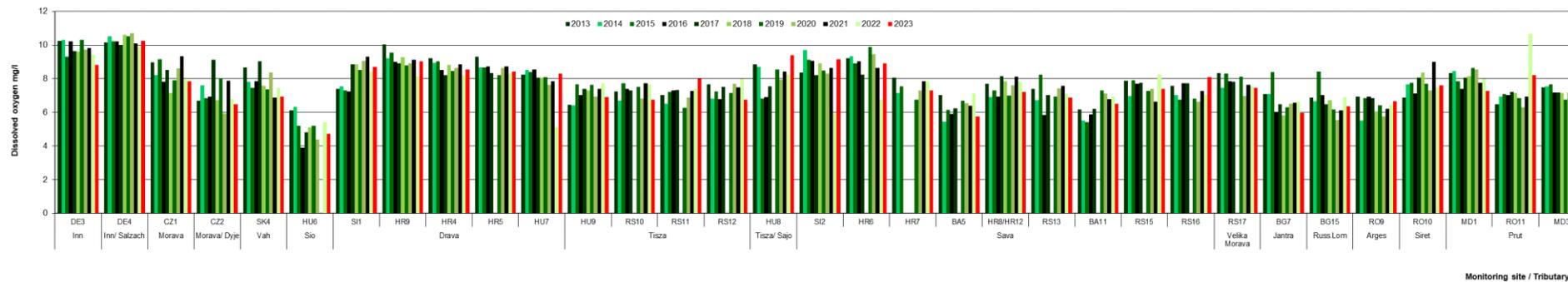


Figure 4.3: Temporal changes (2013-2023) of BOD<sub>5</sub> (C90) in the Danube River.

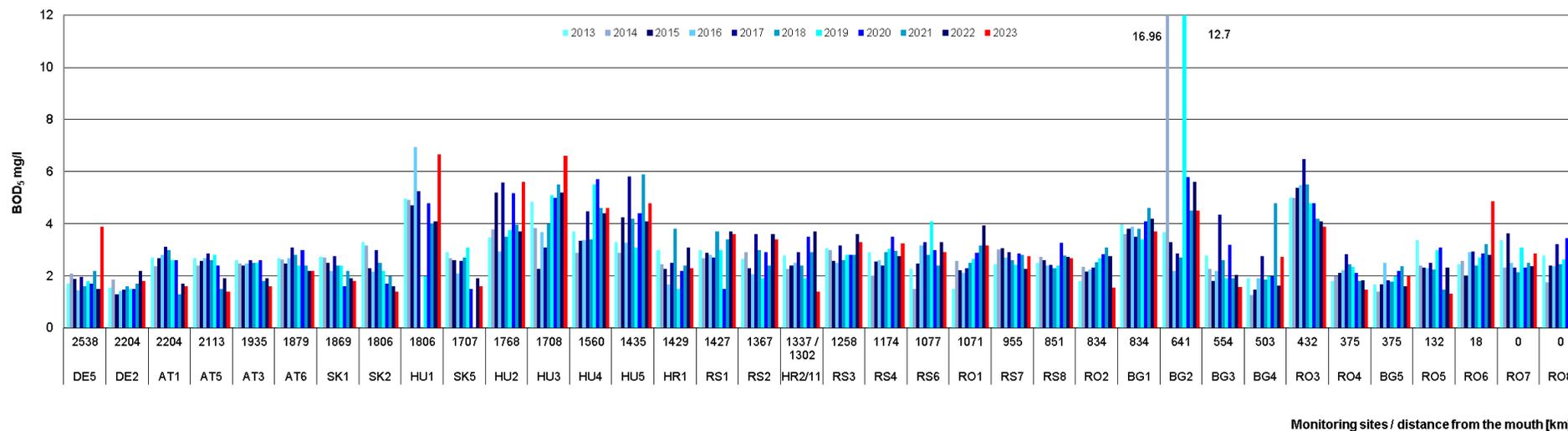


Figure 4.4: Temporal changes (2013-2023) of BOD<sub>5</sub> (C90) in tributaries.

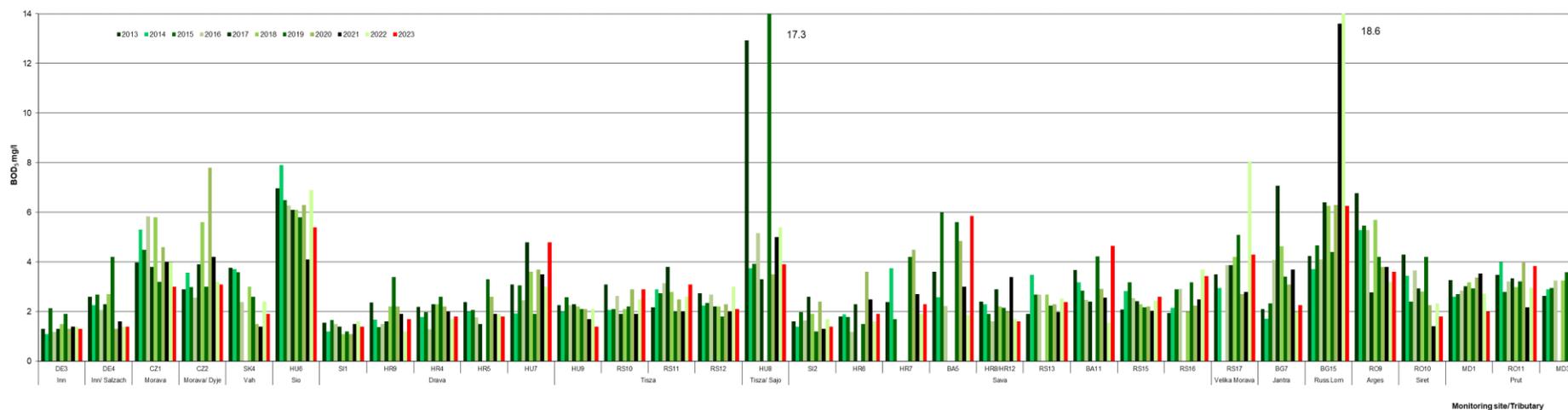
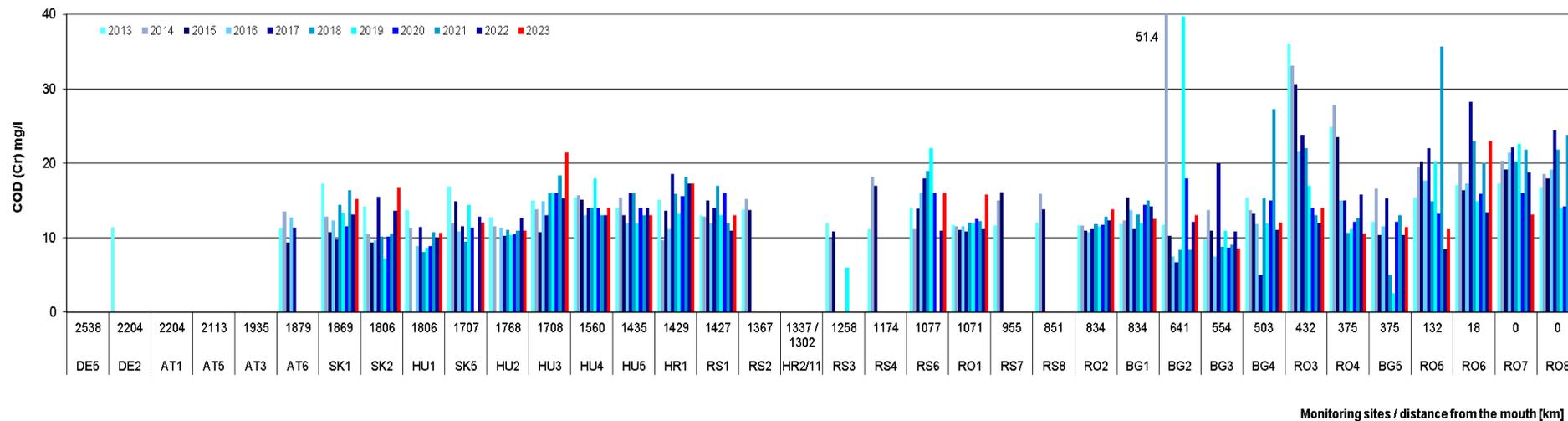
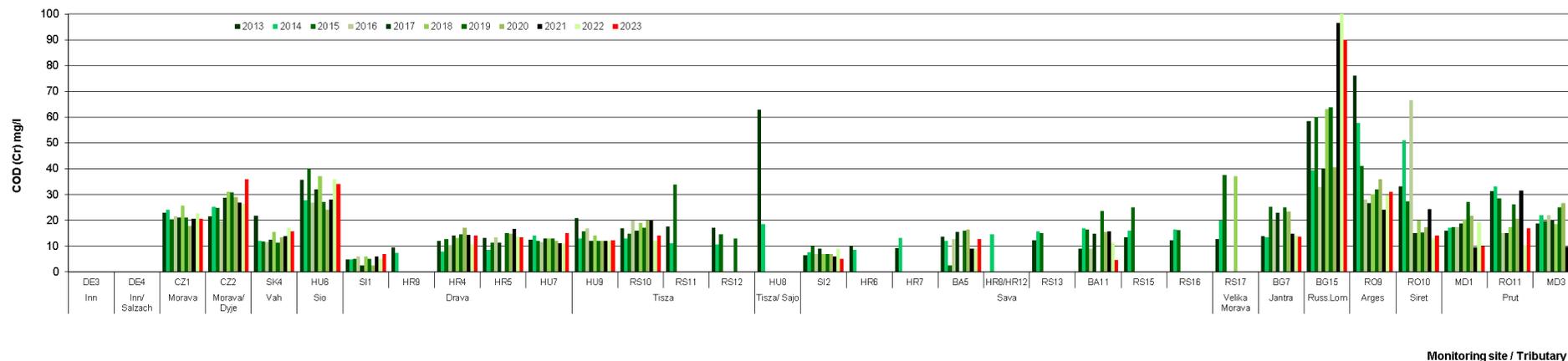


Figure 4.5: Temporal changes (2013-2023) of COD<sub>Cr</sub> (C90) in the Danube River.



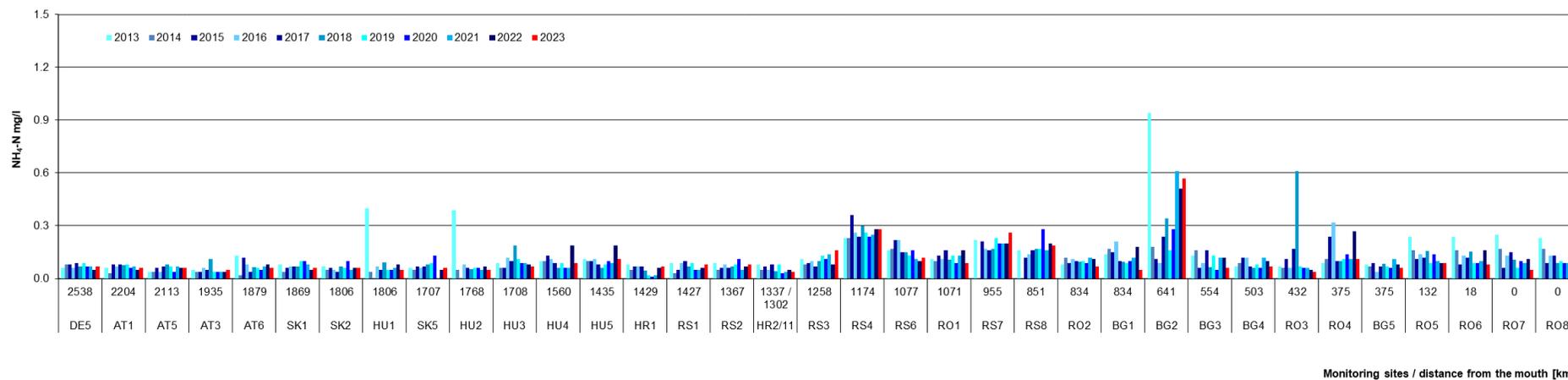
Monitoring sites / distance from the mouth [km]

Figure 4.6: Temporal changes (2013-2023) of COD<sub>Cr</sub> (C90) in tributaries.



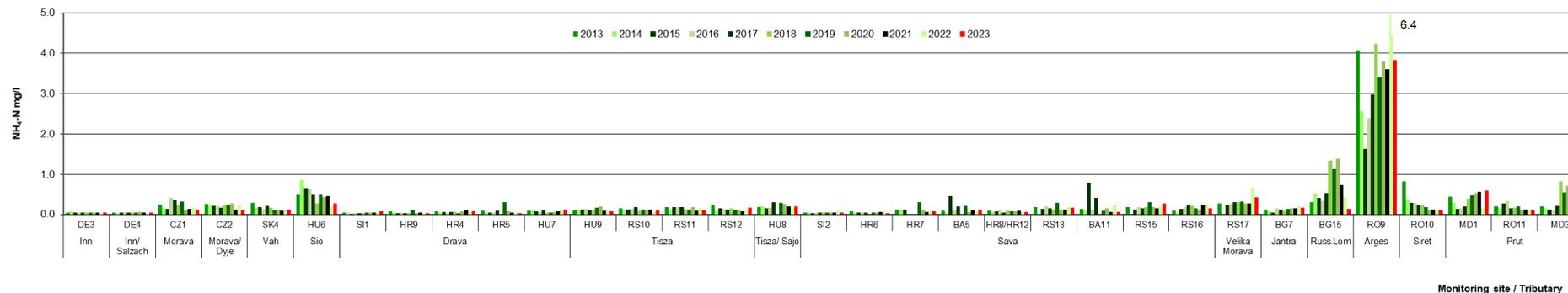
Monitoring site / Tributary

Figure 4.7: Temporal changes (2013-2023) of NH<sub>4</sub>-N (C90) in the Danube River.



Monitoring sites / distance from the mouth [km]

Figure 4.8: Temporal changes (2013-2023) of NH<sub>4</sub>-N (C90) in tributaries.



Monitoring site / Tributary

Figure 4.9: Temporal changes (2013-2023) of NO<sub>3</sub>-N (C90) in the Danube River.

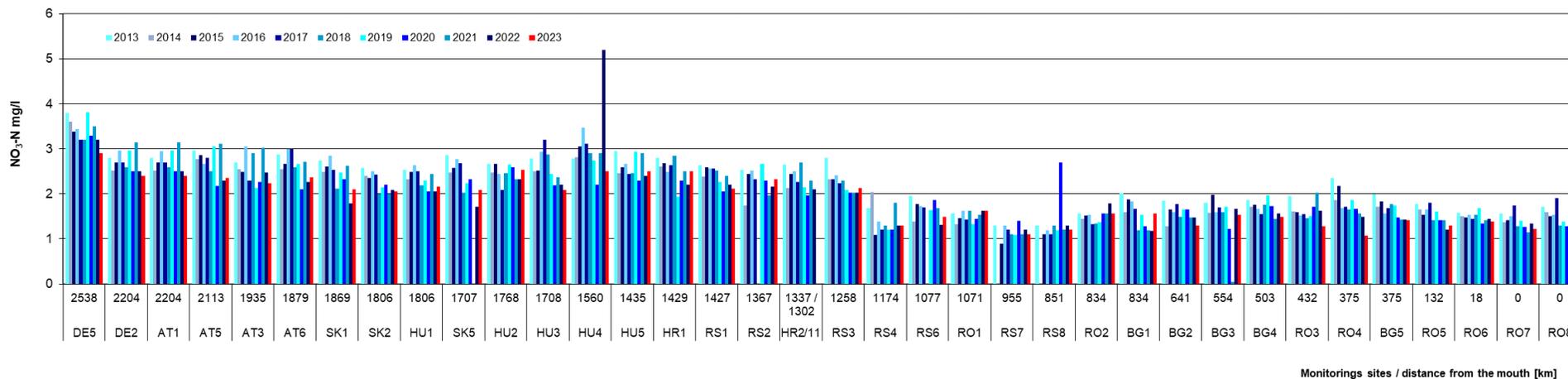


Figure 4.10: Temporal changes (2013-2023) of NO<sub>3</sub>-N (C90) in tributaries.

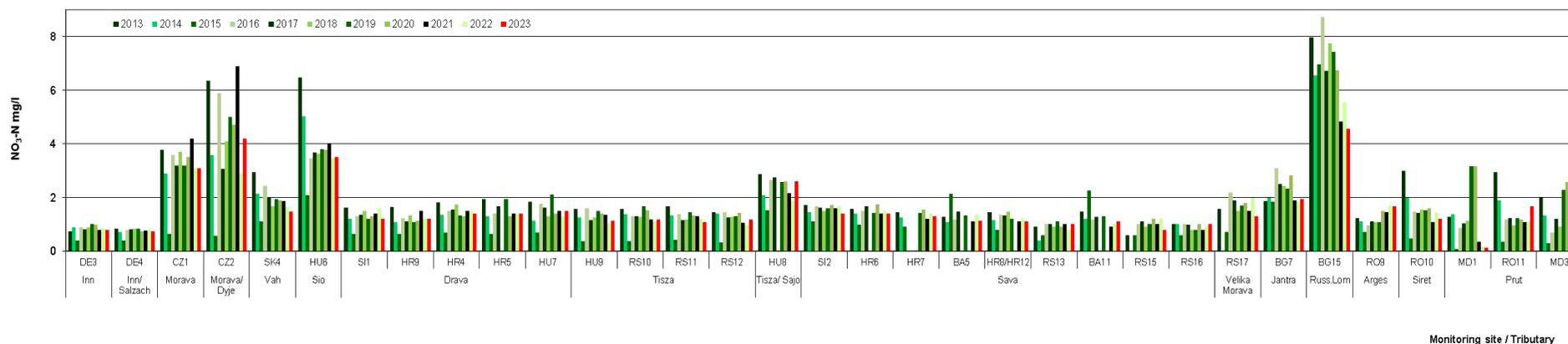


Figure 4.11: Temporal changes (2013-2023) of P-PO<sub>4</sub> (C90) in the Danube River.

