PREFACE

Antecedents

On April 19, 1995 Agreement between the Government of the Slovak Republic and the Government of the Republic of Hungary concerning certain temporary technical measures and discharges in the Danube and Mosoni branch of the Danube[1] (hereinafter the Agreement) was signed in Budapest (**Appendix A.1.**). In the Agreement the monitoring of environmental impact of the increased discharges into the Danube and Mosoni branch of the Danube, and the water supply into the right-side river branch system is defined. The environmental monitoring is coordinated by Nominated Monitoring Agents of both Parties, whose activities are described in the Statute signed on May 29, 1995 in Gabčíkovo[2] (hereinafter the Statute) (**Appendix A.2.**). This Joint Annual Report on environment monitoring in 2019 is the twenty-fifth report since the Agreement was signed.

The Agreement, which was to expire after the judgment of the International Court of Justice in the Haag in the case concerning the Gabčíkovo - Nagymaros Project, have been prolonged by the Slovak Republic on October 23, 1997, by the letter of the Ministry for Foreign Affairs. The prolongation by the Republic of Hungary was done by the Resolution of the Hungarian Government on December 17, 1997. Both Parties prolonged the Agreement, until an agreement on implementation of the Judgement of the International Court of Justice declared on September 25, 1997 is reached.

Nominated Monitoring Agents on April 25, 2007 have agreed on modification of the Statute, which reflected changes in the water quality monitoring according to the Water Framework Directive (2000/60/EC) and defined changes in the time schedule for elaboration of the National and Joint Reports (**Appendix A.3.**). Further significant modifications were accepted at the meeting held on November 29, 2017, when the Nominated Monitoring Agents approved the proposal of experts on monitoring optimisation (**Appendix A.4.**). The optimised monitoring program was to start on January 1, 2018.

In the Agreement the Slovak Party has undertaken to supply an annual average of 400 m3.s-1 of water into the Danube downstream of Čunovo dam, in the case of an annual average flow rate of 2025 m3.s-1 in the Danube at Bratislava-Devín gauging station, and another 43 m3s-1 into the Mosoni branch of the Danube and the right-side seepage canal. Both discharges are subject to hydrological and technical conditions described in Appendices No. 1 and 2 of the Agreement. The Hungarian Party, according to the Agreement, built up the submerged weir in the common section of the Danube at rkm 1843, and put it into operation in June 1995. This weir enables the water supply into Hungarian river branches in the inundation area. The water discharged into the Mosoni branch of the Danube ensures the water supply of the Mosoni Danube and river branches in the Hungarian flood-protected area.

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[1] Agreement between the Government of the Slovak Republic and Government of the Republic of Hungary concerning Certain Temporary Technical Measures and Discharges in the Danube and Mosoni branch of the Danube, signed on April 19, 1995.

[2] Statute on the Activities of the Nominated Monitoring Agents envisaged in the "Agreement between the Government of the Slovak Republic and Government of the Republic of Hungary concerning Certain Temporary Technical Measures and Discharges in the Danube and Mosoni branch of the Danube", signed on May 29, 1995, modified on April 25, 2007.

With regard to Article 4 of the Agreement, the Parties are obliged to mutually exchange and evaluate data obtained by the environmental monitoring on both, Slovak and Hungarian sides of the Danube. These data serve for an assessment of impacts of the increased flow rate in the Danube and the water supply of the Hungarian territory. Technical details of environmental monitoring –definition of the influenced area, determination of sampling and measuring points, frequency of measurements, list of exchanged indicators, data exchange intervals, etc. – are described in the Annex 1 to the Minutes of the meeting held on November 29, 2017 (**Appendix A.4.**).

According to Article 3 of the Statute, the observation results and the measured data in tabular and graphical form, together with their evaluation, constitute the National Annual Reports prepared by the Parties separately. The Joint Annual Report is elaborated jointly and is based on approved and mutually exchanged National Annual Reports.

This Joint Annual Report on environmental monitoring presents the evaluation for the year 2019. The assessment of the Slovak side is based on data collected by the Slovak Hydrometeorological Institute (SHMÚ), Slovak Water Management State Enterprise (SVP-BA), Water Research Institute (VÚVH), Western Slovakia Water Company (ZsVS), Bratislava Water Company (BVS), National Agricultural and Food Centre - Soil Science and Conservation Research Institute (NPPC-VÚPOP), National Forest Centre - Forest Research Institute (NLC-LVÚ), Slovak Academy of Sciences (SAV), Faculty of Natural Sciences of the Comenius University (PriF UK) and Ground Water Consulting Ltd. (GWC). The data exchange and the evaluation of monitoring under the frame of the joint monitoring were co-ordinated by the Plenipotentiary of the Government of the Slovak Republic for Construction and Operation of the Gabčíkovo - Nagymaros Project at the Ministry of Transport and Construction of the Slovak Republic.

The assessment of the Hungarian side is based on data collected by the Government Office of Győr-Moson-Sopron County, Department of Environment Protection, Section of Agriculture and Environment Protection of the District Office (GYMSMKH), North-Transdanubian Water Directorate (ÉDUVIZIG), Regional Water Companies, Faculty of Agricultural and Food Sciences of the Széchényi István University Győr (SZE-MÉK), Forest Research Institute (ERTI), Hungarian Museum of Natural History (MTM), Hungarian Academy of Sciences (MTA) and Eötvös Lóránd University (ELTE). The data exchange and the evaluation of the monitoring were co-ordinated by the State Secretary for Environmental Affairs at the Ministry of Agriculture of Hungary.

Goals of the Joint Monitoring

The main goal of the joint Slovak-Hungarian monitoring, carried out under the Intergovernmental Agreement, is to observe, record and jointly evaluate the quantitative and qualitative changes of surface and groundwater bodies and water dependent natural environment in connection to the implemented measures and the water supply. The water supply into the Hungarian river branches is assured by the submerged weir at rkm 1843 in the Danube old riverbed, which raises the water level upstream of the weir. The water supply into the Mosoni Danube is realised through the intake object at Čunovo and through the right-side seepage canal.

The evaluation includes changes in hydrological regimes of surface and ground water, changes in surface and ground water quality, changes in soil moisture and changes in forest stands and selected biological groups.

The aim of the mutual data exchange is to provide information on monitoring results (measurements, analyses, observations), on the development of indicators included in the data exchange, and on environmental changes in the influenced area of both Parties. The basic condition for the evaluation of the exchanged data is the usage of the same or similar methods of observations, measurements and analyses and application of agreed methods of interpretation.

The final goal of the Joint Annual Report is to present a joint evaluation of monitoring results and joint recommendations for monitoring improvement and environment protection activities to the respective governments.

Joint monitoring activities in the year 2019

The optimised monitoring program, which was to start from January 2018, is being implemented gradually on both sides. On the Slovak side, the monitoring of some indicators was still carried out to its original extent. There are still a number of issues that need to be jointly discussed and clarified in more details. The optimised monitoring program consist of observation of surface water levels, flow rates and water quality, monitoring of ground water levels and quality, soil moisture measurements, monitoring of forest stands and biological observations. All the above parts of the monitoring were carried out on both sides.

In the year 2019, the hydrological conditions on the Danube enabled the realization of an artificial flooding in the spring months. The partial flooding of the right-side river branch system took place from May 2 to May 16, 2019. The mutual exchange of the monitoring data for the year 2019, in accordance with the Statute, was realized on July 22, 2020 (surface water levels and flow rates and groundwater levels) and on August 25, 2020 (surface water quality, hydrobiology, groundwater quality, soil moisture, forest monitoring and biological observations) in Győr (**Appendix A.5.** and **A.6.**). Due to the late conclusion of contracts on the Slovak side, during the year 2019 the Slovak National Annual Report for the year 2017 was elaborated (April 2019). The mutual exchange of National Reports for 2017 was realized on June 13, 2019 in Győr and subsequently the Joint Annual Report for 2017 (September 2019) was prepared. On July 13, 2019, the mutual exchange of data from the monitoring of the natural environment for 2018 took place in Győr. The mutual exchange of National Annual Reports form 2018 was realized on November 20, 2019 in Győr. No other joint activities were realized and no meeting of the Nominated Monitoring Agents was held.

This Joint Annual Report in 2019 was elaborated on the basis of Slovak and Hungarian data, which were mutually exchanged on July 22, 2020 and on August 25, 2020. The mutual exchange of National Annual Reports on environmental monitoring in 2019 was realized on October 5, 2020 in Budapest.

Fulfilment of recommendations in the Joint Annual Report 2018

1. <u>Experts from both parties propose the implementation of negotiations aimed at harmonizing the sampling schedule, specifying monitoring methodologies and identifying renewed or newly established monitoring sites. Field inspections will also be part of the joint negotiations.</u>

Meetings of experts, as well as field inspections of restored or newly established sites, were not held during the year due to restrictions resulting from measures against the spread of coronavirus.

2. On the basis of the above negotiations, the experts of both parties will jointly prepare an update the current Statute on the activities of the Nominated Monitoring Agents, which will be accompanied by a more detailed list and designation of monitored sites, in the sense of the approved monitoring optimization.

As the meetings of experts aimed at harmonizing the sampling schedule, specifying the monitoring methodologies and identifying the restored or newly established sites did not take place, it was not possible to elaborate an update of the Statute on the Activities of the Nominated Monitoring Agents.

Both of the above points can be met once the measures taken have been relaxed. The assumption of performance is the year 2021.

PART 1

Surface Water Hydrology

Since 2018, the monitoring of surface water levels and flow rates, prescribed by the Intergovernmental Agreement of 1995, has been carried out in accordance with amendments approved in 2017 in the frame of optimisation of the joint Slovak-Hungarian monitoring. Data collection on the Slovak side was carried out at eight gauging stations on the Danube, and one gauging station in the reservoir, on the Mosoni branch of the Danube, on the Little Danube and the on the Dobrohošť canal. In addition, operational data were monitored at Čunovo dam, the Gabčíkovo Power Plant and the right-side seepage canal. Surface water levels in the left-side river branch system were monitored at thirteen monitoring sites. Data collection on the Hungarian side was performed on eight gauging stations on the Danube, at four stations on the Mosoni Danube, two gauging stations on the right-side seepage canal, and one on the Zátonyi Danube. The surface water level in the right-side river branch system was observed at eighteen gauging stations. The list of gauging stations on the Slovak and the Hungarian territories is given in the **Table 1-1**. The observation network is presented in **Fig. 1-1**.

