Water Quality in the Danube River Basin - 2016

ICPDR IKSD

International Commission for the Protection of the Danube River

Internationale Kommission zum Schutz der Donau

TNMN – Yearbook 2016

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Table of content

1. Introduction

1.1 History of the TNMN

In June 1994, the Convention on Cooperation for the Protection and Sustainable Use of the Danube River (DRPC) was signed in Sofia, coming into force in October 1998 with the main objectives of achieving sustainable and equitable water management, including the conservation, improvement and the rational use of surface and ground waters in the Danube catchment area. The DRPC also emphasizes that the Contracting Parties shall cooperate in the field of monitoring and assessment. In this respect, the operation of the Trans National Monitoring Network (TNMN) in the Danube River Basin aims to contribute to the implementation of the DRPC. This Yearbook reports on results of the basin-wide monitoring programme and presents TNMN evaluated data for 2010.

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 I: Monitoring of surface water status
- Surveillance monitoring II: Monitoring of specific pressures
- Operational monitoring
- Investigative monitoring

Surveillance monitoring II 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.

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

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

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

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

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

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

2.1 Objectives

Surveillance Monitoring II 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 II 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.

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 in particular on the Danube and its major primary or secondary tributaries near crossing boundaries of the Contracting Parties. List of monitoring sites is in the Table 1.

Table 1: List of monitoring sites

Country code	Site code	River	Name of site	Locations	x- coord	y-coord	River-km	Altitude	Catchment
DE	DE2	Danube	Jochenstein	M	13.703	48.520	2 204	290	77 086
DE	DE5	Danube	Dillingen	L	10.499	48.568	2 538	420	11 315
DE	DE3	/Inn	Kirchdorf	M	12.126	47.782	195	452	9 905
DE	DE4	/Inn/Salzach	Laufen	L	12.933	47.940	47	390	6 113
AT	AT1	Danube	Jochenstein	M	13.703	48.521	2 204	290	77 086
AT	AT5	Danube	Enghagen	R	14.512	48.240	2 113	241	84 869
AT	AT3	Danube	Wien-Nussdorf	R	16.371	48.262	1 935	159	101 700
AT	AT6	Danube	Hainburg	R	16.993	48.164	1 879	136	130 759
CZ	CZ1	/Morava	Lanzhot	M	16.989	48.687	79	150	9 725
CZ	CZ2	/Morava/Dyje	Pohansko	M	16.885	48.723	17	155	12 540
SK	SK1	Danube	Bratislava	LMR	17.107	48.138	1 869	128	131 329
SK	SK2	Danube	Medveďov	MR	17.652	47.794	1 806	108	132 168
SK	SK4	/Váh	Komárno	MR	18.142	47.761	1.5	106	19 661
SK	SK5	Danube	Szob	LMR	18.890	47.805	1 707	100	183 350
SK	SK6	/Morava	Devín	M	16.976	48.188	1	145	26 575
SK	SK7	/Hron	Kamenica	M	18.723	47.826	1.7	114	5 417
SK	SK8	/Ipeľ	Salka	M	18.763	47.886	12	110	5 060
HU	HU1	Danube	Medvedov	MR	17.652	47.792	1 806	108	131 605
HU	HU2	Danube	Komarom	MR	18.121	47.751	1 768	101	150 820
HU	HU3	Danube	Szob	LMR	18.860	47.811	1 708	100	183 350
HU	HU4	Danube	Dunafoldvar	LMR	18.934	46.811	1 560	89	188 700
HU	HU5	Danube	Hercegszanto	LMR	18.814	45.909	1 435	79	211 503
HU	HU6	/Sio	Szekszard-Palank	LM	18.720	46.380	13	85	14 693
HU	HU7	/Drava	Dravaszabolcs	LM	18.200	45.784	78	92	35 764
HU	HU8	/Tisza/Sajo	Sajopuspoki	MR	20.340	48.283	124	148	3 224
HU	HU9	/Tisza	Tiszasziget	LMR	20.105	46.186	163	74	138 498
HU	HU10	/Tisza	Tiszabecs	M	22.831	48.104	757	114	9707
HU	HU11	/Tisza/Szamos	Csenger	M	22.693	47.841	45	113	15283
HU	HU12	/Tisza/Hármas-Körös/Sebes-Körös	Korosszakal	M	21.657	47.020	59	92	2489
HU	HU13	/Tisza/Hármas-Körös/Kettős-Körös/Fekete-Körös	Sarkad	M	21.431	46.694	16	85	4302
HU	HU14	/Tisza/Hármas-Körös/Kettős-Körös/Fehér-Körös	Gyulavari	M	21.336	46.629	9	85	4251
HU	HU15	/Tisza/Maros	Nagylak	R	20.703	46.161	51	80	30149
SI	SI1	/Drava	Ormož most	L	16.155	46.403	300	192	15 356
SI	SI2	/Sava	Jesenice na Dolenjskem	R	15.692	45.861	729	135	10 878
HR	HR1	Danube	Batina	MR	18.829	45.875	1 429	86	210 250
HR	HR2	Danube	Borovo	R	18.967	45.381	1 337	89	243 147
HR	HR11	Danube	Ilok	M	19.401	45.232	1 302	73	253 737
HR	HR9	/Drava	Ormoz	LM	16.155	46.403	300	192	15356
HR	HR4	/Drava	Botovo	MR	16.938	46.241	227	123	31 038
HR	HR5	/Drava	Donji Miholjac	MR	18.201	45.783	78	92	37 142
HR	HR6	/Sava	Jesenice	R	15.692	45.861	729	135	10 834
HR	HR7	/Sava	Upstream Una Jasenovac	L	16.915	45.269	525	87	30 953
HR	HR8	/Sava	Zupanja	LMR	18.696	45.040	254	85	62 890

Country code	Site code	River	Name of site	Locations	x- coord	y-coord	River-km	Altitude	Catchment
HR	HR12	/Sava	Račinovci	M	18.960	44.851	218	78	65 638
RS	RS1	Danube	Bezdan	L	18.860	45.854	1 426	83	210 250
RS	RS2	Danube	Bogojevo	L	19.079	45.530	1 367	80	251 593
RS	RS3	Danube	Novi Sad	R	19.855	45.255	1 255	74	254 085
RS	RS4	Danube	Zemun	R	20.412	44.849	1 173	71	412 762
RS	RS6	Danube	Banatska Palanka	M	21.339	44.826	1 077	70	568 648
RS	RS7	Danube	Tekija	R	22.419	44.700	954	68	574 307
RS	RS8	Danube	Radujevac	R	22.680	44.263	851	32	577 085
RS	RS10	/Tisza (Tisa)	Martonos	R	20.081	46.114	152	76	140 130
RS	RS11	/Tisza (Tisa)	Novi Becej	L	20.135	45.586	65	75	145 415
RS	RS12	/Tisza (Tisa)	Titel	M	20.312	45.198	9	73	157 174
RS	RS13	/Sava	Jamena	L	19.084	44.878	205	77	64 073
RS	RS15	/Sava	Sabac	R	19.699	44.770	106	74	89 490
RS	RS16	/Sava	Ostruznica	R	20.312	44.732	17	72	95 430
RS	RS17	/Velika Morava	Ljubicevski Most	R	21.132	44.586	22	71	37 320
BA	BA5	/Sava	Gradiska	M	17.255	45.141	457	86	39 150
BA	BA6	/Sava/Una	Kozarska Dubica	M	16.836	45.188	16	94	9 130
BA	BA7	/Sava/Vrbas	Razboj	M	17.458	45.050	12	100	6 023
BA	BA8	/Sava/Bosna	Modrica	M	18.313	44.961	24	114	10 500
BA	BA9	/Sava/Drina	Foca	M	18.833	43.344	234	442	3 884
BA	BA10	/Sava/Drina	Badovinci	M	19.344	44.779	16	90	19 226
BA	BA11	/Sava	Raca	M	19.335	44.891	190	80	64 125
BA	BA12	/Sava/Una	Novi Grad	M	16.295	44.988	70	137	4 573
BA	BA13	/Sava/Bosna	Usora	M	18.074	44.664	78	148	7 313
BG	BG1	Danube	Novo Selo harbour	LMR	22.785	44.165	834	35	580 100
BG	BG2	Danube	Bajkal	R	24.400	43.711	641	20	608 820
BG	BG3	Danube	Svishtov	R	25.345	43.623	554	16	650 340
BG	BG4	Danube	Upstream Russe	R	25.907	43.793	503	12	669 900
BG	BG5	Danube	Silistra	LMR	27.268	44.125	375	7	698 600
BG	BG6	Iskar	Orechovitza	M	24.358	43.589	28	31	8 370
BG	BG7	Jantra	Karantzi	M	25.669	43.389	12	32	6 860
BG	BG8	Russenski Lom	Basarbovo	M	25.913	43.786	13	22	2 800
BG	BG12	/Iskar	mouth	M	24.456	43.706	4	27	8 646
BG	BG13	/Vit	Guljantzi	M	24.728	43.644	7	29	3 225
BG	BG14	/Jantra	mouth	M	25.579	43.609	4	25	7 869
BG	BG15	/Russenski Lom	mouth	M	25.936	43.813	1	17	2 974
RO	RO1	Danube	Bazias	LMR	21.384	44.816	1 071	70	570 896
RO	RO18	Danube	Gruia/Radujevac	LMR	22.684	44.270	851	32	577 085
RO	RO2	Danube	Pristol/Novo Selo	LMR	22.676	44.214	834	31	580 100
RO	RO3	Danube	Dunare - upstream Arges (Oltenita)	LMR	26.619	44.056	432	16	676 150
RO	RO4	Danube	Chiciu/Silistra	LMR	27.268	44.128	375	13	698 600
RO	RO5	Danube	Reni	LMR	28.232	45.463	132	4	805 700
RO	RO6	Danube	Vilkova-Chilia arm/Kilia arm	LMR	29.553	45.406	18	1	817 000
RO	RO7	Danube	Sulina - Sulina arm	LMR	29.530	45.183	0	1	817 000
RO	RO8	Danube	Sf. Gheorghe-Ghorghe arm	LMR	29.609	44.885	0	1	817 000
RO	RO9	/Arges	Conf. Danube (Clatesti)	M	26.599	44.145	0	14	12 550
RO	RO10	/Siret	Conf. Danube (Sendreni)	M	28.009	45.415	0	4	42 890
RO	RO11	/Prut	Conf. Danube (Giurgiulesti)	M	28.203	45.469	0	5	27 480
RO	RO12	/Tisza/Somes	Dara (frontiera)	M	22.720	47.815	3	118	15 780
RO	RO13	/Tisza/Hármas-Körös/Sebes-Körös/Crisul Repede	Cheresig	M	21.692	47.030	3	116	2 413
RO	RO14	/Tisza/Hármas-Körös/Kettős-Körös/Crisul Negru	Zerind	M	21.517	46.627	13	86.4	3 750

Country code	Site code	River	Name of site	Locations	x- coord	y-coord	River-km	Altitude	Catchment
RO	RO15	/Tisza/Hármas-Körös/Kettős-Körös/Crisul Alb	Varsand	M	21.339	46.626	0.2	88.9	4 240
RO	RO16	/Tisza/Mures	Nadlac	M	20.727	46.145	21	85.6	27 818
RO	RO17	/Tisza/Bega	Otelec	M	20.847	45.620	7	46	2 632
RO	RO19	/Jiu	Zaval	M	23.845	43.842	9	30.9	10 046
RO	RO20	/Olt	Islaz	M	24.797	43.744	3	32	24 050
RO	RO21	/Ialomita	Downstream Tandarei	M	27.665	44.635	24	8.5	10 309
MD	MD1	/Prut	Lipcani	L	26.483	48.152	658	100	8 750
MD	MD3	/Prut	Conf. Danube-Giurgiulesti	L	28.124	45.285	0	5	27 480
MD	MD5	/Prut	Costesti Reservoir	L	27.145	47.513	557	91	11 800
MD	MD6	/Prut	Braniste	L	27.145	47.475	546	63	12 000
MD	MD7	/Prut	Valea Mare	L	27.515	47.075	387	55	15 200
UA	UA1	Danube	Reni	M	28.288	45.437	132	4	805 700
UA	UA2	Danube	Vylkove	M	29.592	45.394	18	1	817 000
UA	UA4	/Tisza	Chop	M	22.184	48.416	342	92	33000
UA	UA5	/Tisza/Bodrog/Latorits a	Strazh	M	22.212	48.454	144	96	4418
UA	UA6	/Prut	Tarasivtsi	M	26.336	48.183	262	122	9836
UA	UA7	/Siret	Tcherepkivtsi	M	26.030	47.981	100	303	2070
UA	UA8	/Uzh	Storozhnica	R	22.200	48.617	106	112	1582
ME	ME1	/Lim	Dobrakovo	L	19.773	43.121	112	609	2875
ME	ME2	/Cehotina	Gradac	L	19.154	43.396	55.5	55	809.8

Distance:	The distance in km from the mouth of the mentioned river	Sampling location in profile:
Altitude:	The mean surface water level in meters above sea level	L: Left bank
Catchment:	The area in square km, from which water drains through the station	M: Middle of river
ds.	Downstream of	R: Right bank
us.	Upstream of	
Conf.	Confluence tributary/main river	
/	Indicates tributary to river in front of the slash. No name in front of the slash means Danube	

Map: TNMN Monitoring Sites

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

2.3 Quality elements

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

2.3.1 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: Determinand list for water for TNMN

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

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

(1) Only in coastal waters

(2) Soluble reactive phosphorus SRP

(3) Mentioned in the tables of the CIS Guidance document but not in the related mind map

(4) Supporting parameter for hardness-dependent EQS of PS metals

(5) Not for coastal waters

(6) Measured in a dissolved form. Measurement of total concentration is optional

(7) In areas with no risk of failure to meet the environmental objectives for DDT and lindane the monitoring frequency is 12 x per a RBMP period; in case of risk the frequency is 12 x year

(8) Mercury in fish is reported in three year reporting cycles

2.4 Analytical Quality Control (AQC)

Parameters covered and samples distributed in the 2016 QUALCODanube programme were as follows:

- real surface water samples for nutrient analysis: preserved natural surface water, spiked if necessary and adequately homogenised. Sample codes were SW-N-1 and SW-N-2. 500 cm^3 plastic bottles were provided for $NH4^+$, NO_3^-, organic N, total N, PO_4^{3-} 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^- analysis: due to stability concerns during transport, it was decided that participants should compose the proficiency testing samples themselves in situ by mixing prescribed amounts of the spike solutions (synthetic concentrates preserved by addition of $Hg(II)Cl_2$) of the measurand with the matrix water provided (simulated surface water pretreated by bringing to boiling point) according to instructions. Spike solutions were put in 20 cm^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 bottles labelled “SW-N/M-1, SW-N/M-2 WATER FOR DILUTION”. Measurement results were asked to be reported as mg N/dm^3.

Evaluation was performed according to ISO 13528:2015 and ISO/IEC 17043:2010. Reported results were first inspected for obviously erroneous results or blunders, which were excluded from the dataset in accordance with section B.2.5. of ISO/IEC 17043:2010. Then the assigned value of the parameter [$\dot{X}$], the standard uncertainty of the assigned value [u(x)] and the standard deviation for proficiency assessment (SDPA) was determined. Finally, performance statistics was calculated including z-scores, z’- scores and En numbers (section 9.4. and 9.6. of ISO 13528:2015) and assessment was given based on the performance statistics.

Assigned value was determined as a consensus value from all participants. For this end, robust average of all laboratories was calculated according to algorithm “A” (for details see Annex C of ISO 13528:2015). The same algorithm was used to calculate the standard uncertainty of the assigned value, i.e. the robust average of all laboratories. Assigned values were tested against analytical measurements by WESSLING Hungary Ltd. The standard deviation for proficiency assessment was chosen as a fit-for-purpose value, pre-set as percentage of the assigned value. Regulatory requirements, previous experience with the proficiency testing scheme, and expert judgement were taken into consideration when defining SDPA. Robust standard deviations calculated from the current datasets (using algorithm “A”) were given special emphasis.

Number of participants increased slightly compared to previous year, from 48 to 51. Two laboratories did not return results, thus the actual number of participants was 49 (47 in 2015). Most of the new entries were experienced laboratories who had formerly participated in and were familiar with the scheme. The 2016 proficiency testing scheme was performed with good results overall. Number and ratio of unsatisfactory results remained low, evaluation could be performed with z-score assessment for all parameters except for organic nitrogen, where bimodal distribution of proficiency testing results prohibited statistical evaluation. Majority of participants reported their expanded uncertainties together with measurement results, allowing for calculation of E_n numbers, thus assessment of the validity of the underlying uncertainty estimation. E_n numbers were visualized on graphs as expanded uncertainty bars around reported results. Number and ratio of unsatisfactory E_n numbers were similar to previous round. Some unsatisfactory E_n numbers were attributable to reporting expanded uncertainties in % instead of the unit of measurement required.

As previously, determination of ammonium, nitrate and total nitrogen, phosphate and total phosphorus was highly successful, with few unsatisfactory or questionable results if at all (actually zero for total nitrogen in both samples). Ammonium measurements improved further compared to previous years. Nitrite nitrogen proficiency testing were slightly more scattered than in 2015, resulting in somewhat higher standard uncertainties of assigned values and more results in the questionable/unsatisfactory range. Organic nitrogen, which debuted in the scheme in 2013, was measured by 12 participants (decreasing from 18 last year). Although uncertainty of the assigned value compared to the standard deviation of proficiency assessment exceeded the critical limit of 120% in only one sample, evaluation was not performed for either samples, as distribution of reported results was bimodal in both. Organic nitrogen content added to samples correspond to the groups reporting higher concentrations.

In summary, the 2016 QualcoDanube proficiency testing scheme was successful, the scheme remains a useful and relevant tool in the quality framework of the Danube region.

2.5 TNMN Data Management

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

3. Results of basic statistical processing

161 sites at 112 TNMN monitoring stations were monitored in the Danube River Basin in 2016 (some monitoring stations contain two or three sampling sites - left, middle and/or right side of the river). The data was collected from 76 sampling sites at 40 stations on the Danube River and from 85 sampling sites at 72 stations at the tributaries.

The basic processing of the TNMN data includes the calculation of selected statistical characteristics for each determinand/monitoring site. Results are presented in tables in the Annex I using the following format:

Term used	Explanation
Determinand name	name of the determinand measured according to the agreed method
Unit	unit of the determinand measured
N	number of measurements
Min	minimum value of the measurements done in the year 2016
Mean	arithmetical mean of the measurements done in the year 2016
Max	maximum value of the measurements done in the year 2016
C50	50 percentile of the measurements done in the year 2016
C90	90 percentile of the measurements done in the year 2016

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).*

The above mentioned analytical data method according to Directive 2009/90/EC with limit of quantification (LOQ) has been applied since 2009.

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

Table 3, created on the basis of data in tables in the Annex I, shows in an aggregated way the concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2016. These include indicators of the oxygen regime, nutrients, heavy metals, biological determinands and organic micropollutants.

Table 3 also includes information about the number of monitoring locations and sampling sites providing measurements of the determinands.

In the table, there are minimal, maximal values for all determinands calculated from all Danube or tributaries station and minimal and maximal values for all determinands calculated from mean (average) values from all Danube or tributaries.

Table 3: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2016

Determinand name	Unit	Danube					Tributaries				
		No.of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean		No.of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean	
			Min	Max	Min_{avg}	Max_{avg}		Min	Max	Min_{avg}	Max_{avg}
Temperature	°C	69/39	0.6	30.0	10.0	16.4	73/71	-0.1	176.0	9.3	24.4
Suspended solids	mg/l	69/39	< 1	387	9	68	73/71	< 1	4456	6	937
Dissolved oxygen	mg/l	69/39	5.3	16.9	7.5	11.2	73/71	2.6	18.1	7.2	11.2
BOD (5)	mg/l	69/39	< 0.20	8.9	0.9	4.6	73/71	< 0.25	22.9	< 0.25	6.0
COD (Mn)	mg/l	63/33	0.8	9.9	2.1	5.3	47/45	1.2	60.2	1.9	11.0
COD (Cr)	mg/l	58/28	< 2.00	40.5	5.3	20.5	60/58	< 0.00	234.8	3.5	65.7
TOC	mg/l	33/21	< 0.50	20.9	2.1	5.9	33/31	< 0.49	16.6	< 0.49	11.7
DOC	mg/l	6/6	1.4	5.7	2.3	2.8	6/6	< 0.250	9.2	1.1	6.4
pH	-	69/39	7.1	8.7	7.9	8.4	69/69	7.1	8.8	7.6	8.5
Alkalinity - total	mmol/l	69/39	1.2	211.0	1.6	20.5	64/62	0.8	256.0	1.2	190.6
Ammonium (NH4-N)	mg/l	69/39	< 0.004	0.76	0.03	0.19	73/71	< 0.001	3.56	0.02	1.50
Nitrite (NO2-N)	mg/l	69/39	< 0.0005	0.224	0.009	0.056	73/71	< 0.0005	0.223	0.0041	0.0802
Nitrate (NO3-N)	mg/l	69/39	0.16	3.90	0.91	2.96	73/71	< 0.035	9.11	0.41	7.655
Total nitrogen	mg/l	61/31	0.7	4.1	1.5	3.0	64/62	< 0.050	11.0	< 0.500	9.9
Organic nitrogen	mg/l	30/20	< 0.025	2.39	0.04	0.89	32/30	< 0.000	2.68	0.21	1.20
Orthophosphate (PO4-P)	mg/l	69/39	< 0.0025	0.420	0.018	0.110	73/71	< 0.0015	0.958	0.006	0.260
Total phosphorus	mg/l	42/28	< 0.0100	0.500	0.058	0.267	67/65	< 0.0035	1.928	0.024	0.465
Total phosphorus, dissolved	mg/l	40/18	< 0.0150	0.420	0.047	0.129	21/21	< 0.0035	0.460	0.014	0.211
Phytoplankton (biomass - chlorophyll-a)	µg/l	54/26	< 0.0015	54.29	0.79	19.28	48/44	< 0.0015	209.70	1.40	35.73
Conductivity	µS/cm	67/37	240	631	366	502	71/69	170	1372	237	1117
Calcium (Ca++)	mg/l	69/39	3.2	104.0	46.1	86.0	70/68	20.5	151	21.75	99.65
Sulphate (SO4--)	mg/l	46/24	9.2	65.0	17.1	47.7	46/44	7.6	501.0	11.16	153.18
Magnesium (Mg++)	mg/l	69/39	< 2.00	56.6	11.8	24.3	70/68	1.1	64	4.55	57.09
Potassium (K+)	mg/l	17/13	1.6	6.1	< 2.00	3.7	30/28	0.8	11.0	1.15	9.26
Sodium (Na+)	mg/l	17/13	6.70	23.00	10.63	16.31	30/28	2.2	145	5.03	64.26
Manganese (Mn)	mg/l	24/14	<0.0005	0.57	0.0056	0.09	26/24	0.003	40.00	0.0054	6.492
Iron (Fe)	mg/l	19/11	< 0.001	5.38	0.01	1.055	31/29	< 0.005	23.18	0.025	6.187
Chloride (Cl-)	mg/l	69/39	6.5	56.6	15.9	33.0	73/71	1	266	3.57	168.94
Silicates (SiO2)	mg/l	16/8	0.9	24.4	2.6	9.3	15/13	0.5	26.2	1.3182	19.9
Silicates(SiO2), dissolved	mg/l	12/10	2.2	11.9	3.4	6.9	15/15	1.39	15.26	3.11	10.04
Macrozoobenthos- saprobic index		22/18	1.92	2.35	1.92	2.28	39/39	1.46	3.183	1.72	2.79

Table 3: Concentration ranges and mean annual concentrations of selected determinands in the Danube River and its tributaries in 2016 (cont.)