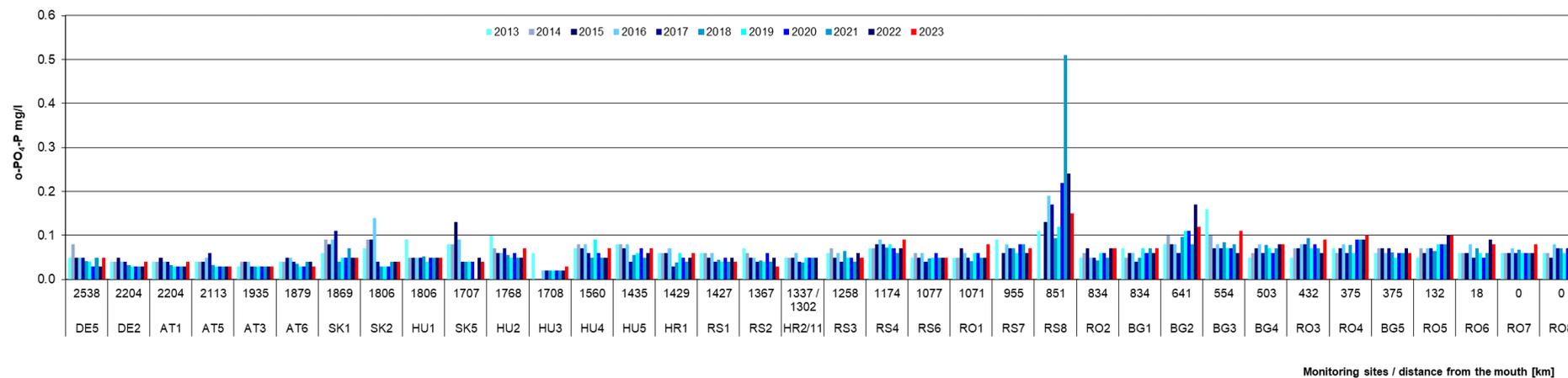


Figure 4.12: Temporal changes (2013-2023) of P-PO<sub>4</sub> (C90) in tributaries

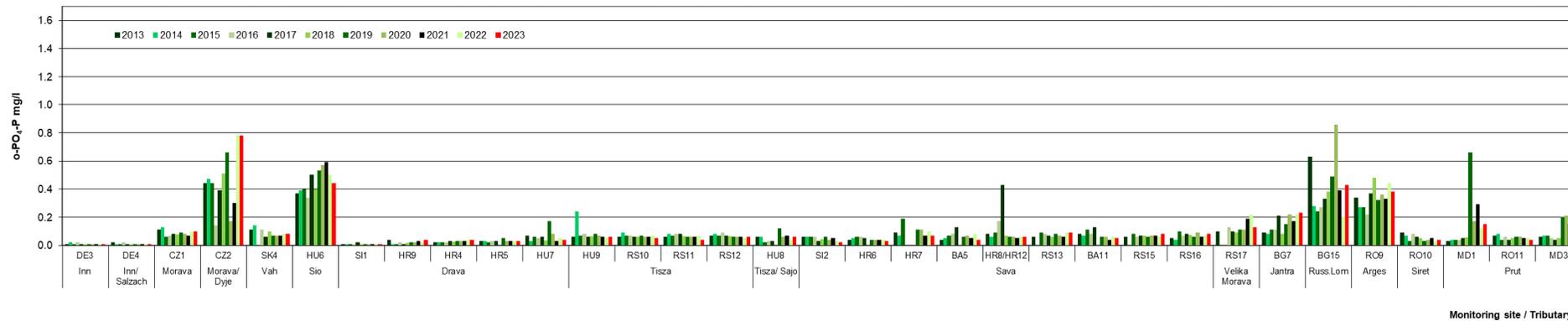


Figure 4.13: Temporal changes (2013-2023) of total phosphorus (C90) in the Danube River.

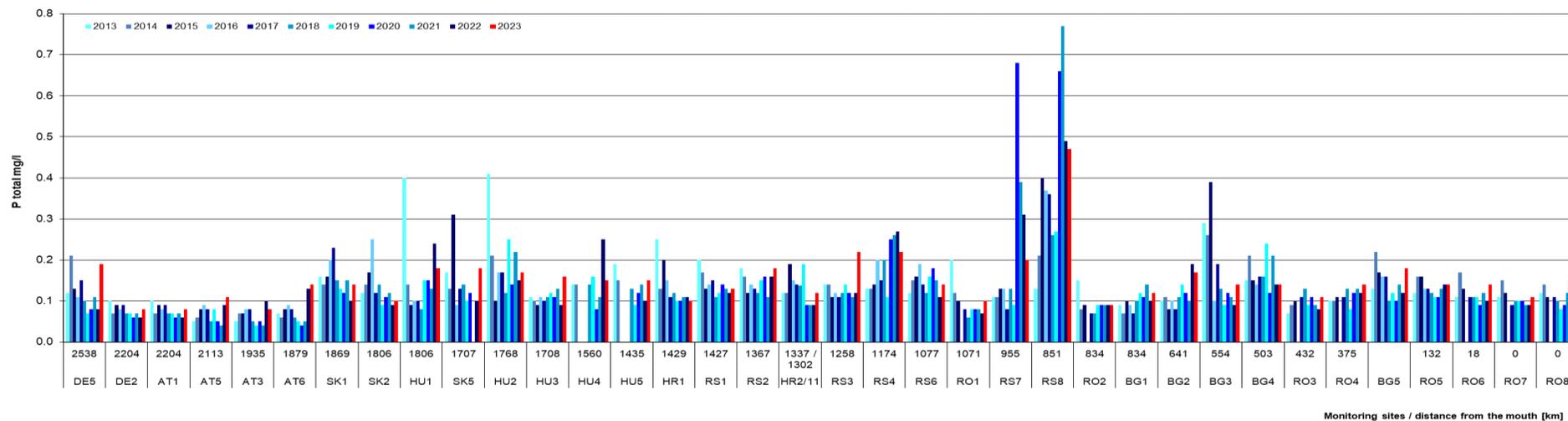


Figure 4.14: Temporal changes (2013-2023) of total phosphorus (C90) in tributaries.

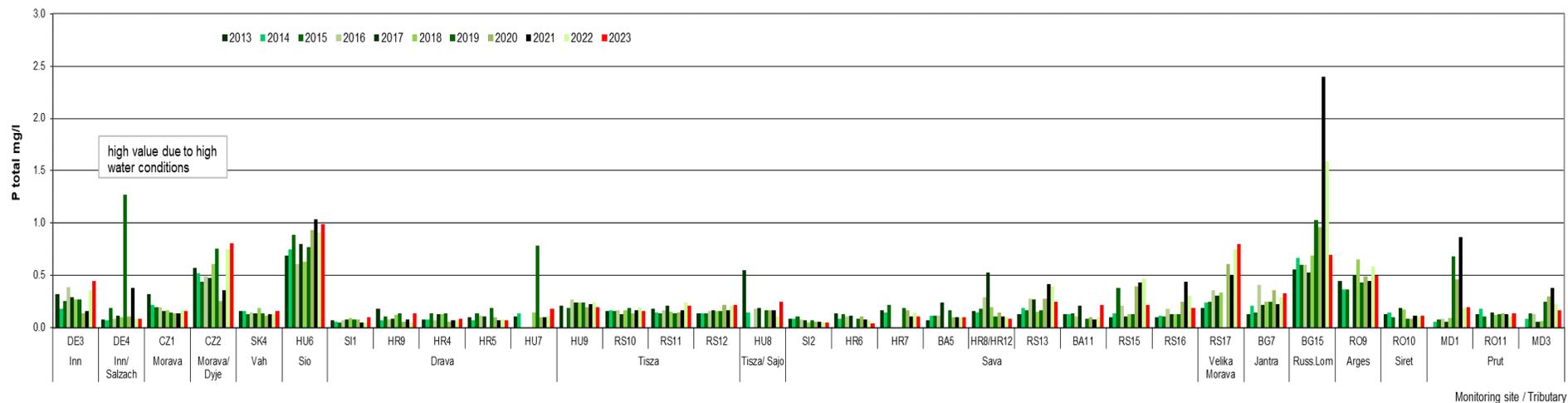


Figure 4.15: Temporal changes (2013-2023) of cadmium dissolved (C90) in the Danube River.

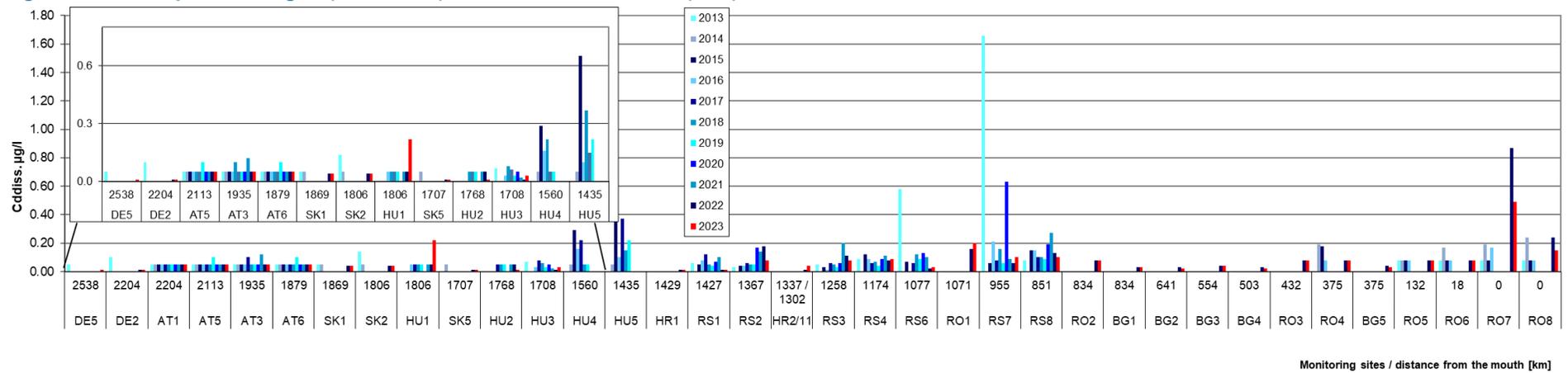


Figure 4.16: Temporal changes (2013-2023) of cadmium dissolved (C90) in tributaries.

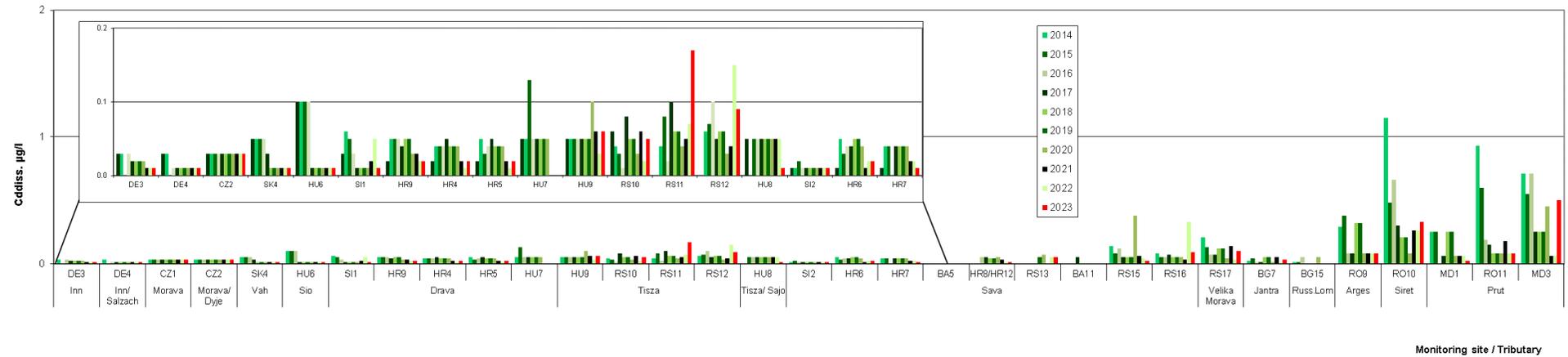


Figure 4.17: Temporal changes (2013-2023) of BOD<sub>5</sub> (C90) in Bratislava

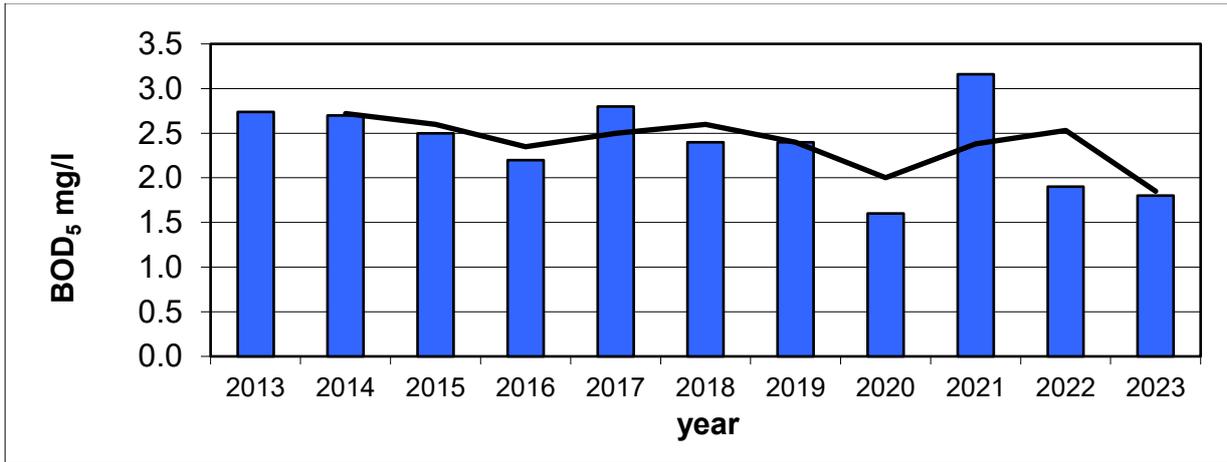


Figure 4.18: Temporal changes (2013-2023) of BOD<sub>5</sub> (C90) in Hercegszanto