Table 1-1: List of gauging stations

No.	ID	Name	Water body	Station name
Slovak side				
1	**1250**	5127	Danube	Bratislava - Devín
2	**2848**	5138	Danube - reservoir	Čunovo dam, upper water level
3	**2552**	-	Danube - old riverbed	Čunovo dam, lower water level
4	**2545**	5149	Danube - old riverbed	Hamuliakovo
5	**2558**	5153	Danube - old riverbed	Dobrohošť
6	**1251**	5143	Danube - old riverbed	Gabčíkovo
7	**1504**	5144	Danube	Sap
8	**1252**	5145	Danube	Medveďov
9	**1505**	6810	Danube	Klížska Nemá
10	**1600**	6849	Danube	Komárno
11	**2851**	5157	Mosoni branch of the Danube	Čunovo
12	**1653**	5150	Little Danube	Bratislava - Malé Pálenisko
13	**2849**	-	power canal	Gabčíkovo Power Plant, upper water level
14	**2850**	-	tail-race canal	Gabčíkovo Power Plant, lower water level
15	**3124**	-	right-side seepage canal	Čunovo, upper water level
16	**3125**	-	right-side seepage canal	Čunovo, lower water level
17	**3126**	5154	Dobrohošť canal	Dobrohošť - intake structure
18	**4045**	A	left-side river arm system	weir A
19	**4046**	B-1	left-side river arm system	weir B-1
20	**4047**	B-2	left-side river arm system	weir B-2
21	**4048**	C-1	left-side river arm system	weir C-1
22	**4049**	D-1	left-side river arm system	weir D-1
23	**4050**	E-2	left-side river arm system	weir E-2
24	**4051**	F-1	left-side river arm system	weir F-1
25	**4053**	G-1	left-side river arm system	weir G-1
26	**4054**	H-1	left-side river arm system	weir H1
27	**4055**	H-3	left-side river arm system	weir H-3
28	**4056**	J-1	left-side river arm system	weir J-1
29	**4057**	Gravel pit B	left-side river arm system	Šulianske lake
30	**4058**	Istragov	left-side river arm system	Gabčíkovo, Dedinský island

No.	ID	Name	Water body	Station name
Hungarian side				
1	**3536**	000001	Danube - old riverbed	Rajka
2	**4352**	003939	Danube - old riverbed	Dunakiliti dam
3	**3720**	004515	Danube - old riverbed	Doborgaz
4	**2547**	000002	Danube - old riverbed	Dunaremete
5	**3537**	003944	Danube	Vámosszabadi
6	**3382**	000003	Danube	Nagybajcs
7	**3383**	000004	Danube	Gönyű
8	**3358**	000005	Danube	Komárom
9	**3360**	003873	Mosoni Danube	Rajka, Lock No. 1.
10	**3366**	003871	Mosoni Danube	Rajka, Lock No. 6.
11	**3532**	000017	Mosoni Danube	Mecsér
12	**3359**	000018	Mosoni Danube	Bácsa
13	**3368**	110106	Zátonyi Danube	Dunakiliti, Gyümölcsös út, upper water level
14	**3362**	003940	right-side seepage canal	Rajka, Lock No. 2, upper water level
15	**3364**	003871	right-side seepage canal	Rajka, Lock No. 5, upper water level
16	**3535**	004516	right-side river arm system	Helena weir
17	**4355**	110113	right-side river arm system	weir Z-1, Jegenyési weir, upper water level
18	**4362**	110127	right-side river arm system	Doborgaz-15, upper water level
19	**4357**	110115	right-side river arm system	B-2, Csákányi weir, upper water level
20	**4359**	110117	right-side river arm system	B-3, Kisvessősi weir, upper water level
21	**4370**	110152	right-side river arm system	Z-8, Barkási bridge, upper water level
22	**4361**	110119	right-side river arm system	B-4, Kőhidi enclosure, upper water level
23	**4378**	110129	right-side river arm system	B-5, Burjáni weir, upper water level
24	**4373**	110162	right-side river arm system	B-6, upper water level
25	**4367**	110138	right-side river arm system	B-7, Szent Kristóf bridge, upper water level
26	**4376**	110198	right-side river arm system	B-8, upper water level
27	**4364**	110131	right-side river arm system	B-9, Hatvanasi weir, upper water level
28	**4366**	110133	right-side river arm system	B-11, Halrekesztői enclosure, upper water level
29	**4369**	110157	right-side river arm system	Z-12, Farkaslyuki enclosure, upper water level
30	**4379**	110155	right-side river arm system	Z-10, Kis Dékányi enclosure, upper water level
31	**4372**	110157	right-side river arm system	Gatya enclosure, upper water level
32	**5680**	111662	right-side river arm system	enclosure at the mouth of the Ásványi river arm
33	**5381**	111666	right-side river arm system	enclosure at the mouth of the Baganéri river arm

The data from the above stations were mutually exchanged by the Parties in order to evaluate the surface water level and flow rate regimes. At ten gauging stations on each side flow rate data were determined, with joint measurements at selected stations. For stations where joint measurement were performed, the time series data were compiled jointly. The mutually agreed data form the basis for the joint assessment of measures and water supply implemented under Articles 1-3 of the Agreement. The assessment of surface water in this joint report covers the period from January 1 to December 31 of the reported year.

The 1995 intergovernmental Agreement set up a temporary water management regime. Parties have agreed that in case of an average annual flow rate of 2025 $m^3.s^{-1}$ in the Danube at gauging station Bratislava - Devín an average annual flow rate of 400 $m^3.s^{-1}$ should be released into the Danube old riverbed downstream of the Čunovo dam. Actual daily amount of water is determined by the flow rate coming into the Bratislava-Devín cross-section, taking into consideration the rules of operation set out in Annex 2 of the Agreement (**Appendix A.1.**). The average daily flow rate in the vegetation period (from April 1 to August 31), depending on the hydrological conditions, should fluctuate between 400 and 600 $m^3.s^{-1}$; in non-vegetation period (between September 1 and March 31) the average daily flow rate should not be less than 250 $m^3.s^{-1}$. According to the methodology agreed in the Joint Annual Report in 2004, in case of flow rates above 5400 $m^3.s^{-1}$ the water amount higher than 600 $m^3.s^{-1}$ discharged through the Čunovo dam is not taken into consideration when the annual average is calculated for the purpose of this evaluation. In the Joint Annual Report in 2011 the methodology for calculating the annual average was further modified. The adjustment concerns flow rates above 600 $m^3.s^{-1}$ discharged through the Čunovo dam during maintenance works. In such cases, for the purpose of calculation the annual average, the higher flow rates shall be reduced to an amount corresponding to flow rates as defined in the Annex 2 of the Agreement. Besides this, another 43 $m^3.s^{-1}$ of water was agreed in the Agreement to be discharged into the Mosoni branch of the Danube and into the right-side seepage canal. All discharges are dependent on hydrological and technical conditions.

The gauging station Bratislava-Devín plays a key role in determining the actual amount of water to be released into the Danube old riverbed downstream of Čunovo dam. The basic monthly characteristics of flow rates in the Danube for the year 2019 are given in the **Table 1-2**. The *Minimum* and the *Maximum* values represent the lowest and the highest recorded data. The *Avg. min* and the *Avg. max* represent the lowest and the highest average daily values. The *Average* is calculated from the average daily values.

Table 1-2: Monthly characteristics of flow rates in the Danube at Bratislava - Devín gauging station in 2019

Year	**2019**												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Minimum	1369	1349	1951	1680	2021	2259	1329	1335	903	953	1117	964	**903**
Avg. min	1390	1374	1996	1710	2072	2436	1369	1402	982	970	1135	995	**970**
Average	1961	1763	2739	2122	2977	3170	1765	1668	1401	1326	1376	1270	**1962**
Avg. max	3298	2675	4491	2580	5299	4045	2934	2081	2225	1947	2063	2052	**5299**
Maximum	3407	2923	4626	2658	5490	4175	3258	2162	2366	2036	2325	2251	**5490**

The minimal annual flow rate in 2019 (**Table 1-2**) occurred in autumn on September 23, 2019 and reached 903.0 $m^3.s^{-1}$, however the lowest average daily flow rate of 969.8 $m^3.s^{-1}$ was recorded on October 28, 2019. The highest annual flow rate occurred during the flow wave on May 30, 2019 with a peak of 5490 $m^3.s^{-1}$, when on this day the highest average daily flow rate of 5299 $m^3.s^{-1}$ was also recorded The average annual flow rate at this station in the year 2019 reached 1962 $m^3.s^{-1}$, which is one of the slightly below-average flow rates on the Danube. Similar average annual flow rates also occurred in 1992, 1993, 1998, 2007 and 2016 (**Table 1-3**).

The flow regime in 2019 was again not typical (**Fig. 1-2, 1-3**). The flow rate at the beginning of the year, after the previous significant flow wave at the end of December 2018, was at the level of the long-term average. After the heavy rainfall in the German Danube basin, the flow rate began to rise and in the middle of the month a more significant flow wave occurred, which culminated on January 15, 2019 at 3407 $m^3.s^{-1}$. Subsequently the flow rates decreased relatively quickly ant at the end of the month they fell slightly below the long-term average. Flow rates in February gradually increased again due to precipitation in the German, but mainly in the Austrian Danube basin, and at the end of the month a flow wave occurred, which culminated on February 23, 2019 just below 3000 $m^3.s^{-1}$. After a temporary decline, the flow rates in March continued to move well above the long-term daily averages, what was caused by almost constant precipitation in the German and especially in the Austrian Danube basin. The most significant increase of flow rate occurred at the end of the second decade of March, when a relatively significant flow wave culminated on March 17, 2019 at 4626 $m^3.s^{-1}$, which was the third highest flow rate recorded in 2019. After passing this flow wave, flow rates until the end of March decrease and at the end of the month they were below the values of long-term daily averages. In April and in the first two decades of May, the flow rates were relatively balanced and below the long-term daily averages.

However, at the end of the second decade of May an above-average amount of precipitation fell in the German Danube basin, which caused a sharp increase of flow rates, which culminated on May 23, 2019, just above 5000 $m^3.s^{-1}$. After a slight decrease, the flow rate, due to heavy rainfall that fell into the saturated basin, increased significantly again. This flow wave, which was the highest in 2019, culminated on May 30, 2019 with a flow rate of 5490 $m^3.s^{-1}$, which was the annual maximum The average daily flow rate on this day was also the highest in 2019 and reached the value of 5299 $m^3.s^{-1}$ (**Fig. 1-2**). After the passage of the flow wave, the flow rates in the first half of June were still significantly above the long-term average daily values. In the second half of June, after a temporary stabilization, flow rates began to gradually decline and decreased until the end of July, while in the second half of the month they reached values close to the lowest recorded flow rates (**Fig. 1-3**). At the end of the month, due to heavy rainfall in the German Danube basin, a short, but relatively significant flow wave occurred, which culminated on July 30, 2019 at 3257 $m^3.s^{-1}$. The flow rate at culmination, for one day exceeded the long-term daily average value. Subsequently, however, it fell sharply again, and until the end of the year, with few exceptions, it moved relatively well below the long-term averages. Only during sporadic insignificant flow waves, caused by increased precipitations in the German or Austrian Danube basin, the flow rate values for several days exceeded the long-term daily average values (**Fig. 1-3**). Such flow waves occurred at the end of the first decade of September, culminating at 2366 $m^3.s^{-1}$, then at the beginning of the second decade of October, at the end of the second decade of November and at the end of December, when the average daily flow rate only slightly exceeded 2000 $m^3.s^{-1}$. During this period, the average daily flow rates were almost exclusively in the range from 1000 to 2000 $m^3.s^{-1}$. In three cases the average daily flow rate dropped below the value of 1000 $m^3.s^{-1}$, while the annual minimum occurred on September 23, 2019 with a flow rate of 903.0 $m^3.s^{-1}$. The lowest average daily flow rate of 969.1 $m^3.s^{-1}$ was recorded on October 28, 2019 (**Fig. 1-2**).

Table 1-3: Average annual flow rates

Station No.	**Period**	**Average annual flow rate in the hydrological year[3] ($m^3.s^{-1}$)**	**% of average flow rate**	**Average annual flow rate in the calendar year ($m^3.s^{-1}$)**	**% of average flow rate**
1249[4]	**1901-2000**	**2050**	**-**	**2050**	**-**
1250	**1990-2014**	**2038**	**-**	**2038**	**-**
1250	1990	1711	84.5	1721	85.0
1250	1991	1752	86.5	1737	85.8
1250	1992	1775	87.7	1934	95.5
1250	1993	2030	100.2	1909	94.3
1250	1994	1908	94.2	1866	92.1
	Agreement	**2025**	**100.0**	**2025**	**100.0**
1250	1995	2278	112.5	2329	115.0
1250	1996	1993	98.4	2015	99.5
1250	1997	2094	103.4	2031	100.3
1250	1998	1723	85.1	1921	94.9
1250	1999	2582	127.5	2387	117.9
1250	2000	2393	118.2	2379	117.5
1250	2001	2170	107.2	2232	110.2
1250	2002	2458	121.4	2683	132.5
1250	2003	2001	98.8	1646	81.3
1250	2004	1807	89.2	1852	91.5

[3] The hydrological year runs from 1st November of the previous year to 31st October of the current year.

