Water Quality in the Danube River Basin – 2021

ICPDR IKSD

International Commission
for the Protection
of the Danube River

Internationale Kommission
zum Schutz der Donau

TNMN – Yearbook 2021

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ICPDR / International Commission for the Protection of the Danube River / www.icpdr.org

Imprint

Published by:
ICPDR – International Commission for the Protection of the Danube River

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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 2021.

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 2021 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/Kettõs-Körös/Fekete-Körös	Sarkad	MR	21.431	46.694	16	85	4 302
31	HU	HU14	/Tisza/Hármas-Körös/Kettõs-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 2021

Danube TransNational Monitoring Network - Surveillance Monitoring 2 stations

LEGEND

Monitoring stations (SM2*)

- ◆ Stations on the Danube River
- ◆ Stations on Tributaries
- ◆ Stations not reported in TNMN 2021 Yearbook
- ☐ Danube River Basin District
- — Danube River
- — Tributaries (with catchment area > 4,000 km²)
- ■ Lake water bodies (with surface area > 100 km²)
- ■ Transitional water bodies
- ■ Coastal water bodies
- = Canals
- — National borders

Cities:

- ● 100,000 - 250,000 inhabitants
- ■ 250,000 - 1,000,000 inhabitants
- > 1,000,000 inhabitants

* 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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Vienna, March 2023

2.3 Quality Elements

The background of the whole TNMN Yearbook is data reported in 2021 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 and number of families once yearly, both Pantle&Buck and Zelinka&Marvan SI are acceptable; optional parameters: ASPT and EPT taxa)
- Phytobenthos (benthic diatoms – an optional parameter)

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

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

Table 2: Surface water determinands list for TNMN

	Surveillance Monitoring 2	
	Water	**Water**
Determinand	**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 ($P\text{-}PO_4^{3}$) (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	Water
	concentrations	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 2021 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.
- spike solutions for organic micropollutant analysis: methanolic spike solutions were distributed. Sample codes were SW-Org-1 and SW-Org-2. 5 cm^3 amber capillary bottles were provided for lindane, atrazine and 4,4’-DDT analysis. Participants had to compose the proficiency testing samples themselves in situ by mixing prescribed amounts of the spike solutions (synthetic concentrates) of the measurand with pesticides-free laboratory water (e.g. high purity water) according to instructions. Measurement results were asked to be reported as $\mu g/dm^3$.

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

Fifty-one laboratories were enrolled into the scheme in 2021, which is similar to previous years. 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 (41 to 47 laboratories per parameter), with the exception of organic N, where only 6 results were available for evaluation, which is the lowest number seen in the AQC scheme. This parameter replaced Kjeldahl N analysis in 2013 at behest of participants, however, it remains unpopular with laboratories, which renders statistical evaluation difficult. Priority organic micropollutants were reported by 19 to 20 laboratories.

In case of simulated concentrates, correlation between theoretical values calculated and actual assigned values (robust averages) was excellent for organic micropollutants, recovery was between 93% and 106%, which was remarkably good compared to previous performance. However, nitrite nitrogen analysis resulted in poorer than usual correlation, recoveries were between 125% and 131%.

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 acceptable, between 67,5% and 112%, the exception being total phosphorous analysis, where the 30% recovery can probably be explained by the small target concentration difference between the two samples.

The 2021 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 half or less of the standard deviation for proficiency assessment set by expert judgement (phosphate phosphorous, total nitrogen and total phosphorous), which is outstanding. Low robust standard deviations (around 10%) of organic micropollutants lindane and 4,4'-DDT were an equally remarkable achievement. Some of the unsatisfactory results were probably attributable to non-analytical errors e.g. reporting in units of measurement other than prescribed. 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 sample SW-N-1, as the ratio of the standard uncertainty of the assigned value (i.e. robust average) and the standard deviation of proficiency assessment exceeded the critical limit of 120%. Diminishing number of interested laboratories (only 6 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. In case of total nitrogen, all reported results were in the satisfactory range. Phosphate phosphorous analysis fared equally well, with unsatisfactory results being solely the ones reported in wrong unit of measurement. Proficiency testing of nitrite nitrogen is traditionally less successful, though a gradual improvement could be observed over the past few years. In 2021, however, there were 6 laboratories with unsatisfactory results in both samples as well as 6 and 9 in the questionable range, typically exceeding critical limits in the same direction (indicative of systematic error for 10 laboratories – in two cases, probably attributable to use of wrong unit of measurement). Nevertheless, analysis of other nutrients, including the traditionally challenging NH_4^+- N analysis, was highly successful.

Organic micropollutants results cluster especially well around assigned values, number and ratio of unsatisfactory results is lower than previously. Results of one participant were excluded from the statistical evaluation due to being higher than the majority of results by an order of magnitude (possibly attributable to reporting in the wrong unit of measurement). Higher uncertainties of assigned values necessitated the use of z'- scores for assessment in sample SW-Org-1 for atrazine.

In summary, the 2021 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 2021,140 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 68 sampling sites at 39 stations were collected directly on the Danube river. Tributaries were monitored at 72 sampling sites representing 70 stations.

Table 3: List of TNMN stations reported in 2021

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	SK4	M	Vah	Komárno	1,5
14	SK6	M	Morava	Devín	1
15	SK7	M	Danube/Hron	Kamenica	1,7
16	SK8	M	Danube/Ipeľ	Salka	12
17	**HU1**	**M**	**Danube**	**Medve/Medvedov**	**1806**
18	**HU2**	**M**	**Danube**	**Komarom/Medvedov**	**1768**
19	**HU3**	**L, M, R**	**Danube**	**Szob**	**1708**
20	**HU4**	**L, M, R**	**Danube**	**Dunafoldvar**	**1560**
21	**HU5**	**M**	**Danube**	**Hercegszanto**	**1435**
22	HU6	L, M	Sio	Szekszard-Palank	13
23	HU7	M	Drava	Dravaszabolcs	78
24	HU8	M	Tisza/Sajo	Sajopuspoki	124
25	HU9	L, M, R	Tisza	Tiszasziget	163
26	HU10	M	Tisza	Tiszabecs	757
27	HU11	M	Tisza/Szamos	Csenger	45
28	HU12	M	Tisza/Hármas-Körös/Sebes-Körös	Korosszakal	9
29	HU13	M	Tisza/Hármas-Körös/Kettős-Körös/Fekete-Körös	Sarkad	16
30	HU14	M	Tisza/Hármas-Körös/Kettős-Körös/Fehér-Körös	Gyulavari	59
31	HU15	R	Tisza/Maros	Nagylak	51
32	SI1	L	Drava	Ormož most	300
33	SI2	R	Sava	JesenicenaDolenjskem	729
34	**HR1**	**M, R**	**Danube**	**Batina**	**1429**
35	**HR11**	**M**	**Danube**	**Ilok**	**1301,5**
36	HR9	M	Drava	Ormož	300
37	HR4	M, R	Drava	Botovo	227

N°	Station code	Location	River	Monitoring station	River km
38	HR5	M, R	Drava	D. Miholjac	78
39	HR6	R	Sava	Jesenice	729
40	HR7	M	Sava	Upstream UnaJasenovac	525
41	HR12	L	Sava	Račinovci	218
42	**RS1**	**L**	**Danube**	**Bezdan**	**1426**
43	**RS2**	**L**	**Danube**	**Bogojevo**	**1367**
44	**RS3**	**R**	**Danube**	**Novi Sad**	**1255**
45	**RS4**	**R**	**Danube**	**Zemun**	**1173**
46	**RS6**	**L**	**Danube**	**Banatska Palanka**	**1077**
47	**RS7**	**R**	**Danube**	**Tekija**	**954**
48	**RS8**	**R**	**Danube**	**Radujevac**	**851**
49	**RS9**	**L**	**Danube**	**Backa Palanka**	**1299**
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	Lalomita	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

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 2021
Mean	arithmetical mean of the measurements done in the year 2021
Max	maximum value of the measurements done in the year 2021
C50	50 percentiles of the measurements done in the year 2021
C90	90 percentiles of the measurements done in the year 2021 (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 2021. 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 2021.

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2021 (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	67/39	1.6	30.3	10.8	18.1	72/70	0.2	28.8	8.1	18.2
Suspended solids	mg/l	67/39	< 1	1208	3	73	72/70	< 1.0	1998	< 1.0	540
Dissolved oxygen	mg/l	67/39	4.92	13.9	6.71	11.16	71/69	4.9	15.2	6.91	11.56
BOD (5)	mg/l	67/39	< 0.25	7.8	1.01	4.48	72/70	< 0.25	18.0	< 0.25	7.53
COD (Mn)	mg/l	60/32	1.23	12.74	2.4	4.9	38/36	0.8	44.9	1.45	15.7
COD (Cr)	mg/l	53/25	< 2.5	59.04	6.06	19.47	59/57	< 2.0	124.0	3.58	44.87
TOC	mg/l	42/24	< 0.5	17.25	2.52	5.55	33/31	< 0.5	49.4	1.76	18.19
DOC	mg/l	33/15	< 0.25	13.22	2.33	5.62	17/17	0.6	10.6	1.233	7.79
pH	-	67/39	7.16	8.92	7.69	8.38	68/68	6.98	9.15	7.38	8.54
Alkalinity - total	mmol/l	67/39	1.28	5.80	1.67	4.46	62/60	0.85	747.50	1.31	234.71
Ammonium (NH4-N)	mg/l	67/39	< 0.004	1.08	0.014	0.32	72/70	< 0.004	4.485	0.017	2.35
Nitrite (NO2-N)	mg/l	66/38	< 0.0010	0.07	0.007	0.03	72/70	< 0.001	0.348	< 0.0025	0.11
Nitrate (NO3-N)	mg/l	67/39	< 0.050	3.7	< 0.05	2.92	72/70	< 0.035	7.64	0.063	4.60
Total nitrogen	mg/l	59/31	0.5	5.8	1.37	2.78	63/61	0.5	8.88	0.808	5.81
Organic nitrogen	mg/l	21/13	0.02	4.21	< 0.25	0.88	25/23	< 0.05	1.8	0.24	1.14
Orthophosphate (PO4-P)	mg/l	67/39	< 0.0017	0.55	0.012	0.24	72/70	< 0.001	0.777	< 0.0035	0.37
Total phosphorus	mg/l	65/37	0.012	0.904	0.027	0.51	72/70	0.003	2.4	0.01	1.17
Total phosphorus, dissolved	mg/l	37/17	< 0.0025	0.182	0.022	0.11	19/19	< 0.0035	0.5245	0.01	0.26
Phytoplankton (biomass - chlorophyll-a)	µg/l	49/23	< 0.0015	67	3.79	27.69	35/33	< 0.0015	192.1	0.735	96.72
Conductivity	µS/cm	65/37	219	674	371.167	516	72/70	43	2360	243	1462
Calcium (Ca++)	mg/l	58/34	< 1.0	93.6	39.09	82.72	66/64	< 1.0	286	30.29	162.15
Sulphate (SO4--)	mg/l	46/24	9.05	79	18	39.64	45/43	7.81	444.2	10.56	104.4
Magnesium (Mg++)	mg/l	58/34	2.4	112.61	12.48	24.23	65/63	< 1.0	63	4.95	59.42
Potassium (K+)	mg/l	29/17	1.6	9.4	< 2.0	3.83	33/31	0.79	13.7	1.14	5.45
Sodium (Na+)	mg/l	29/17	3.7	45.1	12.5	18.88	33/31	2.37	189	5.3	77.1
Manganese (Mn)	mg/l	9/7	< 0.0015	0.473	0.03	0.06	15/13	0.01	0.59	0.0213	0.13
Iron (Fe)	mg/l	8/6	< 0.004	3.31	0.26	0.87	20/18	< 0.01	13	0.041	3.47
Chloride (Cl-)	mg/l	58/34	4.9	88.4	17.72	34.25	66/64	1.02	599	1.76	325.40
Silicates (SiO2)	mg/l	13/7	1.2	9.6	2.1	5.9	15/13	1.0	23.8	5.0	18.8
Silicates(SiO2), dissolved	mg/l	13/11	0.5	10.0	3.3	6.9	12/12	0.9	11.4	2.9	8.9
Macrozoobenthos- saprobic index		12/10	0.64	2.29	0.64	2.21	24/24	0.46	3.18	0.46	2.65

Table 4: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2021 (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	64/36	< 0.5	180.00	< 1.0	26.50	62/60	< 0.5	140.00	< 0.585	50.06
Copper - Dissolved	µg/l	64/36	< 0.15	116.20	1.14	14.22	61/59	< 0.25	36.30	0.80	14.23
Chromium - Dissolved	µg/l	64/36	< 0.05	6.22	< 0.05	1.03	60/58	< 0.05	24.40	0.17	8.03
Lead - Dissolved	µg/l	60/34	< 0.025	5.54	0.078	2.043	51/49	< 0.025	22.60	0.05	7.74
Cadmium - Dissolved	µg/l	60/34	< 0.005	1.14	< 0.005	0.34	51/49	< 0.005	0.67	0.01	0.16
Mercury - Dissolved	µg/l	60/34	< 0.0025	0.49	< 0.0025	0.05	49/47	< 0.0025	0.10	< 0.0025	0.04
Nickel - Dissolved	µg/l	64/36	0.4	22.52	< 0.500	4.75	52/50	< 0.25	14.00	0.38	5.28
Arsenic - Dissolved	µg/l	60/34	< 0.25	5.72	< 0.500	2.30	59/57	0.23	16.00	0.36	5.87
Aluminium - Dissolved	µg/l	18/12	< 2.25	422.00	3.21	63.04	16/14	< 2.25	255.00	5.27	59.33
Zinc *	µg/l	24/20	< 0.25	365.00	1.52	87.57	26/24	1	236.86	4.46	113.91
Copper	µg/l	21/17	< 0.5	163.00	1.80	31.14	22/20	< 0.5	156.00	2.24	24.95
Chromium - total	µg/l	21/17	< 0.1	5.20	0.27	1.90	23/21	< 0.25	54.30	< 0.25	17.41
Lead	µg/l	17/15	< 0.1	15.10	0.43	1.95	20/18	< 0.15	22.10	0.51	8.96
Cadmium	µg/l	17/15	< 0.005	1.46	0.01	0.21	25/23	< 0.01	6.03	< 0.025	0.94
Mercury	µg/l	17/15	< 0.01	0.10	< 0.010000	0.04	26/24	< 0.005	0.70	< 0.005	0.08
Nickel	µg/l	22/18	0.4	15.10	0.91	8.88	26/24	< 0.25	111.00	1.14	26.15
Arsenic	µg/l	17/15	< 0.5	12.00	0.92	4.70	21/19	< 0.25	17.00	0.72	6.42
Aluminium	µg/l	8/6	< 5.0	3332.0	158.1	1112.8	8/6	38.6	14000.0	172.9	3424.3
Phenol index	mg/l	31/11	< 0.0015	0.0126	< 0.0015	0.0052	15/15	< 0.0015	0.0158	< 0.0015	0.005
Anionic active surfactants	mg/l	37/15	< 0.01	0.15	< 0.01	0.12	23/23	< 0.005	0.13	0.01	0.05
AOX	µg/l	11/7	< 5.0	28.00	< 5.0	< 10.0	14/14	< 3.0	33.0	< 5.0	21.42
Petroleum hydrocarbons	mg/l	30/14	< 0.01	0.39	< 0.01	0.19	19/19	0.01	0.84	< 0.01	0.27
Lindane	µg/l	57/29	< 0.0002	0.02	< 0.0002	0.0168	49/47	< 0.0002	9.2	< 0.0002	5.2
pp´DDT	µg/l	56/30	< 0.0003	0.02	< 0.0003	0.014	49/47	< 0.0003	5.9	< 0.0003	5.0
Atrazine	µg/l	57/29	< 0.0005	< 0.09	< 0.0005	< 0.09	43/41	< 0.0005	< 0.09	< 0.0005	< 0.09
Chloroform	µg/l	9/7	< 0.05	1.0	< 0.05	1.0	21/19	< 0.015	5.31	0.029	1.05
Carbon tetrachloride	µg/l	9/7	< 0.05	0.5	< 0.05	0.5	19/17	< 0.05	< 0.5	< 0.05	< 0.5
Trichloroethylene	µg/l	9/7	< 0.05	0.5	< 0.05	0.5	19/17	< 0.05	< 0.5	< 0.05	< 0.5
Tetrachloroethylene	µg/l	7/5	< 0.05	0.50	< 0.05	0.5	18/16	< 0.05	0.2	< 0.05	< 0.1

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 2021 the **highest concentrations of biodegradable organic matter** were observed in the middle and lower parts of the Danube River with a maximum of 5.9 mg.l^{-1} in HU5.

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 2021 were observed in the upper and middle part at the monitoring sites AT3, AT5, AT6, RS2, HR11, RS4, RS6 and RS8 (see Figure 4.3).

The decrease of the BOD_5 has been observed in some tributaries: Morava, Dyje, Vah, Tisza, Drava (HR4,HR5, HR9) and Siret (Figure 4.4). In 2021 the concentration of BOD_5 has increased in Sajo, Russenski Lom and Jantra. The maximal concentration was found in the Russenski Lom (BG15 - 13.6 mg.l^{-1}).

At the selected monitoring points SK1 and HU5 the BOD_5 levels increased in 2021, while at RO5 the BOD_5 levels decreased (Figure 4.17 - 4.19).

The highest values of **dissolved oxygen** (DO) in the Danube River were observed in its upper and middle part (maximum: RS1 Danube Bezdan 9.62 mg.l^{-1}), in the lower Danube the dissolved oxygen levels decreased, minimum was 5.7 mg.l^{-1} in BG5 Danube – Silistra/Chiciu (Figure 4.1).

The maximum value of dissolved oxygen in tributaries was in DE4 Inn (10.1 mg.l^{-1}). The minimal concentration was in BG15 Russenski Lom - 6.1 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 6 - 96.5 - mg.l^{-1} with maximum in BG15 (Russenski Lom-mouth) than in the Danube River sites (range of C90 values 8.4 - 35.7 mg.l^{-1}), maximum in RO5 Danube – Reni-Chilia.

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 0.61 mg.l^{-1}.
In 2021, decreased concentrations of ammonium-nitrogen were found in the tributaries Russenski Lom BG15 and Prut MD3 (see Figure 4.8). In the upper and middle Danube tributaries the concentration of ammonium-nitrogen had a stable level in 2021 (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 and middle part slightly increased (see figure 4.9). A decrease of concentrations was observed in the lower Danube part. Maxiuml concentration was observed at DE5 3.5 mg.l^{-1}.
In the tributaries Dyje, Vah and Sio the **nitrate-nitrogen** concentrations increased. An decrease was observed in the Russenski Lom, Jantra 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 increase in SK1 and HU5 and a stable situation in RO5. The lowest value of C90 in 2021 was 1.41 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 2021 results were stable. An increase of the ortho-phosphate-phosphorus was observed at RS8 (Danube-Radujevac) which was the highest value detected in 2021 (0.51 mg.l^{-1}).

An increase of ortho-phosphate-phosphorus concentrations was observed in Sio, Dyje and Velika Morava with a maximum of 0.59 mg.l^{-1} in Sio HU6 (Figure 4.12).

Concentrations of **total phosphorus** (Figure 4.13) in the upper and middle Danube were stable. In the Serbian part at RS4 and RS8 the **total phosphorus** concentrations increased in 2021. The **total phosphorus** values in 2021 showed an increase in the upper Danube tributaries (Figure 4.14). Increasing values were observed in Inn, Sio, Dyje and Russenski Lom. The highest concentration in 2021 of 2.4 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 2021 the concentrations increased in all selected monitoring points.

The **cadmium** concentration (Figure 4.15) was constant or slightly increasing (AT3) in the upper part of the Danube. In the Serbian part concentrations increased and the maximum value was 0.27 mg.l^{-1} at RS8 in 2021.

Higher concentrations of Cd were detected in tributaries, with the maximum of 1.5 mg.l^{-1} in Sava RS16. In 2018, a high concentration of C90 being 89.2 mg.l^{-1} was found in HU9 (Tisza-Tiszasziget) and this value decreased to 0.12 mg.l^{-1} in 2021.

The comparison of statistical characteristics of 90 and 10 percentiles (C90, C10) in 2021 for selected determinands (N-NH_4, P-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 C90 and C10 have an insignificant variation for COD_{Cr}, P-PO_4, N-NH_4 in the in upper and middle Danube. Visible differences were observed for BOD_5 in the middle and lower part of the Danube. The highest difference was observed for COD_{Cr} in RO5 and for BOD_5 in HU5 .

The 10 and 90 percentile values fluctuate for COD_{Cr} and BOD_5 in lower tributaries. The significant differences for the COD_{Cr} were observed in the lower tributaries Ialomita, Olt , Prut and Russenski Lom. For the BOD_5 differences were visible also in the upper and middle tributaries Dyje, Morava, Drina and Una and in the lower part in Mures, Ialomita, Prut and Russenski Lom.

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

Figure 4.1: Temporal changes (2011-2021) of dissolved oxygen (C10) in the Danube River

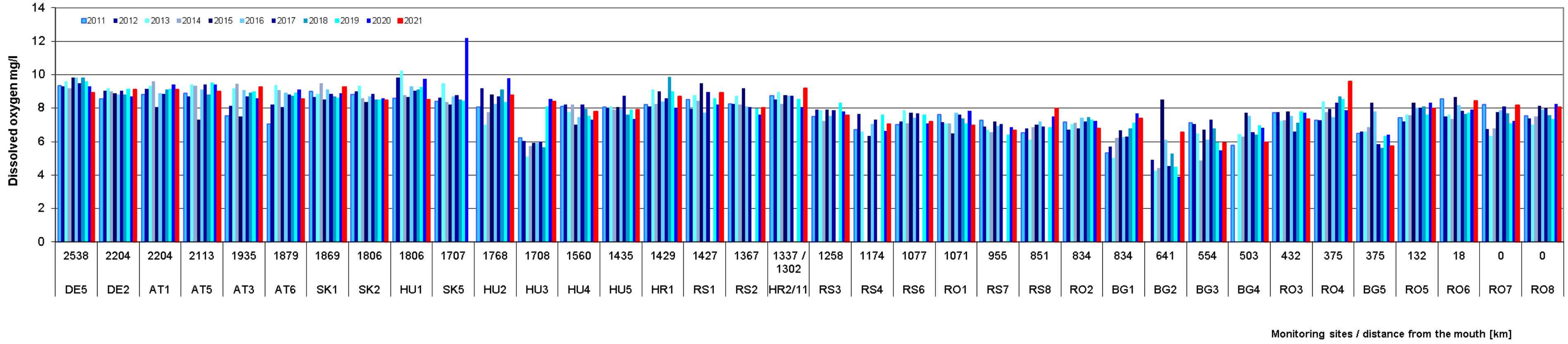


Figure 4.2: Temporal changes (2011-2021) of dissolved oxygen (C10) in tributaries

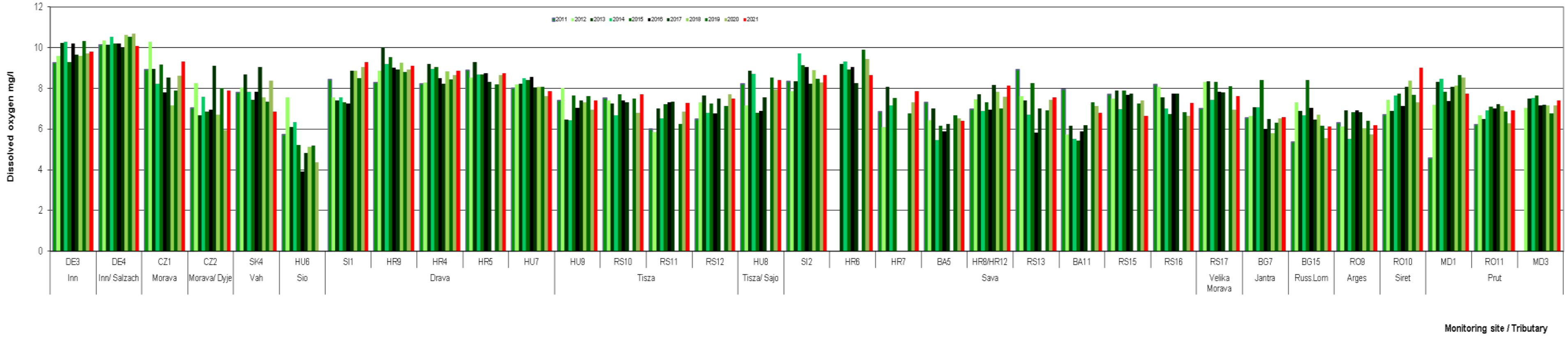


Figure 4.3: Temporal changes (2011-2021) of BOD₅ (C90) in the Danube River.

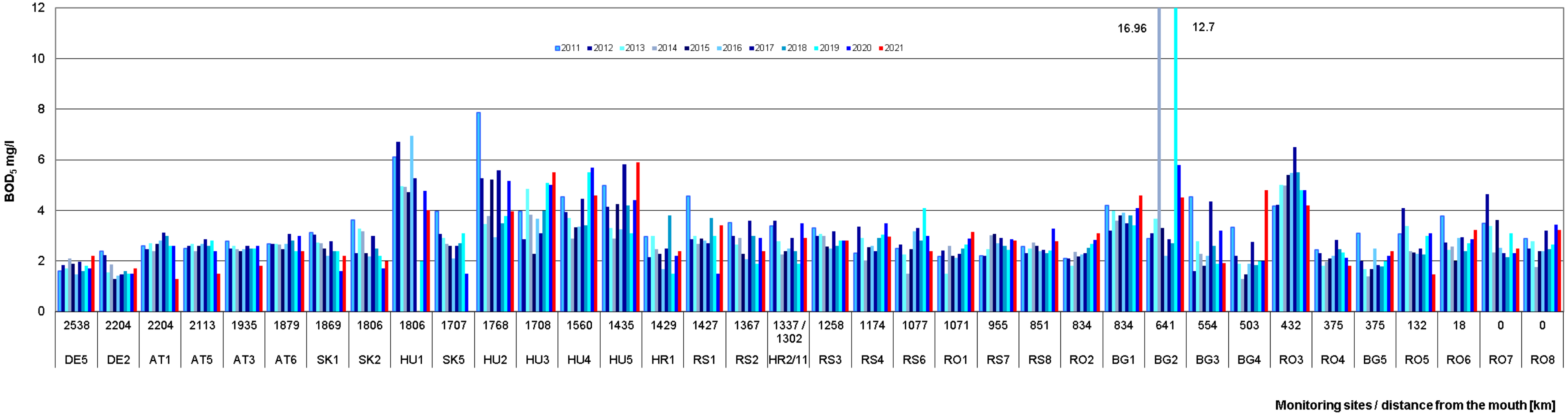


Figure 4.4: Temporal changes (2011-2021) of BOD₅ (C90) in tributaries.

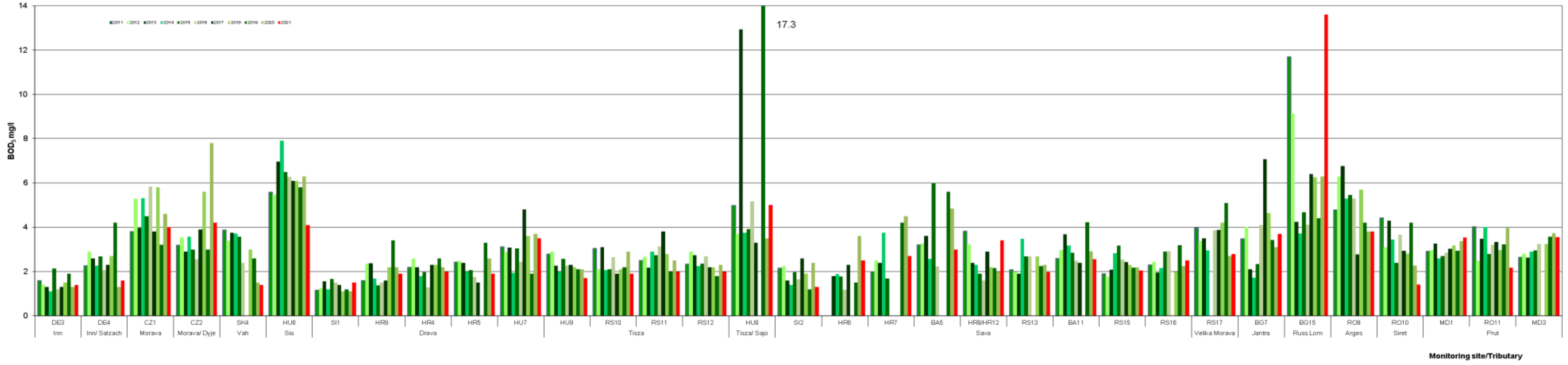


Figure 4.5: Temporal changes (2011-2021) of COD_{Cr} (C90) in the Danube River.