Determinand name	Unit	Danube					Tributaries				
		No.of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean		No.of monitoring locations / No. of monitoring sites with measurements	Range of values		Mean	
			Min	Max	Min_{avg}	Max_{avg}		Min	Max	Min_{avg}	Max_{avg}
Zinc - Dissolved *	µg/l	69/39	< 0.150	187.20	2.03	38.08	71/69	< 0.150	258.30	< 1.500	31.92
Copper - Dissolved	µg/l	69/39	< 0.100	55.70	0.89	9.23	72/70	< 0.100	19.70	< 0.500	5.52
Chromium - Dissolved	µg/l	66/38	< 0.10	8	0.2	3.96	61/59	< 0.05	142.00	< 0.05	16.01
Lead - Dissolved	µg/l	56/30	< 0.050	16.76	< 0.050	2.627	55/53	< 0.050	15.16	< 0.050	3.52
Cadmium - Dissolved	µg/l	67/37	< 0.003	7.12	< 0.003	0.72	63/61	< 0.003	0.87	0.01	0.26
Mercury - Dissolved	µg/l	67/37	< 0.0010	0.05	< 0.0025	< 0.0500	57/55	< 0.0010	0.15	< 0.0025	< 0.0500
Nickel - Dissolved	µg/l	67/37	< 0.100	9.76	0.36	3.81	62/60	< 0.100	16.72	0.46	5.08
Arsenic - Dissolved	µg/l	67/37	< 0.050	5.34	< 0.500	2.48	59/57	< 0.050	10.00	0.34	6.57
Aluminium - Dissolved	µg/l	21/13	< 0.25	321.00	2.76	59.16	15/13	< 1.50	2000.00	< 1.50	221.45
Zinc *	µg/l	37/23	< 1.0	530.40	3.61	70.11	36/34	< 0.25	277.00	< 5.00	108.41
Copper	µg/l	35/21	< 0.100	834.30	2.01	74.85	31/29	< 0.100	176.00	1.80	23.65
Chromium - total	µg/l	38/22	< 0.1000	11.92	0.44	3.38	28/26	< 0.1000	92.40	0.45	24.95
Lead	µg/l	37/23	< 0.0250	16.10	< 0.0250	2.19	36/34	< 0.0250	57.35	0.12	9.45
Cadmium	µg/l	35/21	< 0.00250	2.21	0.01	0.25	35/33	< 0.00250	11.29	0.03	2.61
Mercury	µg/l	35/21	< 0.0075	0.10	< 0.0075	0.05	32/30	< 0.0050	0.27	< 0.0075	0.20
Nickel	µg/l	35/21	< 0.250	18.60	0.64	4.96	35/33	< 0.250	84.40	< 0.500	15.68
Arsenic	µg/l	32/20	< 0.250	4.90	0.93	2.77	22/20	< 0.050	10.70	0.80	4.92
Aluminium	µg/l	11/7	< 5.000	3353.00	189.11	572.10	8/6	34.1	14000.00	97.04	3901.92
Phenol index	mg/l	34/12	< 0.0025	0.033	< 0.0025	0.0057	22/22	< 0.0004	0.0088	< 0.0004	0.0045
Anionic active surfactants	mg/l	40/16	< 0.0025	0.27	0.01	0.22	28/28	< 0.0025	64.00	< 0.0025	16.04
AOX	µg/l	43294	2.9	72.00	< 5.0000	28.92	14/14	< 5.0000	120.00	9.43	48.90
Petroleum hydrocarbons	mg/l	35/13	< 0.0025	0.80	< 0.0025	0.50	25/25	< 0.0100	0.48	0.02	0.32
Lindane	µg/l	60/30	< 0.0003	0.1087	< 0.0003	0.0291	55/53	< 0.0003	0.037	< 0.0003	< 0.0100
pp´DDT	µg/l	53/27	< 0.0002	< 0.0250	< 0.0002	< 0.0250	50/48	< 0.0002	< 0.0125	< 0.0002	< 0.0125
Atrazine	µg/l	61/31	< 0.0002	0.331	0.0007	< 0.0900	48/46	< 0.0002	0.261	0.000	< 0.0900
Chloroform	µg/l	23/15	< 0.081	1.1	< 0.081	0.55	29/27	< 0.050	2.000	< 0.050	< 0.500
Carbon tetrachloride	µg/l	14/10	< 0.025	1.5	< 0.025	0.583	24/22	< 0.050	0.5	< 0.050	< 0.500
Trichloroethylene	µg/l	14/10	< 0.050	< 0.500	< 0.050	< 0.500	24/22	< 0.050	0.5000	< 0.050	< 0.500
Tetrachloroethylene	µg/l	14/10	< 0.025	< 0.500	< 0.025	< 0.500	24/22	< 0.050	< 0.500	< 0.050	< 0.500

4. Profiles and trend assessment of selected determinands

The 90 percentiles (C90) of selected determinands (dissolved oxygen, BOD_5, COD_{Cr}, N-NH_4, N-NO_3, P-PO_4, Ptotal and Cd) measured in last ten years are displayed in the Figures 4.1-4.16. Due to revision of the TNMN in 2006 following monitoring points on the Danube were replaced: AT2 rkm 2120 to AT5 rkm 2113, AT4 rkm 1874 to AT6 rkm 1879, DE1 rkm 2581 to DE5 rkm 2538. Among tributaries, the site HR3 rkm 288 was replaced by HR9 rkm 300 BG8 rkm 54 to BG14 rkm 4 and BG8 rkm 13 to BG15 rkm 1. In 2009 SK3 was replaced with SK5, this monitoring point is also in graphs illustrated as Hungarian point HU3. For trend graphs was used illustration of SK5 and HU3.

To indicate the long-term trends in the upper, middle and lower Danube a more detailed analysis for selected parameters (BOD_5, N-NO_3, P_{total}) is 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 2016 the highest concentrations of biodegradable organic matter were observed in the lower parts of the river. The concentration of nutrients and cadmium reached their highest concentration values in the lower part of the Danube.

The highest values of dissolved oxygen were observed in the upper part of the Danube, in the lower Danube dissolved oxygen levels decrease (Figure 4.1). The lowest DO value was measured at the monitoring point HU3. Low values of dissolved oxygen were in 2016 measured in tributaries Sio, Sava, and Jantra (Figure 4.2).

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 was observed in the upper Danube. Decreasing tendency of BOD continues in year 2016 at the monitoring site BG2 (see Figure 4.3).

A decreasing tendency of levels the BOD in the tributaries Sio, Russenski Lom and Sava has been observed (Figure 4.4). In 2016, concentration of BOD increased in Morava, Tisza/Sajo and Jantra.

The decreasing or stable level of concentration of ammonium-N was recorded in the whole Danube River. Concentration of ammonium-N in 2015 and 2016 decreased in monitoring point BG2 (Figure 4.7). During the last ten years of TNMN operation, concentration of ammonium was decreasing in the Vah, Russenski Lom, Sava and Tisza rivers. In 2016 decreased concentration of ammonium-N in tributary Russenski Lom and Sio (see Figure 4.8). The concentration of ammonium-N in Arges has a decreasing tendency over the past ten years but it is still the highest from all tributaries.

The level of nitrate-N concentrations is rather stable during recent years. A decrease was observed at several stations in the whole Danube also in lower part (for example RO3, RO4, BG5, BG3 see Figure 4.9). At selected monitoring sites (SK1, HU5 and RO5) nitrate-N concentrations increased slightly in 2016 (Figure 4.20-4.22).

In tributaries, the nitrate-N increased in 2016 in Morava, Dyje, Sio, Siret, Prut, Russenski Lom, Velika Morava and Jantra (Figure 4.10).

In the last decade, a decreasing tendency of ortho-phosphate-P concentrations is mostly seen in the upper part of the Danube, and at some sites in the lower Danube (RO1, RO2, BG5; Figure 4.11). Decreasing tendency of ortho-phosphate-P was observed in the tributaries Dyje, Arges and Jantra (Figure 4.12). In

2016, concentration slightly increased in the tributary Russenski Lom. An increase of ortho-phosphate-P concentrations was observed at several sites (SK2, RS7, RS8, RO8).

P-total concentration has decreasing tendency in the last decade in the upper and middle Danube (Figure 4.13). In 2016, P-total concentration decreased in Bulgarian monitoring sites BG1, BG3 and BG4. In 2016, the P-total concentration has decreased in the tributary Sio and increased in Inn, Jantra and Velika Morava (see Figure 4.14).

The cadmium concentration is constant or slightly decreasing in the whole Danube River as well as in its tributaries (Figures 4.15 and 4.16). In 2016, the concentration of cadmium decreased in the tributaries Morava and Velika Morava and it increased in Siret and Prut (MD3).

The 90 and 10 percentiles of selected determinands (N-NH_4, P-PO_4, COD_{Cr}, BOD_5) measured in 2016 are displayed in the Figures 4.26-4.33. Pictures indicate the margins of a usual annual concentration range for a given parameter and site. In graphs for tributaries there are rkm of Danube, where tributary discharge to the Danube River.

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

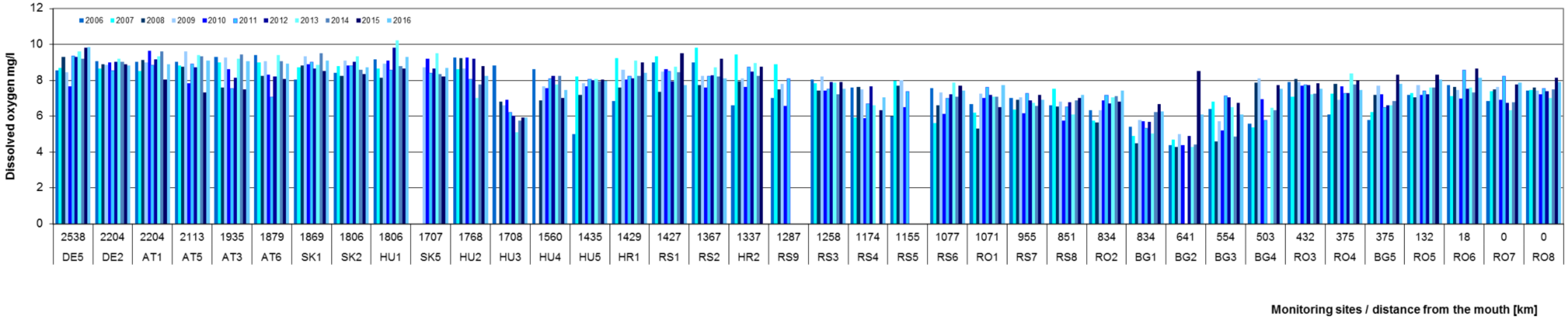


Figure 4.2.: Temporal changes of dissolved oxygen (c10) in tributaries.

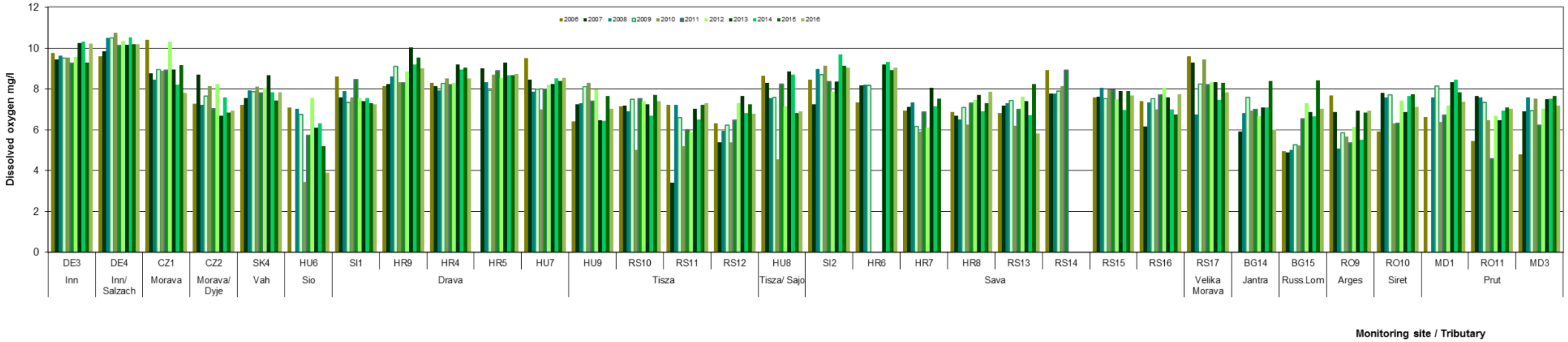


Figure 4.3.: Temporal changes of BOD_5 (c90) in the Danube River.

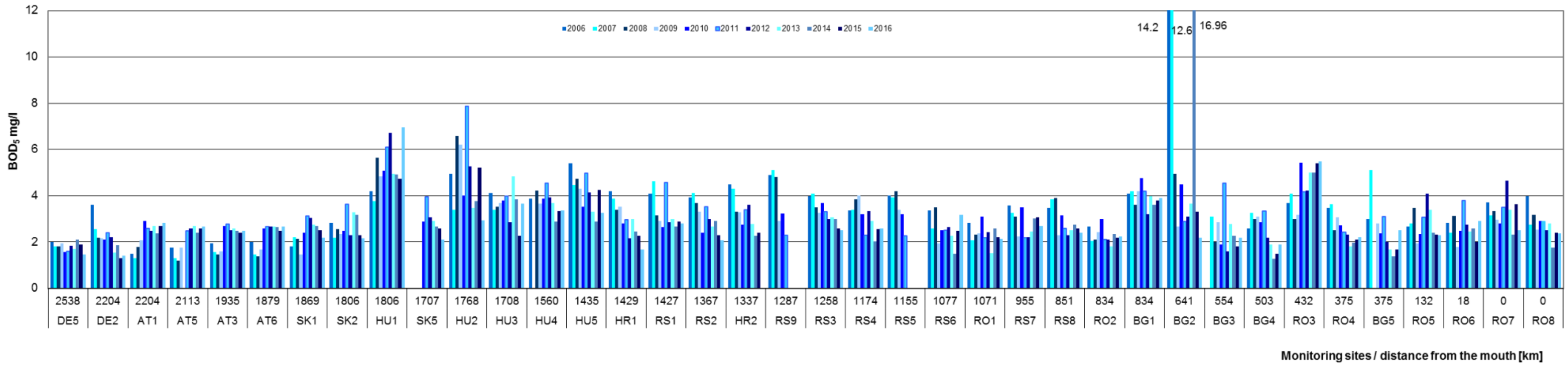


Figure 4.4.: Temporal changes of BOD_5 (c90) in tributaries.

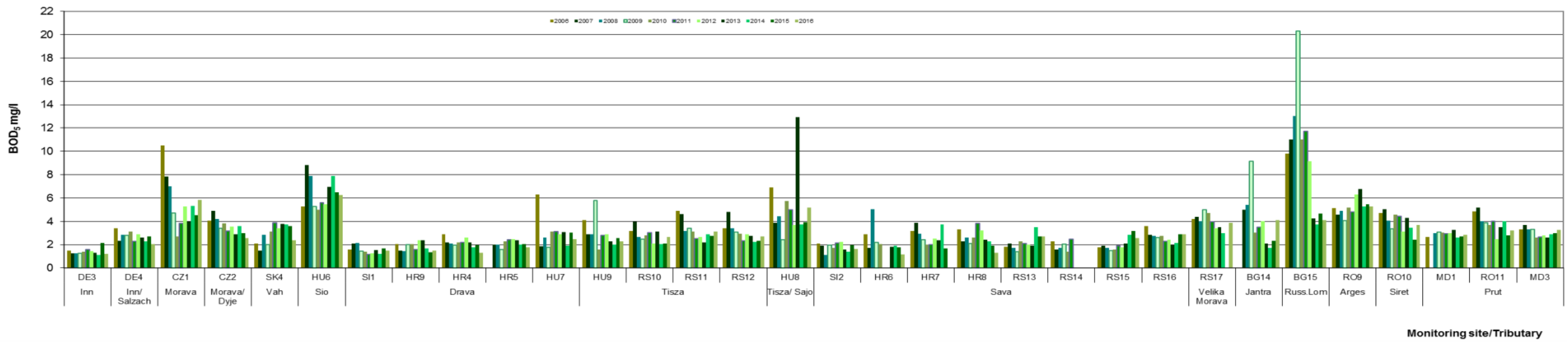


Figure 4.5.: Temporal changes of COD_{Cr} (c90) in the Danube River.

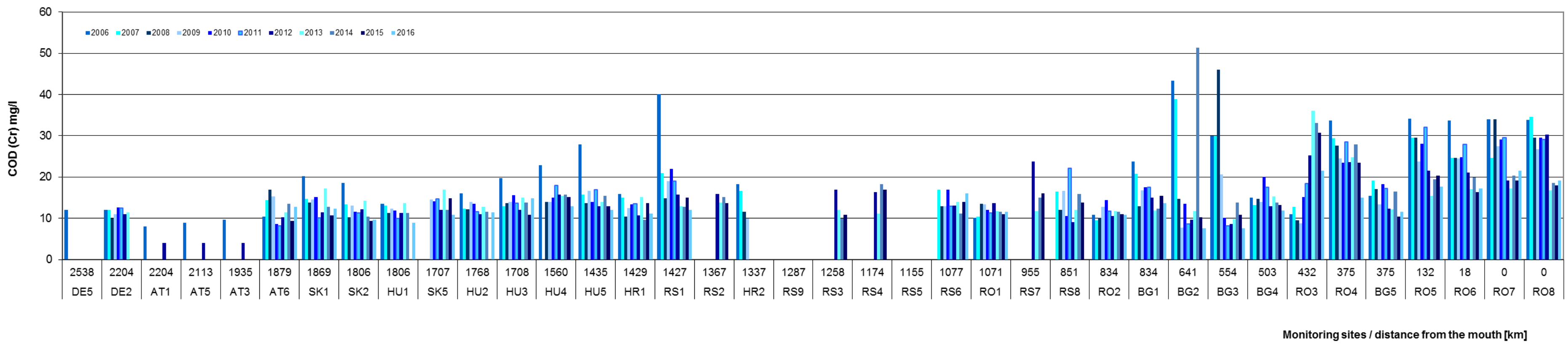


Figure 4.6.: Temporal changes of COD_{Cr} (c90) in tributaries.

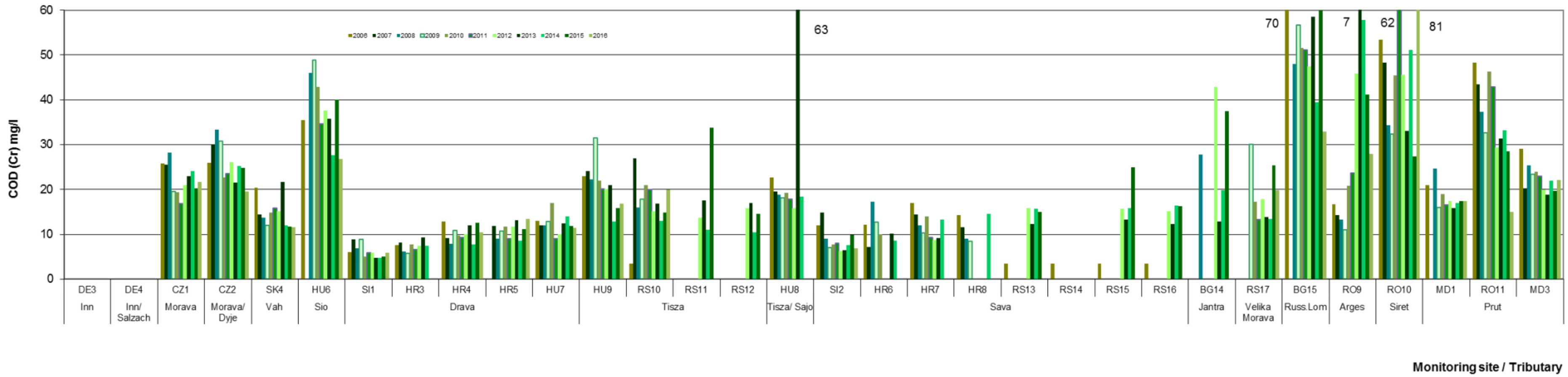


Figure 4.7.: Temporal changes of N-NH_4 (c90) in the Danube River.

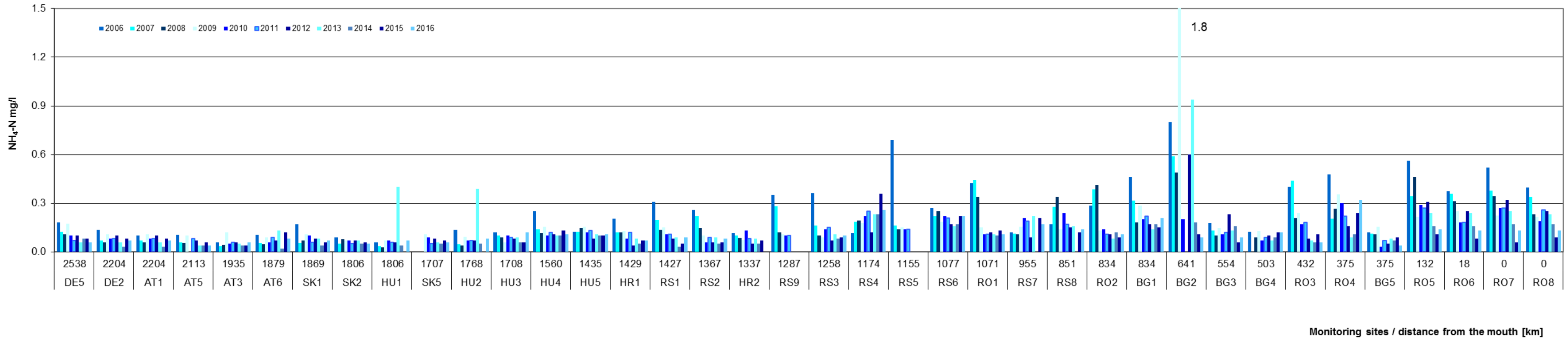


Figure 4.8.: Temporal changes of N-NH_4 (c90) in tributaries.

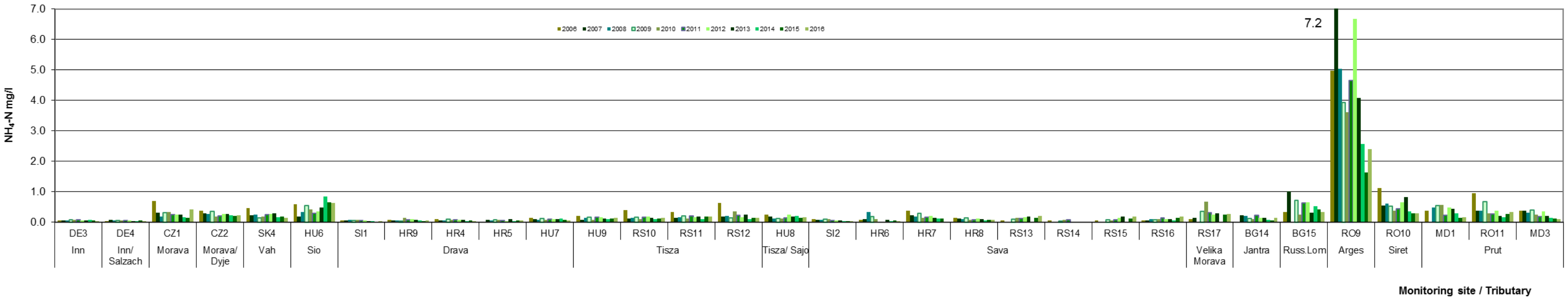


Figure 4.9.: Temporal changes of N-NO_3 (c90) in the Danube River.