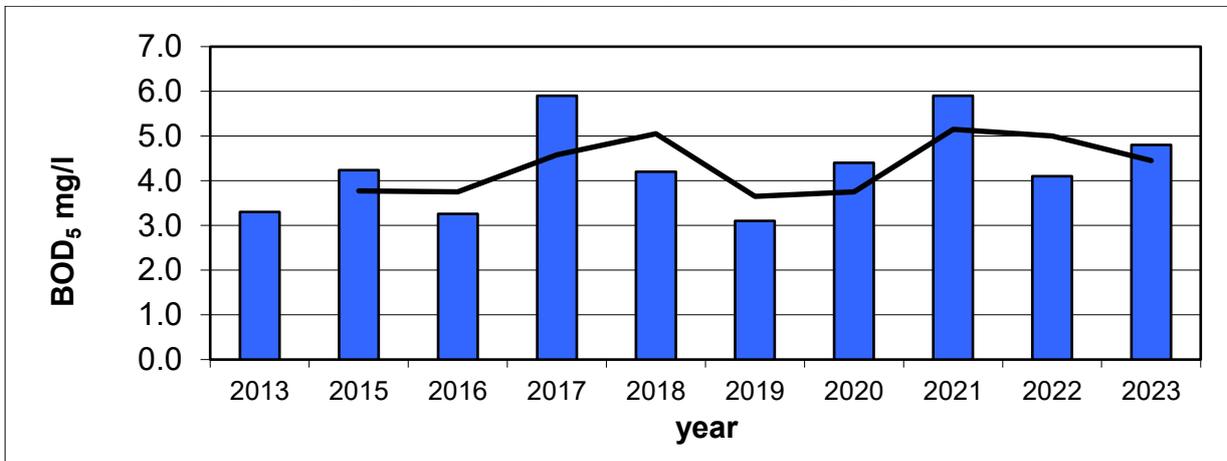


Figure 4.19: Temporal changes (2013-2023) of BOD<sub>5</sub> (C90) in Reni

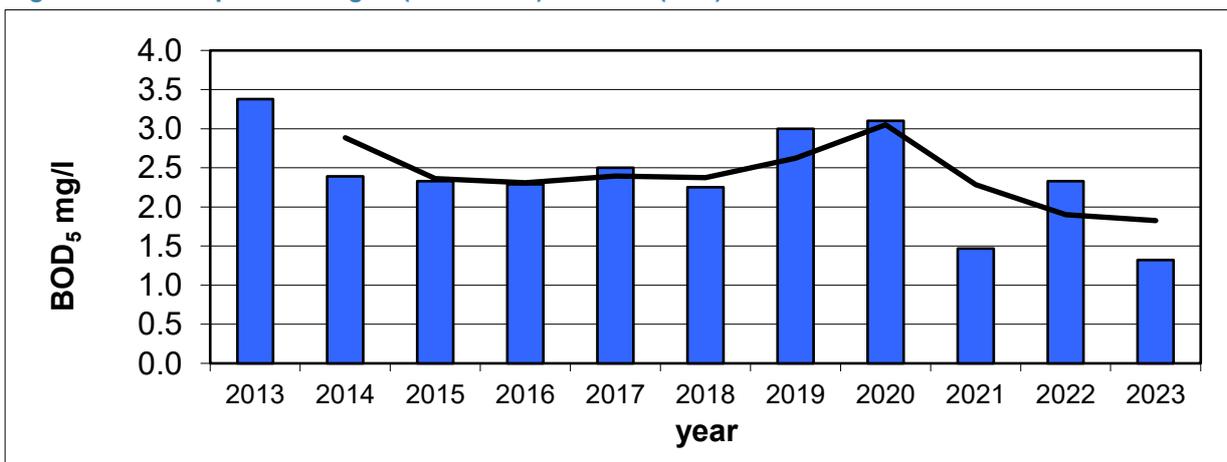


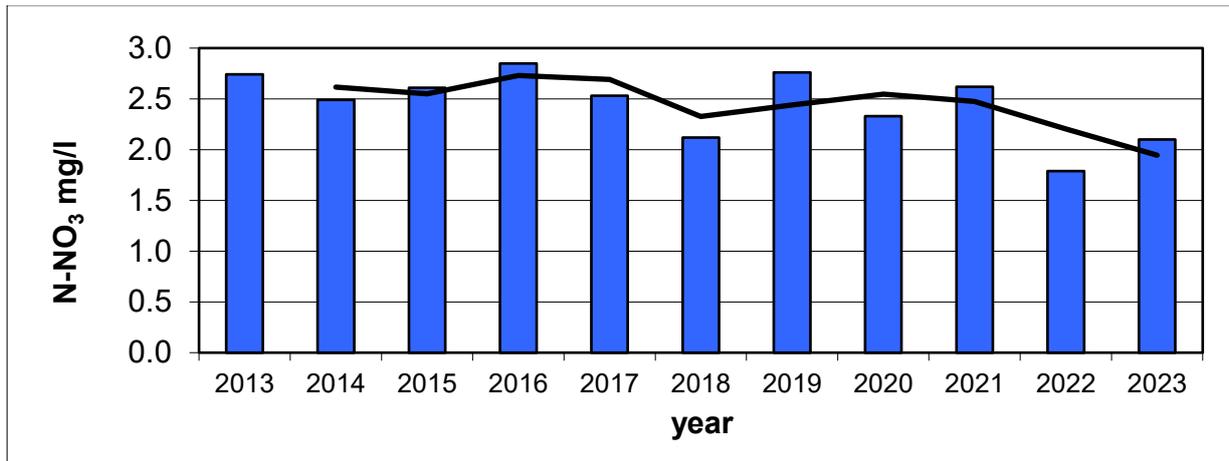
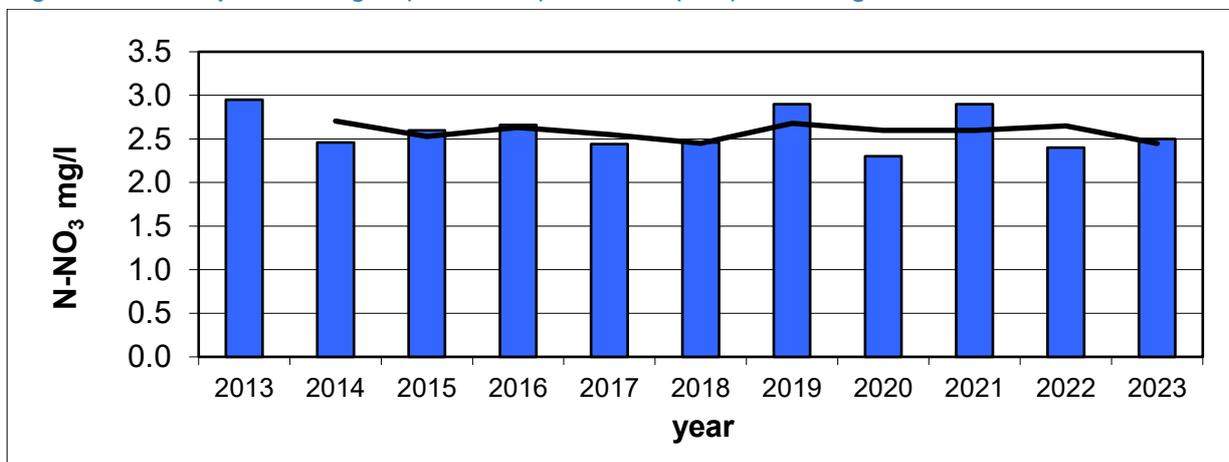
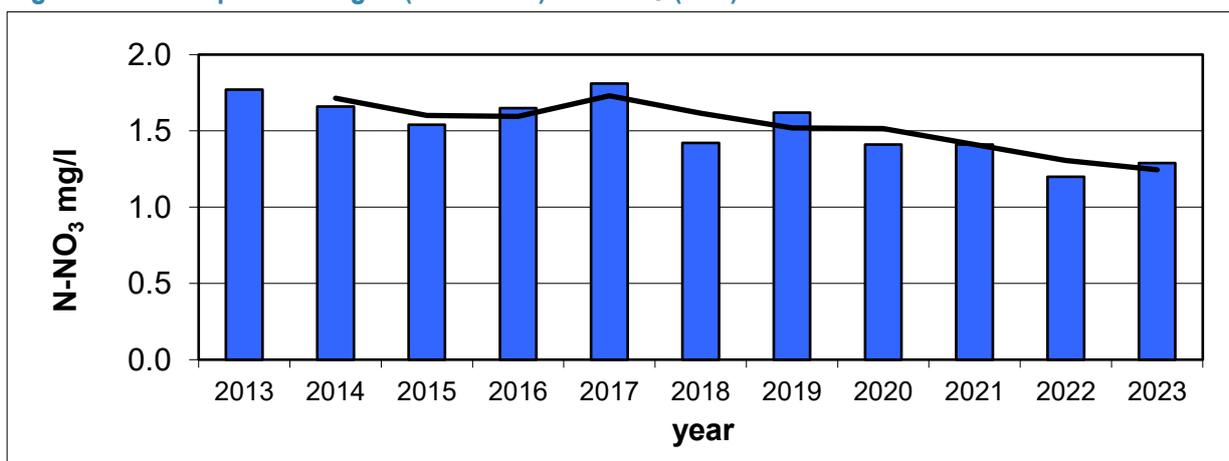
Figure 4.20: Temporal changes (2013-2023) of N-NO<sub>3</sub> (C90) in BratislavaFigure 4.21: Temporal changes (2013-2023) of N-NO<sub>3</sub> (C90) in HercegszantoFigure 4.22: Temporal changes (2013-2023) of N-NO<sub>3</sub> (C90) in Reni

Figure 4.23: Temporal changes (2013-2023) of total phosphorus (C90) in Bratislava

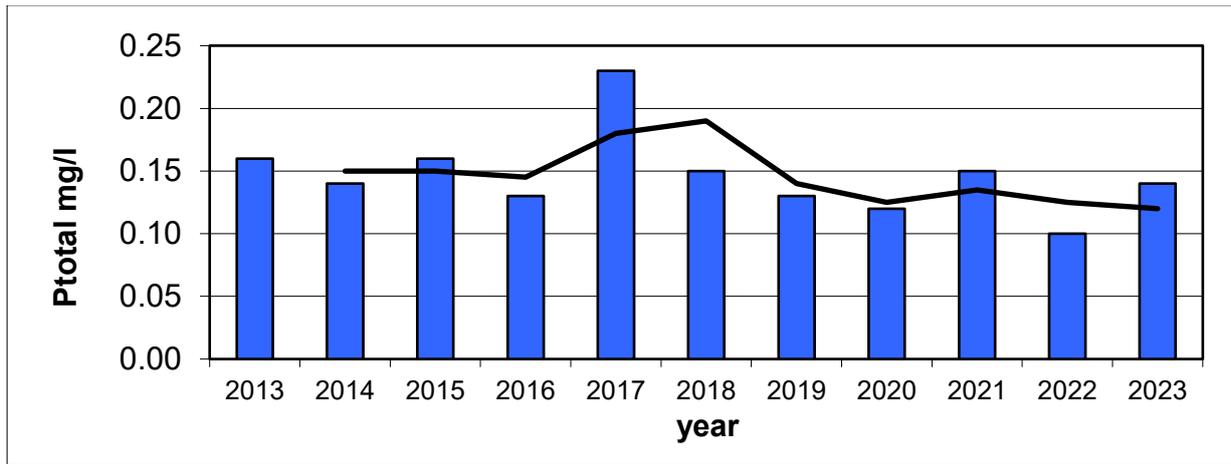


Figure 4.24: Temporal changes (2013-2023) of total phosphorus (C90) in Hercegszanto

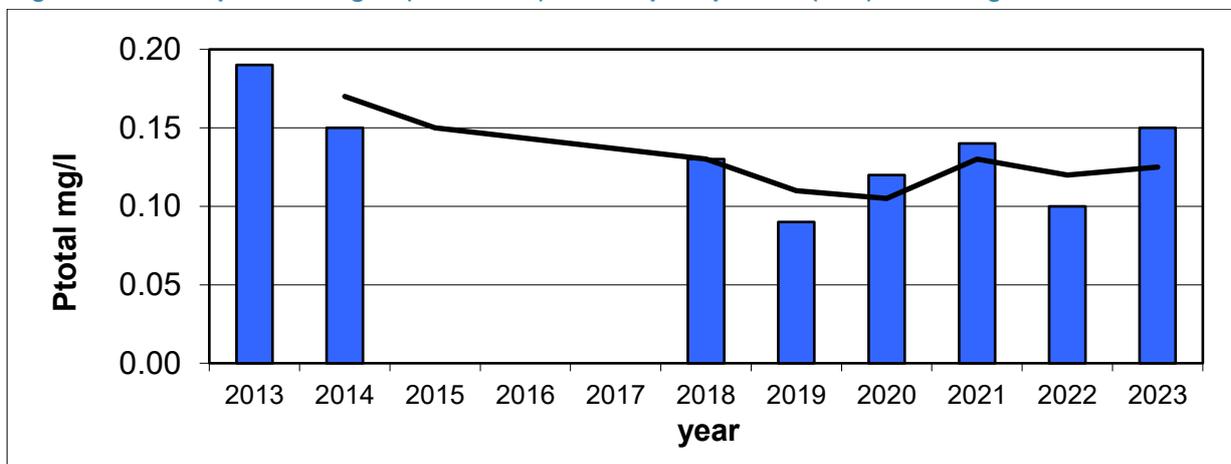


Figure 4.25: Temporal changes (2013-2023) of total phosphorus (C90) in Reni

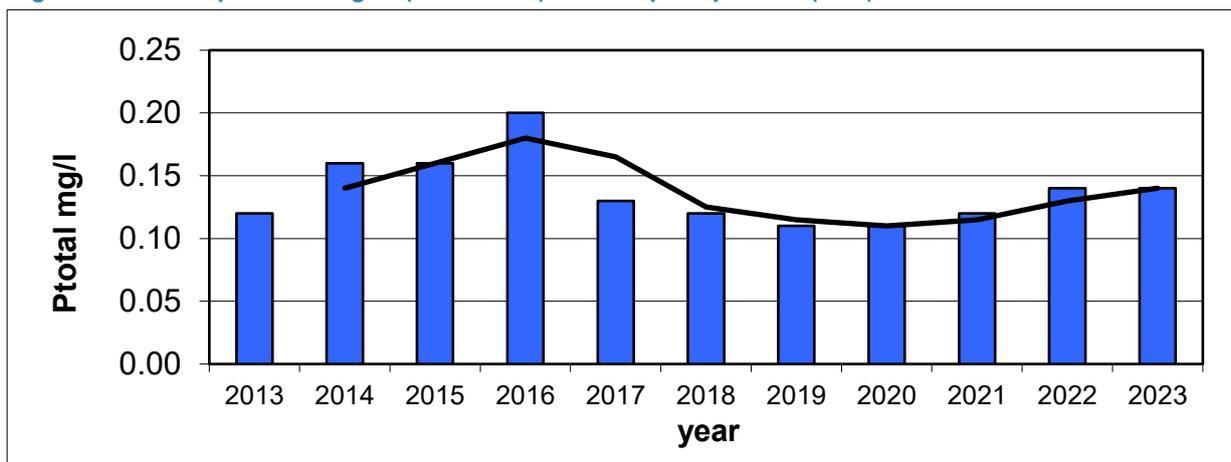




Figure 4.28: The percentile (90, 10) of P-PO<sub>4</sub> concentration along the Danube River in 2023

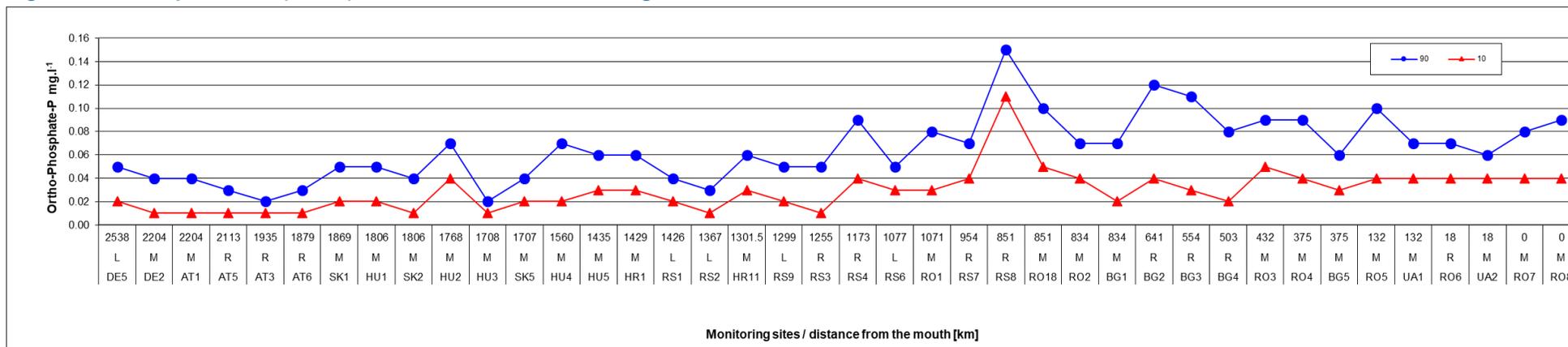


Figure 4.29: The percentile (90, 10) of P-PO<sub>4</sub> concentration in the tributaries in 2023

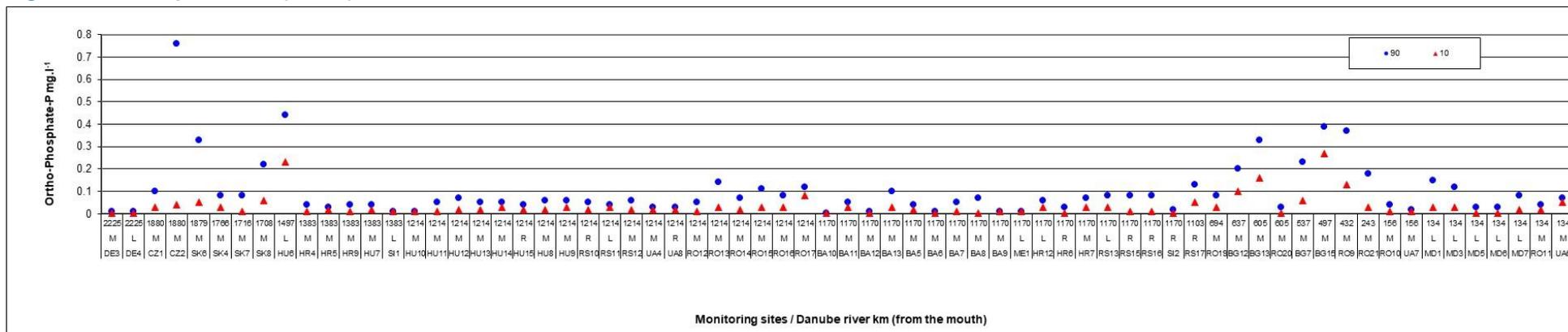


Figure 4.30: The percentile (90, 10) of COD<sub>Cr</sub> concentration along the Danube River in 2023

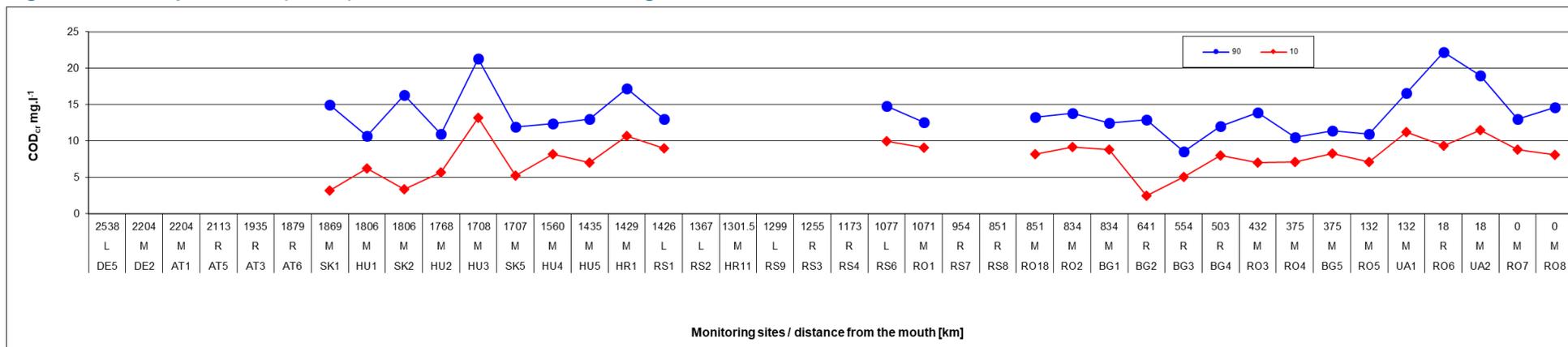


Figure 4.31: The percentile (90, 10) of COD<sub>Cr</sub> concentration in the tributaries in 2023

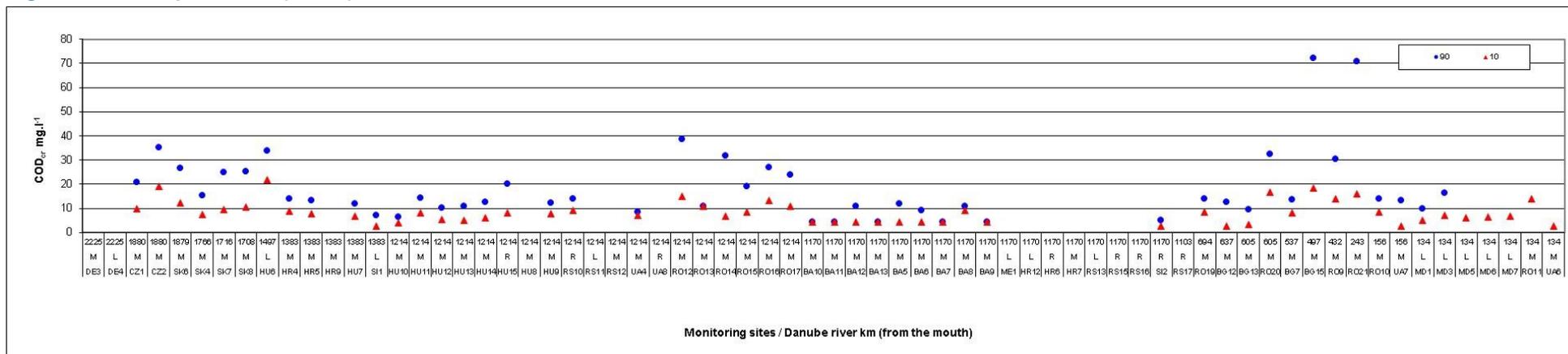


Figure 4.32: The percentile (90, 10) of BOD<sub>5</sub> concentration along the Danube River in 2023

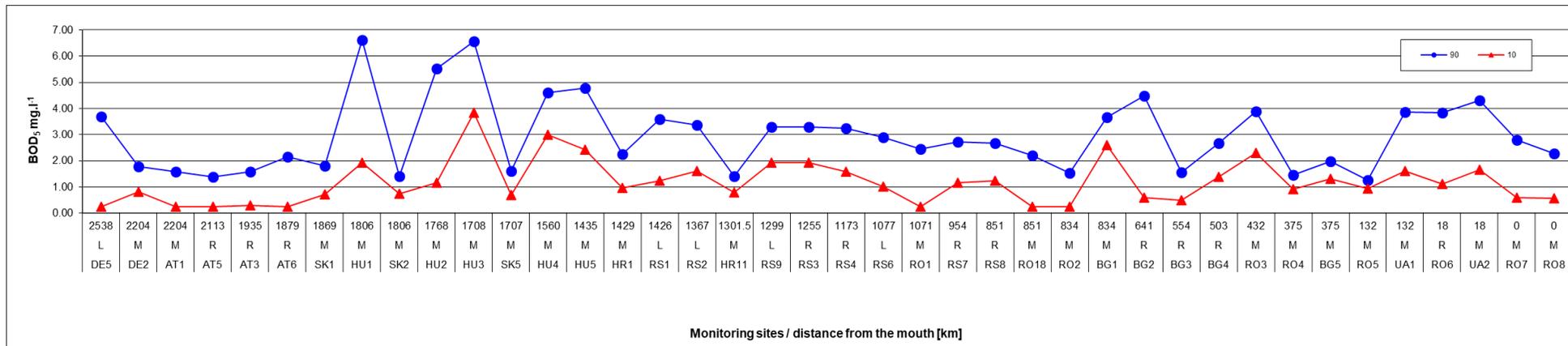
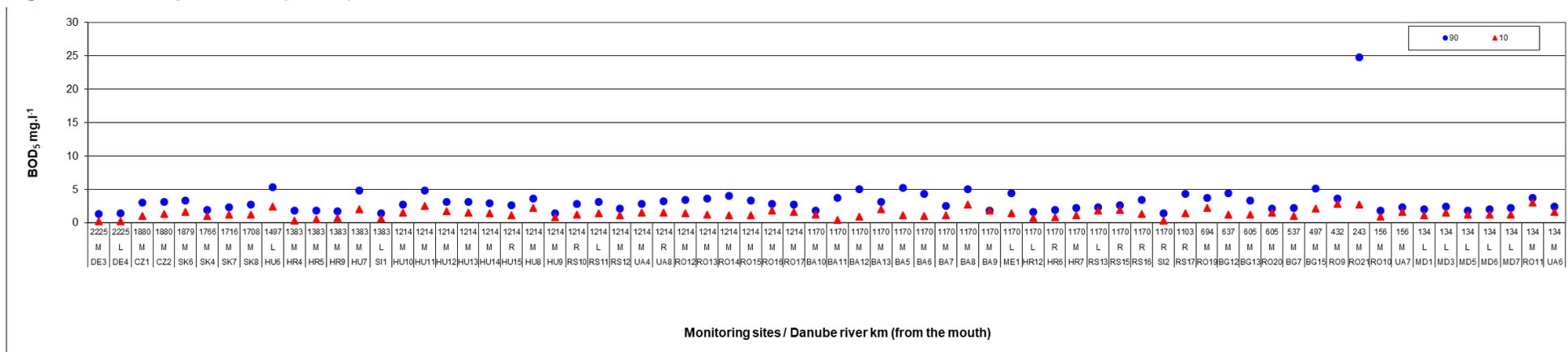


Figure 4.33: The percentile (90, 10) of BOD<sub>5</sub> concentration in the tributaries in 2023



### 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 2023 for 14 monitoring points located in the Danube River and for 30 monitoring points in the tributaries. The maximal value of saprobic index was determined in RO4 and in RO21 Ialomita tributary.

