Water Quality in the Danube River Basin – 2022

ICPDR IKSD

International Commission for the Protection of the Danube River

Internationale Kommission zum Schutz der Donau

TNMN – Yearbook 2022

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1. Introduction

1.1 History of the TNMN

In June 1994, the Convention on Cooperation for the Protection and Sustainable Use of the Danube River (DRPC) was signed in Sofia, coming into force in October 1998 with the main objectives of achieving sustainable and equitable water management, including the conservation, improvement and the rational use of surface and ground waters in the Danube catchment area. The DRPC also emphasizes that the Contracting Parties shall cooperate in the field of monitoring and assessment. In this respect, the operation of the Trans-National Monitoring Network (TNMN) in the Danube River Basin (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 2022.

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.

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

2.1 Objectives

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

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

2.2 Selection of Monitoring Sites

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

- Monitoring sites that have been monitored in the past and are therefore suitable for long-term trend analysis; these include sites:
    - located just upstream/downstream of an international border,
    - located upstream of confluences between Danube and main tributaries or main tributaries and larger sub-tributaries (to enable estimation of mass balances),
    - located downstream of the major point sources,
    - located to control important water uses.
- Sites required to estimate pollutant loads (e.g. of nutrients or priority pollutants) which are transferred across boundaries of Contracting Parties, and which are transferred into the marine environment.

The sites are located on the Danube river and its major primary or secondary tributaries near crossing boundaries of the Contracting Parties. 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 2022 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	Alti-tude	Catchment area
1	**DE**	**DE2**	**Danube**	**Jochenstein**	**M**	**13.703**	**48.520**	**2 204**	**290**	**77 086**
2	**DE**	**DE5**	**Danube**	**Dillingen**	**L**	**10.499**	**48.568**	**2 538**	**420**	**11 315**
3	DE	DE3	/Inn	Kirchdorf	M	12.126	47.782	195	452	9 905
4	DE	DE4	/Inn/Salzach	Laufen	L	12.933	47.940	47	390	6 113
5	**AT**	**AT1**	**Danube**	**Jochenstein**	**M**	**13.703**	**48.521**	**2 204**	**290**	**77 086**
6	**AT**	**AT5**	**Danube**	**Enghagen**	**R**	**14.512**	**48.240**	**2 113**	**241**	**84 869**
7	**AT**	**AT3**	**Danube**	**Wien-Nussdorf**	**R**	**16.371**	**48.262**	**1 935**	**159**	**101 700**
8	**AT**	**AT6**	**Danube**	**Hainburg**	**R**	**16.993**	**48.164**	**1 879**	**136**	**130 759**
9	CZ	CZ1	/Morava	Lanžhot	M	16.989	48.687	79	150	9 725
10	CZ	CZ2	/Morava/Dyje	Pohansko	M	16.885	48.723	17	155	12 540
11	**SK**	**SK1**	**Danube**	**Bratislava**	**LMR**	**17.107**	**48.138**	**1 869**	**128**	**131 329**
12	**SK**	**SK2**	**Danube**	**Medveďov**	**MR**	**17.652**	**47.794**	**1 806**	**108**	**132 168**
13	SK	SK4	/Váh	Komárno	MR	18.142	47.761	1.5	106	19 661
14	**SK**	**SK5**	**Danube**	**Szob**	**LMR**	**18.853**	**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	Dravaszabolcs	LM	18.200	45.784	78	92	35 764
25	HU	HU8	/Tisza/Sajo	Sajopuspoki	LMR	20.340	48.283	124	148	3 224
26	HU	HU9	/Tisza	Tiszasziget	LMR	20.105	46.186	163	74	138 498
27	HU	HU10	/Tisza	Tiszabecs	LM	22.831	48.104	757	114	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	Alti-tude	Catchment area
42	HR	HR12	/Sava	Račinovci	L	18.960	44.851	218	78	65 638
43	RS	RS1	Danube	Bezdan	L	18.860	45.854	1 426	83	210 250
44	RS	RS2	Danube	Bogojevo	L	19.079	45.530	1 367	80	251 593
45	RS	RS3	Danube	Novi Sad	R	19.842	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	/Vit	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	Alti-tude	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 2022

Danube TransNational Monitoring Network - Surveillance Monitoring 2 stations*

Figure 1

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

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2.3 Quality Elements

The background of the whole TNMN Yearbook is data reported in 2022 by 13 countries. Data provided by all countries should serve for evaluation of trends, longitudinal development and to calculate and know the changes in loads status. Data imported into 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)
- Phytobenthos (benthic diatoms – an optional parameter)

2.3.2 Priority Pollutants and Parameters Indicative of General Physico-Chemical Quality Elements

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

Table 2: Surface water determinands list for TNMN

Determinand	Surveillance Monitoring 2	
	Water concentrations	Water load assessment
Flow	annually / 12 x per year	Daily
Temperature	annually / 12 x per year	
Transparency (1)	annually / 12 x per year	
Suspended Solids (5)	annually / 12 x per year	annually / 26 x per year
Dissolved Oxygen	annually / 12 x per year	
pH (5)	annually / 12 x per year	
Conductivity @ 20 °C (5)	annually / 12 x per year	
Alkalinity (5)	annually / 12 x per year	
Inorganic Nitrogen	annually / 12 x per year	annually / 26 x per year
Total Nitrogen	annually / 12 x per year	
Total Phosphorus	annually / 12 x per year	annually / 26 x per year
Dissolved Phosphorus	annually / 12 x per year	annually / 26 x per year
Ortho-Phosphate ($P\text{-}PO_4^{3}$) (2)	annually / 12 x per year	annually / 26 x per year
Calcium (Ca^{2+}) (3, 4, 5)	annually / 12 x per year	
Magnesium (Mg^{2+}) (4, 5)	annually / 12 x per year	
Chloride (Cl^{-})	annually / 12 x per year	annually / 26 x per year
Atrazine	annually / 12 x per year	
Cadmium (6)	annually / 12 x per year	
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 concentrations	Water load assessment
Zinc (6)	annually / 12 x per year	
p,p´-DDT and its derivatives (7)	see below	
COD_{Cr} (5)	annually / 12 x per year	
COD_{Mn} (5)	annually / 12 x per year	
Dissolved Silica		annually / 26 x per year
BOD_5	annually / 12 x per year	annually / 26 x per year

(1) Only in coastal waters
(2) Soluble reactive phosphorus SRP
(3) Mentioned in the tables of the CIS Guidance document but not in the related mind map
(4) Supporting parameter for hardness-dependent EQS of PS metals
(5) Not for coastal waters
(6) Measured in a dissolved form. Measurement of total concentration is optional.
(7) In areas with no risk of failure to meet the environmental objectives for DDT and lindane the monitoring frequency is 12 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 2022 QUALCODanube programme were as follows:

- real surface water samples for nutrient analysis: preserved natural surface water, spiked if necessary and adequately homogenised. Sample codes were SW-N-1 and SW-N-2. 500 cm^3 plastic bottles were provided for NH_4^+-N, NO_3^--N, organic N, total N, PO_4^{3-}-P and total P analysis. Measurement results were asked to be reported as mg/dm^3 N and P, respectively.
- spike solutions together with matrix water for NO_2^--N analysis: due to stability concerns during transport, it was decided that participants should compose the proficiency testing items themselves in situ by mixing prescribed amounts of the spike solutions (synthetic concentrates) of the measurand with the matrix water provided (simulated surface water, preatreated by bringing to boiling point) according to instructions. Spike solutions were put in 20 cm^3 plastic containers with sample codes SW-N/M-1 and SW-N/M-2, whereas matrix water was provided in 500 cm^3 plastic bottle labelled "WATER FOR DILUTION - NO_2- N". Measurement results were asked to be reported as mg/dm^3 N.

Evaluation of results was performed according to ISO 13528:2015. Reported results were first inspected for obviously erroneous results or blunders (e.g. results reported in measurement units other than requested, swapping samples or parameters etc.) which were excluded from the calculation of statistical characteristics in accordance with section B.2.5. of ISO/IEC 17043:2010. Then statistical characteristics, i.e., the assigned value of the parameter (x_{pt}), the standard uncertainty of the assigned value [u(x_{pt})] and the standard deviation for proficiency assessment (σ_{pt}) was determined. Finally, performance statistics was calculated including z-scores, z'-scores and E_n numbers and performance assessment was given (section 9.4., 9.5. and 9.7. 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.

Forty-five laboratories were enrolled into the scheme in 2022, 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 (37 to 45 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. This is the lowest number seen in the AQC scheme. Organic N replaced Kjeldahl N analysis in 2013 at behest of participants, however, it remains unpopular with laboratories, which renders statistical evaluation difficult or even impossible. In case of simulated concentrates, correlation between theoretical values calculated and actual assigned values (robust

averages) is excellent: 101% for both samples of nitrite nitrogen, which is remarkably good compared to last year. 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 nitrate and total nitrogen as well as total phosphorus (between 99% and 107%), while unusually poorer for ammonium nitrogen and phosphate phosphorous (165% and 170%, respectively). This can probably be explained by the small target concentration difference between the
two samples. Performance assessment was based on z-scores in all cases, due to the general good agreement among participants.

The 2022 proficiency testing scheme was successful overall, number and ratio of unsatisfactory results was lower or similar to previous years' values. In some cases, low spread of reported values led to calculated robust standard deviations being less than of the standard deviation for proficiency assessment set by expert judgement, which is outstanding. Some of the unsatisfactory results are attributable to non-analytical errors e.g. probable switching of samples (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 total phosphorous. Significant improvement can be observed in nitrite nitrogen analysis, which is traditionally less successful. In summary, the 2022 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).

3. Results of Basic Statistical Processing

In the whole Danube River Basin District in 2022,147 sites at 109 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 71 sampling sites at 39 stations were collected directly on the Danube river. Tributaries were monitored at 76 sampling sites representing 70 stations.

Table 3: List of TNMN stations reported in 2022

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**	**Danube**	**Medveďov**	**1806**
13	**SK5**	**L, M, R**	**Danube**	**Szob**	**1707**
14	SK4	M	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	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	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**	**L, M, R**	**Danube**	**Reni-Chilia/Kilia arm**	**132**
83	**RO6**	**L, M, 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	Ialomita	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	**UA1**	**M**	**Danube**	**Reni**	**132**
104	**UA2**	**M**	**Danube**	**Vylkove**	**18**
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
Determinand name	name of the determinand measured according to the agreed method
Unit	unit of the measured determinand
N	number of measurements
Min	minimum value of the measurements done in the year 2022
Mean	arithmetical mean of the measurements done in the year 2022
Max	maximum value of the measurements done in the year 2022
C50	50 percentiles of the measurements done in the year 2022
C90	90 percentiles of the measurements done in the year 2022 (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 2022. 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 2022.

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2022 (Part 1)

Determinand name	Unit	Danube					Tributaries				
		No.of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean		No.of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean	
			Min	Max	Min_{avg}	Max_{avg}		Min	Max	Min_{avg}	Max_{avg}
Temperature	°C	69/39	1	28.9	3.5	16.7	74/72	0.4	31	4.4	18.7
Suspended solids	mg/l	69/39	< 1	231	6	65	72/70	< 1	702	< 1	293
Dissolved oxygen	mg/l	69/39	5.03	15.1	6.85	12.83	74/72	< 0.1	75.8	7.05	73.67
BOD (5)	mg/l	69/39	< 0.2	6.5	0.97	4.54	74/72	< 0.1	56	0.81	13.44
COD (Mn)	mg/l	63/33	< 0.25	9.5	< 0.25	4.82	43/41	1.4	15.8	1.7	6.49
COD (Cr)	mg/l	57/27	< 2.5	23.8	6.07	16.53	58/56	< 2.5	171	4.29	93.83
TOC	mg/l	33/21	1.5	7.22	2.64	4.51	34/32	0.9	49.1	1.58	27.35
DOC	mg/l	33/15	1.42	7.47	2.28	5.73	17/17	0.6	32.04	1.15	7.53
pH	-	69/39	7.08	9.38	7.7	8.36	70/70	6.21	9.17	7.33	8.45
Alkalinity	mmol/l	69/39	1.34	5.26	1.63	4.77	66/64	0.95	284.00	1.36	227.80
Ammonium nitrogen (NH4-N)	mg/l	69/39	< 0.004	0.84	0.016	0.36	74/72	< 0.004	6.726	0.02	3.32
Nitrite-Nitrogen (NO2-N)	mg/l	69/39	< 0.001	0.171	0.009	0.03	74/72	< 0.001	0.2	0.0038	0.11
Nitrate-Nitrogen (NO3-N)	mg/l	69/39	< 0.01	5.2	0.75	2.78	74/72	0.017	5.98	0.069	4.57
Total nitrogen	mg/l	61/31	< 0.25	6.6	1.23	2.67	67/65	0.14	10.1	0.633	5.83
Organic nitrogen	mg/l	27/15	0.09	2.97	0.33	0.92	25/23	0.009	2.08	0.157	1.42
Orthophosphate (PO4-P)	mg/l	69/39	< 0.0015	1.25	0.011	0.26	74/72	< 0.002	1.05	< 0.0035	0.35
Total phosphorus	mg/l	67/37	< 0.005	1.374	0.048	0.38	74/72	< 0.0035	1.76	0.0085	0.92
Total phosphorus, dissolved	mg/l	40/18	< 0.0025	1.318	0.027	0.30	21/21	< 0.0035	0.5504	0.0057	0.34
Phytoplankton (biomass - chlorophyll-a)	µg/l	43/21	< 0.5	92	0.96	47.82	38/36	< 0.0015	301.03	0.15	115.09
Conductivity	µS/cm	67/37	180	1321	367	583	74/72	156	1786	237	1713
Calcium (Ca++)	mg/l	69/39	28.9	119	44.84	85.83	74/72	19.5	624	27.75	309.83
Sulphate (SO4--)	mg/l	46/24	7.9	43.2	18.82	36.11	47/45	1.9	185	4.78	115.21
Magnesium (Mg++)	mg/l	69/39	< 2.00	53.9	9.99	26.23	73/71	1.25	62	4.51	54.91
Potassium (K+)	mg/l	29/17	1.1	7.59	1.95	3.34	37/35	0.7	10.3	0.88	6.03
Sodium (Na+)	mg/l	29/17	7.5	25.7	11.07	18.44	37/35	1.8	229.28	2.7	99.42
Manganese (Mn)	mg/l	11/9	< 0.0005	0.135	< 0.0005	0.03	24/22	< 0.0005	96.964	< 0.0005	67.65
Iron (Fe)	mg/l	12/10	< 0.001	2.25	< 0.005	0.39	26/24	< 0.001	47	< 0.001	3.62
Chloride (Cl-)	mg/l	69/39	2.7	356	17.19	79.43	74/72	< 0.25	503	2.6	417.00
Silicates (SiO2)	mg/l	16/8	1.5	13.3	2.3	6.9	15/13	1	37.3	4.52	23.6
Silicates(SiO2), dissolved	mg/l	9/7	< 0.05	7.7	0.8	4.6	11/11	1	11.6	2.715	7.6
Macrozoobenthos- saprobic index		14/10	1.90	11.80	1.90	7.23	29/29	0.44	11.00	1.00	6.61

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2022 (Part 2)

Determinand name	Unit	Danube					Tributaries				
			Range of values		Mean		No.of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean	
			Min	Max	Min_{avg}	Max_{avg}		Min	Max	Min_{avg}	Max_{avg}
Zinc - Dissolved *	µg/l	66/36	0.24	322.10	1.04	76.53	72/70	0.43	478.10	< 0.585	163.43
Copper - Dissolved	µg/l	66/36	< 0.05	123.10	0.93	32.90	71/69	< 0.150	290.50	< 0.500	62.04
Chromium - Dissolved	µg/l	66/36	< 0.1	9.22	< 0.10	1.41	67/65	< 0.05	8.7	< 0.05	3.82
Lead - Dissolved	µg/l	62/34	0.021	10.2	0.057	3.932	56/54	0.02	13.5	0.036	5.168
Cadmium - Dissolved	µg/l	62/34	< 0.005	1.27	< 0.005	0.29	58/56	< 0.005	0.94	< 0.005	0.15
Mercury - Dissolved	µg/l	62/34	< 0.0025	0.24	< 0.0025	0.05	52/50	< 0.0025	0.09	< 0.0025	0.04
Nickel - Dissolved	µg/l	66/36	< 0.25	74.40	< 0.5	17.18	59/57	< 0.1	27.00	0.32	18.09
Arsenic - Dissolved	µg/l	62/34	< 0.5	6.12	< 0.5	2.35	61/59	< 0.1	22.37	< 0.1	12.44
Aluminium - Dissolved	µg/l	18/12	< 2.25	67.10	4.34	24.28	21/19	< 2.25	474.00	< 2.25	102.10
Zinc *	µg/l	24/20	0.80	367.50	2.43	136.26	31/29	1.27	576.5	3.05	218.45
Copper	µg/l	20/16	< 0.5	185.10	1.46	46.49	27/25	1.14	660.8	1.90	124.28
Chromium - total	µg/l	21/17	< 0.1	14.10	0.41	3.04	36/34	0.128	79	< 0.2500	17.06
Lead	µg/l	15/13	< 0.1	4.40	< 0.5	1.63	28/26	< 0.15	78.4	0.29	11.37
Cadmium	µg/l	16/14	< 0.005	3.00	0.01	1.54	33/31	< 0.01	2.8	< 0.02500	0.49
Mercury	µg/l	16/14	<0.01	0.07	<0.01	0.047	28/26	<0.01	0.34	<0.01	0.20
Nickel	µg/l	22/18	< 0.5	48.70	0.82	23.01	34/32	< 0.25	113.00	1.11	26.79
Arsenic	µg/l	16/14	< 0.5	3.60	< 0.500	2.40	24/22	< 0.5	21.00	0.89	7.48
Aluminium	µg/l	8/6	< 5.0	1762.0	138.8	773.8	11/13	21.7	46000.0	100.8	4889.0
Phenol index	mg/l	43/17	< 0.001	0.0134	< 0.001	0.0072	16/16	< 0.001	0.0244	< 0.0010	0.0048
Anionic active surfactants	mg/l	39/15	< 0.01	0.14	< 0.01	0.13	28/28	< 0.005	0.10	0.01	0.10
AOX	µg/l	45486	< 5.0	77.00	5.8333	13.83	14/14	< 3.0	41.00	6.5	23.75
Petroleum hydrocarbons	mg/l	31/15	< 0.01	0.40	< 0.01	0.20	26/26	< 0.0025	0.49	< 0.0025	0.25
Lindane	µg/l	59/29	< 0.0001	0.02	< 0.0001	0.0116	53/51	< 0.0001	< 0.0250	< 0.0001	< 0.025
pp´DDT	µg/l	57/29	< 0.0001	0.02	< 0.0002	0.010	52/50	< 0.0001	7.60	< 0.0002	5.00
Atrazine	µg/l	58/28	< 0.0005	0.161	< 0.0005	< 0.0250	49/47	< 0.0005	0.12	< 0.0005	< 0.07
Chloroform	µg/l	14/8	< 0.081	0.5	< 0.081	0.5	22/22	< 0.015	< 0.5	0.0380	< 0.5
Carbon tetrachloride	µg/l	14/8	< 0.063	0.5	< 0.063	< 0.5	21/21	< 0.05	< 1.0	< 0.5	< 1.000
Trichloroethylene	µg/l	5/3	< 0.075	0.5	< 0.075	0.5	15/15	< 0.05	< 0.25	< 0.5	< 0.25
Tetrachloroethylene	µg/l	5/3	< 0.081	0.50	< 0.081	0.5	15/15	< 0.05	< 0.25	< 0.5	< 0.25

In this chapter, in Figures 4.1-4.16 **the temporal changes for selected determinands** (dissolved oxygen (DO), BOD_5, COD_{Cr}, N-NH_4, N-NO_3, P-PO_4, P_{total} 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_5, N-NO_3, P_{total}) 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 2022 the **highest concentrations of biodegradable organic matter** were observed in the middle and lower parts of the Danube River with a maximum of 5.6 $mg.l^{-1}$ in BG2.

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 2022 were observed in the upper and middle part (see Figure 4.3).

The decrease of the BOD_5 has been observed in some tributaries: Dyje, Drava (HR4, HR9, HU7) and Jantra (Figure 4.4). In 2022 the concentration of BOD_5 has increased in Sio, Sajo, Russenski Lom Velika Morava and Siret. The maximal concentration was found in the Russenski Lom (BG15 - 18.6 $mg.l^{-1}$).

At the selected monitoring points SK1 and HU5 the BOD_5 levels decreased in 2022, while at RO5 the BOD_5 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 5.6 $mg.l^{-1}$ in BG4 (Figure 4.1).

The maximum value of dissolved oxygen in tributaries was in RO11 Prut (10.66 $mg.l^{-1}$), but there was a lower measurement frequency. The minimal concentration was in HU7 Drava Dravaszabolcs - 5.1 $mg.l^{-1}$. The concentrations have a stable character (Figure 4.2).

Concentrations of **chemical oxygen demand (COD_{Cr})** (Figure 4.5 and Figure 4.6) show the difference in pollution between the Danube River and tributaries. The concentrations in tributaries are higher (range of C90 values 5 - 171 - $mg.l^{-1}$ with maximum in BG15 (Russenski Lom-mouth) than in the Danube River sites (range of C90 values 8.5 - 21.1 $mg.l^{-1}$), maximum in RO8 Danube – Sf. Gheorghe-Ghorghe arm.

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 0.51 $mg.l^{-1}$.
In 2022, increased concentrations of ammonium-nitrogen 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 2022 (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). A increase of concentrations was observed in HU4 with a maxium concentration 5.2 $mg.l^{-1}$.
In the upper part tributaries the **nitrate-nitrogen** concentrations decreased. An increase was observed in the Russenski Lom, Siret and Velika Morava (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 decrease in all monitoring points. The lowest value of C90 in 2022 was 1.2 $mg.l^{-1}$ in RO5 - Reni.