[4] Data from gauging stations No. 1249 - Bratislava (until 23.10.1992) and 1250 - Bratislava-Devín were used in the average annual flow rate calculation for the period 1901-2000.

Station No.	Period	Average annual flow rate in the hydrological year[3] ($m^3.s^{-1}$)	% of average flow rate	Average annual flow rate in the calendar year ($m^3.s^{-1}$)	% of average flow rate
1250	2005	2128	105.1	2097	103.6
1250	2006	2152	106.3	2186	108.0
1250	2007	1768	87.3	1916	94.6
1250	2008	2014	99.5	1876	92.6
1250	2009	2163	106.8	2186	108.0
1250	2010	2098	103.6	2130	105.2
1250	2011	1782	88.0	1700	84.0
1250	2012	2018	99.7	2121	104.7
1250	2013	2444	120.7	2417	119.4
1250	2014	1809	89.3	1788	88.3
1250	2015	1768	87.3	1788	88.3
1250	2016	1909	94.3	1944	96.3
1250	2017	1757	86.8	1844	91.1
1250	2018	1732	85.5	1644	81.2
1250	**2019**	**1883**	**93.0**	**1962**	**96.9**

Based on the above assessment, it can be stated that the flow regime of the Danube in 2019 was again not typical. The first half of the year was significantly more water bearing, the average daily flow rates were around the long-term average daily values (**Fig. 1-3**) and there were also three more significant flow waves (**Fig. 1-2**). January and March were extremely water bearing. From the third decade of March to the end of second decade of May, flow rates were mostly below the long-term daily averages, but with one exception the deviation were not large. Thanks to the higher flow rates, May and June were also above-average water bearing months, while at the end of May also the highest flow wave in 2019 occurred. However, even this flow wave did not exceeded 5500 $m^3.s^{-1}$, which means that it could not cause significant flooding. The second half of the year, unlike the first, was less water bearing and the average daily flow rates were rather well below the long-term average daily values for almost the entire period. The exceptions were several insignificant flow waves, which were caused by higher precipitation totals in the Danube basin. However, even the highest of them (3257 $m^3.s^{-1}$ at culmination), which occurred at the end of July, did not significantly exceeded the long-term average daily values and the others only slightly exceeded 2000 $m^3.s^{-1}$ and were only slightly above the long-term daily averages (**Fig. 1-3**). Low flow rates, which use to be typical for the winter months, occurred in the period from September to December. In addition, in the third decade of July and at the end of September, for several days there were such flow rates that were close to the lowest recorded average daily flow rates for a given day (**Fig. 1-3**).

When comparing the average daily flow rates measured at stations No. 1250 –Bratislava-Devín, 1252 – Medveďov and 1600 – Komárno it is still possible to state a relatively good agreement. the flow rates in these gauging stations did not show any significant deviation even in 2019. The largest differences between the stations Bratislava-Devín and Medveďov occurred during the culmination of higher flow waves, when the partial accumulation function of the reservoir is manifested. Smaller differences, besides the losses and accumulation of water in the river branch system, are caused also by abstraction of water into the Little Danube and the Mosoni Danube, which returns to the Danube below the Medveďov station.

1.1. Discharge into the Danube downstream of the Čunovo dam

The average daily amount of water in the Danube downstream of Čunovo dam is determined on the basis of the average daily flow rates at gauging stations Doborgaz and Helena (**Fig. 1-4**). At these stations joint flow rate measurements are performed. The basic monthly characteristics of water amount supplied to the Danube downstream of the Čunovo dam (consisting of the sum of flow rates in gauging stations at Doborgaz and Helena) for the year 2019 are shown in **Table 1-4**. The *Minimum* and the *Maximum* values represent the lowest and the highest data recorded at gauging station Rajka. The *Avg. min* and the *Avg. max* represent the lowest and the highest average daily values. The *Average* is calculated from the average daily values.

Table 1-4: Monthly characteristics of flow rates in the Danube downstream of the Čunovo dam in 2019

Year	**2019**												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Minimum	217	229	227	342	464	446	362	361	239	229	238	235	**217**
Avg. min	239	244	247	394	538	493	405	384	249	244	244	239	**239**
Average	274	261	416	470	710	552	496	447	341	263	257	251	**396**
Avg. max	450	357	610	534	886	639	637	571	790	350	309	290	**886**
Maximum	499	373	622	560	1110	741	660	619	843	377	347	348	**1110**

The flow rate that to be discharged into the Danube old riverbed in the assessed year, in accordance with the Agreement, is calculated on the basis of the following relationship:

$$Q_{Danube} = \frac{(Q_{Dev'n} \times 400)}{2025},$$

where: Q_{Danube} – is the average annual flow rate into the Danube old riverbed in the relevant year

$Q_{Devín}$ – is the average annual flow rate at the Bratislava-Devín station in the relevant year

400 $m^3.s^{-1}$ – the agreed average annual flow rate into the Danube old riverbed according to the Agreement for the long-term average annual flow rate of 2025 $m^3.s^{-1}$ at the Bratislava - Devín station

2025 $m^3.s^{-1}$ – the long-term average annual flow rate in the Danube at the Bratislava-Devín station

The average annual flow rate that was to be released into the Danube old riverbed is as follows:

$Q_{Devín}$ – 1962 $m^3.s^{-1}$, which represents 96,9 % of the flow rate considered in the Agreement

Q_{Danube} – 387,6 $m^3.s^{-1}$, which represents the average annual flow rate that was to be released into the Danube old riverbed in 2019

The total average annual flow rate in the Danube downstream of the Čunovo dam in 2019 was 396 $m^3.s^{-1}$ (**Table 1-4**), which represents 102.2 % of the agreed water amount. The minimal annual flow rate of 217 $m^3.s^{-1}$ occurred on January 2, 2019, while the lowest average daily flow rate of 239 $m^3.s^{-1}$ was recorded on December 31, 2019. The highest annual flow rate of 1110 $m^3.s^{-1}$ occurred on May 31, 2019, when also the highest average daily flow rate was recorded with a value of 886 $m^3.s^{-1}$. The minimal and the maximal annual flow rates were recorded at the Rajka gauging station. Taking into consideration the obligations envisaged in the intergovernmental Agreement, the Slovak Party, in the case of average annual flow rate of

1962 m^3.s^{-1} at Bratislava-Devín, was obliged to release an average annual discharge of 387.6 m^3.s^{-1} into the Danube riverbed downstream of Čunovo dam.

In the year 2019, even during the highest flow wave, there was no such flow rate at the Bratislava-Devín gauging station (more than 5400 m^3.s^{-1}), when it would be necessary to release increased flow rates (above 600 m^3.s^{-1}) into the Danube old riverbed. However, higher flow rate was released during one day due to the technical maintenance of the Gabčíkovo Hydropower Plant (September 4, 2019). If, in accordance with the methodology for calculating the average annual flow rate, reduction of the flow rate to 600 m^3.s^{-1} is applied for this day, an average annual flow rate of 395 m^3.s^{-1} (101,9 %) is obtained. Based on the above assessment, it can be stated that the flow rate required by the Intergovernmental Agreement was fulfilled in 2019. The hydrological conditions in the spring of 2019 were favourable, so at the request of the Hungarian Party it was possible from 2. to 16. May 2019 to release a higher amount of water (800 m^3.s^{-1}) into the Danube old riverbed and to realize partial artificial flooding of the right-side river branch system.

As far as the daily flow rate management table is concerned, it can be stated that this was fulfilled as well. In regard of the minimal flow rates in non-vegetation period (250 m^3.s^{-1}), there was not a single case, when the deficit of the average flow rate would exceed the acceptable deviation of ± 7 %. Even in the case of the minimal values for the summer regime (400 m^3.s^{-1}), in 2019 there was no case when the deficit of flow rate would exceed the acceptable deviation ± 7 %. Based on the above evaluation it can be stated that also the flow rate regime was fulfilled in 2019.

1.2. Discharge into the Mosoni branch of the Danube

In terms of the intergovernmental Agreement from April 1995 the flow rate into the Mosoni Danube, which consist of flow rate released into the Mosoni branch of the Danube through the intake structure at Čunovo and flow rate through the seepage canal, should be 43 m^3.s^{-1}.

Joint discharge measurements in the Mosoni branch of the Danube are carried out downstream of intake structure on the Slovak territory at 0.160 rkm and also upstream of lock No. I on the Hungarian territory. Average daily flow rates were agreed upon joint evaluation of common discharge measurements performed at both profiles.

Regarding the discharge released into the Mosoni branch of the Danube data measured downstream of intake structure were considered in this evaluation (**Fig. 1-5, Table 1-5**.

Table 1-5: Monthly characteristics of water amount released into the Mosoni branch of the Danube through the intake at Čunovo in 2019

Year	**2019**												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Minimum	25.6	27.9	19.0	17.4	16.2	23.6	8.7	18.1	21.1	21.1	16.8	22.0	**8.7**
Avg. min	33.9	34.0	35.6	17.6	19.1	37.0	25.8	30.1	25.0	21.3	22.1	22.2	**17.6**
Average	36.3	39.8	38.8	28.5	38.3	40.9	41.4	40.0	30.6	24.8	25.0	25.1	**34.1**
Avg. max	46.2	46.5	39.9	42.1	41.4	42.5	44.1	41.8	41.0	25.7	25.7	25.8	**46.5**
Maximum	47.1	47.0	41.8	46.2	45.9	44.7	45.5	43.1	41.4	27.3	25.8	27.4	**47.1**

In the year 2019 the average annual discharge released into the Mosoni branch of the Danube through the intake at Čunovo was 34.1 m^3.s^{-1} (**Table 1-5**). The minimal annual discharge of 8.7 m^3.s^{-1} occurred on July 2, 2019, while the lowest average daily discharge of 17.6 m^3.s^{-1} was recorded on April 2, 2019. The highest annual discharge of 47.1 m^3.s^{-1} occurred on January 30, 2019, and the highest average daily discharges of 46.5 m^3.s^{-1} were recorded on February 20, 2019.

The flow rate in the right-side seepage canal was also measured at two sites. The first is on the Slovak territory at Čunovo; the second is on the Hungarian territory upstream of the Lock No. II. In this evaluation the data observed at the Lock No. II were considered (**Table 1-6**).

Table 1-6: Monthly characteristics of flow rate determined at the Lock No. II in 2019

Year	2019												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Minimum	0.90	0.83	0.83	0.02	0.47	0.83	1.63	1.54	2.11	1.82	1.54	1.13	**0.02**
Avg. min	0.92	0.86	0.84	0.63	0.56	0.89	1.63	1.68	2.11	1.85	1.62	0.80	**0.56**
Average	1.09	1.03	1.06	0.83	1.16	1.73	1.94	1.99	2.28	2.23	1.90	1.32	**1.55**
Avg. max	1.56	1.26	1.33	0.97	1.62	3.49	2.20	2.21	2.65	2.60	2.01	1.63	**3.49**
Maximum	1.73	1.29	1.37	1.05	1.63	3.56	2.22	2.22	2.65	2.65	2.01	1.63	**3.56**

In the year 2019 (**Table 1-6**) the average annual flow rate in the right-side seepage canal at Lock. No. II was 1.55 $m^3.s^{-1}$. The minimal annual flow rate of 0.02 $m^3.s^{-1}$ occurred on April 25, 2019, while the lowest average daily flow rate of 0.56 $m^3.s^{-1}$ was recorded on May 7, 2019. The highest annual flow rate of 3.56 $m^3.s^{-1}$ occurred on June 5, 2015, when also the highest average daily flow rate of 3.49 $m^3.s^{-1}$ was recorded.