Figure 4.34: The maximum values of saprobic index based on macrozoobenthos along the Danube River in 2023

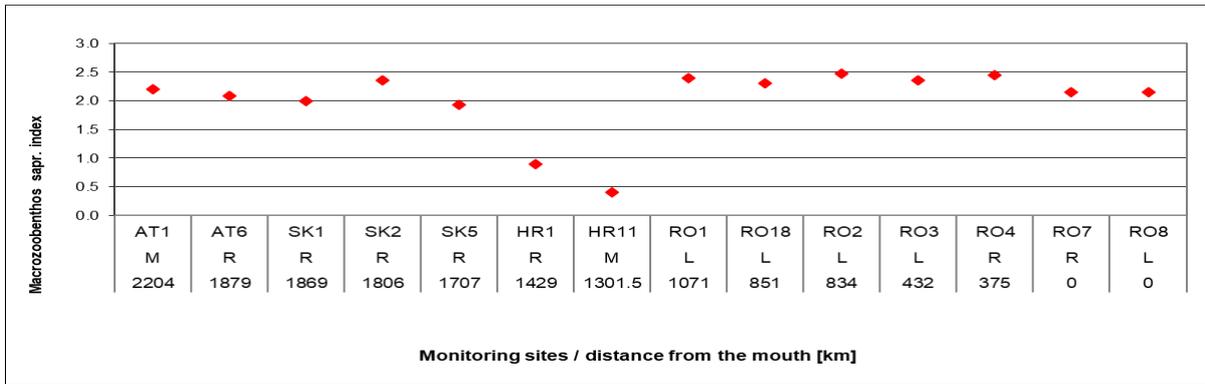


Figure 4.35: The maximum values of saprobic index based on macrozoobenthos in the tributaries in 2023

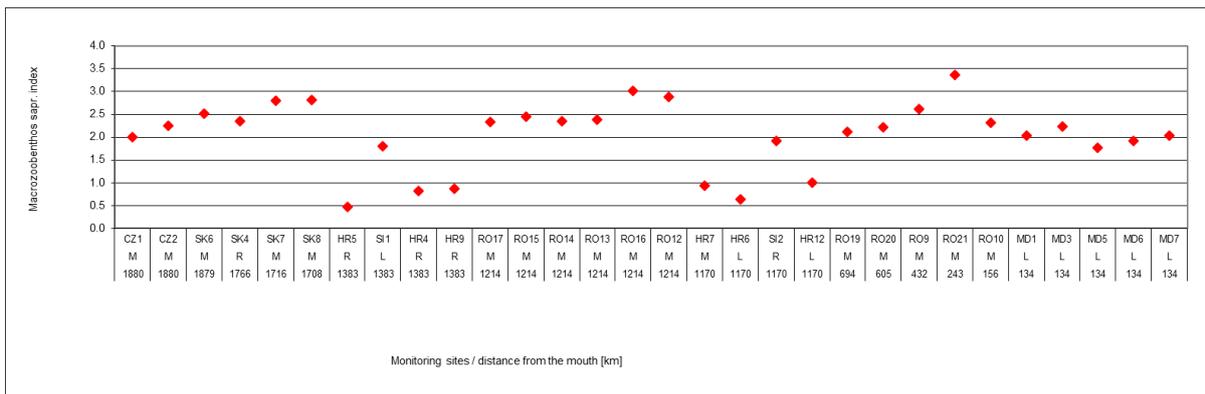
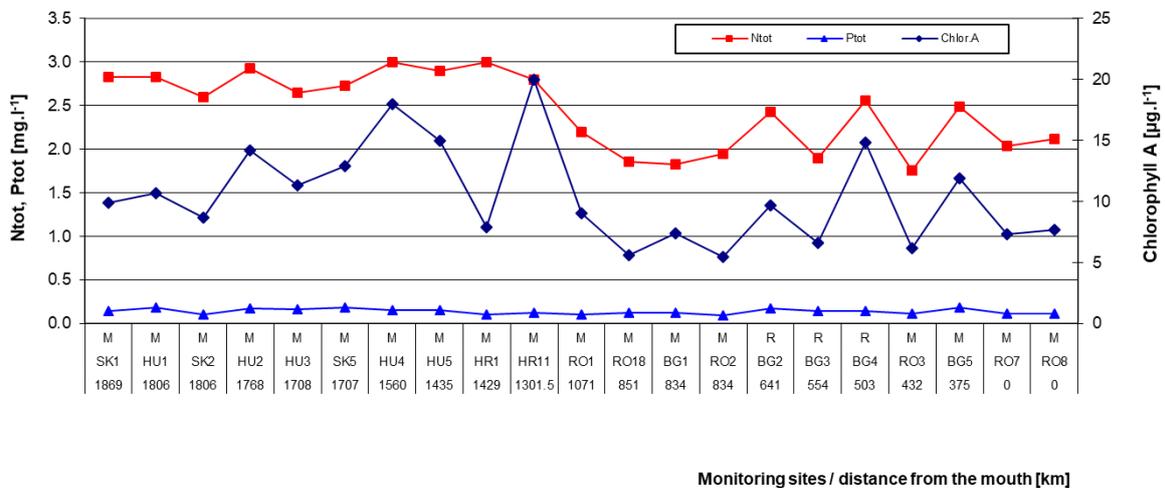


Figure 4.36: The percentile (90) of total nitrogen, total phosphorus and chlorophyll-a concentration along the Danube River in 2023



The concentration of nutrients ( $N_{tot}$ ,  $P_{tot}$ ) and the **chlorophyll-a** are presented on the Figure 4.36 (only those monitoring points are shown where all three determinands were measured).

The maximal concentration of chlorophyll-a was observed in HR11  $20 \mu\text{g.l}^{-1}$  and in HR1 Ilok was maximum of  $N_{total}$   $3.0 \text{ mg.l}^{-1}$ ). The highest concentration of  $P_{total}$   $0.18 \text{ mg.l}^{-1}$  was observed in the BG5.

### 4.2 The Sava and Tisza Rivers

The 90 percentiles of nutrients, and  $BOD_5$  measured in 2023 in the Sava and Tisza rivers are presented in the Figures 4.37-4.40. The highest value of  $N-NH_4$  in the Sava River (Figure 4.37) was found in monitoring point RS15 ( $0.27 \text{ mg.l}^{-1}$ ). The maximum concentration of  $N-NO_3$  was in SI2 Jesenice:  $1.41 \text{ mg.l}^{-1}$  and the maximum of  $N_{total}$  was observed in HR6 and RS 16 ( $1.80 \text{ mg.l}^{-1}$ ).

The highest value of  $BOD_5$  and COD in the Sava River was measured in monitoring point BA5 ( $5.86 \text{ mg.l}^{-1}$  and COD  $12.8 \text{ mg.l}^{-1}$ ).

Figure 4.37: The percentile (90) of total nitrogen,  $N-NH_4$  and  $N-NO_3$  concentration along the Sava River in 2023

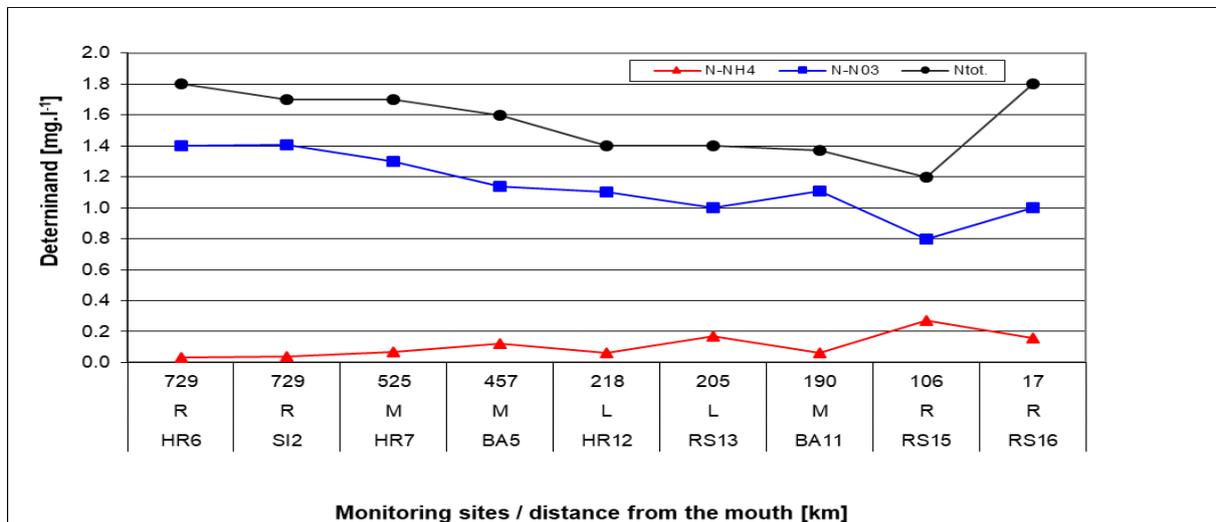


Figure 4.38: The percentile (90) of  $BOD_5$  concentration along the Sava River in 2023

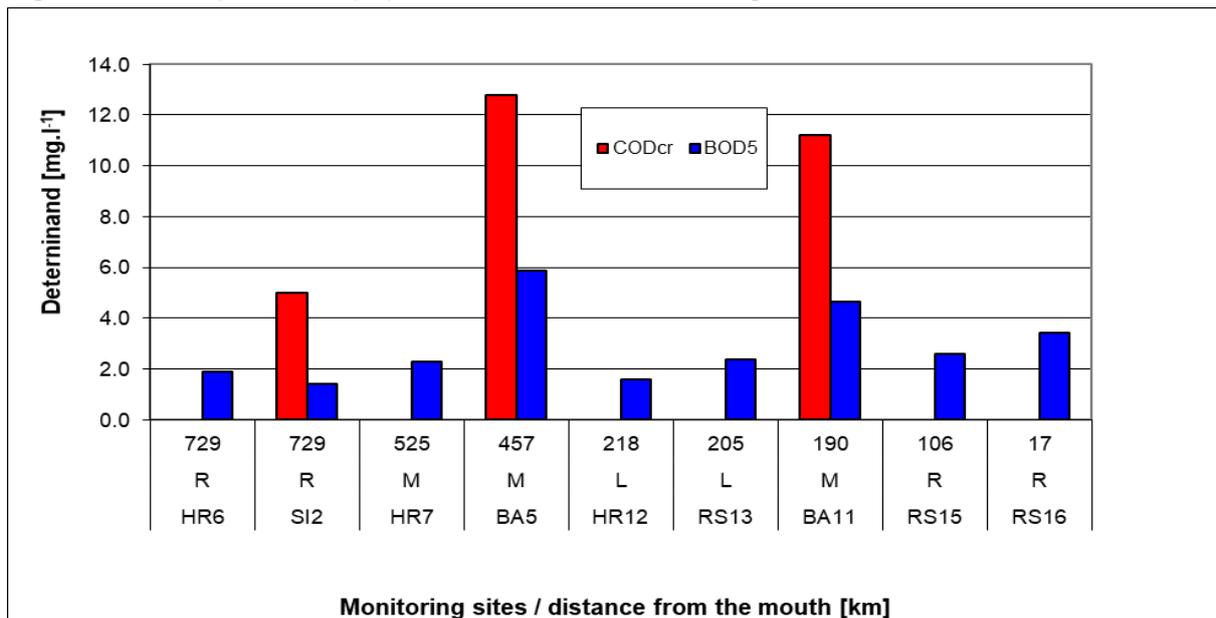


Figure 4.39: The percentile (90) of total nitrogen, N-NH<sub>4</sub> and N-NO<sub>3</sub> concentration along the Tisza River in 2023

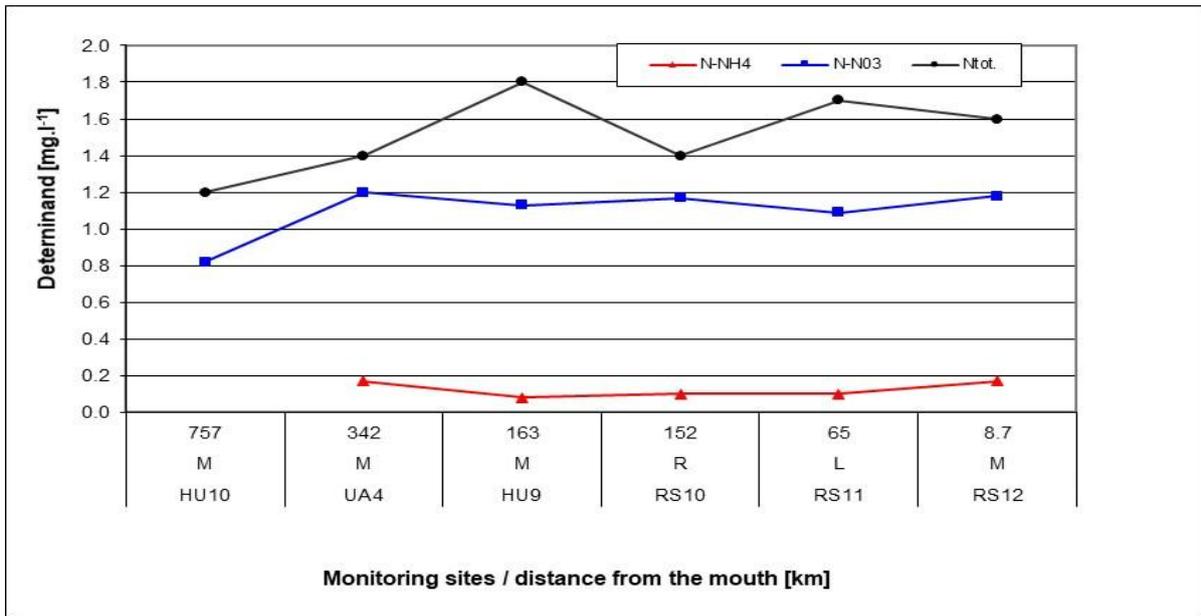
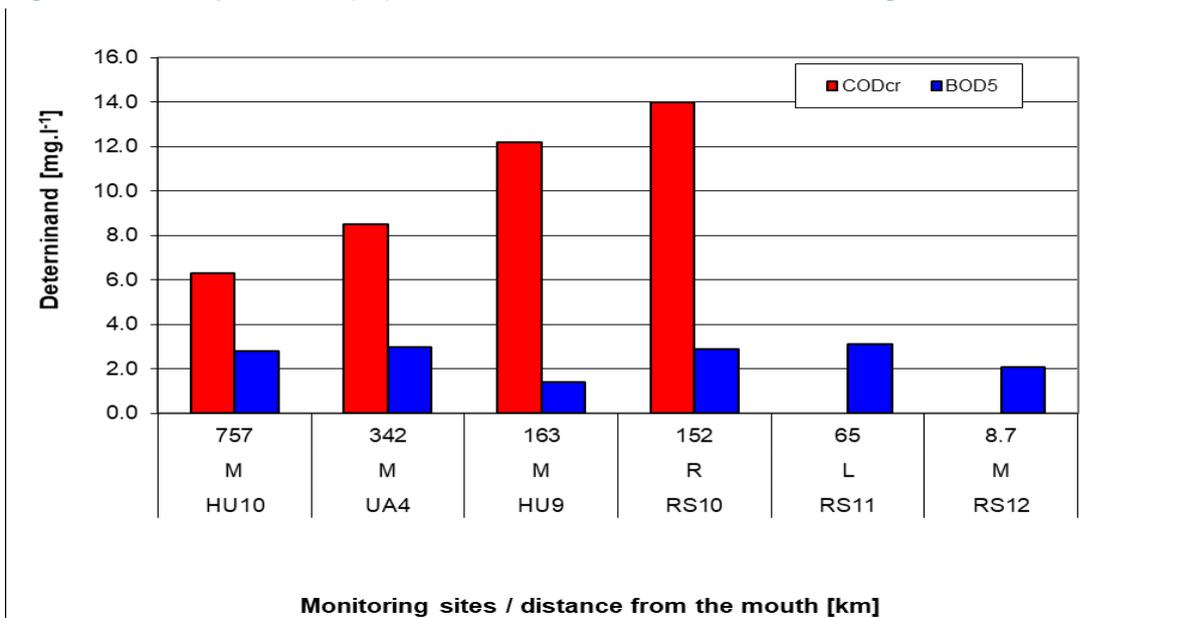


Figure 4.40: The percentile (90) of BOD<sub>5</sub> and COD<sub>Cr</sub> concentration along the Tisza River in 2023



The maximum value of N-NH<sub>4</sub> in the Tisza River was found in RS 12 (0.17 mg.l<sup>-1</sup>). The highest value of N-NO<sub>3</sub> being 1.2 mg.l<sup>-1</sup> was measured in UA4 Chop. The maximum of N<sub>total</sub> 1.8 mg.l<sup>-1</sup> was measured in HU9 Tiszasziget.