The data for **ortho-phosphate-phosphorus** in the Danube River are presented in Figure 4.11 showing that the 2022 results were stable. An decrease of the ortho-phosphate-phosphorus was observed at RS8 (Danube-Radujevac) where was the highest value detected in previous year 2021.

An increase of ortho-phosphate-phosphorus concentrations was observed in Dyje , Arges and Velika Morava with a maximum of 0.78 $mg.l^{-1}$ 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 2022 showed an increase in the upper Danube tributaries (Figure 4.14). Increasing values were observed in Inn, Dyje Jantra and Arges. The highest concentration in 2022 of 1.59 $mg.l^{-1}$ was found in the Russenski Lom.

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

The **cadmium** dissolved concentration (Figure 4.15) was constant in the upper part of the Danube. The maximum value was 0.87 $mg.l^{-1}$ in RO2 Pristol/Novo Selo.

The concentrations of $Cd_{diss.}$ was stable in the upper part tributaries with the maximum of 0.33 $mg.l^{-1}$ in Sava RS16. The concentration has increased in Tisza- RS 12.

The comparison of statistical characteristics of 90 and 10 percentiles (C90, C10) in 2022 for selected determinands ($N\text{-}NH_4$, $P\text{-}PO_4$, COD_{Cr}, 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 COD_{Cr}, $P\text{-}PO_4$, $N\text{-}NH_4$ in the in upper and middle Danube. Some differences were observed for BOD_5 in the middle and lower part of the Danube. The highest difference was observed for COD_{Cr} in SK2 and for BOD_5 in BG2 .

The differences for percentiles 10 and 90 percentile values was obsereved for COD_{Cr} and BOD_5 in lower tributaries. The significant differences for the COD_{Cr} were observed in the lower tributaries Ialomita, Olt and Russenski Lom. For the BOD_5 significant differences was also in the lower part in Mures, Ialomita and Russenski Lom.

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

Figure 4.1: Temporal changes (2012-2022) of dissolved oxygen (C10) in the Danube River

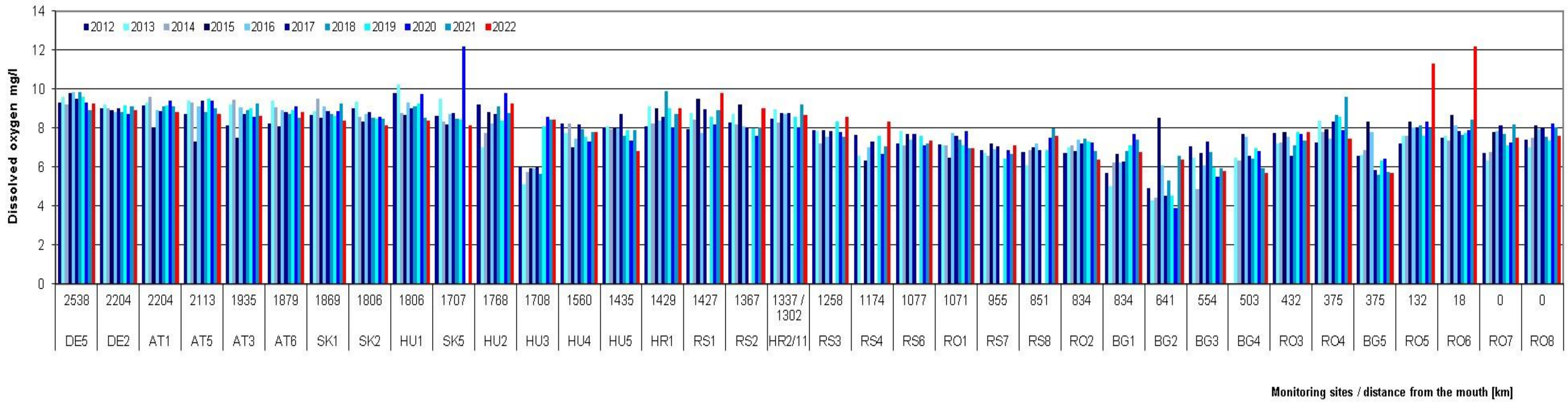


Figure 4.2: Temporal changes (2012-2022) of dissolved oxygen (C10) in tributaries

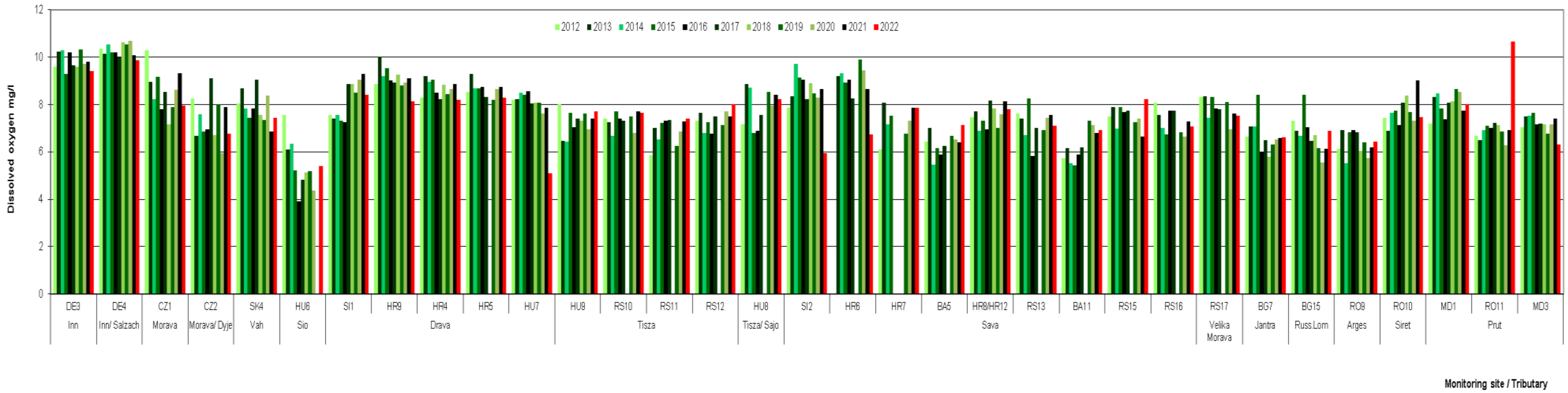


Figure 4.3: Temporal changes (2012-2022) of BOD_5 (C90) in the Danube River.

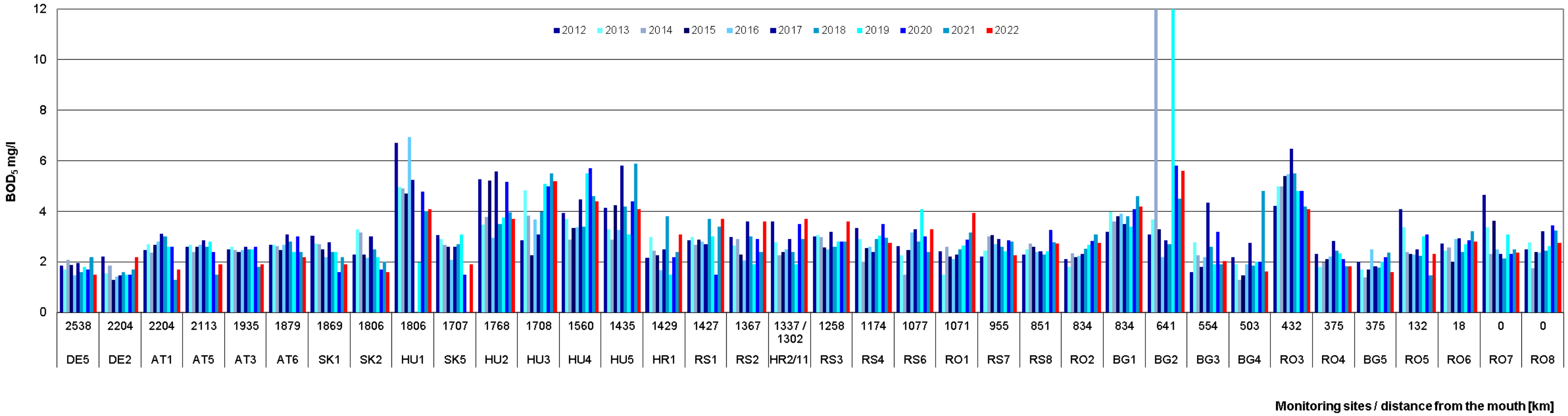


Figure 4.4: Temporal changes (2012-2022) of BOD_5 (C90) in tributaries.

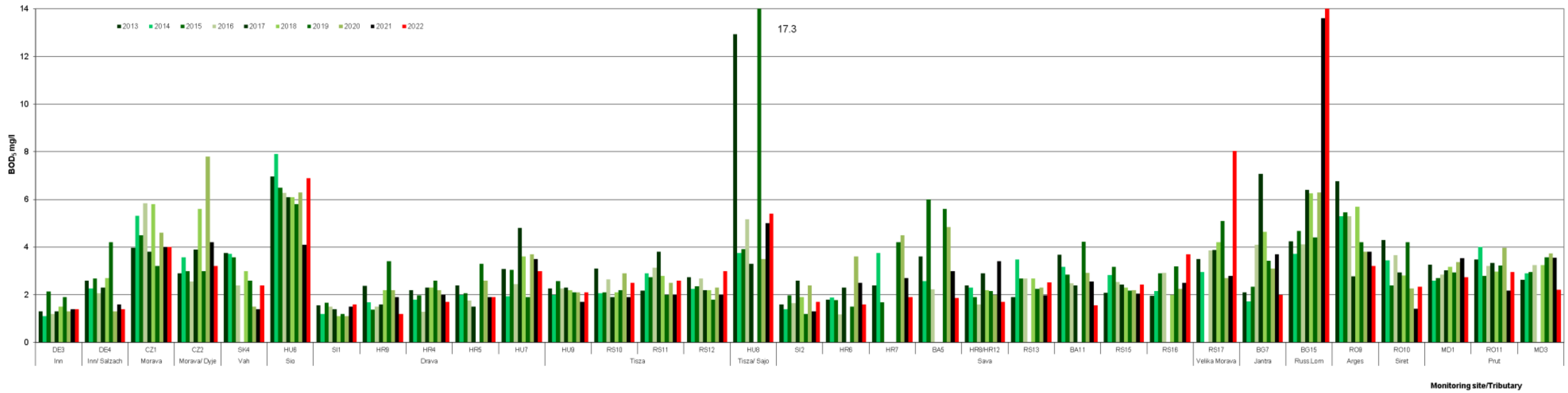


Figure 4.5: Temporal changes (2012-2022) of COD_{Cr} (C90) in the Danube River.

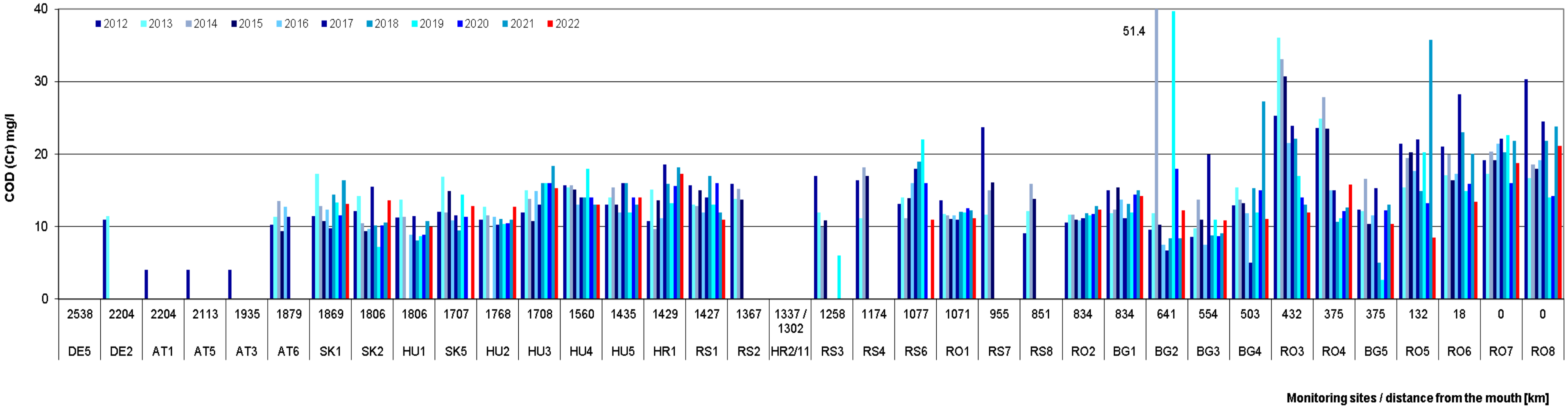


Figure 4.6: Temporal changes (2012-2022) of COD_{Cr} (C90) in tributaries.

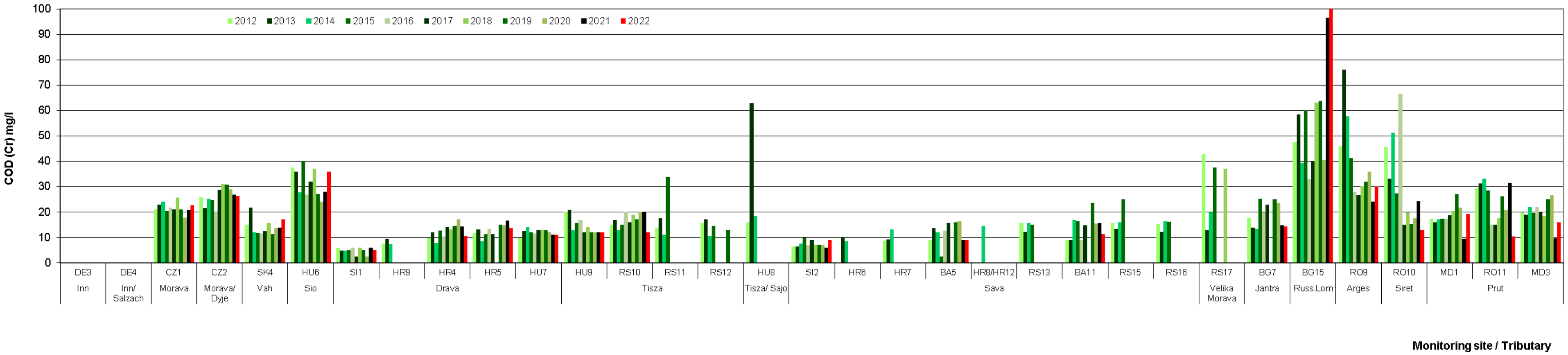


Figure 4.7: Temporal changes (2012-2022) of NH_4-N (C90) in the Danube River.

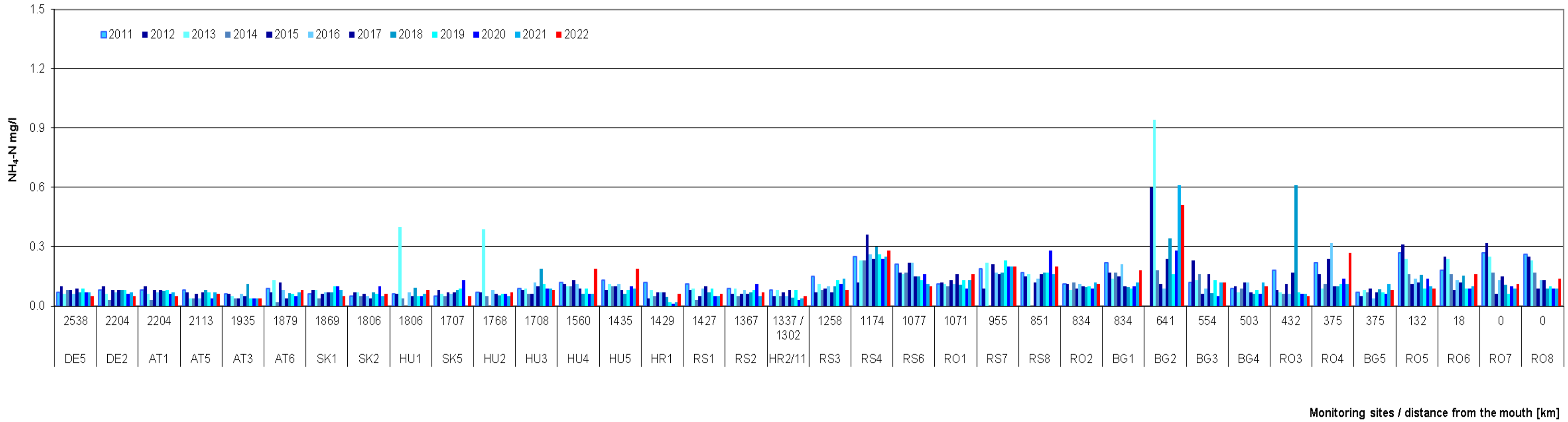


Figure 4.8: Temporal changes (2012-2022) of NH_4-N (C90) in tributaries.

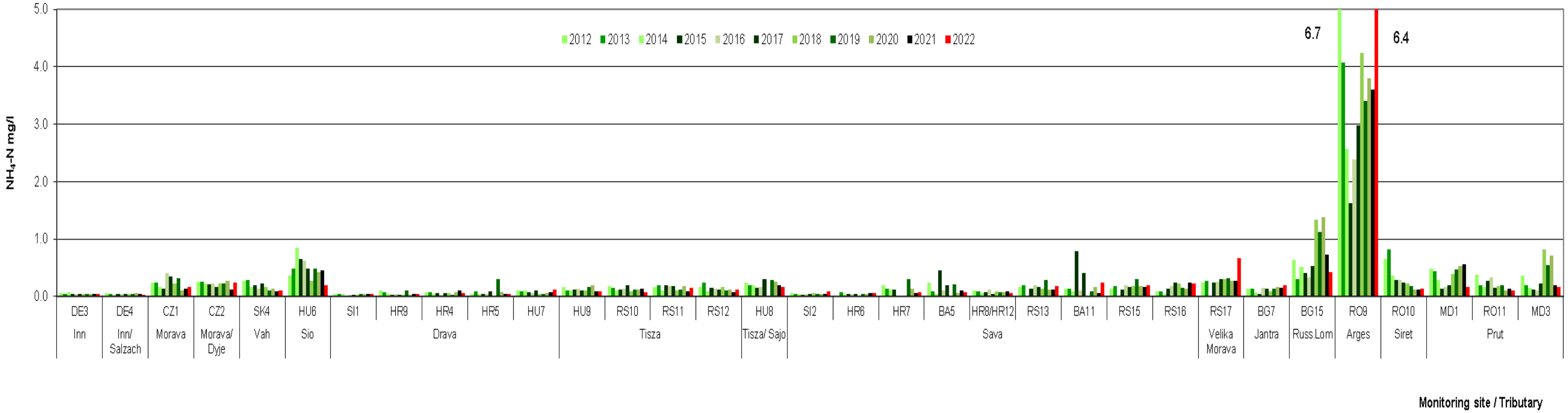


Figure 4.9: Temporal changes (2012-2022) of NO_3-N (C90) in the Danube River.

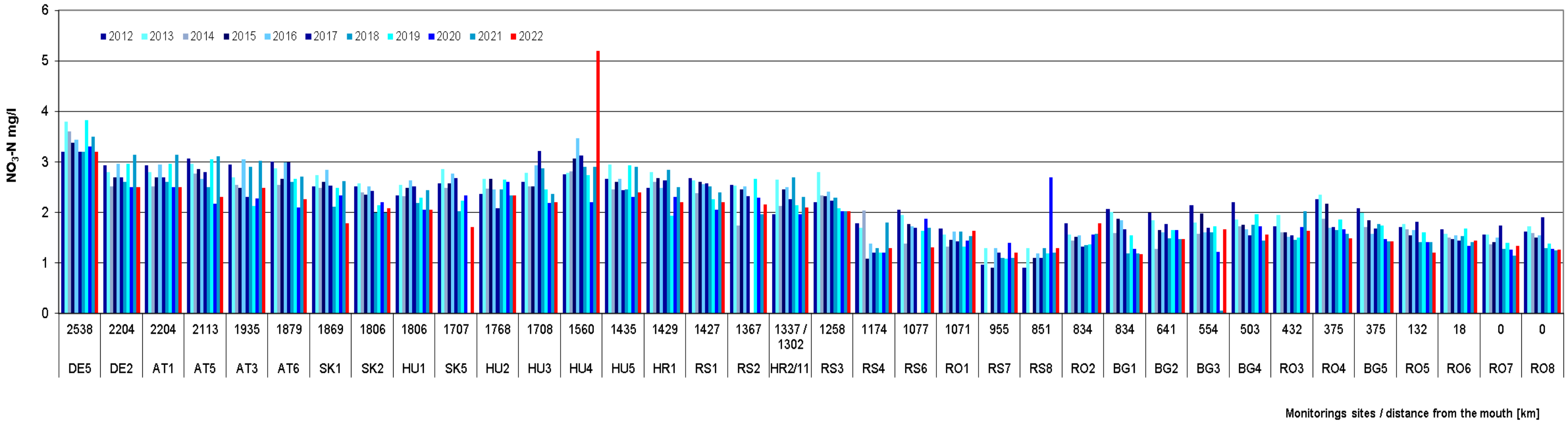


Figure 4.10: Temporal changes (2012-2022) of NO_3-N (C90) in tributaries.