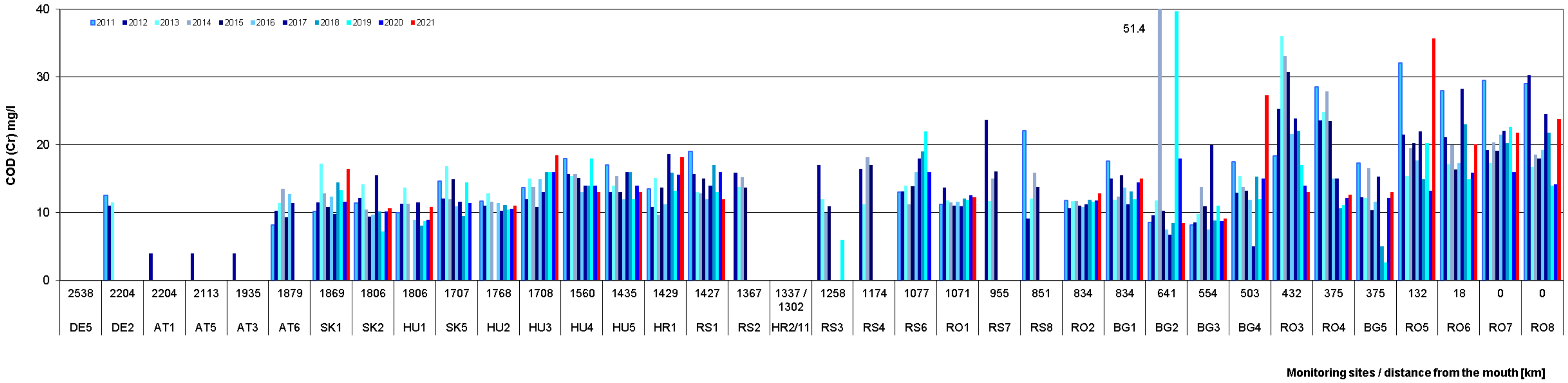


Figure 4.6: Temporal changes (2011-2021) of COD_{Cr} (C90) in tributaries.

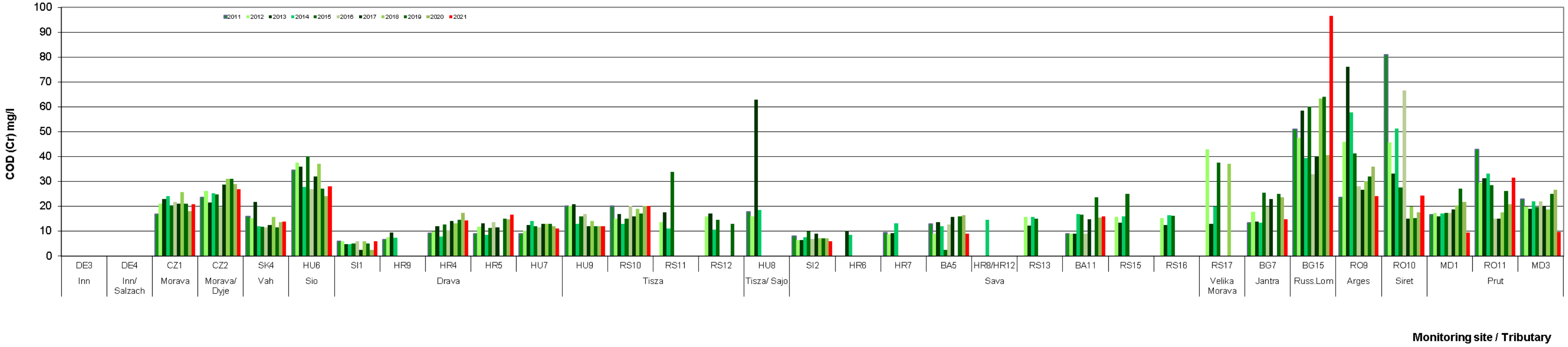


Figure 4.7: Temporal changes (2011-2021) of NH_4-N (C90) in the Danube River.

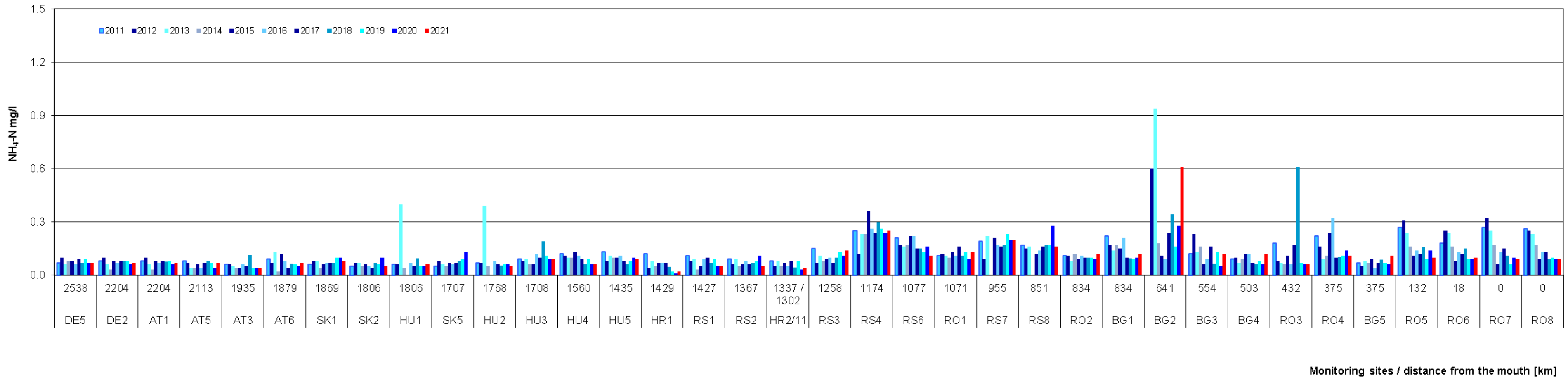


Figure 4.8: Temporal changes (2011-2021) of NH_4-N (C90) in tributaries.

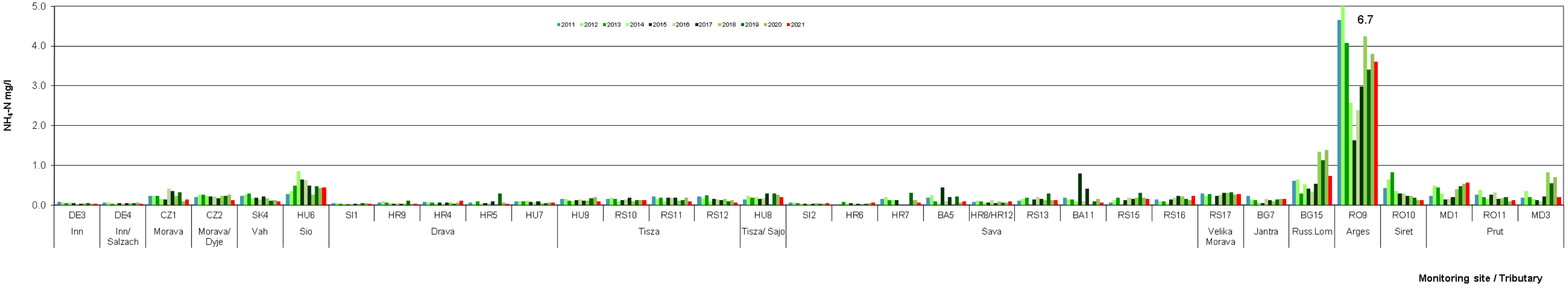


Figure 4.9: Temporal changes (2011-2021) of NO_3-N (C90) in the Danube River.

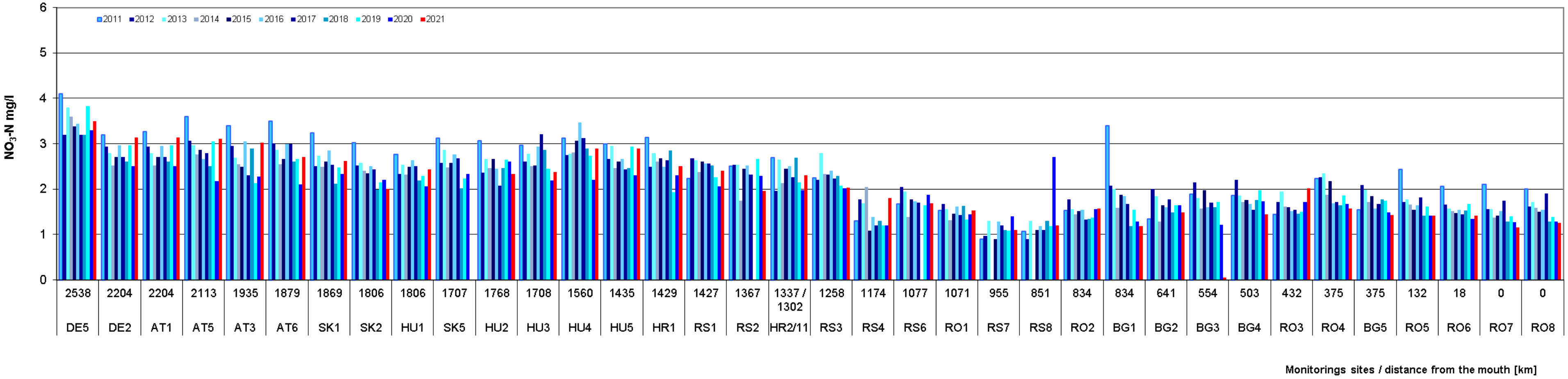


Figure 4.10: Temporal changes (2011-2021) of NO_3-N (C90) in tributaries.

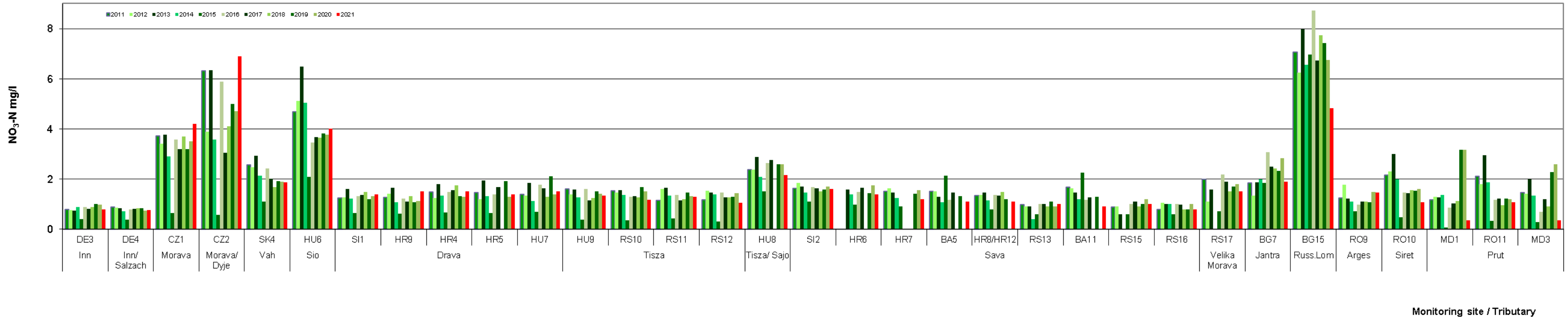


Figure 4.11: Temporal changes (2011-2021) of P-PO4 (C90) in the Danube River.

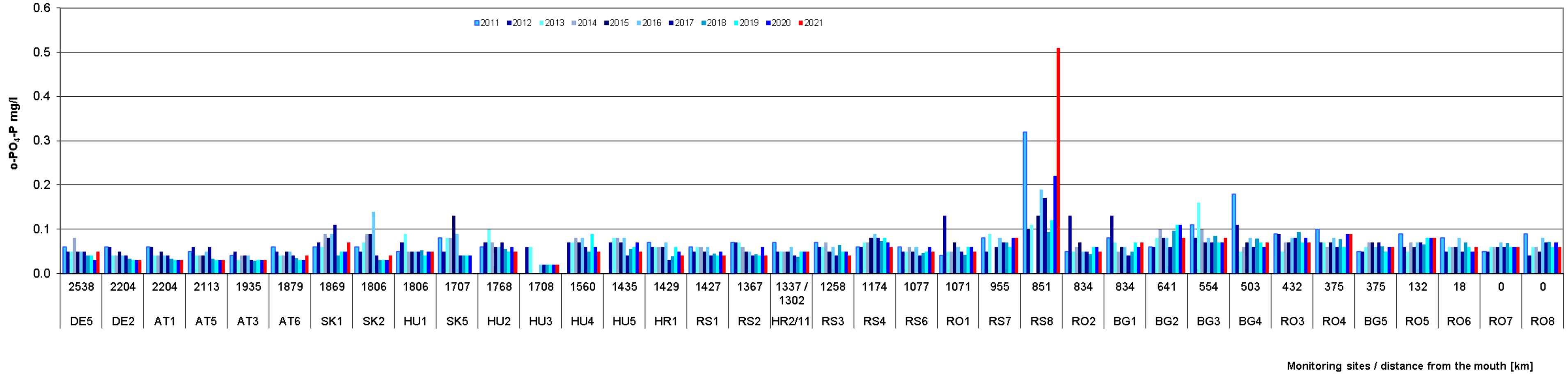


Figure 4.12: Temporal changes (2011-2021) of P-PO4 (C90) in tributaries

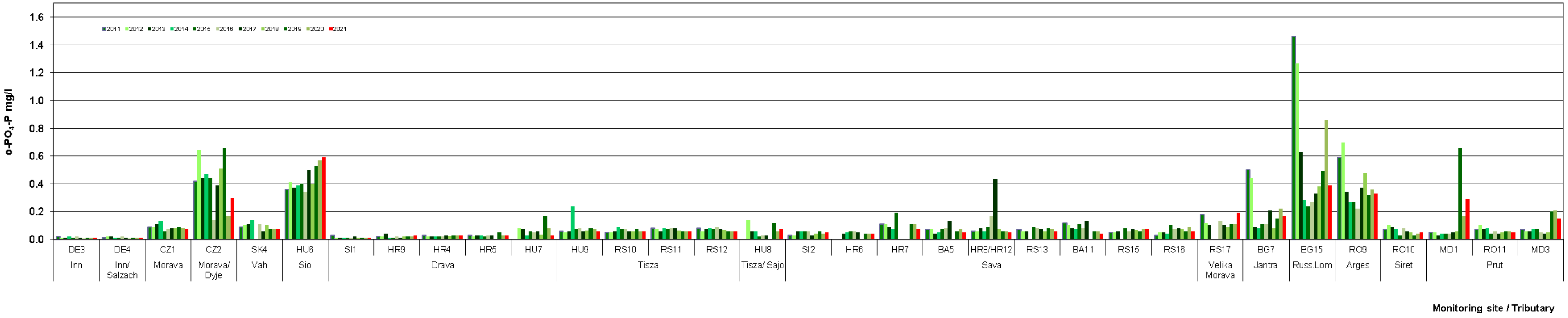


Figure 4.13: Temporal changes (2011-2021) of total phosphorus (C90) in the Danube River.

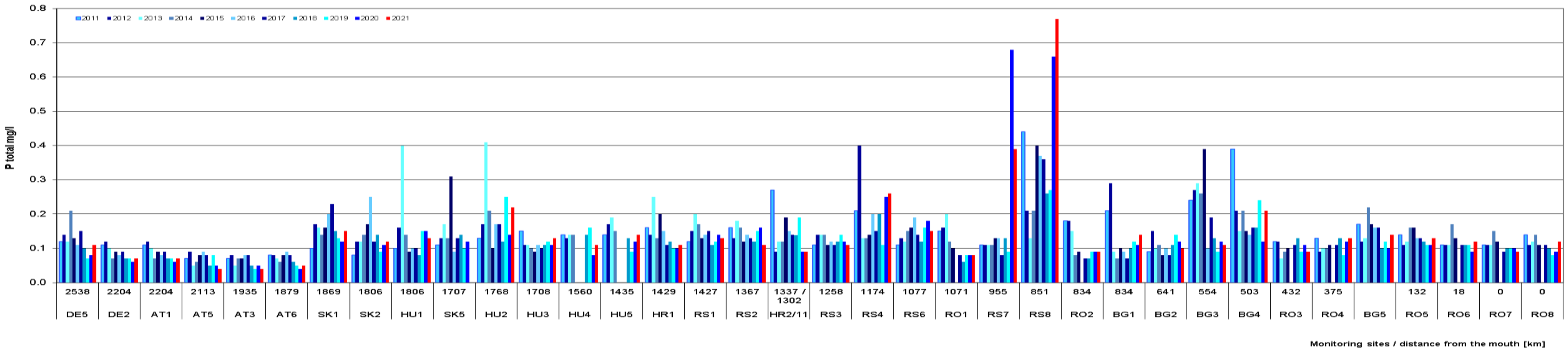


Figure 4.14: Temporal changes (2011-2021) of total phosphorus (C90) in tributaries.

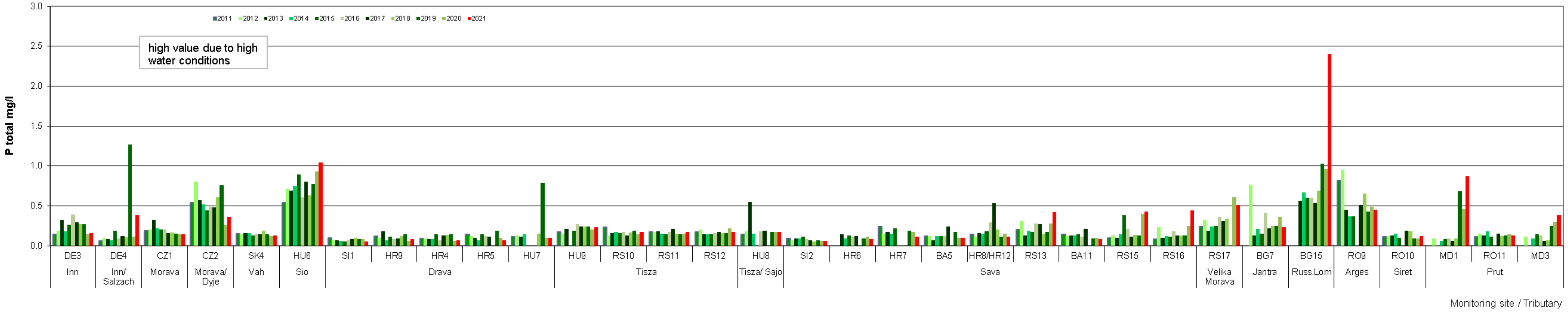


Figure 4.15: Temporal changes (2011-2021) of cadmium dissolved (C90) in the Danube River.

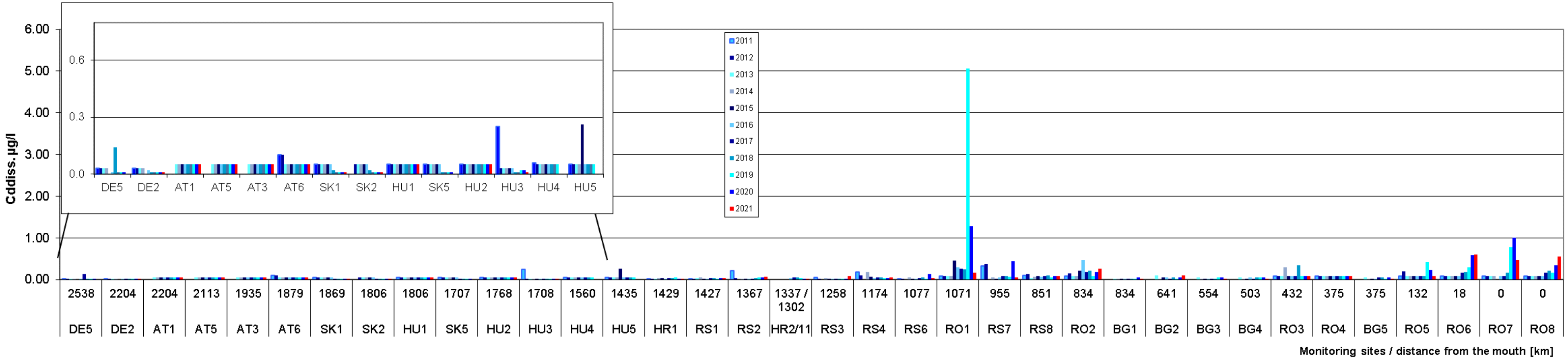


Figure 4.16: Temporal changes (2011-2021) of cadmium dissolved (C90) in tributaries.