The highest value of BOD<sub>5</sub> and COD<sub>Cr</sub> were measured in RS 11 and RS 10: BOD<sub>5</sub> 3.1 mg.l<sup>-1</sup> and COD<sub>Cr</sub> 14 mg.l<sup>-1</sup> (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 program 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<sub>5</sub>, 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 a 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 5.4. 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.*

Table 5 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 2023

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 the number of samples taken in 2023.

The differences are presented by different colours. The majority of determinands were measured in a frequency of 11 and more times. Due to the war in Ukraine, RO5 Reni was monitored with a low frequency of 3-4 times.

In 2010, load calculation for Slovakian monitoring points on the tributaries Morava, Hron and Ipel’ 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 15 locations. Also, the silicates/ silicates dissolved load was calculated at 11/5 monitoring points.

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

Country	River	Water quality monitoring location		Hydrological station		
		Station code	Location	River-km	Location	River-km
Germany	Danube	DE2	Jochenstein	2 204	Achleiten	2 223
Germany	Inn	DE3	Kirchdorf	195	Oberaudorf	211
Germany	Inn/Salzach	DE4	Laufen	47	Laufen	47
Austria	Danube	AT1	Jochenstein	2 204	Aschach	2 163
Austria	Danube	AT6	Hainburg	1 879	Hainburg (Danube) Angern (March)	1 884 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	1 869	Bratislava	1 869
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	Salka	12.2
Hungary	Danube	HU3	Szob	1 708	Nagymaros	1 695
Hungary	Danube	HU5	Hercegszántó	1 435	Mohács	1 447
Hungary	Tisza	HU9	Tiszasziget	163	Szeged	174
Croatia	Danube	HR11	Ilok	1 302	Ilok	1 302
Croatia	Sava	HR6	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:

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

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  $C_m \cdot Q_m$  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 groups of the Danube River monitoring sites (Table 9) and sites located on tributaries (Table 10), connected with hydrological stations for agreed determinands: suspended solids, inorganic nitrogen, and ortho-phosphate-phosphorus, total phosphorus, BOD<sub>5</sub>, 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 the 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
<b>Station Code</b>	TNMN monitoring location code
<b>Profile</b>	location of sampling site in profile (L-left, M-middle, R-right)
<b>River Name</b>	name of river
<b>Location</b>	name of monitoring location
<b>River km</b>	distance to mouth of the river
<b>Qr</b>	mean annual discharge in the year 2023
<b>C<sub>mean</sub></b>	arithmetical mean of the concentrations in the year 2023
<b>Annual Load</b>	annual load of given determinand in the year 2023

The calculated loads **for 2023**, for Danube monitoring sites are presented in Table 9 and for tributaries sites in 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 the previous year 2022 (distinguished by different font and/or colour, explanation given below the tables).

Based on Table 9 for the Danube River sites, it is seen that the majority of determinands increased in the assessed monitoring points. It evidence from results that data for Reni are not reliable due to the low frequency.

The highest load of suspended solids, total phosphorus and silicate was in Tisza HU9, inorganic nitrogen, ortho-phosphate phosphorus, chlorides and s in HR12 Sava River were observed. The maximal load of BOD<sub>5</sub> was in Sava HR7 and the maximum of total phosphorus dissolved was found in river Ipoly.

The longitudinal development of the annual load along the Danube River is presented for suspended solids (Figure 5.1), inorganic nitrogen (Figure 5.3), ortho-phosphate-phosphorus (Figure 5.5), total phosphorus (Figure 5.7), BOD<sub>5</sub> (Figure 5.9) and chlorides (Figure 5.11).

Except BOD<sub>5</sub> in the lower part of the Danube River, at the monitoring sites RO2 and RO4 the highest loads were obtained for all determinands.

**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 represents the loads from the Danube into the Black Sea and it is monitored since 2005. The load monitoring at Reni focuses on nutrients and heavy metals. Mean annual concentrations at Reni are presented in the second part of the Table 11 and the calculated annual loads are in its third part. Due to the war in Ukraina and low frequency of monitoring, these results are not accurate.

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 for all determinands increased in 2023, but results but results are not comparable for low frequency.

The mean annual discharges in 2023 on the whole Danube River sites and all tributaries monitoring points were higher than in 2022.

Table 6: Number of measurements at TNMN locations selected for assessment of pollution load in 2023

Country Code	River	Location	Location in profile	River Km	Number of measurements in 2023									
					Qr (2023)	SS	N <sub>inorg</sub>	P-PO <sub>4</sub>	P <sub>total</sub>	BOD <sub>5</sub>	Cl	P <sub>diss</sub>	SiO <sub>2</sub>	
DE2	Danube	Jochenstein	M	2204	365	12	24	24	24	24	12	12		
DE3	Inn	Kirchdorf	M	195	365	12	12	12	12	12	12	12		
DE4	Inn/Salzach	Laufen	L	47	365	12	12	12	12	12	12	12		
AT1	Danube	Jochenstein	M	2204	365	12	24	24	24	24	12	12	12	
AT6	Danube	Hainburg	R	1879	365	24	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	26	26	26	26
SK1	Danube	Bratislava	M	1869	365	41	41	41	41	38	38	41	41	36
SK1	Danube	Bratislava	R	1869	365	26	26	26	26	26	26	26	26	26
SK4	Váh	Komárno	M	1.5	365	12	12	12	12	12	12	12	12	12
SK6	Morava	Devín	M	1.0	365	12	12	12	12	12	12	12	12	12
SK7	Hron	Kamenica	M	1.7	365	12	12	12	12	12	12	12	12	12
SK8	Ipoly	Salka	M	12	365	12	12	12	12	12	12	12	12	12
HU3	Danube	Szob	L	1708		12	26	26	26	12	12	12	12	12
			M	1708	365	12	23	26	26	12	12	12	12	12
			R	1708		12	22	26	26	12	12	12	12	12
HU5	Danube	Hercegszántó	M	1435	365	12	23	24	24	12	10	10	10	10
HU9	Tisza	Tiszasziget	L	163		12	11	12	12	12	12	12	12	12
			M	163	364	11	21	25	25	11	11	11	11	11
			R	163		12	11	12	12	12	12	12	12	12
HR11	Danube	Ilok	M	1302		12	12	12	12	12	12	12	12	12*
HR6	Sava	Jesenice	R	729	365	12	12	12	12	12	12	12	12	12*
HR7	Sava	us Una Jesenovac	M	525	365	12	12	12	12	12	12	12	12	12*
HR12	Sava	Račinovci	L	218	365	11	11	11	11	11	11	11	11	11*
SI1	Drava	Ormoz	L	300	365	24	23	24	24	24	12	12	12	12
SI2	Sava	Jesenice	R	729	365	25	25	25	25	25	12	12	12	12
RO2	Danube	Pristol-Novo Selo	L	834		24	24	24	24	24	12	12	24	24*
			M	834	365	22	22	22	22	22	11	11	22	22*
			R	834		22	22	22	22	22	11	11	20	22*
RO4	Danube	Chiciu-Silistra	L	375	365	26	26	26	26	26	12	12	24	24
			M	375		26	26	26	26	26	12	12	25	25
			R	375		26	26	26	26	26	12	12	25	25
RO5	Danube	Reni	L	132		4	4	4	4	4	3	3	4	4
			M	132	365	9	10	10	10	10	8	4	6	6
			R	132										
RO10	M	Siret	M	0	365	26	26	26	26	26	12	12	18	18
RO11	M	Prut	M	0	365	4	4	4	4	4	4	4	4	4
UA2	Danube	Vylkove	M	18	365	12	12	12	12	12	12	12	12	12

\*Silicates (SiO<sub>2</sub>) 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 2023

Station Code	Profile	River Name	Location	River km	Qr (2023)	C <sub>mean</sub>							
						Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD <sub>5</sub>	Chlorides	Phosphorus - dissolved	Silicates
					(m <sup>3</sup> .s <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )
DE2+AT1	M	Danube	Jochenstein	2204	1443	21.28	1.68	0.02	0.05	1.18	20.30	0.03	
AT6	R	Danube	Hainburg	1879	1963	36.83	1.65	0.02	0.08	1.21	17.68	0.03	
SK1	LMR	Danube	Bratislava	1869	1968	34.00	1.31	0.03	0.09	1.20	17.93	0.04	5.47
HU3	LMR	Danube	Szob	1708	2264	49.81	1.58	0.02	0.13	5.25	19.11		4.55
HU5	M	Danube	Hercegszántó	1435	2296	40.17	1.77	0.05	0.12	3.72	18.70		5.66
HR11	M	Danube	Ilok	1302	2964	16.45	1.52	0.04	0.08	1.18	17.50		4.14*
RO2	LMR	Danube	Pristol-Novo Selo	834	5534	35.31	1.33	0.07	0.09	0.81	20.54	0.08	0.89*
RO4	LMR	Danube	Chiciu-Silistra	375	6267	23.58	0.89	0.06	0.11	1.18	22.15	0.09	
RO5	LMR	Danube	Reni	132	6665	18.33	1.07	0.07	0.10	1.25	32.24	0.10	
UA2	M	Danube	Vylkove	18	3261	44.06	1.29	0.05		3.23	29.39	0.08	2.78

\*Silicates (SiO<sub>2</sub>) in dissolved form

Table 8: Mean annual concentrations in monitoring locations selected for load assessment on tributaries in 2023

Station Code	Profile	River Name	Location	River km	Qr (2023)	C <sub>mean</sub>							
						Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD <sub>5</sub>	Chlorides	Phosphorus - dissolved	Silicates
					(m <sup>3</sup> .s <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )
DE3	M	Inn	Kirchdorf	195	311	127.31	0.57	0.00	0.14	0.90	6.68		
DE4	L	Inn/Salzach	Laufen	47	243	48.58	0.60	0.01	0.06	0.86	7.82		
CZ1	M	Morava	Lanzhot	79	52	31	2.17	0.06	0.11	2.05	37.53	0.07	8.26
CZ2	L	Morava/Dyje	Pohansko	17	30	10	2.34	0.30	0.33	2.08	56.79	0.30	56.79
SK4	M	Váh	Komárno	1.5	145	15	1.29	0.06	0.12	1.41	18.41	0.08	6.08
SK6	M	Morava	Devín	1.0	51	44	1.80	0.16	0.27	2.23	38.89	0.18	9.58
SK7	M	Hron	Kamenica	1.7	54	29	1.37	0.06	0.13	1.73	16.72	0.08	13.75
SK8	M	Ipoly	Salka	12	195	45	1.70	0.13	0.25	2.03	27.25	0.18	22.74
HU9	LMR	Tisza	Tiszasziget	163	905	54	0.89	0.05	0.15	1.22	32.91		10.64
SI1	L	Drava	Ormoz	300	398	14	1.03	0.01	0.04	1.00	7.77		
SI2	R	Sava	Jesenice	729	389	6	1.23	0.01	0.03	0.82	6.84		
HR6	R	Sava	Jesenice	729	382	5	1.27	0.02	0.03	1.25	7.35		3.46*
HR7	M	Sava	us. Una Jasenovac	525	1031	9	1.11	0.04	0.08	1.83	7.49		4.10*
HR12	L	Sava	Račinovci	218	1460	24	1.02	0.04	0.08	1.30	23.45		5.02*
RO10	M	Siret	Conf. Danube (Sendreni)	0	108	51	0.89	0.02	0.07	1.37	63.35	0.07	
RO11	M	Prut	Conf. Danube (Giurgulesti)	0	65	48	0.99	0.03	0.10	3.31	48.22	0.05	

\*Silicates (SiO<sub>2</sub>) in dissolved form

Table 9: Annual load in selected monitoring locations on Danube River in 2023

Station Code	Profile	River Name	Location	River km	Annual Load in 2023							
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD <sub>5</sub>	Chlorides	Phosphorus - dissolved	Silicates
					( x10 <sup>6</sup> tonns )	( x10 <sup>3</sup> tonns )	( x10 <sup>6</sup> tonns )	( x10 <sup>3</sup> tonns )	( x10 <sup>6</sup> tonns )			
DE2+AT1	M	Danube	Jochenstein	2204	1.10	76.26	1.08	2.65	56.58	0.84	1.54	
AT6	R	Danube	Hainburg	1879	3.15	104.74	1.38	5.66	78.21	1.05	2.20	
SK1	LMR	Danube	Bratislava	1869	2.84	86.24	2.02	6.33	80.30	1.08	2.69	0.36
HU3	LMR	Danube	Szob	1708	3.70	115.01	1.31	9.49	374.99	1.40		0.32
HU5	M	Danube	Hercegszántó	1435	1.89	111.70	2.85	7.51	374.99	0.99		0.33
HR11	M	Danube	Ilok	1302	1.55	141.84	4.07	7.71	108.35	1.60		0.42*
RO2	LMR	Danube	Pristol-Novo Selo	834	6.25	233.64	12.40	15.77	161.09	3.42	13.98	0.58*
RO4	LMR	Danube	Chiciu-Silistra	375	4.87	177.06	12.06	21.01	214.47	3.85	18.26	
RO5	LMR	Danube	Reni	132	2.38	129.22	6.99	9.43	163.86	1.70	4.03	
UA2	M	Danube	Vylkove	18	4.94	136.94	5.00		336.96	2.96	7.62	0.29

\*Silicates (SiO<sub>2</sub>) in dissolved form

#### Explanations for comparison of values:

**Bold font** increased value in comparison with 2022

**6.25** maximum value of determinand in 2023 and also increased value in comparison with 2022

**4.87** maximum value of determinand in 2023, but decreased value in comparison with 2022

**3.85** maximum value of determinand in 2021, but equal value in comparison with 2020

**0.29** missing value in 2023 - not assessed

Table 10: Annual load in selected monitoring locations on tributaries in 2023

Station Code	Profile	River Name	Location	River km	Annual Load in 2023							
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD <sub>5</sub>	Chlorides	Phosphorus - dissolved	Silicates
					( x10 <sup>6</sup> tonns )	( x10 <sup>3</sup> tonns )	( x10 <sup>6</sup> tonns )	( x10 <sup>3</sup> tonns )	( x10 <sup>6</sup> tonns )			
DE3	M	Inn	Kirchdorf	195	1.79	5.14	0.04	1.89	8.61	0.06		
DE4	L	Inn/Salzach	Laufen	47	0.555	4.41	0.06	0.56	6.51	0.05		
CZ1	M	Morava	Lanzhot	79	0.05	3.28	0.07	0.16	2.58	0.04	0.08	0.01
CZ2	L	Morava/Dyje	Pohansko	17	0.01	2.42	0.13	0.16	2.58	0.04	0.14	0.01
SK4	M	Váh	Komárno	1.5	0.07	6.26	0.25	0.53	6.51	0.09	0.33	0.03
SK6	M	Morava	Devín	1.0	0.10	3.36	0.20	0.44	3.67	0.06	0.23	0.02
SK7	M	Hron	Kamenica	1.7	0.05	2.59	0.09	0.21	3.01	0.03	0.12	0.03
SK8	M	Ipoly	Salka	12	0.28	10.96	0.79	1.45	12.91	0.16	0.99	0.14
HU9	LMR	Tisza	Tiszasziget	163	1.83	27.91	1.17	4.81	35.72	0.73		0.32
SI1	L	Drava	Ormoz	300	0.20	12.58	0.09	0.59	10.84	0.09		
SI2	R	Sava	Jesenice	729	0.09	15.11	0.17	0.44	9.42	0.08		
HR6	R	Sava	Jesenice	729	0.06	15.16	0.24	0.42	13.55	0.08		0.05*
HR7	M	Sava	us. Una Jasenovac	525	0.31	35.38	1.49	2.62	55.24	0.24		0.14*
HR12	L	Sava	Račínovci	218	1.13	41.57	1.73	3.22	50.26	0.81		0.22*
RO10	M	Siret	Conf. Danube (Sendreni)	0	0.20	3.11	0.08	0.24	4.74	0.23	0.22	
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	0.02	0.44	0.01	0.04	1.36	0.02	0.02	

\*Silicates (SiO<sub>2</sub>) in dissolved form**Explanations for comparison of values:****Bold font** increased value in comparison with 2022

1.83 maximum value of determinand in 2023 and also increased value in comparison with 2022

1.73 maximum value of determinand in 2023, but decreased value in comparison with 2022

0.04 stability

missing value in 2022- 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 2023																				
					Or 2023	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD <sub>5</sub>	Chlorides	Phosphorus - dissolved	Silicates diss.	N-NH <sub>4</sub>	N-NO <sub>2</sub>	N-NO <sub>3</sub>	N <sub>org</sub>	Cu	Cu <sub>diss</sub>	Pb	Pb <sub>diss</sub>	Cd	Cd <sub>diss</sub>	Hg	Hg <sub>diss</sub>
RO5	Danube	Reni	LMR	132	365	9	10	10	10	8	4	6		10	10	10	10		7		8		8		8
Country Code	River	Location	Location in profile	River km	C <sub>mean</sub>																				
					Or 2023	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD <sub>5</sub>	Chlorides	Phosphorus - dissolved	Silicates diss.	N-NH <sub>4</sub>	N-NO <sub>2</sub>	N-NO <sub>3</sub>	N <sub>org</sub>	Cu	Cu <sub>diss</sub>	Pb	Pb <sub>diss</sub>	Cd	Cd <sub>diss</sub>	Hg	Hg <sub>diss</sub>
					(m <sup>3</sup> s <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(mg.l <sup>-1</sup> )	(µg.l <sup>-1</sup> )							
RO5	Danube	Reni	LMR	132	6664.536	18.33	1.071	0.067	0.095	1.253	32.24	0.102		0.0390	0.0120	1.025	1.644		2.5840		0.5000		0.0750		0.008
Country Code	River	Location	Location in profile	River km	Annual Load in 2023																				
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD <sub>5</sub>	Chlorides	Phosphorus - dissolved	Silicates diss.	N-NH <sub>4</sub>	N-NO <sub>2</sub>	N-NO <sub>3</sub>	N <sub>org</sub>	Cu	Cu <sub>diss</sub>	Pb	Pb <sub>diss</sub>	Cd	Cd <sub>diss</sub>	Hg	Hg <sub>diss</sub>	
					(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(x10 <sup>6</sup> tonns)	(tonns)								
RO5	Danube	Reni	LMR	132	2.38	129.22	6.99	9.38	163.86	1.70	4.03		3.42	1.43	124.99	197.64		262.55		59.99		9.00		0.83	