The total flow rate into the Mosoni Danube consist of flow rate released into the Mosoni branch of the Danube through the intake structure at Čunovo and flow rate through the right-side seepage canal, determined at Lock. No. II (**Table 1-7**).

Table 1-7: Monthly characteristics of flow rate released into the Mosoni Danube in 2019 (average daily values)

Year	2019												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Avg. min	34.9	35.0	36.9	18.5	20.3	38.0	27.8	32.2	27.4	23.4	24.1	23.5	**18.5**
Average	37.4	40.8	39.8	29.3	39.4	42.7	43.4	42.0	32.8	27.0	26.9	26.4	**35.7**
Avg. max	47.8	47.7	40.9	42.9	42.6	44.5	46.2	43.7	43.2	27.9	27.6	27.4	**47.8**

In the year 2019 (**Table 1-7**) the average annual discharge released into the Mosoni Danube was 35.7 $m^3.s^{-1}$. The lowest average daily flow rate of 18.5 $m^3.s^{-1}$ was recorded on April 2, 2019. The highest average daily flow rate of 47.8 $m^3.s^{-1}$ occurred on January 8, 2019.

During 2019, there were several periods when the flow rate into the Mosoni Danube was reduced. Due to technical maintenance the flow rate was reduce to about 20 $m^3.s^{-1}$ on three occasions, in the first half of April for 16 days (April 2-17, 2019), in mid-October for 4 days (October 15-18, 2019) and 2 day in the first half of December (December 10-11, 2019). However, a more significant reduction of the flow rate into the Mosoni Danube took place at the request of the Hungarian Party, due to reconstruction works on the objects on the Mosoni Danube and the right side seepage canal. The reduction of the flow rate to approx. 25 $m^3.s^{-1}$ lasted 112 days (September 9 - December 31, 2019). Due to the above limitations, the average annual flow rate into the Mosoni Danube in the year 2019 reached only 35.7 $m^3.s^{-1}$, which is 83.0 % of the agreed amount. However, for the above reasons, it can be stated that the Slovak Party fulfilled the obligation set out in the Intergovernmental Agreement. Both Parties informed each other about the above restrictions.

1.3. Water distribution on the Hungarian territory

The water distribution on the Hungarian territory is regulated by the Operation rules, that take into account the water amount entering the Bratislava-Devín cross-section and the season. The water discharged to the Hungarian side is distributed between the Danube old riverbed, river branches in the inundation area, Mosoni Danube and river branches in the flood-protected area.

1.3.1. Water supply into the inundation area

River branches in the inundation area on the Hungarian territory are supplied with water from two sources:

a) the main supply comes from the Danube old riverbed through three openings in the riverbank, the supplied amount of water is regulated by manipulating the water level impounded by the submerged weir and the Dunakiliti dam;

b) the additional source is the amount of water that remains after the water supply to the Mosoni Danube and the river branches in the flood protected area and is supplied from the right-side seepage canal through the lock No. V.

These two sources are summed to determine the total amount.

The water distribution is regulated in accordance with the criteria of the reference status, that was determined with participation of stakeholders in the late nineties. The water distribution should reflect the hydrological regime of the fifties which is represented by the characteristic water levels in river branches in the inundation area. The environmental status of Szigetköz in the reference period has been identified as the most similar to a state that can be sustainable on a long run, and provides sufficient information on riverbed morphology and hydro-geological regime for determining the reference status. The daily flow rate is determined as a function of flow rate entering the Bratislava - Devín cross-section, while the seasons are also taken into account.

The total water amount inflowing through the three openings in the Danube riverbank upstream of the submerged weir is determined on the gauging station at the Helena weir. At this gauging station, joint flow rate measurements were performed by both Parties. The measurements were jointly evaluated and average daily flow rate data were adopted (**Table 1-8**).

Table 1-8: Monthly characteristics of flow rate determined at the Helena weir in 2019

Year	**2019**												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Minimum	30.9	31.0	7.7	61.4	91.2	120	70.3	66.0	33.2	26.5	18.9	19.4	**7.7**
Avg. min	32.2	32.1	21.6	76.8	108	126	79.0	71.8	37.4	30.1	20.4	20.6	**20.4**
Average	47.9	40.3	75.5	93.6	173	144	102	87.4	59.7	40.8	30.8	24.7	**76.7**
Avg. max	85.6	61.3	141	112	213	166	133	124	87.8	68.1	40.5	34.8	**213**
Maximum	95.0	67.2	145	118	218	168	141	138	91.4	75.0	43.6	46.7	**218**

In the year 2019 (**Table 1-8**) the average annual discharge into the right-side river branches at Helena gauging station was 76.7 $m^3.s^{-1}$. The minimal annual flow rate of 7.70 $m^3.s^{-1}$ was recorded on March 6, 2019, while the lowest average daily flow rate of 20.4 $m^3.s^{-1}$ was determined on November 27, 2019. The highest annual flow rate of 218 $m^3.s^{-1}$ occurred on May 11, 2019, while the highest average daily flow rate of 213 $m^3.s^{-1}$ was recorded on May 8, May 11 and May 12, 2019 as well.

The water amount inflowing from the right-side seepage canal is determined at the Lock No. V. The residual amount of water from the Mosoni Danube supply is released through this object (**Table 1-9**).

Table 1-9: Monthly characteristics of flow rate determined at the Lock No. V in 2019

Year	2019												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Minimum	0.40	0.60	0.30	0.00	0.00	0.00	0.00	0.40	0.00	0.20	0.20	0.10	**0.00**
Avg. min	0.53	0.79	0.46	0.15	0.00	0.00	0.41	1.09	0.60	0.50	0.30	0.26	**0.00**
Average	1.05	0.95	5.73	0.47	0.18	0.16	2.18	1.71	4.47	2.62	4.51	5.88	**2.51**
Avg. max	1.27	1.13	17.1	1.02	0.84	0.80	6.33	2.09	13.1	4.98	8.18	7.72	**17.1**
Maximum	1.40	1.30	17.5	1.70	1.00	1.60	7.60	3.70	15.1	5.20	8.70	8.70	**17.5**

In the year 2019 the average annual flow rate through the Lock. No. V was 2.51 $m^3.s^{-1}$ (**Table 1-9**). The minimal annual flow rate was 0.00 $m^3.s^{-1}$ and in 2019, similarly to the previous year, it occurred several times (e.g. on April 1, July 3, September 11 and in all terms, when the average daily flow rate was equal to 0). The lowest average daily flow rate of 0.00 $m^3.s^{-1}$ also occurred multiple times (19 times) and was recorded from May 2 to May 16, 2019, from May 30 to June 2, 2019, on June 6, 2019 and June 13, 2019. The highest annual flow rate of 17.5 $m^3.s^{-1}$ occurred on March 7, 2019, while the highest average daily flow rate of 17.1 $m^3.s^{-1}$ was recorded on March 8, 2019..

The total amount of water inflowing to the inundation area consist of water amount flowing through the Helena cross-section and water amount flowing through the Lock No. V in the right-side seepage canal (**Fig. 1-6, Table 1-10**).

Table 1-10: Monthly characteristics of total water amount released into the inundation area in 2019 (average daily values)

Year	2019												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Avg. min	33.3	32.9	32.1	77.2	109	126	80.4	73.0	38.8	33.3	27.2	24.8	**24.8**
Average	48.9	41.3	81.2	94.1	173	142	104	89.2	64.2	43.4	35.3	30.6	**79.2**
Avg. max	86.5	62.3	143	113	213	166	135	126	89.4	69.3	43.0	41.1	**213**

Regarding the total flow rate in the right-side river branch system in the year 2019 (**Table 1-10**) the average annual value was 79.2 $m^3.s^{-1}$. The lowest average daily flow rate of 24.8 $m^3.s^{-1}$ was recorded on December 10, 2019 and the highest average daily flow rate of 213 $m^3.s^{-1}$ occurred on May 8, May 11 and May 12, 2019.

As the hydrological conditions in 2019 were favourable, the artificial partial flooding in the right-side river branch system was realized from May 2 to May 16, 2019.

1.3.2. Water levels in the right-side river branch system

The aim of the water supply and its regulation in the right-side river branch system is to create and manage the water level regime in the river arms so that the water levels shall correspond to the selected reference status. Concerning the water supply system the right-side inundation area can be divided into four parts. In the individual parts of the river branch system characteristic water levels were determined for the selected reference status.

Thanks to the rehabilitation works in the right-side inundation area, which were completed in 2015, the water levels in the river branches were brought closer to the required reference status. In the Tejfalusi river branch system, the water levels, which are influenced by the inflowing flow rate, were close to the target water levels. In the central part of the inundation area, in the Cikolai river branch system, the water levels generally achieved the projected level, but in the Bodaki river branch system they were slightly above it. The water levels in the lower part of the inundation, in the Ásványi and Bagoméri river branch systems, are closer to the targeted levels in comparison with the previous years, but they are still slightly below them.

Based on the above facts, it can be concluded that the water levels on a large part of the right-side inundation area in the case of low and average flow rates correspond to the required reference status. However, as a result of the adjustments made during rehabilitation of river arms, minor adjustments in the operation of water supply would be required so that the water levels at the key regulation objects could correspond even better to the reference status.

1.3.3. Water supply into the Mosoni Danube

The water supply into the Mosoni Danube is realized from the right-side seepage canal through the Lock No. VI (**Fig. 1-7**). The flow rate is measured at the cross-section downstream of the lock (**Table 1-11**).

Table 1-11: Monthly characteristics of flow rate discharged into the Mosoni Danube through the Lock No. VI in 2019

Year	**2019**												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Oct**	**Nov**	**Dec**	**Year**
Minimum	19.3	23.9	14.1	13.1	10.6	32.1	15.3	14.3	22.0	19.1	17.1	15.1	**10.6**
Avg. min	23.2	24.4	17.7	13.8	18.65	35.5	24.9	27.2	22.3	19.4	19.9	19.8	**13.8**
Average	24.7	25.3	31.6	25.9	36.9	38.9	34.6	33.0	24.0	22.7	22.7	22.0	**28.6**
Avg. max	26.0	26.1	38.2	39.3	40.8	41.3	37.1	34.2	33.6	24.3	24.6	24.6	**41.3**
Maximum	26.1	28.9	38.9	41.1	41.7	42.7	38.0	35.3	33.6	24.7	25.8	25.0	**42.7**

In the year 2019 (**Table 1-11**) the average annual discharge released through the Lock No. VI into the Mosoni Danube was 28.6 $m^3.s^{-1}$. The minimal annual flow rate of 10.6 $m^3.s^{-1}$ occurred on May 14, 2019, while the lowest average daily flow rate of 13.80 $m^3.s^{-1}$ was recorded on April 12, 2019. The highest annual flow rate of 42.7 $m^3.s^{-1}$ occurred on June 30, 2019, while the highest average daily flow rate of 41.3 $m^3.s^{-1}$ was recorded on June 10, 2019.

The water supply regime of the Mosoni Danube is controlled by the rules of operation and follows the Danube's water regime, similarly to the river branch water supply.