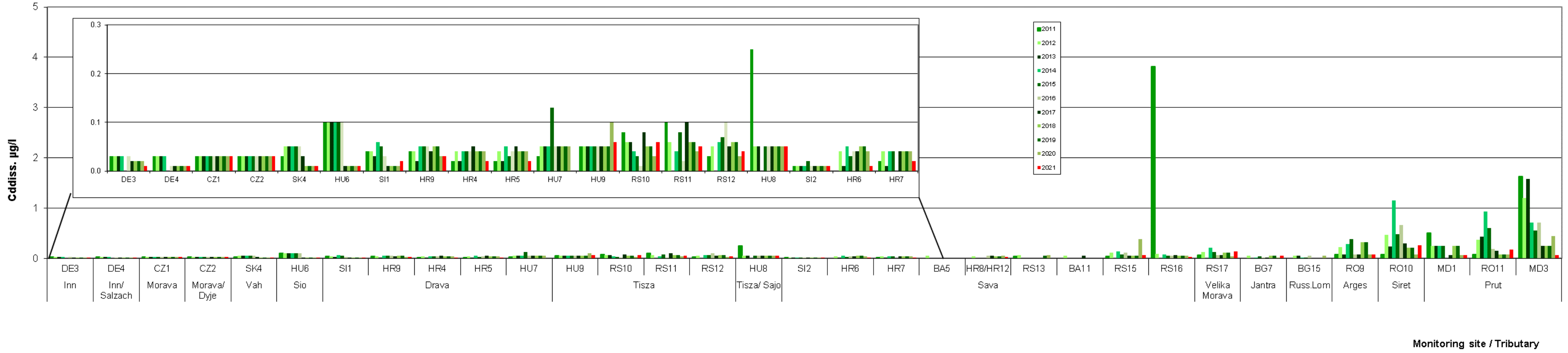


Figure 4.17: Temporal changes (2011-2021) of BOD_5 (C90) in Bratislava

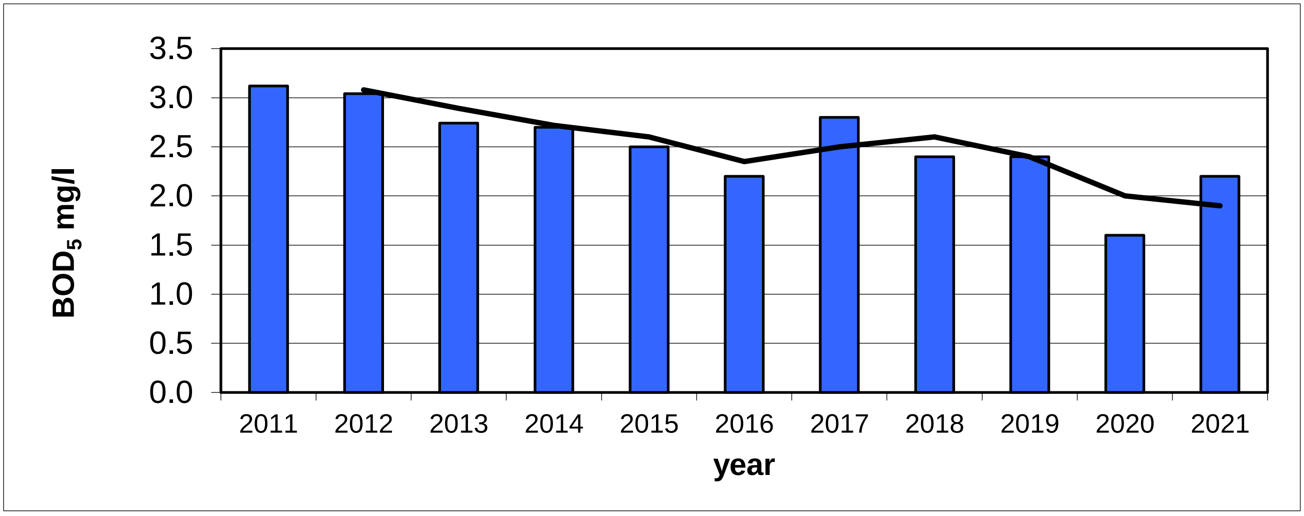


Figure 4.18: Temporal changes (2011-2021) of BOD_5 (C90) in Hercegszanto

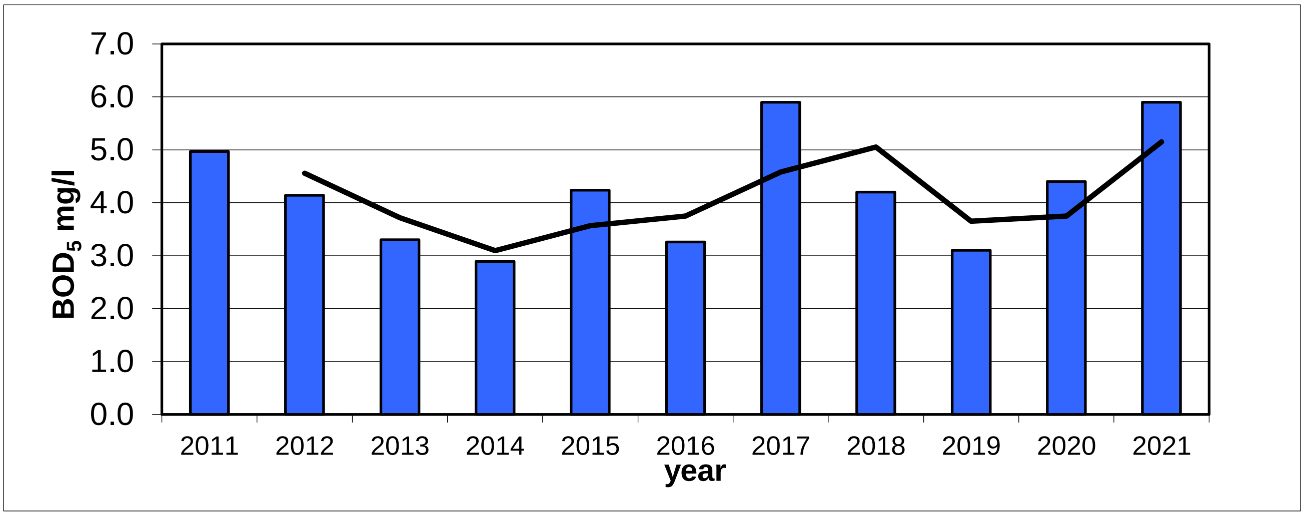


Figure 4.19: Temporal changes (2011-2021) of BOD_5 (C90) in Reni

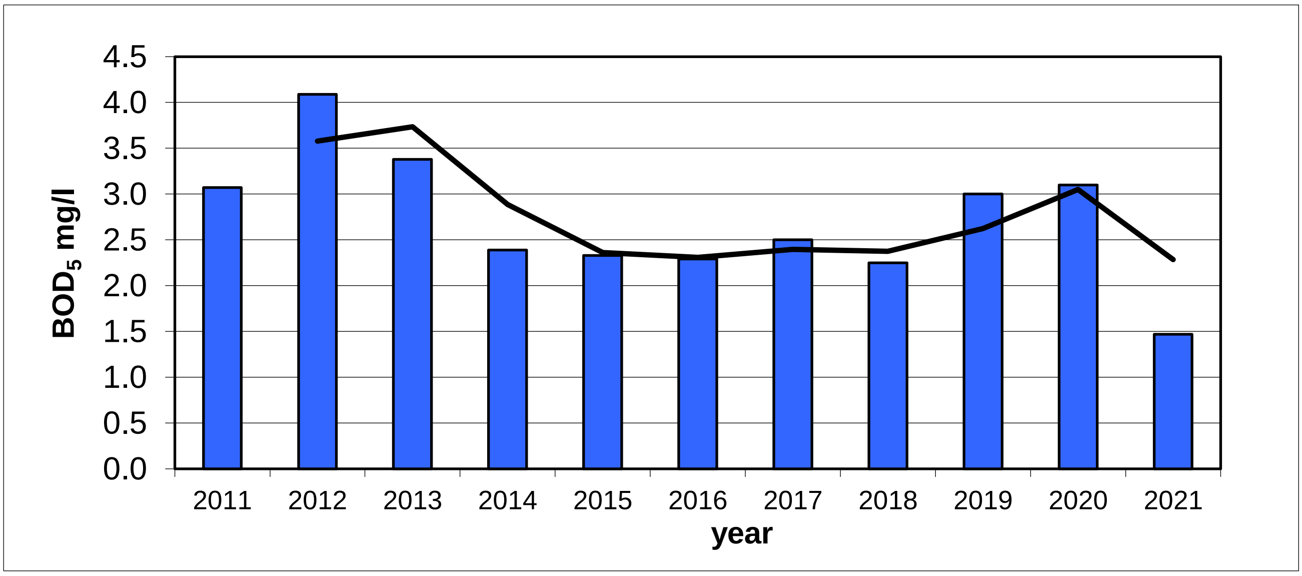


Figure 4.20: Temporal changes (2011-2021)) of N-NO_3 (C90) in Bratislava

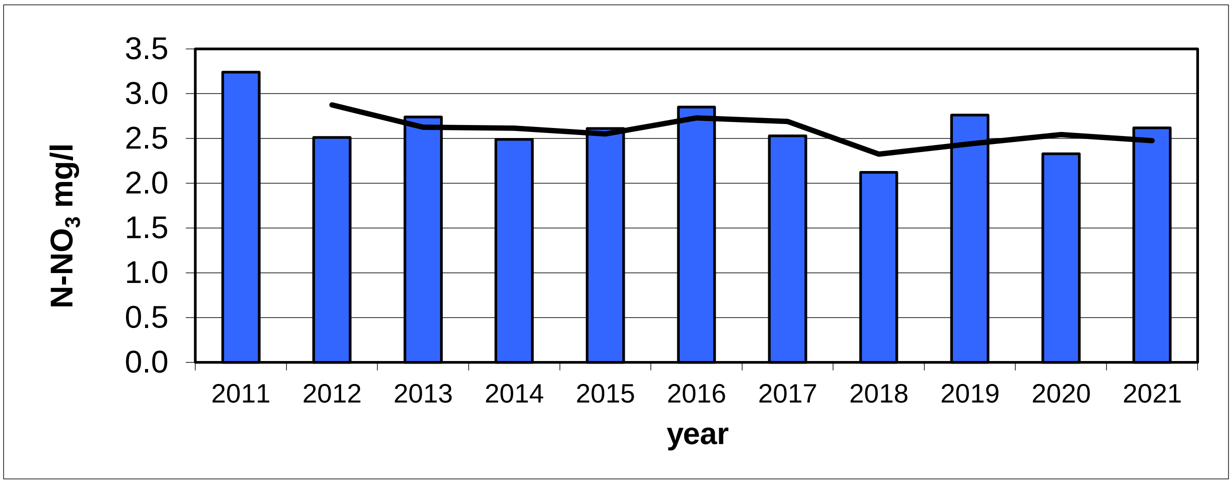


Figure 4.21: Temporal changes (2011-2021) of N-NO_3 (C90) in Hercegszanto

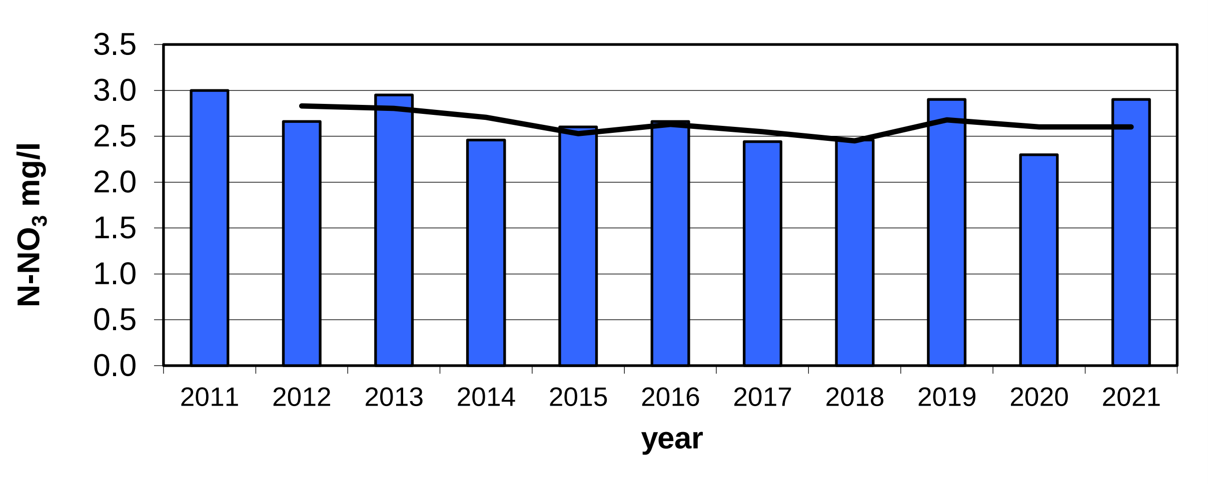


Figure 4.22: Temporal changes (2011-2021) of N-NO_3 (C90) in Reni

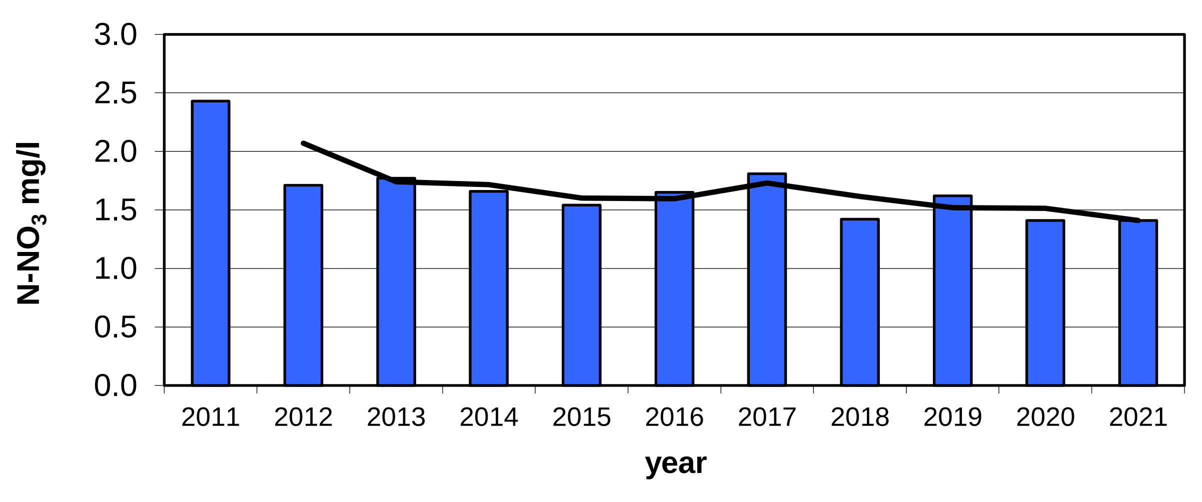


Figure 4.23: Temporal changes (2011-2021) of total phosphorus (C90) in Bratislava

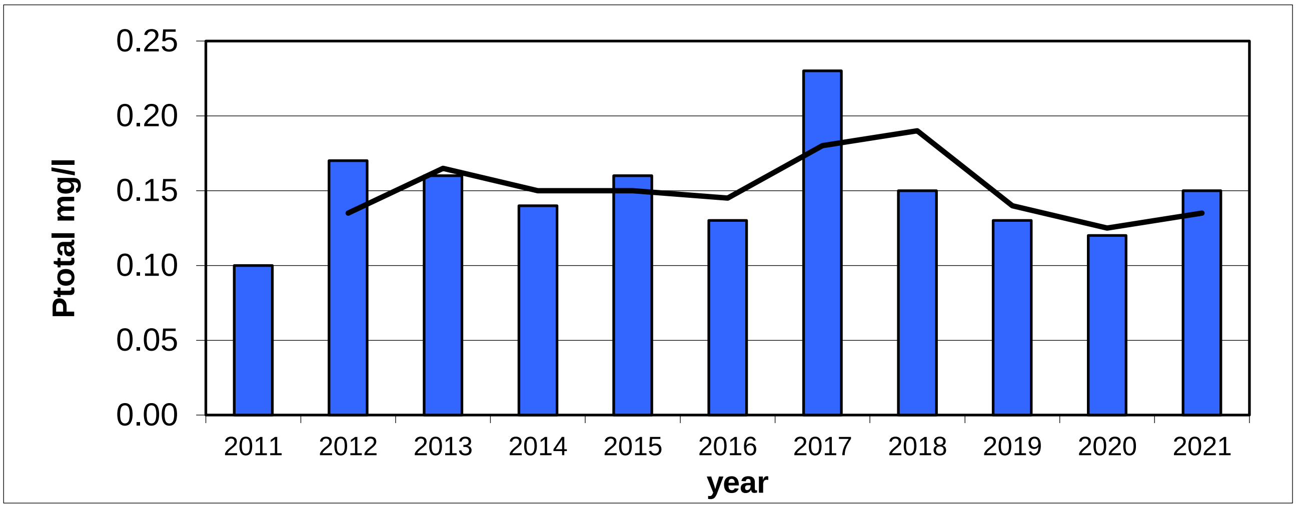


Figure 4.24: Temporal changes (2011-2021) of total phosphorus (C90) in Hercegszanto

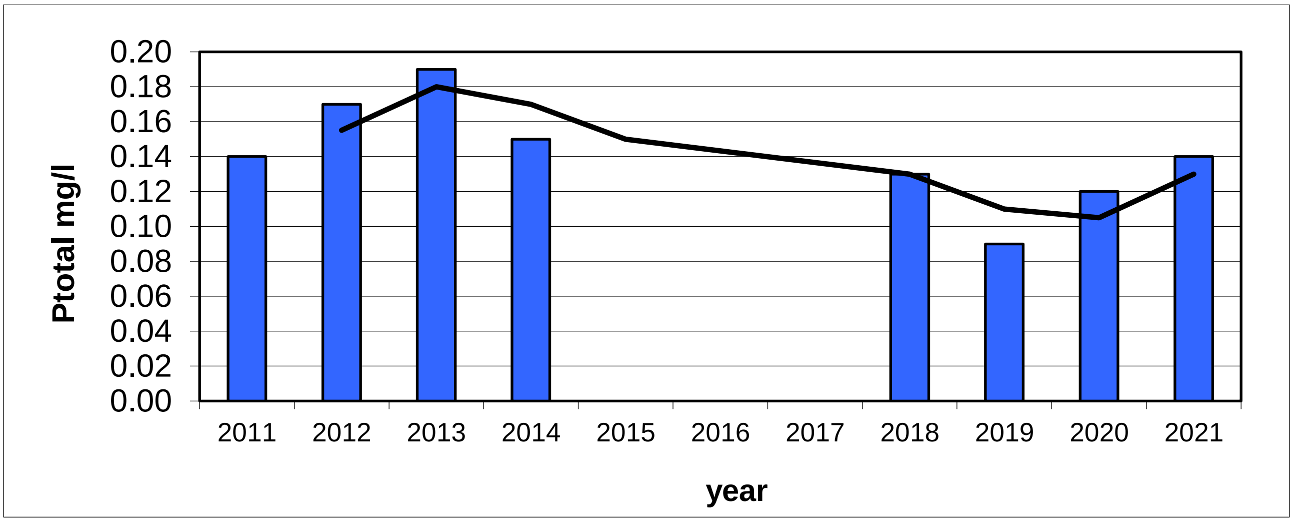


Figure 4.25: Temporal changes (2011-2021) of total phosphorus (C90) in Reni

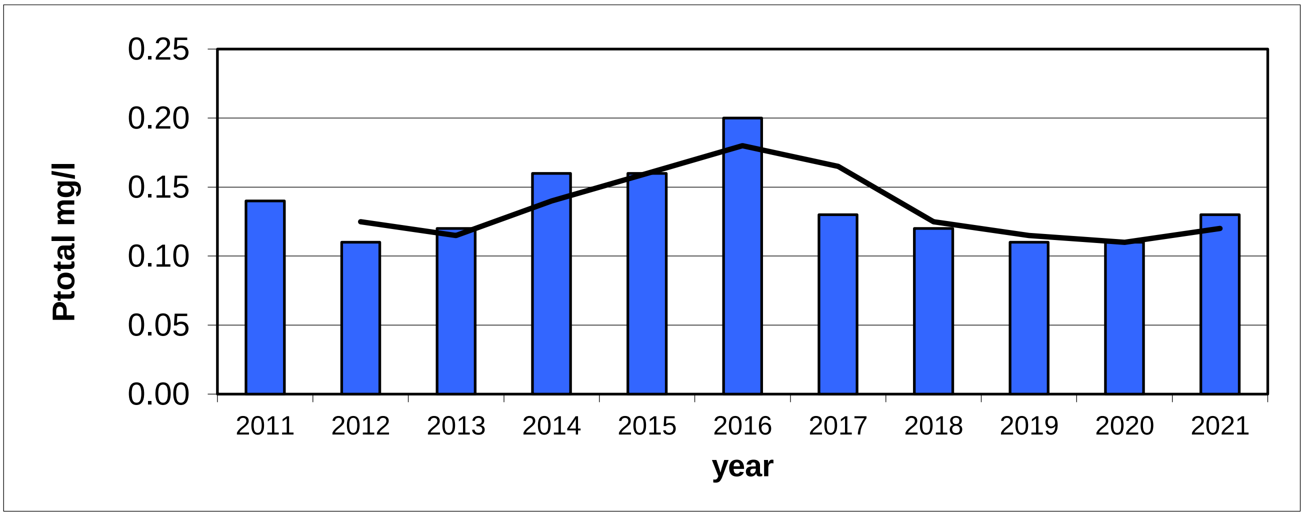


Figure 4.26: The percentile (90, 10) of N-NH_4 concentration along the Danube River in 2021

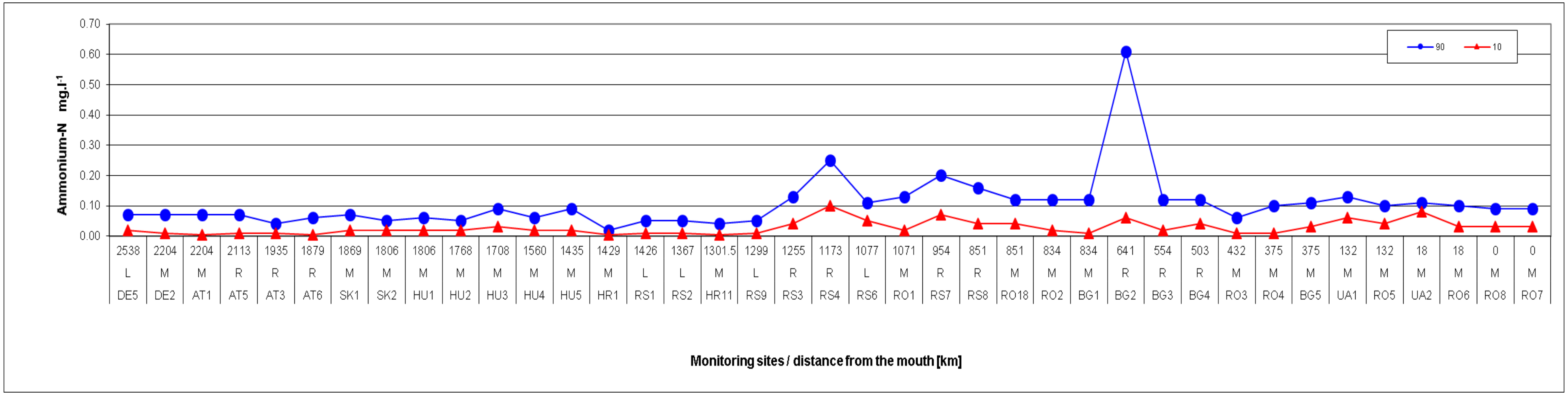


Figure 4.27: The percentile (90, 10) of N-NH_4 concentration in the tributaries in 2021

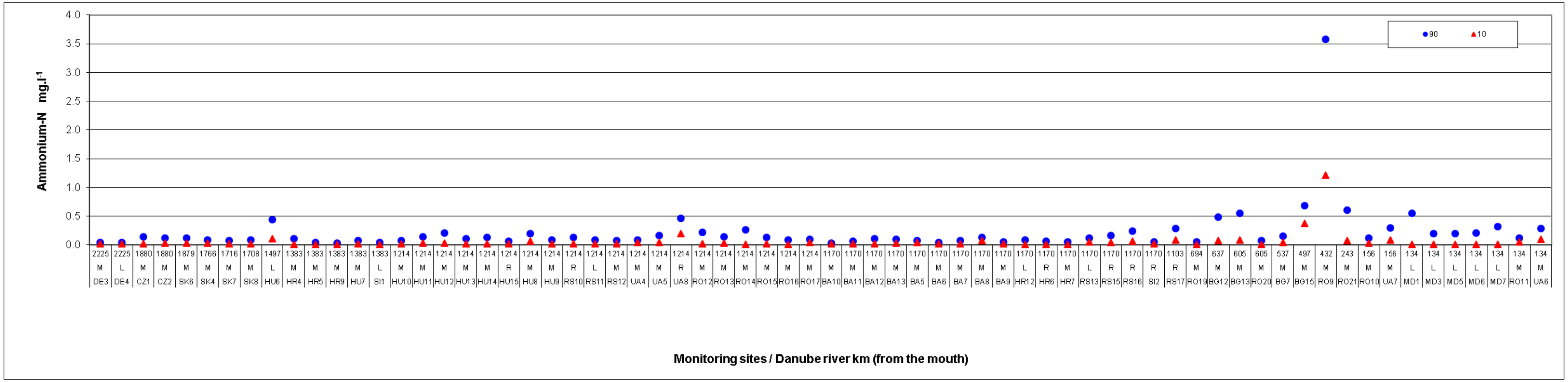


Figure 4.28: The percentile (90, 10) of P-PO$_4$ concentration along the Danube River in 2021

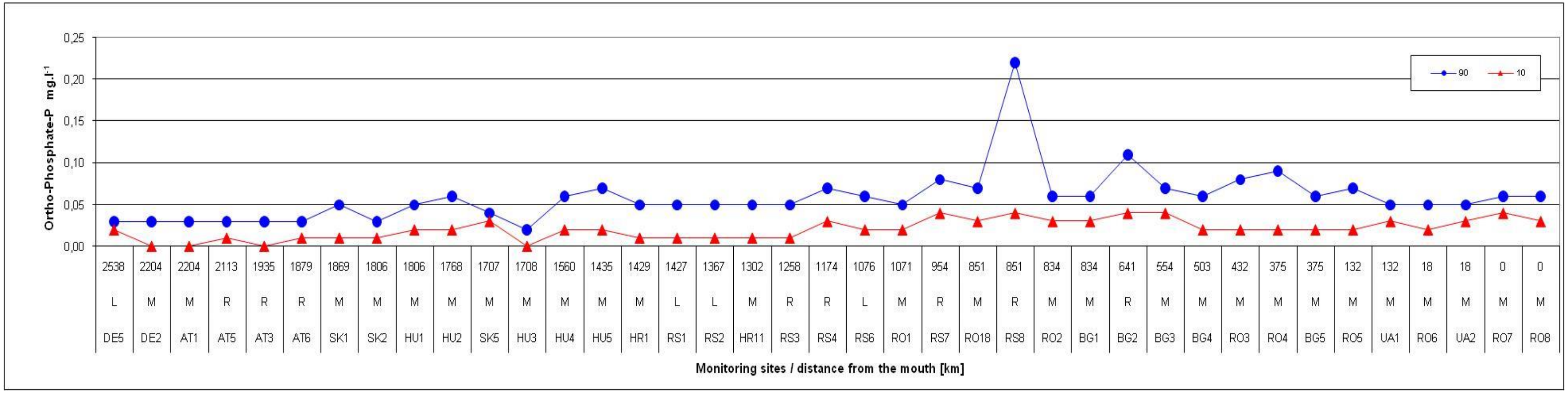


Figure 4.29: The percentile (90, 10) of P-PO$_4$ concentration in the tributaries in 2021

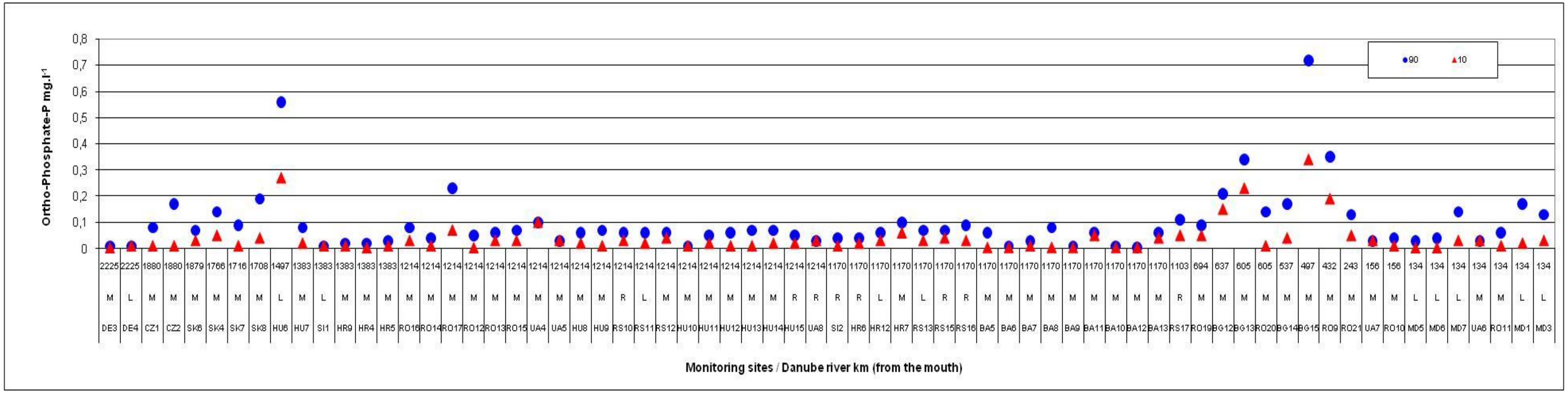


Figure 4.30: The percentile (90, 10) of COD$_{Cr}$ concentration along the Danube River in 2021

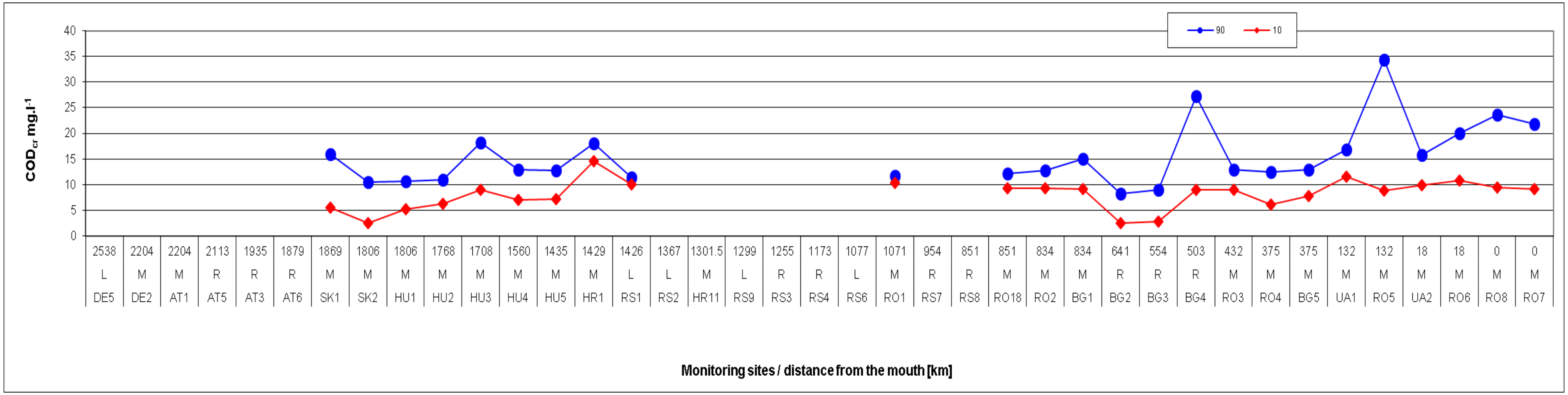


Figure 4.31: The percentile (90, 10) of COD$_{Cr}$ concentration in the tributaries in 2021

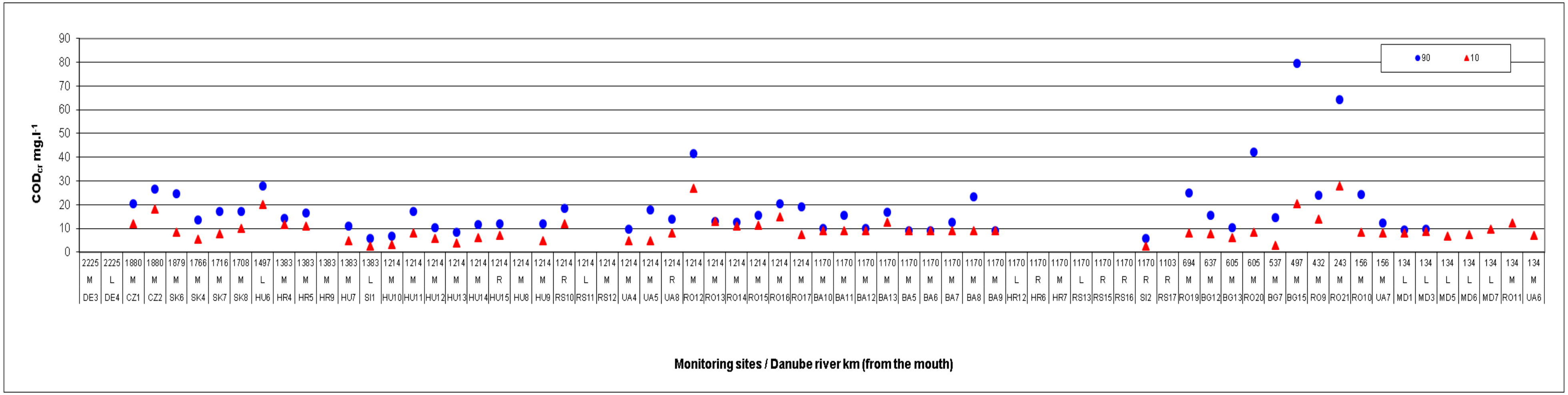


Figure 4.32: The percentile (90, 10) of BOD_5 concentration along the Danube River in 2021