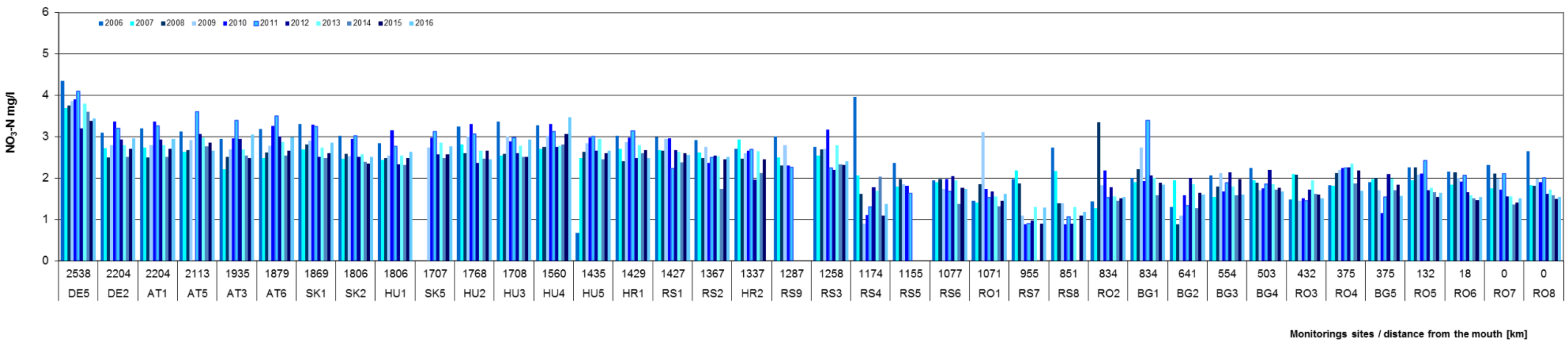


Figure 4.10.: Temporal changes of N-NO_3 (c90) in tributaries.

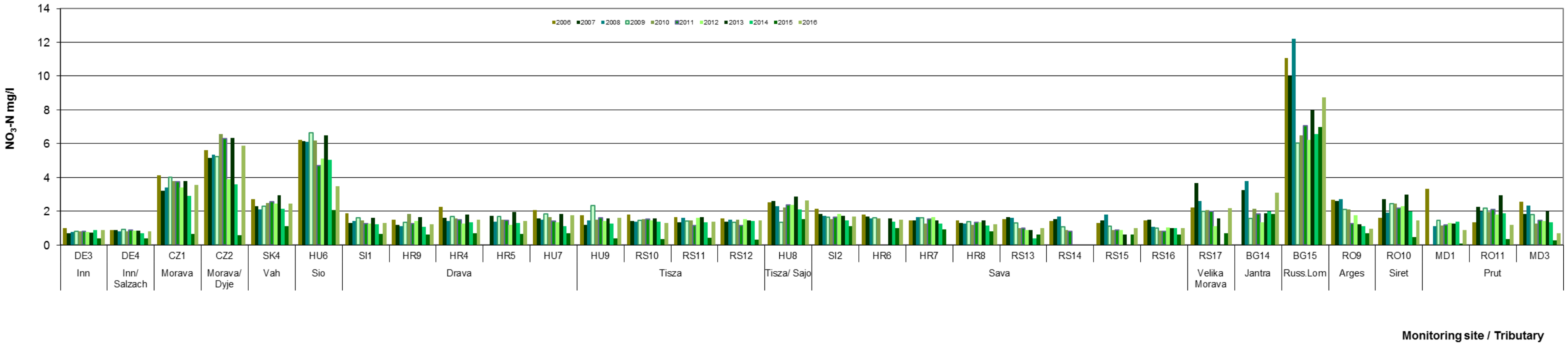


Figure 4.11.: Temporal changes of P-PO_4 (c90) in the Danube River.

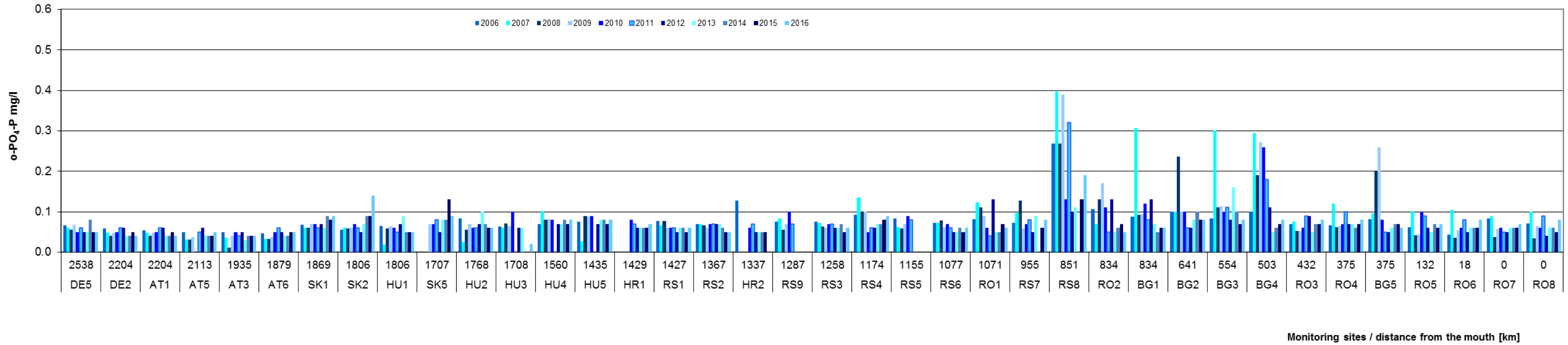


Figure 4.12.: Temporal changes of P-PO_4 (c90) in tributaries

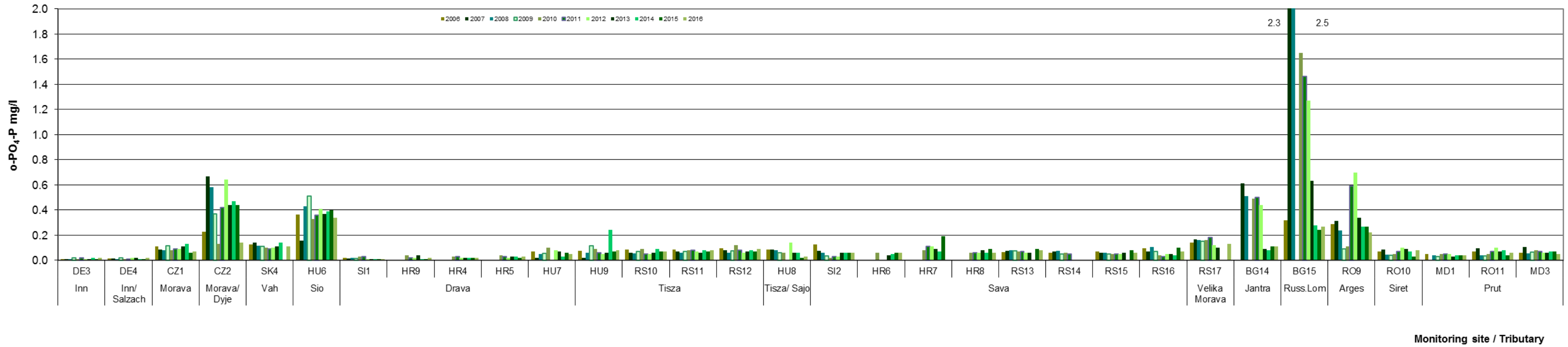


Figure 4.13.: Temporal changes of total phosphorus (c90) in the Danube River.

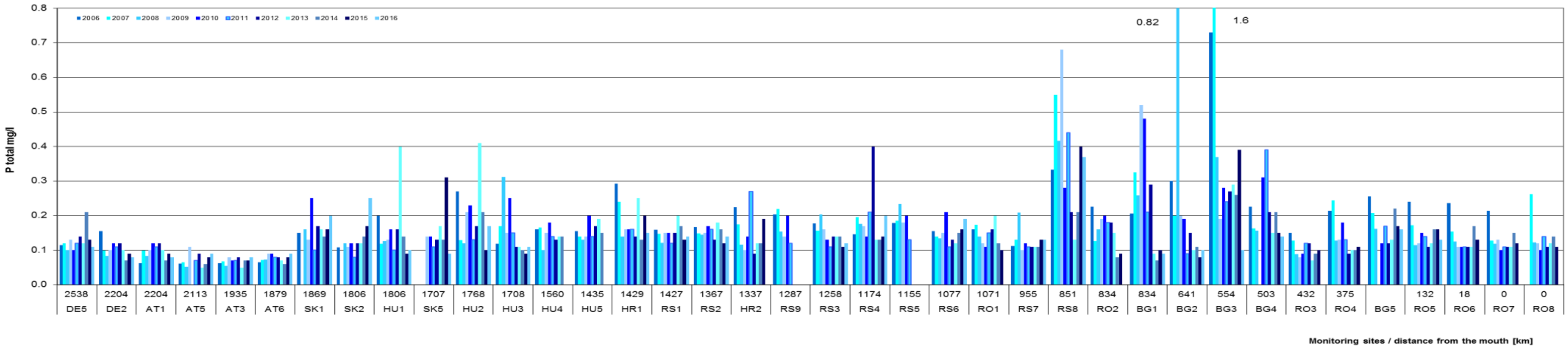


Figure 4.14.: Temporal changes of total phosphorus (c90) in tributaries.

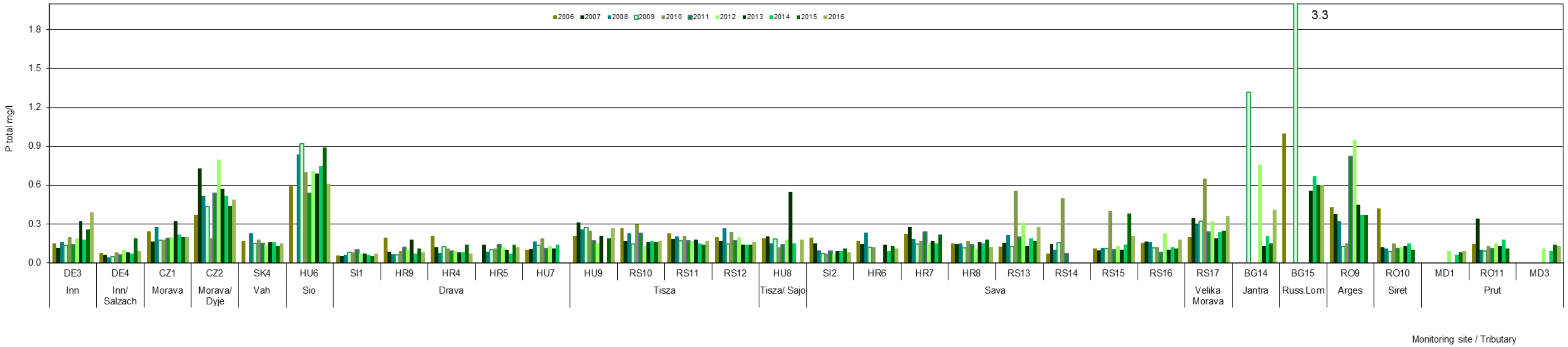


Figure 4.15.: Temporal changes of cadmium (c90) in the Danube River.

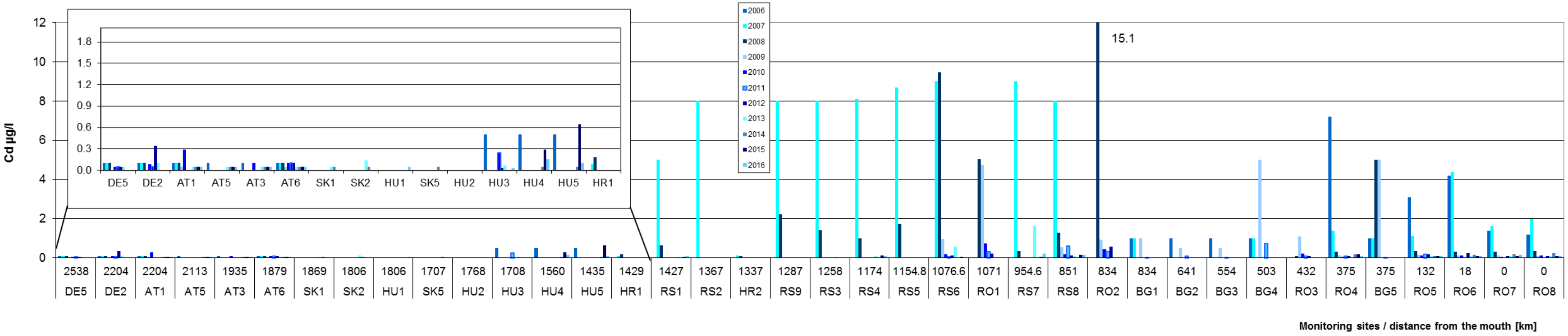


Figure 4.16.: Temporal changes of cadmium (c90) in tributaries.