1.4. The Danube water level characteristics on the stretch Čunovo-Klížska Nemá/Gönyű

With regard to the water level regime, the Danube flow in the stretch between Čunovo and Klížska Nemá/Gönyű can be divided into four different sections according to the prevailing influence. These sections are characterised by data obtained from gauging stations situated on these sections: Rajka and Hamuliakovo, Dunakiliti, Doborgaz and Dobrohošť, Dunaremete, Gabčíkovo, Sap, Vámosszabadi and Medveďov, Klížska Nemá and Gönyű.

Water level characteristics on the stretch Čunovo - Klížska Nemá/Gönyű in the year 2019 were as follows:

a) <u>Section Čunovo - Dunakiliti.</u> The water level in this section is impounded by the submerged weir. By regulating the water level with the Dunakiliti dam, the amount of water gravitationally flowing into the right-side river branch system is regulated as well. Under normal circumstances the water level is maintained in the mid-water riverbed. The flow velocities measured in the Rajka profile in 2019 ranged between 0.30-0.82 $m.s^{-1}$ (263-883 $m^3.s^{-1}$). Flow rates exceeding 600 $m^3.s^{-1}$ in 2019 occurred mainly during the artificial flooding of the right-side river branch system, during which the highest flow velocity was measured, and during one day in September during the technical maintenance of the Gabčíkovo Hydroelectric Power Plant.

In the year 2019 the average daily water level at the Hamuliakovo gauging station (rkm 1850) fluctuated from 122.72 to 123.89 m a. s. l. (122.67-123.43 m a. s. l. in the year 2018) and the average annual water level was 123.10 m a. s. l (123.05 m a. s. l. in 2018). The average daily water level in the Rajka profile (rkm 1848.4) fluctuated from 122.70 to 123.79 m a. s. l. (122.67-123.31 m a. s. l. in 2018) and the average annual water level was 123.06 m a. s. l. (122.99 m a. s. l. in 2018) (**Fig. 1-8**). Compared with the previous year the minimal average daily water levels in the year 2019 were slightly higher by 0.05 m and 0.03 m respectively, and the maximal average daily water levels on both stations were higher by 0.46 m and by 0,48 m respectively. The average annual water levels at both stations, Hamuliakovo and Rajka, were slightly higher by 0.05 m and 0.07 m respectively.

b) Section between Dunakiliti and Dunaremete. This section of the Danube is not influenced by any measures and the water level is determined only by the flow rate in this stretch of the river. In the upper part of this section the water level in the river branches is about 3 m higher than the water level in the main riverbed. In the year 2019 the average daily water level at the Dobrohošť gauging station (rkm 1838.6) fluctuated in the range from 117.25 to 118.92 m a. s. l. (117.13-118.98 m a. s. l. in the year 2018) and the average annual water level was 117.75 m a. s. l. (117.75 in 2018). The average daily water level at the Dunaremete profile (1825.5) fluctuated from 113.53 to 115.61 m a. s. l. (113.49-115.02 m a. s. l. in 2018) and the average annual water level was 114.01 m a. s. l. (113.97 in 2018) (**Fig. 1-9**). Flow velocities measured in the Dunaremete profile fluctuated in the range from 0.74 to 1.28 $m.s^{-1}$ (256-651 $m^3.s^{-1}$). Compared with the previous year the minimal average water levels in 2019 at Dobrohošť was higher by 0.12 m, at Dunaremete by 0.04 m. The maximal average water level at Dobrohošť was higher by 0.04 m, but at Dunaremete it was higher by 0.59 m. The average annual water level at the Dobrohošť gauging station was the same as in the previous year, while at the Dunaremete gauging station in comparison with the previous year it was slightly higher by 0.04 m.

c) Section between Dunaremete and Sap. The water level in this section is influenced by backwater effect from the confluence of the tailrace canal and the Danube old riverbed (rkm 1811). The water level changes, especially in the lower part of this section, are influenced by the flow rates in the tailrace canal. Length of the upstream section influenced by the backwater effect depends on the actual flow rate distribution between the hydropower plant and the Danube old riverbed. In normal operation it can be stated that the backwater effect reaches the Dunaremete profile (rkm 1825.5) at flow rates exceeding 2500 $m^3.s^{-1}$ at Medveďov. In the year 2019 the average daily water level at Gabčíkovo gauging station (rkm 1819) fluctuated in the range from 111.75 to 114.78 m a. s. l. (111.74-114.18 in the year 2018) and the average annual water level was 112.27 m a. s. l. (112.20 m a. s. l. in 2018) (**Fig. 1-10**). The average daily water level at the gauging station at Sap (rkm 1811) moved from 108.44 to 114.15 m a .s .l. (107.93 to 113,73 m a. s. l. in 2018). and the average annual water level was 110.32 m a. s. l. (109.83 m a. s. l. in 2018). Daily water level fluctuation at Sap gauging station in the Danube can reach about 0.30 m as a consequence of hydropower plant operation. Compared with the previous year the minimal average daily level in 2019 was at Gabčíkovo higher by 0.01 m, but at the station at Sap it was higher by 0.51 m. The maximal average daily water level at Gabčíkovo was higher by 0.60 m, at Sap it was higher by 0.43 m. The average annual water level at Gabčíkovo was higher by 0.07 m and at Sap it was higher by 0,49 m.

d) Section Sap - Klížska Nemá/Gönyű. Daily water level fluctuation in the upper part of this stretch (up to 0.30 m) depends on the hydropower plant operation. Major changes occur at low flow rates in the Danube due to the ratio of total flow rate and the capacity of one turbine, which may be put into operation or stopped. The average annual flow rate at Medveďov/Vámosszabadi profile in the year 2019 was 1878 $m^3.s^{-1}$. In the year 2019 the average daily water level at Medveďov profile (rkm 1806.3) fluctuated in the range from 108.07 to 113.64 m a. s. l. (107.47-113.22 in the year 2018) and the average annual water level was 109.89 m a. s. l. (109.37 m a. s. l. in the year 2018). The average daily water level in the gauging station at Gönyű (rkm 1790.6) fluctuated from 105.93 to 110.90 m a. s. l. (105,40-110,25 m a. s. l. in 2018) and the average annual water level was 107.45 m a. s. l. (107.00 m a. s. l. in 2018) (**Fig. 1-11**). Flow velocities measured during flow rate measurements at Medveďov/Vámosszabadi fluctuated in the range between 1.10-1.50 $m.s^{-1}$ (1103-2809 $m^3.s^{-1}$). Compared with the previous year the minimal average daily water level in 2019 at Medveďov was higher by 0.60 m and in the station at Gönyű higher by 0.53 m. The maximal average daily water levels were at both stations higher by 0.42 m and by 0.65 m, respectively. The average annual water level at Medveďov was higher by 0.57 m and at Gönyű higher by 0.45 m.

PART 2

Surface Water Quality

In 2019, the surface water quality monitoring, carried out in accordance with the 1995 Intergovernmental Agreement, was realized according to the optimisation of the joint Slovak-Hungarian monitoring approved on November 29, 2017. On the Slovak territory, the quality of surface water is monitored at twelve and the quality of sediments at four sampling sites. On the Hungarian territory, the surface water quality is observed at ten and the quality of sediments at four sampling sites. The list of sites is given in **Table 2-1**, and they are shown in **Fig. 2-1**.

Table 2-1: List of monitoring sites

No.	ID	Name	Water body	Station name
Slovak side - physico-chemical and hydrobiological analyses				
1	**109**	D002015D	Danube	Bratislava, middle
2	**1203***	D011000D	Danube - old riverbed	Rajka, right side
3	**4025**	1106	Danube - old riverbed	Dobrohošť, left side
4	**3739**	8028	Danube - old riverbed	Sap, upstream of the confluence
5	**112***	D017000D	Danube	Medveďov, middle
6	**307**	8012	Danube - reservoir	Kalinkovo, navigation line
7	**311**	8016	Danube - reservoir	Šamorín, left side
8	**3530**	1151	tail-race canal	Sap, left side
9	**3529***	D085001D	Mosoni Danube	Čunovo, middle
10	**3531***	D092001D	right-side seepage canal	Čunovo, middle
11	**3376**	8026	Dobrohošť canal	Dobrohošť, left side
12	**3528**	8027	left-side river arm system	Bačianske river arm
Analyses of bottom sediments				
	4016	0002	Danube - old riverbed	upstream of the submerged weir
	307	8012	Danube - reservoir	Kalinkovo, navigation line
	311	8016	Danube - reservoir	Šamorín, left side
	4301	S-21	left-side river arm system	Bodíky, Kráľovská lúka
Hungarian side - physico-chemical and hydrobiological analyses				
1	**3536**	0001*	Danube - old riverbed	Rajka, right side
2	**3534**	0042	Danube - old riverbed	Dunakiliti, downstream of the submerged weir
3	**4354**	0002	Danube - old riverbed	Dunaremete, right side
4	**3537**	2306*	Danube	Medve, middle
5	**3538**	1141	Mosoni Danube	Mecsér
6	**3360**	0082*	Mosoni Danube	Rajka, Lock No. I
7	**3362**	0084*	right-side seepage canal	Rajka, Lock No. II
8	**3535**	1112	right-side river arm system	Dunakiliti, Helena weir
9	**3542**	1114	right -side river arm system	Dunasziget, Szigeti river arm
10	**3541**	1126	right -side river arm system	Ásványráró, Ásványi river arm
Analyses of bottom sediments				
	3533	0043	Danube - old riverbed	Dunakiliti, upstream of the submerged weir
	3534	0042	Danube - old riverbed	Dunakiliti, downstream of the submerged weir
	3542	1114	right -side river arm system	Dunasziget, Szigeti river arm,
	3541	1126	right -side river arm system	Ásványráró, Ásványi river arm

* - jointly observed monitoring sites

At all monitoring sites, the impact of the measures, described in the Agreement, on surface water quality is observed. The main factors that could affect the water quality, are: the backwater effect upstream of the submerged weir, increased discharges into the Danube downstream of the Čunovo dam and into the Mosoni branch of the Danube, the water supply into the right-side river branch system, and morphological changes in the riverbed.

Surface water quality and sediment quality data for agreed monitoring sites, and graphical representation of the time-series data of particular surface water quality indicators, are presented in the Slovak and Hungarian National Annual Reports on the Environment Monitoring in 2019 or in their Annexes. The figures in the Joint Report represent the data of selected indicators at selected monitoring sites.