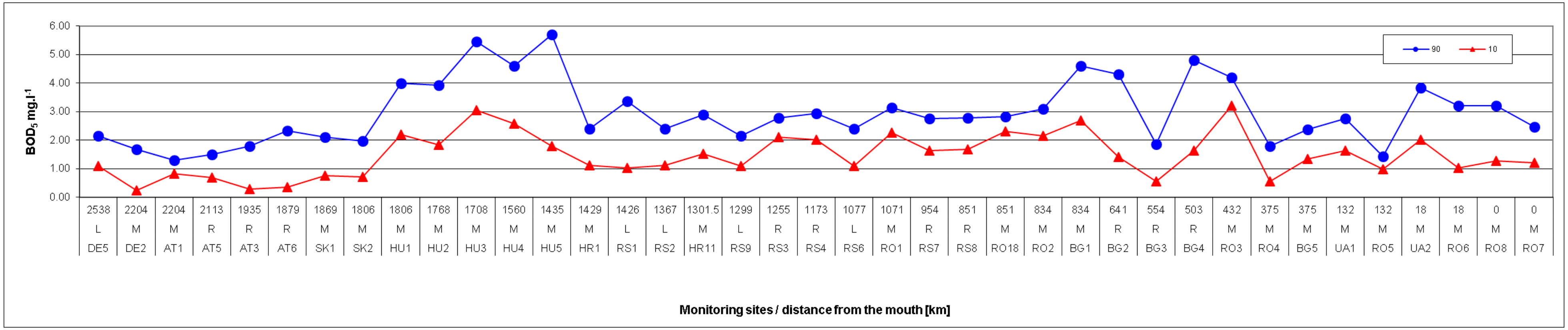
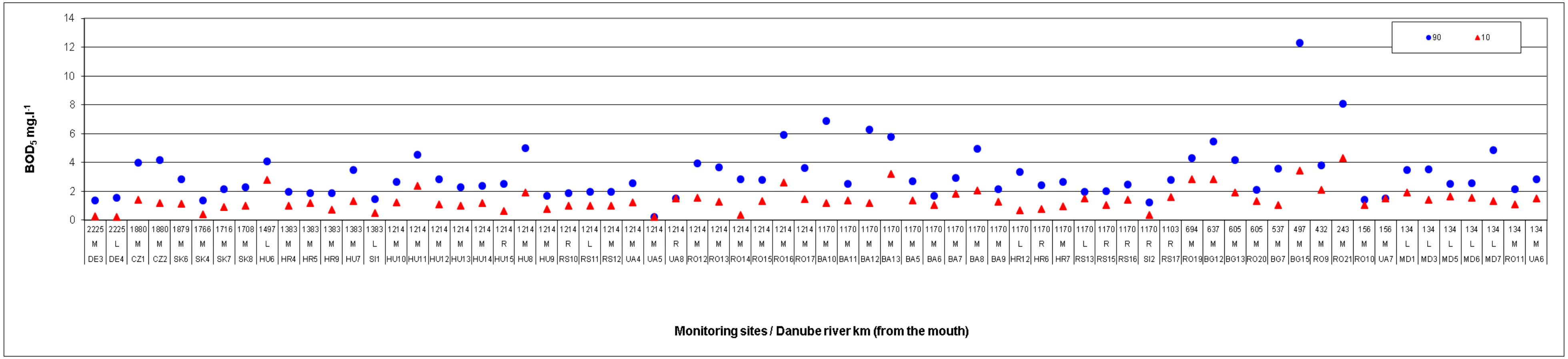


Figure 4.33: The percentile (90, 10) of BOD_5 concentration in the tributaries in 2021



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 2021 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 2021

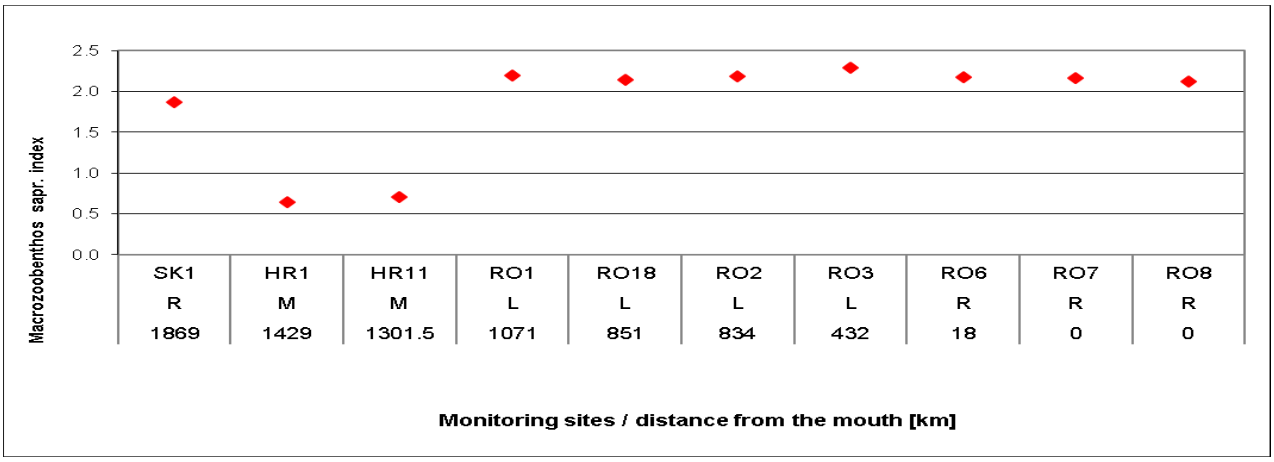


Figure 4.35: The maximum values of saprobic index based on macrozoobentos in the tributaries in 2021

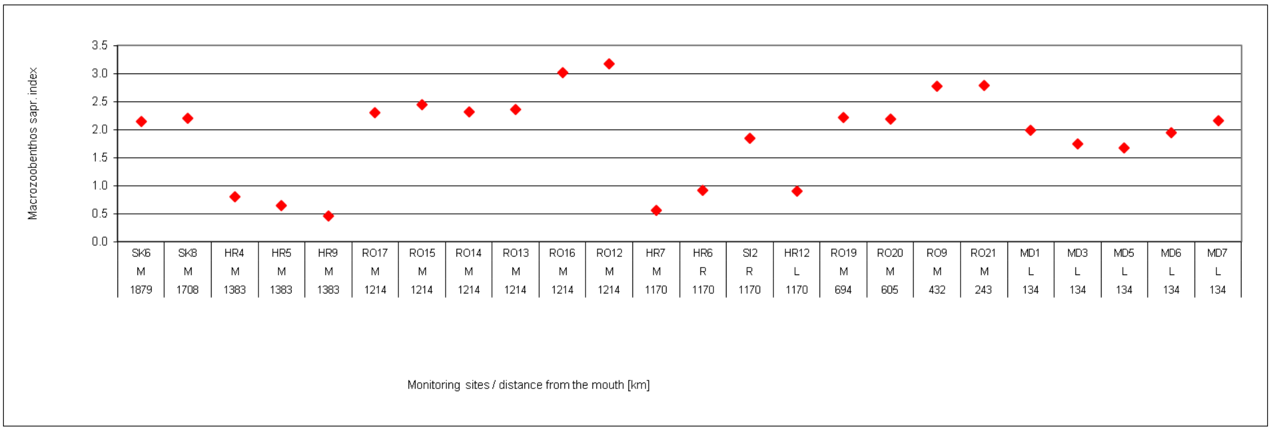
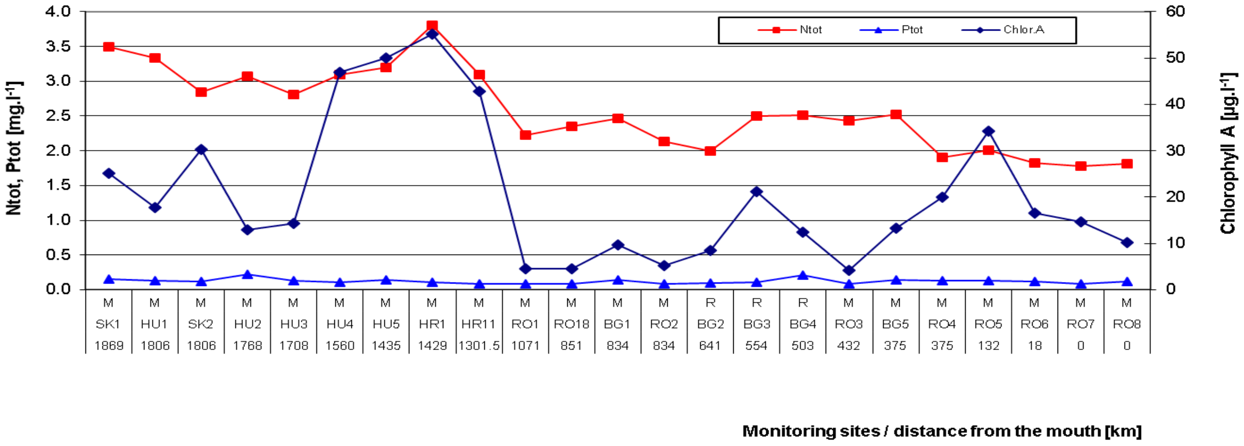


Figure 4.36: The percentile (90) of total nitrogen, total phosphorus and chlorophyll-a concentration along the Danube River in 2021



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 and N_{total} was observed in HR1 Ilok (55.1 µg.l^{-1} N_{total} 3.8 mg.l^{-1}). The highest concentration of P_{total} 0.22 mg.l^{-1} was observed in the Hungarian part – HU2 Komarom.

4.2 The Sava and Tisza Rivers

The 90 percentiles of nutrients, and BOD_5 measured in 2021 in the Sava and Tisza rivers are presented in the Figures 4.37-4.38. The highest value of $N\text{-}NH_4$ in the Sava River (Figure 4.37) was found in monitoring point RS16 (0.24 mg.l^{-1}). The maximum concentration of $N\text{-}NO_3$ was observed in SI2 (Jesenice, 1.55 mg.l^{-1}) and the highest value of N_{total} was measured inHR6 (Jesenice 1.89 mg.l^{-1}).
The highest value of BOD_5in the Sava River was measured in monitoring point HR12 Račinovci (3.3 mg.l^{-1}). The maximum value of COD 15.62 mg.l^{-1} was measured in BA11 Raca.

Figure 4.37: The percentile (90) of total nitrogen, $N\text{-}NH_4$ and $N\text{-}NO_3$ concentration along the Sava River in 2021

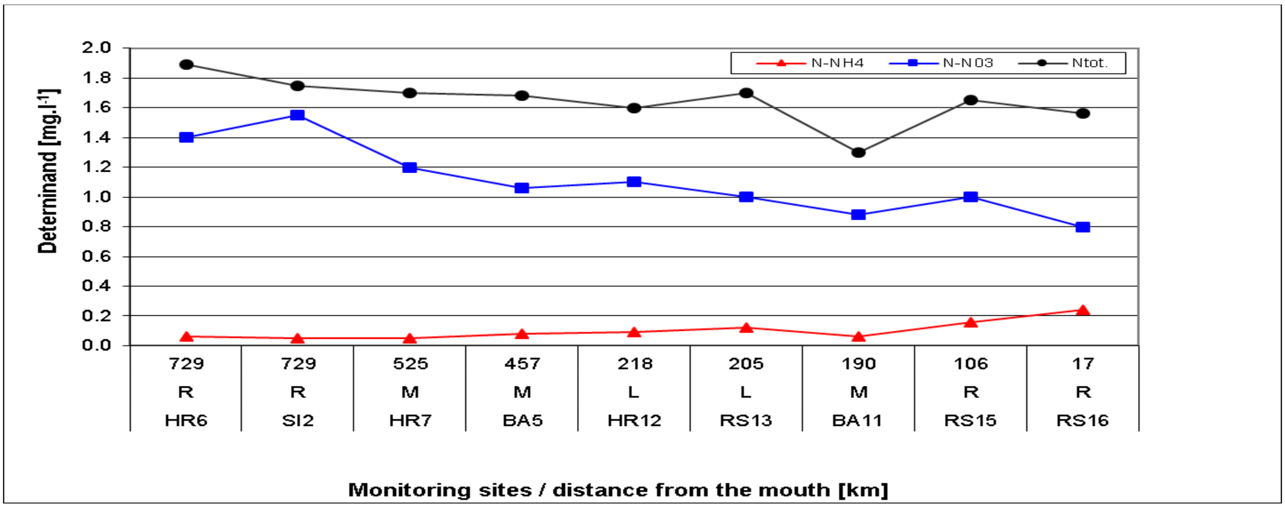


Figure 4.38: The percentile (90) of BOD_5 concentration along the Sava River in 2021

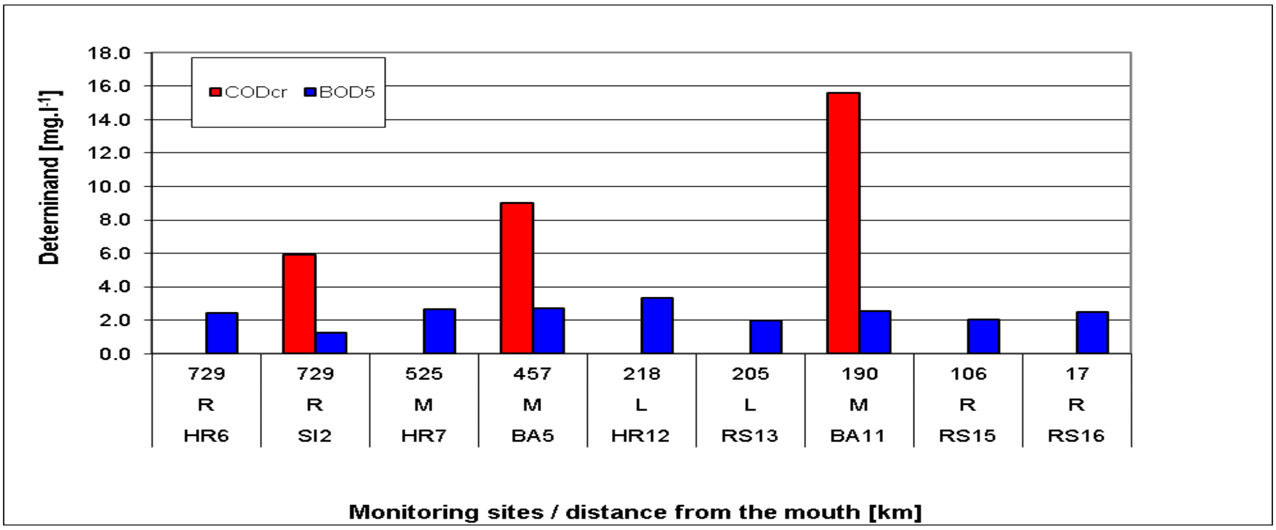


Figure 4.39: The percentile (90) of total nitrogen, N-NH4 and N-NO3 concentration along the Tisza River in 2021

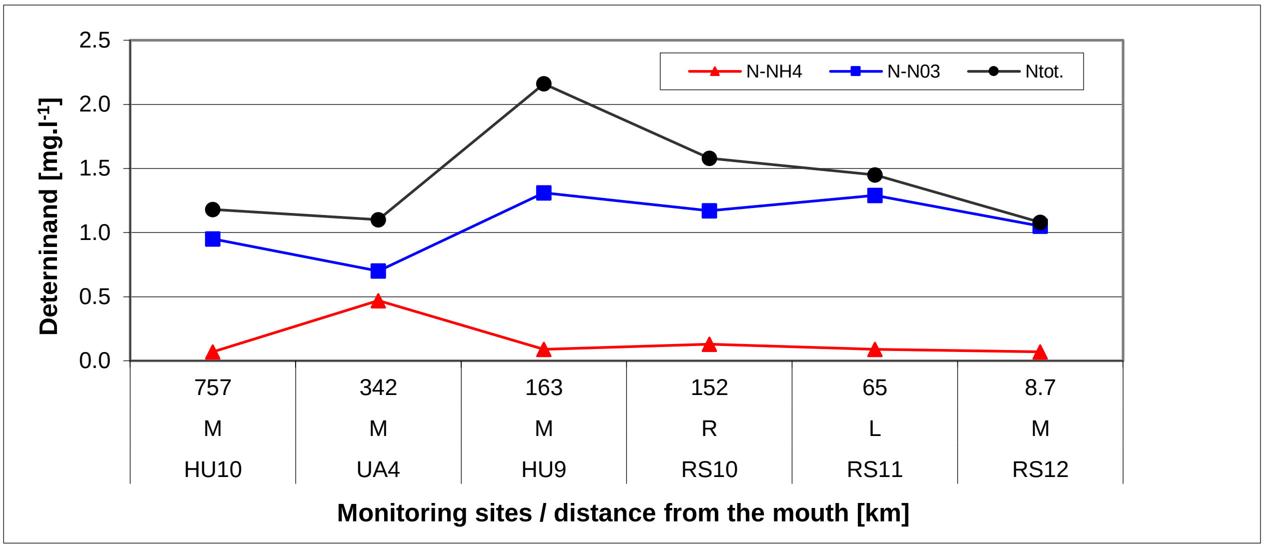
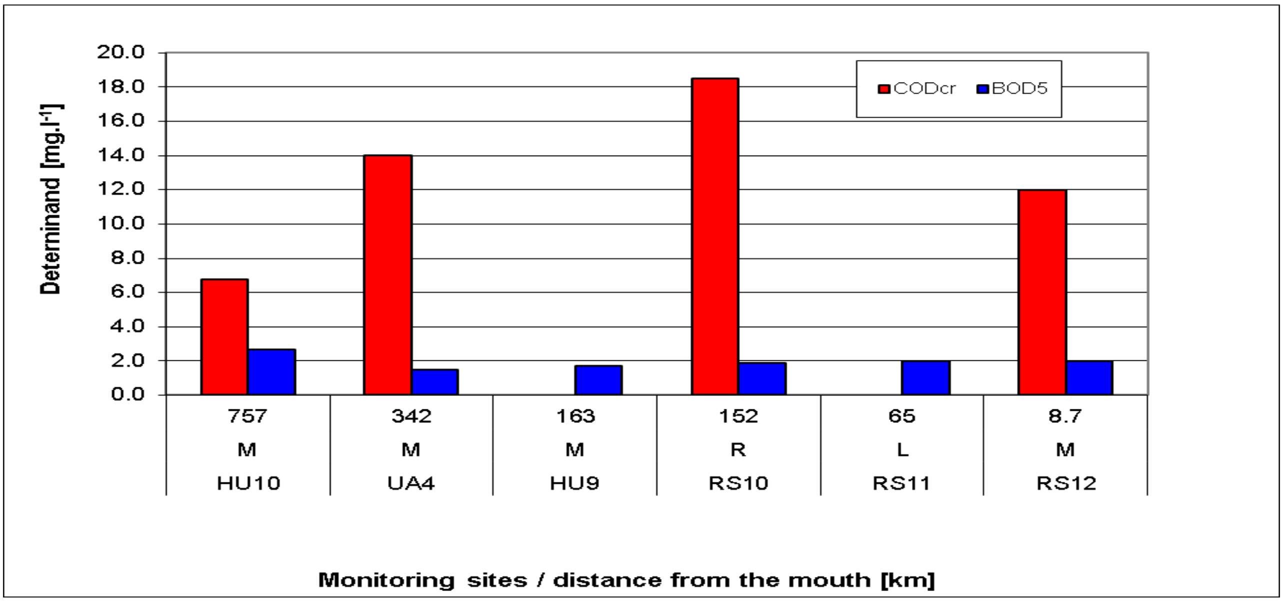


Figure 4.40: The percentile (90) of BOD5 and CODCr concentration along the Tisza River in 2021



The maximum value of $N\text{-}NH_4$ in the Tisza River was found in UA4 Chop ($0.47 mg.l^{-1}$). The highest value of $N\text{-}NO_3$ being $1.31\ mg.l^{-1}$ and maximum of N_{total} being $2.16\ mg.l^{-1}$ were measured in HU9 Tiszasziget.

The highest value of BOD_5 was measured in HU10 Tiszabecs ($2.67\ mg.l^{-1}$) and maximum of COD_{cr} ($18.5\ mg.l^{-1}$) was measured in RS10 Martonos (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 2021

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 2021.

The differences are presented by different colours. The majority of determinands were measured in a frequency of 11 and more 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 21 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:

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

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

The monthly load is calculated by using the formula:

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

where	L_m	monthly load
	Q_m	average monthly discharge

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

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

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

5.5 Results

The above described procedure allows calculation of loads, separately for selected 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 2021
c_{mean}	arithmetical mean of the concentrations in the year 2021
Annual Load	annual load of given determinand in the year 2021

The calculated loads **for 2021**, 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 2020 (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 suspended solids, inorganic nitrogen, chlorides and ortho-phosphate phosphorus increased at most of the assessed monitoring points. BOD_5 load increased at 7 monitoring points and total phosphorus in 5. Ortho-phosphate and dissolved phosphorus increased at 4 monitoring points. Silicates increased at 2 monitoring points. In the monitoring site RO5 (Reni) it is seen that for 7 of 8 assessed determinands loads were higher in 2021.

In tributaries the load values increased at several monitoring points in case of inorganic nitrogen, chlorides and suspended solids.. The highest load of inorganic nitrogen, ortho-phosphate phosphorus and BOD_5 in was found in the Sava River. The maximal load of total phosphorus and silicates was observed in HU9 Tiszasziget. The highest load of suspended solids was measured in the Inn. The maximum of total phosphorus dissolved was found in Siret.

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). In the lower part of the Danube River, at the monitoring sites RO2, RO4 and RO5 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. The loads of most of the determinands were higer than in 2020; only loads of BOD_5, $Pb_{diss.}$, $Cd_{diss.}$ and $Hg_{diss.}$ decreased in 2021.

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 2021.

The mean annual discharges in 2021 on the whole Danube River sites were higher than in 2020. In the upper tributaries and in the middle tributaries these were lower than in 2020. In Ipoly, Tisza and Sava annual discharges were higher than in 2020. In Siret and Prut annual discharges were lower than in 2020.

Table 6: Number of measurements at TNMN locations selected for assessment of pollution load in 2021

Country Code	River	Location	Location in profile	River Km	Number of meausrements in 2021								
					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	24	24	24	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	12	23	24	24	12	12	12	
AT6	Danube	Hainburg	R	1879	365	24	24	24	24	24	24	24	
CZ1	Morava	Lanzhot	M	79	365	12	12	12	12	12	12		
CZ2	Morava/Dyje	Pohansko	M	17	365	12	12	12	12	12	12		
SK1	Danube	Bratislava	L	1869	365	26	26	26	26	26	12	26	26
SK1	Danube	Bratislava	M	1869	365	26	26	26	26	26	12	26	26
SK1	Danube	Bratislava	R	1869	365	26	26	26	26	26	12	26	26
SK4	Váh	Komárno	M	1	365	12	12	12	12	12	12	12	12
SK6	Morava	Devín	M	1	365	11	11	11	11	11	11	11	11
SK7	Hron	Kamenica	M	2	365	12	12	12	12	12	12	12	12
SK8	Ipoly	Salka	M	12	365	12	12	12	12	12	12	12	12
HU3	Danube	Szob	L	1708		12	25	25	25	12	12		12
			M	1708	365	12	25	25	25	12	12		12
			R	1708		12	25	25	25	12	12		12
HU5	Danube	Hercegszántó	M	1435	365	12	25	25	25	12	12		12
HU9	Tisza	Tiszasziget	L	163		12	12	12	12	12	12		12
			M	163	365	11	25	25	25	11	11		11
			R	163		11	11	11	11	11	11		11
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	12	12	12	12	12	12		12*
SI1	Drava	Ormoz	L	300	365	26	26	26	26	26	12		
SI2	Sava	Jesenice	R	729	365	26	26	25	25	26	12		
RO2	Danube	Pristol-Novo Selo	L	834		23	23	23	23	23	12	23	
			M	834	365	24	24	24	24	24	13	24	
			R	834		23	23	23	23	23	12	23	
RO4	Danube	Chiciu-Silistra	L	375	365	26	26	26	25	12	12	12	
			M	375		26	26	26	25	12	12	12	
			R	375		26	26	26	26	12	12	12	
RO5	Danube	Reni	L	132		27	27	27	27	12	12	12	27
			M	132	365	27	27	27	27	12	12	12	27
			R	132		27	27	27	27	12	12	12	27
RO10	M	Siret	M	0	365	26	26	26	25	12	12	9	
RO11	M	Prut	M	0	365	26	26	26	26	12	12	11	
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

Table 7: Mean annual concentrations in monitoring locations selected for load assessment on Danube River in 2021

Station Code	Profile	River Name	Location	River km	Qr (2021)			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	1304	33.61	1.96	0.02	0.04	1.03	20.98	0.02	
AT6	R	Danube	Hainburg	1879	1845	69.11	1.98	0.02	0.03	3.93	19.77	0.02	
SK1	LMR	Danube	Bratislava	1869	1838	29.68	1.47	0.04	0.09	1.34	20.94	0.05	5.56
HU3	LMR	Danube	Szob	1708	2028	23.47	1.70	0.01	0.09	4.36	21.48		4.01
HU5	M	Danube	Hercegszántó	1435	2178	16.67	1.87	0.04	0.08	1.45	21.92		4.01
HR11	M	Danube	Ilok	1302	2733	13.03	1.52	0.03	0.07	2.31	18.42		3.47*
RO2	LMR	Danube	Pristol-Novo Selo	834	4696	36.93	1.29	0.04	0.07	2.74	24.80	0.06	
RO4	LMR	Danube	Chiciu-Silistra	375	5505	23.28	1.28	0.06	0.10	1.32	25.12	0.09	
RO5	LMR	Danube	Reni	132	5998	69.86	1.20	0.06	0.09	1.25	25.35	0.09	5.57*
UA2	M	Danube	Vylkove	18	2911	34.35	1.35	0.04		2.72	31.00	0.10	2.13

Table 8: Mean annual concentrations in monitoring locations selected for load assessment on tributaries in 2021

Station Code	Profile	River Name	Location	River km	Qr (2021)	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	282	74.72	0.61	0.005	0.09	0.93	7.38		
DE4	L	Inn/Salzach	Laufen	47	234	127.63	0.66	0.01	0.11	0.89	9.04		
CZ1	M	Morava	Lanzhot	79	53	22.25	2.39	0.04	0.10	2.83	31.45		
CZ2	L	Morava/Dyje	Pohansko	17.00	39	13.79	3.45	0.15	0.20	2.40	44.84		
SK4	M	Váh	Komárno	1	181	12.33	1.23	0.05	0.10	1.04	20.20	0.06	5.73
SK6	M	Morava	Devín	1	98	21.42	2.33	0.10	0.19	2.08	38.37	0.11	8.60
SK7	M	Hron	Kamenica	2	48	15.25	1.21	0.04	0.11	1.58	17.57	0.06	12.05
SK8	M	Ipoly	Salka	12	44	15.88	1.33	0.12	0.19	1.65	28.46	0.14	18.83
HU9	LMR	Tisza	Tiszasziget	163	781	46.11	0.86	0.04	0.16	1.19	38.53		12.00
SI1	L	Drava	Ormoz	300	328	11.44	1.04	0.01	0.02	0.85	7.48		
SI2	R	Sava	Jesenice	729	276	4.89	1.25	0.02	0.03	0.83	7.76		
HR6	R	Sava	Jesenice	729	274	5.47	1.25	0.03	0.06	1.52	7.91		3.68*
HR7	M	Sava	us. Una Jasenovac	525	711	5.53	1.18	0.04	0.08	1.67	8.48		3.56*
HR12	L	Sava	Računovci	218	1048	21.76	1.00	0.03	0.07	1.87	30.22		4.47*
RO10	M	Siret	Conf. Danube (Sendreni)	729	145	131.00	0.99	0.03	0.07	1.16	62.66	0.09	
RO11	M	Prut	Conf. Danube (Giurgiulesti)	729	72	78.81	0.86	0.04	0.08	1.67	36.35	0.09	

Table 9: Annual load in selected monitoring locations on Danube River in 2021

Station Code	Profile	River Name	Location	River km	Annual Load in 2021							
					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	**2.02**	**74.32**	0.75	1.87	40.42	**0.78**	0.86	🟦
AT6	R	Danube	Hainburg	1879	**7.76**	**112.78**	1.10	1.85	86.31	**1.09**	1.36	🟦
SK1	LMR	Danube	Bratislava	1869	**2.25**	83.20	**2.23**	**5.8**	**73.24**	**1.16**	**3.03**	0.33
HU3	LMR	Danube	Szob	1708	**1.71**	**109.19**	0.97	6.54	**286.46**	**1.34**	🟦	0.25
HU5	M	Danube	Hercegszántó	1435	**1.13**	**129.55**	2.45	**6.1**	**272.30**	1.49	🟦	0.27
HR11	M	Danube	Ilok	1302	1.17	**129.84**	2.55	**5.67**	**192.09**	**1.56**	🟦	0.29*
RO2	LMR	Danube	Pristol-Novo Selo	834	**5.38**	**201.75**	5.53	9.11	**410.14**	**3.55**	7.56	🟦
RO4	LMR	Danube	Chiciu-Silistra	375	**5.18**	**220.61**	**10.16**	**16.79**	**236.30**	**4.21**	**16.56**	🟦
RO5	LMR	Danube	Reni	132	**13.28**	**232.03**	**11.70**	**18.37**	239.83	**4.63**	**18.11**	**1.01***
UA2	M	Danube	Vylkove	18	**3.42**	**132.32**	**3.80**	🟦	**252.00**	**2.78**	**9.71**	**0.20**