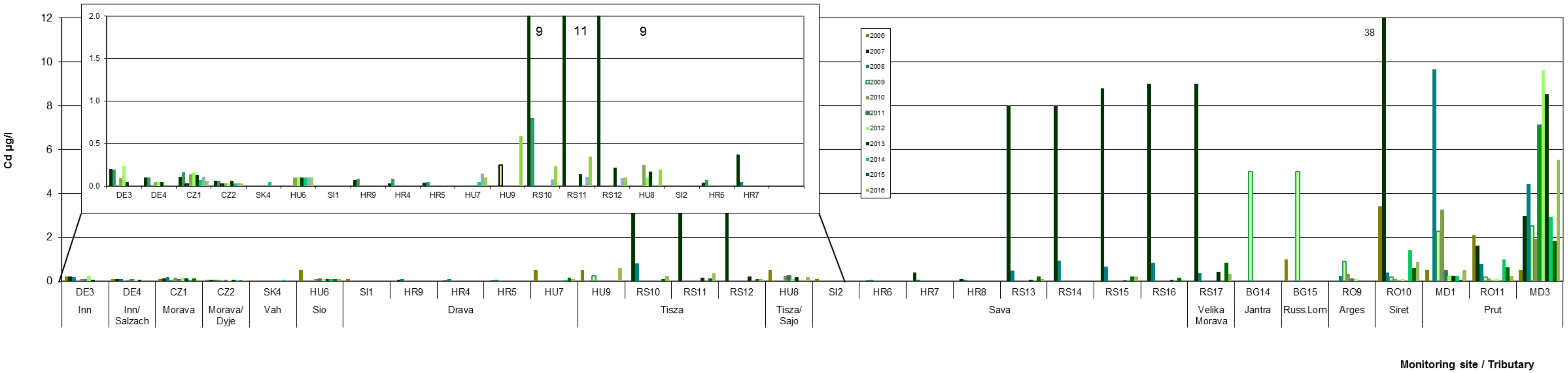


Figure 4.17.: Temporal changes of BOD_5 (c90) in Bratislava

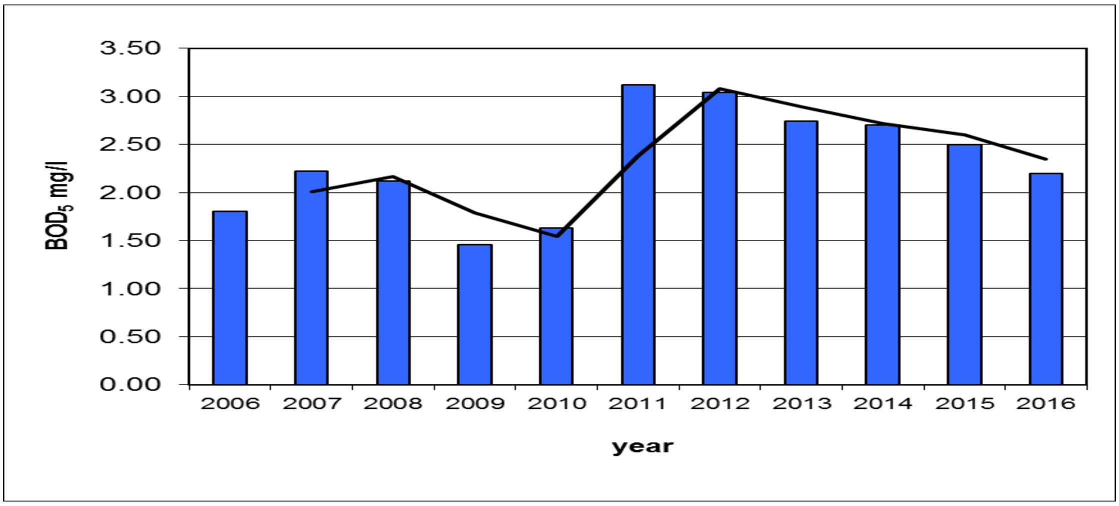


Figure 4.18.: Temporal changes of BOD_5 (c90) in Hercegszanto

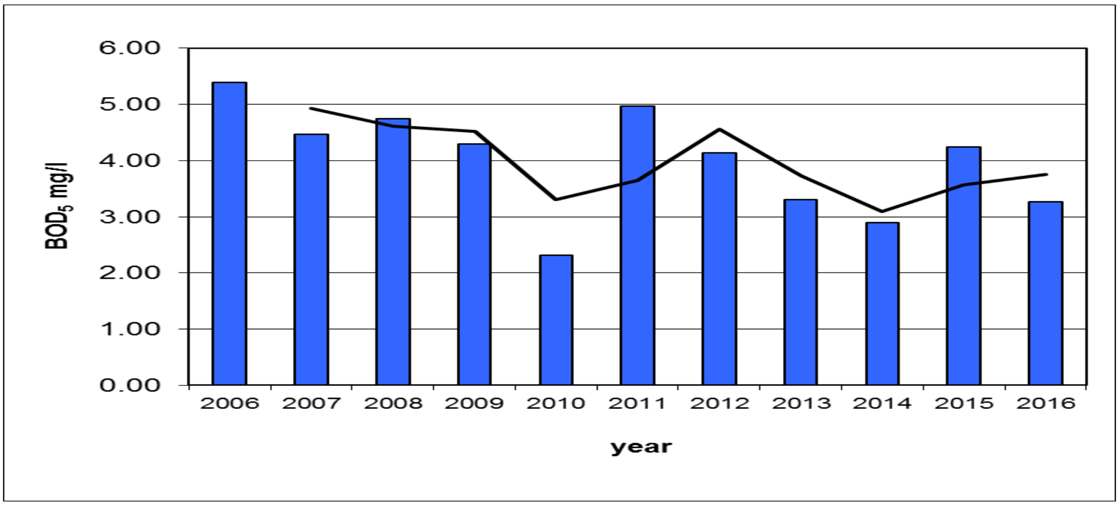


Figure 4.19.: Temporal changes of BOD_5 (c90) in Reni

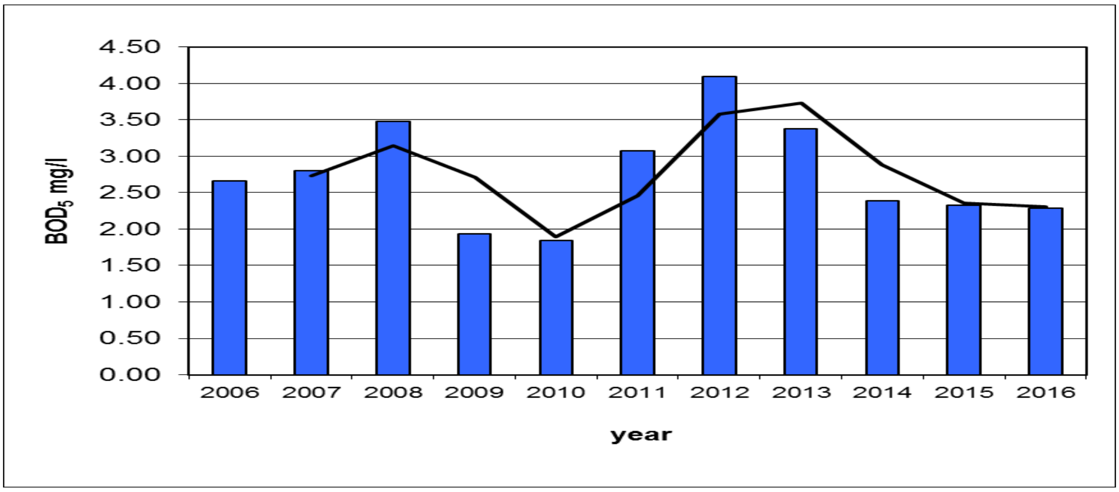


Figure 4.20.: Temporal changes of N-NO_3 (c90) in Bratislava

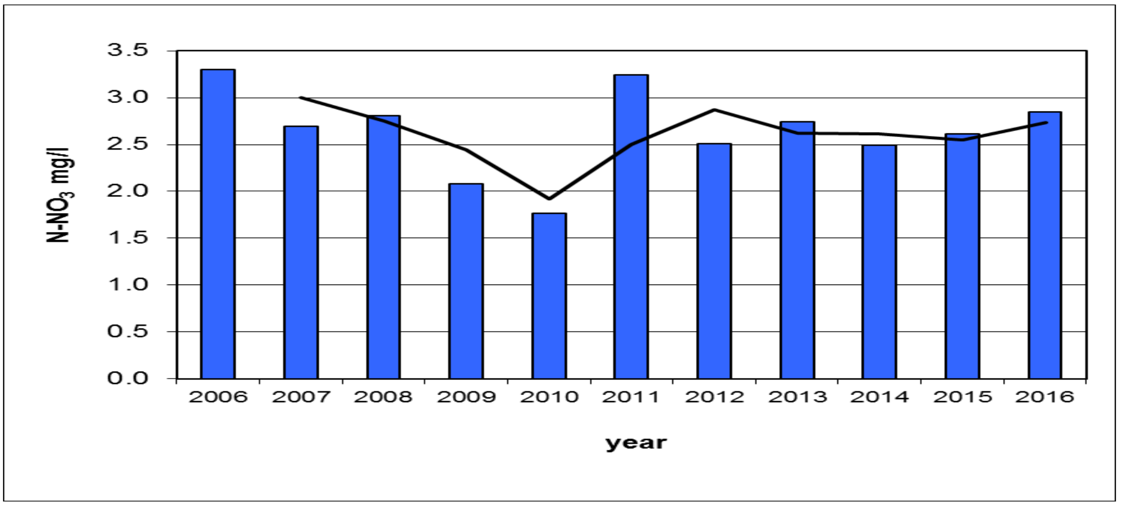


Figure 4.21.: Temporal changes of N-NO_3 (c90) in Hercegszanto

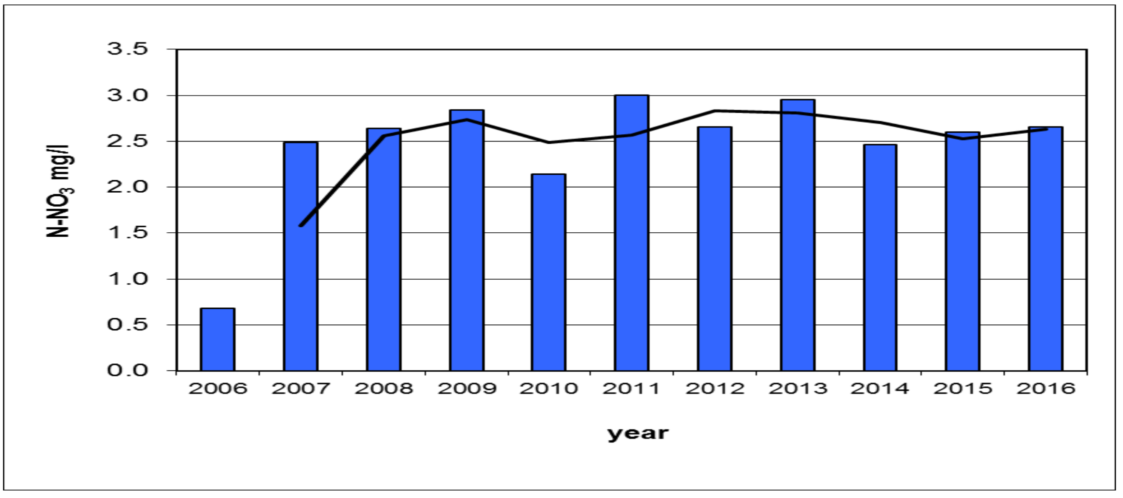


Figure 4.22.: Temporal changes of N-NO_3 (c90) in Reni

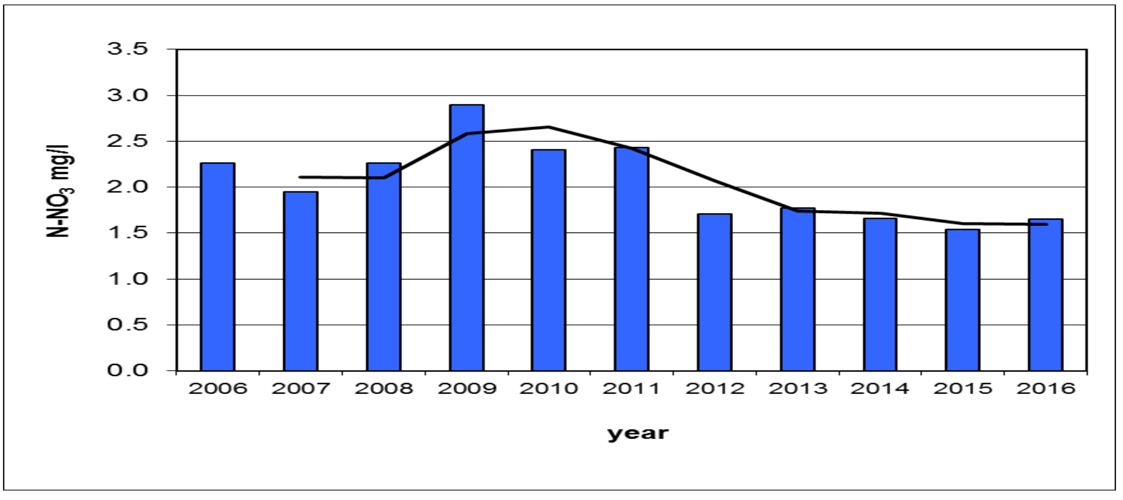


Figure 4.23.: Temporal changes of total phosphorus (c90) in Bratislava

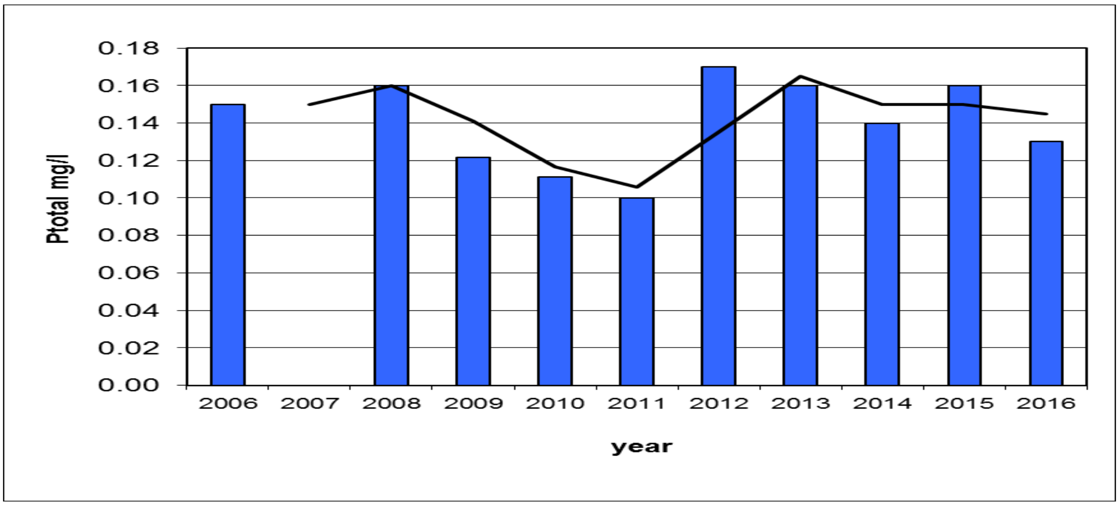


Figure 4.24.: Temporal changes of total phosphorus (c90) in Hercegszanto

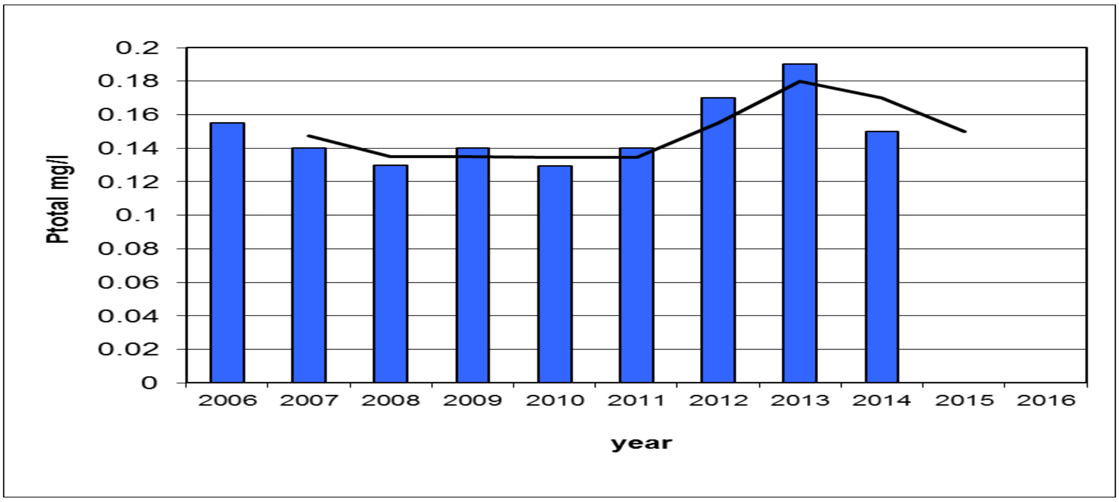


Figure 4.25.: Temporal changes of total phosphorus (c90) in Reni

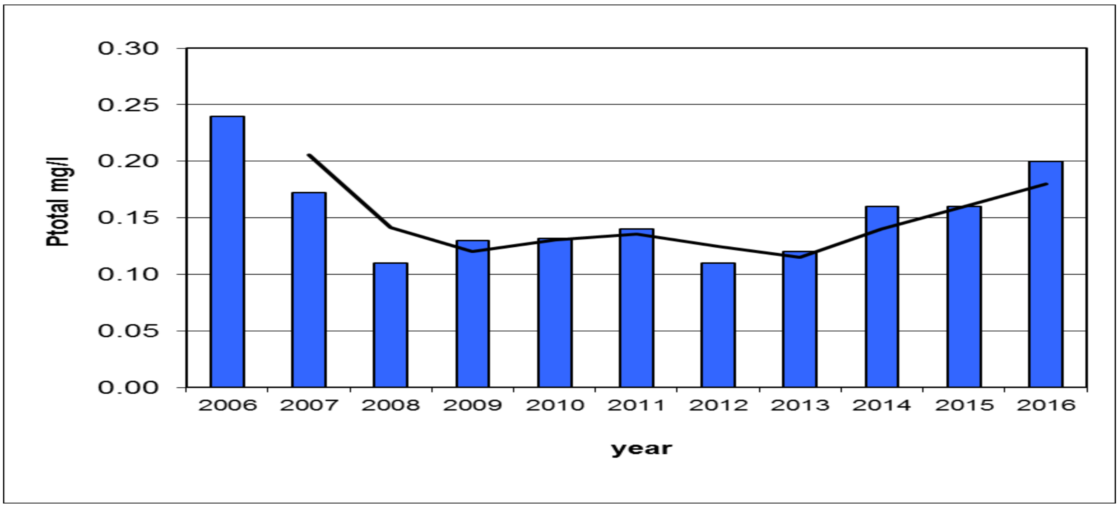


Figure 4.26.: The percentile (90, 10) of N-NH$_4$ concentration along the Danube River in 2016.

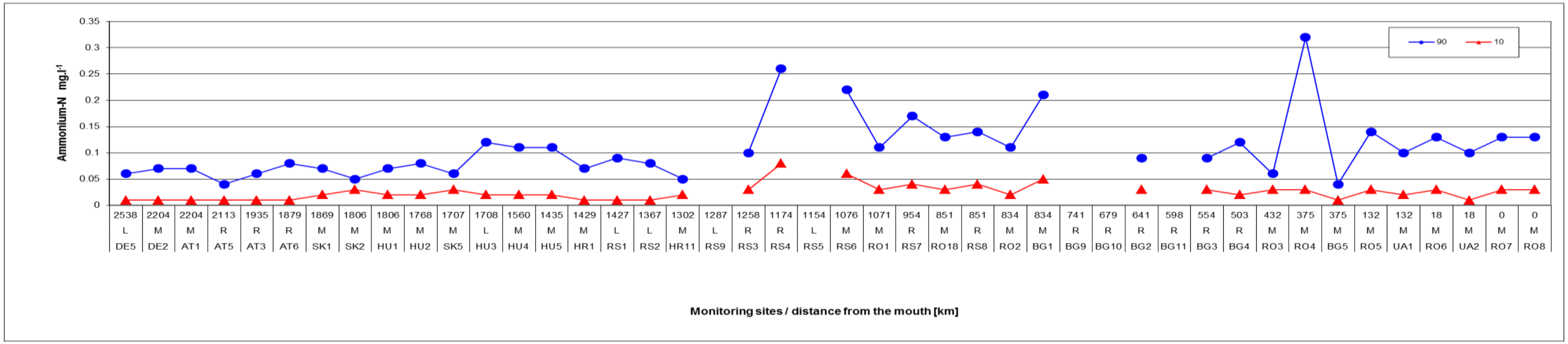


Figure 4.27.: The percentile (90, 10) of N-NH$_4$ concentration in the tributaries in 2016.

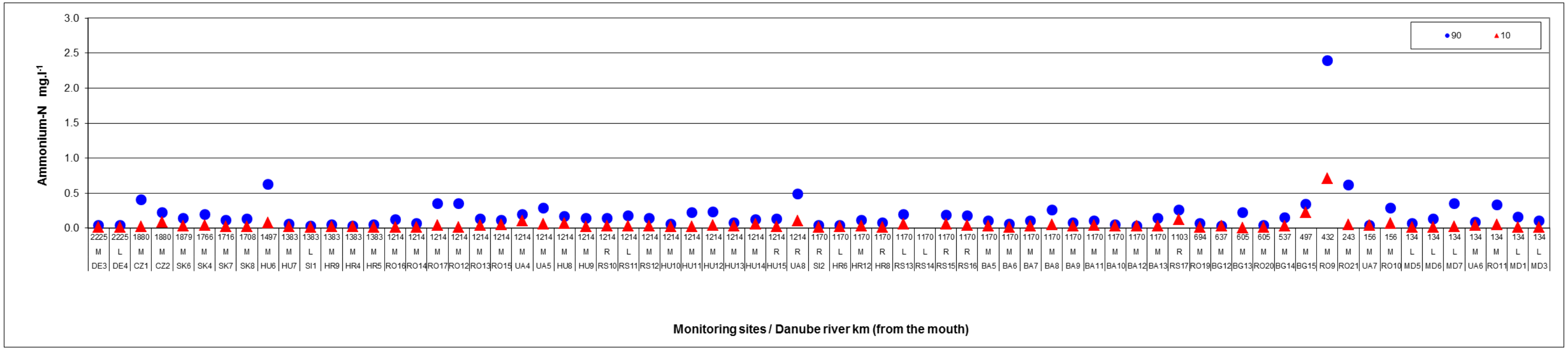


Figure 4.28.: The percentile (90, 10) of P-PO$_4$ concentration along the Danube River in 2016.

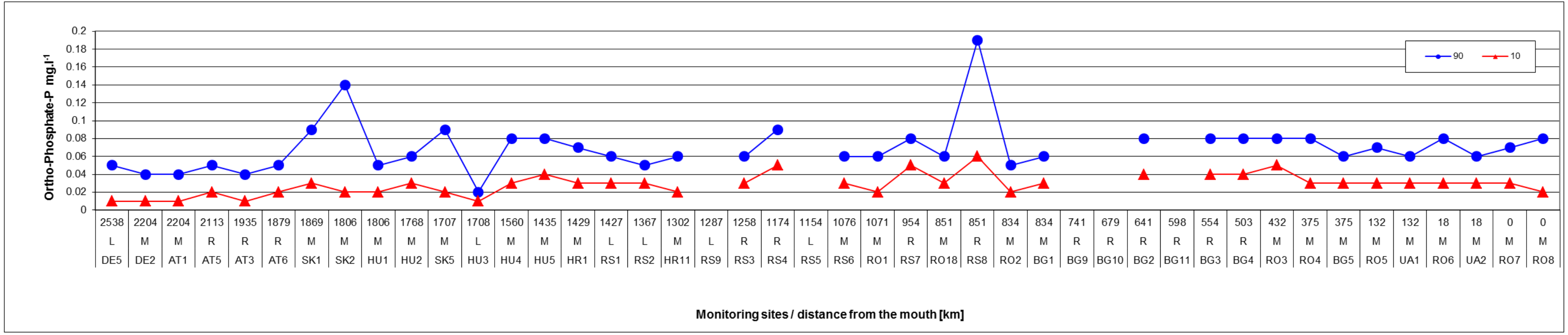


Figure 4.29.: The percentile (90, 10) of P-PO$_4$ concentration in the tributaries in 2016.

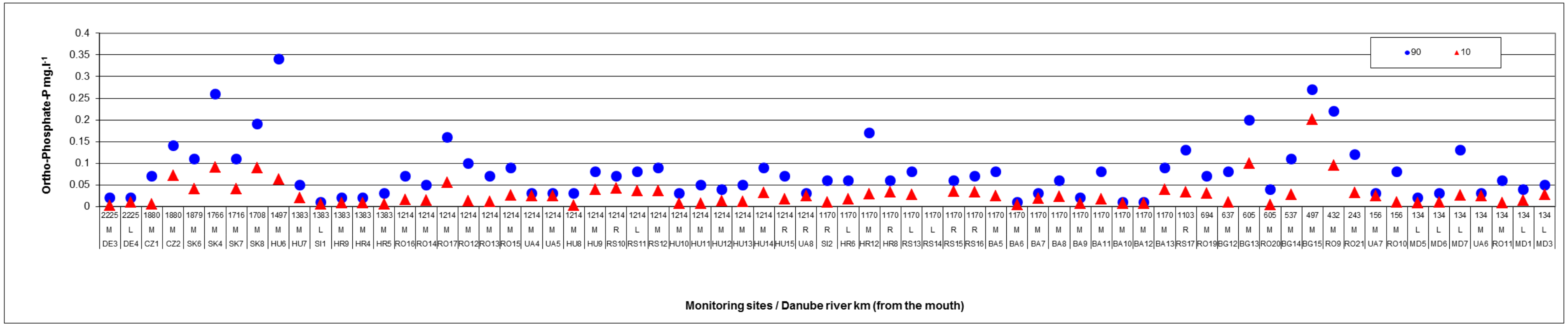


Figure 4.30.: The percentile (90, 10) of COD_{Cr} concentration along the Danube River in 2016.

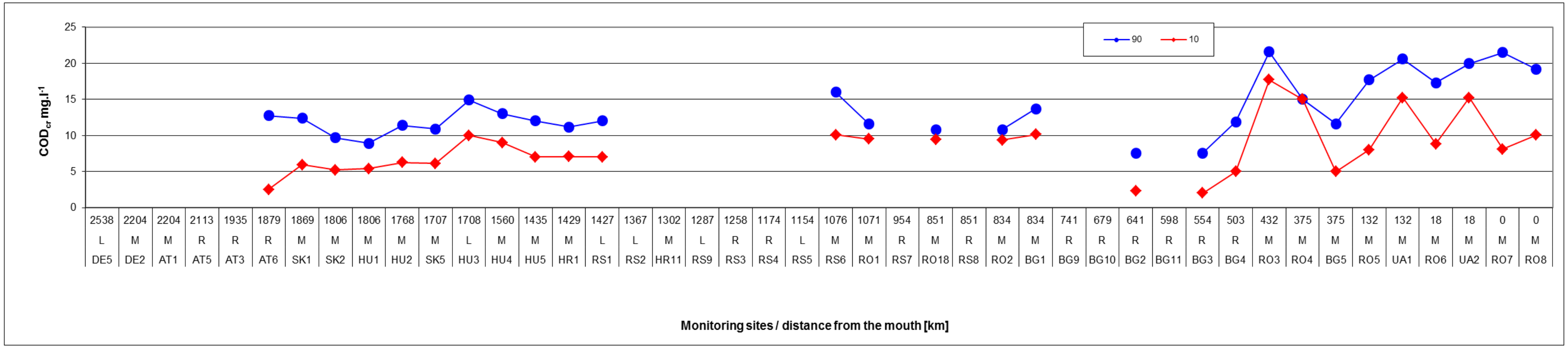


Figure 4.31.: The percentile (90, 10) of COD_{Cr} concentration in the tributaries in 2016.

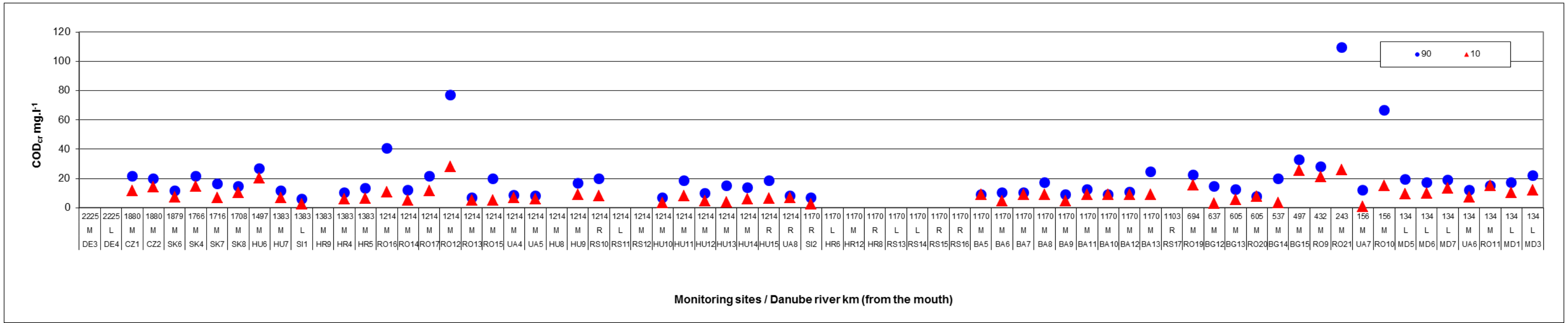


Figure 4.32.: The percentile (90, 10) of BOD_5 concentration along the Danube River in 2016.

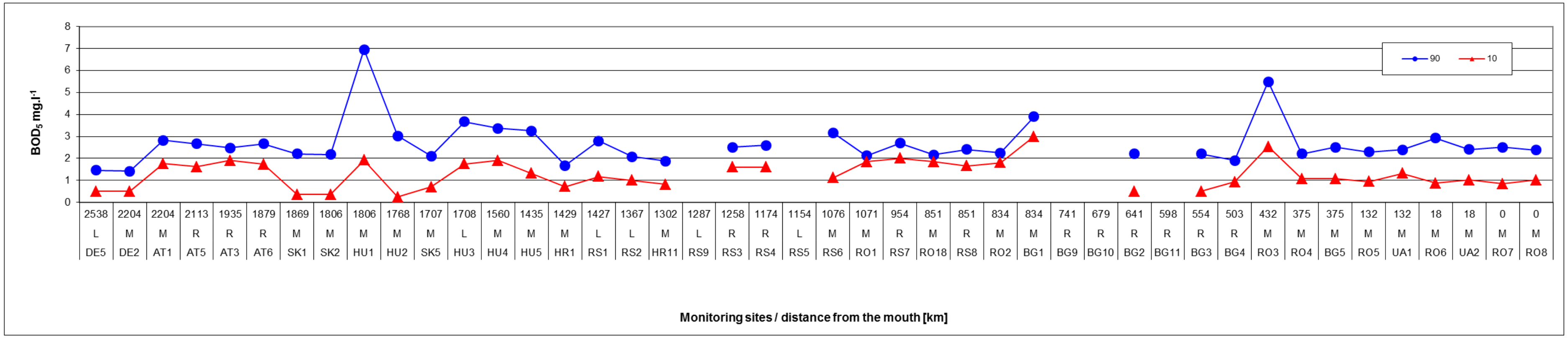
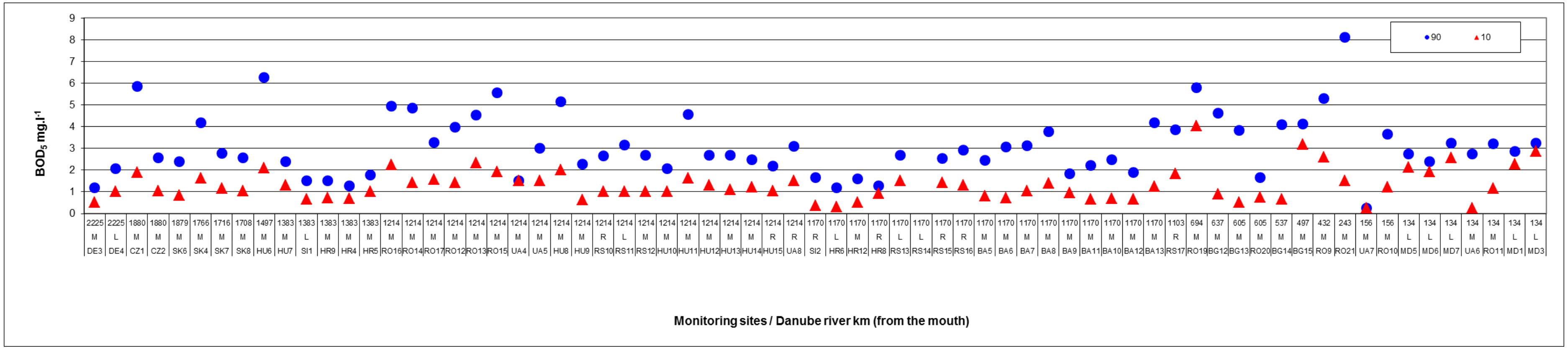


Figure 4.33.: The percentile (90, 10) of BOD_5 concentration in the tributaries in 2016.



4.1 Mercury in fish

DRBMP – Update 2015 highlighted the fact that the concentration of mercury in biota exceeded the EQS in all surface water bodies monitored so far. In most of the Danube countries methods for the analysis of mercury in fish were not available so a significant gap in the assessment of the chemical status exists.

In order to fill this gap all the ICPDR Contracting Parties were encouraged at StWG-13 meeting to establish in line with the Article 2 (2) 2 of the Directive 2013/39/EU the monitoring of mercury in fish at least at one TNMN sampling site. The MA EG agreed that TNMN would report on Hg in biota in 3-year cycles.

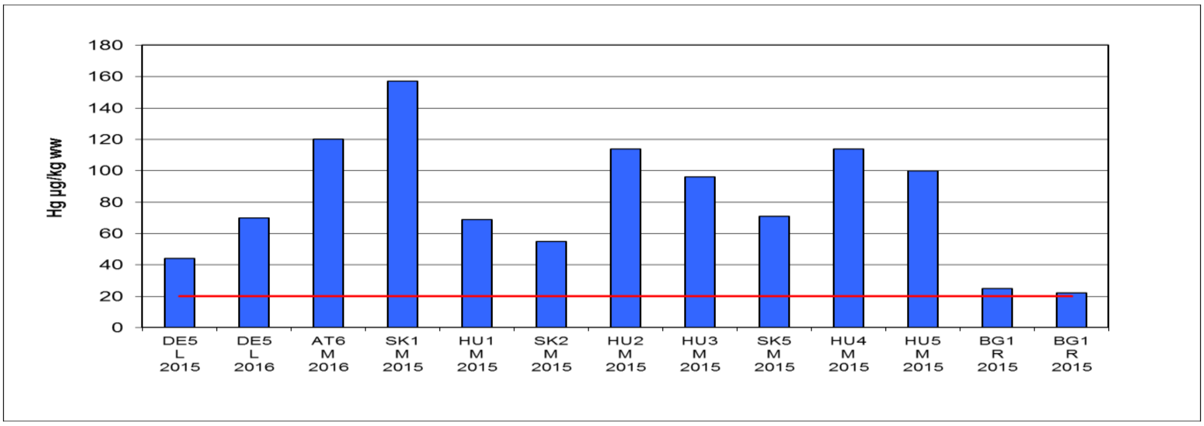
The first cycle for reporting is 2014-2016. Czech Republic, Germany, Slovakia, Slovenia, Romania, Hungary and Austria have nominated the sampling sites. Table 4 lists the analytical methods applied for the analysis of mercury in fish. Data were sent from 6 countries, in which there are 12 monitoring sites on the Danube River and 16 sites on the tributaries. Most of countries analysed the whole fish, Czech Republic and Germany analysed fish muscle (filet) and Germany calculated also the whole fish concentration by using a factor of 0,7 according to literature[1].