Figure 5.1: Annual load of suspended solids along the Danube River in 2023

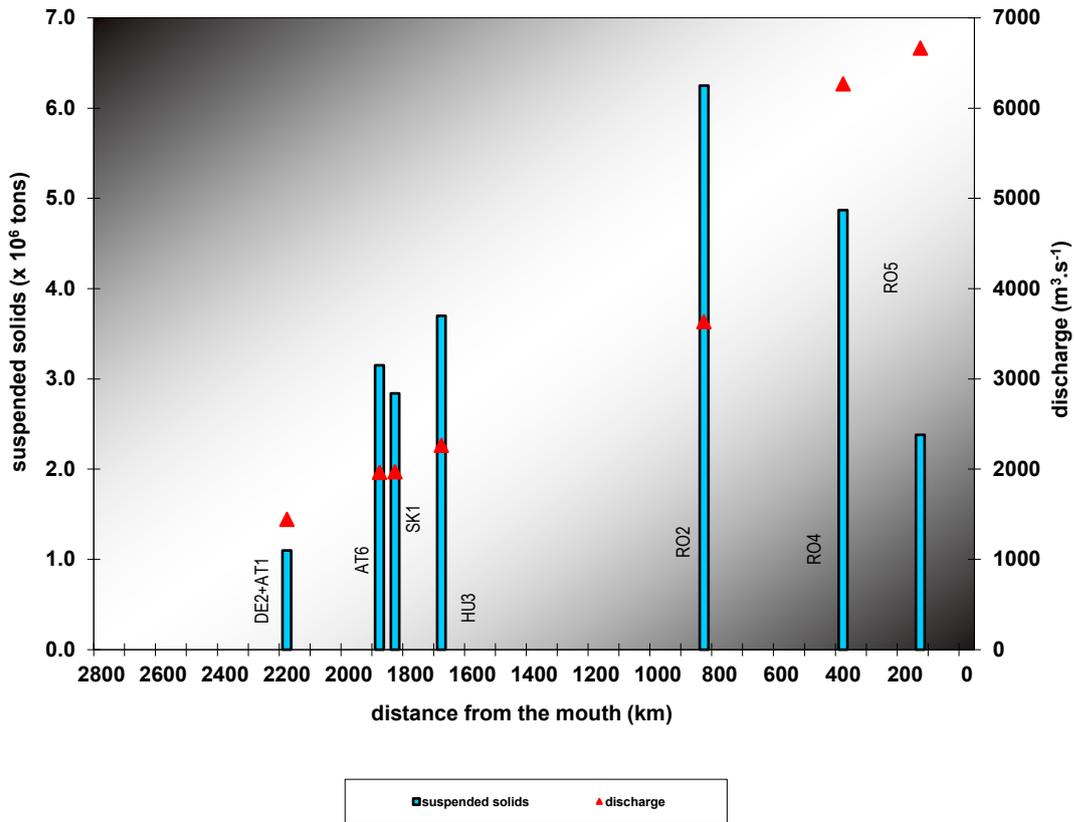


Figure 5.2: Annual load of suspended solids at monitoring locations on tributaries in 2023

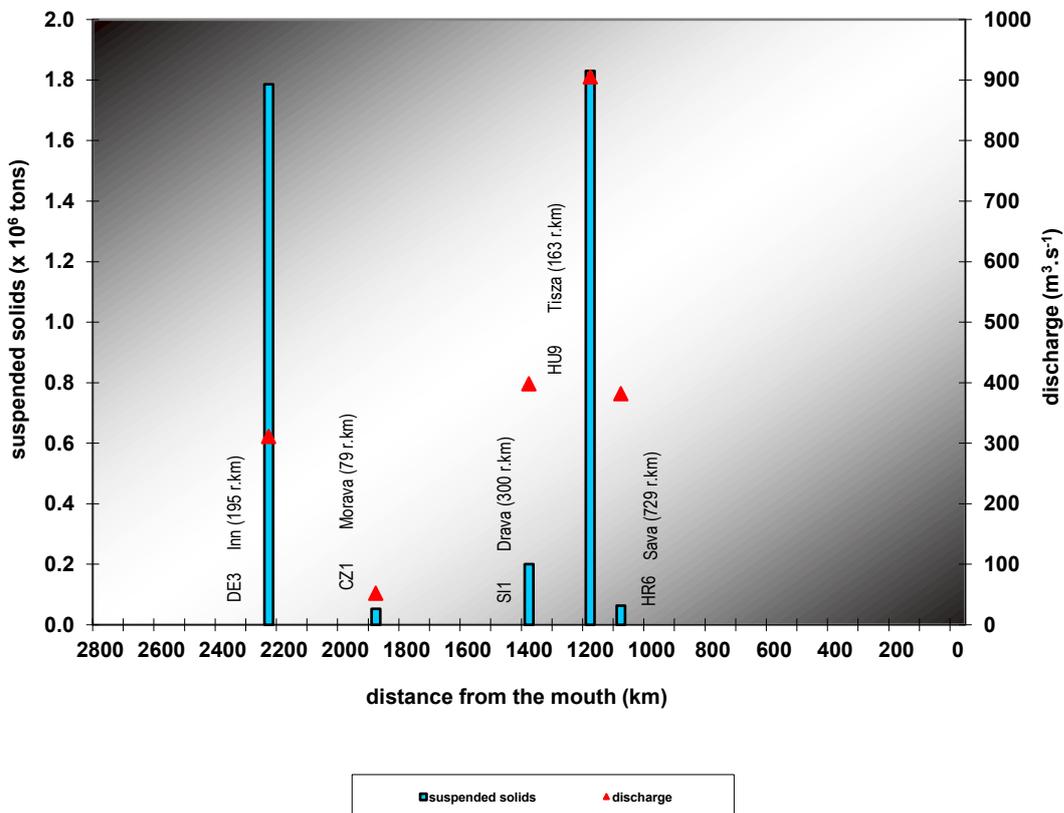


Figure 5.3: Annual loads of inorganic nitrogen along the Danube River in 2023

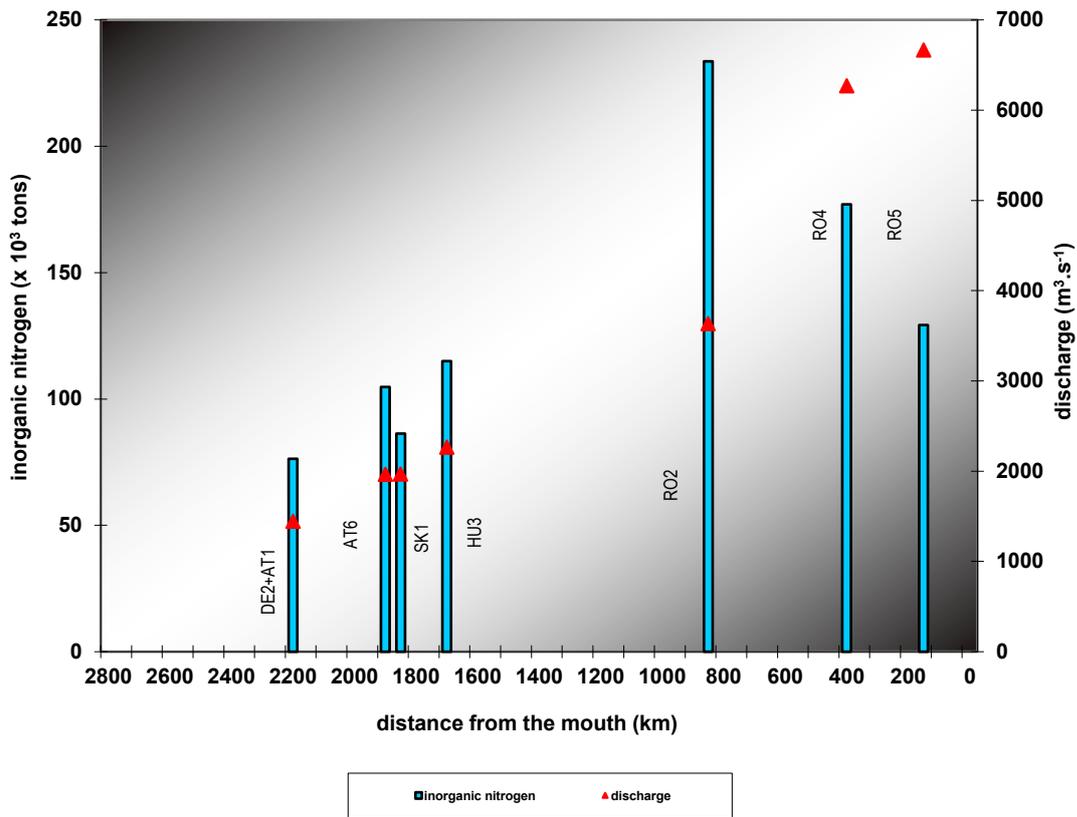


Figure 5.4: Annual loads of inorganic nitrogen at monitoring locations on tributaries in 2023

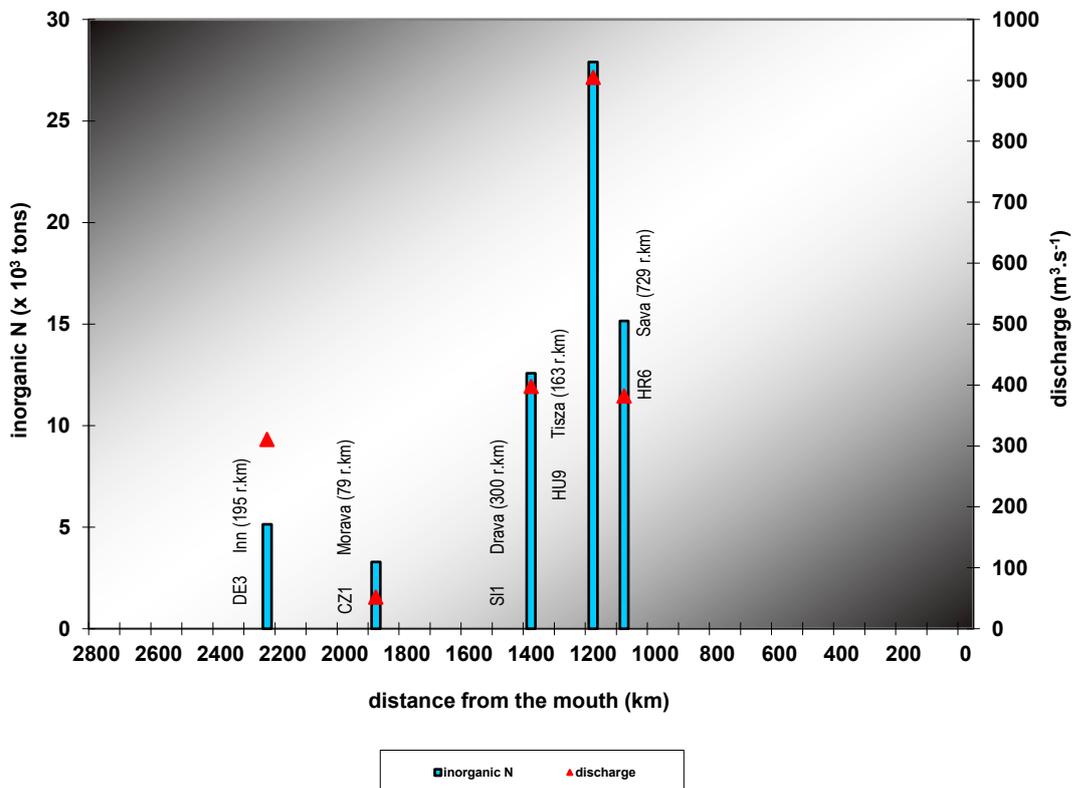


Figure 5.5: Annual loads of P-PO<sub>4</sub> at monitoring locations along the Danube River in 2023

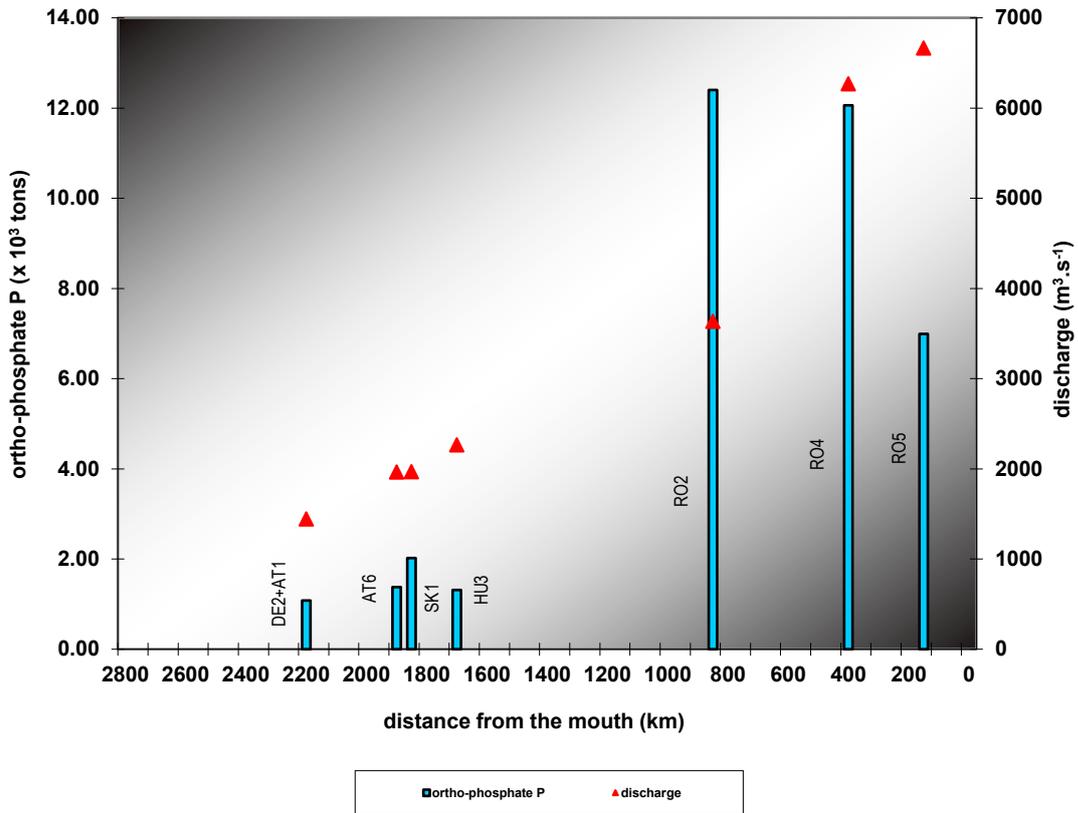


Figure 5.6: Annual loads of P-PO<sub>4</sub> at monitoring locations on tributaries in 2023

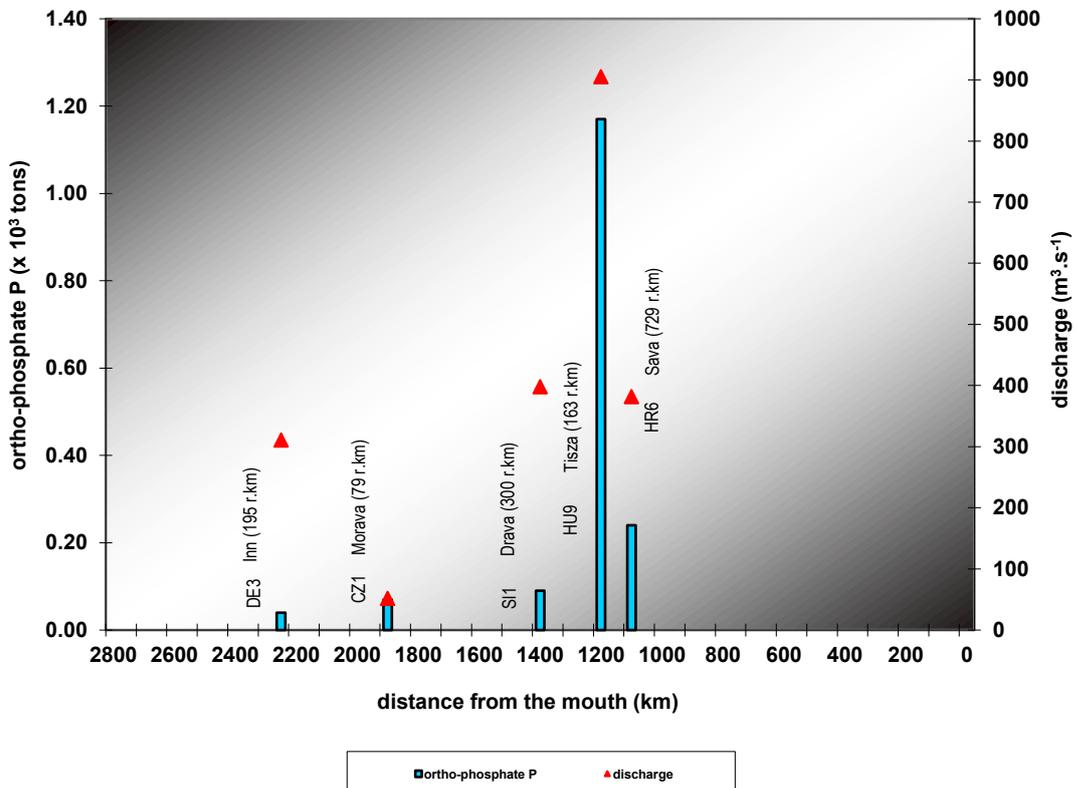


Figure 5.7: Annual loads of total phosphorus along the Danube River in 2023

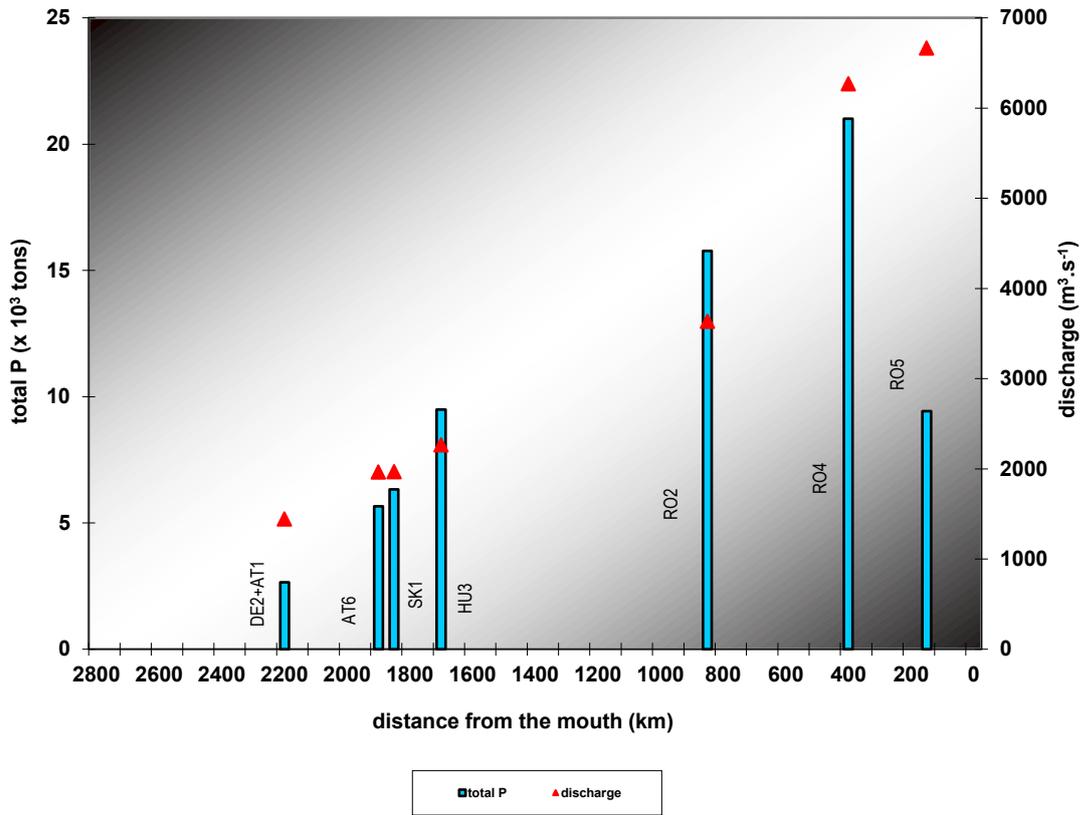


Figure 5.8: Annual loads of total phosphorus at monitoring locations on tributaries in 2023