Table 2-2: Agreed limits for surface water quality classification

Parameter / Class	Unit	I.	II.	III.	IV.	V.
Temperature	°C	<20	25	27	30	>30
pH	-	6.5-<8	8-<8.5	6-<6.5 8.5-<9.0	5.5-<6.0 9.0<9.5	<5.5 >=9.5
Electric conductivity	$mS.m^{-1}$	<40	70	110	130	>130
Suspended solids	$mg.l^{-1}$	<20	30	50	100	>100
Fe	$mg.l^{-1}$	<0.5	1	2	5	>5
Mn	$mg.l^{-1}$	<0.05	0.1	0.3	0.8	>0.8
O_2	$mg.l^{-1}$	>7	6	5	4	<4
BOD_5	$mg.l^{-1}$	<3	5	10	25	>25
COD_{Mn}	$mg.l^{-1}$	<5	10	20	50	>50
TOC	$mg.l^{-1}$	<3	7	10	12	>12
NH_4^+	$mg.l^{-1}$	<0.26	0.39	0.77	1.93	>1.93
NO_3^-	$mg.l^{-1}$	<4.4	13.3	26.6	66.4	>66.4
NO_2^-	$mg.l^{-1}$	<0.03	0.20	0.39	0.99	>0.99
PO_4^{3-}	$mg.l^{-1}$	<0.15	0.31	0.61	1.53	>1.53
total N	$mg.l^{-1}$	<1.5	4	8	20	>20
total P	$mg.l^{-1}$	<0.1	0.2	0.4	1	>1
Cl^-	$mg.l^{-1}$	<100	150	200	300	>300
SO_4^{2-}	$mg.l^{-1}$	<150	250	350	450	>450
Dissolved solids	$mg.l^{-1}$	<300	500	800	1000	>1000
UV oil	$mg.l^{-1}$	<0.01	<0.05	0.1	0.3	>0.3
As	$\mu g.l^{-1}$	<0.5	1	2	5	>5
Cr	$\mu g.l^{-1}$	<1	2	4	10	>10
Cd	$\mu g.l^{-1}$	<0.05	0.1	0.2	0.5	>0.5
Cu	$\mu g.l^{-1}$	<1	2	4	10	>10
Ni	$\mu g.l^{-1}$	<0.5	1	2	5	>5
Pb	$\mu g.l^{-1}$	<0.5	1	2	5	>5
Hg	$\mu g.l^{-1}$	<0.05	0.1	0.2	0.5	>0.5
Zn	$\mu g.l^{-1}$	<2	5	10	50	>50
Chlorophyll-a	$mg.m^{-3}$	<10	35	75	180	>180

The results from surface water quality monitoring at selected sampling sites, assessed according to the limits in **Table 2-2**, are presented at the end of this chapter**.**

2.1. General evaluation of the actual year

The year 2019 was moderately water-bearing in terms of flow rates. The highest flow rates (above 5000 $m^3.s^{-1}$) at station No. 1250 - Bratislava - Devín occurred during May, while the highest flow wave peaked on May 30, 2019 at 5490 $m^3.s^{-1}$ (on this day the highest average daily flow rate of 5299 $m^3.s^{-1}$ was also recorded). The second highest flow wave occurred also in May (May 23), when the flow rate culminated just above 5000 $m^3.s^{-1}$. Higher flow waves (above 3000 $m^3.s^{-1}$ at culmination) occurred in mid-January, during March and at the end of July. Increased flow rates were also recorded at the end of February and in the period from the second half of April to mid-May. In other months, the flow rate was low and mostly fluctuated up to 2000 $m^3.s^{-1}$, only occasionally just exceeding this value (smaller flow waves in August, in the first half of September and October and in the second half of November and December). Since July, the flow rates have mostly been below 1500 $m^3.s^{-1}$ and were quite significantly below the value of the long-term average daily flow rate for the period 1901 to 2018. Significantly above the long-term average, the values of average daily flow rate in 2019 moved only in January, March, at the end of May and a substantial part of June. The lowest flow rates below 1000 $m^3.s^{-1}$ were recorded at the end of September, at the end of October and in mid-December, with an annual minimum of 903.0 $m^3.s^{-1}$ recorded on 23 September 2019 (the lowest average daily flow rate of 969.1 $m^3.s^{-1}$ occurred on October 28, 2019).

Significant cooling in 2019 occurred in May, when the average daily air temperature for a longer period dropped relatively significantly below the long-term daily average. Milder coolings were documented in late January, the first half of July, September, October and at the beginning of December, when the average daily temperature for a short period fell to the level of long-term daily averages. For most of the year, the average temperature was above the long-term average, most notably at the turn of February-March, in June and in the second half of July, August and December.

The average water temperature in the Danube (Bratislava, No. 1249) in 2019 was mostly above the long-term average, reaching its highest values in the second half of July. It also fluctuated significantly above the values of the long-term daily average in the first half of March, in the second half of June, at the turn of August and September, and also in the second half of October and December. It fell below the long-term average at the end of January, and from the end of April to the beginning of June, while the water temperature during May moved significantly below the long-term average daily temperature.

The annual precipitation amount was slightly higher compared to the previous yea (**Fig. 5-9**). The highest monthly precipitation total at the station Bratislava-airport (No. 2565) was recorded during May (118.2 mm). Relatively high values occurred also in January, November and December (59.7 mm, 68.3 mm and 56.6 mm). The driest month in terms of monthly precipitation was June with 17.5 mm, but in term of precipitation the month of February, April and October were also poor (17.9 mm. 20.6 mm and 20.3 mm). In the other months (March, July, August and September) the values fluctuated from 27.3 to 45.1 mm. The highest daily precipitation total (23.9 mm) was recorded on November 5, 2019.

2.2. Basic physical and chemical parameters

<u>Water temperature</u>

The development of water temperature during the year is closely related to climatic and hydrologic conditions. The course of the measured water temperature values show seasonal character and their fluctuation is similar, except the sampling site in the seepage canal. The water temperature in the winter period is low and maximal values occur in the summer period. Due to the climatic conditions at the beginning of the year, the lowest values of water temperature were recorded at the end of January or the beginning of February, the highest values occurred in July or August, depending on sampling site. The lowest (0,0 °C) and the highest (23,9 °C) water temperatures were recorded in the river branch system at the sampling site No. 1126 in the

Ásványi river arm. Significant cooling in May caused a temporary decline of values. The water temperature in the Danube, in the Mosoni Danube, in the reservoir and in the tail-race channel ranged from 1.2 to 21.7 °C, in the river branch system from 0.0 to 23.9 °C. Due to its origin, the seepage water is characterized by small variation in values. At the common sampling site No. 3531/0082 in the right-side seepage canal at Čunovo/Rajka the water temperature ranged from 6.4 to 20.4 °C. Compared to the previous year, it can be stated that the water temperature at most of the monitored sampling sites decreased or was similar. The exceptions were two sites (No. 1126 the Ásványi river arm and No. 3531/0084 in the right-side seepage channel at Čunovo/Rajka), where the recorded maxima achieved slightly higher values than in 2018. The course of water temperature at selected sites is shown in **Fig. 2-2**.

pH

The water quality indicator pH is closely related to the development of phytoplankton. Higher values occur in seasons that correspond to periods with increased phytoplankton assimilation activity. In the evaluated year, higher pH values related to phytoplankton development were documented in May, at some sites also in July. Overall, the pH ranged from 7.30 to 8.96. The lowest value was recorded in June on the common sampling site No. 3531/0084 in the right-side seepage channel at Čunovo/Rajka. The highest value was measured in April in the right-side river branch system at sampling site No. 1114 (Szigeti river arm). The pH values in the seepage water usually fluctuate over the year in a narrow range. In the evaluated year, however, the Slovak Party determined rather high value in (8.81), but it was not confirmed by the Hungarian Party, as in the given month they recorded a pH value 8.08 (**Fig. 2-3**). The narrowest range from 8.16 to 8.58 was registered on the sampling site No. 3376 in the left-side river branch system at Dobrohošť. Due to cooling and high water levels (at the end of May) the pH values dropped significantly in June on most sites to the lowest annual values. Compared to 2018, the pH values fluctuated in wider ranges, at most sampling sites the values slightly decreased or were similar. Higher values were recorded only on the site in the Danube at Bratislava and also at common sampling sites (No. 112/2306, 3529/0082 and No. 3531/0084) by the Slovak Party.

Specific electric conductivity

The specific electric conductivity of surface water indicates the content of dissolved salts of mineral origin. It has a seasonal character, which is less pronounced in the seepage channel. The values are higher in the winter months, lower values occurs during summer. In 2019, the highest conductivity values were recorded in February, at the beginning or in the middle of the month, depending on the sampling site. The exception was the sampling site No. 3531 in the right-side seepage channel at Čunovo, where the maximum was reached at the beginning of March and the minimum only in September. Since March, the conductivity has gradually decreased to the lowest values recorded in June or July. At the beginning of April, there was an increase in values on some sites, which was probably related to the previous cooling. Since August, the values have risen again. The specific electric conductivity on the monitored sites varied in the range from 26.3 to 52.6 $mS.m^{-1}$ and compared to the previous year (30.3 - 52.0 $mS.m^{-1}$) fluctuated in a wider range. The highest value was measured on sampling site No. 307 in the upper part of the reservoir at Kalinkovo and the lowest in the Danube old riverbed on the sampling site No. 0042 downstream of the submerged weir at Dunakiliti. The dissolved salt content in the seepage channel is relatively stable during the year. The values of electric conductivity fluctuate here in a narrow range, in 2019 from 34.8 to 46.1 $mS.m^{-1}$ (common sampling site No. 3531/0084 at Čunovo/Rajka). Compared to the previous year, the conductivity values at the monitored localities fluctuated in wider range (they reached lower minimum values). The course of conductivity at selected sampling sites is documented in **Fig. 2-4**.

Suspended solids

The suspended solids content is closely related to the flow rate. It rises at flow waves and higher values are characteristic mainly for the summer period. In 2019, the highest contents were found in June in connection with the highest flow wave at the end of May, which culminated at 5490 $m^3.s^{-1}$. At individual sampling sites, they reached values from 42.2. to 202 $mg.l^{-1}$ and the highest values (202. and 200 $mg.l^{-1}$) were recorded on the sampling site No. 109 in the Danube at Bratislava. On the common sampling sites, there were no such large differences as was the case in 2018. The largest difference was found in the Danube old riverbed at Rajka (No. 1203/0001), where the Slovak Party in June recorded a suspended solids content of 97 $mg.l^{-1}$ and the Hungarian Party 113 $mg.l^{-1}$. Besides the June values, higher contents on some sampling sites occurred in March, in connection to the flow wave in the mid-month, that culminated at 4626 $m^3.s^{-1}$. The highest March content of suspended solids (122 $mg.l^{-1}$) was again documented on the sampling site No. 109 in the Danube at Bratislava and slightly lower (107 $mg.l^{-1}$) in the upper part of the reservoir on the site No. 307. In the lower part of the reservoir (the sampling site No. 311), the suspended solids content was low during the year (4.6 to 42.2 $mg.l^{-1}$) and in the left-side river branch system on the sampling site No. 3528 in the Bačianske river arm, the contents fluctuated maximally up to 28 $mg.l^{-1}$. The purest water was again the seepage water, where the values fluctuated in a narrow range from <2 to 14 $mg.l^{-1}$. Due to the origin of water, the content of suspended solids here is low for a long time. Compared to the previous year, the suspended solids contents were higher at most sampling sites, in the Danube at Medveďov (No. 112/2306), in the right-side seepage channel at Čunovo/Rajka (No. 3531/0084) and at the end of the left-side river branch system (No. 3528) they were similar. The content of suspended solids measured in the Danube downstream of the reservoir at Medveďov, was lower during flow waves than in the Danube at Bratislava, what indicates the sedimentation effect of the reservoir. The suspended solids content at selected sampling sites is shown in **Fig. 2-5**.

Iron

The amount of suspended solids affects the iron content in the surface water, therefore a higher iron content occurs in samples taken at higher flow rates. In the evaluated year, the iron content on the Slovak side was not determined at Bratislava, and on common sampling sites, on the Hungarian side in the Mosoni Danube at Mecsér (**Table 2-1**). On the other sites, the iron concentrations in the assessed year varied in the range from <0.01 to 1,43 $mg.l^{-1}$. The annual maximum of 1.43 mg.l-1 was found at the end of February on the sampling site No. 1112 in the river branch system (Helena weir). The highest values on other monitored sites occurred in March, at the end of May or in June. Even in the seepage water, a high concentration of iron (1.07 $mg.l^{-1}$) was detected in March, however, the other values on this sampling site (No. 0084) fluctuated in a narrow range, from <0.01 to 0,28 $mg.l^{-1}$. At sites on the left bank of the Danube old riverbed, in the lower part of the reservoir and in the left-side river branch system, the iron contents fluctuated maximally up to 0.67 $mg.l^{-1}$. The narrowest range (0.02 to 0.20 $mg.l^{-1}$) was documented on the sampling site No. 3528 at the mouth of the left-side river branch system (Bačianske river arm). The highest values on particular sites occurred in March or in June, only the highest annual concentration (1.43 $mg.l^{-1}$) was found at the end of February. Overall, the iron contents in 2019 were higher or similar as in the previous year. only in the Danube at Medveďov a lower maximum was found.