*Silicates (SiO_2) in dissolved form

Explanations for comparison of values:

Bold font **increased value in comparison with 2020**

9.69 **maximum value of determinand in 2021 and also increased value in comparison with 2020**

191.98 **maximum value of determinand in 2021, but decreased value in comparison with 2020**

🟦 missing value in 2021 - not assessed

Table 10: Annual load in selected monitoring locations on tributaries in 2021

Station Code	Profile	River Name	Location	River km	Annual Load in 2021							
					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	**1.14**	4.59	0.04	**1.22**	6.65	0.05	🟦	🟦
DE4	L	Inn/Salzach	Laufen	47	**1.64**	**4.45**	0.05	**1.29**	**6.32**	**0.06**	🟦	🟦
CZ1	M	Morava	Lanzhot	79	0.04	4.92	0.06	0.14	3.70	0.04	🟦	🟦
CZ2	L	Morava/Dyje	Pohansko	17	0.02	**5.39**	0.12	0.17	2.25	0.05	🟦	🟦
SK4	M	Váh	Komárno	1	0.07	7.26	0.26	0.56	5.76	0.11	0.34	0.03
SK6	M	Morava	Devín	1	0.06	9.79	0.26	0.51	6.03	0.11	0.29	0.03
SK7	M	Hron	Kamenica	2	0.03	1.82	0.05	0.17	**2.15**	0.02	0.08	0.02
SK8	M	Ipoly	Salka	12	0.01	0.63	0.04	0.08	0.77	0.01	0.05	0.01
HU9	LMR	Tisza	Tiszasziget	163	**1.57**	**25.28**	**0.96**	**4.46**	**30.34**	**0.72**	🟦	**0.33**
SI1	L	Drava	Ormoz	300	0.16	**10.68**	0.05	0.29	8.32	0.07	🟦	🟦
SI2	R	Sava	Jesenice	729	**0.06**	**10.77**	0.16	0.26	5.86	**0.07**	🟦	🟦
HR6	R	Sava	Jesenice	729	0.06	**10.97**	**0.25**	**0.51**	11.45	**0.07**	🟦	**0.03***
HR7	M	Sava	us. Una Jasenovac	525	0.15	**26.55**	0.83	1.80	39.34	0.18	🟦	**0.07***
HR12	L	Sava	Račinovci	218	**0.65**	**35.48**	**1.11**	**2.45**	**67.50**	**0.71**	🟦	**0.13***
RO10	M	Siret	Conf. Danube (Sendreni)	0	**1.22**	4.53	**0.14**	0.31	5.30	0.27	**0.34**	🟦
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	**0.19**	**2.12**	0.08	0.20	4.18	**0.08**	0.21	🟦

*Silicates (SiO$_2$) in dissolved form

Explanations for comparison of values:

Bold font	**increased value in comparison with 2020**
1.18	**maximum value of determinand in 2021 and also increased value in comparison with 2020**
2.75	**maximum value of determinand in 2021, but decreased value in comparison with 2020**
🟦	missing value in 2021 - not assessed

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

Location	Location	River	Number of measurements in 2021																				
	in profile	km	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	$Hg_{diss.}$
Reni	LMR	132	365	27	27	27	27	12	12	12	27	27	27	27	25		12		12		12		12
Location	**Location**	**River**	c_{mean}																				
	in profile	km	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	$Hg_{diss.}$
			$(m^3.s^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(mg.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$	$(\mu g.l^{-1})$
Reni	LMR	132	5998	69.86	1.20	0.061	0.094	1.25	25.35	0.09	5.57	0.07	0.02	1.11	1.61		4.71		0.54		0.08		0.005
Location	**Location**	**River**	Annual Load in 2021																				
	in profile	km		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)
Reni	LMR	132		13.28	232.03	11.70	18.37	239.83	4.63	18.11	1.01	13.74	3.44	214.96	306.86		877.48		100.60		14.19		0.98

Figure 5.1: Annual load of suspended solids along the Danube River in 2021

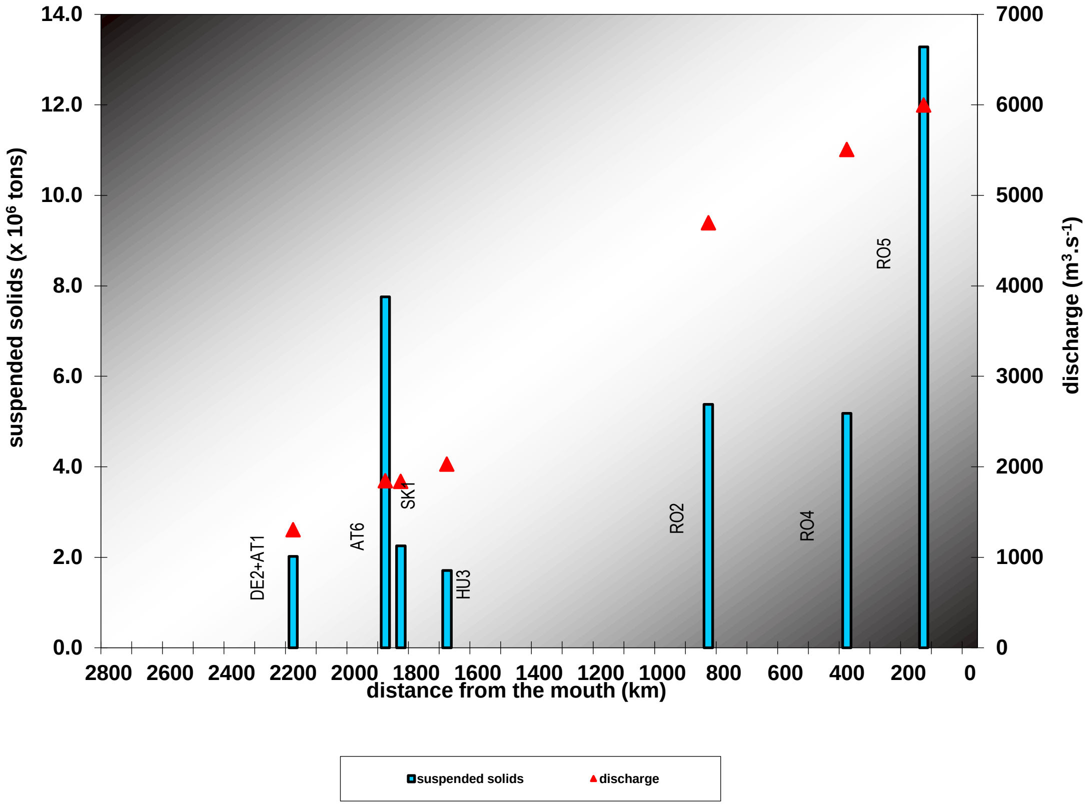


Figure 5.2: Annual load of suspended solids at monitoring locations on tributaries in 2021

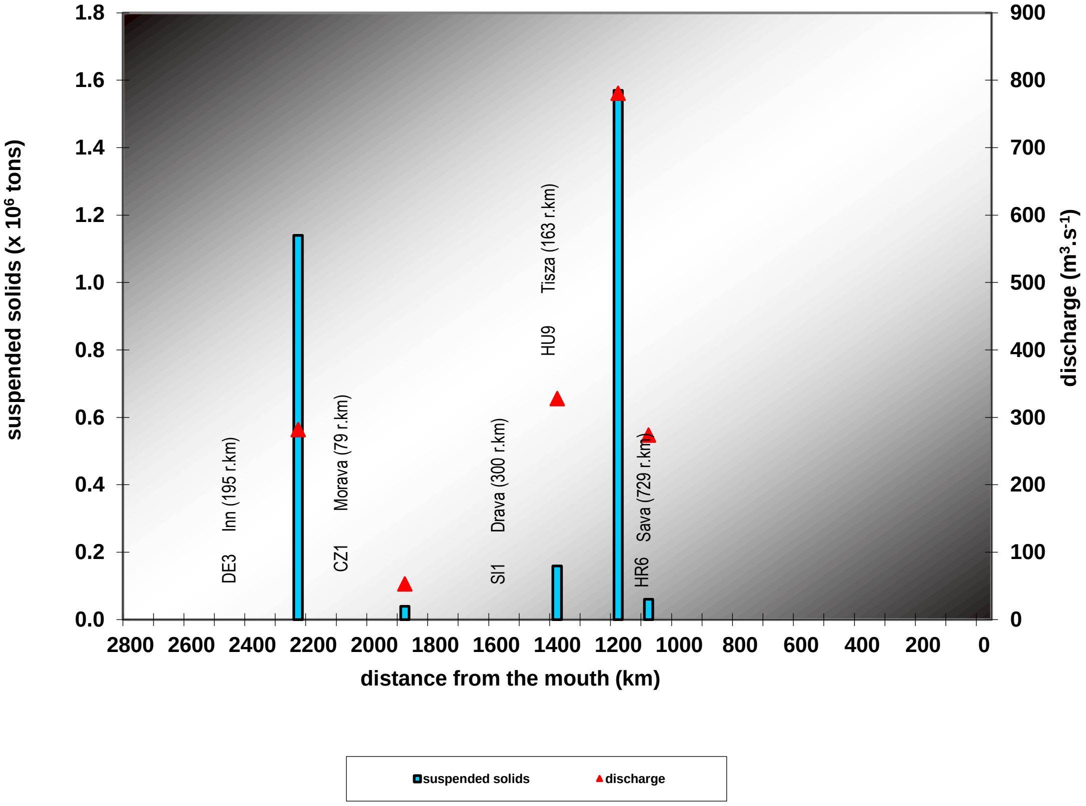


Figure 5.3: Annual loads of inorganic nitrogen along the Danube River in 2021

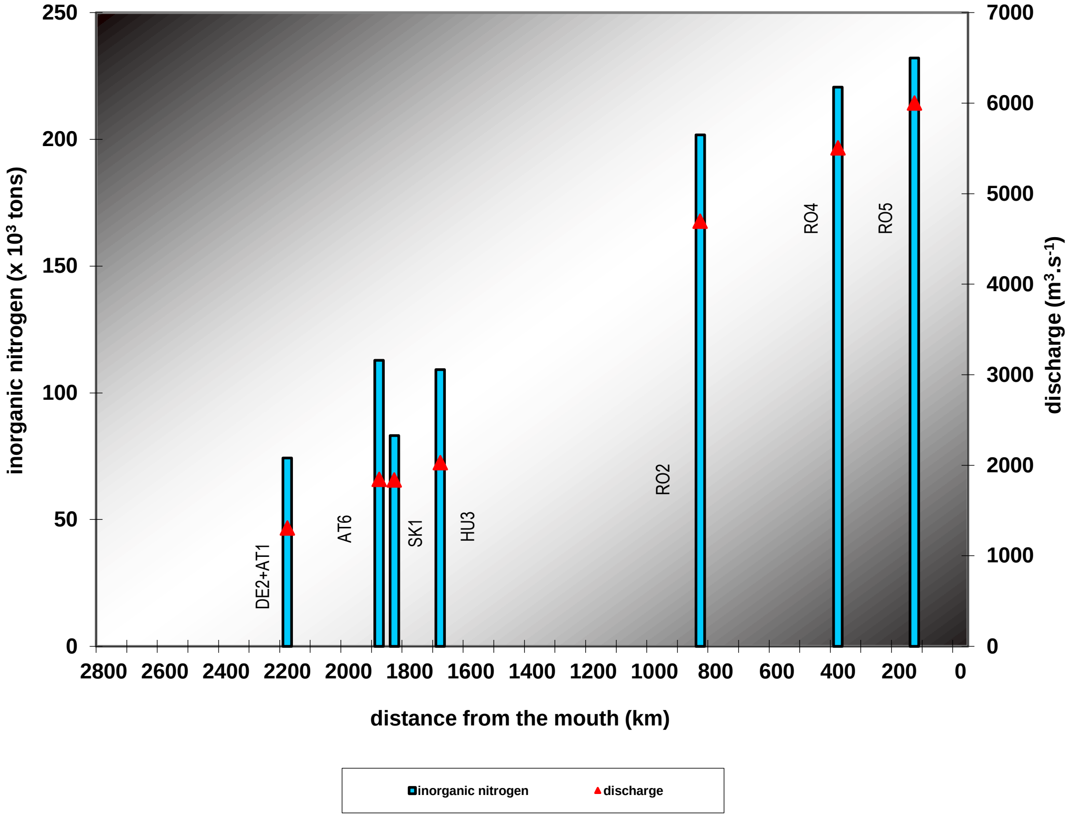


Figure 5.4: Annual loads of inorganic nitrogen at monitoring locations on tributaries in 2021

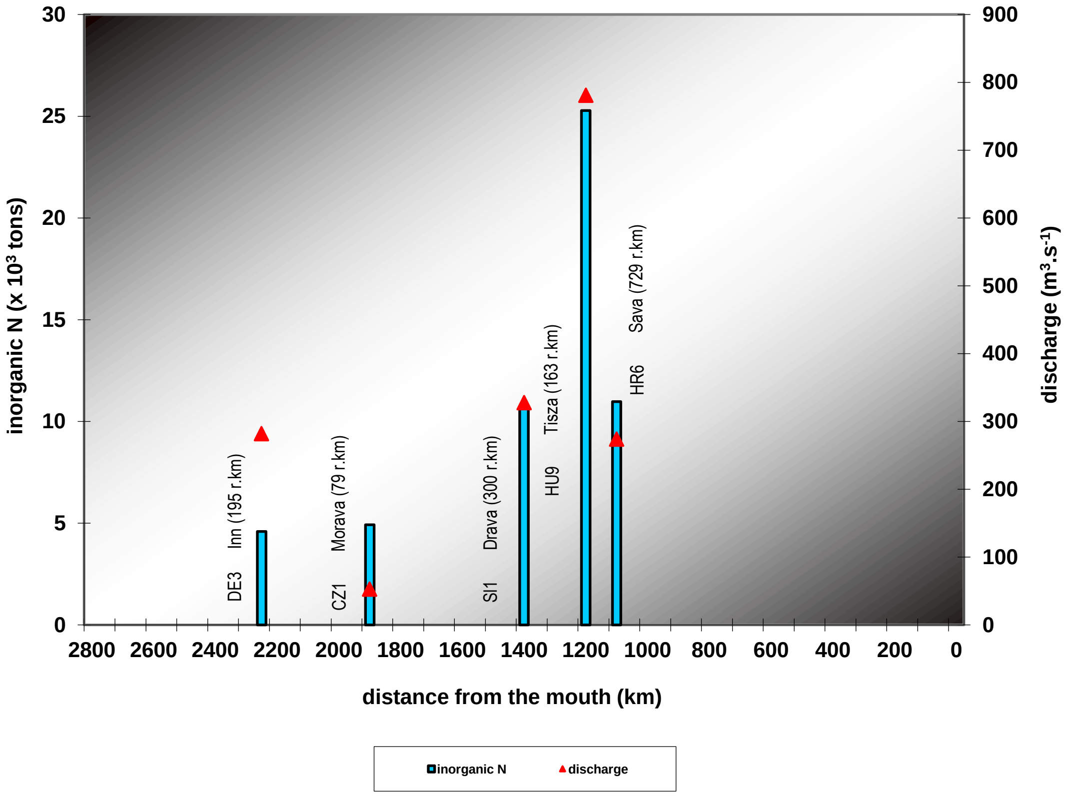


Figure 5.5: Annual loads of P-PO$_4$ at monitoring locations along the Danube River in 2021

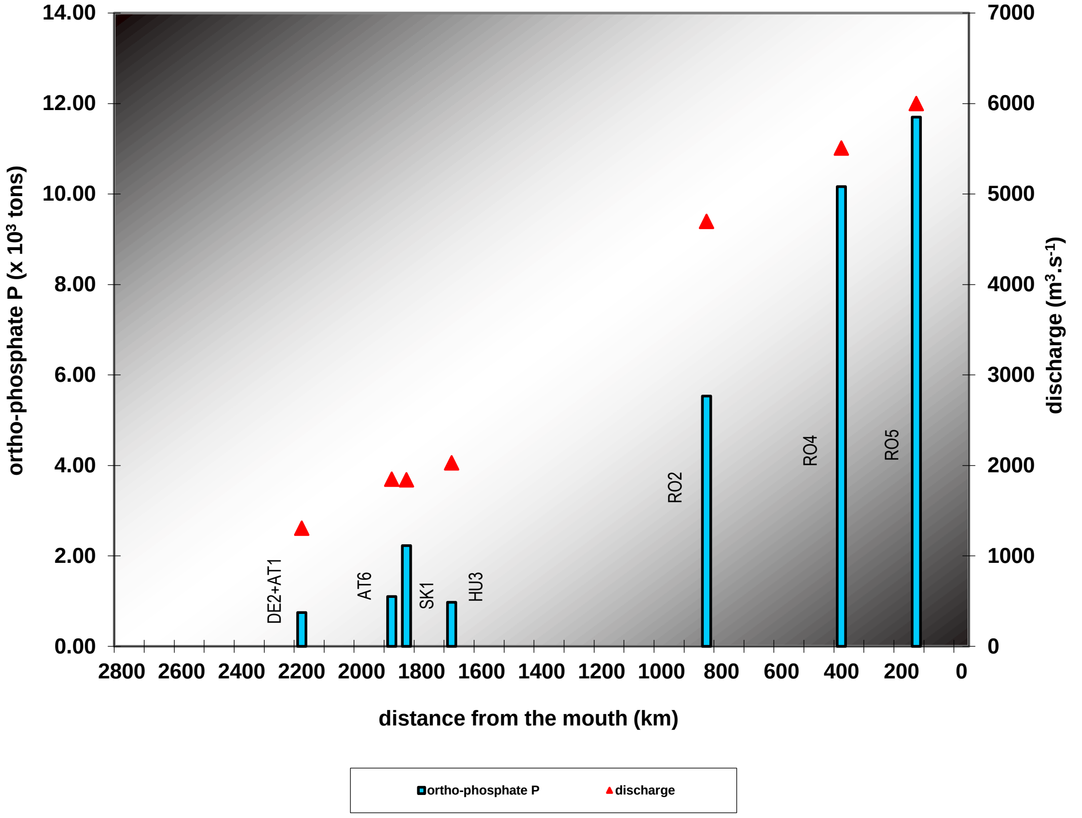


Figure 5.6: Annual loads of P-PO$_4$ at monitoring locations on tributaries in 2021

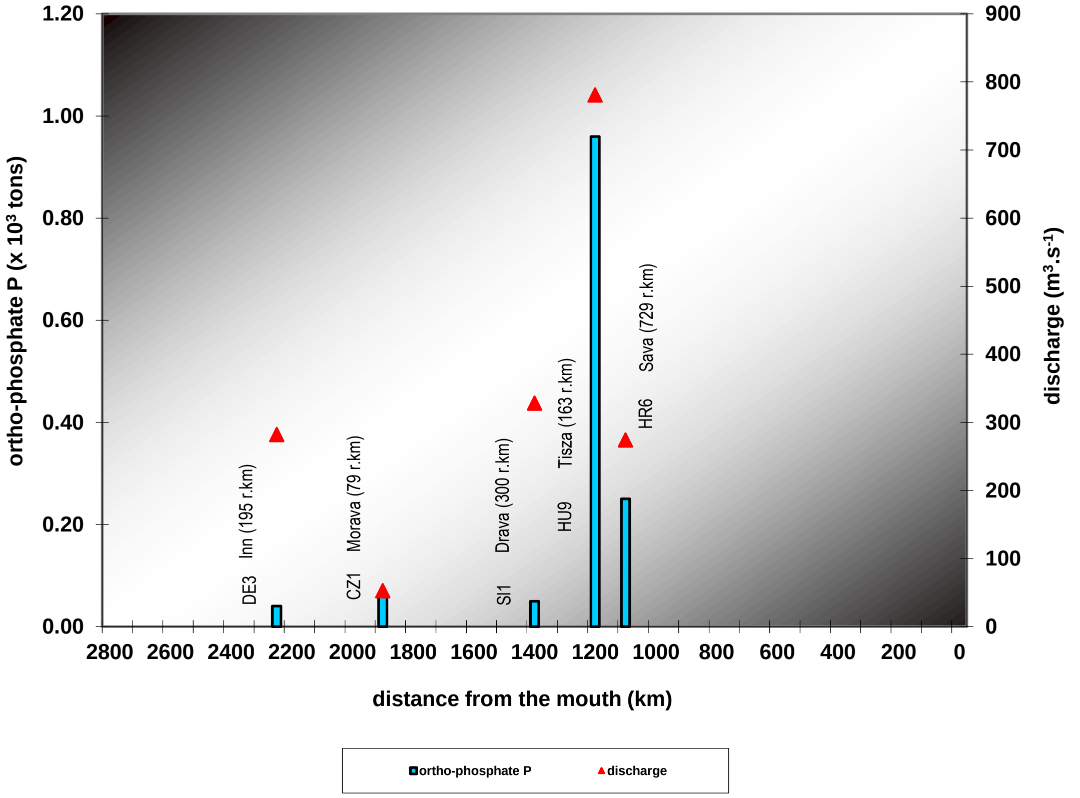


Figure 5.7: Annual loads of total phosphorus along the Danube River in 2021

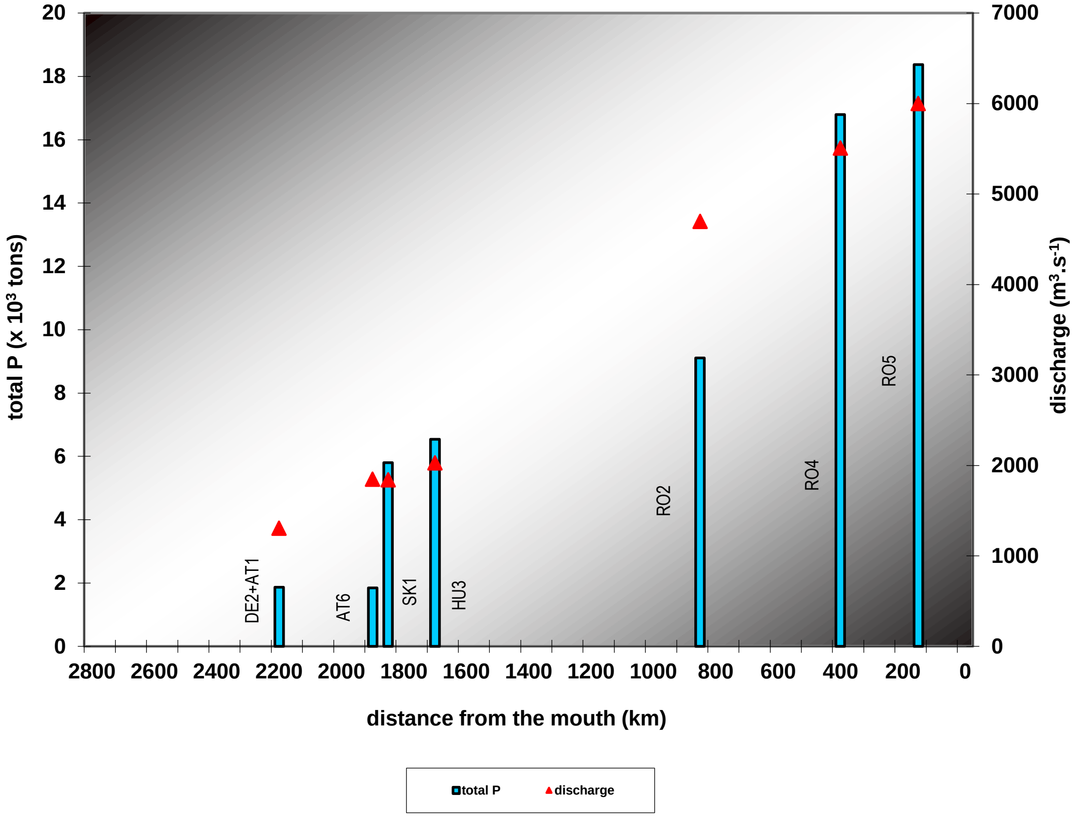


Figure 5.8: Annual loads of total phosphorus at monitoring locations on tributaries in 2021

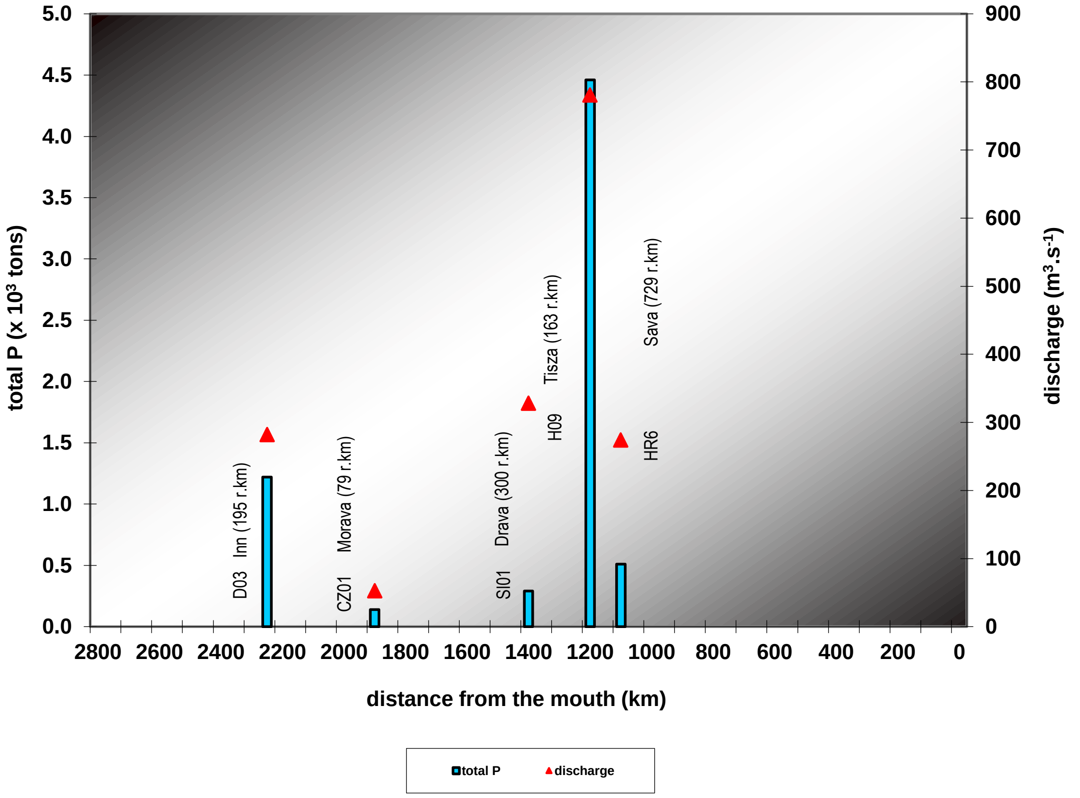


Figure 5.9: Annual loads of BOD_5 along the Danube River in 2021

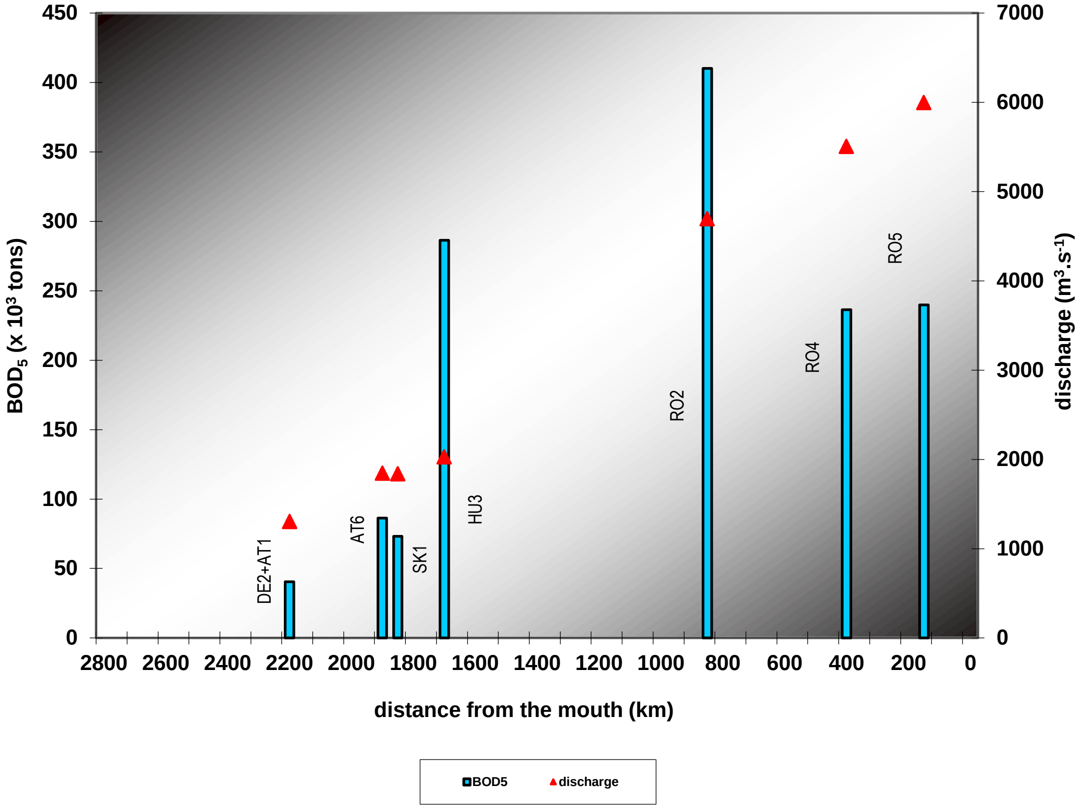


Figure 5.10: Annual loads of BOD_5 at monitoring locations on tributaries in 2021