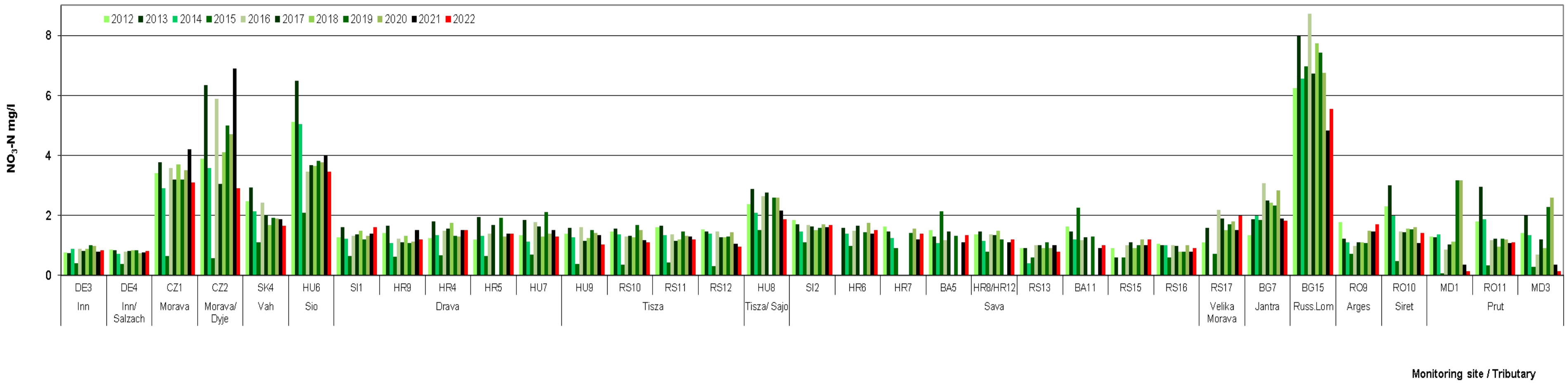


Figure 4.11: Temporal changes (2012-2022) of P-PO4 (C90) in the Danube River.

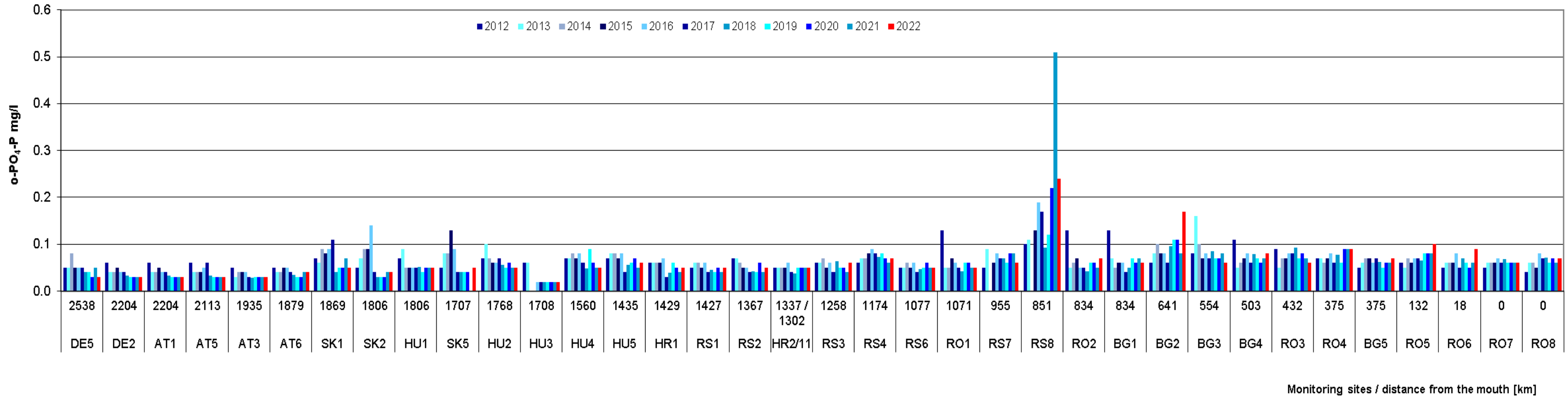


Figure 4.12: Temporal changes (2012-2022) of P-PO4 (C90) in tributaries

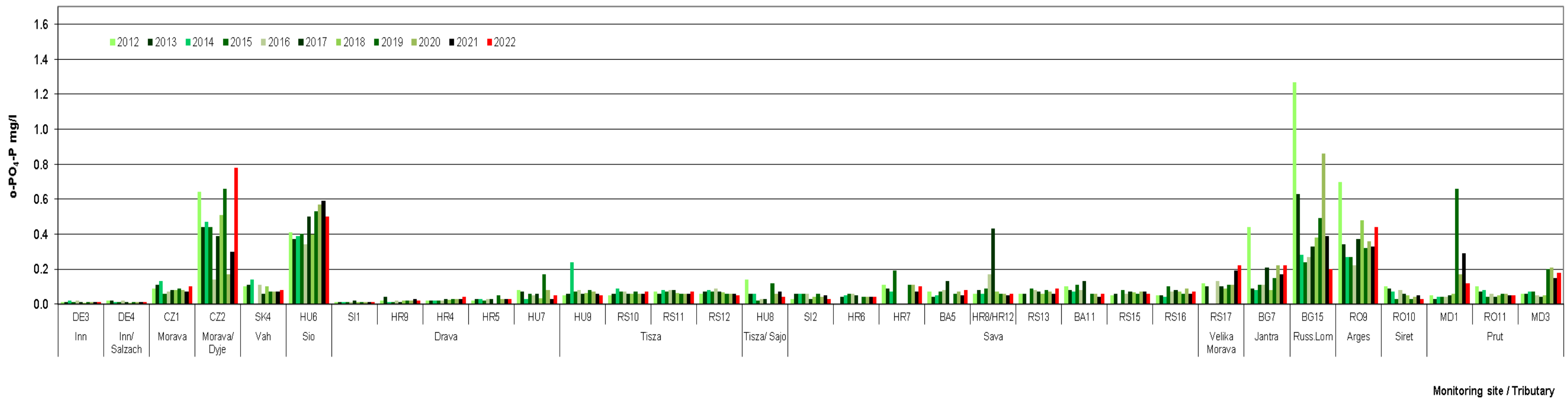


Figure 4.13: Temporal changes (2012-2022) of total phosphorus (C90) in the Danube River.

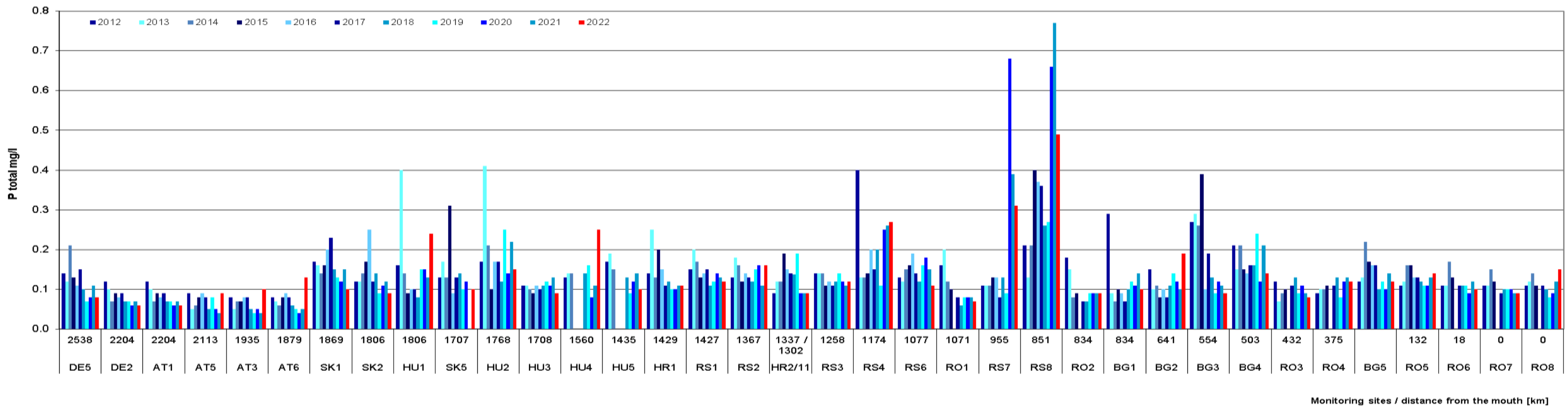


Figure 4.14: Temporal changes (2012-2022) of total phosphorus (C90) in tributaries.

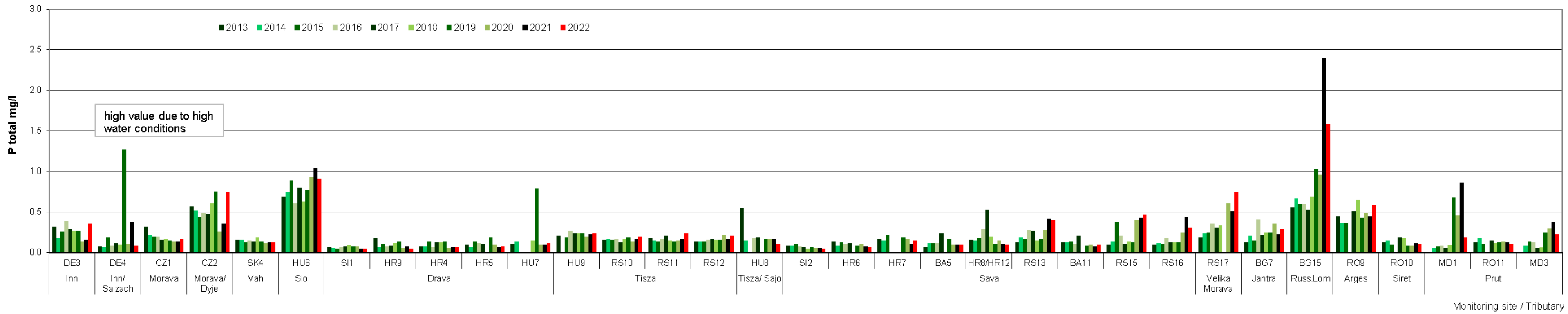


Figure 4.15: Temporal changes (2012-2022) of cadmium dissolved (C90) in the Danube River.

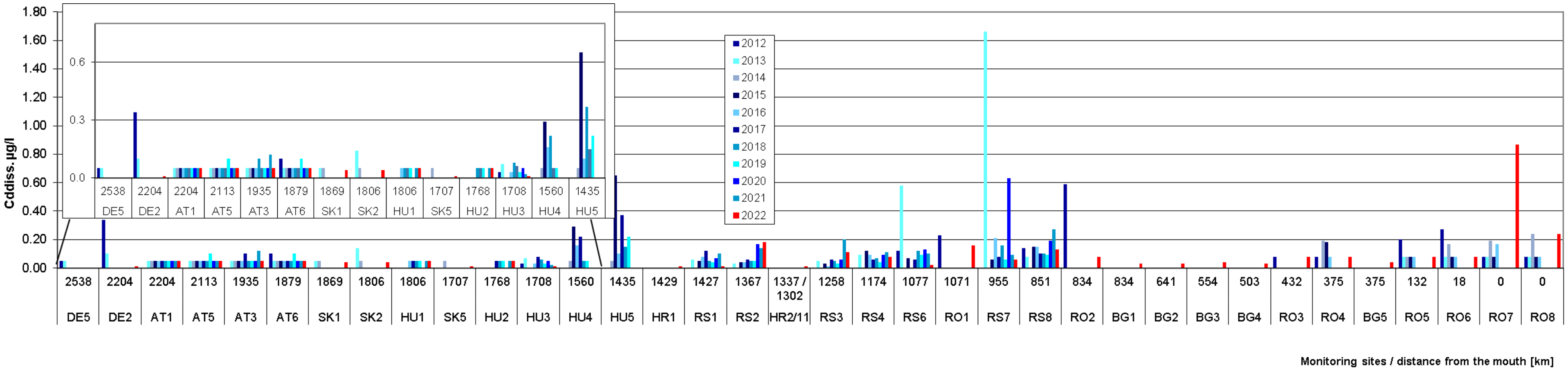


Figure 4.16: Temporal changes (2012-2022) of cadmium dissolved (C90) in tributaries.