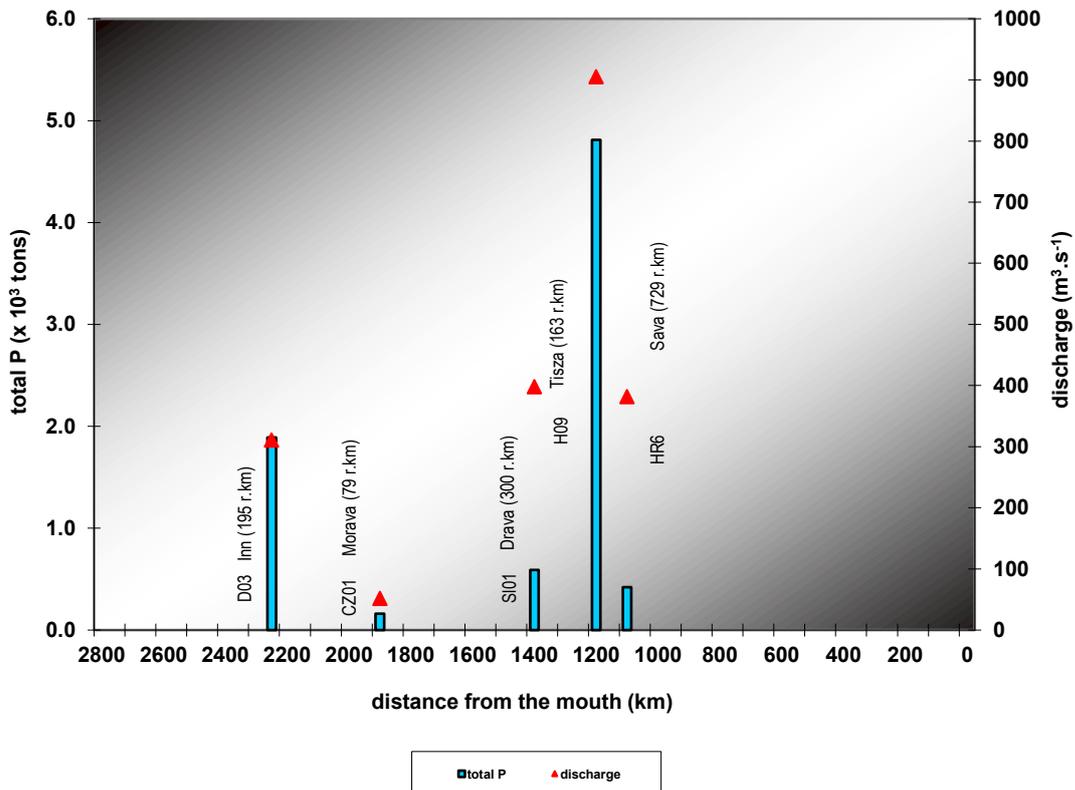


Figure 5.9: Annual loads of BOD<sub>5</sub> along the Danube River in 2023

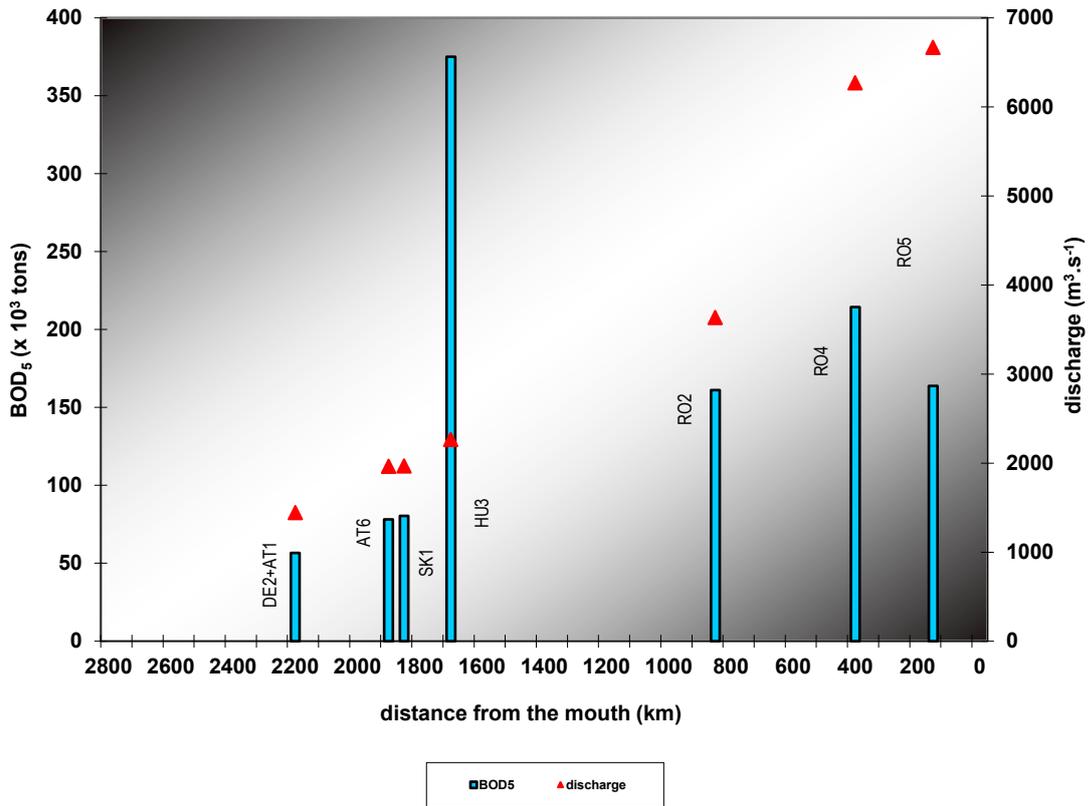


Figure 5.10: Annual loads of BOD<sub>5</sub> at monitoring locations on tributaries in 2023

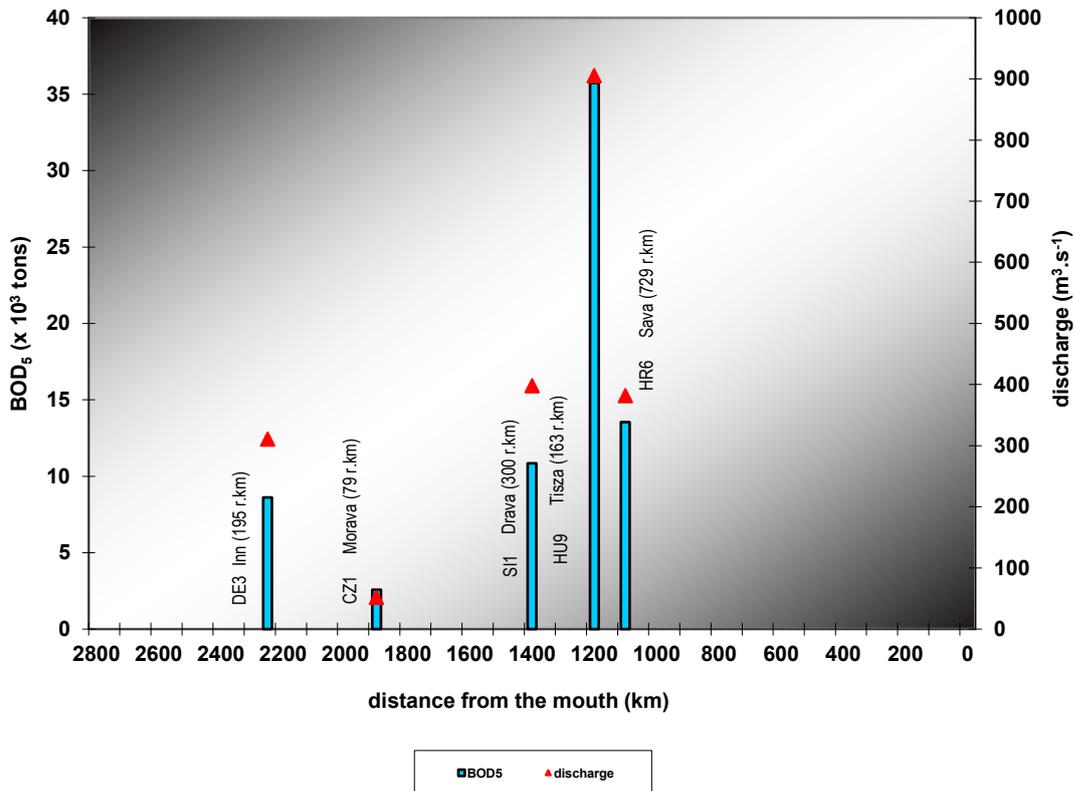


Figure 5.11: Annual loads of chlorides along the Danube River in 2023

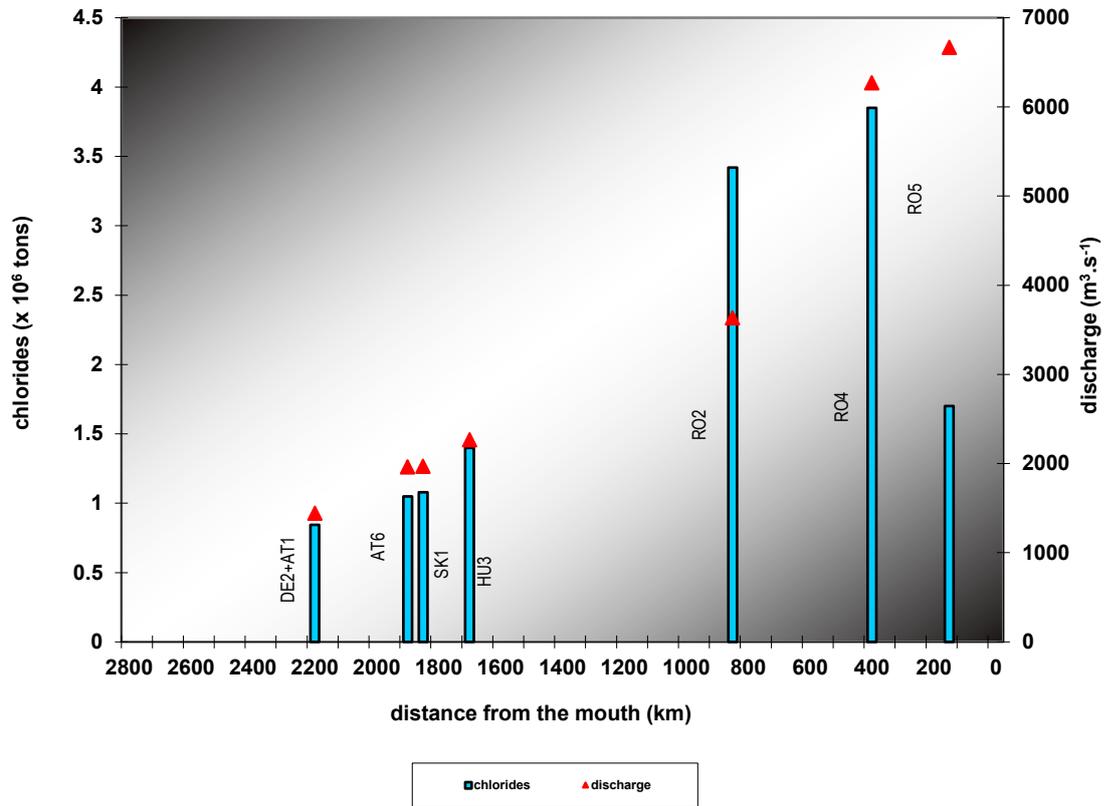


Figure 5.12: Annual loads of chlorides at monitoring locations on tributaries in 2023

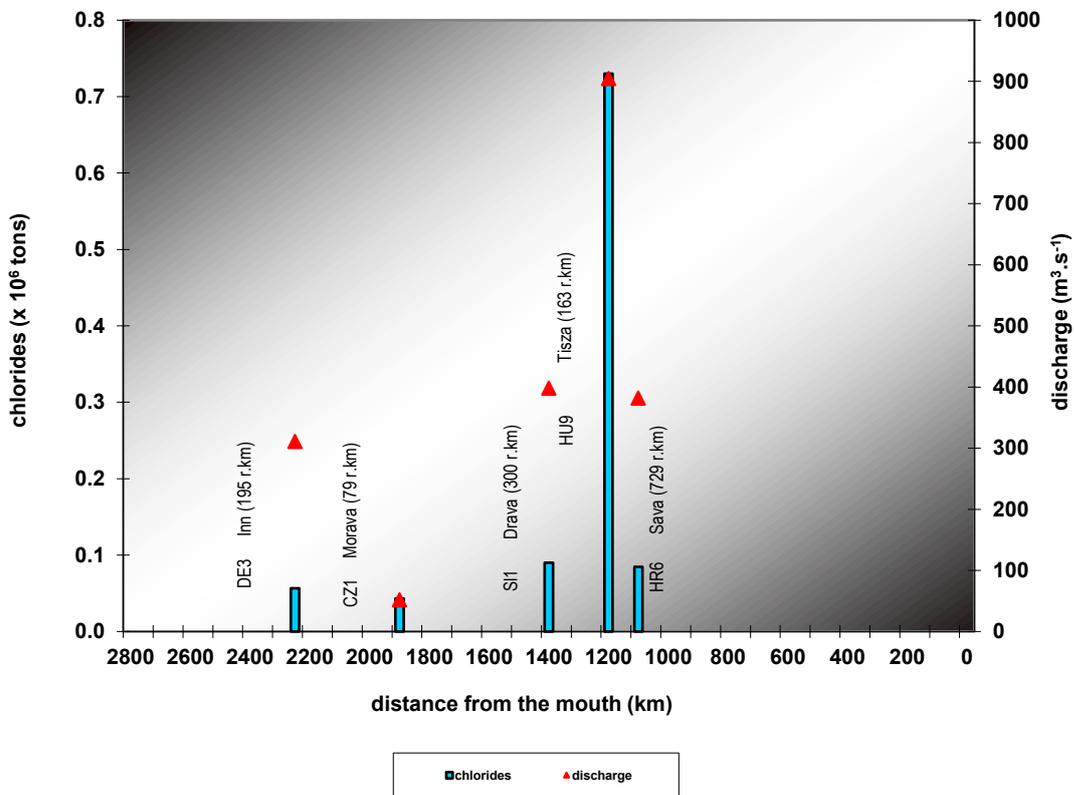


Figure 5.13: Development trend of annual loads of suspended solids at Reni.

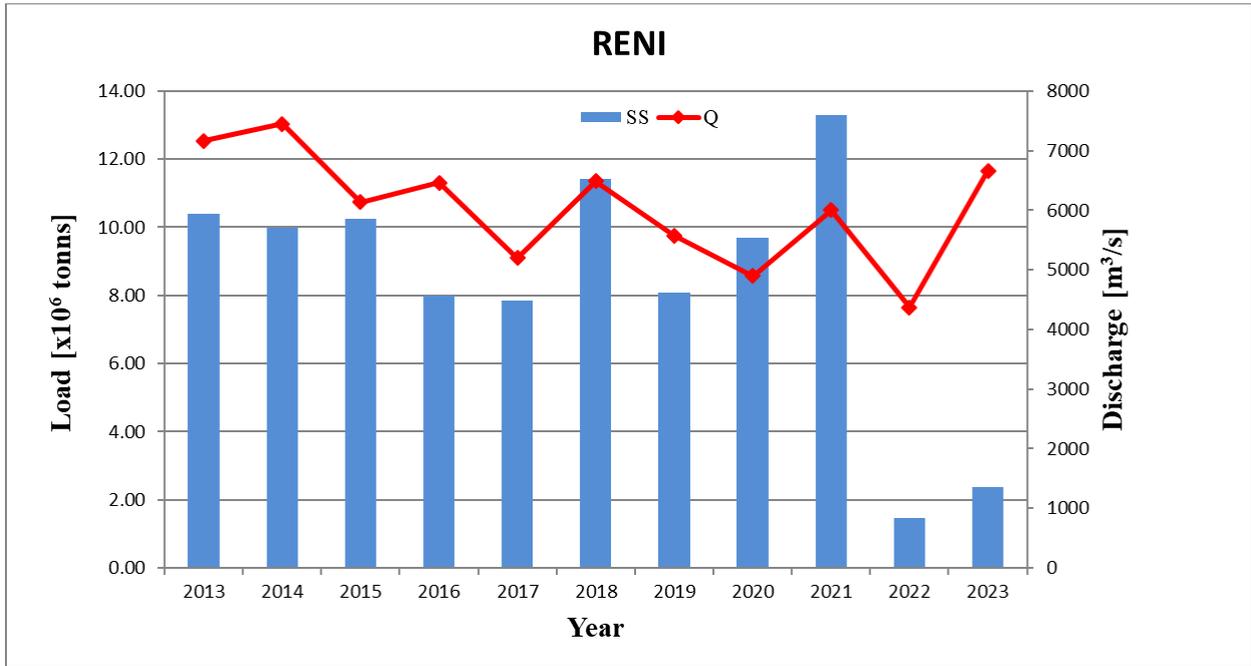


Figure 5.14: Development trend of annual loads of inorganic nitrogen at Reni.