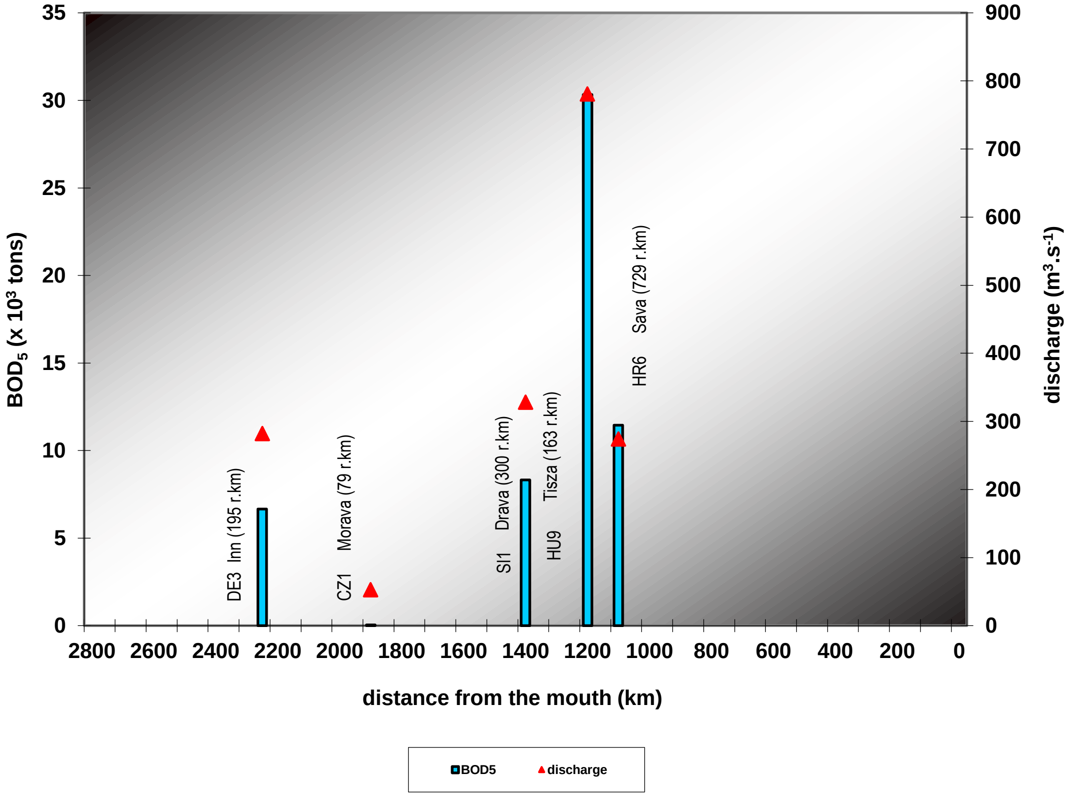


Figure 5.11: Annual loads of chlorides along the Danube River in 2021

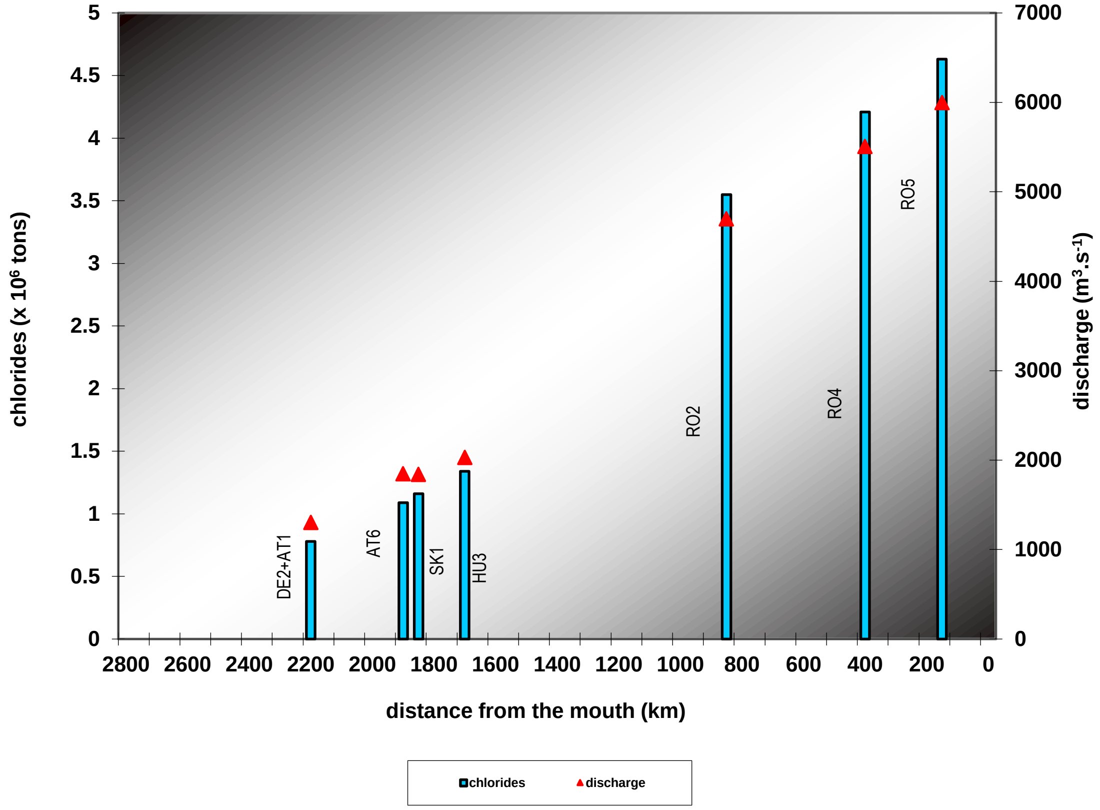


Figure 5.12: Annual loads of chlorides at monitoring locations on tributaries in 2021

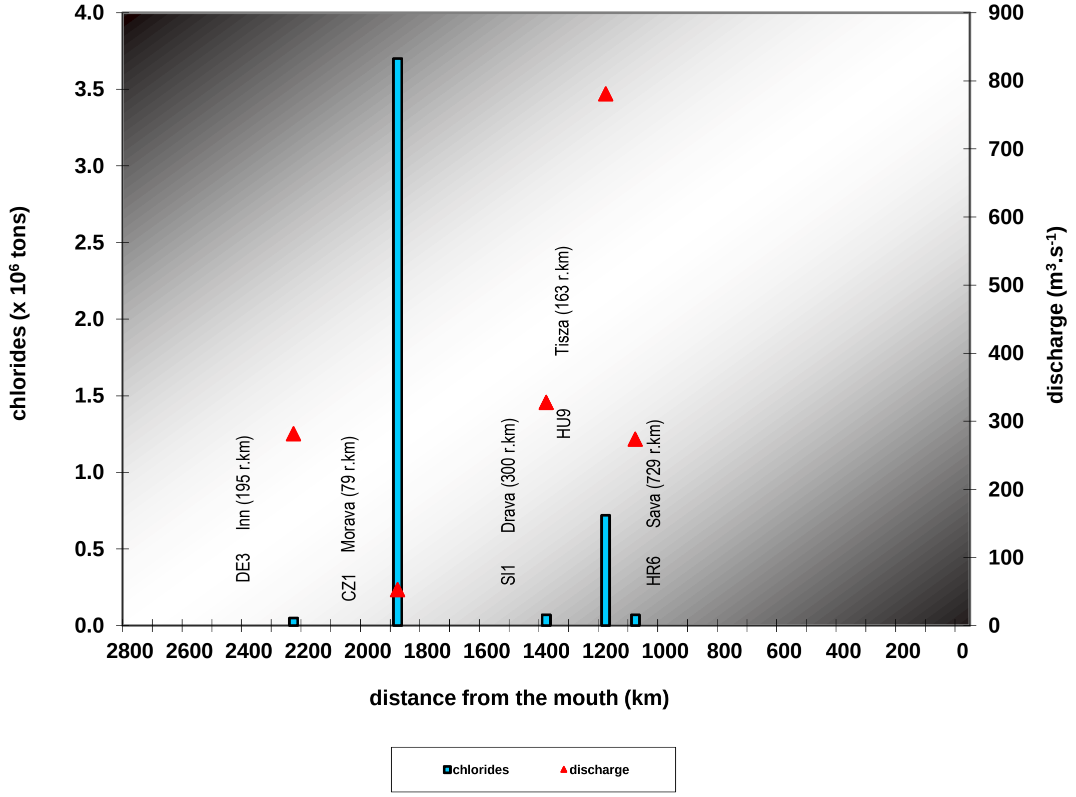


Figure 5.13: Development trend of annual loads of suspended solids at Reni.

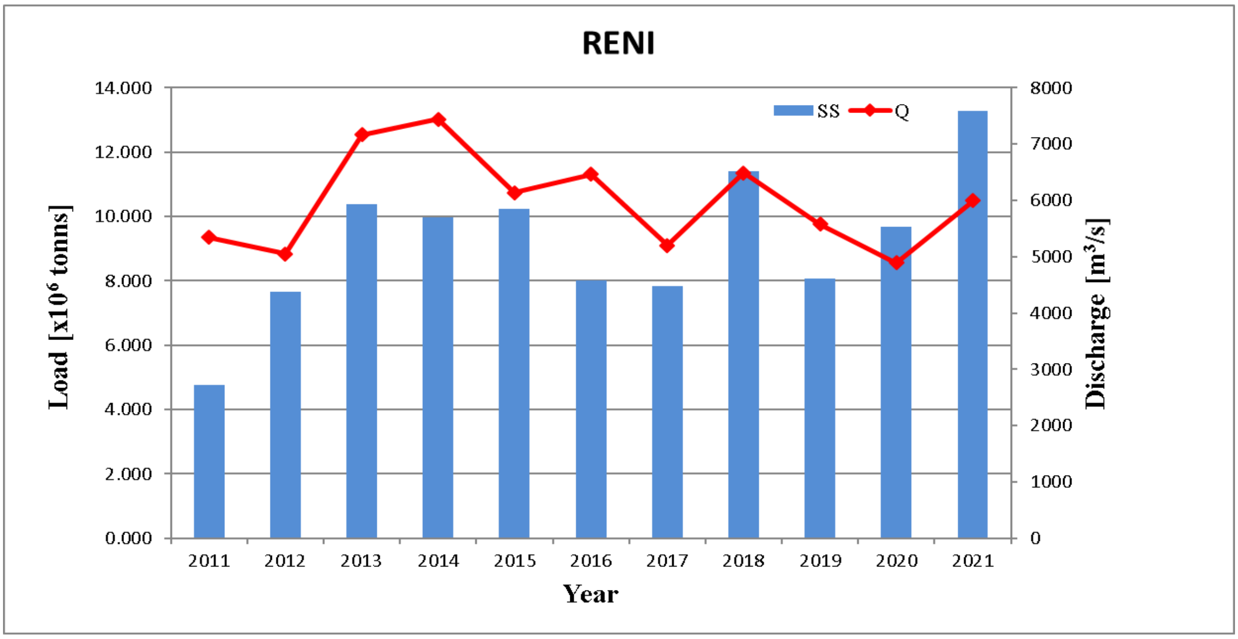


Figure 5.14: Development trend of annual loads of inorganic nitrogen at Reni.

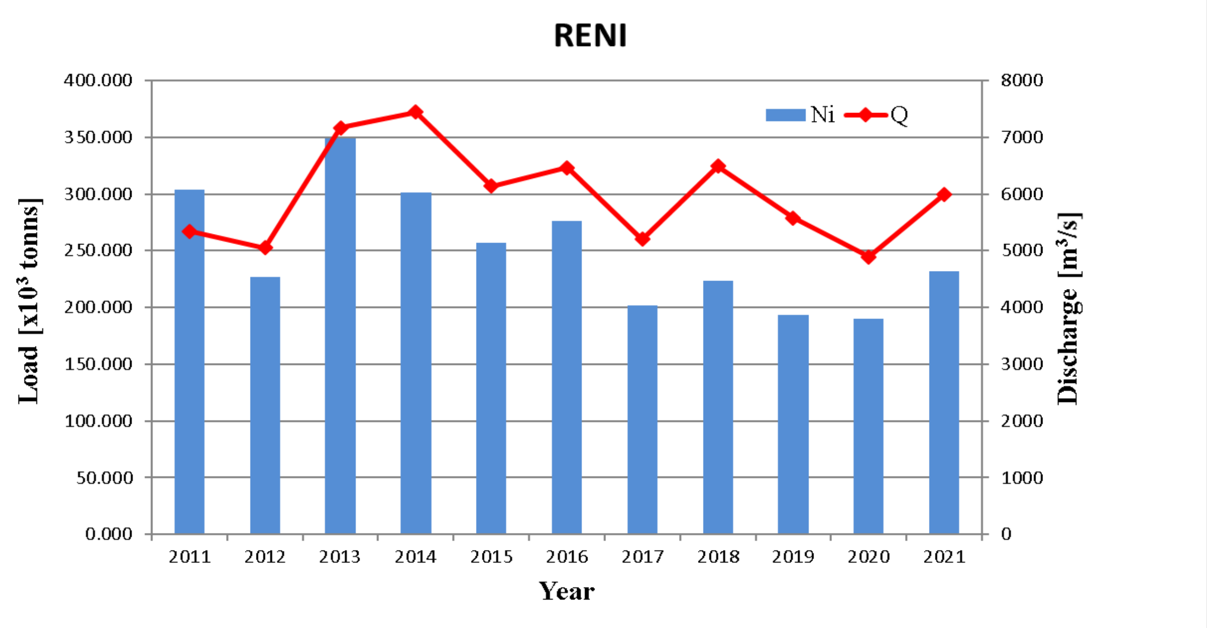


Figure 5.15: Development trend of annual loads of ortho-phosphate phosphorus, total phosphorus and dissolved phosphorus at Reni.

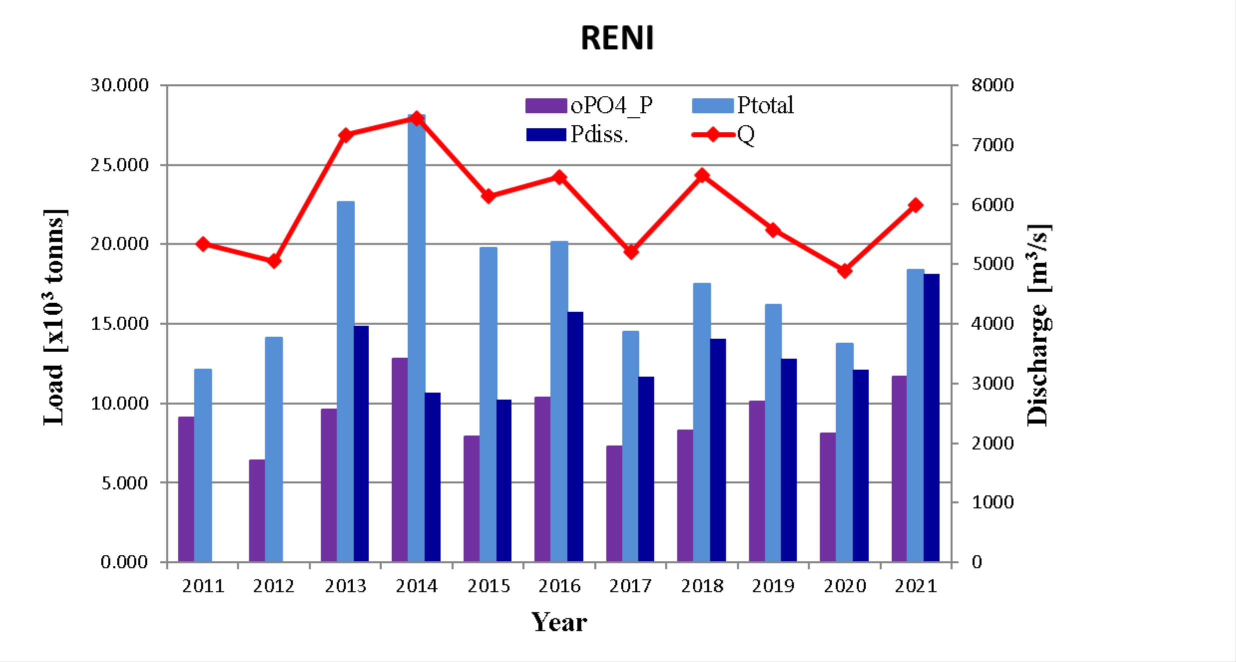


Figure 5.16: Development trend of annual loads of BOD_5 at Reni.

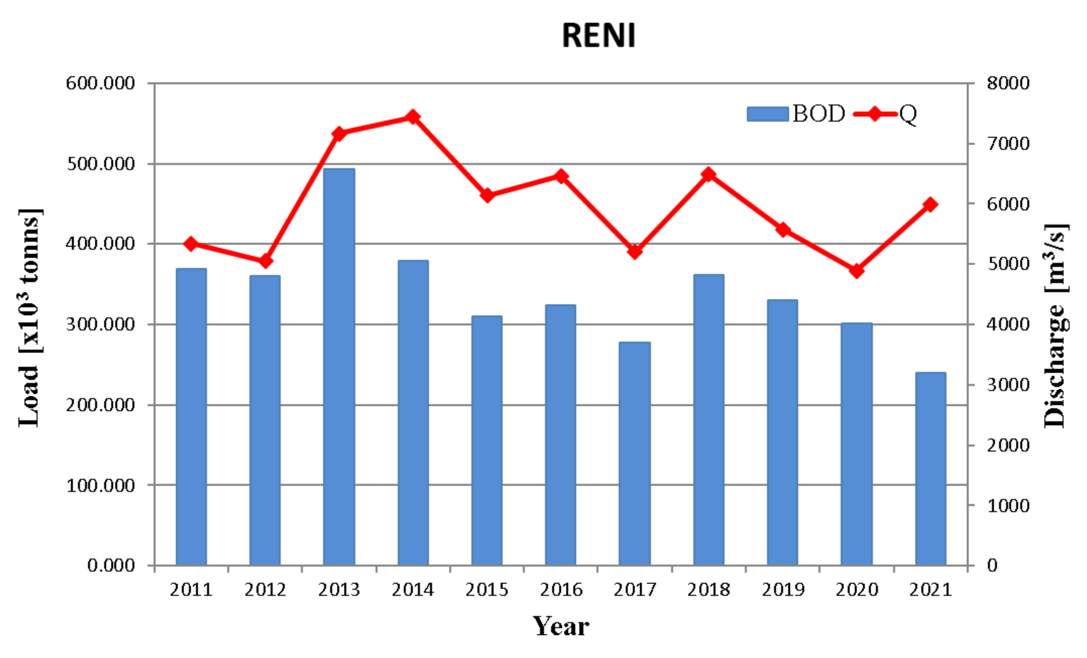


Figure 5.17: Development trend of annual loads of chlorides at Reni.

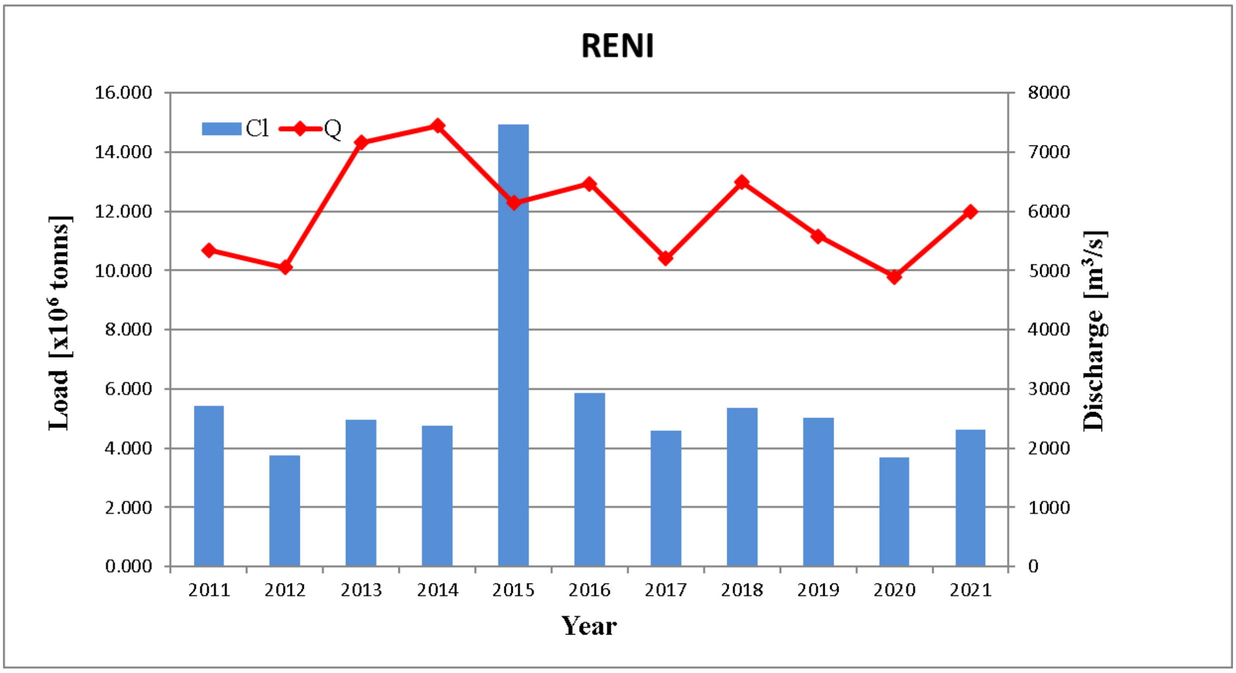
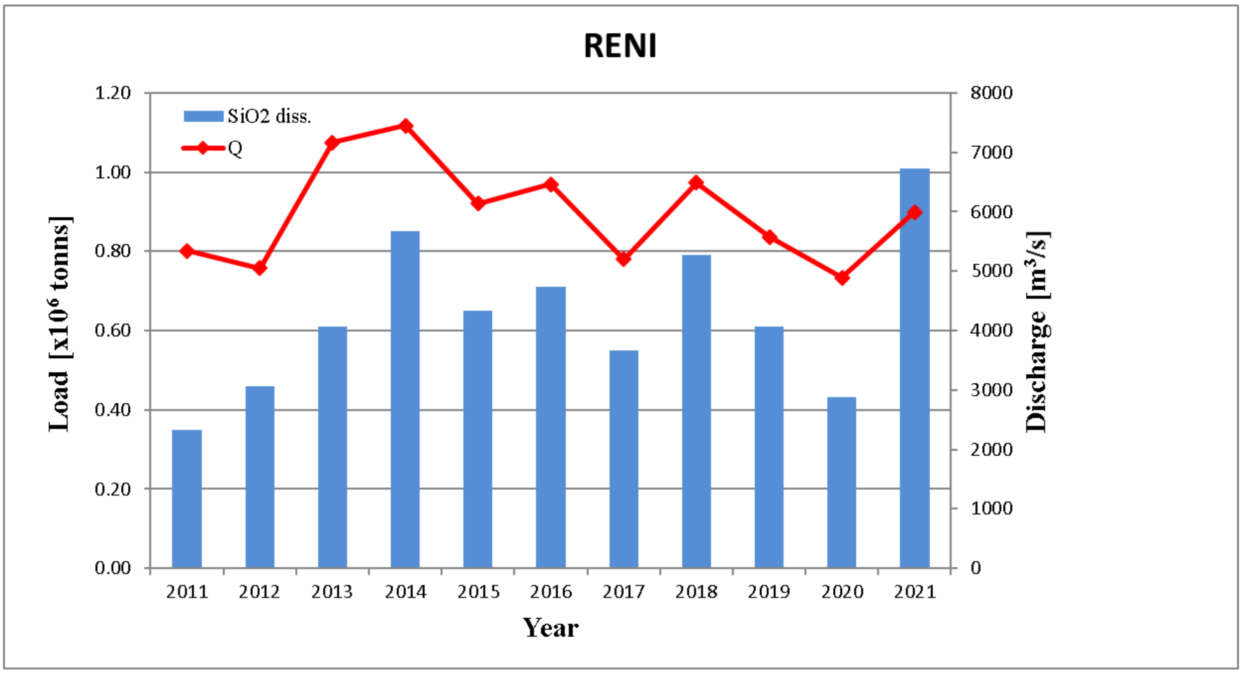


Figure 5.18: Development trend of annual loads of silicates at Reni.



6. Groundwater Monitoring

6.1 GroundwaterBodies of Basin-Wide Importance

In 2000 the Water Framework Directive (2000/60/EC, WFD) entered into force and ICPDR countries including non-EU Member States, agreed to implement the WFD throughout the entire Danube basin. The ICPDR was assigned acting as facilitating platform to coordinate WFD-related work. It was agreed that the River Basin Management Plan (RBMP) for the whole Danube River Basin (DRB) is addressing key issues requiring joint actions on the basin-wide level (Level A), underpinned by more detailed River Basin Management Plans at the national level (Level B).

Within ICPDR the Groundwater Task Group (GW TG) was established to act as the main platform for facilitating and promoting transnational coordination and harmonization of groundwater related aspects in the Danube basin. The GW TG interconnects representatives of the ICPDR Contracting Parties and the ICPDR secretariat and, amongst others, defines criteria and methodologies for the compilation of all necessary information and data for the preparation of the Danube River Basin Management Plan (DRBM Plan) as far as they are relevant on a Danube basin-wide scale.

The ICPDR has agreed to address at the basin-wide level the transboundary groundwater bodies (GWBs) of basin-wide importance. This approach aims to avoid duplicity with the national plans, which provide information on all GWBs, but it enables providing methodological guidance on groundwater management, which is applicable to all GWBs in the DRB.

Transboundary GWBs of basin-wide importance were defined as:

- important due to the size of the GW-body which means an area larger than 4,000 km²; or
- important due to various criteria e.g. socio-economic importance, uses, impacts, pressures interaction with aquatic eco-system. The criteria and the nomination need to be agreed bilaterally.

This means that other GWBs even those with an area larger than 4,000 km², which are fully situated within one country of the DRB, are dealt with at the national level.

The GWBs of basin-wide importance are built up by their national parts. Each national part may constitute of more than one individual national GWB, which are not further considered at the basin-wide level. A link between the content of the DRBM Plan and the national RBMPs is established by the national codes of the individual GWBs.

Over the years, the ICPDR and Danube countries have identified 12 transboundary GWBs of basin-wide importance (the last one, GWB-12 on Ipel/Ipoly, was added in 2019), which are addressed by the DRBM Plan Update 2021[1].