Table 4: Analytical methods for Hg in fish

COUNTRY CODE	LOQ	REFERENCE TO LITERATURE	UNIT	ANALYTICAL METHOD NAME	VALIDATION	UNCERTAINTY
HU	6	EN 13805:2015 Analysis EPA Method 6020A:2007	µg/kg ww	ICP-MS	N	0.2
AT	3	EN ISO12846	µg/kg ww	CV-AAS	Y	
CZ	3	ČSN 757440	µg/kg ww	AMA 254	Y	0.02
DE	2	EPA-7473	µg/kg ww	DMA-80 Direct Mercury Analyzer	Y	
SK	20	STN EN ISO 17852	µg/kg ww	Method of atomic fluorecsence spectrometry	Y	0.02
SI	5	EPA 7473	µg/kg ww	DMA	Y	0.02
BG	10	EN ISO 17852	µg/kg ww	AFS	N	

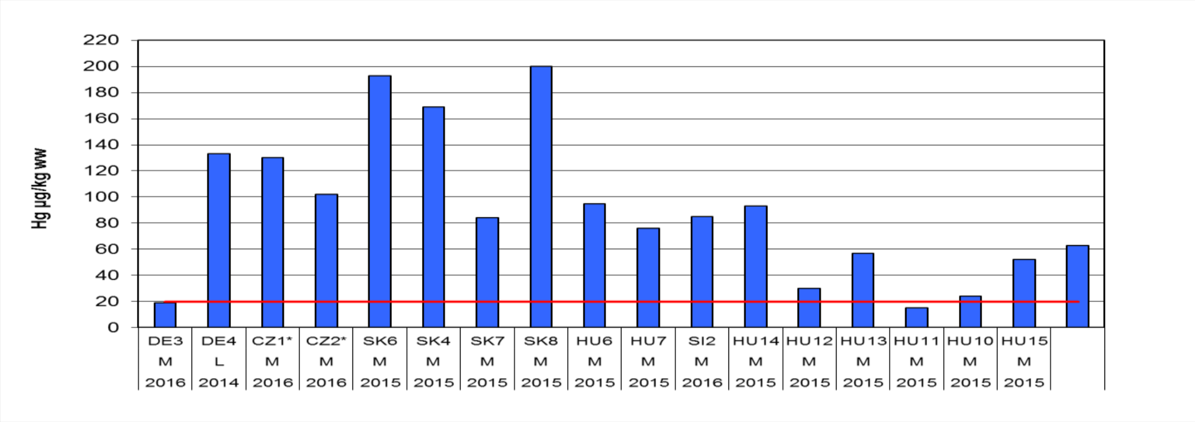
The data for mercury in fish in the Danube River and the tributaries are presented in Figure 4.34 and Figure 4.35. The data refer to whole fish except the data for Czech tributaries which stand for fish muscle concentrations (marked with * in figure 4.35).

Figure 4.34. Hg in fish in the Danube River.



[1] (*Fliedner A., Heinz Rüdel H., Lohmann N., Buchmeier G., Koschorreck J., Biota monitoring under the Water Framework Directive: On tissue choice and fish species selection, Environmental Pollution, 235, 2018, 129-140)

Figure 4.35. Hg in fish in tributaries.



In the Danube River (Fig.4.34) the observed concentrations variegate between 22 µg/kg ww and 157 µg/kg ww. Only the mercury concentration in fish from HU11 is below the EQS from the Directive 2013/39/EU (20 µg/kg wet weight). The scientific literature of the last years has shown, that the selected fish species and their age strongly influence the amount of mercury observed in the fish tissue. Therefore, for the further interpretation of these results one has to consider the details for fish species, age, number of fish etc., which are presented in table 5.

Table 5: Hg in fish – monitoring details

Monitoring_point_code	Location_in_profile	Year	Sampling_method	Value [µg/kg ww]	Number of fish	Fish species, Latin	Fish species, English	Category of age of fish	type of sample	dry weight %	lipid content %	length cm	weight g
HU14	M	2015	Whole fish	93	6	Rutilus rutilus	roach	3-5	mixture	no data	no data	no data	no data
HU12	M	2015	Whole fish	30	5	Carassius auratus gibelio	silver Prussian carp	3-5	mixture	no data	no data	no data	no data
HU13	M	2015	Whole fish	57	2	Carassius auratus gibelio, Scardinius erythrophthalmus	silver Prussian carp, common rudd	3-5	mixture	no data	no data	no data	no data
HU11	M	2015	Whole fish	15	9	Leuciscus cephalus	European chub	3-5	mixture	no data	no data	no data	no data
HU10	M	2015	Whole fish	24	10	Leuciscus cephalus	European chub	3-5	mixture	no data	no data	no data	no data
HU7	M	2015	Whole fish	76	3	Rutilus rutilus	roach	3-5	mixture	no data	no data	no data	no data
HU15	M	2015	Whole fish	52	7	Leuciscus idus, Leuciscus cephalus, Abramis sapa	ide, European chub, White-eye bream	3-5	mixture	no data	no data	no data	no data
HU9	M	2015	Whole fish	63	2	Leuciscus idus	ide	3-5	mixture	no data	no data	no data	no data
HU6	M	2015	Whole fish	95	6	Rutilus rutilus	roach	3-5	mixture	no data	no data	no data	no data
HU3	M	2015	Whole fish	96	7	Blicca bjoerkna, Leuciscus cephalus, Rutilus rutilus	silver bream, European chub, roach	3-5	mixture	no data	no data	no data	no data
HU1	M	2015	Whole fish	69	10	Leuciscus cephalus, Rutilus rutilus	European chub, roach	3-5	mixture	no data	no data	no data	no data
HU2	M	2015	Whole fish	114	13	Blicca bjoerkna, Leuciscus cephalus	silver bream, European chub	3-5	mixture	no data	no data	no data	no data
HU5	M	2015	Whole fish	100	11	Blicca bjoerkna, Leuciscus idus	silver bream, ide	3-5	mixture	no data	no data	no data	no data
HU4	M	2015	Whole fish	114	11	Blicca bjoerkna, Leuciscus cephalus, Rutilus rutilus	silver bream, European chub, roach	3-5	mixture	no data	no data	no data	no data
AT6	M	2016	Whole fish	120	4	Abramis brama	bream	3-5	pool	30.8	7.7	12.4	621
CZ1*	M	2016	Fish muscle	130	3	Leuciscus cephalus	European chub	>5	mixture	20	10	38.0	1765
CZ2*	M	2016	Fish muscle	102	3	Leuciscus cephalus	European chub	>5	mixture	20	10	34.0	1216
DE2*	M	2011	Fish muscle	64	10	Squalius sephalus	chub	3-5	mixture	22.2		29.0	281
DE5*	L	2015	Fish muscle	63	10	Squalius sephalus	chub	3-5	mixture	22.4	1.1	28.0	283
DE4*	L	2014	Fish muscle	190	4	Squalius sephalus	chub	>5	mixture	29	3.6	46.0	1491
DE5*	L	2016	Fish muscle	100	10	Squalius sephalus	chub	>5	mixture	20.6	1.3	38.0	701
DE3*	M	2016	Fish muscle	27	2	Salmo trutta f. fario	trout	3-5	mixture	25.7	5	32.0	355
DE2	M	2011	Whole fish	45	10	Squalius sephalus	chub	3-5	mixture			29.0	281
DE5	L	2015	Whole fish	44	10	Squalius sephalus	chub	3-5	mixture			28.0	283
DE4	L	2014	Whole fish	133	4	Squalius sephalus	chub	>5	mixture			46.0	1491
DE5	L	2016	Whole fish	70	10	Squalius sephalus	chub	>5	mixture			38.0	701
DE3	M	2016	Whole fish	19	2	Salmo trutta f. fario	trout	3-5	mixture			32.0	355
SI2	R	2016	Whole fish	85	1	Squalius sephalus	chub	>5	pool	27.5		40.2	755
SK2	M	2015	Whole fish	55	3	Leuciscus cephalus	chub	3-5	mixture	24.56	3.17	19.3	110
SK1	M	2015	Whole fish	157	1	Leuciscus cephalus	chub	3-5	mixture	23.67	2.45	41.0	1012
SK7	M	2015	Whole fish	84	13	Leuciscus cephalus	chub	3-5	mixture	24.39	5.19	33.2	731
SK6	M	2015	Whole fish	193	4	Leuciscus cephalus	chub	3-5	mixture	24.54	3.4	22.9	313
SK5	M	2015	Whole fish	71	1	Leuciscus cephalus	chub	3-5	mixture	33.1	12	38.0	2500
SK4	M	2015	Whole fish	169	5	Leuciscus cephalus	chub	3-5	mixture	28.85	4.58	22.0	127
SK8	M	2015	Whole fish	200	3	Leuciscus cephalus	chub	3-5	mixture	28.54	6.6	27.2	399
BG1	R	2015	Whole fish	25	1	Barbus barbus	white barbel	3-5	single				
BG1	R	2015	Whole fish	22	1	Barbus barbus	white barbel	3-5	single				

4.2 Macrozoobenthos saprobic index and chlorophyll

The maximum values of macrozoobenthos- saprobic index in Danube River and tributaries is presented in the Figures 4.36 and 4.37. The data of macrozoobenthos were delivered during the year 2016 for 18 monitoring points located in the Danube River and for 39 monitoring points in tributaries. The maximal value of saprobic index was determined in RO4 Chiciu. The highest value of macrozoobenthos- saprobic index was found in tributary Olt (RO20).

Figure 4.36.: The maximum values of macrozoobenthos- saprobic index along the Danube River in 2016.

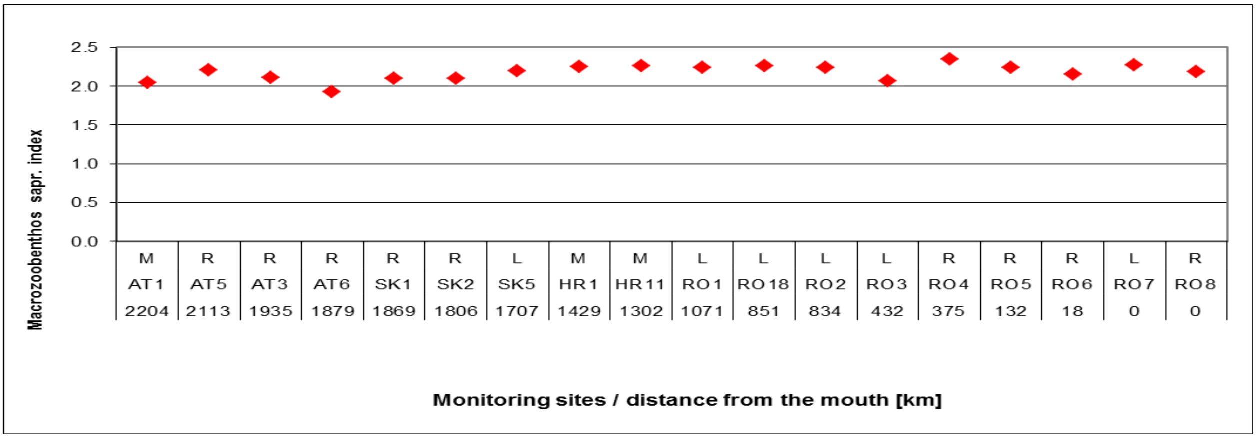


Figure 4.37.: The maximum values of macrozoobenthos- saprobic index in the tributaries in 2016.

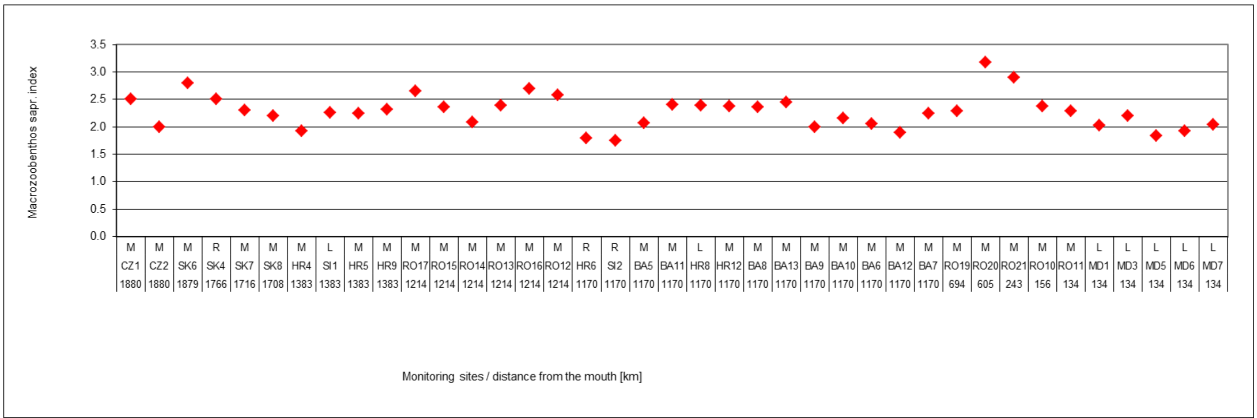
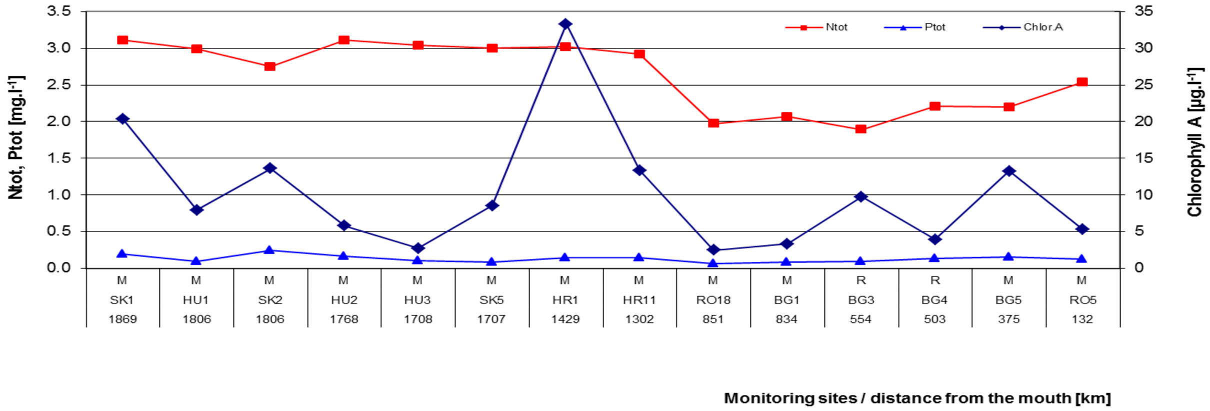


Figure 4.38.: The percentile (90) of total nitrogen, phosphorus and chlorophyll *a* concentration along the Danube River in 2016.



The concentration of nutrients and the chlorophyll *a* are presented in Figure 4.38 (in figure there are described only monitoring points where all three determinands were measured). The maximal concentration of chlorophyll *a* was observed in HR11. The highest concentration of N_{total} was observed in HU2 and maximal concentration of P_{total} was in SK2.

4.3 Sava and Tisza Rivers

The percentiles 90 of nutrients COD_{Cr}, BOD_5 measured in 2016 in Sava and Tisza Rivers are presented in the Figures 4.39-4.42. The highest value of $N\text{-}NH_4$ in Sava River was found in monitoring point RS13 (rkm 205). The maximal concentration of $N\text{-}NO_3$ was also observed in SI2 (rkm 729, Figure 4.37) and the highest value of N_{total} was measured in RS15 (rkm 106, Figure 4.37).

The highest values of BOD_5 in Sava River was measured in monitoring point RS16 rkm 17 and the highest COD_{Cr} value was measured in monitoring point BA11 (rkm 190, Figure 4.38).

Figure 4.39.: The percentile (90) of $N_{tot.}$, $N\text{-}NH_4$ and $N\text{-}NO_3$ concentration along the Sava River in 2016.

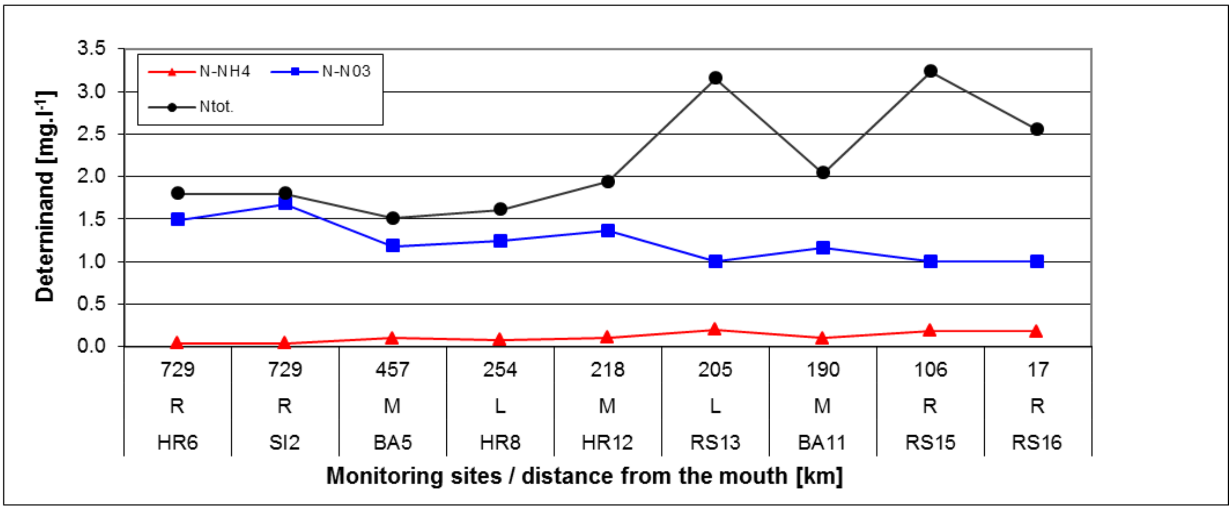


Figure 4.40.: The percentile (90) of BOD_5 and COD_{Cr} concentration along the Sava River in 2016.

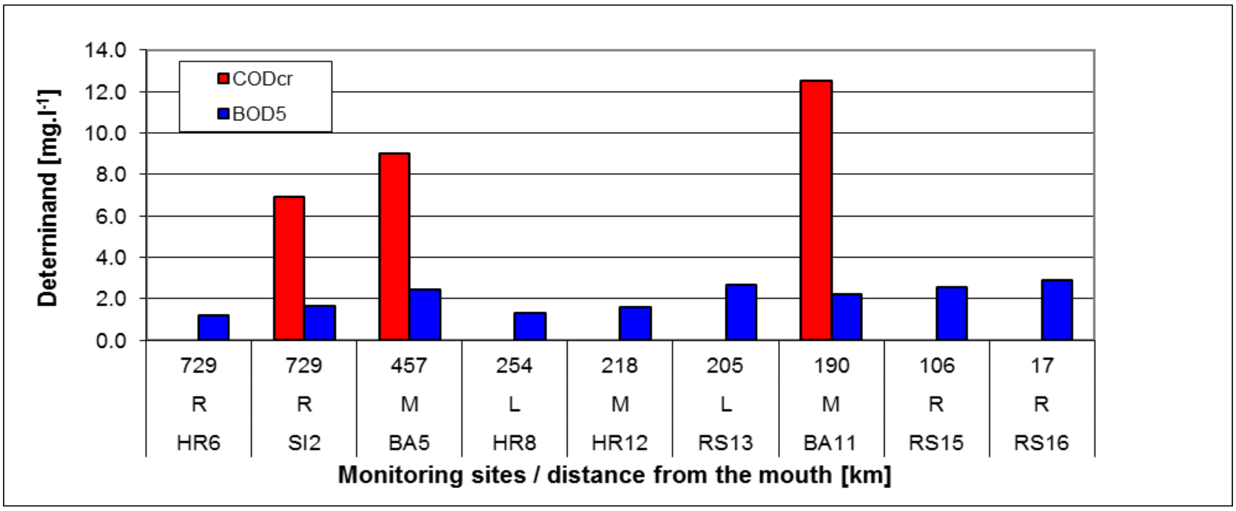


Figure 4.41.: The percentile (90) of total nitrogen, $N\text{-}NH_4$ and $N\text{-}NO_3$ concentration along the Tisza River in 2016.

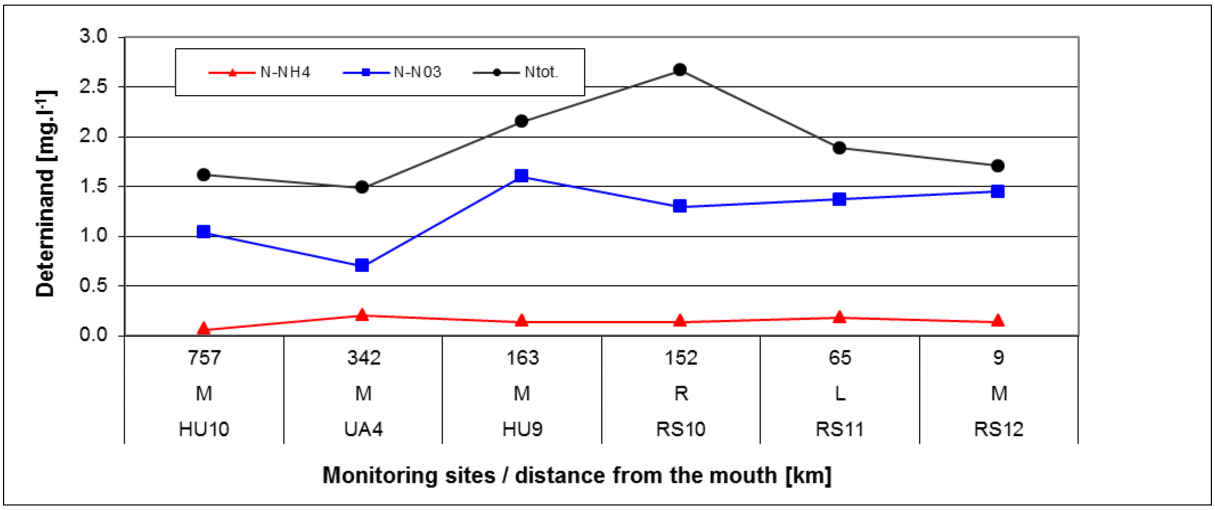
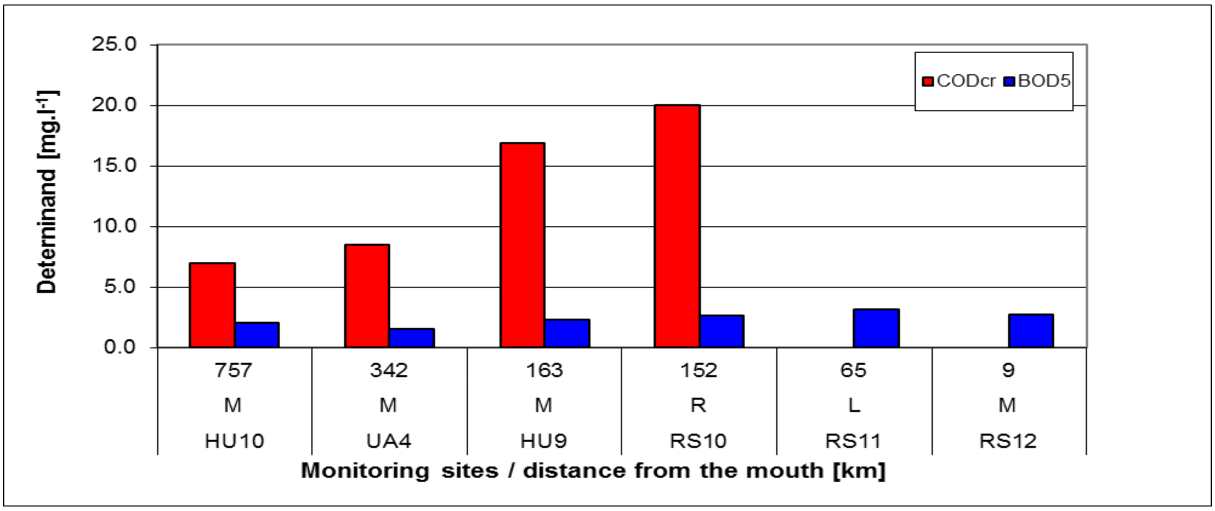


Figure 4.42.: The percentile (90) of BOD_5 and COD_{Cr} concentration along the Tisza River in 2016.