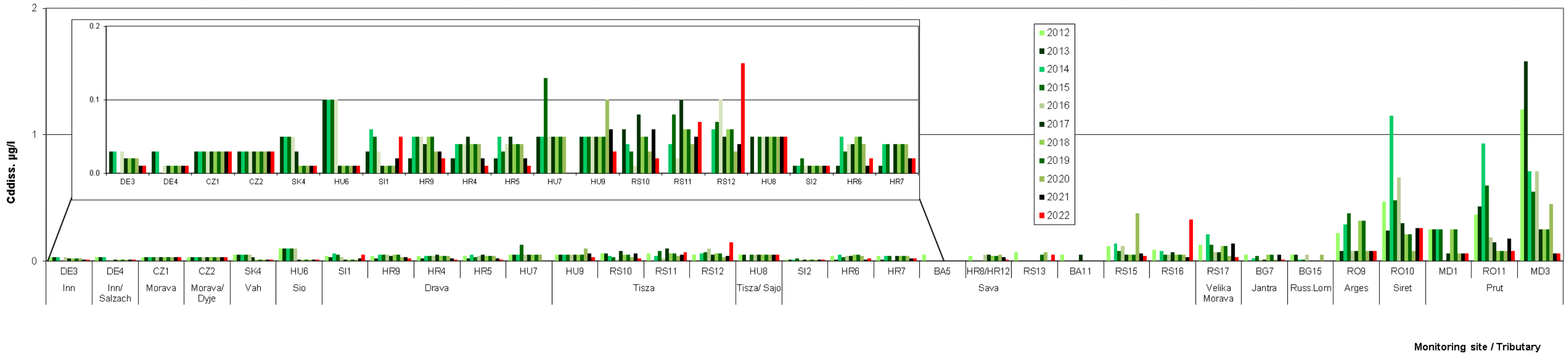


Figure 4.17: Temporal changes (2012-2022) of BOD_5 (C90) in Bratislava

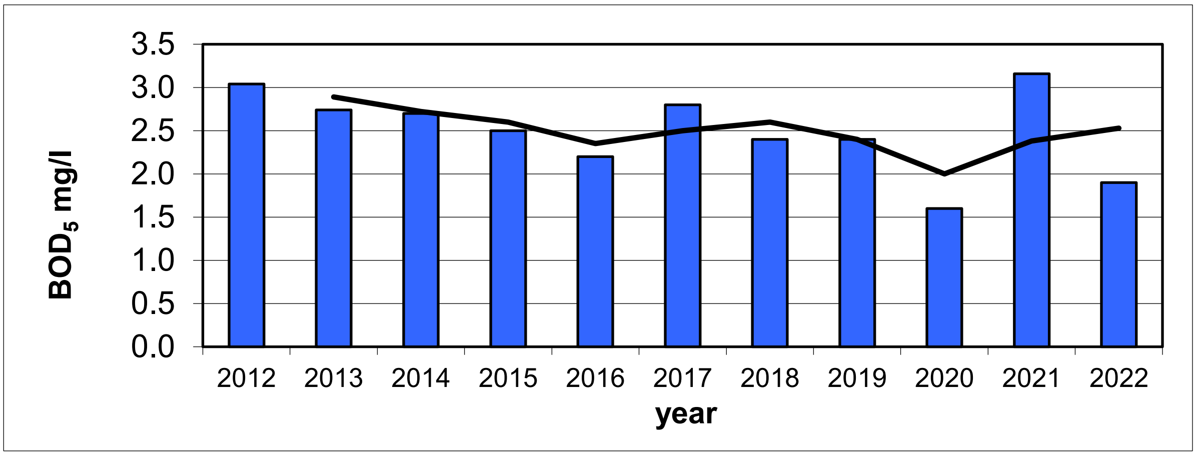


Figure 4.18: Temporal changes (2012-2022) of BOD_5 (C90) in Hercegszanto

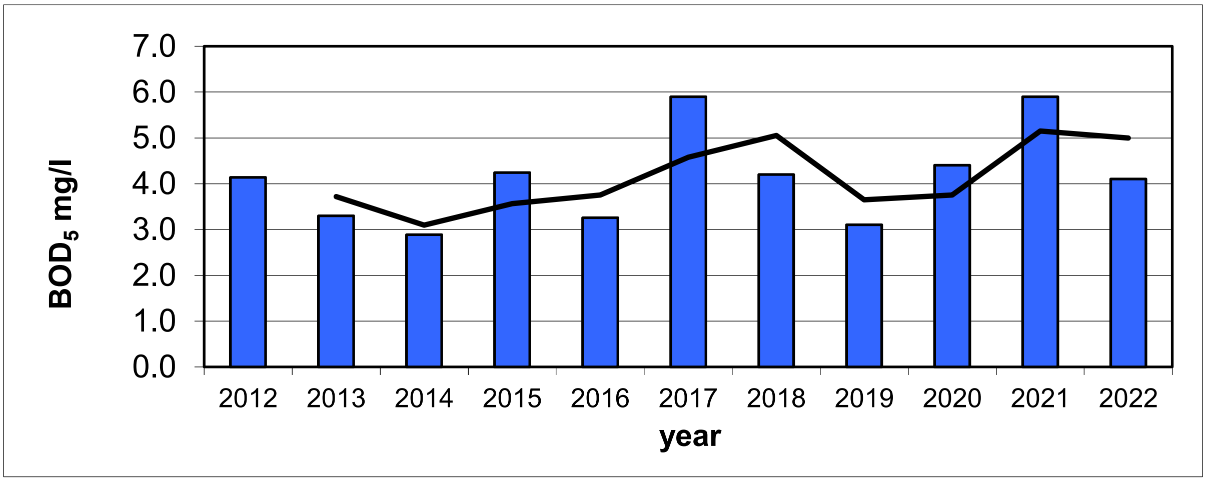


Figure 4.19: Temporal changes (2012-2022) of BOD_5 (C90) in Reni

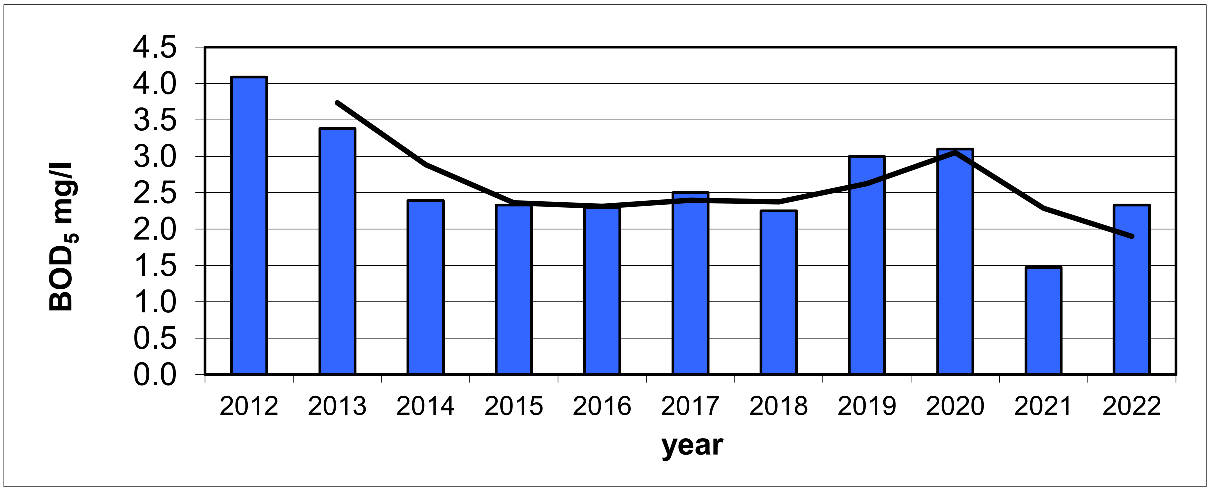


Figure 4.20: Temporal changes (2012-2022)) of N-NO_3 (C90) in Bratislava

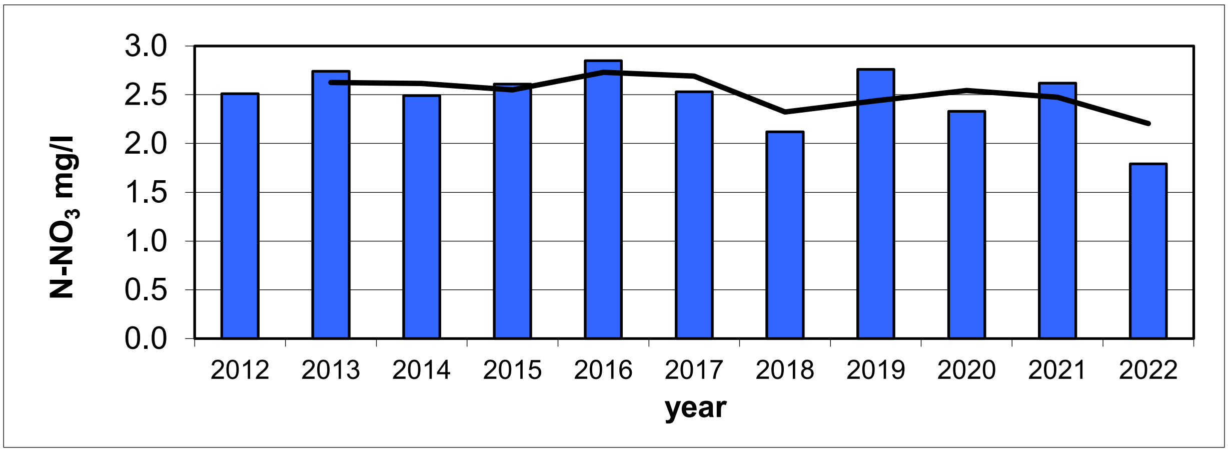


Figure 4.21: Temporal changes (2012-2022) of N-NO_3 (C90) in Hercegszanto

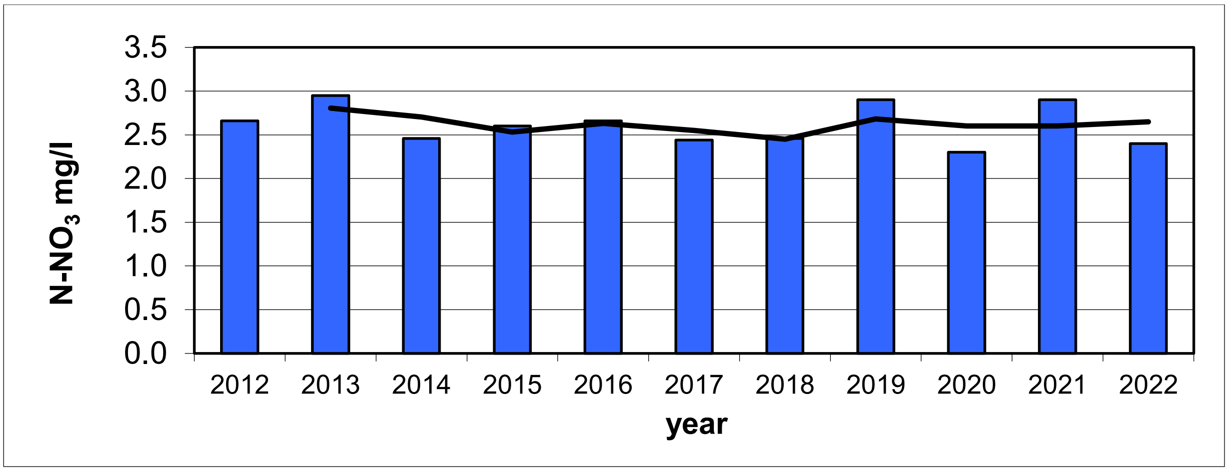


Figure 4.22: Temporal changes (2012-2022) of N-NO_3 (C90) in Reni

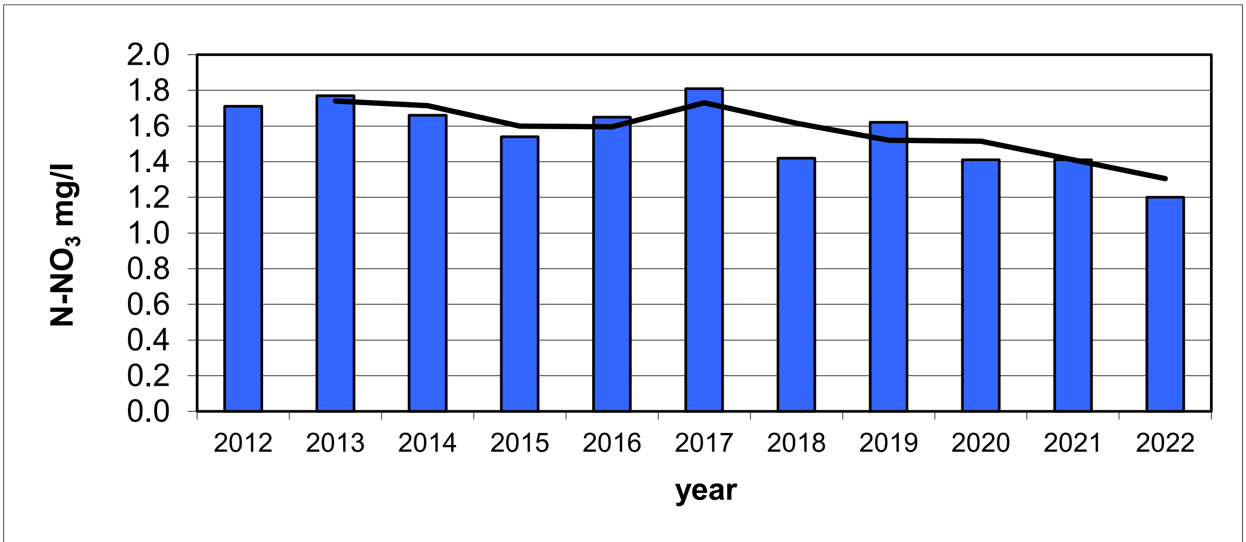


Figure 4.23: Temporal changes (2012-2022) of total phosphorus (C90) in Bratislava

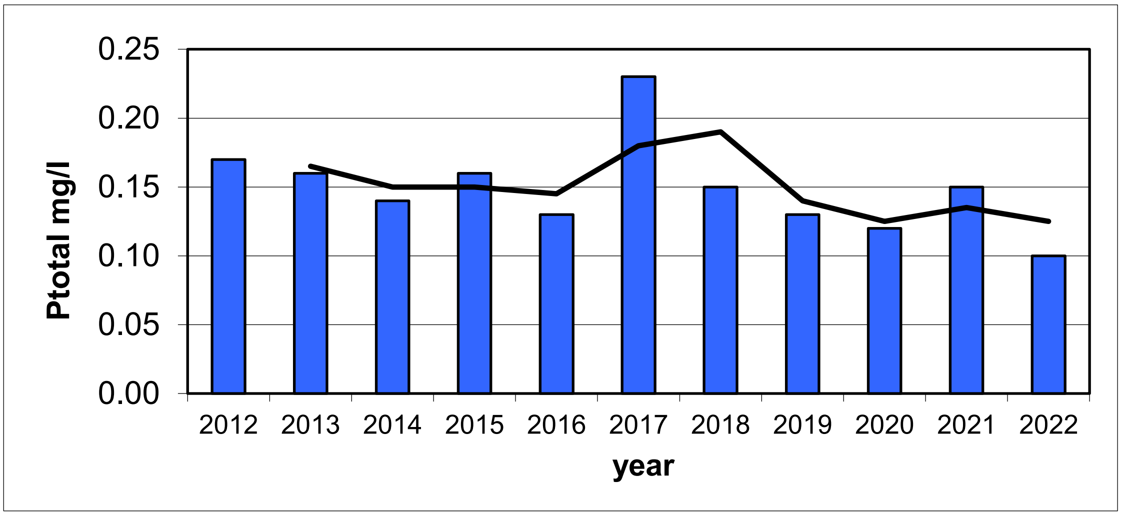


Figure 4.24: Temporal changes (2012-2022) of total phosphorus (C90) in Hercegszanto

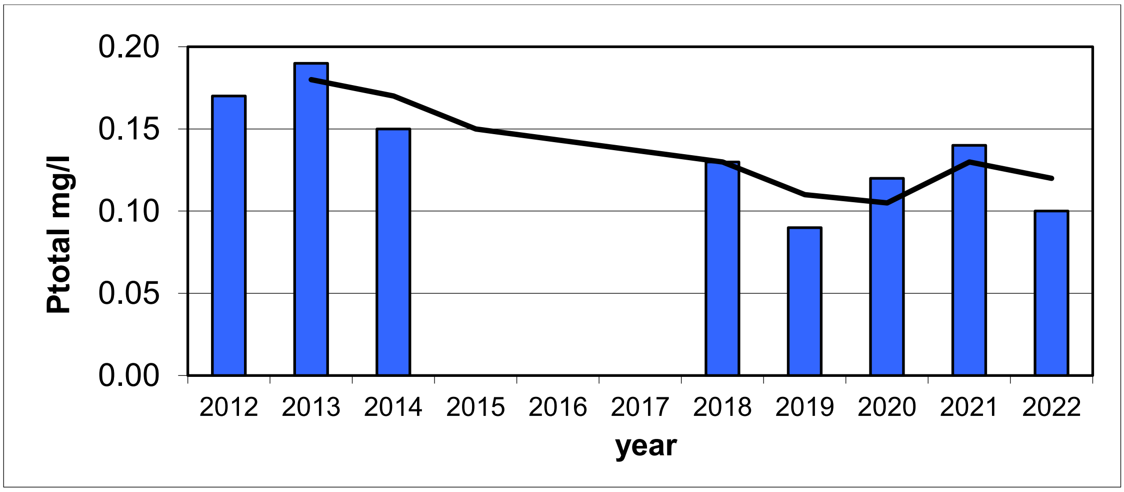


Figure 4.25: Temporal changes (2012-2022) of total phosphorus (C90) in Reni

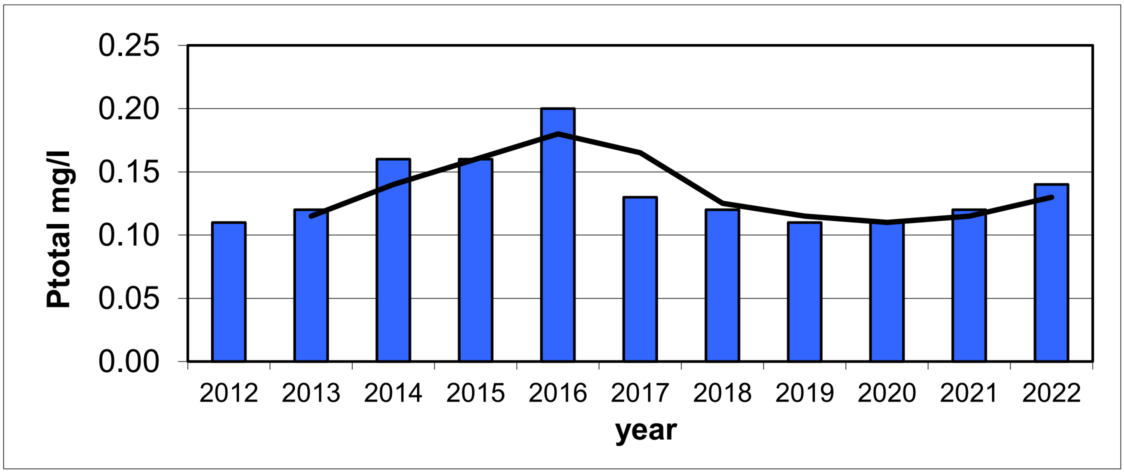


Figure 4.26: The percentile (90, 10) of N-NH_4 concentration along the Danube River in 2022

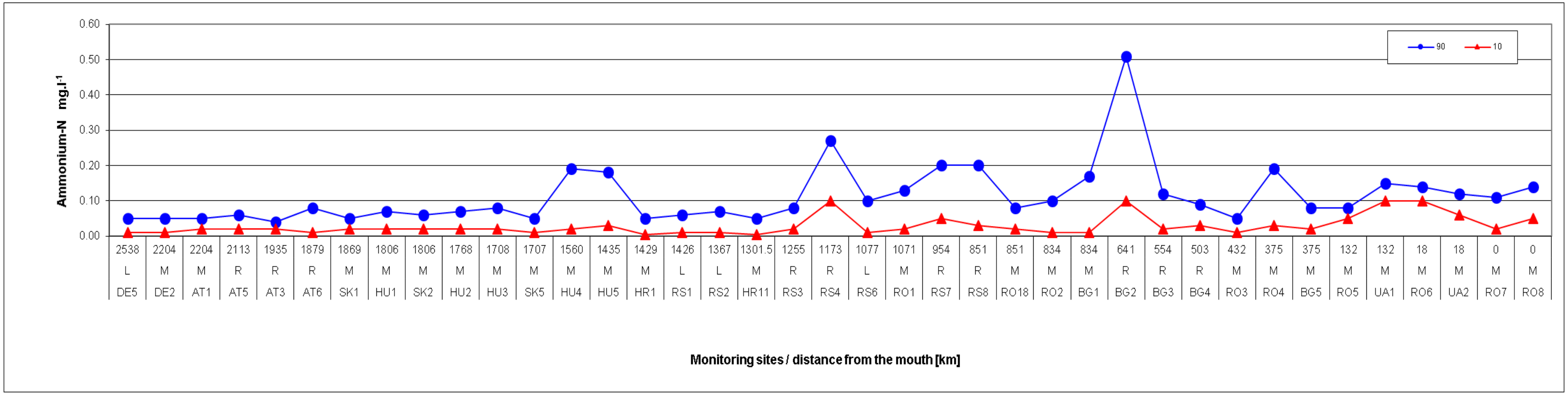


Figure 4.27: The percentile (90, 10) of N-NH_4 concentration in the tributaries in 2022

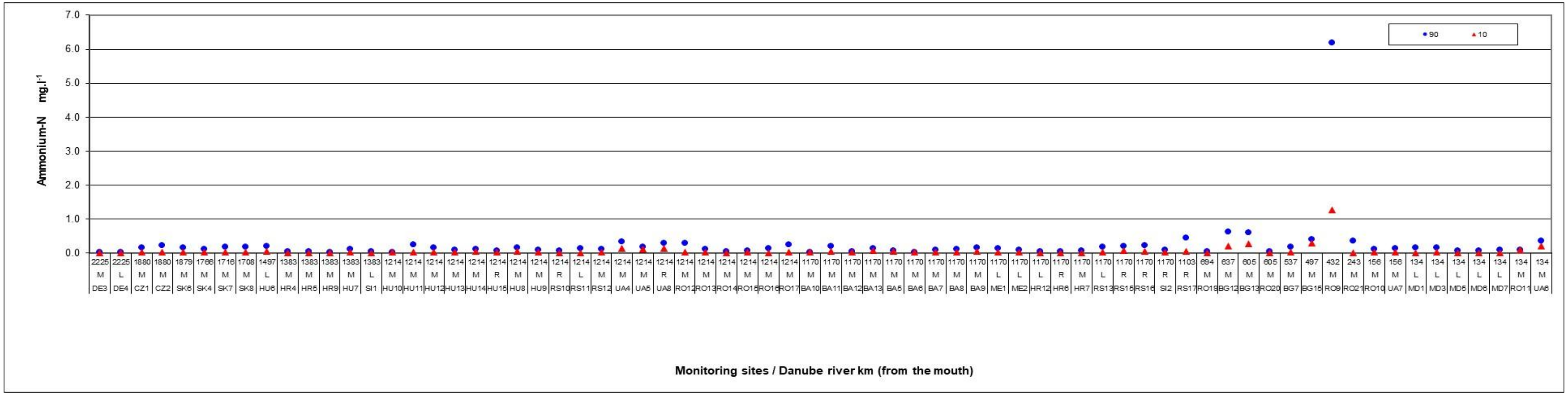


Figure 4.28: The percentile (90, 10) of P-PO$_4$ concentration along the Danube River in 2022

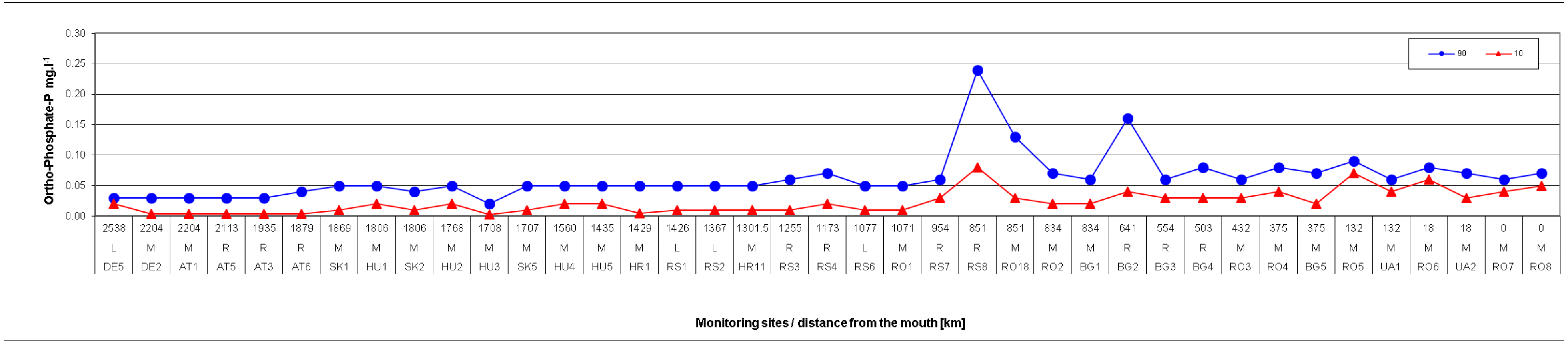


Figure 4.29: The percentile (90, 10) of P-PO$_4$ concentration in the tributaries in 2022

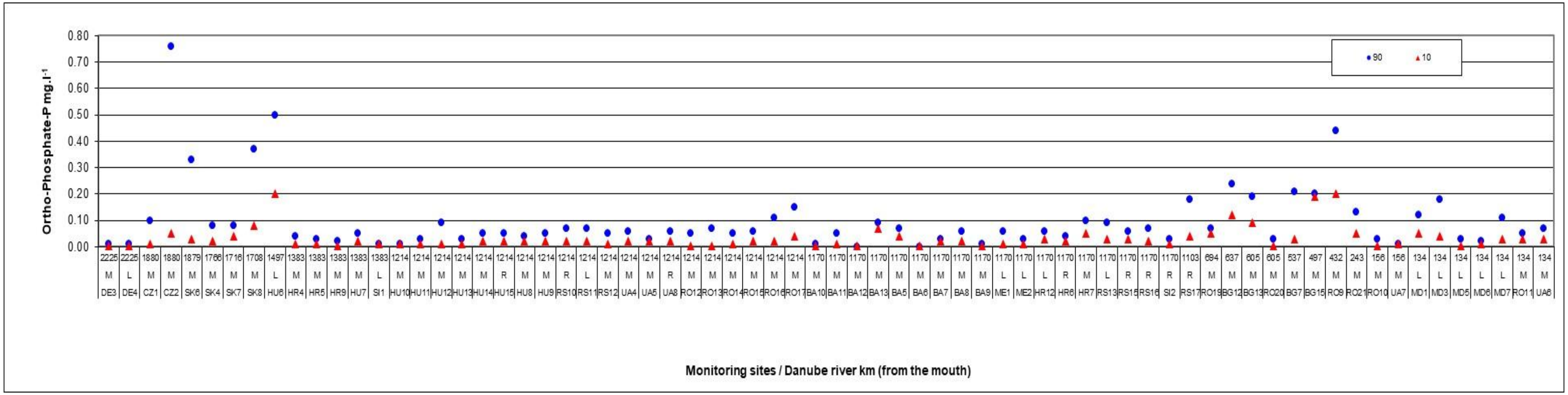


Figure 4.30: The percentile (90, 10) of COD_{Cr} concentration along the Danube River in 2022

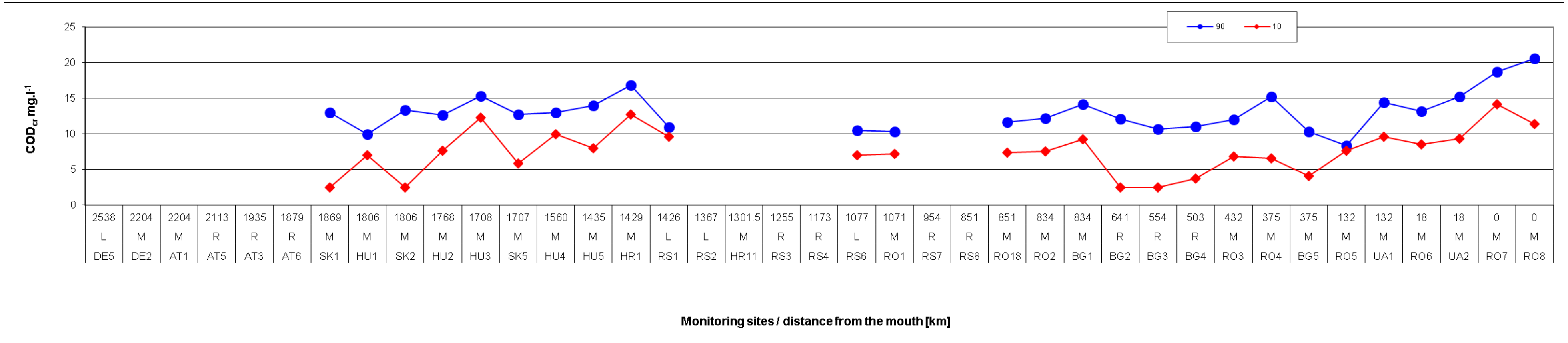


Figure 4.31: The percentile (90, 10) of COD_{Cr} concentration in the tributaries in 2022

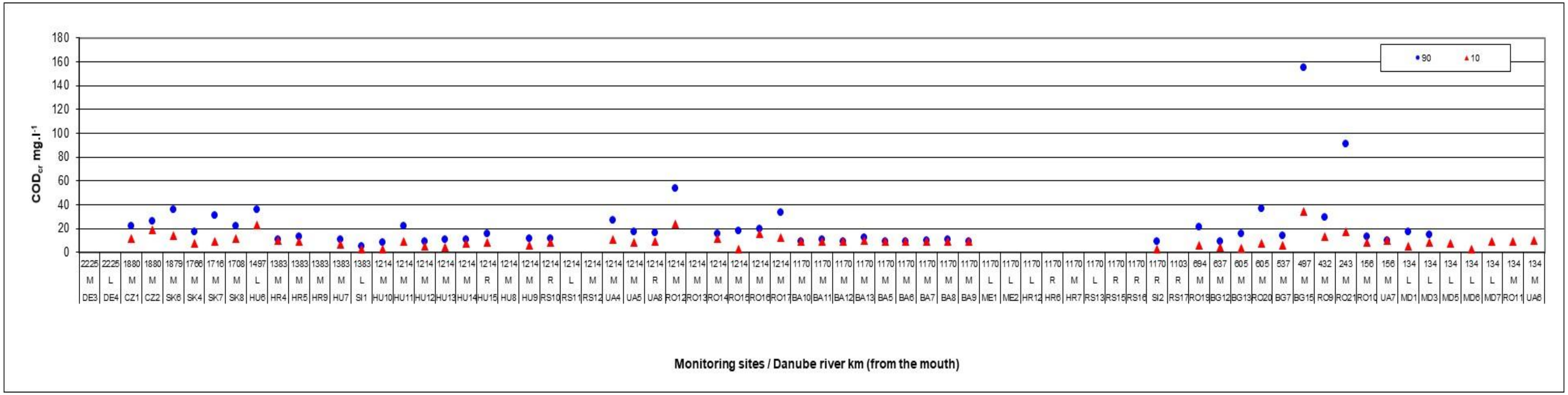


Figure 4.32: The percentile (90, 10) of BOD_5 concentration along the Danube River in 2022