6.2 Groundwater status assessment

As decided by the GW TG, the result of the status assessment is illustrated for each national part of a GWB of basin-wide importance, despite this national part is built up by only one or by more individual national GWBs. As the WFD only foresees status indication (green and red color) for individual GWBs, criteria have been developed for the uniform presentation of status results at the basin-wide level for the national parts as a whole. Hence, if a national part of a GWB of basin-wide importance consists of several individual national-level GWBs then the poor status of only one national-level GWB is decisive for characterizing the whole national part of a GWB of basin-wide importance in poor status (see Figure 6.1)

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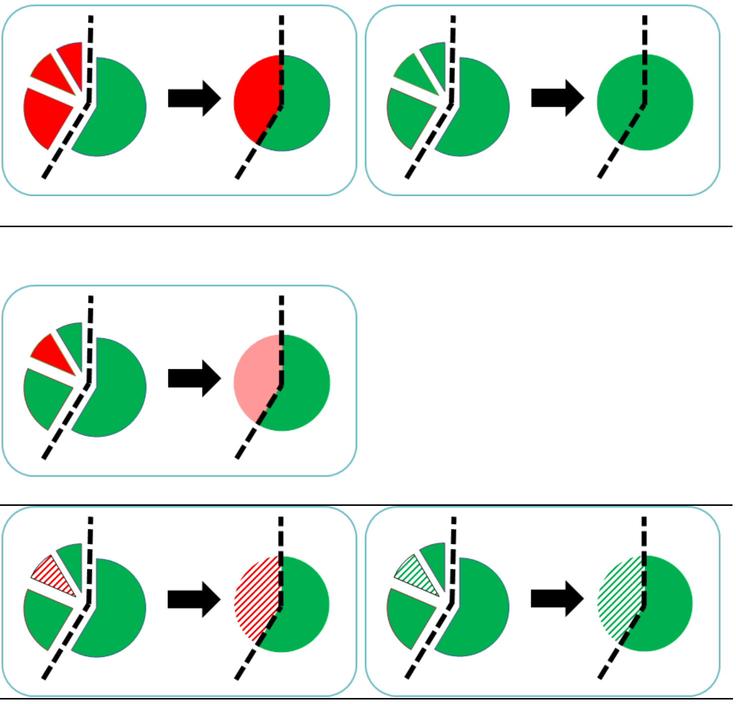
[1] https://www.icpdr.org/main/publications/danube-river-basin-management-plan-drbmp-update-2021

To indicate the (in)homogeneity of the status within a national part of a GWB of basin-wide importance the concept of confidence in status assessment was introduced (illustrated in Figure 6.1). High confidence expresses that all national-level GWBs forming a national part of a GWB of basin-wide importance show the same status (either all good or all poor). Medium confidence is assigned when national-level GWBs show different status results within one national part of a GWB of basin-wide importance. Low confidence indicates that the status assessment is based on risk assessment data.

Figure 6.1: Aggregation confidence levels in groundwater status assessment



High confidence
Good or poor status

- Status assessment is based on WFD compliant monitoring data.
- The national part of a GWB of basin-wide importance is formed by individual national-level GWBs which have the **same status**.

Medium confidence
Poor status

- Status assessment is based on WFD compliant monitoring data.
- The national part of a GWB of basin-wide importance is formed by individual national-level GWBs which do **not have the same status**.

Low confidence
Good or poor status

- The status assessment of at least one individual GWB is based on risk assessment data.

🟥 Poor Status 🟩 Good Status ▨▨ Poor/Good Status based on Risk Assessment

The level of confidence is color coded together with the groundwater status and illustrated in the maps on groundwater quantitative (Table compares the results of the DRBM Plan Update 2015 and the recent Update 2021 concerning the risk and the status assessment for the 12 transboundary GWBs. Compared to the DRBM Plan 2015, the three national shares HU-5, HU-7 and RS-7, which were in poor status, still remain at the same poor status, HU-8 that was in poor status in 2015 is now identified as of good status and HU-9 that was in good status in 2015 is now in poor status. Five national shares (all four currently at poor status and SK-10 at good status) are at risk of failing good quantitative status by 2027.

Figure 6.2) and chemical status (Figure 6.3).

6.3 Groundwater quantitative status

As reported in the DRBM Plan Update 2021, in nine out of 12 transboundary GWBs of basin-wide importance, *good quantitative status* was observed in all 18 national parts. In the three transboundary GWBs – GWB-5, GWB-7 and GWB-9 – three national shares are in good quantitative status and four are in poor status. Altogether, good quantitative status was identified in 21 out of 25 national shares of the 12 transboundary GWBs and four national shares are in poor quantitative status.

The poor quantitative status is caused in HU-7, RS-7 and HU-9 by the exceeding of available groundwater resources; in HU-5 and HU-7 by significant damage to groundwater dependent terrestrial ecosystems and in RS-7 by affected legitimate uses of groundwater.

The results of the quantitative status assessment in the DRBM Plan 2021 are illustrated in Figure 6.2. The summary overview (Table) gives details on the achievement of the individual good quantitative status objectives which had to be considered within the WFD status assessment.

Table compares the results of the DRBM Plan Update 2015 and the recent Update 2021 concerning the risk and the status assessment for the 12 transboundary GWBs. Compared to the DRBM Plan 2015, the three national shares HU-5, HU-7 and RS-7, which were in poor status, still remain at the same poor status, HU-8 that was in poor status in 2015 is now identified as of good status and HU-9 that was in good status in 2015 is now in poor status. Five national shares (all four currently at poor status and SK-10 at good status) are at risk of failing good quantitative status by 2027.

Figure 6.2: Transboundary GWBs of basin-wide importance – Groundwater quantitative status (Source: DRBM Plan Update 2021).

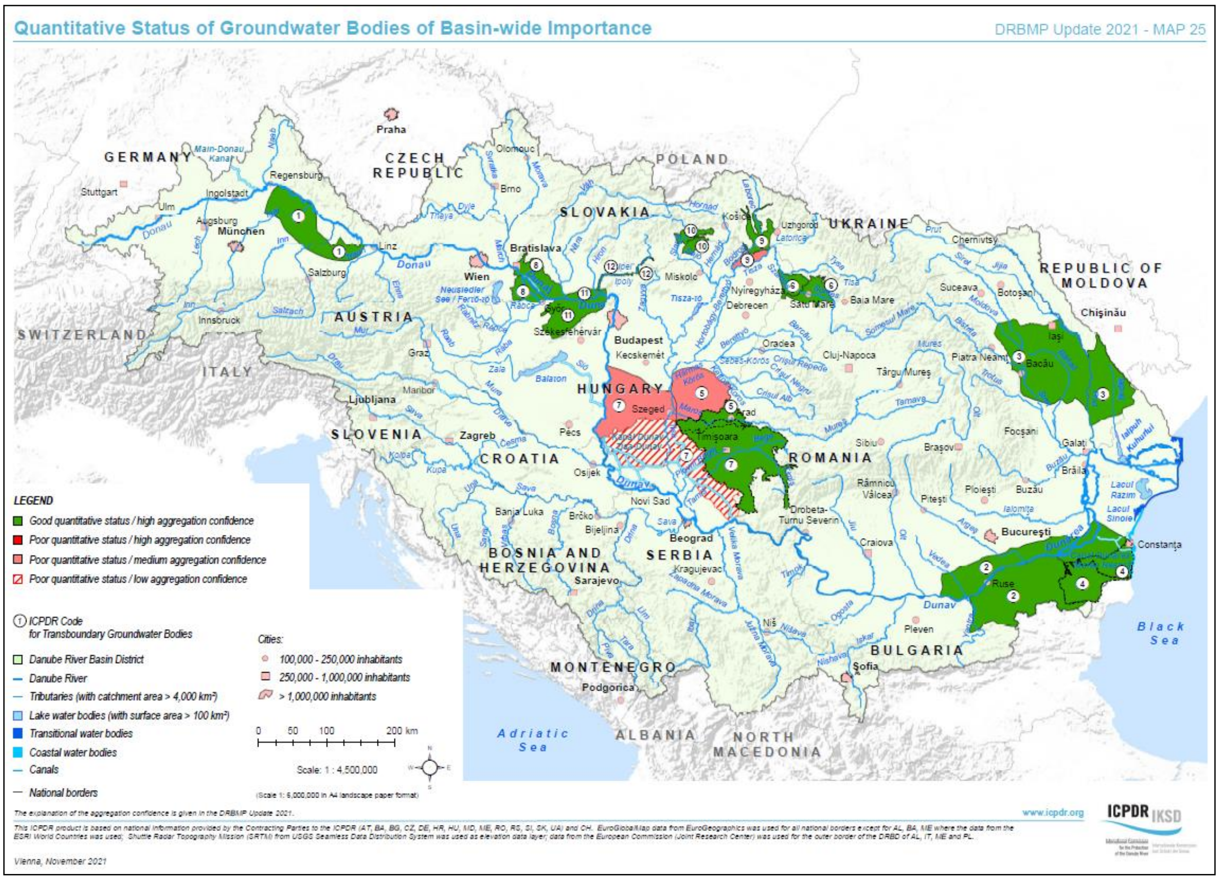


Table 12: Transboundary GWBs of basin-wide importance – Groundwater quantitative status and reasons for failing good status (Source: DRBM Plan Update 2021, Table 34)

GWB	GWB Name	Nat. part	Year of status assessment	Quantitative status 2021	Exceedance of available GW resource	Failed achievement of Article 4 objectives for associated surface waters	Significant damage to GW dependent terrestrial ecosystem	Uses affected (drinking water use, irrigation etc.)	Intrusions detected or likely to happen due to alterations of flow directions resulting from level changes
				good / poor	Yes / - / Unknown	Yes / - / Unknown	Yes / - / Unknown	Yes / - / Unknown If yes, which?	Yes / - / Unknown
GWB-1	Deep GWB – Thermal Water	AT-1	2020	Good	-	-	-	-	-
		DE-1							
GWB-2	Upper Jurassic – Lower Cretaceous GWB	BG-2	2019	Good	-	-	-	-	-
		RO-2	2017						
GWB-3	Middle Sarmatian - Pontian GWB	MD-3	2017	Good	-	-	-	-	-
		RO-3							
GWB-4	Sarmatian GWB	BG-4	2019	Good	-	-	-	-	-
		RO-4	2017						
GWB-5	Mures / Maros	HU-5	2020	Poor	-	-	Yes	-	-
		RO-5	2017	Good			-		
GWB-6	Somes / Szamos	HU-6	2020	Good	-	-	-	-	-
		RO-6	2017						
GWB-7	Upper Pannonian – Lower Pleistocene / Vojvodina / Duna-Tisza köze deli r.	HU-7	2020	Poor	Yes	-	Yes	-	-
		RO-7	2017	Good	-	-	-	-	-
		RS-7	2019	Poor	Yes	Unknown	Unknown	Yes	Unknown
GWB-8	Podunajska Basin, Zitny Ostrov / Szigetköz, Hanság-Rábca	HU-8	2020	Good	-	-	-	-	-
		SK-8	2013-2017						
GWB-9	Bodrog	HU-9	2020	Poor	Yes	-	-	-	Unknown
		SK-9	2013-2017	Good	-				-
GWB-10	Slovensky kras / Aggtelek-hgs.	HU-10	2020	Good	-	-	-	-	-
		SK-10	2013-2017						
GWB-11	Komarnanska Kryha / Dunántúli-khgs. északi r.	HU-11	2020	Good	-	-	-	-	-
		SK-11	2015-2017						
GWB-12	Ipel / Ipoly	HU-12	2020	Good	-	-	-	-	-
		SK-12	2013-2017						

Note: ‘-‘ means ‘No’.

Table 13: Transboundary GWBs of basin-wide importance – Groundwater quantitative risk and status information over a period of 2013 to 2027 (Source: DRBM Plan Update 2021, Table 32)

		Danube RBM Plan 2015				Danube RBM Plan 2021			
GWB	**Nat. part**	**Status 2015**	**Status Pressure Types 2015**	**Risk 2013→2021**	**Risk Pressure Types →2021**	**Status 2021**	**Status Pressure Types 2021**	**Risk 2019→2027**	**Risk Pressure Types →2027**
GWB-1	AT-1	Good	-	-	-	Good	-	-	-
	DE-1								
GWB-2	BG-2	Good	-	-	-	Good	-	-	-
	RO-2								
GWB-3	MD-3	Good	-	-	-	Good	-	-	-
	RO-3								
GWB-4	BG-4	Good	-	-	-	Good	-	-	-
	RO-4								
GWB-5	HU-5	Poor	WA	**Risk**	WA	Poor	WA	**Risk**	WA
	RO-5	Good	-	-	-	Good	-	-	-
GWB-6	HU-6	Good	-	-	-	Good	-	-	-
	RO-6								
GWB-7	HU-7	Poor	WA	**Risk**	WA	Poor	WA	**Risk**	WA
	RO-7	Good	-	-	-	Good	-	-	-
	RS-7	Poor*	WA	**Risk**	WA	Poor	WA	**Risk**	WA
GWB-8	HU-8	Poor	WA	**Risk**	WA	Good	-	-	-
	SK-8	Good	-	-	-				
GWB-9	HU-9	Good	-	-	-	Poor	OP	**Risk**	OP
	SK-9					Good	-	-	-
GWB-10	HU-10	Good	-	-	-	Good	-	-	-
	SK-10							**Risk**	WA
GWB-11	HU-11	Good	-	-	-	Good	-	-	-
	SK-11	Unknown							
GWB-12	HU-12	Good	-	-	-	Good	-	-	-
	SK-12								

*'-' means 'No'; * The status information is of low confidence as it is based on risk assessment.*

Explanation to Table and Table

GWB	ICPDR GWB code which is a unique identifier.	
Nat. part	Code of national shares of ICPDR GWBs	
Danube RBM Plan 2015	**Danube RBM Plan 2021**	
Status 2015	**Status 2021**	**Good / Poor / Unknown**
Status Pressure Types 2015	**Status Pressure Types 2021**	Indicates the significant pressures causing poor status in 2015. **AR** = artificial recharge, **DS** = diffuse sources, **PS** = point sources, **OP** = other significant pressures, **WA** = water abstractions
Significant upward trend (parameter)	**Significant upward trend (parameter)**	Indicates for which parameter a significant sustained upward trend has been identified.
Trend reversal (parameter)	**Trend reversal (parameter)**	Indicates for which parameter a trend reversal could have been achieved.
Risk 2013 ► 2021	**Risk 2019 ► 2027**	**Risk** / - (which means 'no risk')
Risk Pressure Types ► 2021	**Risk Pressure Types ► 2027**	Indicates the significant pressures causing risk of failing to achieve good status in 2021. **AR** = artificial recharge, **DS** = diffuse sources, **PS** = point sources, **OP** = other significant pressures, **WA** = water abstractions

6.4 Groundwater chemical status

As reported in the DRBM Plan 2021, in seven out of 12 transboundary GWBs of basin-wide importance, *good chemical status* was observed in all 14 national shares. In the five transboundary GWBs – GWB-4, GWB-5, GWB-7, GWB-9 and GWB-12 – five national shares are in good chemical status and six are in poor status.

Altogether, good chemical status was identified in 19 out of 25 national shares of the 12 transboundary GWBs and six national shares are in poor chemical status.

The poor chemical status is caused in RO-4, HU-5, RO-5, HU-7, SK-9 and SK-12 by diffuse and point source pollution by nitrates, ammonium, phosphates, sulphates and chlorides, either due to failing the general status assessment objectives of GWBs as a whole (RO-4, RO-5, HU-7, SK-9 and SK-12) or due to failing the requirements of the drinking water protected areas under Article 7 of the WFD (HU-5).

Nitrates were the cause of poor status in five national shares, sulphates, phosphates and ammonium in two and chlorides in one national share.

Significant upward trends of pollutants were identified in 6 national shares, three already in poor status and three in good status. The pollutants comprise phosphates, sulphates, nitrates, ammonium, chlorides, electrical conductivity, chromium and lead.

The results of the chemical status assessment in the DRBM Plan 2021 are illustrated in Figure 6.3. The summary overview (Table) gives details on the achievement of the individual good chemical status objectives which had to be considered within the WFD status assessment.

Figure 6.4 compares the results of the DRBM Plan Update 2015 and the recent Update 2021 concerning the risk, status and trend assessment for the 12 transboundary GWBs. Therein, the number of national shares in poor chemical status increased between 2015 and 2021 from four to six, the number of national shares at risk increased from five to nine and the national shares with significant upward trends remained at six (but not the same national shares and substances in each plan period). In the DRBM Plan 2021 the first trend reversals were reported for in total 3 national shares for 5 different substances.

The four national shares HU-5, RO-5, HU-7 and SK-12, which were in poor status in 2015, still remain at poor status, and the two national shares RO-4 and SK-9 deteriorated from good to poor status. Nine of 25 national shares (all six currently at poor status and SK-8, HU-9 and HU-10 which are in good status) are at risk of failing good chemical status by 2027.

Figure 6.3: Transboundary GWBs of basin-wide importance – Groundwater chemical status (Source: DRBM Plan Update 2021).

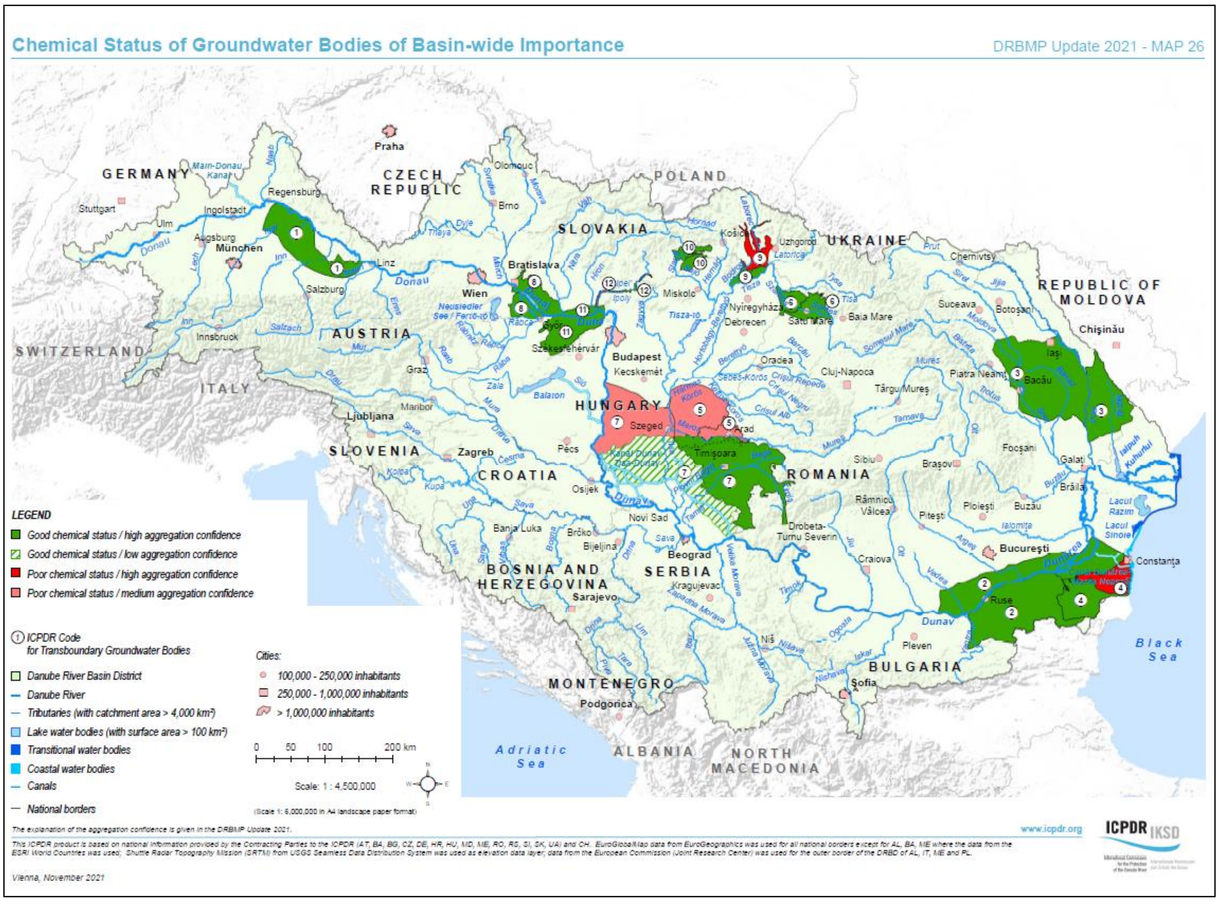
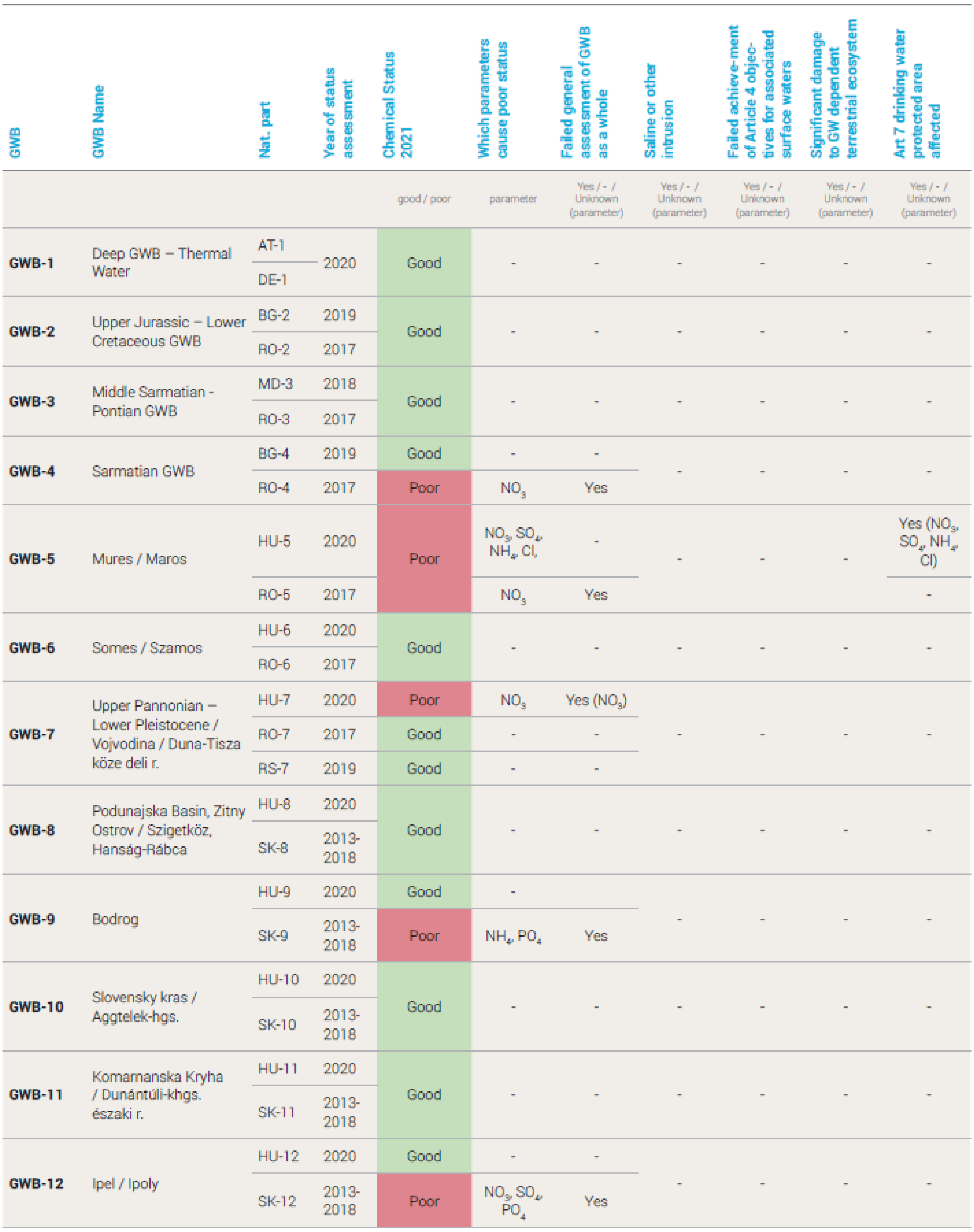


Table 14: Transboundary GWBs of basin-wide importance – Groundwater chemical status and reasons for failing good status (Source: DRBM Plan Update 2021, Table 33)



GWB	GWB Name	Nat. part	Year of status assessment	Chemical Status 2021	Which parameters cause poor status	Failed general assessment of GWB as a whole	Saline or other intrusion	Failed achieve-ment of Article 4 objec-tives for associated surface waters	Significant damage to GW dependent terrestrial ecosystem	Art 7 drinking water protected area affected
				good / poor	parameter	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)	Yes / - / Unknown (parameter)
GWB-1	Deep GWB – Thermal Water	AT-1	2020	Good	-	-	-	-	-	-
		DE-1								
GWB-2	Upper Jurassic – Lower Cretaceous GWB	BG-2	2019	Good	-	-	-	-	-	-
		RO-2	2017							
GWB-3	Middle Sarmatian - Pontian GWB	MD-3	2018	Good	-	-	-	-	-	-
		RO-3	2017							
GWB-4	Sarmatian GWB	BG-4	2019	Good	-	-	-	-	-	-
		RO-4	2017	Poor	NO_3	Yes				
GWB-5	Mures / Maros	HU-5	2020	Poor	NO_3, SO_4, NH_4, Cl,	-	-	-	-	Yes (NO_3, SO_4, NH_4, Cl)
		RO-5	2017		NO_3	Yes				-
GWB-6	Somes / Szamos	HU-6	2020	Good	-	-	-	-	-	-
		RO-6	2017							
GWB-7	Upper Pannonian – Lower Pleistocene / Vojvodina / Duna-Tisza köze deli r.	HU-7	2020	Poor	NO_3	Yes (NO_3)	-	-	-	-
		RO-7	2017	Good	-	-				
		RS-7	2019	Good	-	-				
GWB-8	Podunajska Basin, Zitny Ostrov / Szigetköz, Hanság-Rábca	HU-8	2020	Good	-	-	-	-	-	-
		SK-8	2013-2018							
GWB-9	Bodrog	HU-9	2020	Good	-		-	-	-	-
		SK-9	2013-2018	Poor	NH_4, PO_4	Yes				
GWB-10	Slovensky kras / Aggtelek-hgs.	HU-10	2020	Good	-	-	-	-	-	-
		SK-10	2013-2018							
GWB-11	Komarnanska Kryha / Dunántúli-khgs. északi r.	HU-11	2020	Good	-	-	-	-	-	-
		SK-11	2013-2018							
GWB-12	Ipel / Ipoly	HU-12	2020	Good	-	-	-	-	-	-
		SK-12	2013-2018	Poor	NO_3, SO_4, PO_4	Yes				

Note: '-' means 'No'.