The maximal value of $N\text{-}NH_4$ in Tisza River was measured in monitoring point UA4 rkm 342 (see Figure 4.40). The highest value of $N\text{-}NO_3$ was measured in HU9 rkm 163. In 2016 maximum of N_{total} was measured in RS10 rkm 152.

The highest value of COD_{Cr} in Tisza River was found in monitoring point RS10 and maximum of BOD_5 was measured in RS11 rkm 65. (Figure 4.41).

5. Load Assssment

5.1 Introduction

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

5.2 Description of load assessment procedure

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

- *Load is calculated for the following determinands: BOD_5, inorganic nitrogen, ortho-phosphate-phosphorus, dissolved phosphorus, total phosphorus, suspended solids and - on a voluntary basis – chlorides and dissolved silica; based on the agreement with the Black Sea Commission, silicates are measured at the Romanian load assessment sites since 2004;*
- *The minimum sampling frequency at sampling sites selected for load calculation is set at 24 per year;*
- *The load calculation is processed according to the procedure recommended by the Project "Transboundary assessment of pollution loads and trends" and described in Chapter 6.4. Additionally, countries can calculate annual load by using their national calculation methods, results of which should be presented together with data prepared on the basis of the agreed method;*
- *Countries should select for load assessment those TNMN monitoring sites for which valid flow data is available (see Table 6).*

Table 6 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. Rivers Prut and Siret were added in the year 2010.

5.3 Monitoring Data in 2016

The monitoring frequency is an important factor for the assessment of pollution loads in watercourses. Table 7 shows the number of measurements of flow and water quality determinands in the TNMN load assessment sites.

Data are shown in tables 7 - 12. In most of the locations, the number of samples was higher than 20, lower frequency was observed for chlorides. A frequency of 10-12 times per year was applied for Czech, Croatian, German and Ukrainian monitoring stations. In 2010, load calculation for Slovakian monitoring points on tributaries Morava, Hron and Ipeľ was added, at a monitoring frequency of 12.

The loads in the Danube at Jochenstein are being assessed based on combined data from Germany and Austria; there is no issue with insufficient frequency there. For two Croatian stations, there is a complex data calculation using different hydrological stations and quality monitoring points: Danube HR2 Borovo rkm 1337 and HR11 Ilok rkm 1302; Sava HR7 us Una Jesenovac rkm 525 and HR12 Račinovci rkm 218.

There is still a lack of data on dissolved phosphorus as it was measured at 13 locations only. Also the silicate /dissolved silica load was calculated at 13 monitoring points.

Table 6: List of TNMN locations selected for load assessment program

Country	River	Water quality monitoring location			Hydrological station	
		Station Code	Location	Distance from mouth (Km)	Location	Distance from mouth (Km)
Germany	Danube	DE2	Jochenstein	2204	Achleiten	2223
Germany	Inn	DE3	Kirchdorf	195	Oberaudorf	211
Germany	Inn/Salzach	DE4	Laufen	47	Laufen	47
Austria	Danube	AT1	Jochenstein	2204	Aschach	2163
Austria	Danube	AT6	Hainburg	1879	Hainburg (Danube) Angern (March)	1884 32
Czech Republic	Morava	CZ1	Lanzhot	79	Lanzhot	79
Czech Republic	Morava/Dyje	CZ2	Pohansko	17	Breclav-Ladná	32,3
Slovak Republic	Danube	SK1	Bratislava	1869	Bratislava	1869
Slovak Republic	Váh	SK4	Komárno		Sum of: Maly Dunaj -Trstice Vah- Sala Nitra -Nove Zamky	22,5 58,8 12,3
Slovak Republic	Morava	SK6	Devín		Zahorska Ves	32,5
Slovak Republic	Hron	SK7	Kamenica		Kanenin	10,9
Slovak Republic	Ipeľ	SK8	Salka		Salka	12,2
Hungary	Danube	HU3	Szob	1708	Nagymaros	1695
Hungary	Danube	HU5	Hercegszántó	1435	Mohács	1447
Hungary	Tisza	HU9	Tiszasziget	163	Szeged	174
Croatia	Danube	HR2	Borovo	1337	Vukovar	1337
Croatia	Sava	HR6	Jesenice	729	Jesenice	729
Croatia	Sava	HR7	Una Jesenovac	525	Una Jesenovac	525
Croatia	Sava	HR8	Zupanja	254	Zupanja	254
Slovenia	Drava	SI1	Ormoz	300	Borl HE Formin Pesnica-Zamusani	325 311 10.1(to the Drava)
Slovenia	Sava	SI2	Jesenice	729	Catez Sotla -Rakovec	737 8.1 (to the Sava)
Romania	Danube	RO2	Pristol-Novo Selo	834	Gruia	858
Romania	Danube	RO4	Chiciu-Silistra	375	Chiciu	379
Romania	Danube	RO5	Reni	132	Isaccea	101
Romania	Siret	RO10	Sendreni	0	Sendreni	0
Romania	Prut	RO11	Giurgiulesti	0	Giurgiulesti	0
Ukraine	Danube	UA2	Vylkove	18		

5.4 Calculation Procedure

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

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

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

The monthly load is calculated by using the formula:

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

where L_m monthly load
Q_m average monthly discharge

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

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

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

Table 7: Number of measurements at TNMN locations selected for assessment of pollution load in 2016

Country Code	River	Location	Location in profile	River Km	Number of measurements in 2016 Q	SS	N_{inorg}	$P\text{-}PO_4$	P_{total}	BOD_5	Cl	P_{diss}	SiO_2
DE2	Danube	Jochenstein	M	2204	366	10	25	25	25	10	10	10	
DE3	Inn	Kirchdorf	M	195	366	12	12	12	11	12	10		
DE4	Inn/Salzach	Laufen	L	47	366	13	13	13	13	13	13		
AT1	Danube	Jochenstein	M	2204	366	10	25	25	25	10	10	10	
AT6	Danube	Hainburg	R	1879	366	24	24	24	24	24	24	24	
CZ1	Morava	Lanzhot	M	79	366	12	12	6	12	12	12		6
CZ2	Morava/Dyje	Pohansko	M	17	366	12	12	6	12	12	12		6
SK1	Danube	Bratislava	M	1869	366	26	26	26	19	26	12	26	26
SK4	Váh	Komárno	M	1	366	12	12	12	4	12	12	12	12
SK6	Morava	Devín	M	1	366	12	12	12	12	12	6	12	11
SK7	Hron	Kamenica	M	2	366	12	12	12	8	12	12	12	12
SK8	Ipoly	Salka	M	12	366	12	12	12	8	12	12	12	12
HU3	Danube	Szob	L	1708		14	25	25	25	12	12		10
			M	1708	366	14	25	25	25	12	12		11
			R	1708		14	25	25	25	12	12		10
HU5	Danube	Hercegszántó	M	1435	366	15	24	24		15	14		14
HU9	Tisza	Tiszasziget	L	163		14	14	14	14	12	12		14
			M	163	366	15	26	26	25	12	12		15
			R	163		14	14	14	14	12	12		14
HR2	Danube	Borovo	R	1337	366								
HR11	Danube	Ilok	M	1302		12	12	12	12	12	12		12
HR6	Sava	Jesenice	R	729	366	12	12	12	12	12	12		12
HR7	Sava	us Una Jesenovac	L	525	366	12	12	12	12	12	12		12
HR12	Sava	Račinovci	M	218		12	12	12	12	12	12		12
HR8	Sava	ds Zupanja	ML	254	366	12	12	12	12	12	12		
SI1	Drava	Ormoz	L	300	366	26	24	26	26	26	12		
SI2	Sava	Jesenice	R	729	366	26	26	26	26	26	12		
RO2	Danube	Pristol-Novo Selo	L	834		25	25	25		25	12	25	
			M	834	366	25	25	25		25	12	25	
			R	834		25	25	25		25	12	25	
RO4	Danube	Chiciu-Silistra	L	375	365	25	26	26		26	12	13	
			M	375		26	26	26		26	12	12	
			R	375		26	26	26		26	12	12	
RO5	Danube	Reni	L	132		25	26	26	26	26	12	12	26
			M	132	366	25	26	26	26	26	12	12	26
			R	132		25	26	26	26	26	12	12	26
RO10	M	Siret	M	0	366	23	23	23		23	13	13	
RO11	M	Prut	M	0	366	27	27	27	13	12	12	13	
UA2	Danube	Vylkove	M	18	366	12	3	12		12	12	12	12

5.5 Results

The mean annual concentrations and annual loads of suspended solids, inorganic nitrogen, ortho-phosphate-phosphorus, total phosphorus, BOD_5, chlorides and – where available – dissolved phosphorus and silicates - are presented in tables 8 to 12, separately for monitoring locations on the Danube River and for monitoring locations on tributaries. The explanation of terms used in the tables 8 to 12 is 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
Q_a	mean annual discharge in the year 2016
c_{mean}	arithmetical mean of the concentrations in the year 2016
Annual Load	annual load of given determinand in the year 2016

Table 12 shows loads of other determinands (nitrogen forms and heavy metals) at the profile Reni, which are monitored since 2005 based on the agreement with the Black Sea Commission. Annual loads for Danube and tributaries are in figures 5.5.1 -5.5.12.

Trends for load during last 10 years in the Reni are in figures 5.5.13.-5.5.18. In general, loads had a decreasing tendency in years 2011 and 2012. Due to the high discharges in 2005 and 2010 higher loads were observed in those years. In 2016 loads decreased for suspended solids and chlorides while for inorganic nitrogen, ortho-phosphate, total phosphorus dissolved phosphorus and silicates the loads slightly increased.

The mean annual discharge was higher in whole Danube River as in 2015. Also in most tributaries discharges were higher than in 2015. Only in Inn, Morava, Dyje and Prut the annual discharge was lower than in 2015.

The spatial pattern of the annual load along the Danube River is similar to the previous year. In the case of suspended solids, inorganic nitrogen, BOD_5, ortho-phosphate, total phosphorus and chlorides, the highest load is observed in the lower part of the Danube River. The maximum load has been of suspended solids, ortho-phosphate, total phosphorus, chlorides and silicates at monitoring location Danube-Reni (RO5). Maximal concentration for inorganic nitrogen and dissolved phosphorus was observed at RO4 Chiciu-Silistra. Maximal load for BOD_5 was calculated for RO2 Pristol-Novo Selo.

In the case of tributaries, the highest load of inorganic nitrogen, BOD_5, chlorides is coming from the Sava River (HR8). The highest load of the total phosphorus was observed in the Tisza.

Table 8: Mean annual concentrations in monitoring locations selected for load assessment on Danube River in 2016

Station Code	Profile	River Name	Location	River km	Q_a	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	1412	13.19	2.21	0.03	0.06	1.44	18.68	0.05	
AT6	R	Danube	Hainburg	1879	1924	18.49	2.17	0.04	0.07	2.25	18.62	0.06	
SK1	M	Danube	Bratislava	1869	1944	36.00	2.19	0.07	0.12	1.38	19.37	0.08	6.09
HU3	LMR	Danube	Szob	1708	2196	28.41	2.22	0.02	0.11	3.30	20.02		5.14
HU5	M	Danube	Hercegszántó	1435	2261	19.27	1.92	0.06		2.16	21.44		4.28
HR2	R	Danube	Borovo	1337	2979								
HR11	M	Danube	Ilok	1302									
RO2	LMR	Danube	Pristol-Novo Selo	834	5339	35	1.28	0.04		2.08	19.86	0.05	
RO4	LMR	Danube	Chiciu-Silistra	375	5993	21	1.47	0.05		1.69	21.01	0.05	
RO5	LMR	Danube	Reni	132	6465	37.84	1.36	0.05	0.10	1.62	28.45	0.08	3.43*
UA2	M	Danube	Vylkove	18	3171	68.16	1.30	0.05		1.69	32.98	0.13	2.74

Table 9: Mean annual concentrations in monitoring locations selected for load assessment on tributaries in 2016

Station Code	Profile	River Name	Location	River km	Q_a	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	287	78.58	0.60	0.01	0.15	0.70	8.30		
DE4	L	Inn/Salzach	Laufen	47	268	28.92	0.68	0.01	0.04	1.51	8.08		
CZ1	M	Morava	Lanzhot	79	39	42.79	2.42	0.03	0.14	3.38	29.42		6.95*
CZ2	L	Morava/Dyje	Pohansko	17.00	26	8.29	2.85	0.10	0.27	1.83	49.33		9.39*
SK4	M	Váh	Komárno	1	187	15.17	1.98	0.07	0.12	1.68	20.62	0.09	7.48
SK6	M	Morava	Devín	1	68	81.83	2.70	0.19	0.27	2.70	44.93	0.19	10.45
SK7	M	Hron	Kamenica	2	46	12.50	1.80	0.08	0.12	2.03	18.80	0.09	13.31
SK8	M	Ipoly	Salka	12	18	26.75	2.44	0.15	0.20	1.90	30.21	0.16	19.88
HU9	LMR	Tisza	Tiszasziget	163	731	74.84	1.15	0.06	0.18	1.49	26.25		8.23
SI1	L	Drava	Ormoz	300	315	11.12	0.94	0.01	0.04	1.09	6.06		
SI2	R	Sava	Jesenice	729	291	5.91	1.39	0.03	0.06	1.00	7.29		
HR6	R	Sava	Jesenice	729	279	6.98	1.29	0.04	0.08	0.80	7.24		3.11*
HR7	L	Sava	us. Una Jasenovac	525	804								
HR12	M	Sava	Račinovci	218		9	1.30	0.09	0.15	1.15	7.85		3.88*
HR8	ML	Sava	ds. Zupanja	254	1209	12.77	1.08	0.05	0.10	1.10	23.95		4.55*
RO10	M	Siret	Conf. Danube (Sendreni)	0	181	388	1.29	0.04		0.06	80.86	2.35	
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	40	68	0.78	0.03		2.25	43.44	0.05	

Table 10: Annual load in selected monitoring locations on Danube River

Station Code	Profile	River Name	Location	River km	Annual Load in 2016							
					Suspended Solids	Inorganic Nitrogen	Ortho-Phosphate Phosphorus	Total Phosphorus	BOD_5	Chlorides	Phosphorus - dissolved	Silicates
					($x10^6$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^3$ tonns)	($x10^6$ tonns)	($x10^3$ tonns)	($x10^6$ tonns)
DE2+AT1	M	Danube	Jochenstein	2204	0.67	91.66	1.30	2.65	63.28	0.79	1.68	
AT6	R	Danube	Hainburg	1879	1.41	127.40	2.18	4.46	137.05	1.06	3.77	
SK1	M	Danube	Bratislava	1869	3.21	125.74	3.73	5.32	78.72	1.06	4.36	0.36
HU3	LMR	Danube	Szob	1708	1.44	154.63	1.65	8.27	239.15	1.36		0.35
HU5	M	Danube	Hercegszántó	1435	1.55	134.89	4.15		137.65	1.50		0.29
HR2HR/11	R/M	Danube	Borovo/Ilok	1337/1302	3.08	163.14	3.80	10.82	135.12	1.60		0.50*
RO2	LMR	Danube	Pristol-Novo Selo	834	5.97	220.04	7.30		350.65	3.28	8.86	
RO4	LMR	Danube	Chiciu-Silistra	375	4.65	294.01	10.06		318.15	4.08	16.06	
RO5	LMR	Danube	Reni	132	8.00	275.80	10.38	20.14	323.30	5.88	15.73	0.71*
UA2	M	Danube	Vylkove	18	7.99	43.33	4.72		167.99	3.28	12.82	0.28

*Silicates (SiO_2) in dissolved form

Table 11: Annual load in selected monitoring locations on tributaries

Station Code	Profile	River Name	Location	River km	Annual Load in 2016							
					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	1.00	4.21	0.13	1.63	6.53	0.05		
DE4	L	Inn/Salzach	Laufen	47	0.28	5.40	0.09	0.41	12.57	0.06		
CZ1	M	Morava	Lanzhot	79	0.05	3.47	0.03	0.15	3.12	0.03		0.006*
CZ2	L	Morava/Dyje	Pohansko	17	0.01	2.87	0.05	0.16	1.42	0.04		0.005*
SK4	M	Váh	Komárno	1	0.09	12.04	0.43	0.41	10.48	0.12	0.52	0.049
SK6	M	Morava	Devín	1	0.31	7.34	0.36	0.50	5.61	0.03	0.37	0.021
SK7	M	Hron	Kamenica	2	0.02	2.89	0.11	0.08	2.98	0.03	0.13	0.022
SK8	M	Ipoly	Salka	12	0.03	1.67	0.07	0.03	1.13	0.01	0.08	0.010
HU9	LMR	Tisza	Tiszasziget	163	2.08	27.57	1.16	4.45	38.12	0.53		0.195
SI1	L	Drava	Ormoz	300	0.12	8.95	0.06	0.43	11.26	0.06		
SI2	R	Sava	Jesenice	729	0.06	12.66	0.30	0.51	7.33	0.06		
HR6	R	Sava	Jesenice	729	0.08	11.68	0.30	0.61	6.76	0.06		0.031*
HR7/HR12	L/M	Sava	us. Una Jasenovac/Račinovci	2	0.25	30.59	1.93	3.29	32.63	0.19		0.102*
HR8	ML	Sava	ds. Zupanja	254	0.55	40.11	1.75	3.69	43.09	0.68		0.184*
RO10	M	Siret	Conf. Danube (Sendreni)	0	2.96	7.44	0.27		13.73	0.50	0.38	
RO11	M	Prut	Conf. Danube (Giurgiulesti)	0	0.09	0.99	0.04		2.79	0.05	0.07	

*Silicates (SiO_2) in dissolved form

Table 12: Additional annual load data at Reni for reporting to the Black Sea Commission

Country Code	River	Location	Location in profile	River km	Number of measurements in 2016												
					Q	N-NH_4	N-NO_2	N-NO_3	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
RO5	Danube	Reni	LMR	132	366	26	26	26	26	12	12	12	12	12	12	14	14
Country Code	River	Location	Location in profile	River km	c_{mean}												
					Q_a	N-NH_4	N-NO_2	N-NO_3	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
					($m^3.s^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($mg.l^{-1}$)	($\mu g.l^{-1}$)	($\mu g.l^{-1}$)	($\mu g.l^{-1}$)	($\mu g.l^{-1}$)	($\mu g.l^{-1}$)	($\mu g.l^{-1}$)	($\mu g.l^{-1}$)	($\mu g.l^{-1}$)
RO5	Danube	Reni	LMR	132	6465	0.09	0.02	1.26	1.94	7.51	3.16	1.19	0.52	0.08	0.08	0.01	0.009
Country Code	River	Location	Location in profile	River km	Annual Load in 2016												
						N-NH_4	N-NO_2	N-NO_3	N_{total}	Cu	$Cu_{diss.}$	Pb	$Pb_{diss.}$	Cd	$Cd_{diss.}$	Hg	$Hg_{diss.}$
						($x10^3$tonns)	($x10^3$tonns)	($x10^3$tonns)	($x10^3$tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)	(tonns)
RO5	Danube	Reni	LMR	132		17.55	3.39	254.86	397.74	1541.08	655.31	248.01	108.33	15.33	15.33	1.88	1.69

Figure 5.1.: Annual load of suspended solids at monitoring locations along the Danube River.

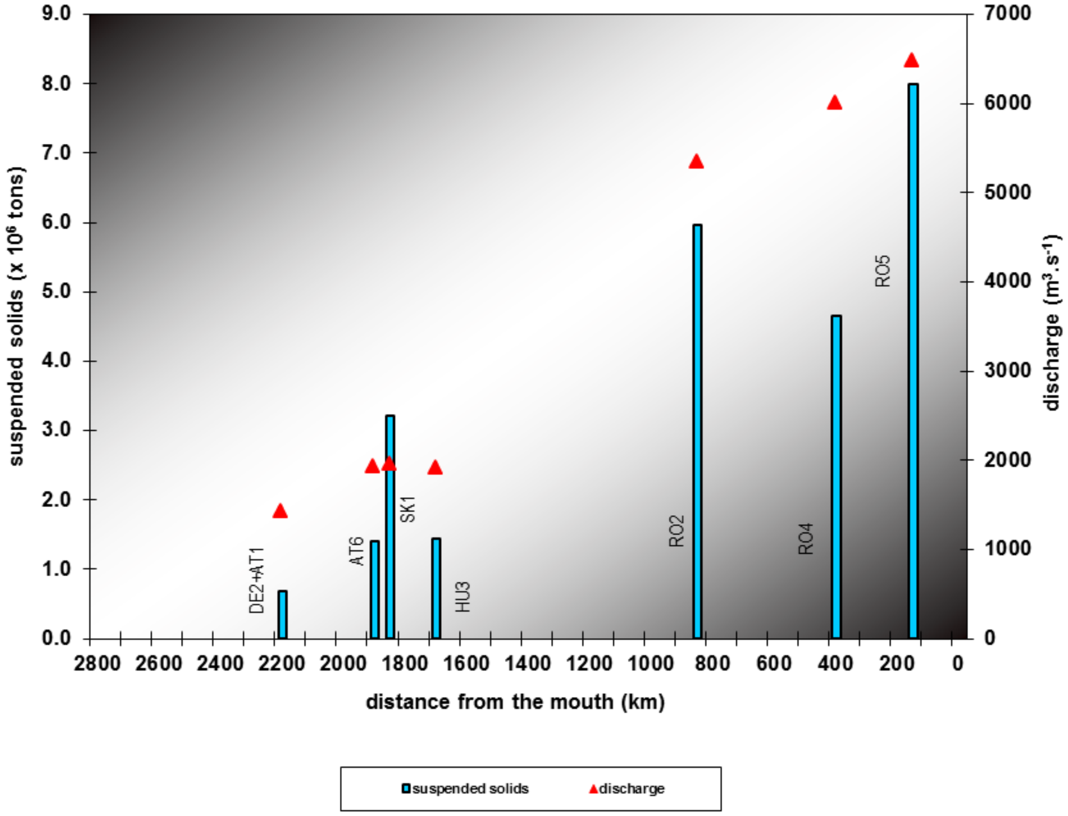


Figure 5.2.: Annual load of suspended solids at monitoring locations on tributaries.

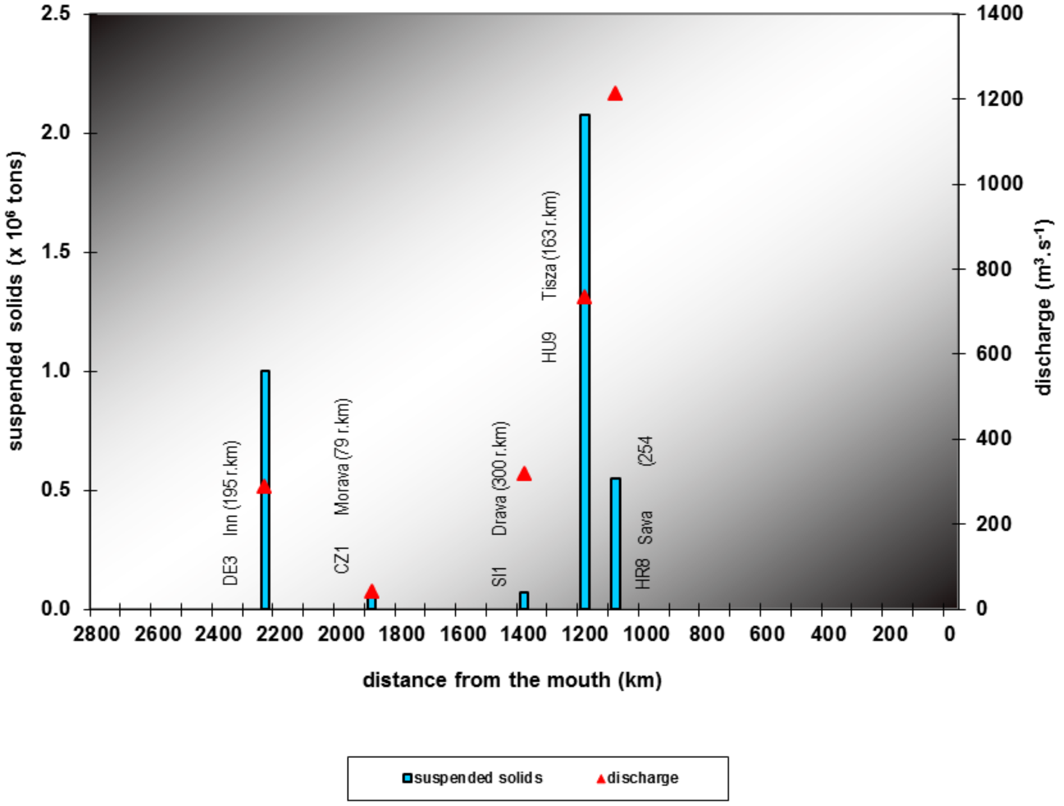


Figure 5.3.: Annual loads of inorganic nitrogen at monitoring locations along the Danube River.