Manganese

Similarly to iron, nor the manganese was monitored by the Slovak Party on the sampling site in the Danube at Bratislava, and on the common sampling sites, on the Hungarian side in the Mosoni Danube at Mecsér (**Table 2-1**). The annual maximum of 0.74 $mg.l^{-1}$ was recorded in

March on the sampling site No. 0001 in the Danube old riverbed at Rajka. Other concentrations of manganese on the observed locations in the evaluated year varied in the range from <0.001 to 0.35 $mg.l^{-1}$. On the sampling site in the reservoir (No. 307 and 311) and in the tail-race channel at Sap (No. 3530), the manganese contents were low, fluctuating maximally up to 0.11 $mg.l^{-1}$. Even lower contents (maximally up to 0.05 $mg.l^{-1}$) were documented on the left-side of the Danube old riverbed (sampling sites No. 4025 and 3739) and in the left-side river branch system (No. 3376 and 3528). The narrowest range of values (0.005 to 0.017 $mg.l^{-1}$) in 2019 was registered on the sampling site no. 3528 in the river branch system - Bačianske river arm. Compared to the previous year, the manganese contents decreased on the sampling site No. 1126 in the Ásványi river arm and Danube old riverbed at Dunaremete, while on the other monitored sites they increased or were similar as in the year 2018.

2.3. Cations and Anions

The quantitative ratio of the ionic composition of surface water in the evaluated year 2019 showed high stability, just as in previous years. Seasonal fluctuation in the content of individual ions followed changes in conductivity. Changes of dissolved solids content are related to the flow rate fluctuation in the Danube. Compared to the long-term measurements, the values of basic cations and anions did not change. The development of their concentrations at particular sampling sites was similar. Higher contents of some ions (sodium, calcium, chlorides and sulphates) were documented in 2019 on the sampling site No. 1141 in the Mosoni Danube at Mecsér. The most stable ionic composition is characteristic for the seepage water. Concentrations of cations and anions fluctuate here in narrower ranges.

The highest values of individual cations and anions on the monitored sites occurred at the end of January or in February in connection with significant cooling, the lowest values were documented in June or in July. On some sampling sites, a temporary increase in concentrations occurred in April and a temporary decrease in September. Compared to the previous year, the chlorides and sodium contents (on locations monitored by the Slovak Party) fluctuated in wider ranges and reached higher maxima. Sodium concentrations were lower in the Danube at Medveďov, on the right bank of the Danube old riverbed and in the right-side river branch system. Calcium, magnesium, sulphates and hydrogen carbonates contents decreased slightly or were similar as in the year 2018. Exceptions were the sampling sites in the right-side river branch system, where higher concentrations of magnesium were recorded, and the sampling site in the Danube at Medveďov, in the Danube old riverbed at Rajka and in the Mosoni Danube at Mecsér, where contents of sulphates increased slightly. For the sampling site in the Mosoni Danube at Mecsér, compared to the other sites, significantly higher content of sulphates is characteristic.

2.4. Nutrients

Ammonium ions

In the evaluated year, the content of ammonium ions ranged from <0.02 to 0.16 $mg.l^{-1}$, except the sampling site in the Mosoni Danube at Mecsér (No. 1141), where a higher maximum was found (0.28 $mg.l^{-1}$). The highest values on the observed localities occurred at the beginning of the year in January or February. In the following period of the year, the concentrations of ammonium ions were low. A slight increase on some sampling sites was recorded at the end of May or at the beginning of June and September, the values ranged up to 0.01 $mg.l^{-1}$. In the right-side seepage channel at Čunovo/Rajka (common sampling site No. 3531/0084) the concentrations of ammonium ions fluctuated only in a narrow range from 0.03 to 0.11 $mg.l^{-1}$. In the evaluated year, the concentrations determined by the Hungarian Party on this sampling site were mostly higher. In general, the contents of ammonium ions in the assessed year were similar as in 2018 or slightly decreased. Increase of values was recorded only in the Danube at Bratislava, at Medveďov (only by the Slovak Party), in the upper part of the reservoir and in the river branch system at Helena weir.

Nitrates

In the case of nitrates, seasonal fluctuation of the measured values is characteristic, which is less apparent in the seepage channel. Seasonal fluctuation is related to the growing season and the consumption of nutrients in the water. In the growing period, the nitrates content usually decreases to a half of the winter amount. Except the seepage channel, the course of values was similar on individual sites and the concentrations varied from 3.5 to 15.2 $mg.l^{-1}$ (**Fig. 2-6**). The highest concentrations at particular sampling sites were recorded at the beginning of the year, in January or early February, the lowest in the period from May to September. In early April, late May and early June, there were slight increases in values on some localities in connection with strong cooling and high water stages. Since September, the contents of nitrates have been gradually increasing. The annual maximum (15.2 $mg.l^{-1}$) was measured in the Szigeti river arm on the sampling site No. 1114. A similar content (15.0 $mg.l^{-1}$) was found also in the Danube at Bratislava (No. 109), while on other monitored localities the concentrations of nitrates fluctuated in narrower ranges and maximally up to 12.6 $mg.l^{-1}$. The lowest content (from 2.4 to 7.0 $mg.l^{-1}$) was characteristic for the seepage water, where the seasonality is not so significant. In 2019, the contents of nitrates at monitored sampling sites were mostly higher than in the previous year or the contents in the Danube old river were similar. A slight decrease was recorded at two sites in the right-side river branch system (No. 1112 at the Helena weir and No. 1126 in the Ásványi river arm).

Nitrites

The amount of nitrites, that are considered to be a transient product of nitrification processes, also changed seasonally and varied only in a narrow range. Overall, the contents of nitrites at monitored sampling sites fluctuated in 2019 from 0.011 to 0.276 $mg.l^{-1}$. Except the seepage canal, the highest values occurred in January or at the beginning of February. The annual maximum of 0,276 $mg.l^{-1}$ was measured at the end of January on the sampling site No. 0002 in the Danube old riverbed at Dunaremete. In May, there was a temporary increase in concentrations in some localities, up to a maximum of 0.103 $mg.l^{-1}$ (the highest value on the sampling site No. 109 in the Danube at Bratislava). On the common sampling site No. 3531/0084 in the seepage canal at Čunovo/Rajka, nitrites fluctuated only in a narrow range of 0.016 to 0.053 $mg.l^{-1}$. The highest concentrations during the year were recorded on the sampling site No. 1141 in the Mosoni Danube at Mecsér, where values fluctuated from 0.039 to 0.226 $mg.l^{-1}$. In 2019, the contents of nitrites at monitored sites increased in comparison with the previous year. Only in the right-side seepage channel a slight decrease was documented.

Total nitrogen

The total nitrogen belongs to water quality indicators with significant seasonal fluctuation. Changes of total nitrogen in the water usually follow the seasonal changes of nitrates. The highest contents are recorded at the beginning of the year in the coldest period. In the evaluated year, it was the end of January or the beginning of February, depending on the sampling site. Low values were recorded in the summer months. Except the seepage canal, the development of total nitrogen concentrations was similar (**Fig. 2-7**). As in the case of nitrates, there were slight increases if contents in early April, late May and early June (due to cooling and higher flow rates). Except the seepage channel, the total nitrogen contents in surface water in the evaluated year fluctuated from 1,02 to 4,19 mg.l^{-1}. The highest concentration (4,19 mg.l^{-1}) was measured in the Danube old riverbed at Dunaremete (sampling site No. 0002). The lowest concentrations (0.80 to 1.75 mg.l^{-1}) were characteristic for water in the seepage channel, where the development of total nitrogen is different and the seasonality is not so significant. Compared to the year 2018, the amount of total nitrogen on observed sites increased and concentrations fluctuated in wider ranges. The only exception was the common sampling site No. 3531/0084 in the right-side seepage channel at Čunovo/Rajka, where the content of total nitrogen in comparison with the previous year slightly decreased.

Phosphates

Higher contents of phosphates are characteristic for colder months and during high flow rates. Low values are typical for the growing season, when intensive growth of algae going on. In 2019, due to high water levels in March, the main development of phytoplankton was postponed to May, when the highest abundance values were found. Low concentrations of phosphates (often below the limit of determination) occurred at the beginning of April and in May, and a decrease of concentrations was recorded on several site also in July, when a milder development of phytoplankton was documented in the summer. In the Danube at Bratislava (sampling site No. 109), the development of phosphates as different from other sites (also due to the higher number of data). Increase of values on this sampling site occurred in several months, with a maximum of 0.22 mg.l^{-1}, which was recorded in January and also at the end of September. This value represents the annual maximum in 2019 and besides the sampling site in the Danube at Bratislava was measured by the Slovak Party also on the common sampling site No. 1203/0001 in the Danube old riverbed at Rajka in June. However, this value was not confirmed by the Hungarian Party, as they recorded a concentration of only 0.07 mg.l^{-1} at that time. On other localities, the contents of phosphates fluctuated maximally up to 0.19 mg.l^{-1}. The highest values during the year were documented on the site No. 1141 in the Mosoni Danube at Mecsér, where they fluctuated in the range 0.10 to 0.19 mg.l^{-1} (**Fig. 2-8**). The narrowest range (<0.03 to 0,10 mg.l^{-1}) was characteristic for the sampling site No. 3531/0084 in the right-side seepage channel at Čunovo/Rajka. In 2019, similarly high contents (above 0.30 mg.l^{-1}) as in the previous yea did not occurred on any site. Except the above mentioned high values, contents of phosphates on individual sites were mostly similar. A slight decrease as was recorded only in the Danube at Medveďov (common sampling site No. 112/2306) and in the Mosoni Danube at Čunovo/Rajka (No. 3529/0082).

Total phosphorus

Changes of the total phosphorus content over time only partially follow the quantitative changes of phosphates. The increase of its concentration in surface water is often caused by phosphorus bound to suspended solids. Therefore, higher concentrations may occur in connection with flow waves. The highest concentrations in the evaluated year occurred most often in May or in the first half of June in connection with the highest flow waves in May (in the middle and at the end of the month). The exceptions were the sampling site in the right-side river branch system (No. 1114 Szigeti river arm and No. 1126 Ásványi river arm), when the maximum was recorded in October, but increased concentrations occurred also in May and June (**Fig. 2-9**). Higher values of total phosphorus were documented on several sites also in March in connection with the third highest flow wave in the year. The contents of total phosphorus on observed sampling sites ranged from <0.02 to 0.37 mg.l^{-1}. The maximum of 0.37 mg.l^{-1} was recorded on the sampling site No,. 1141 in the Mosoni Danube at Mecsér in May. On other localities, the total phosphorus fluctuated maximally up to 0.23 mg.l^{-1}. The lowest concentrations were characteristic for the seepage water (sampling site No. 0084 in the right-side seepage channel at Rajka), where the values fluctuated within a narrow range from <0.02 to 0.06 mg.l^{-1}. The contents of total phosphorus did not change significantly compared to the previous year, on some sites there were higher maxima (in the Mosoni Danube at Rajka, in the river branch system, in the tail-race channel, in the upper part of the reservoir and in the seepage channel), on others they decreased slightly (in the main flow, in the Danube old riverbed and in the lower part of the reservoir). Only on the sampling site No. 1141 in the Mosoni Danube at Mecsér, the contents increased compared to 2018.