Table 15: Transboundary GWBs of basin-wide importance – Groundwater chemical risk, status and trend information over a period of 2013 to 2027 (Source: DRBM Plan Update 2021, Table 31)

		Danube RBM Plan 2015						Danube RBM Plan 2021					
GWB	Nat. part	Status 2015	Status Pressure Types 2015	Significant upward trend (parameter)	Trend reversal (parameter)	Risk 2013→2021	Risk Pressure Types →2021	Status 2021	Status Pressure Types 2021	Significant upward trend (parameter)	Trend reversal (parameter)	Risk 2019→2027	Risk Pressure Types →2027
GWB-1	AT-1	Good	-	-	-	-	-	Good	-	-	-	-	-
	DE-1												
GWB-2	BG-2	Good	-	-	-	-	-	Good	-	-	-	-	-
	RO-2									Cl			
GWB-3	MD-3	Good	-	-	-	Risk	PS, DS, WA	Good	-	-	-	-	-
	RO-3					-	-						
GWB-4	BG-4	Good	-	-	-	-	-	Good	-	-	-	-	-
	RO-4							Poor	DS			Risk	DS
GWB-5	HU-5	Poor	DS	SO_4	-	Risk	DS	Poor	DS	NO_3, NH_4, EC, SO_4		Risk	DS
	RO-5			NH_4						Cr, Pb			
GWB-6	HU-6	Good	-	-	-	-	-	Good	-	-	-	-	-
	RO-6												
GWB-7	HU-7	Poor	DS	NO_3	-	Risk	DS	Poor	DS	-	-	Risk	DS
	RO-7	Good	-	-	-	-	-	Good	-	-	PO_4, Cl	-	-
	RS-7	Good*	-			-	-	Good	-	-	-	-	-
GWB-8	HU-8	Good	-	-	-	-	-	Good	-	-		-	-
	SK-8	Good		NH_4, NO_3, Cl, As, SO_4			PS, DS			PO_4	NH_4**, Cl**, SO_4, TOC	Risk	PS, DS
GWB-9	HU-9	Good	-	-	-	-	-	Good		NH_4	-	Risk	DS
	SK-9							Poor	DS, PS	PO_4	NH_4		
GWB-10	HU-10	Good	-	-	-	-	-	Good	-	-	-	Risk	PS
	SK-10												
GWB-11	HU-11	Good	-	-	-	-	-	Good	-	-	-	-	-
	SK-11	Unknown		Unknown*									
GWB-12	HU-12	Good	DS	NO_3	-	Risk	-	Good	-	-	-	-	-
	SK-12	Poor	DS	SO_4				Poor	DS	-	-	Risk	DS

Note: '-' means 'No'. The status information is of low confidence as it is based on risk assessment; ** The trend was partially reversed, it means that for some monitoring sites significant upward trends in the DRBM Plan 2015 were identified. TOC - total organic carbon

6.5 Reporting on groundwater quality within the TNMN

The transnational groundwater management activities in the DRB were initiated in 2002 and were triggered by the implementation of the WFD. Monitoring of the now 12 transboundary GWBs of basin-wide importance has been integrated into the TNMN of the ICPDR and a 6-year reporting cycle has been set, which is in line with reporting requirements under the WFD and which will sufficiently allow for making statements on significant changes in concentrations of certain substances for these GWBs. Now groundwater quality data have been collected the third time.

The core set of parameters which were agreed to be reported are: electrical conductivity, nitrates, ammonium, all parameters posing risk or causing poor status and all parameters which are characterizing groundwater chemistry. As it can be seen in Table , nitrates, ammonium, phosphates, sulphates and chlorides are causing poor chemical status in the DRBM Plan Update 2021.

For each national part of a GWB of basin-wide importance and each parameter the following statistical distribution values are presented: minimum, mean and maximum values and the 10-, 25-, 50-, 75- and 90-percentiles. The statistical values are based on annual arithmetic mean values (for the reference year) for each monitoring site. The number of monitoring sites and the groundwater threshold values complement the data collection.

6.6 Groundwater chemical monitoring results

All countries sharing transboundary GWBs of basin-wide importance provided the requested statistical values on groundwater quality data, except Moldova (MD-3). In addition to the 25 national shares of GWBs of basin-wide importance, Hungary distinguished the data for HU-5, HU-6, HU-7, HU-8 and HU-9 between a shallow porous and a deep porous part and Romania distinguished the data for RO-5 and RO-6 into two parts due to striking differences in groundwater chemistry. For this data assessment, the reference year of the data is 2020 for all Hungarian GWBs and 2021 for all GWBs in Austria, Bulgaria, Germany, Romania, Serbia and Slovak Republic (except for SK-11 with 2019).

The data coverage is almost complete. For all national shares except MD-3 (24 of 25 shares), data are available for ammonium, chloride and sulphate. Nitrates data are available for 22 national shares, phosphates for 21 and electrical conductivity for 18 (not monitored in Romania - with 6 shares).

To give a broader picture on the current situation the data are presented in Box-and-Whisker-Plots where the 10- and 90-percentiles represent the Whiskers.

The overview of threshold values in 12 transboundary GWBs of basin-wide importance is provided in Table .

Table 16: Groundwater threshold values

	National share	Reference year	NO3* [mg/l]	NH4 [mg/l]	EC 25°C [µS/cm]	EC 20°C [µS/cm]	Cl [mg/l]	SO4 [mg/l]	PO4 [mg/l]
GWB-1	AT-1	2021							
	DE-1	2021		0.5			250	250	
GWB-2	BG-2	2021	38	0.45	1,641	1,470	189	192	
	RO-2	2021		0.5			250	250	
GWB-3	MD-3								
	RO-3	2021		6.4			250	250	
GWB-4	BG-4	2021	40	0.38	1,714	1,536	188.75	189	
	RO-4	2021		0.7			250	250	
GWB-5	HU-5s	2020		2-5			500	500	
	Hu-5d	2020		2-5			250	250	
	RO-5	2021		0.5-1.9			250	250	
GWB-6	HU-6s	2020		2-5			250	250	
	HU-6d	2020		2-3			250	250	
	RO-6	2021		0.5-1.3			250	250	
GWB-7	HU-7s	2020		3-5			250	250-500	

	HU-7d	2020		2-5			250	250	
	RO-7	2021		6.4			250	250	
	RS-7	2021		0.5		2,500	250	250	0.15
GWB-8	HU-8s	2020		1-2			250	250	
	HU-8d	2020		2			250	250	
	SK-8	2021		0.26			135.8-137.3	148.9-157.6	0.22
GWB-9	HU-9s	2020		5			250	250	
	HU-9d	2020		2			250	250	
	SK-9	2021		0.3			147.4	167.35	0.22
GWB-10	HU-10	2020	25	0.5			250	250	
	SK-10	2021		0.27			131.8	167.6	0.24
GWB-11	HU-11	2020	25	0.5			250	250	
	SK-11	2019		-			-	-	-
GWB-12	HU-12	2020		2			250	250	
	SK-12	2021		0.9			135.7	140.8	0.24

Note: the quality standard of 50 mg/l nitrates is mandatory according to the Groundwater Directive and only limit values beyond that are called threshold values and listed in the table.

6.6.1 Nitrates in groundwater

Nitrate in groundwater is a main indicator for pollution by agricultural fertilizers and urban wastewater. The EU Groundwater Directive (2006/118/EC) established a groundwater quality standard of 50 mg/l to be considered within the groundwater chemical status assessment. If this standard could still lead to a failure of achieving the WFD objectives, more stringent standards, so called ‘groundwater threshold values’ have to be established by the EU Member States. The reported threshold values (TVs) for nitrates vary between 25 and 40 mg/l. Hungary established a TV of 25 mg/l in HU-10 and HU-11 and Bulgaria established TVs of 38 (BG-2) and 39.9 mg/l (BG-4).

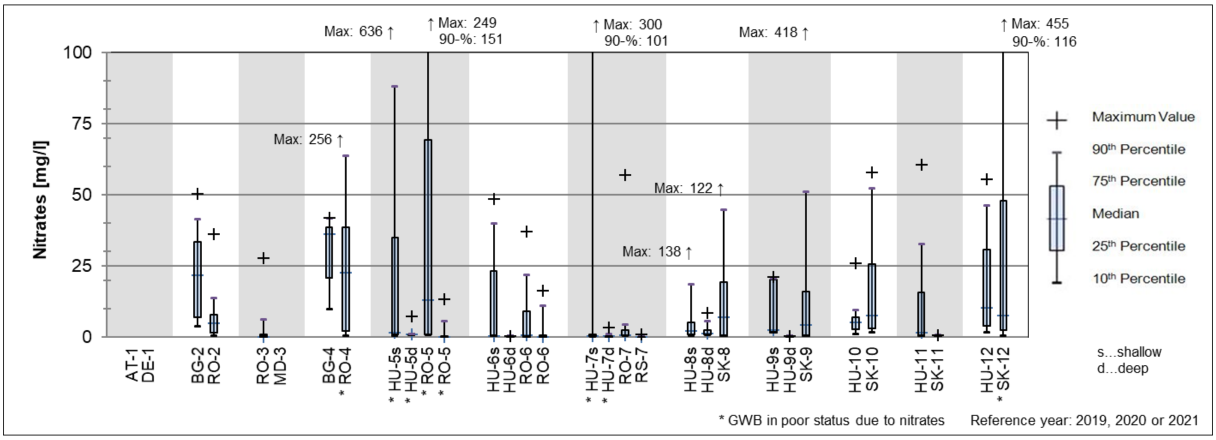
According to Table , five of 25 national shares (RO-4, HU-5, RO-5, HU-7 and SK-12) are failing good status in 2021 for nitrates, compared to RO-5 and HU-7 in 2015.

The nitrates distributions in 2021 for the national shares are shown in Figure 6.4. There are no data available for MD-3 and for GWB-1 (AT-1 and DE-1) where nitrate is not relevant as this deep thermal GWB is free of oxygen and therefore free of nitrates. The distribution of measured nitrate concentrations shows that within each transboundary GWB of basin-wide importance the concentration ranges in the single national parts are often similar.

The majority of the measured nitrate concentrations are far below 50 mg/l. The reported arithmetic mean values are between 0.2 and 50.1 mg/l and the highest reported median value is about 36 mg/l. Only in 7 of 21 national parts of GWB of basin-wide importance (where data are available) the 90-percentile exceeds 50 mg/l. In 13 of the 21 national parts with data, the maximum values exceed 50 mg/l with the highest nitrate concentration of 636 mg/l in HU-5 (shallow porous GWB).

Comparing the average values between 2015 and 2021, at three national shares (BG-2, BG-4, RO-5) both the arithmetic mean and the median values showed significant (more than 5 mg/l) increases and at two national shares (RO-2 and RO-4) both the arithmetic mean and the median values showed significant (more than 5 mg/l) decreases. For SK-9 only the arithmetic mean increased significantly and at three national shares (HU-5s, HU-7s and SK-10) only the arithmetic mean decreased significantly.

Figure 6.4: Transboundary GWBs of basin-wide importance – Nitrate concentrations in groundwater



6.6.2 Ammonium in groundwater

Ammonium in groundwater is a good indicator of pollution by agricultural fertilizers, wastewater and leachates from landfills. Naturally occurring ammonium concentrations in groundwater are generally around 0.1 mg/l and caused by bacteriological processes in the soil.

The parametric value of the EU Drinking Water Directive (98/83/EC, repealed with effect from 13 January 2023) and the indicator parameter of the Recast Drinking Water Directive (2020/2184) is established at 0.5 mg/l. Six countries reported groundwater TVs in a range between 0.26 and 6.4 mg/l. Slovakia reported TVs in a range of 0.26 to 0.9 mg/l, Hungary reported a range of 0.5 and 5.0 mg/l, Romania reported a range of 0.5 to 6.4 mg/l, Bulgaria established values between 0.38 and 0.45 mg/l and Germany and Serbia reported a TV of 0.5 mg/l.

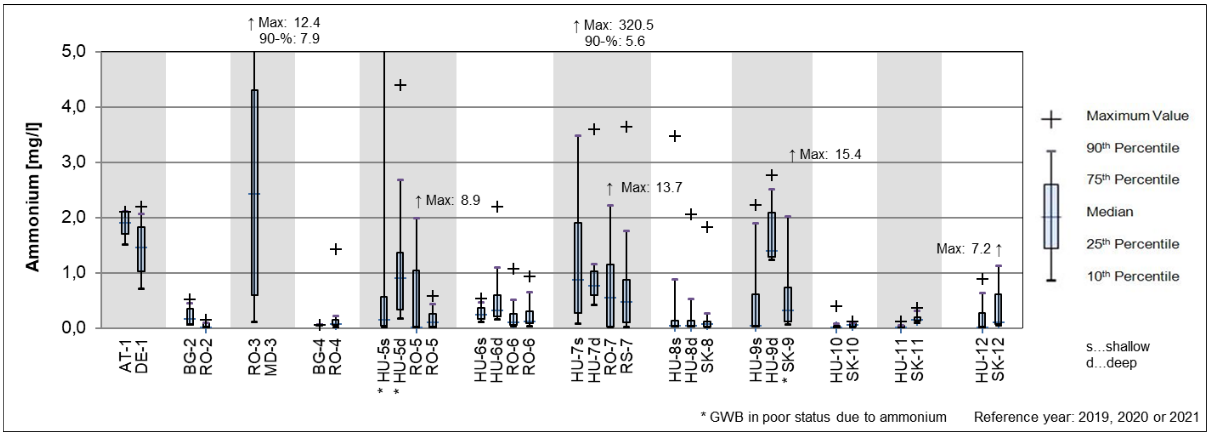
According to Table , two of 25 national shares (HU-5 and SK-9) are failing good status in 2021 for ammonium, compared to only HU-5 in 2015.

Figure 6.5 illustrates the distribution of ammonium in the national parts of the 12 transboundary GWBs of basin wide importance. There are no data available for MD-3.

The majority of the measured ammonium concentrations are below 1 mg/l. The reported arithmetic mean values are between 0.03 and 5.6 mg/l and the median values range between 0.01 and 2.4 mg/l where ten of the 24 reported national shares do not exceed 0.1 mg/l. In eleven national parts the 90-percentile exceeds 1 mg/l. In seven of the 24 national parts with data, the maximum values exceed 5 mg/l with the highest ammonium concentration of 320.5 mg/l in HU-7 (shallow porous GWB).

Comparing the average values between 2015 and 2021 it can be seen that at RO-3 both the arithmetic mean and the median values showed significant (> + 0.2 mg/l) increases and at HU-9 and RS-7 both the arithmetic mean and the median values showed significant (> - 0.2 mg/l) decreases. For three national shares (HU-5, HU-7 and SK-9) only the arithmetic mean increased significantly (> + 0.2 mg/l) and at three national shares (RO-4, HU-6, and RO-7) only the arithmetic mean decreased significantly (> - 0.2 mg/l).

Figure 6.5: ICPDR GW-bodies – Ammonium concentrations in groundwater



6.6.3 Electrical conductivity of groundwater

Electrical conductivity is an indicator of the degree of mineralization of groundwater which is determined by natural geological conditions and anthropogenic pollution. It is an indirect measure of salinity and often used as a general indicator for characterizing groundwater chemistry.

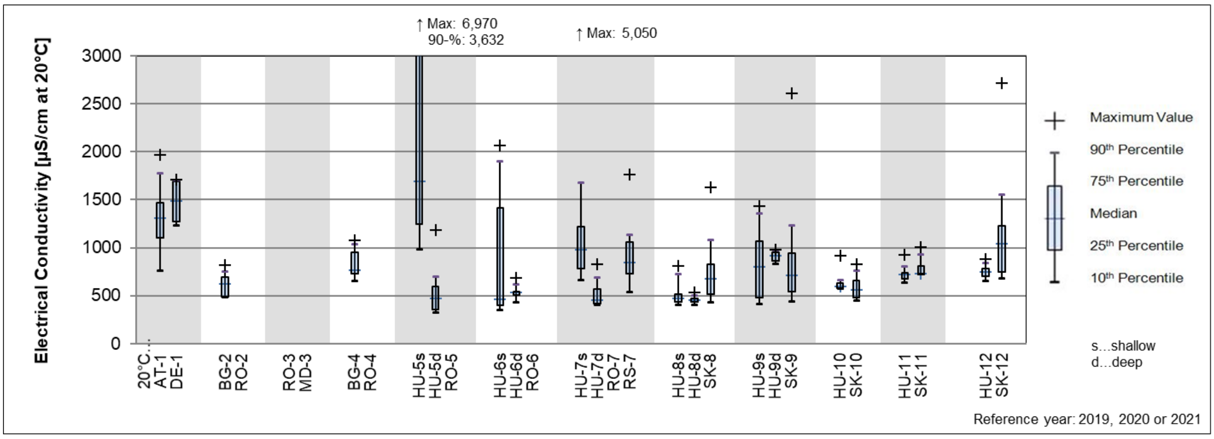
The parametric value of the EU Drinking Water Directive (98/83/EC, DWD, repealed with effect from 13 January 2023) and the indicator parameter of the Recast Drinking Water Directive (2020/2184) is established at 2,500 µS/cm at 20°C. Bulgaria reported groundwater TVs between 1,470 and 1,536 µS/cm at 20°C and Serbia reported 2,500 µg/S.

Figure 6.6 illustrates the distribution of electrical conductivity of groundwater at 20°C. Data which referred to the reference temperature of 25°C were re-calculated to 20°C in order to guarantee overall comparability of the data. There are no data available for all eight shares in MD and RO.

The reported arithmetic mean values of electrical conductivity are in a range of 452–2,257 µS/cm and the median values between 450 and 1,695 µS/cm where 14 of 17 reported median values are below 1,000 and 8 are below 700 µS/cm. In seven of 17 national parts, where respective percentile data were available, the 90-percentile exceeds 1,300 µS/cm. In two of 17 national parts, the maximum values exceed 3,000 µS/cm with the highest electrical conductivity of 6,970 µS/cm in HU-5.

Comparing the average values between 2015 and 2021 (for 13 national shares possible) at three national shares (SK-8, SK-9 and SK-10) both the arithmetic mean and the median values showed significant (more than 10%) increases. For BG-2 and BG-4 only the arithmetic mean increased significantly. The two national shares HU-6 and HU-8, which were divided by depth, show significant changes of median and arithmetic mean in both directions.

Figure 6.6: ICPDR GW-bodies – Electrical conductivity of groundwater



6.6.4 Chloride

Chloride background concentrations in groundwater usually range from 10–40 mg/l and originate naturally from weathering and leaching of sedimentary rocks and the dissolution of salt deposits. Other sources are saltwater intrusion, leachates from landfills, sewage, chloride containing fertilizers and de-icing of roads. Chloride concentrations hardly change with physico-chemical and biochemical processes and remain very stable in the groundwater.

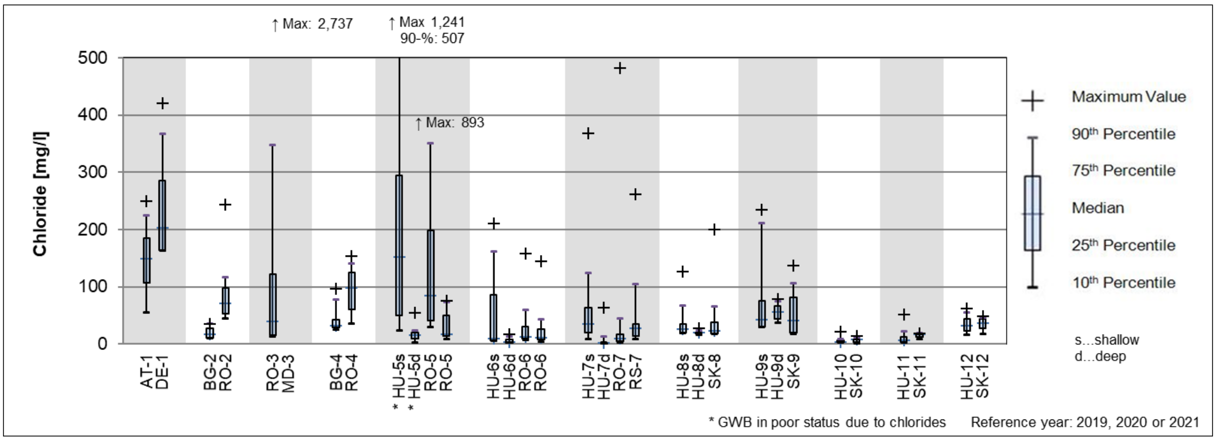
The EU Drinking Water Directive (98/83/EC, repealed with effect from 13 January 2023) and the indicator parameter of the Recast Drinking Water Directive (2020/2184) lay down a parametric value of 250 mg/l. Five countries reported groundwater TVs in a range between 189 and 500 mg/l. Germany, Hungary, Romania and Serbia reported a TV of 250 mg/l (except for HU-5s with 500 mg/l) and Bulgaria established a range around 189 mg/l.

According to Table , only HU-5 is failing good status in 2021 for chlorides, compared to no failures in 2015.

Figure 6.7 compares the chloride concentrations for the 24 national parts where data were provided. Most of the values are found below 100 mg/l (three median values are above 100 mg/l). The highest salinisation (up to 2,737 mg/l) was found in RO-3.

Comparison of statistical figures between 2015 and 2021 is only possible for seven national shares. Both the arithmetic mean and the median values showed significant increases of around 30% in BG-2 and in RO-4 and RO-7 only the median increased significantly.

Figure 6.7: ICPDR GW-bodies – Chloride in groundwater



6.6.5 Sulphate

Natural origin of most sulfate compounds in groundwater is the oxidation of pyrite (ferrous sulphide) which is widely present in sedimentary rocks. Natural concentrations in groundwater range between 10 and 30 mg/l. Higher sulphate concentrations can be caused by anthropogenic inputs like leachates from landfills, industrial effluents, fertilizers and emissions from traffic (input via rain).

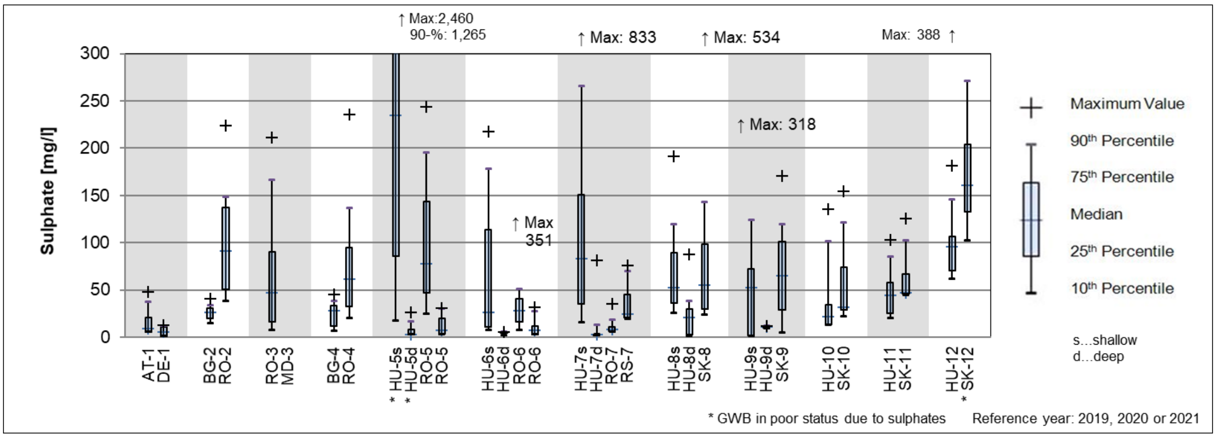
The EU Drinking Water Directive (98/83/EC, repealed with effect from 13 January 2023) and the indicator parameter of the Recast Drinking Water Directive (2020/2184) lay down a parametric value of 250 mg/l. Six countries reported groundwater TVs in a range between 140.8 and 500 mg/l. Germany, Hungary, Romania and Serbia reported a TV of 250 mg/l (except for HU-5 with 500 mg/l and HU-7s with a range of 250-500 mg/l), Bulgaria established 189 and 192 mg/l and Slovakia reported 140.8 mg/l.

According to Table , HU-5 and SK-12 are failing good status in 2021 for sulphates, compared to no failures in 2015.

Figure 6.8 compares the sulphate concentrations for the 24 national shares where data were provided. Most of the values are below 100 mg/l. In 13 national shares the median values are below 50 mg/l and in two above 100 mg/l. The highest value was found in HU-5s with 2,460 mg/l.

A comparison of statistical figures between 2015 and 2021 is only possible for few national shares due to limited data availability for 2015. Most obvious is that in five national shares both the arithmetic mean and the median values show decreases between 12% and 52% (RO-2, RO-3, BG-4, RO-4 and RS-7). In the other shares the changes are indifferent.

Figure 6.8: ICPDR GW-bodies – Sulphate in groundwater



6.6.6 Phosphate

Natural origin of most phosphate compounds in groundwater is the weathering of rocks and mineral deposits. Natural concentrations in groundwater highly depend on the redox conditions (higher in anoxic water) are typically low because phosphorus tends to sorb to soil and aquifer sediments. Higher phosphate concentrations can be caused by anthropogenic activities such as agricultural use of chemical phosphorus fertilizer and they can impact groundwater associated aquatic ecosystems.

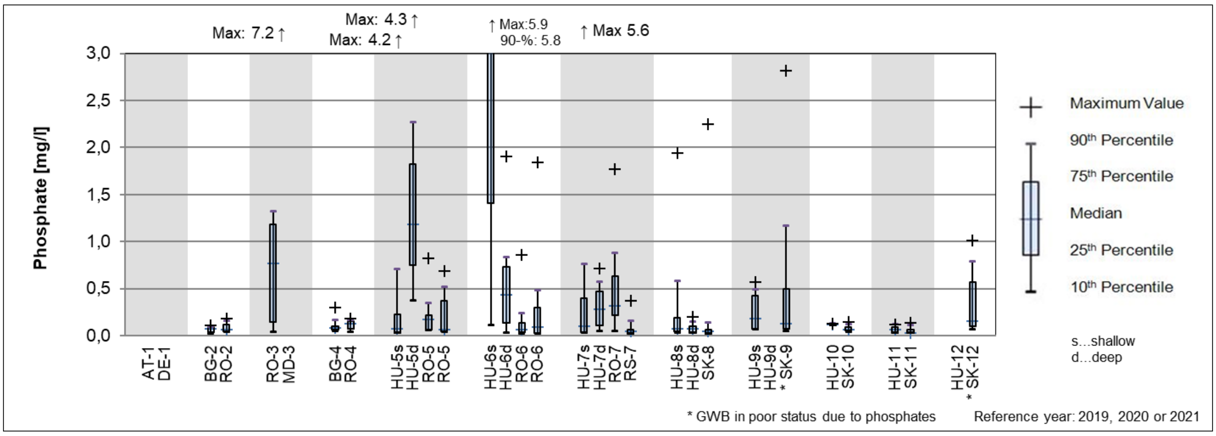
Phosphate is not covered by the EU Drinking Water Directive and only Slovak Republic reported groundwater TVs of 0.22 and 0.24 mg/l and Serbia of 0.15 mg/l.

According to Table , SK-9 and SK-12 are failing good status in 2021 for phosphates, compared to no failures in 2015.

Figure 6.9 compares the phosphate concentrations for the 21 national shares where data were provided. Most of the values are below 0.5 mg/l. In ten national shares the median values are below 0.1 mg/l and in five above 0.2 mg/l. The highest value was found in RO-3 with 7.17 mg/l.

A comparison of statistical figures between 2015 and 2021 is not possible as data for phosphate were not collected last time.

Figure 6.9: ICPDR GW-bodies – Phosphate in groundwater



6.7 Groundwater in Joint Danube Survey 4

Seven groundwater monitoring sites along the Danube River were sampled during Joint Danube Survey 4 (JDS4) in summer 2019 and the results were compared to the concentrations detected at the closest Danube sites to identify any kind of interaction. The seven groundwater monitoring sites are supposed to be more or less interconnected with the water from the Danube River through bank-filtration.

In total 286 pesticide substances, pharmaceuticals, drugs, artificial sweeteners, industrial substances, isotopes, dissolved organic matter and rare earth elements, which are usually not monitored within standard monitoring programs, have been detected in either groundwater or in a Danube monitoring site closest to a monitored groundwater site.

The analysis showed that in many cases the bank-filtration process contributes to a smaller number of substances and lower concentrations detected in groundwater than in the Danube River. Nevertheless, this effect cannot be generalised and is compound and site specific. For many of the detected substances the situation was opposite and the concentration in groundwater was often higher than in the Danube. Even, a considerable number of substances (23%) has only been detected in a groundwater site and was not found in any of the adjacent Danube sites, which indicates that pollution of groundwater is caused by local or regional polluting activities.

A broad range of chemical substances is widely used in industrial, medical and agricultural activities and thus many of those compounds were also present in the groundwater samples. The goal of JDS4 was to perform a comprehensive target and nontarget screening of substances which are normally not analysed during ongoing monitoring at the most extreme limits of detection and quantification. Hence, a lot of substances were detected, but it should be kept in mind, that most of the findings are at a concentration range of few ng/l (= 0.001 µg/l) or even pg/l (= 0.001 ng/l). This is owed to the extreme sensitivity of detection of the applied methods – 1 pg/l = 1/2 sugar cube (= 2 g) in Lake Balaton with 1.9 km^3 (1.9 trillion liters) of water – which means that many of these substances would have never been detected with standard laboratory methods and their concentrations are far below any currently existing European quality standard. Nevertheless, it has to be considered that certain substances have adverse (e.g., endocrine) effects at such low concentration levels.

Further details on the results of the JDS4 groundwater monitoring are available in the chapter 25 of the JDS4 final report[2]

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[2] http://www.danubesurvey.org/jds4/publications/scientific-report

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

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

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