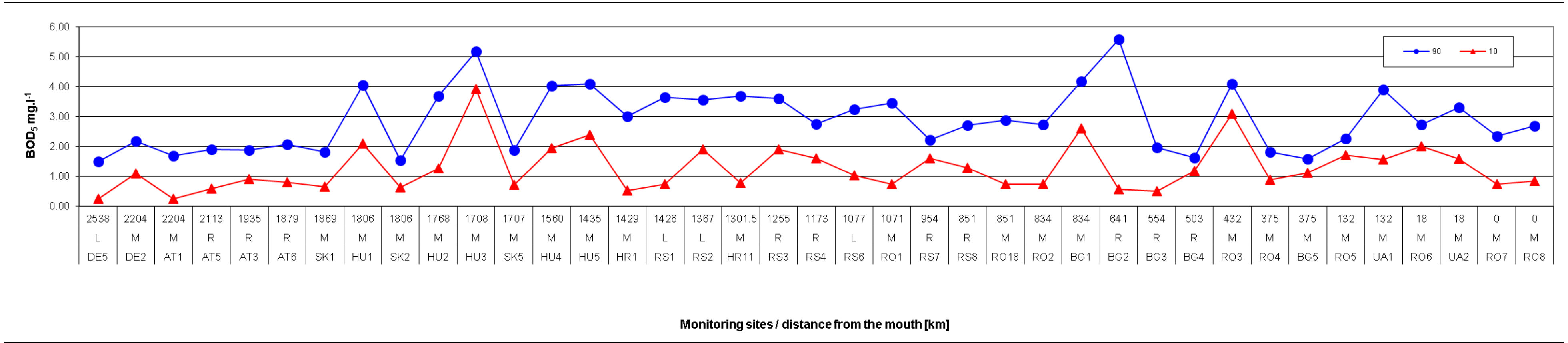
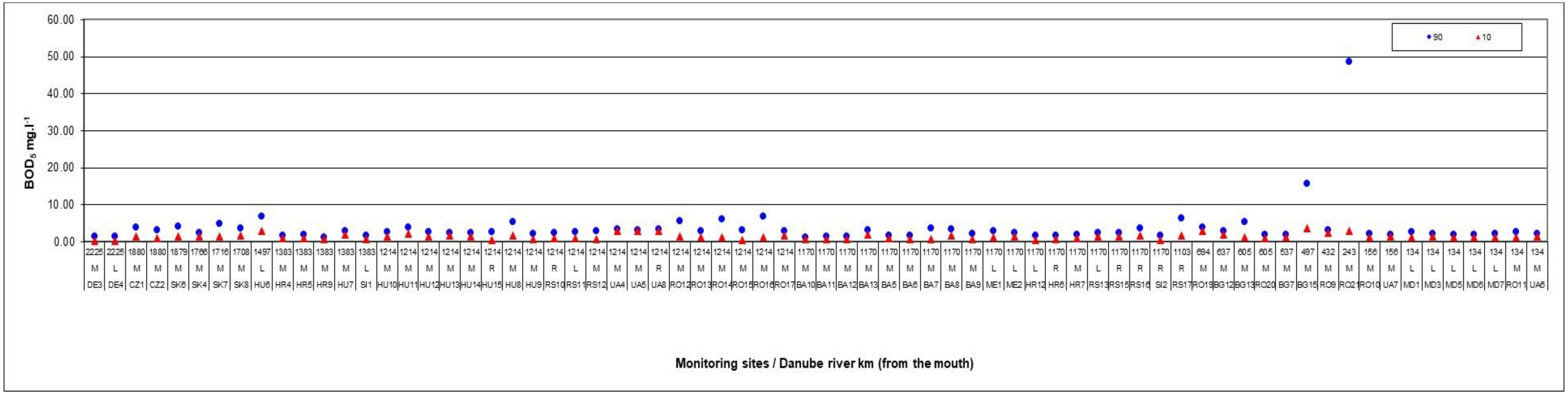


Figure 4.33: The percentile (90, 10) of BOD_5 concentration in the tributaries in 2022



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 2022 for 10 monitoring points located in the Danube River and for 24 monitoring points in the tributaries. The maximal value of saprobic index was determined in RO3 and in RO12 Somes tributary.

Figure 4.34: The maximum values of saprobic index based on macrozoobenthos along the Danube River in 2022

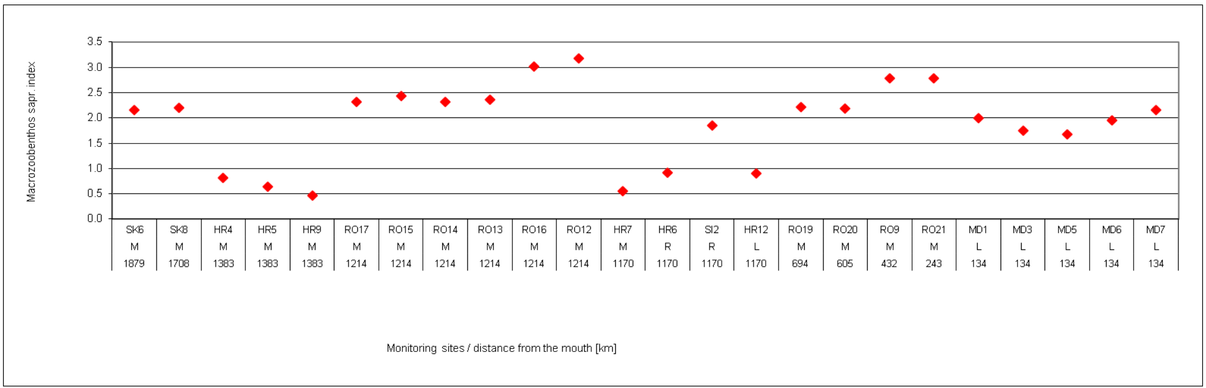


Figure 4.35: The maximum values of saprobic index based on macrozoobentos in the tributaries in 2022

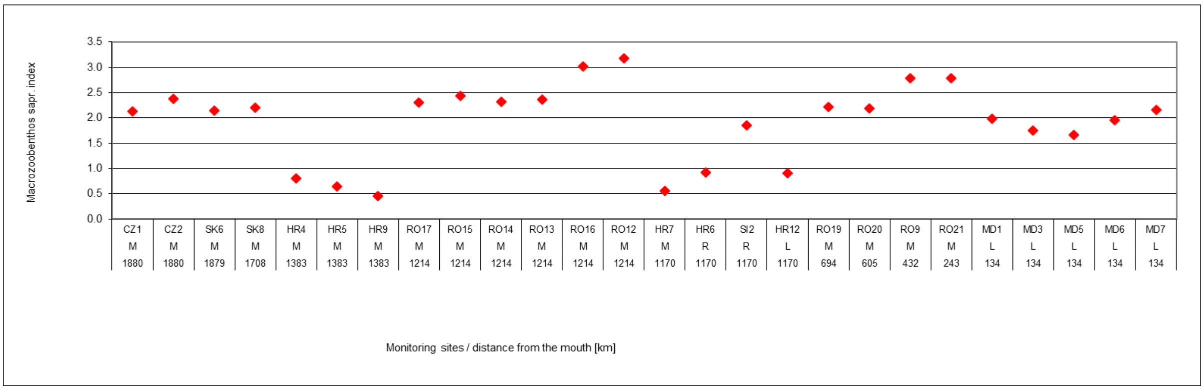
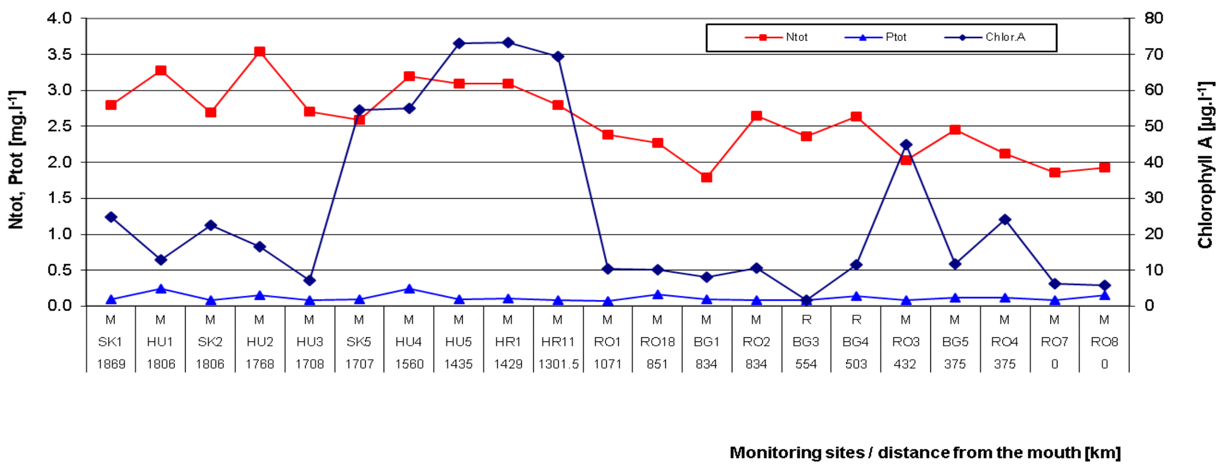


Figure 4.36: The percentile (90) of total nitrogen, total phosphorus and chlorophyll-a concentration along the Danube River in 2022



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 HR1 Ilok (69.4 µg.l^{-1} N_{total} 3.8 mg.l^{-1}). The highest concentration of P_{total} 0.25 mg.l^{-1} was observed in the Hungarian part – HU4 Dunafoldvar and and the highest N_{total} was observed in HU2 Komarom.

4.2 The Sava and Tisza Rivers

The 90 percentiles of nutrients, and BOD_5 measured in 2022 in the Sava and Tisza rivers are presented in the Figures 4.37-4.38. The highest value of N-NH_4 in the Sava River (Figure 4.37) was found in monitoring point BA11 (0.24 mg.l^{-1}). The maximum concentration of N-NO_3 and N_{total} was observed in SI2 Jesenice: N-NO_3 1.68 mg.l^{-1} and 1.90 mg.l^{-1}.
The highest value of BOD_5 in the Sava River was measured in monitoring point RS16 Ostruznica (3.7 mg.l^{-1}). The maximum value of COD 11.2 mg.l^{-1} was measured in BA11 Raca.

Figure 4.37: The percentile (90) of total nitrogen, N-NH_4 and N-NO_3 concentration along the Sava River in 2022

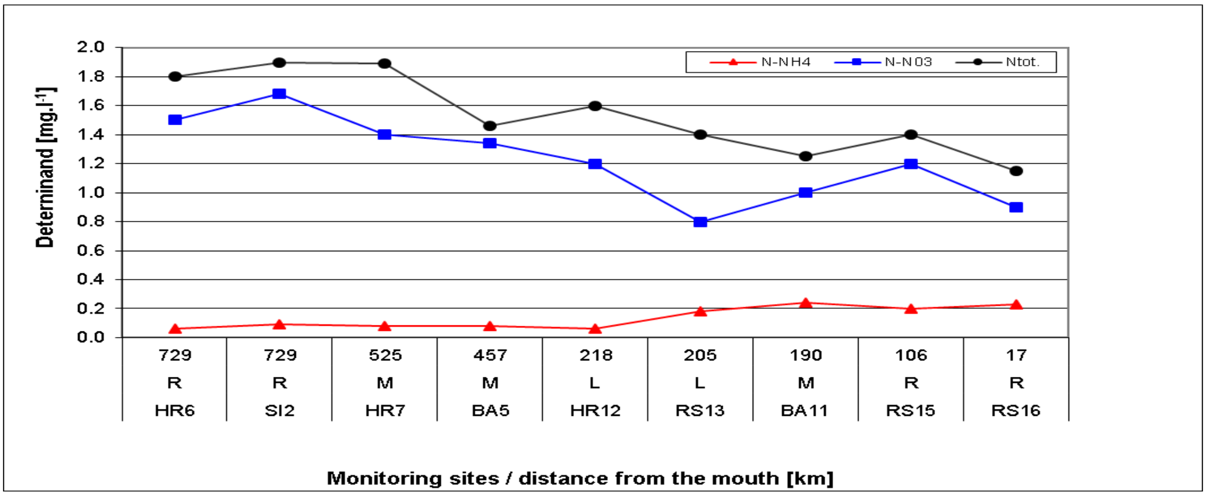


Figure 4.38: The percentile (90) of BOD_5 concentration along the Sava River in 2022

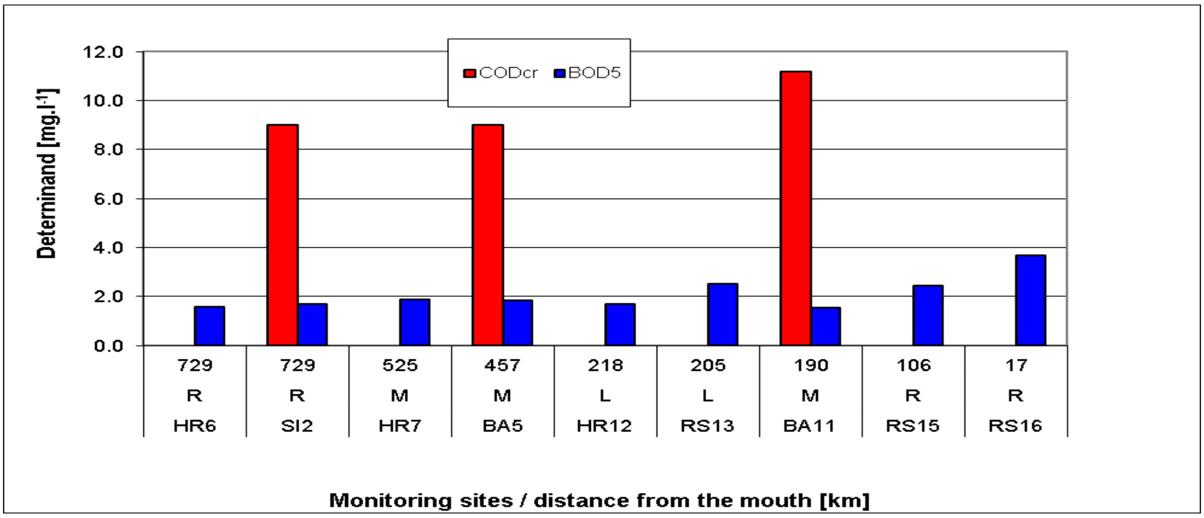


Figure 4.39: The percentile (90) of total nitrogen, N-NH4 and N-NO3 concentration along the Tisza River in 2022

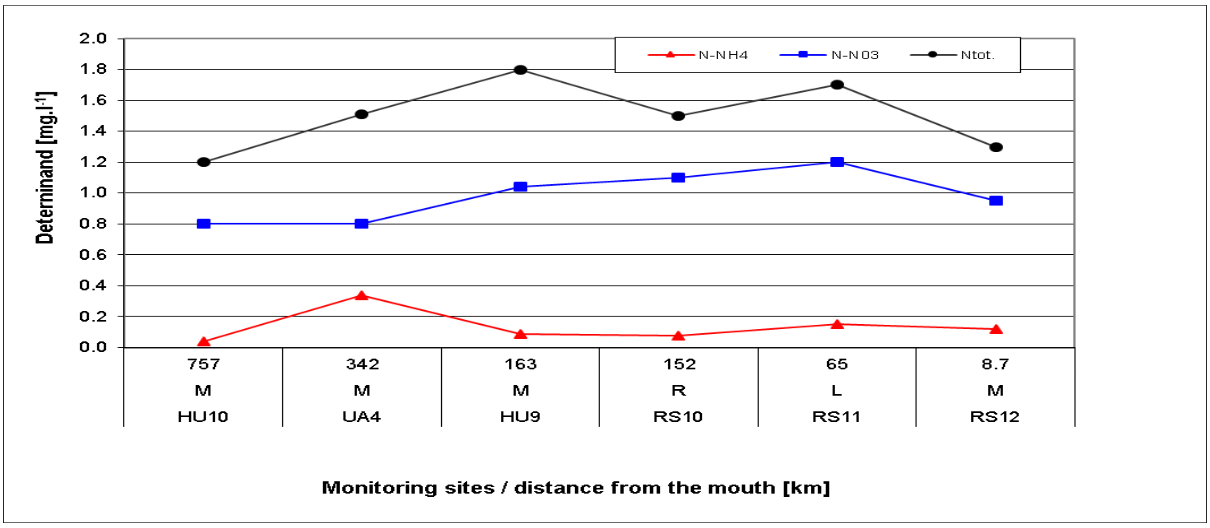
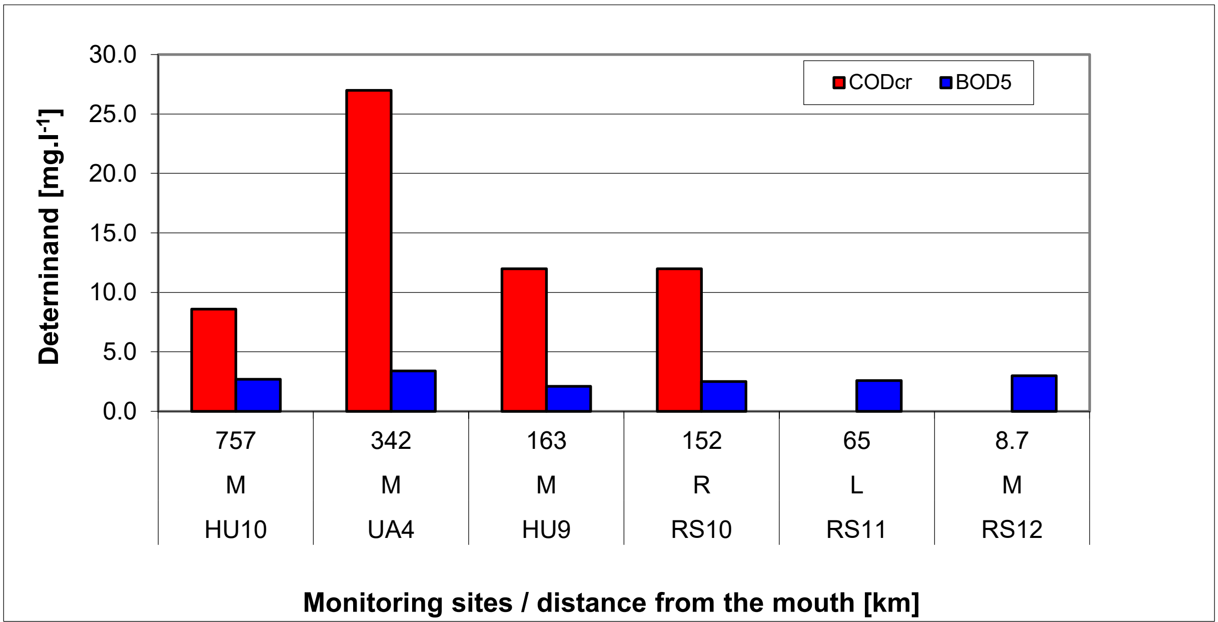


Figure 4.40: The percentile (90) of BOD5 and CODCr concentration along the Tisza River in 2022



The maximum value of N-NH_4 in the Tisza River was found in UA4 Chop (0.34 mg.l^{-1}). The highest value of N-NO_3 being 1.2 mg.l^{-1} was measured in RS11 Novi Becej and maximum of N_{total} 1.8 mg.l^{-1} was measured in HU9 Tiszasziget.
The highest value of BOD_5 and COD_{cr} were measured in UA4 Chop :BOD_5 3.4 mg.l^{-1} and COD_{cr} 27 mg.l^{-1} (see Figure 4.40).

5. Load Assessment

5.1 Introduction

The long-term development of loads of agreed determinands (Table 2) in the important rivers of the Danube Basin is one of the main objectives of the TNMN. This is the reason why the load assessment 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_5, inorganic nitrogen, ortho-phosphate-phosphorus, dissolved phosphorus, total phosphorus, suspended solids and - on a voluntary basis – chlorides and dissolved silica; based on the agreement with the Black Sea Commission, silicates are measured at the Romanian load assessment sites since 2004;*
- *The minimum sampling frequency is 24 times a year at 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 2022

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 2022.

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 2-4 times.

In 2010, load calculation for Slovakian monitoring points on the tributaries Morava, Hron and Ipeľ was added, at a monitoring frequency of 12.

The loads in the Danube at Jochenstein are being assessed based on data from Germany and Austria together; there is no issue with insufficient frequency there. There is still a lack of data on dissolved phosphorus, measured at 13 locations. Also, the silicates/ silicates dissolved load was calculated at 9/5 monitoring points.

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

Country	River	Water quality monitoring location			Hydrological station	
		Station code	Location	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	Lanžhot	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:

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

where C_m average monthly concentrations

C_i concentrations in the sampling days of each month

Q_i discharges in the sampling days of each month

The monthly load is calculated by using the formula:

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

where L_m monthly load

Q_m average monthly discharge

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

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

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

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_5, 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
Station Code	TNMN monitoring location code
Profile	location of sampling site in profile (L-left, M-middle, R-right)
River Name	name of river
Location	name of monitoring location
River km	distance to mouth of the river
Qr	mean annual discharge in the year 2022
c_{mean}	arithmetical mean of the concentrations in the year 2022
Annual Load	annual load of given determinand in the year 2022

The calculated loads **for 2022**, 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 2021 (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 Ortho-phosphate, total phosphorus and BOD_5 increased one most of the assessed monitoring points. Other determinads decerase or were the same as in 2021.It evidence from results that data for Reni are not reliable due to the low frequency.

The highest load of suspended solids was in Siret RO10, inorganic nitrogen, ortho-phosphate phosphorus, chlorides and silicates in HR12 Sava River were observed. The maximal load of total phosphorus and BOD_5 were in HU9 Tiszasziget.The maximum of total phosphorus dissolved was found in river Vah.

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_5 (Figure 5.9) and chlorides (Figure 5.11).

Except BOD_5 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 frwquency 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 decreased in 2022, but resalts but results are not comparable for low frequency.

The mean annual discharges in 2022 on the whole Danube River sites and all tributaries monitoring points were lower than in 2021.