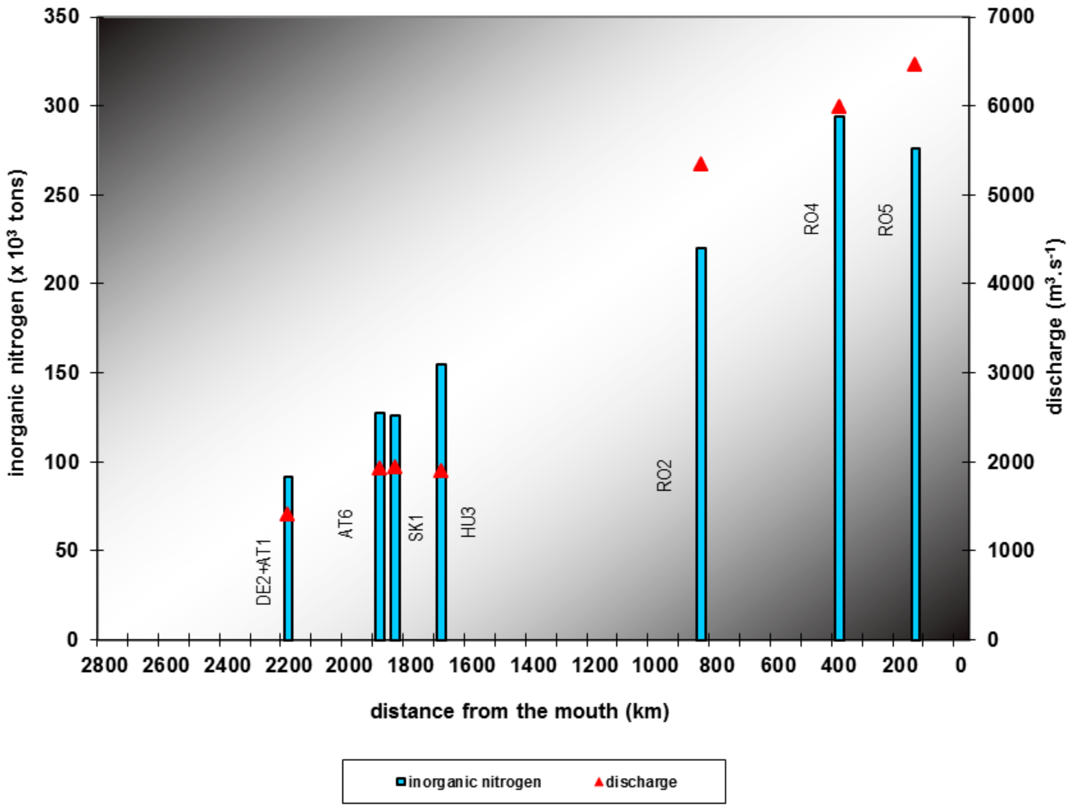


Figure 5.4.: Annual loads of inorganic nitrogen at monitoring locations on tributaries.

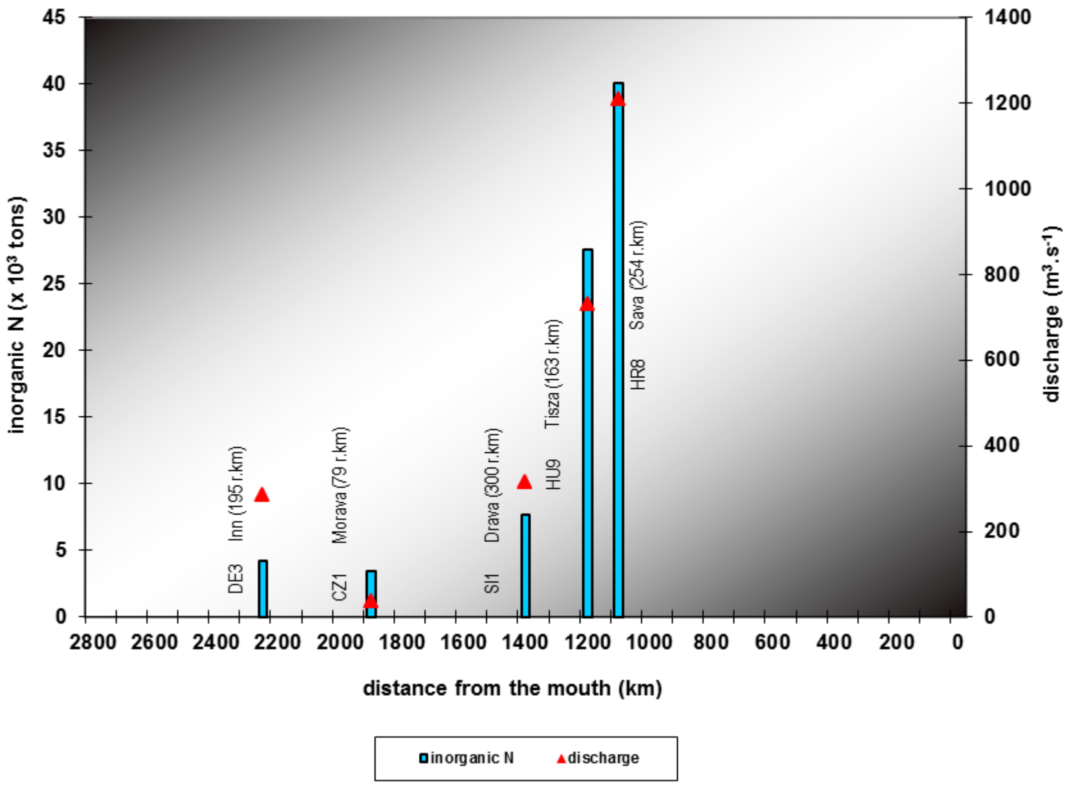


Figure 5.5.: Annual loads of P-PO_4 at monitoring locations along the Danube River.

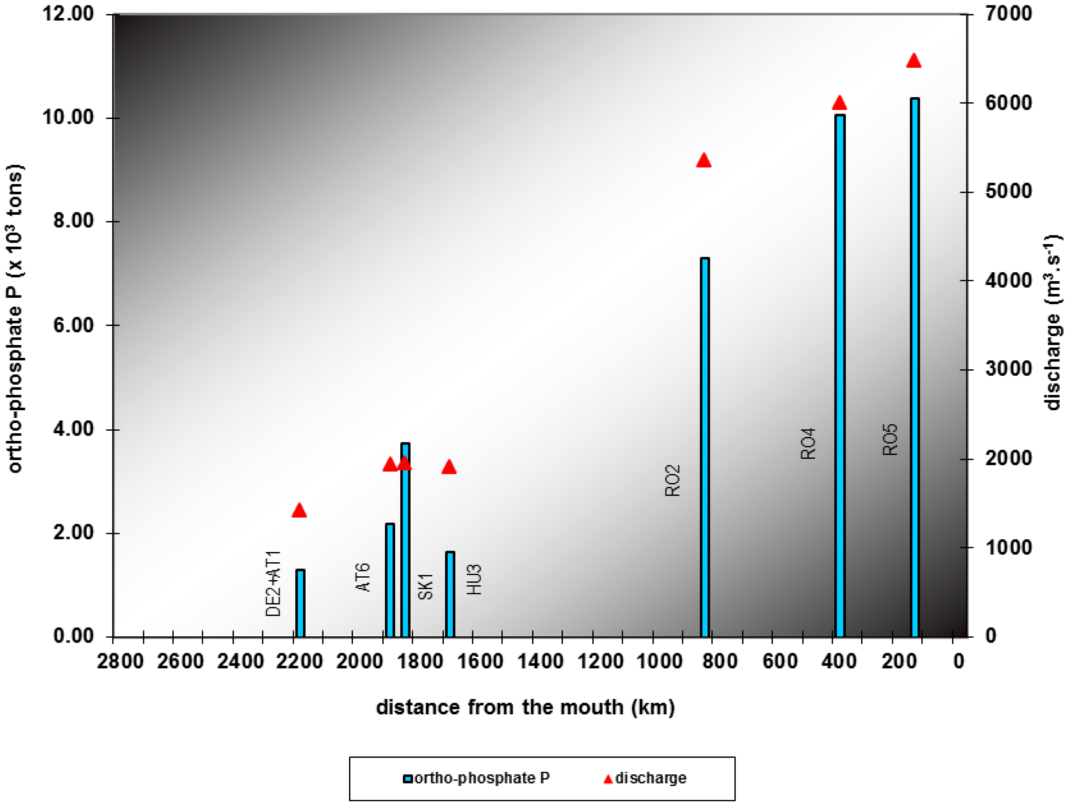


Figure 5.6.: Annual loads of P-PO_4 at monitoring locations on tributaries.

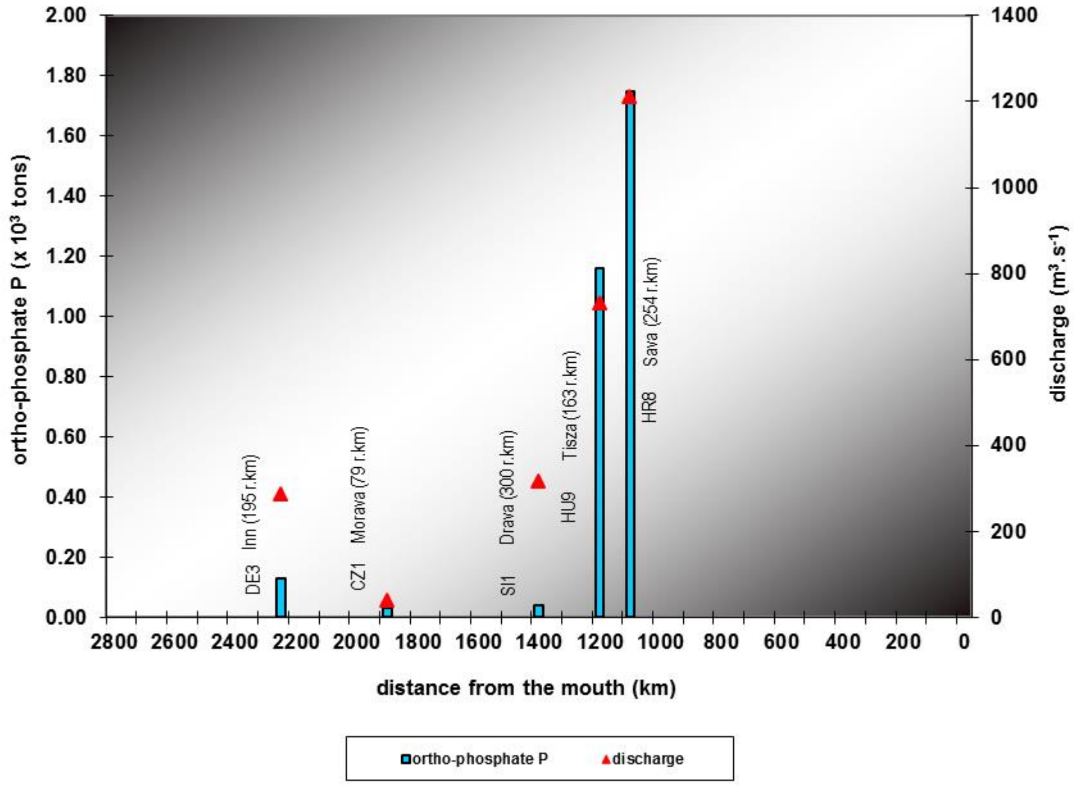


Figure 5.7.: Annual loads of total phosphorus at monitoring locations along the Danube River.

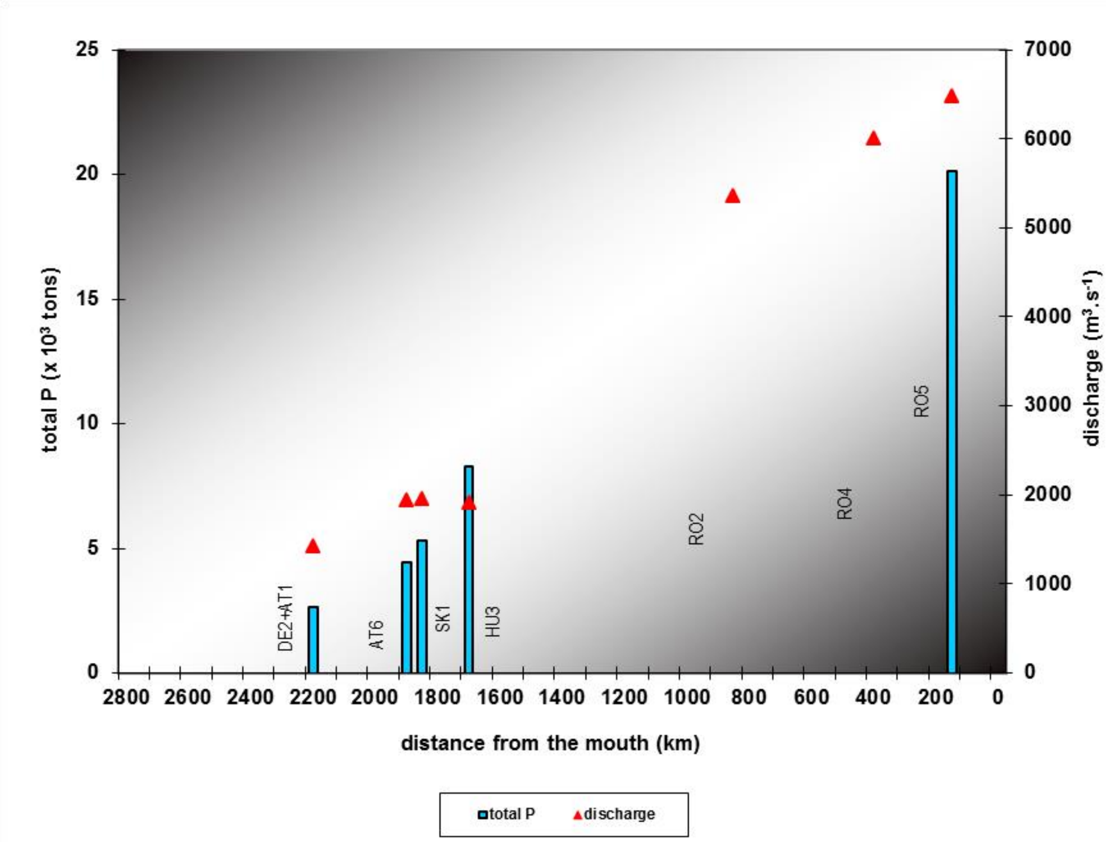


Figure 5.8.: Annual loads of total phosphorus at monitoring locations on tributaries.

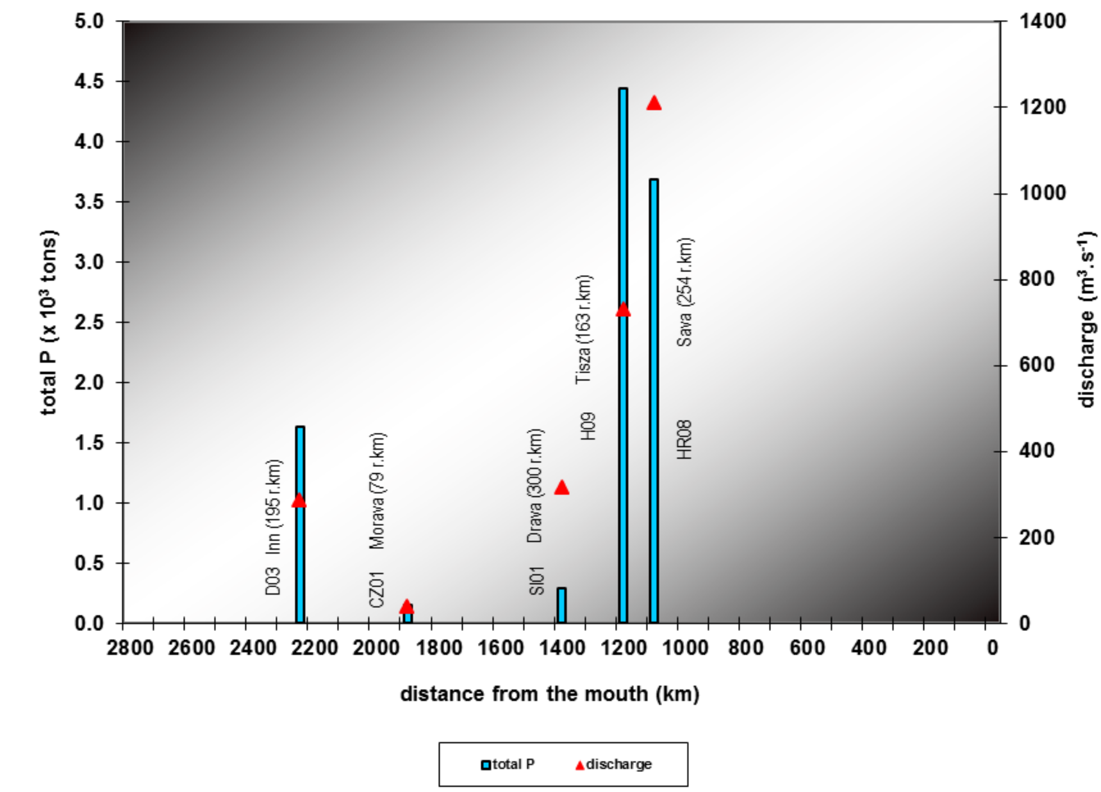


Figure 5.9.: Annual loads of BOD_5 at monitoring locations along the Danube River.

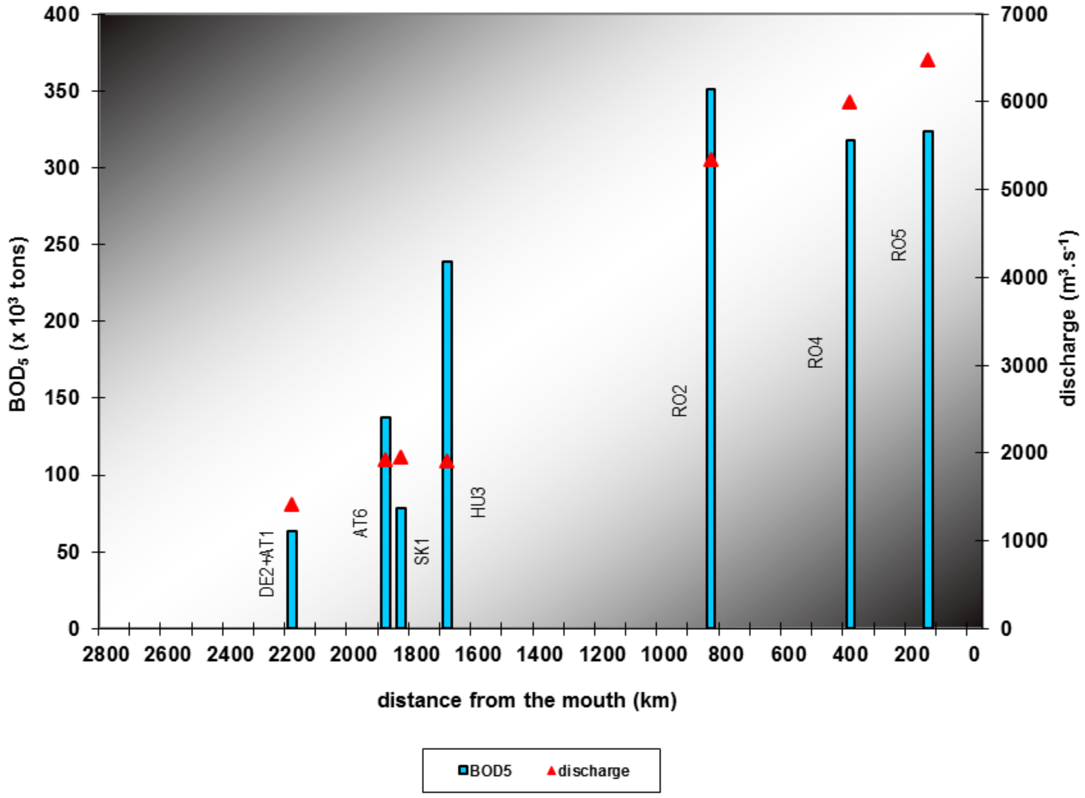


Figure 5.10.: Annual loads of BOD_5 at monitoring locations on tributaries.

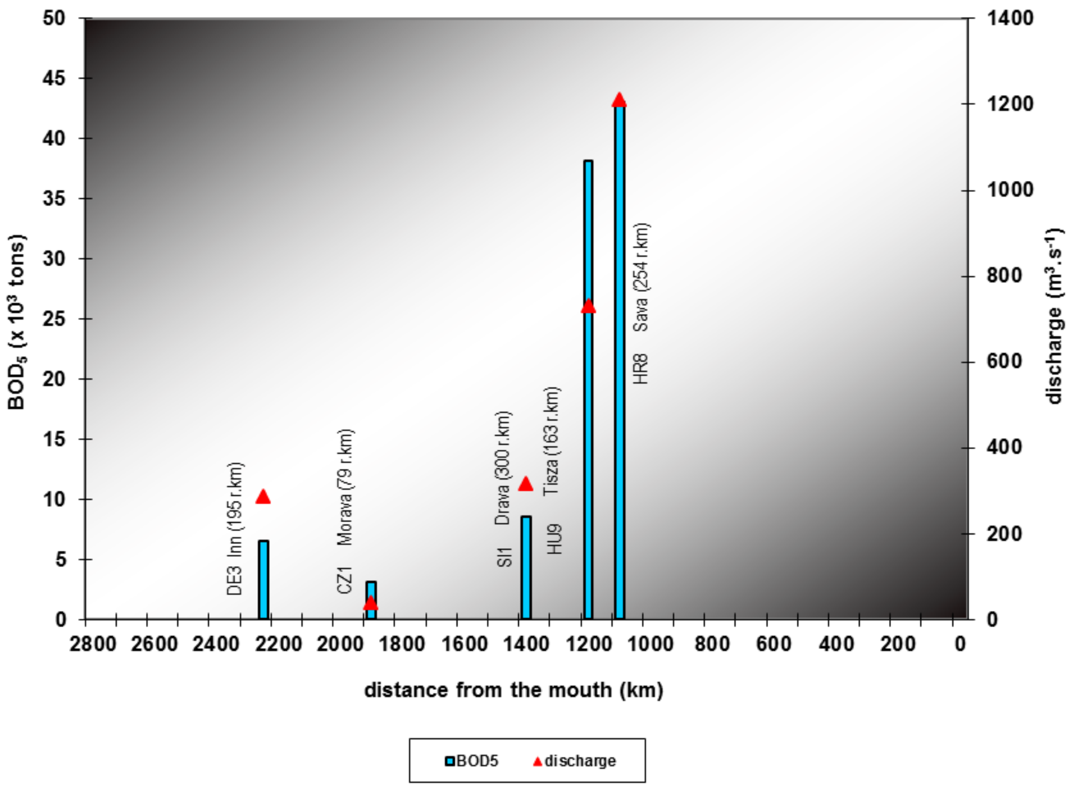


Figure 5.11.: Annual loads of chlorides at monitoring locations along the Danube River.