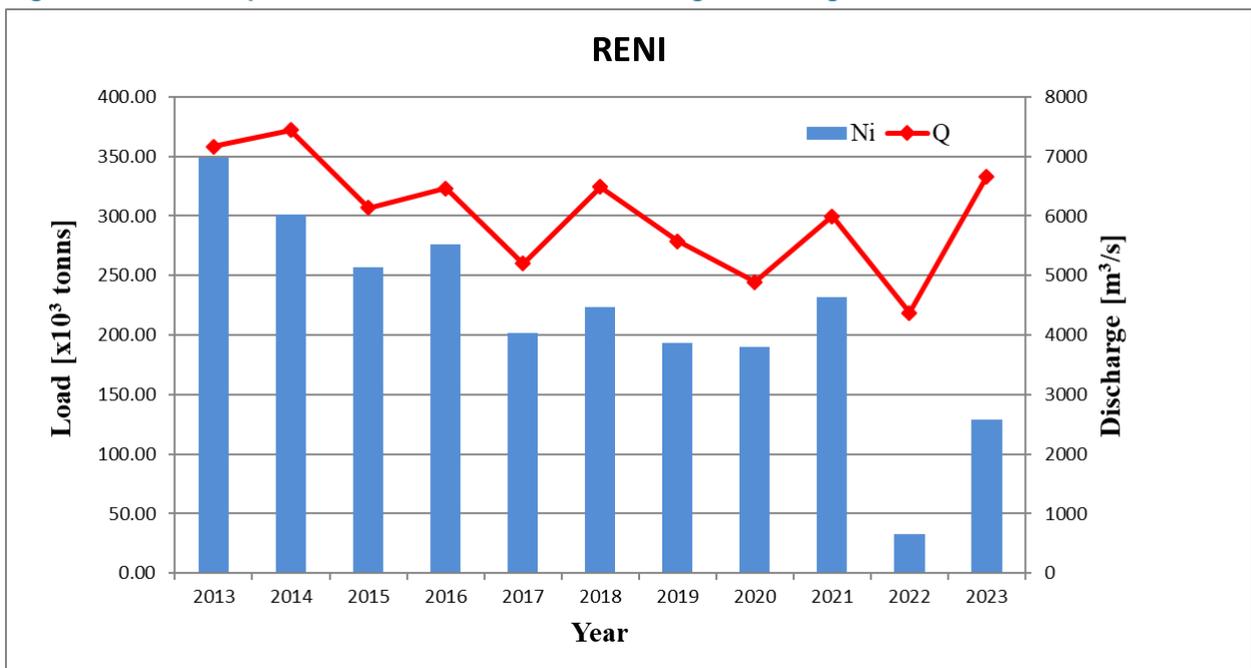


Figure 5.15: Development trend of annual loads of ortho-phosphate phosphorus, total phosphorus and dissolved phosphorus at Reni.

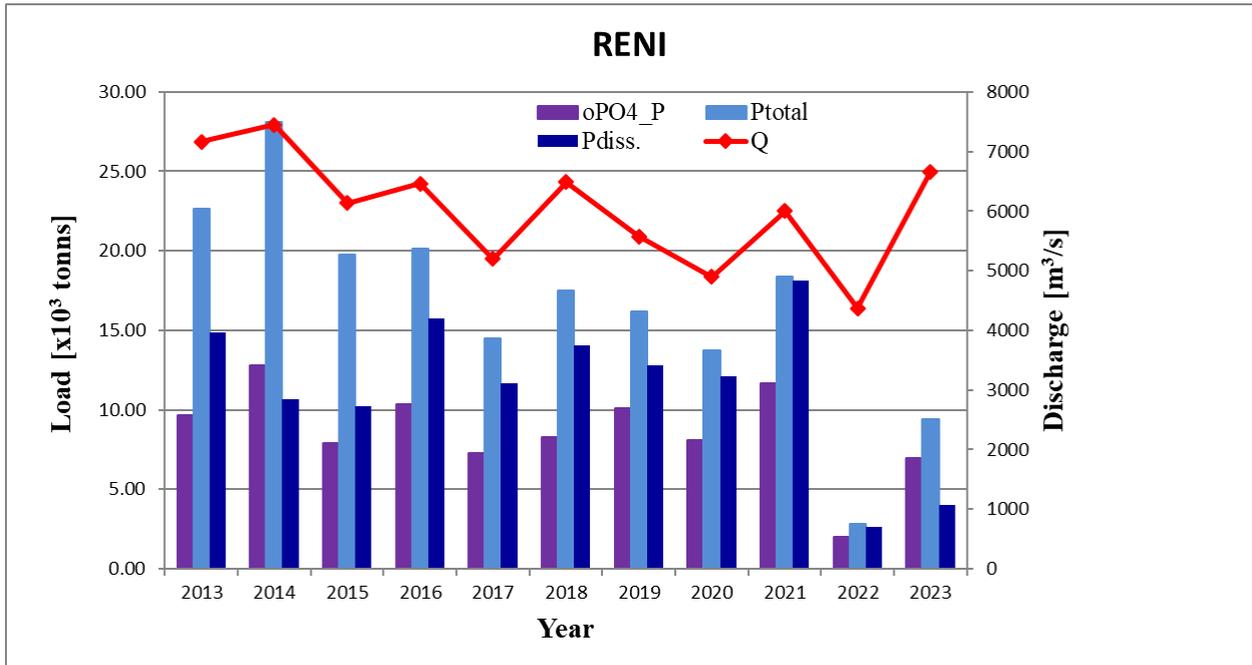


Figure 5.16: Development trend of annual loads of BOD<sub>5</sub> at Reni.

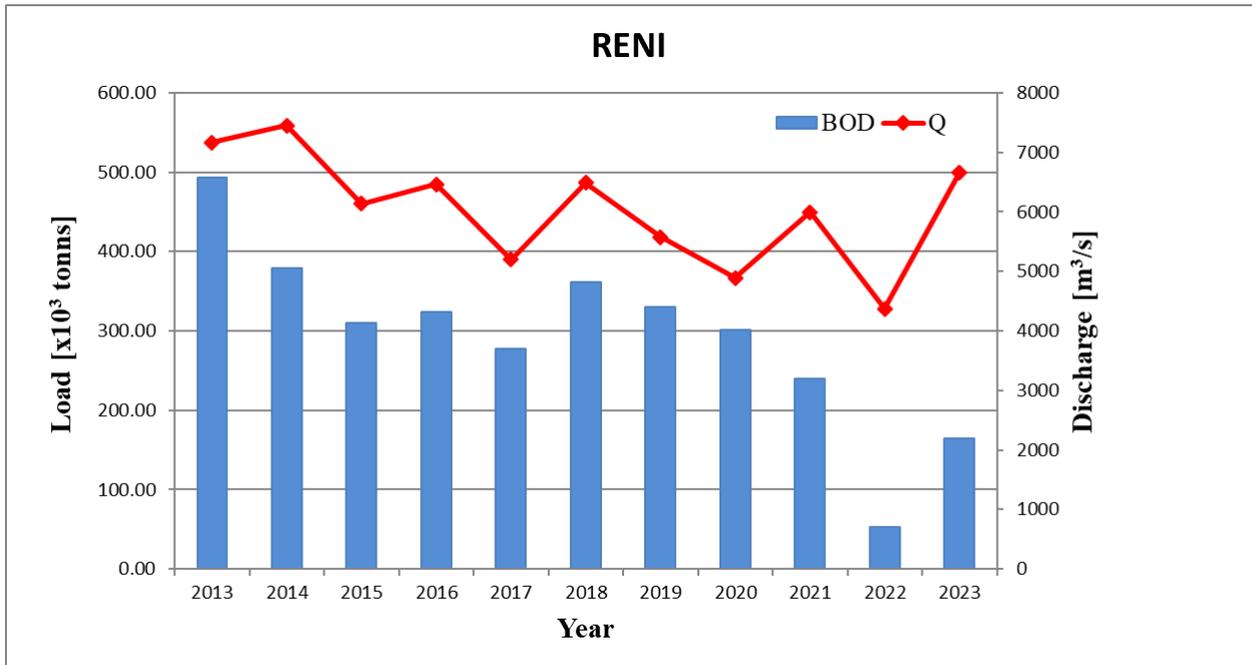


Figure 5.17: Development trend of annual loads of chlorides at Reni.

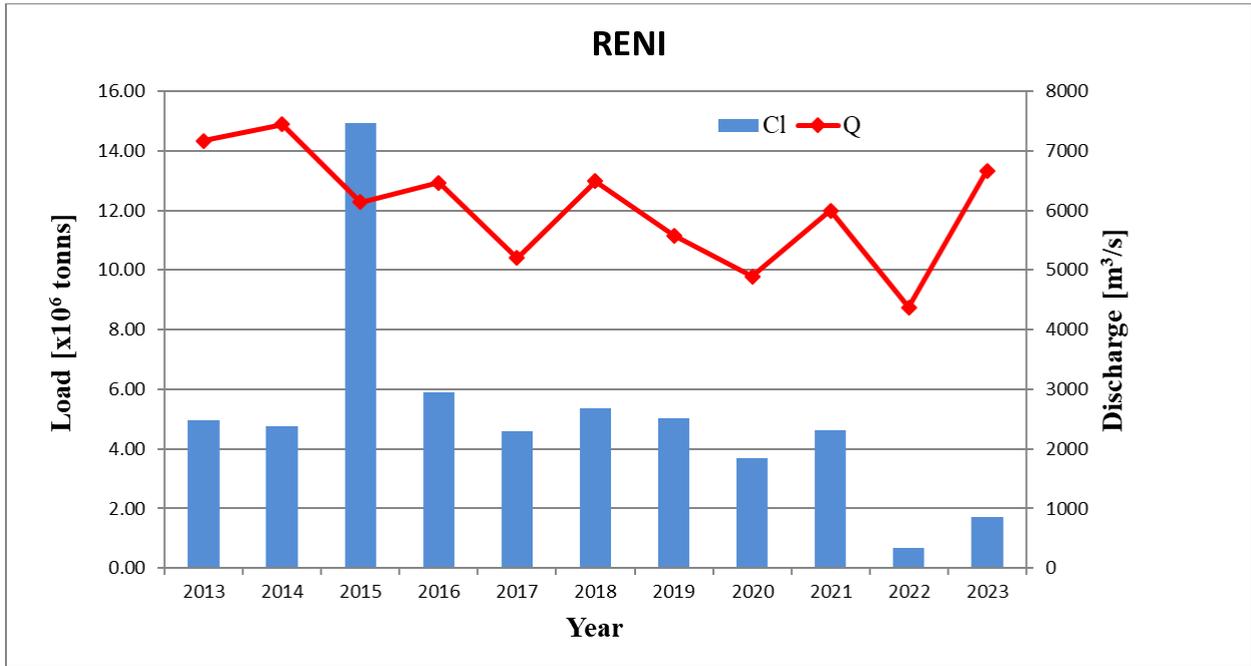
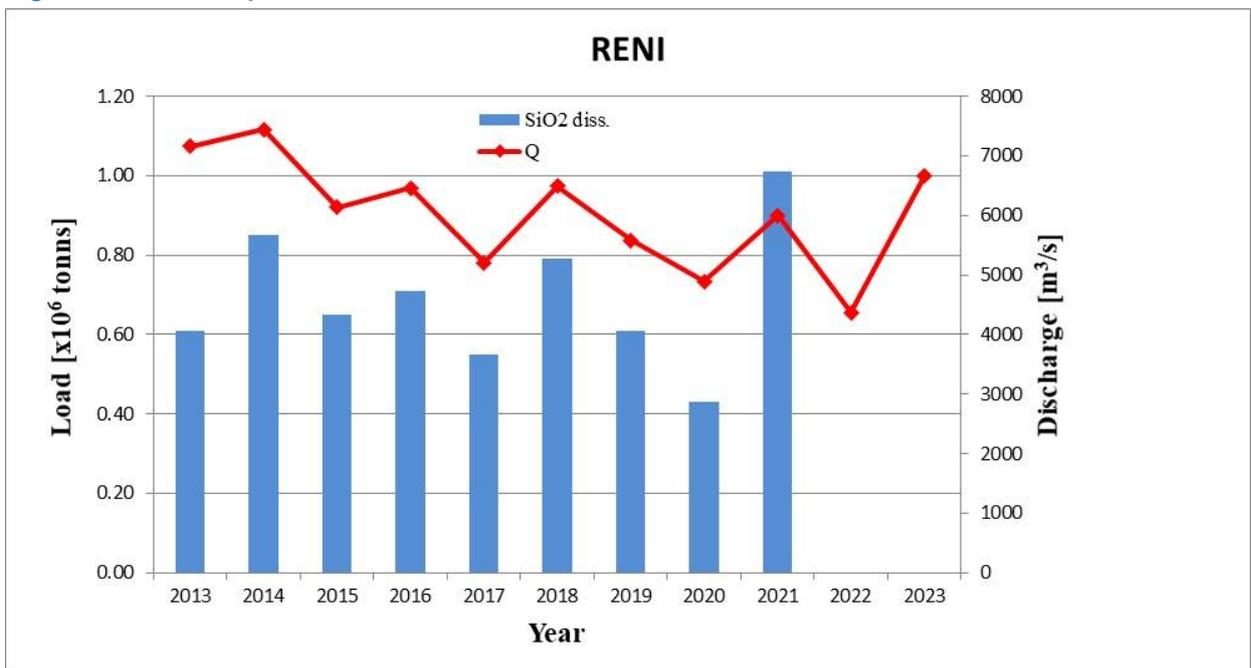


Figure 5.18: Development trend of annual loads of silicates at Reni.

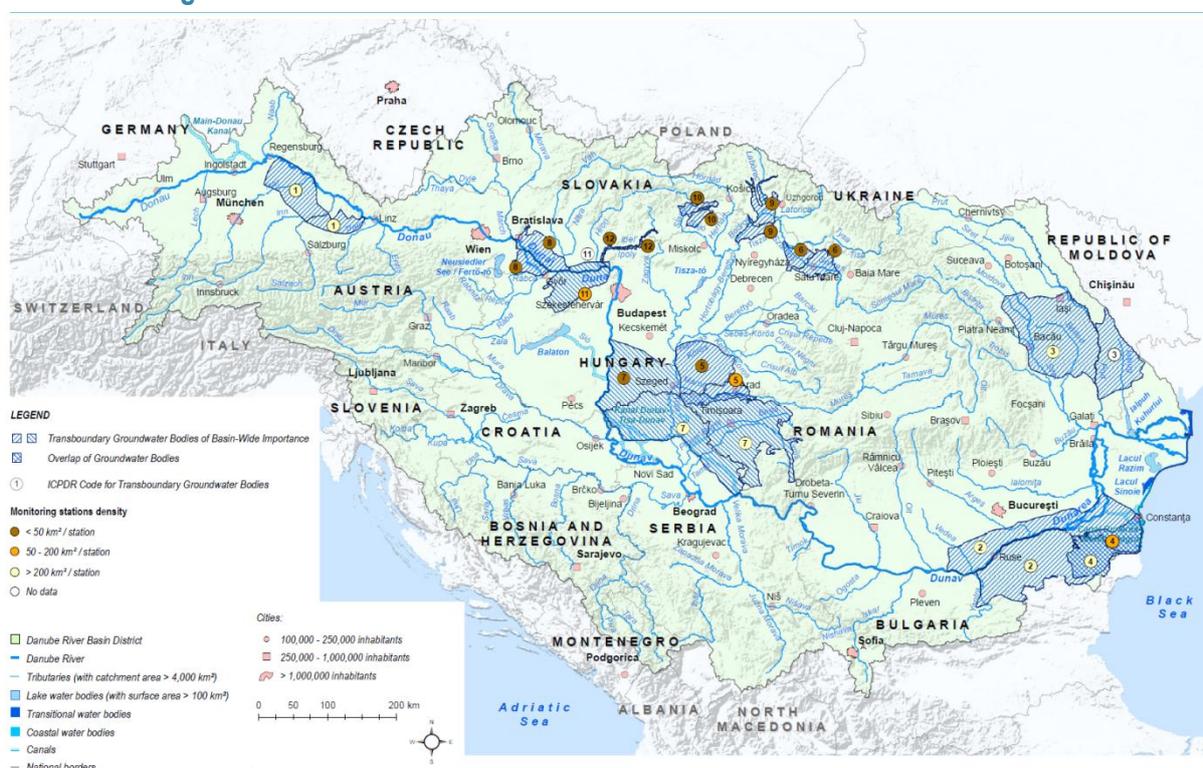


## 6. Groundwater Monitoring

### 6.1 Groundwater 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 (GW) 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 on the map below (Figure 6.1).

**Figure 6.1: Transboundary groundwater 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 km<sup>2</sup> 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 km<sup>2</sup>, 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 (see DRBMP 2021 Annex 8 Table 2).

## **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
ASPT	Average Score per Taxon
BOD <sub>5</sub>	Biochemical oxygen demand (5 days)
BSC	Black Sea Commission
COD <sub>Cr</sub>	Chemical oxygen demand (Potassium dichromate)
COD <sub>Mn</sub>	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)
EPT	Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly)
GW	Groundwater
GWB	Groundwater body
ICPDR	International Commission for the Protection of the Danube River
ISO	International Organization for Standardization
LOQ	Limit of Quantification
MA EG	Monitoring and Assessment Expert Group (formerly MLIM EG)
SS	Suspended solids
Ni	Inorganic nitrogen
N-NO <sub>2</sub>	Nitrite-nitrogen
N-NO <sub>3</sub>	Nitrate-nitrogen
Ntot.	Total nitrogen
P-PO <sub>4</sub>	Orto-phosphate-phosphorus
Pdiss.	Phosphorus dissolved
Ptot.	Total phosphorus
SiO <sub>2</sub>	Silicates
SiO <sub>2</sub> 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



ICPDR – International Commission for the Protection of the Danube River

Secretariat

Vienna International Centre / D0412

P.O. Box 500 / 1400 Vienna / Austria

T: +43 (1) 26060-5738 / F: +43 (1) 26060-5895

[secretariat@icpdr.org](mailto:secretariat@icpdr.org) / [www.icpdr.org](http://www.icpdr.org)