Table 6: Number of measurements at TNMN locations selected for assessment of pollution load in 2022

Country Code	River	Location	Location in profile	River Km	Number of measurements in 2022								
					Qr (2021)	SS	N_{inorg}	$P\text{-}PO_4$	P_{total}	BOD_5	Cl	P_{diss}	SiO_2
DE2	Danube	Jochenstein	M	2204	365	12	23	23	23	12	12		
DE3	Inn	Kirchdorf	M	195	365	12	12	12	12	12	12		
DE4	Inn/Salzach	Laufen	L	47	365	12	12	12	12	12	12		
AT1	Danube	Jochenstein	M	2204	365	11	23	23	23	11	11	11	
AT6	Danube	Hainburg	R	1879	365	24	24	24	24	24	24	24	
CZ1	Morava	Lanzhot	M	79	365	12	12	12	12	12	12		
CZ2	Morava/Dyje	Pohansko	M	17	365	12	12	12	12	12	12		
SK1	Danube	Bratislava	L	1869	365	25	25	25	25	25	25	25	25
SK1	Danube	Bratislava	M	1869	365	42	42	42	42	38	38	42	38
SK1	Danube	Bratislava	R	1869	365	26	26	26	26	26	25	26	26
SK4	Váh	Komárno	M	1.5	365	12	12	12	12	12	12	12	12
SK6	Morava	Devín	M	1.0	365	12	12	12	12	12	12	12	12
SK7	Hron	Kamenica	M	1.7	365	12	12	12	12	12	12	12	12
SK8	Ipoly	Salka	M	12	365	12	12	12	12	12	12	12	12
HU3	Danube	Szob	L	1708		12	26	26	26	12	12		12
			M	1708	365	12	26	26	26	12	12		12
			R	1708		12	25	25	25	12	12		12
HU5	Danube	Hercegszántó	M	1435	365	11	23	23	23	11	11		10
HU9	Tisza	Tiszasziget	L	163		12	12	12	12	12	12		12
			M	163	365	12	26	26	26	12	12		12
			R	163		12	12	12	12	12	12		12
HR11	Danube	Ilok	M	1302		12	12	12	12	12	12		12*
HR6	Sava	Jesenice	R	729	365	12	12	12	12	12	12		12*
HR7	Sava	us Una Jesenovac	M	525	365	12	12	12	12	12	12		12*
HR12	Sava	Račinovci	L	218	365	11	11	11	11	11	11		11*
SI1	Drava	Ormoz	L	300	365	26	26	26	26	26	12		
SI2	Sava	Jesenice	R	729	365	25	25	25	25	25	12		
RO2	Danube	Pristol-Novo Selo	L	834		24	24	24	24	12	12	24	24*
			M	834	365	24	24	24	24	12	12	23	23*
			R	834		24	24	24	24	12	12	24	24*
RO4	Danube	Chiciu-Silistra	L	375	365	26	18	26	26	12	12	26	
			M	375		26	19	26	26	12	12	26	
			R	375		26	16	26	26	12	12	26	
RO5	Danube	Reni	L	132		4	4	4	4	2	2	4	
			M	132	365	4	4	4	4	2	2	4	
			R	132		4	4	4	4	2	2	4	
RO10	M	Siret	M	0	365	25	25	25	25	12	12	12	
RO11	M	Prut	M	0	365	4	1	4	4	2	2	4	
UA2	Danube	Vylkove	M	18	365	12	12	12		12	12	12	12

*Silicates (SiO2) in dissolved form

11 and more samples

less than 11 and more than 4 samples

< 4 data were not used for calculation of loads - to little data to calculate reliable load data

Table 7: Mean annual concentrations in monitoring locations selected for load assessment on Danube River in 2022

Station Code	Profile	River Name	Location	River km	Qr (2022)	c_{mean}							
						Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates
					$(m^3.s^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$
DE2+AT1	M	Danube	Jochenstein	2204	1134	17.51	1.69	0.02	0.05	1.46	20.30	0.03	
AT6	R	Danube	Hainburg	1879	1579	19.70	1.59	0.02	0.07	1.36	18.45	0.04	
SK1	LMR	Danube	Bratislava	1869	1557	18.32	1.33	0.03	0.07	1.25	21.95	0.04	5.15
HU3	LMR	Danube	Szob	1708	1751	19.94	1.48	0.01	0.08	4.53	20.15		3.89
HU5	M	Danube	Hercegszántó	1435	1744	18.73	1.46	0.03	0.08	3.18	20.64		3.81
HR11	M	Danube	Ilok	1302	2164	8.95	1.33	0.03	0.06	1.91	18.75		2.75*
RO2	LMR	Danube	Pristol-Novo Selo	834	3633	38.32	1.27	0.06	0.08	1.77	27.27	0.07	0.89*
RO4	LMR	Danube	Chiciu-Silistra	375	4107	10.63	1.11	0.06	0.09	1.31	29.75	0.08	
RO5	LMR	Danube	Reni	132	4373	59.33	1.19	0.08	0.11	2.00	25.18	0.10	
UA2	M	Danube	Vylkove	18	2111	34.76	1.23	0.05		2.31	34.51	0.08	2.44

*Silicates (SiO_2) in dissolved form

Mean annual concentrations in monitoring stations selected for load assessment on tributaries.

Table 8: Mean annual concentrations in monitoring locations selected for load assessment on tributaries in 2022

Station Code	Profile	River Name	Location	River km	Qr (2022)	c_{mean}							
						Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates
					$(m^3.s^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$
DE3	M	Inn	Kirchdorf	195	240	80.73	0.62	0.01	0.12	0.81	7.73		
DE4	L	Inn/Salzach	Laufen	47	213	27.29	0.63	0.01	0.04	0.92	9.21		
CZ1	M	Morava	Lanzhot	79	28	17.90	1.97	0.05	0.10	2.19	40.38		
CZ2	L	Morava/Dyje	Pohansko	17	17	9.00	1.67	0.32	0.35	1.98	69.70		
SK4	M	Váh	Komárno	1.5	145	12.21	1.22	0.06	0.11	1.71	20.98	0.07	5.38
SK6	M	Morava	Devín	1.0	51	23.17	1.41	0.17	0.27	2.46	48.43	0.19	9.85
SK7	M	Hron	Kamenica	1.7	25	24.38	1.33	0.06	0.15	2.78	24.45	0.08	12.25
SK8	M	Ipoly	Salka	12	14	31.92	1.77	0.20	0.29	2.48	36.54	0.22	23.61
HU9	LMR	Tisza	Tiszasziget	163	593	35.50	0.68	0.04	0.15	1.44	39.01		9.79
SI1	L	Drava	Ormoz	300	214	8	1.04	0.01	0.03	1.11	10.09		
SI2	R	Sava	Jesenice	729	206	4	1.26	0.02	0.03	1.00	9.46		
HR6	R	Sava	Jesenice	729	200	4	1.27	0.03	0.05	1.25	9.03		2.72*
HR7	M	Sava	us. Una Jasenovac	525	600	5	1.30	0.07	0.10	1.30	10.53		3.26*
HR12	L	Sava	Račinovci	218	828	12	1.06	0.06	0.09	1.11	40.36		3.41*
RO10	M	Siret	Conf. Danube (Sendreni)	0	103	29.15	0.96	0.02	0.06	1.48	65.95	0.07	
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	39	34.75	1.19	0.04	0.09	2.04	48.22	0.08	

*Silicates (SiO_2) in dissolved form

Table 9: Annual load in selected monitoring locations on Danube River in 2022

Station Code	Profile	River Name	Location	River km	Annual Load in 2022							
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates
					($x10^6$tonns)	($x10^3$tonns)	($x10^3$tonns)	($x10^3$tonns)	($x10^3$tonns)	($x10^6$tonns)	($x10^3$tonns)	($x10^6$tonns)
DE2+AT1	M	Danube	Jochenstein	2204	0.73	59.49	0.74	1.82	**50.99**	0.70	0.78	
AT6	R	Danube	Hainburg	1879	1.15	78.87	**1.17**	**3.84**	71.23	0.91	1.80	
SK1	LMR	Danube	Bratislava	1869	0.97	66.37	1.44	3.49	62.22	1.01	1.88	0.27
HU3	LMR	Danube	Szob	1708	1.13	83.51	0.73	4.54	248.94	1.12		0.21
HU5	M	Danube	Hercegszántó	1435	0.93	70.92	1.55	3.92	149.49	0.97		0.18
HR11	M	Danube	Ilok	1302	0.64	92.89	2.02	4.18	137.39	1.28		0.19*
RO2	LMR	Danube	Pristol-Novo Selo	834	4.39	153.23	6.16	8.92	219.78	3.13	7.73	0.09*
RO4	LMR	Danube	Chiciu-Silistra	375	1.62	157.40	6.86	11.60	171.29	3.85	10.40	
RO5	LMR	Danube	Reni	132	1.47	32.54	1.98	2.82	52.20	0.68	2.63	
UA2	M	Danube	Vylkove	18	2.71	85.58	3.37		154.77	2.28	5.56	0.17

*Silicates (SiO_2) in dissolved form

Explanations for comparison of values:

Bold font	**increased value in comparison with 2021**
	maximum value of determinand in 2022 and also increased value in comparison with 2021
4.39	**maximum value of determinand in 2022, but decreased value in comparison with 2021**
	missing value in 2022 - not assessed

Table 10: Annual load in selected monitoring locations on tributaries in 2022

Station Code	Profile	River Name	Location	River km	Annual Load in 2022							
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates
					($x10^6$tonns)	($x10^3$tonns)	($x10^3$tonns)	($x10^3$tonns)	($x10^3$tonns)	($x10^6$tonns)	($x10^3$tonns)	($x10^6$tonns)
DE3	M	Inn	Kirchdorf	195	0.91	4.19	0.04	1.32	6.04	0.05		
DE4	L	Inn/Salzach	Laufen	47	0.21	3.99	0.05	0.29	5.62	0.05		
CZ1	M	Morava	Lanzhot	79	0.01	1.77	0.03	0.07	1.30	0.02		
CZ2	L	Morava/Dyje	Pohansko	17	0.004	0.82	0.11	0.13	0.72	0.03		
SK4	M	Váh	Komárno	1.5	0.05	5.77	0.24	0.46	**7.73**	0.10	0.29	0.02
SK6	M	Morava	Devín	1.0	0.04	2.53	0.21	0.38	3.69	0.07	0.24	0.02
SK7	M	Hron	Kamenica	1.7	0.02	1.21	0.05	0.11	1.97	0.02	0.06	0.01
SK8	M	Ipoly	Salka	12	0.01	**0.79**	**0.06**	**0.10**	**0.93**	**0.02**	**0.07**	0.01
HU9	LMR	Tisza	Tiszasziget	163	0.91	15.36	0.68	3.25	28.71	0.60		0.20
SI1	L	Drava	Ormoz	300	0.05	6.32	0.03	0.19	6.71	0.06		
SI2	R	Sava	Jesenice	729	0.04	8.78	0.12	0.23	5.36	0.05		
HR6	R	Sava	Jesenice	729	0.05	8.39	0.20	0.34	8.05	0.05		0.02*
HR7	M	Sava	us. Una Jasenovac	525	0.11	24.87	**1.23**	**1.83**	27.57	0.17		0.06*
HR12	L	Sava	Račinovci	218	0.51	26.25	**1.83**	**2.61**	26.85	**0.72**		0.08*
RO10	M	Siret	Conf. Danube (Sendreni)	0	0.10	3.07	0.06	0.18	4.72	0.21	0.20	
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	0.01		0.01	0.02	0.44	0.01	0.02	

*Silicates (SiO_2) in dissolved form

Explanations for comparison of values:

Bold font	**increased value in comparison with 2020**
4.72	**maximum value of determinand in 2022 and also increased value in comparison with 2021**
26.25	**maximum value of determinand in 2022, but decreased value in comparison with 2021**
	missing value in 2022- not assessed

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

River	Location	Location in profile	River km	Number of measurements in 2022																				
				Qr 2022	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates diss.	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
Danube	Reni	LMR	132	365	4	4	4	4	2	2	4		4	4	4	4	2	2	2	2	2	2	2	2
River	**Location**	**Location in profile**	**River km**	c_{mean}																				
				Qr 2021	Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates diss.	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
				$(m^3.s^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$
Danube	Reni	LMR	132	4373	59.33	1.19	0.0754	0.111	2.00	25.18	0.103		0.0613	0.0226	1.108	2.103	8.57	7.48		0.65	1.54	0.075	0.005	0.005
River	**Location**	**Location in profile**	**River km**	Annual Load in 2022																				
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates diss.	$N\text{-}NH_4$	$N\text{-}NO_2$	$N\text{-}NO_3$	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
					($x10^6$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^6$ tonns)	($x10^3$ tonns)	($x10^6$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)
Danube	Reni	LMR	132		1.470	32.54	1.980	2.824	52.196	0.680	2.634		1.590	0.603	30.345	56.340	202.87	177.04		16.78	33.59	2.02	0.135	0.135

Figure 5.1: Annual load of suspended solids along the Danube River in 2022

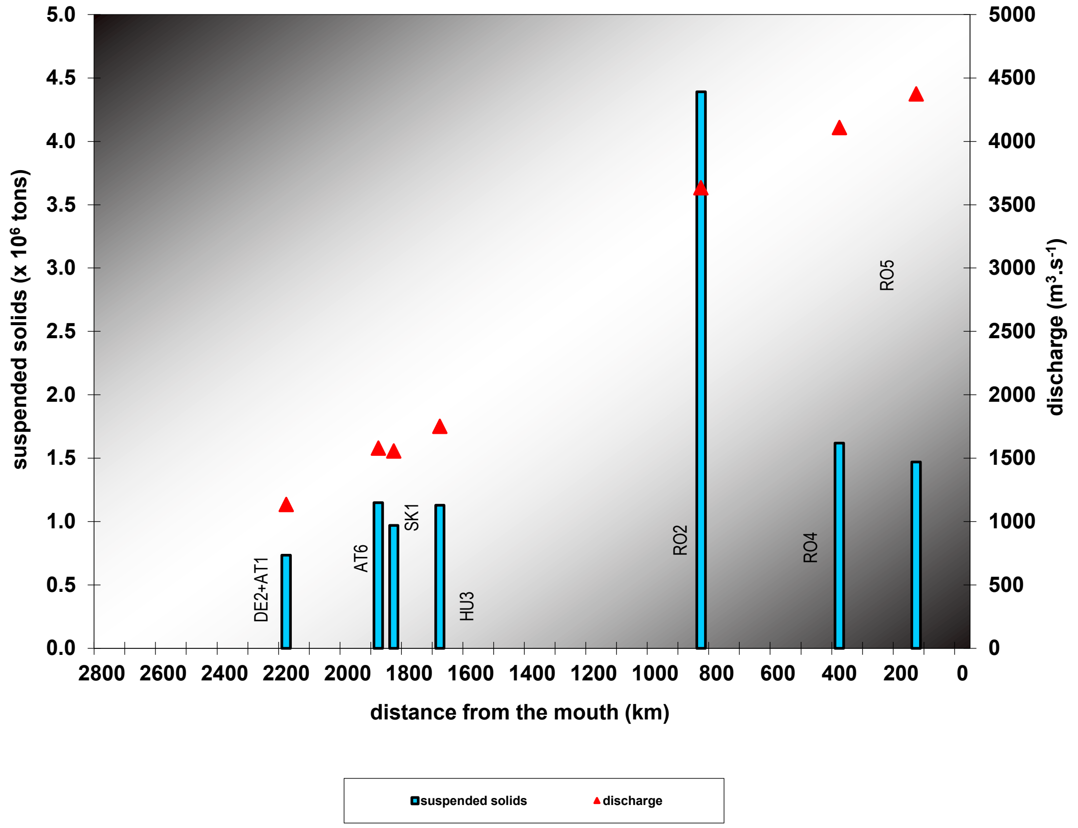


Figure 5.2: Annual load of suspended solids at monitoring locations on tributaries in 2022

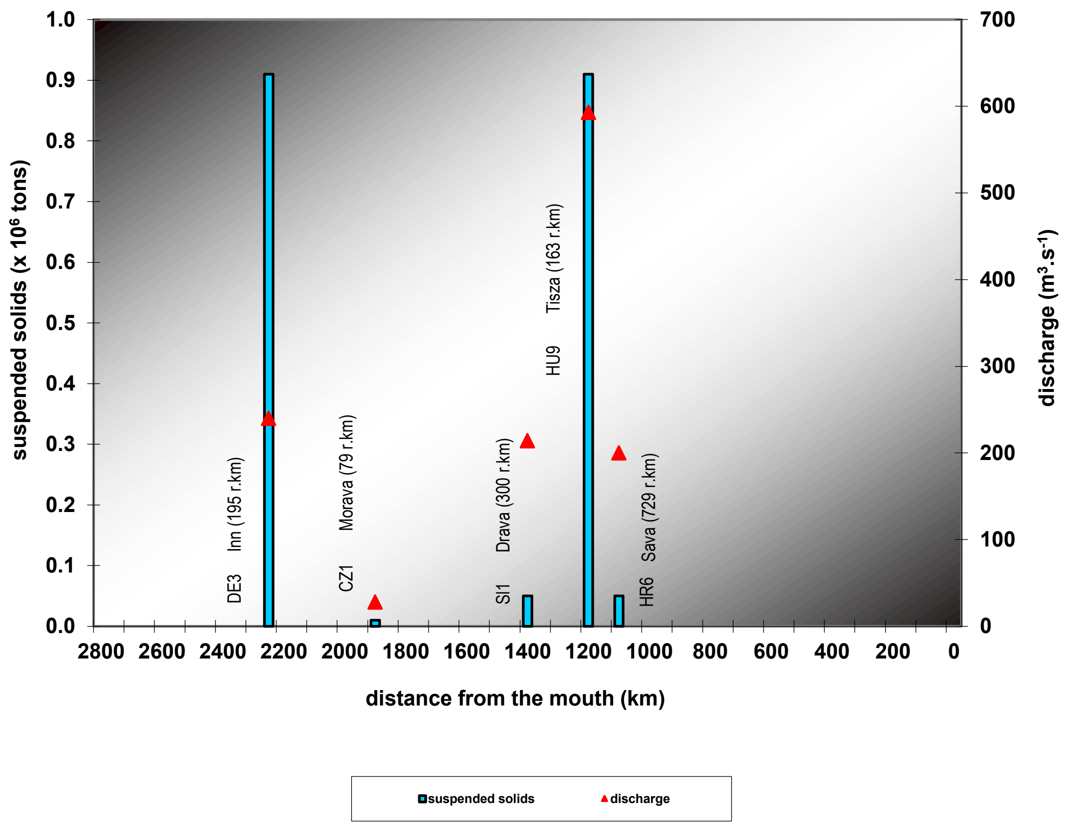


Figure 5.3: Annual loads of inorganic nitrogen along the Danube River in 2022

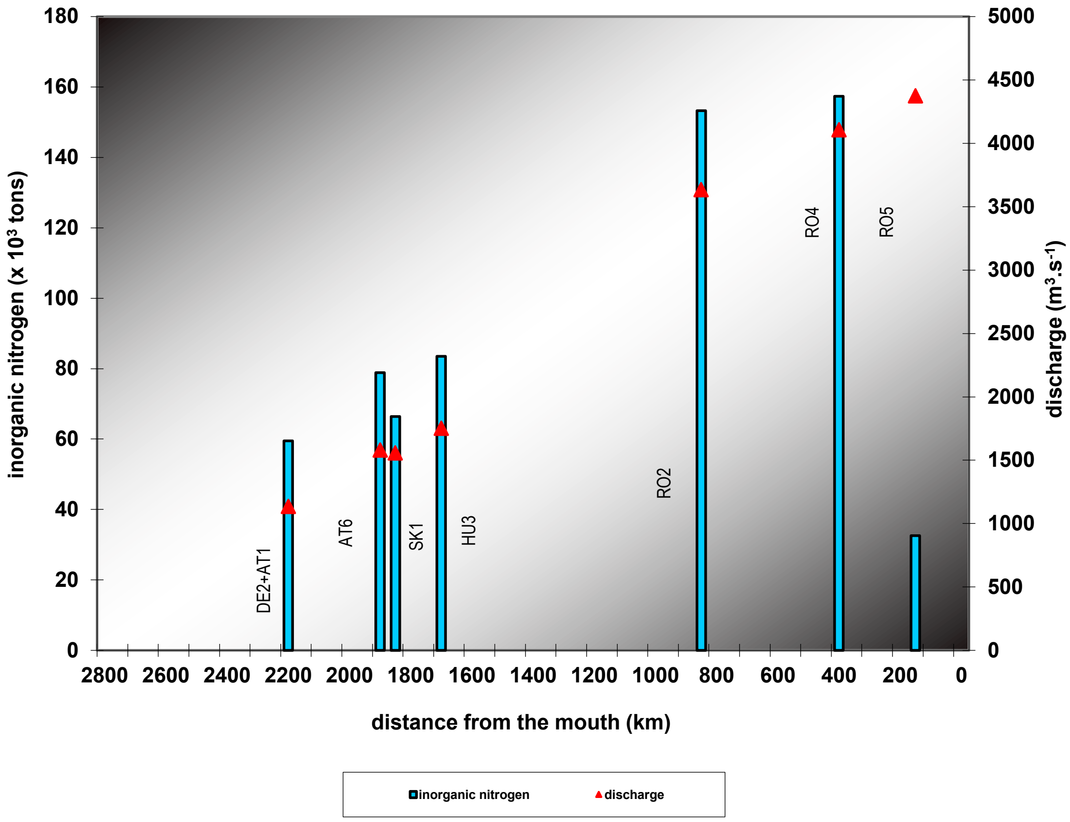


Figure 5.4: Annual loads of inorganic nitrogen at monitoring locations on tributaries in 2022