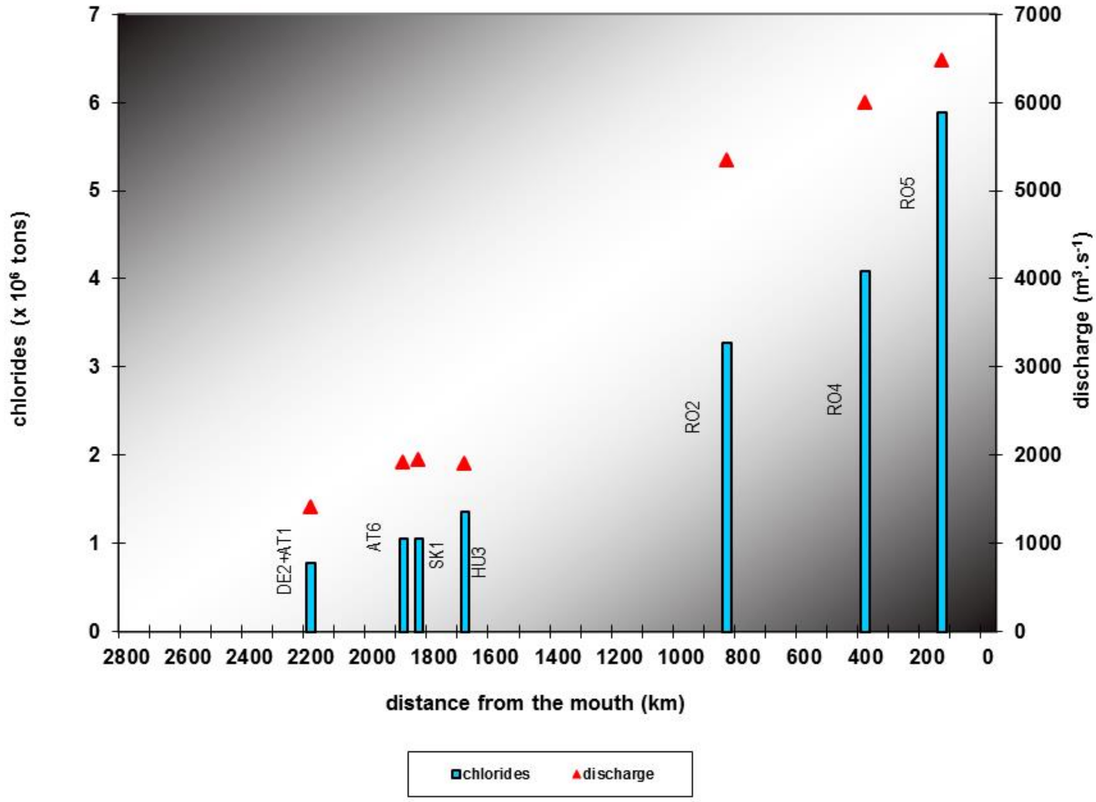


Figure 5.12.: Annual loads of chlorides at monitoring locations on tributaries.

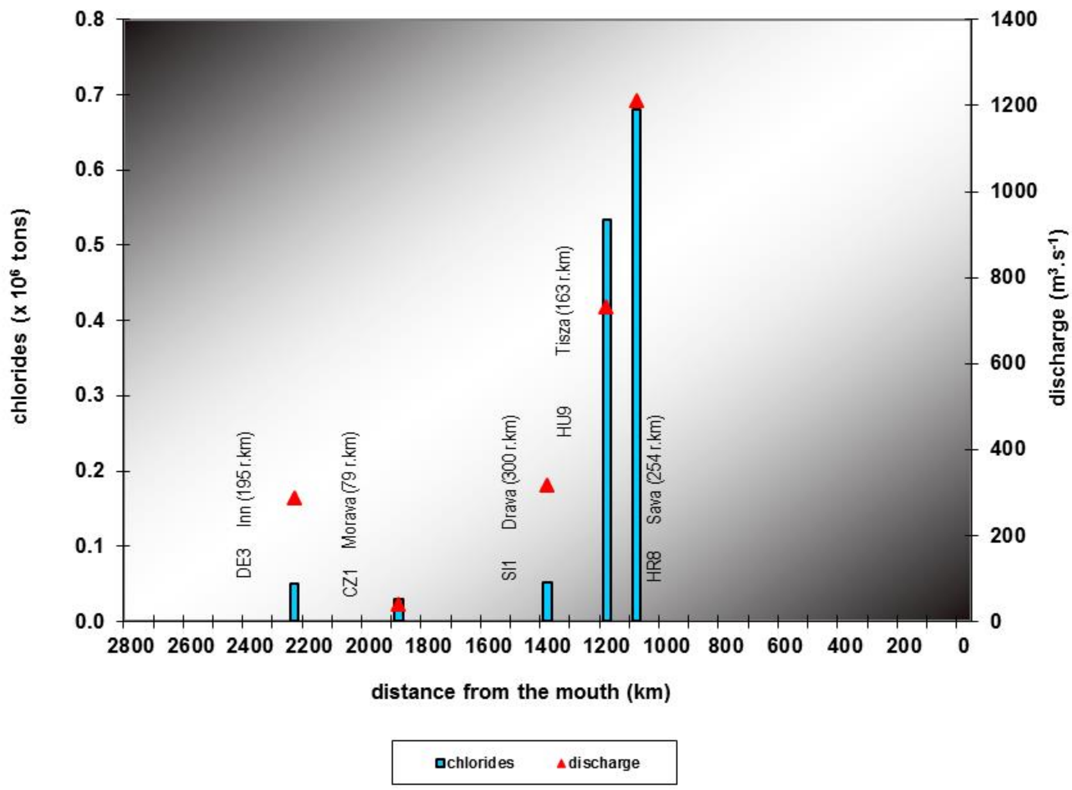


Figure 5.13.: Trends of annual loads of suspended solids at Reni.

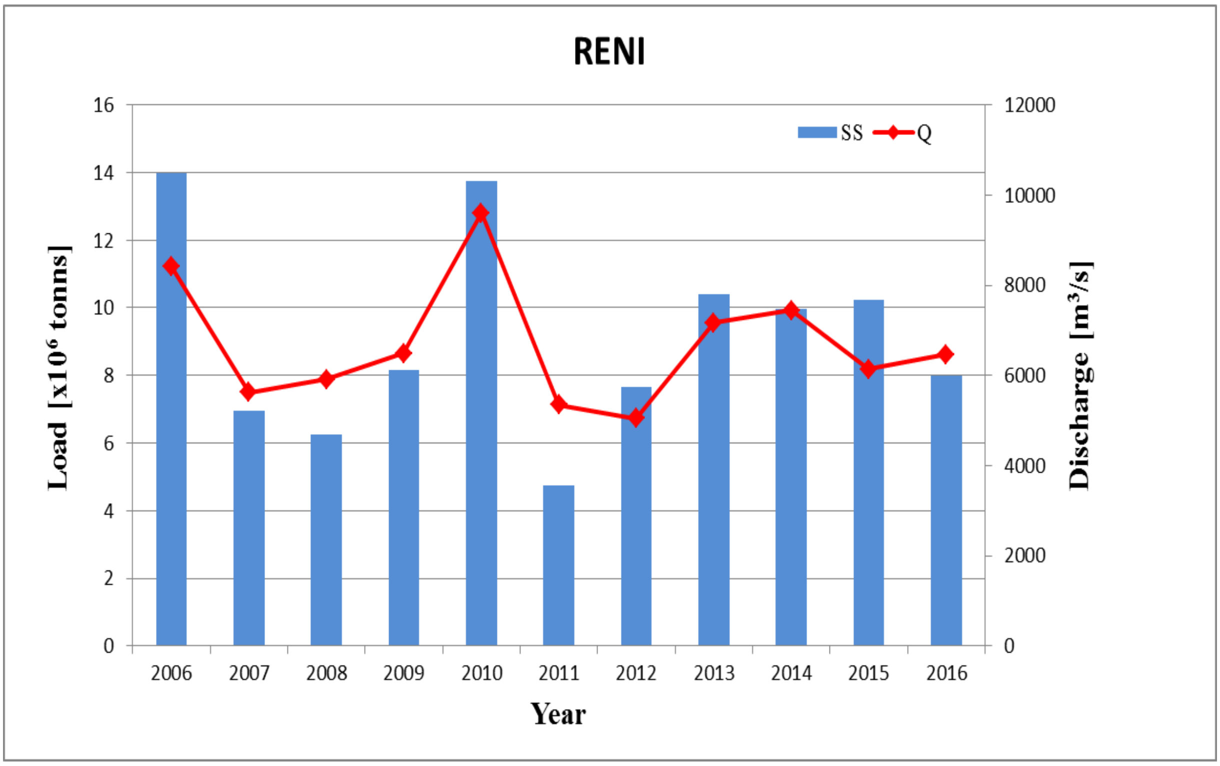


Figure 5.14.: Trends of annual loads of inorganic nitrogen at Reni.

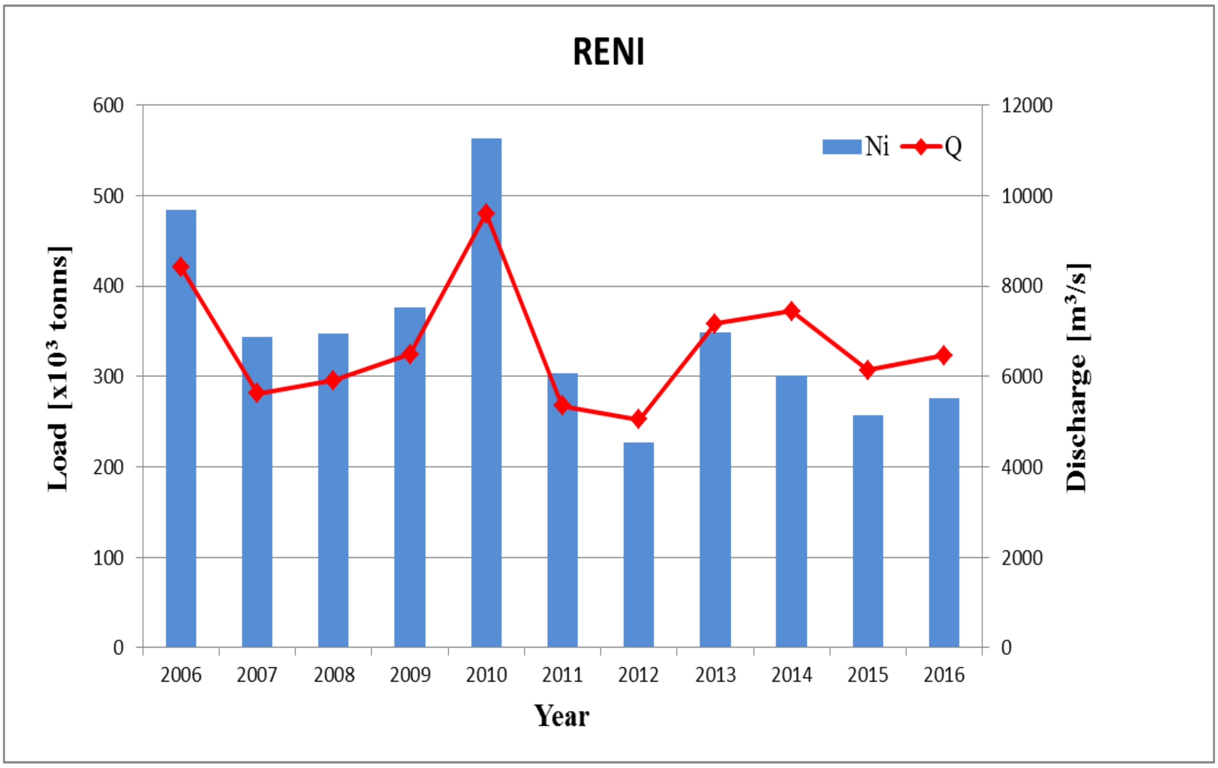


Figure 5.15.: Trends of annual loads of P-PO_4 and total phosphorus and dissolved phosphorus at Reni.

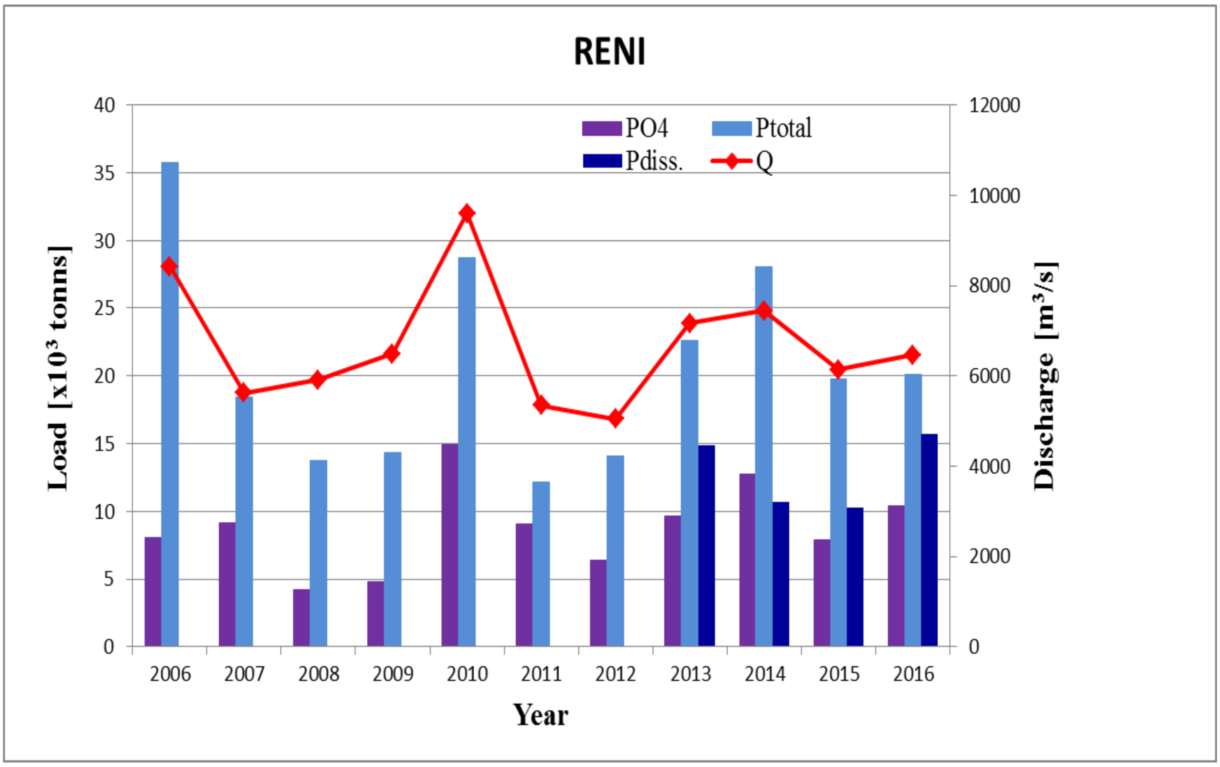


Figure 5.16.: Trends of annual loads of BOD_5 at Reni.

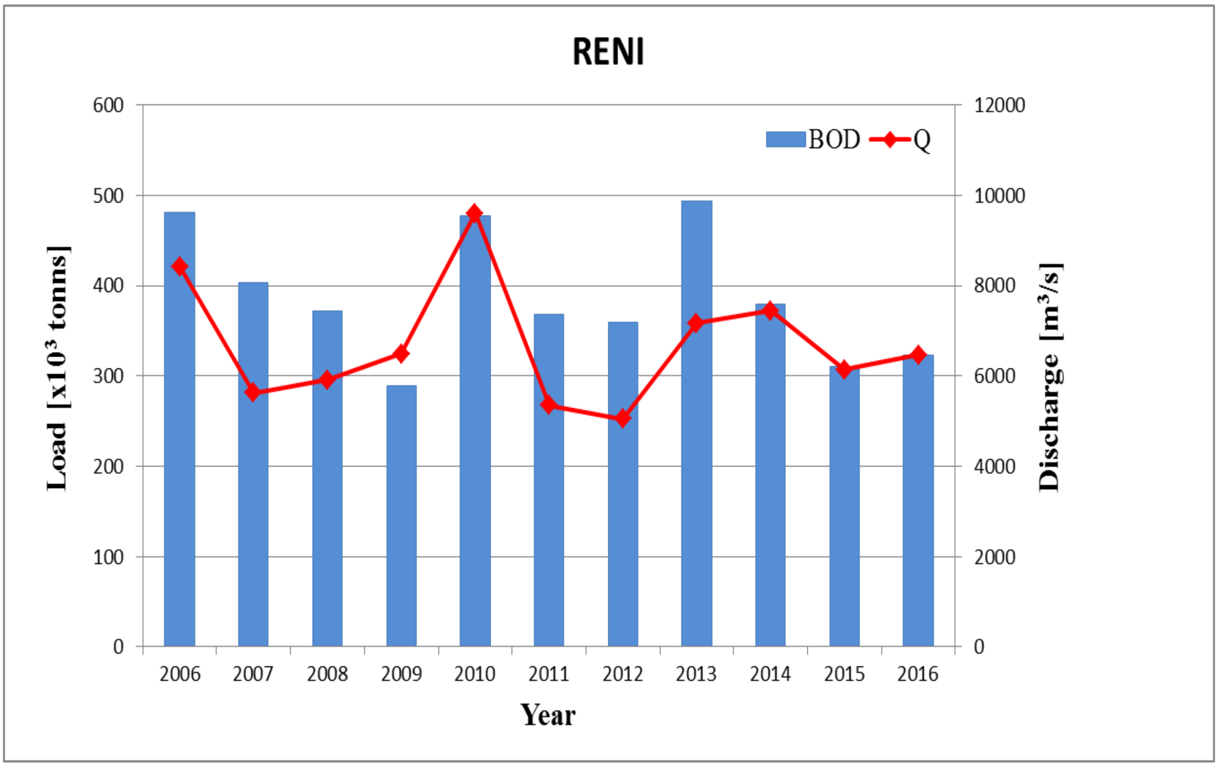


Figure 5.17.: Trends of annual loads of chlorides at Reni.

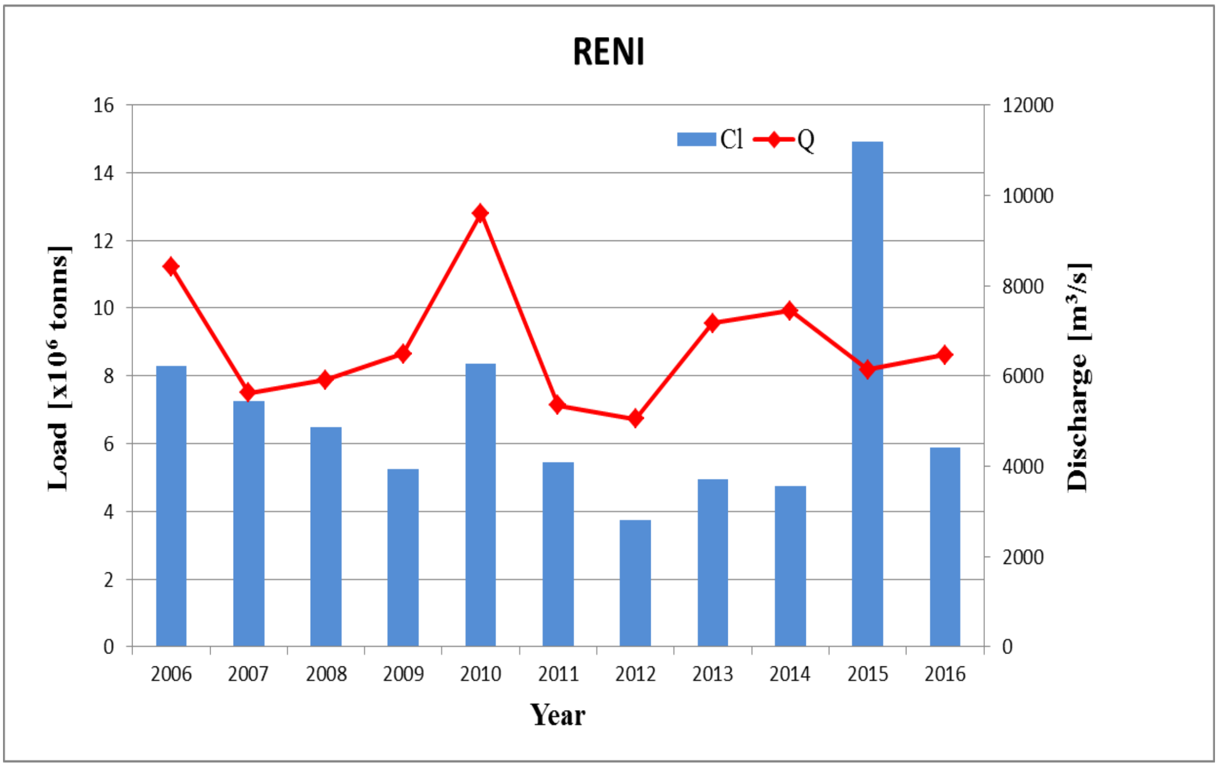
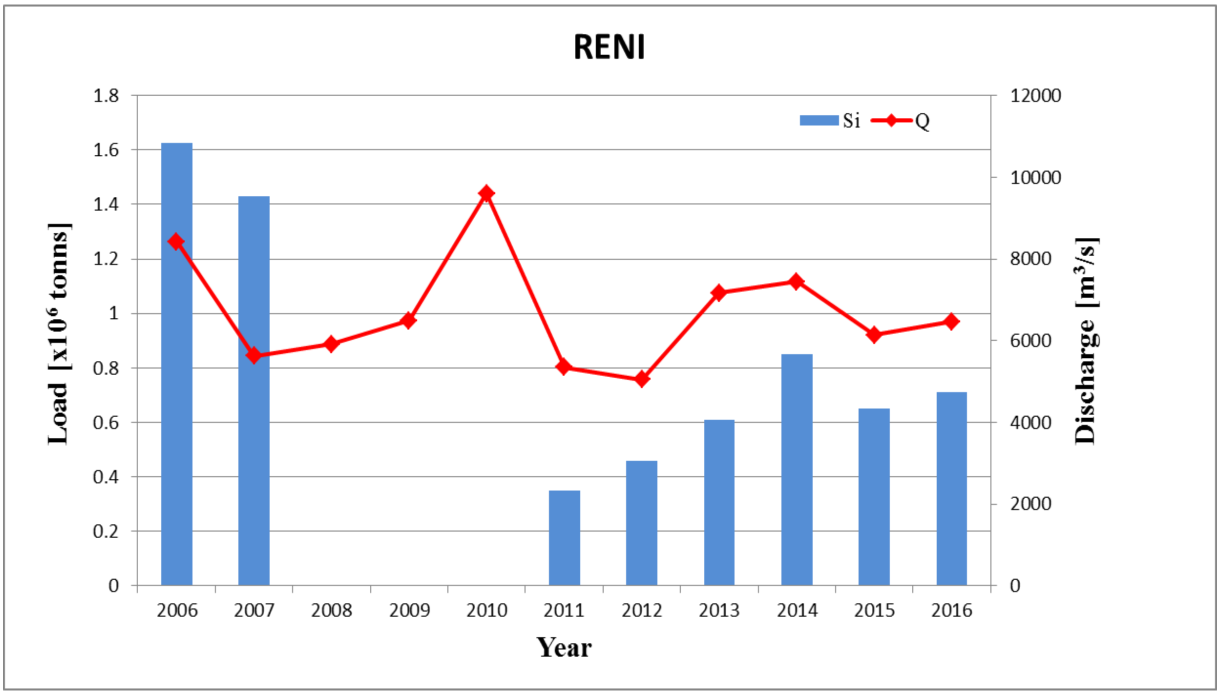


Figure 5.18.: Trends of annual loads of silicates at Reni.



6. Groundwater monitoring

5.1 GW bodies of basin-wide importance

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

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

- important due to the size of the groundwater body which means an area larger than 4000 km² or
- important due to various criteria e.g. socio-economic importance, uses, impacts, pressures interaction with aquatic eco-system. The criteria need to be agreed bilaterally.

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

Map 2: Transboundary GW-bodies of basin-wide importance and their transnational monitoring network

5.2 Reporting on groundwater quality

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

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

7. Abbreviations

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

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