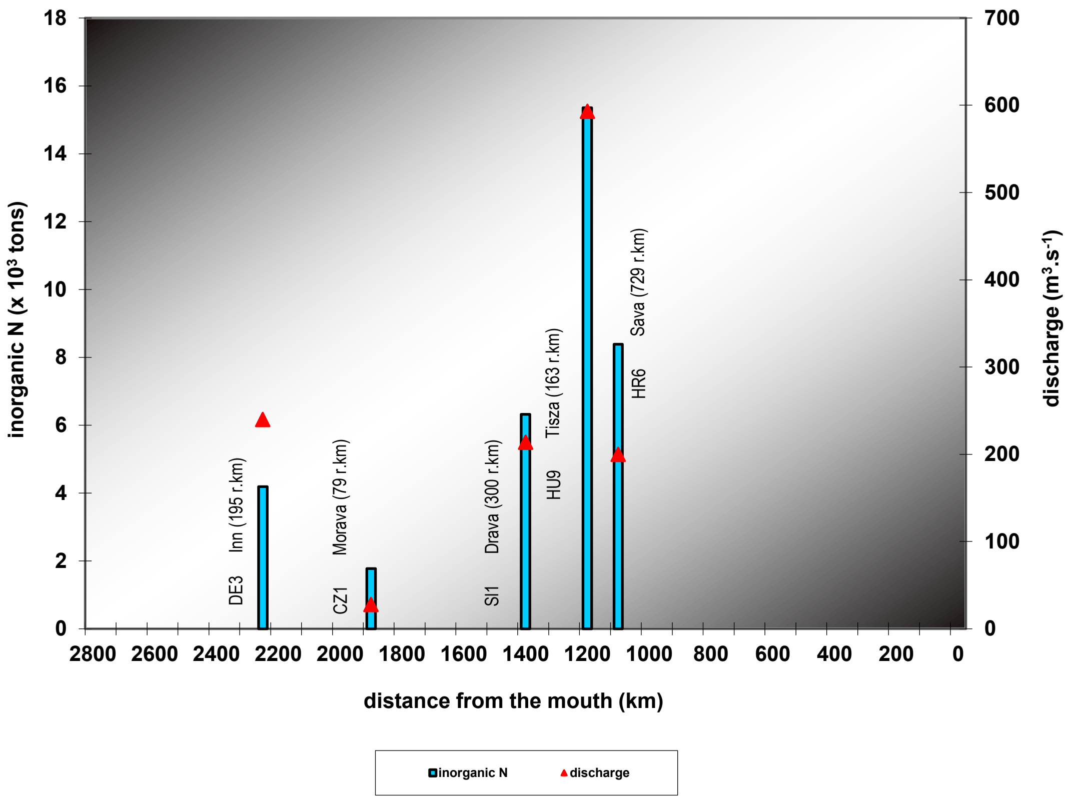


Figure 5.5: Annual loads of P-PO_4 at monitoring locations along the Danube River in 2022

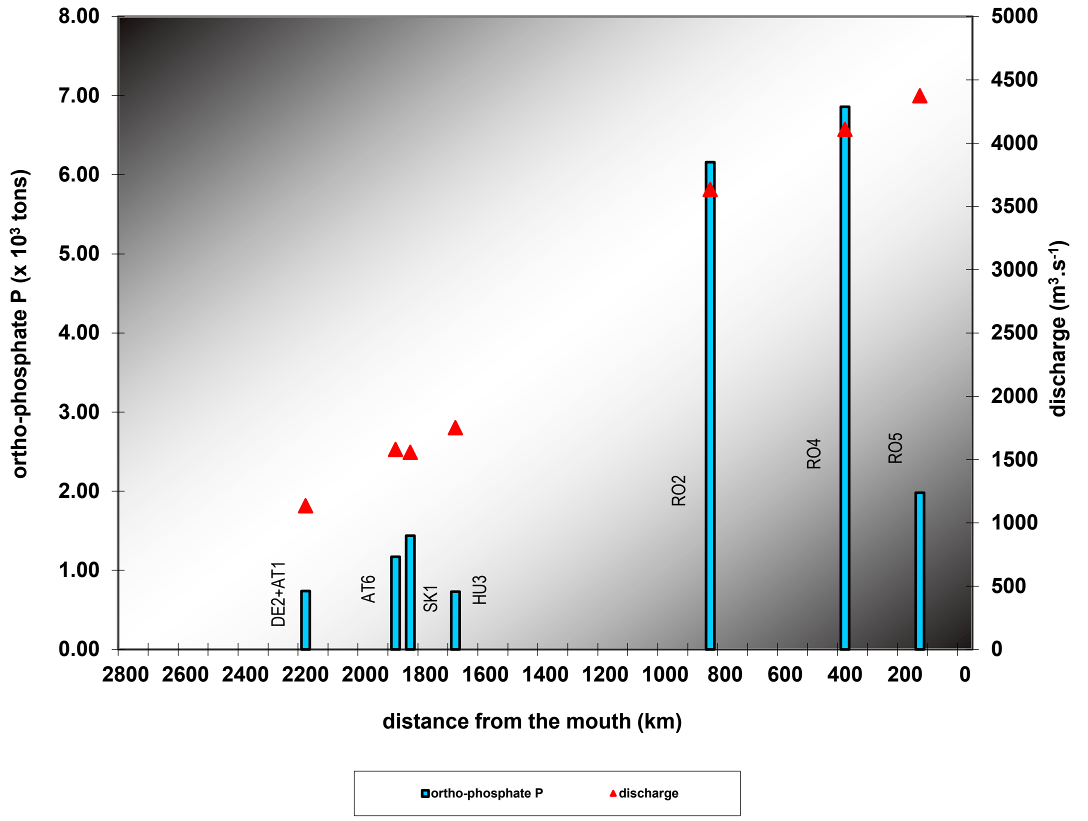


Figure 5.6: Annual loads of P-PO_4 at monitoring locations on tributaries in 2022

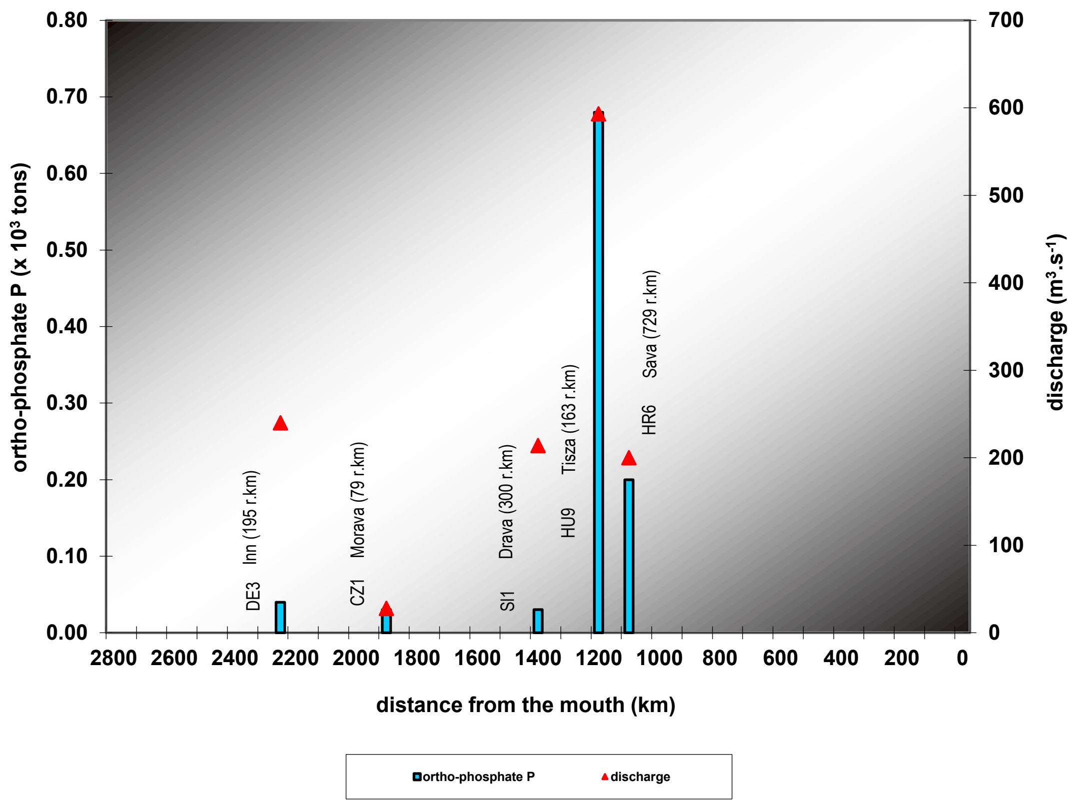


Figure 5.7: Annual loads of total phosphorus along the Danube River in 2022

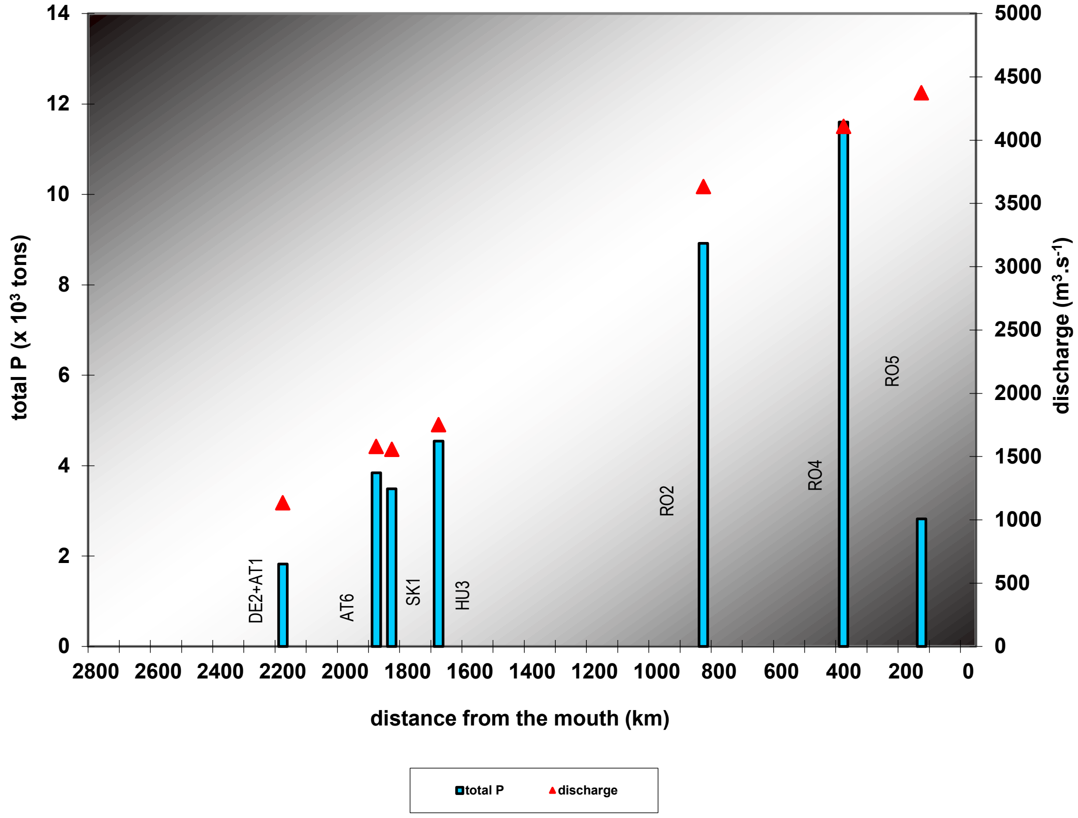


Figure 5.8: Annual loads of total phosphorus at monitoring locations on tributaries in 2022

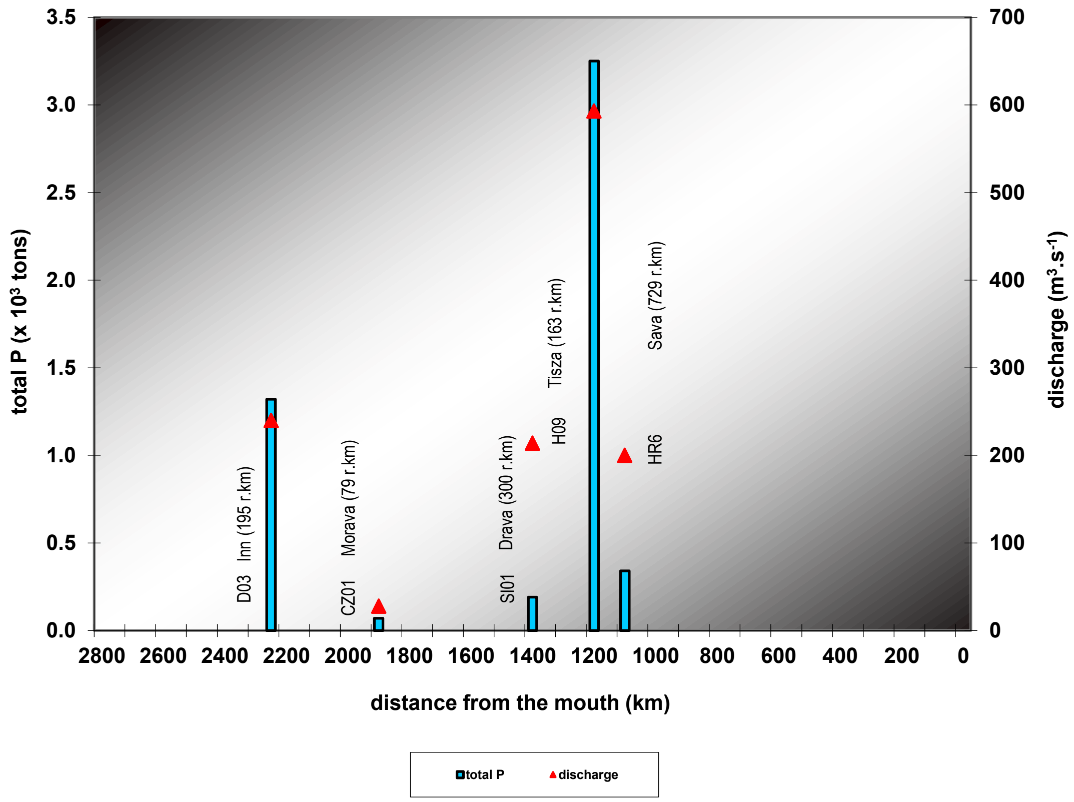


Figure 5.9: Annual loads of BOD_5 along the Danube River in 2022

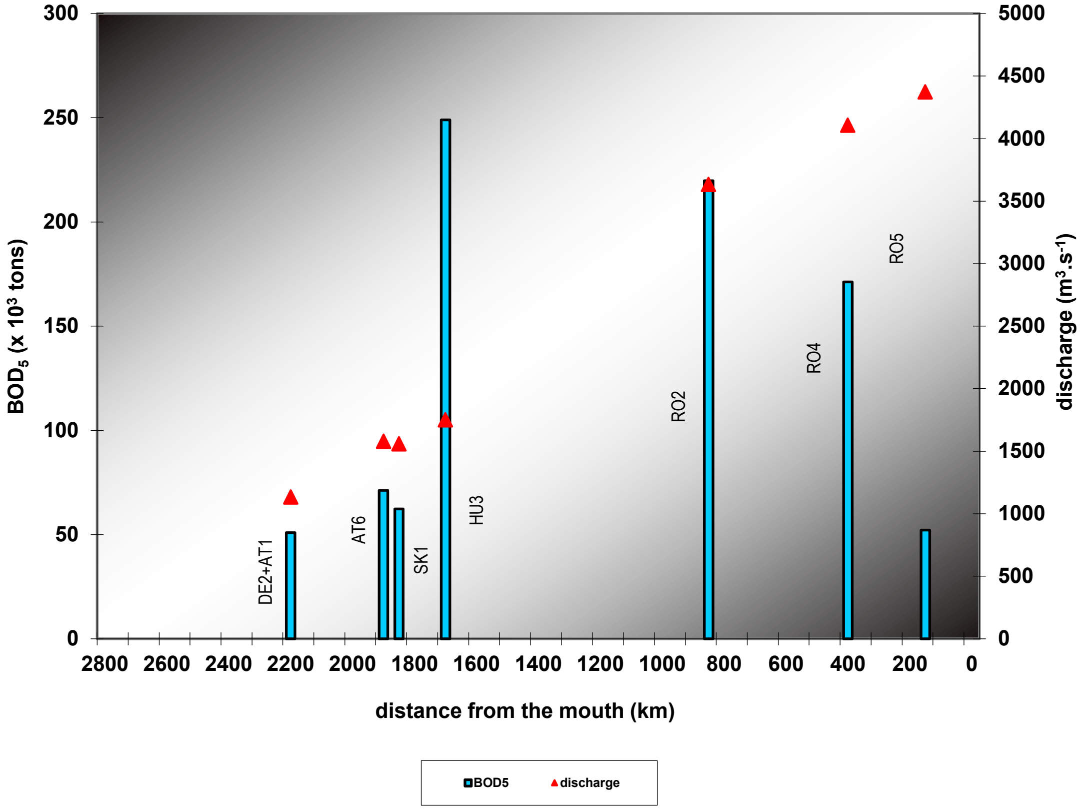


Figure 5.10: Annual loads of BOD_5 at monitoring locations on tributaries in 2022

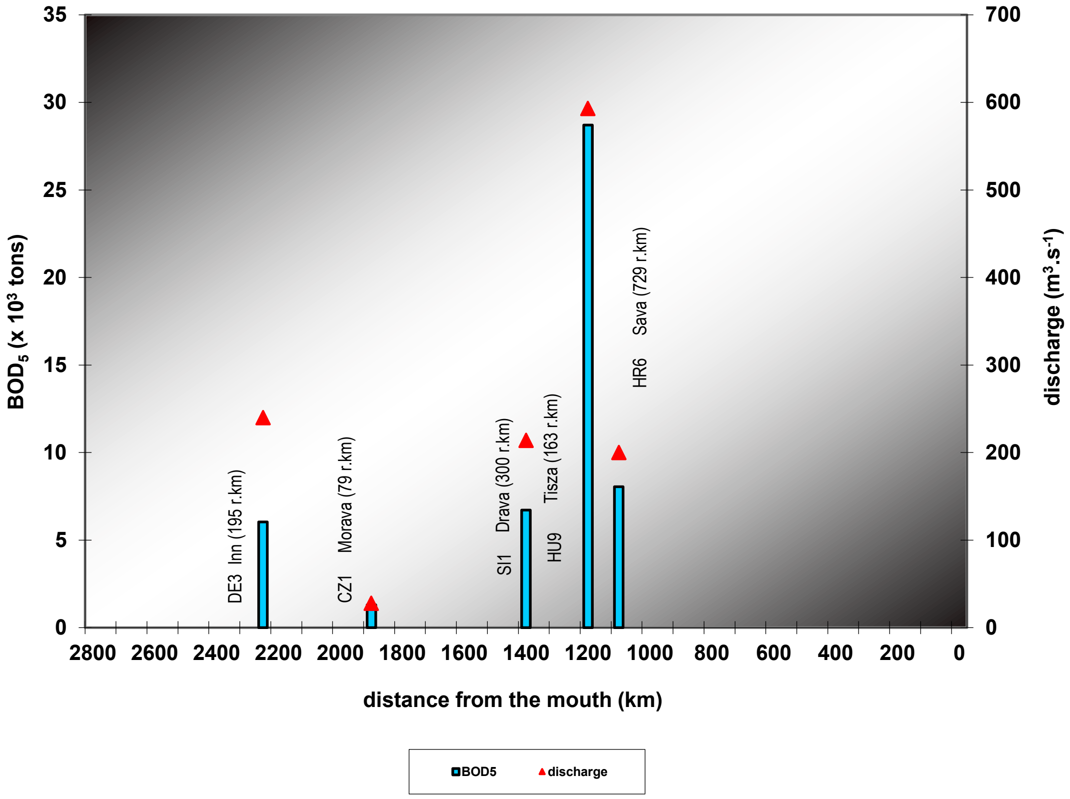


Figure 5.11: Annual loads of chlorides along the Danube River in 2022

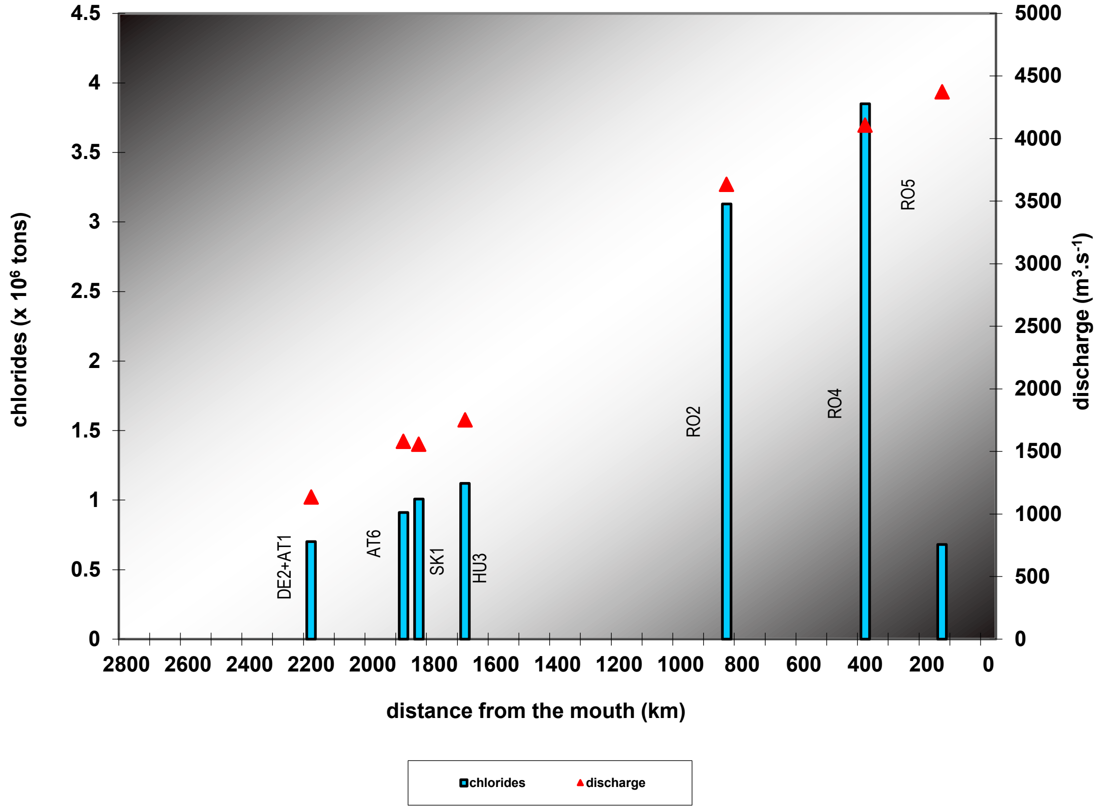


Figure 5.12: Annual loads of chlorides at monitoring locations on tributaries in 2022

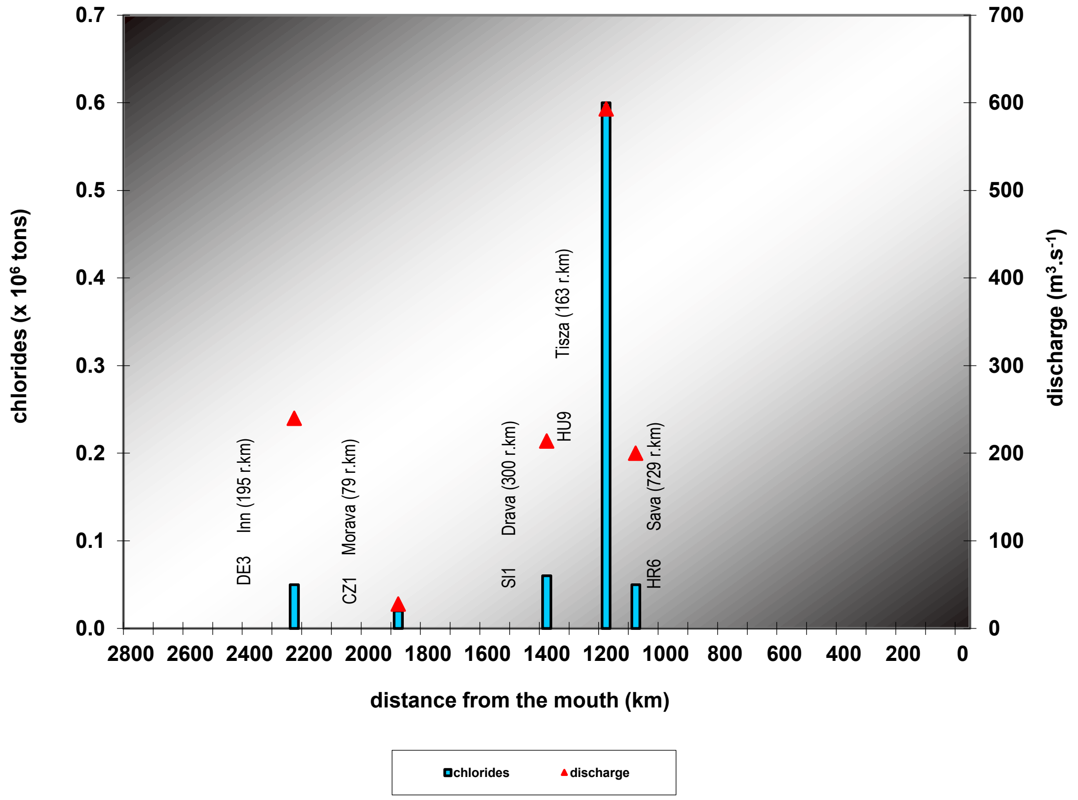


Figure 5.13: Development trend of annual loads of suspended solids at Reni.

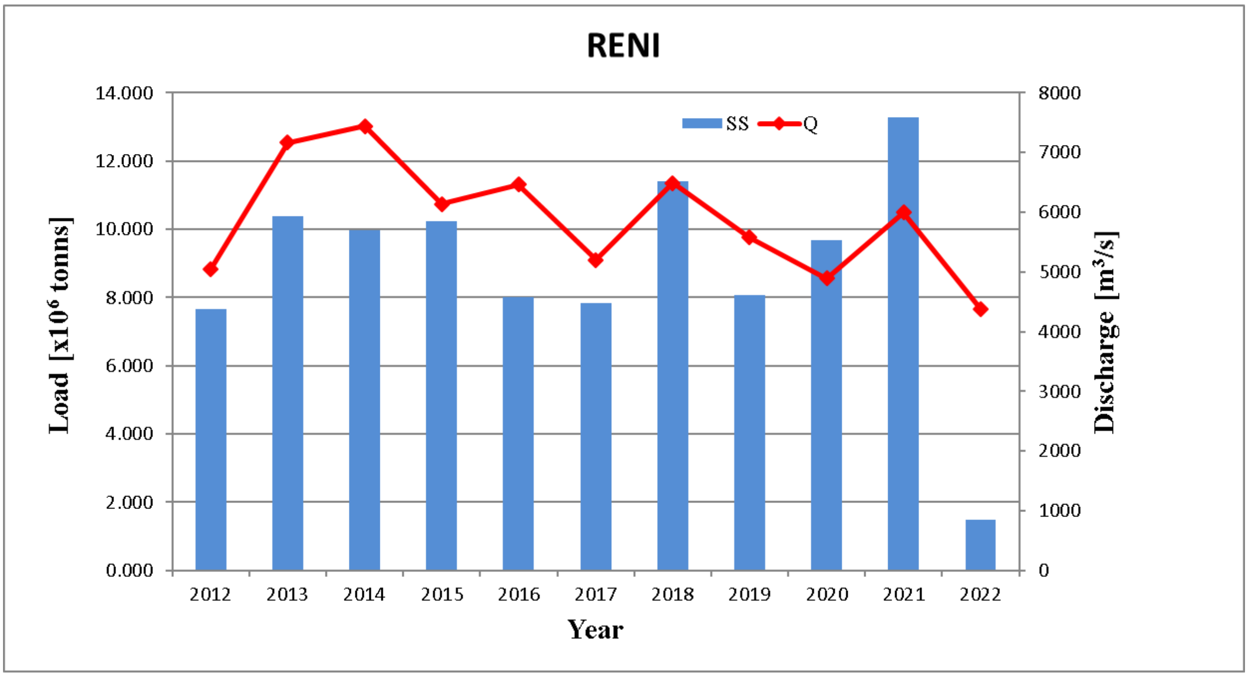


Figure 5.14: Development trend of annual loads of inorganic nitrogen at Reni.

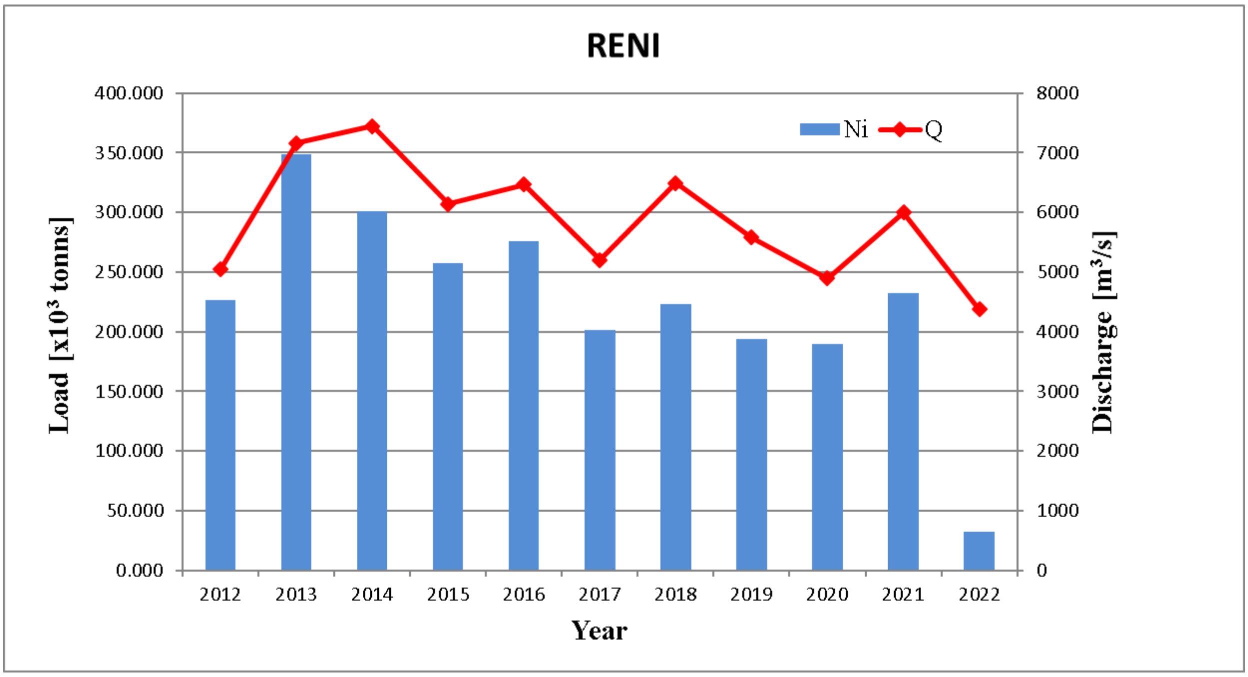


Figure 5.15: Development trend of annual loads of ortho-phosphate phosphorus, total phosphorus and dissolved phosphorus at Reni.

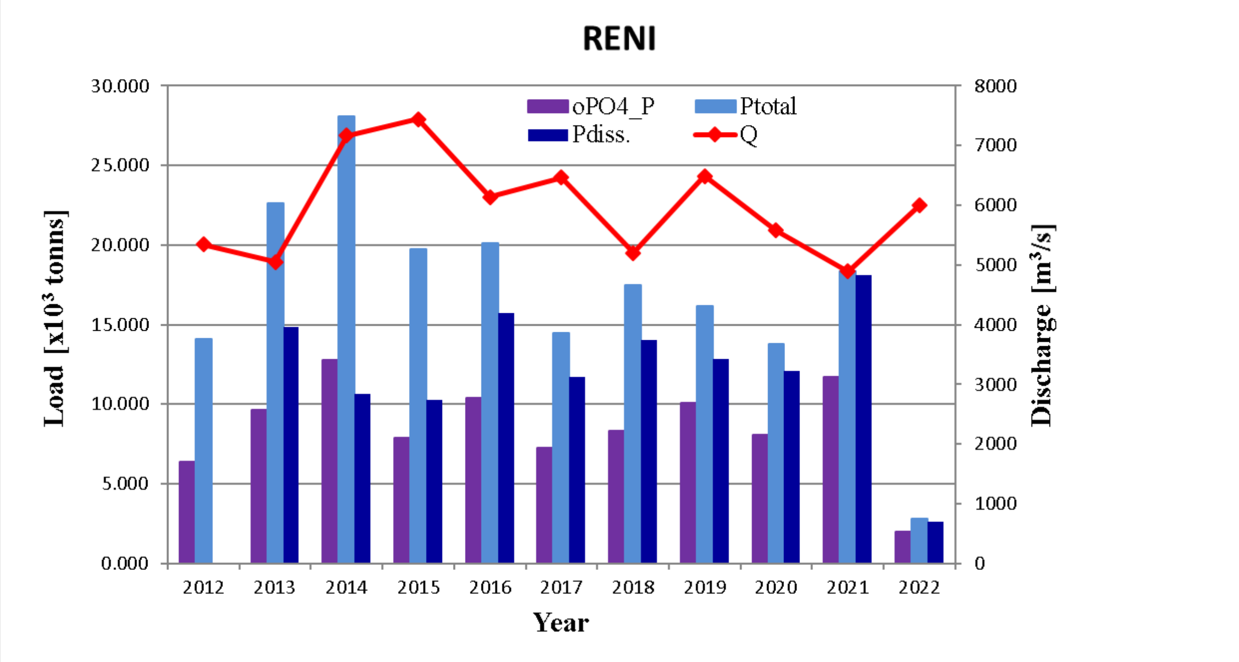


Figure 5.16: Development trend of annual loads of BOD_5 at Reni.

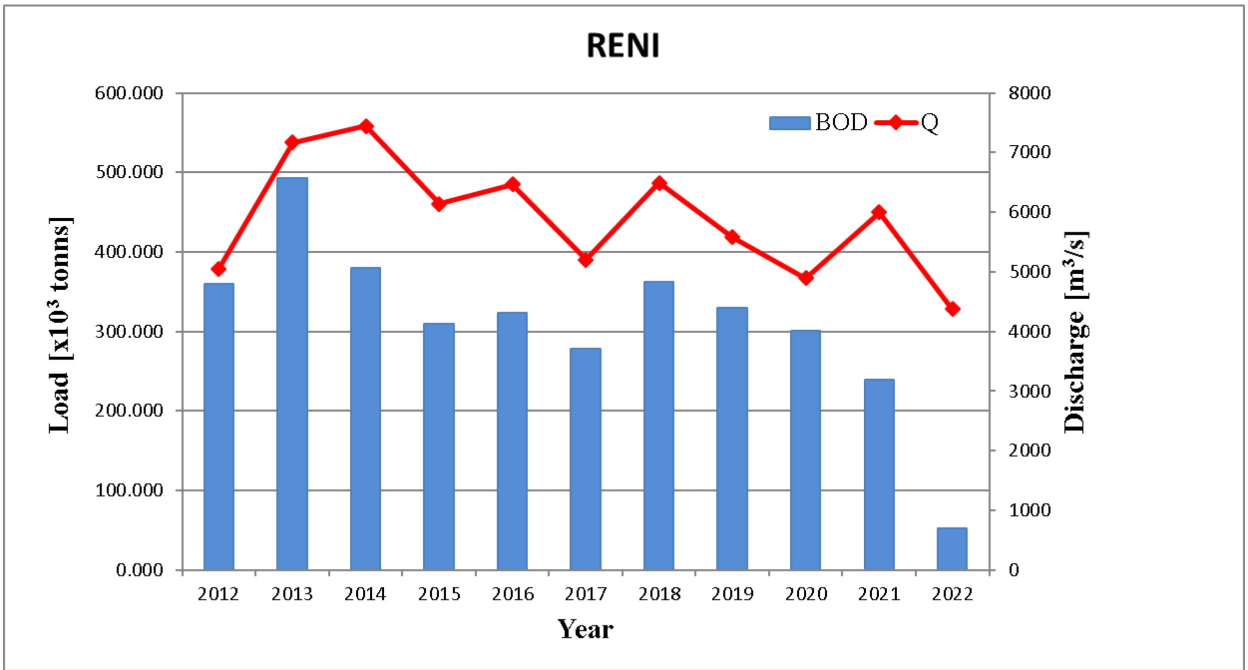


Figure 5.17: Development trend of annual loads of chlorides at Reni.

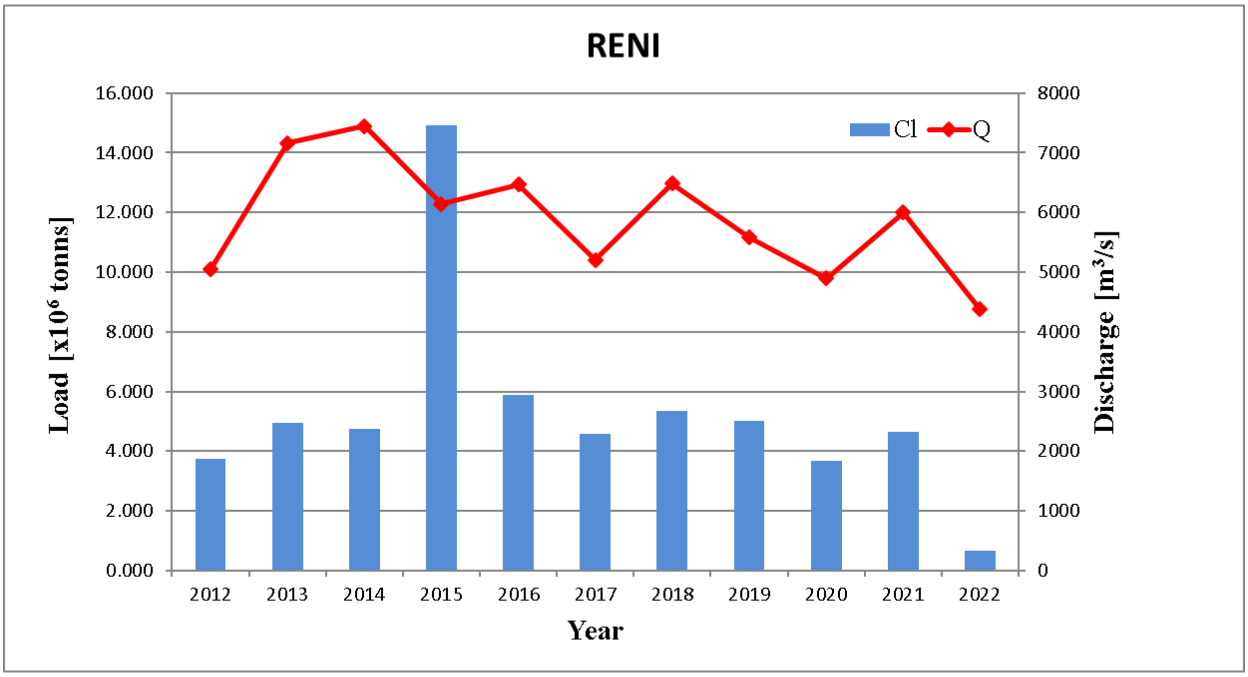
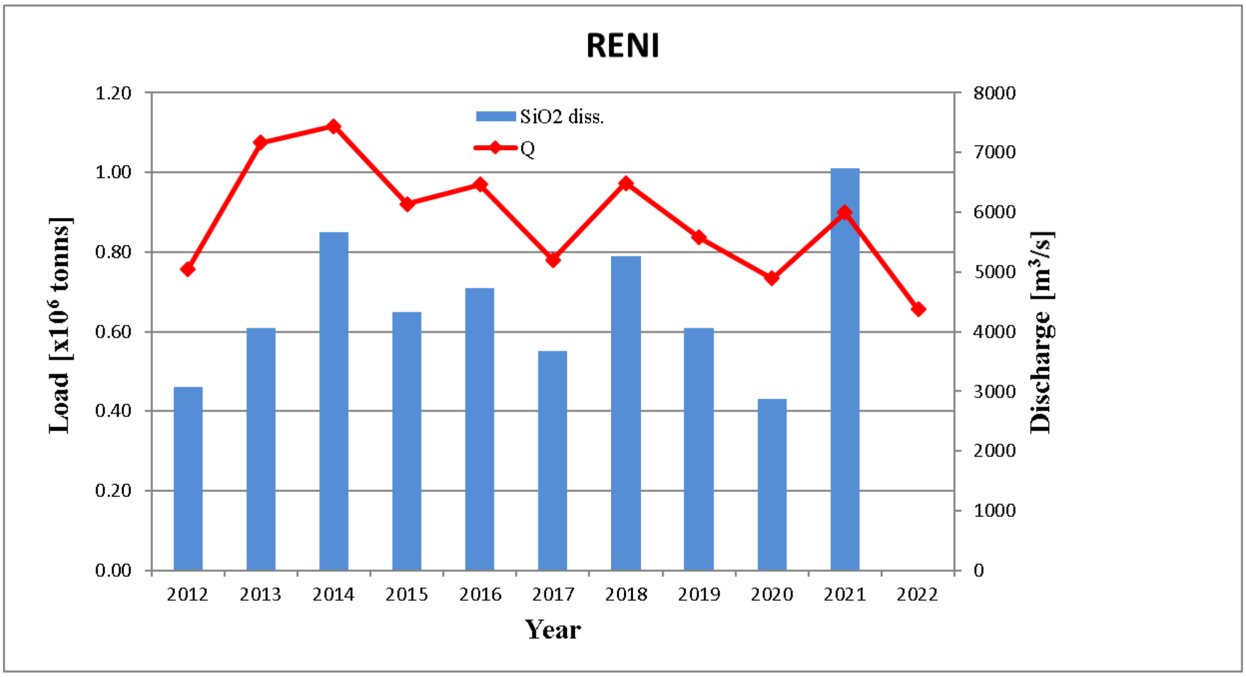


Figure 5.18: Development trend of annual loads of silicates at Reni.



6. Groundwater Monitoring

6.1 GroundwaterBodies 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 km² or
- important due to various criteria e.g., socio-economic importance, uses, impacts, pressures interaction with aquatic eco-system. The criteria need to be agreed bilaterally.

This means that the other groundwater bodies even those with an area larger than 4000 km², which are fully situated within one country of the DRB, are dealt with at the national level. A link between the content of the DRBMP and the national plans is given by the national codes of the groundwater bodies (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_5	Biochemical oxygen demand (5 days)
BSC	Black Sea Commission
COD_{Cr}	Chemical oxygen demand (Potassium dichromate)
COD_{Mn}	Chemical oxygen demand (Potassium permanganate)
DEFF	Data Exchange File Format
DOC	Dissolved organic carbon
DRB	Danube River Basin
DRBMP	Danube River Basin Management Plan
DRPC	Convention on Cooperation for the Protection and Sustainable Use of the Danube River (short: Danube River Protection Convention)
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
$N\text{-}NO_2$	Nitrite-nitrogen
$N\text{-}NO_3$	Nitrate-nitrogen
Ntot.	Total nitrogen
$P\text{-}PO_4$	Orto-phosphate-phosphorus
Pdiss.	Phosphorus dissolved
Ptot.	Total phosphorus
SiO_2	Silicates
SiO_2 diss.	Silicates dissolved
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
Qr	Mean annual discharge
SOP	Standard Operational Procedure
TNMN	Trans-National Monitoring Network
TOC	Total organic carbon
WFD	EU Water Framework Directive

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