2.5. Oxygen regime parameters

Dissolved oxygen

The content of dissolved oxygen in surface water is influenced, besides the decay processes of organic pollution, by hydrometeorological conditions and the assimilation activity of phytoplankton. The dissolved oxygen content decreases proportionally with the increasing water temperature. Low values in 2019 were recorded from May to September. The highest concentrations were characteristic for the first two months of the year and relatively high values were found on some sites at the end of the year. Overall. it can be stated that the oxygen conditions in 2019 were good and the concentrations of dissolved oxygen ranged from 7.8 to 14.9 $mg.l^{-1}$ (except the sampling site in the seepage channel). The lowest and the highest concentration was measured in the river branch system on the sampling site No. 3528 in Bačianske river arm. A significant decrease of water temperature during flow waves in May (in the middle and at the end of the month) was reflected on some sites by increased values of dissolved oxygen. In the right-side seepage channel on the common sampling site No. 3531/0084 at Čunovo/Rajka, the oxygen conditions improved in the summer period, as the frequency of concentrations below 7 $mg.l^{-1}$, which is the limit for the I. quality class according to **Table 2-2**, was lower than in the previous year. The concentrations fluctuated here from 5.9 to 11.3 mg.l-1, while only two values below 7 $mg.l^{-1}$ occurred - **Fig. 2-10**. Overall, the dissolved oxygen content in the surface water on monitored location was similar to that in the year 2018.

COD_{Mn} and BOD_5

The COD_{Mn} and BOD_5 indicators are used to express the organic pollution of water, they indicate the chemically and biologically degradable content of organic substances. Higher values of COD_{Mn} and BOD_5 usually occur in periods with higher flow rates in the Danube, when the water contains higher amount of natural organic substances.

In 2019, except the sampling site in the Danube at Medveďov, the Slovak Party did not observe the COD_{Mn} indicator on other common sampling sites. Overall, the organic pollution on the observed sites ranged from 0.9 to 6.60 $mg.l^{-1}$. The annual minimum was recorded in the upper part of the reservoir on the sampling site No. 307, the annual maximum in the river branch system on the site No. 1112 at Helena weir. In connection with the highest flow rates in the Danube in May 2019, higher value of COD_{Mn} occurred on several sampling sites (at six they were higher than 5 $mg.l^{-1}$). Further increases were recorded in March as a result of the flow wave and on sites in the reservoir also in September. In the Danube at Bratislava (No. 109) and at Medveďov (No. 112/2306) and in the Mosoni Danube at Rajka (No. 0082), the pollution fluctuated maximally up to 3.7 $mg.l^{-1}$.The least polluted water in terms of organic pollution was the water in the seepage channel, where the COD_{Mn} values fluctuated in a narrow range, from 0.9 to 1.6 $mg.l^{-1}$ (the sampling site No. 0084 in the right-side seepage canal at Rajka). In general, it can be stated that the organic pollution expressed by the COD_{Mn} was higher compared to the previous year, except of sampling sites in the Danube at Medveďov (No. 112/2306), in the Danube old riverbed at Rajka (No. 0001) and in the Mosoni Danube at Rajka (No. 0082), where the values decreased slightly compared to 2018.

In the case of BOD_5 water quality indicator, the greatest differences in values measured by the Hungarian and the Slovak Parties are characteristic in long-term, which is most visible at common sampling sites (**Fig. 2-11**). Higher values are determined by the Hungarian Party. In 2019, the BOD_5 values determined by the Hungarian Party varied from 0.5 to 6.0 $mg.l^{-1}$ (maximum in January on the sampling site No. 1126 in Ásványi river arm), while the Slovak values ranged from <0.5 to 2.6 $mg.l^{-1}$ (maximum in May on the sampling site No. 3530 in the tail-race channel at Sap). The highest values on individual sites were registered on the Hungarian side mainly in January and March, on the Slovak side most frequently in May. The lowest pollution in the evaluated year was characteristic for the common sampling site No. 3531/0084 in the right-side seepage canal at Čunovo/Rajka, where the Slovak Party recorded values in the range from 0,7 to 1,8 $mg.l^{-1}$ and the Hungarian Party in the range from 1,8 to 3,9 $mg.l^{-1}$. Compared to 2018, the organic pollution expressed by the BOD_5 indicator was similar or slightly increased. Only in the Danube at Medveďov and in the Mosoni Danube at Mecsér it decreased slightly.

2.6. Heavy metals

From among the heavy metals, joint monitoring includes observation of zinc, mercury, arsenic, copper, chromium, cadmium, nickel and lead contents. The heavy metals are determined from filtered samples. From the long-term point of view, their contents in the surface water of the monitored area are mostly low with occasional higher values.

The arsenic pollution of surface water in the assessed year was lower at sampling sites on the Slovak territory monitored by VÚVH (from <1 to 1,6 $\mu g.l^{-1}$) than at sampling sites monitored by the Hungarian Party, where concentrations ranged from <2 to 4,7 $\mu g.l^{-1}$. The highest value was recorded in July on the sampling site No. 0002 in the Danube old riverbed at Dunaremete. The measured concentrations occurred at eight sampling sites, with a frequency from 1 to 4 times. In the case of sampling site observed by SVP-PD, concentrations were below the limit of determination, which in this case was 5.0 $\mu g.l^{-1}$.

The cadmium concentrations were low in the evaluated year, and except one value (0.13 $\mu g.l^{-1}$) on the sampling site No. 1141 at Mecsér, did not exceed the limits of determination, which are 0.02 $\mu g.l^{-1}$ (VÚVH), 0.08 $\mu g.l^{-1}$ (SVP-PD) and 0.10 $\mu g.l^{-1}$ (Hungarian data).

Similarly, in the case of chromium, there was only one value at the level of the limit of determination (1.0 $\mu g.l^{-1}$) on the common sampling site in the Mosoni Danube at Rajka by the Hungarian side, all other concentrations were below the limit of determination, so lower than 1.0 $\mu g.l^{-1}$, or 0.5 $\mu g.l^{-1}$ (SVP-PD).

The highest number of concentrations above the limit of determination is characteristic for copper. In 2019, higher values were found on two sampling sites in January: 7.7 $\mu g.l^{-1}$ (No. 0002 in the Danube old riverbed at Dunaremete) and 9.9 $\mu g.l^{-1}$ (No. 1126 in the Ásványi river arm). Other concentrations of copper varied in the range from 0.84 to 4.0 $\mu g.l^{-1}$.

The contents of nickel in the evaluated year fluctuated in the range from <1.0 to 3.9 $\mu g.l^{-1}$. Many values did not exceed the limit of determination. The highest content was recorded in May on the sampling site No. 0002 in the Danube old riverbed at Dunaremete.

The pollution of the surface water by lead was low in 2019. Many concentrations were below the limits of determination, which are 0.3 $\mu g.l^{-1}$ for VÚVH, and 1.0 $\mu g.l^{-1}$ for SVP-PD and Hungarian data. Overall, the contents ranged from <1.0 to 3.3 $\mu g.l^{-1}$ with one higher value (5.8 $\mu g.l^{-1}$) found in May on the site No. 0002 in the Danube old riverbed at Dunaremete.

In 2019, mercury occurred on sampling sites in quantities below the limit of determination (0,05 $\mu g.l^{-1}$ in the case of SVP PD and 0,02 $\mu g.l^{-1}$ in the case of other data).

The zinc concentrations fluctuated in the range from <1.0 to 18.5 $\mu g.l^{-1}$. The highest value was measured in January on sampling site No. 1126 in the river branch system (Ásványi arm).

In summary, it can be concluded that the concentrations of heavy metals, which were determined from filtered samples, were low during the assessed year. A large part of concentrations of monitored heavy metals were below the limits of determination of the analytical methods used. Such concentrations were characteristic mainly for mercury, cadmium and chromium. The highest number of concentrations above the limit of determination was characteristic for copper. Compared to the previous year, the pollution of surface water by heavy metals was similar, except of zinc, the contents of which decreased. In the case of arsenic lower annual maximum was found (4.7 $\mu g.l^{-1}$, while in 2018 the maximum was 5.8 $\mu g.l^{-1}$.), and in the case of copper and lead a higher annual maximum (in the case of copper 9.9 $\mu g.l^{-1}$, in 2018 6.7 $\mu g.l^{-1}$, and in the case of lead 5.8 $\mu g.l^{-1}$, while in 2018 the maximum was 4.2 $\mu g.l^{-1}$).

The limits of determination of heavy metals are currently at the level of I. and II. quality class according to the **Table 2-2**. Only in the case of arsenic the limit of determination varies from II. to IV. quality class, depending on laboratory. The evaluation of heavy metals according to the agreed limits (**Table 2-2**) at selected sampling sites is given in **Table 2-8**.

Based on the comparison of heavy metal concentrations with the limits pursuant to the Directive of the European Parliament and of the Council No. 2008/105/EC on environmental quality standards, and limits according to the national standards („Decree of the Hungarian Ministry of Rural Development No. 10/2010 (VIII.18.) on surface water pollution limit values and rules of their application" and „Regulation of the Government of the Slovak Republic No. 269/2010 Coll, laying down the requirements for achieving good water status" as amended), it can be stated, that in 2019 concentrations of heavy metals were in accordance with environmental quality standards.

2.7. Chlorophyll-a

The chlorophyll-a content refers to the amount of phytoplankton and provides information on the eutrophic status of the water. The amount of chlorophyll-a is influenced by the flow rate and temperature conditions of the evaluated year and by the fluctuation of nutrients content in the surface water. In 2019, the highest chlorophyll-a values occurred most frequently at the end of April or in May, when the main development of phytoplankton was documented. Due to rapid cooling and high flow rates at the end of May, the chlorophyll-a content dropped sharply to the lowest values (on some sites below the limit of determination). The summer development of phytoplankton was weak and the values of chlorophyll-a only on two sampling sites in the river branch system (No. 3376 at Dobrohošť and No. 1126 Ásványi river arm) exceeded the value of 10 $mg.m^{-3}$ (13.4 $mg.m^{-3}$ and 11.8 $mg.m^{-3}$, respectively). On other sampling sites, the contents were low until the end of the growing season. Overall, the contents of chlorophyll-a in the evaluated year fluctuated from 0.9 to 33.1 $mg.m^{-3}$ and the highest value was recorded in May on the sampling site No. 307 in the upper part of the reservoir. In the main flow and in the Mosoni Danube, chlorophyll-a ranged maximally up to 18.1 $mg.m^{-3}$, in the Danube old riverbed up to 24.9 $mg.m^{-3}$. On the common sampling site No. 3531/0084 in the right-side seepage canal at Čunovo/Rajka, the chlorophyll-a contents were low during the year, fluctuated in the range from 1.0 to 11.8 $mg.m^{-3}$ and the highest value was found at the beginning of April. Low contents were documented also on the site No. 3530 in the tail-race channel at Sap (<2,0 to 9,4 $mg.m^{-3}$) and No. 3528 in Bačianske river arm (<2,0 to 7,0 $mg.m^{-3}$). Compared to 2018, the chlorophyll-a contents increased slightly on the common sampling site No. 3531/0084 in the right-side seepage channel at Čunovo/Rajka. Higher maxima were found in the reservoir (No. 307 and 311) and on two sampling sites in the river branch system (No. 3376 and 1114). A decrease of maxima was documented in the Danube at Bratislava (No. 109), in the Mosoni Danube at Mecsér (No. 1141) and in the Bačianske river arm (No. 3528). Other values of chlorophyll-a ranged at similar intervals as in 2018. The development of chlorophyll-a at selected sampling sites is shown in **Fig. 2-12**.

2.8. Other biological indicators

Within the frame of optimisation of the monitoring under the 1995 Agreement, macrophyte monitoring and determination of the saprobic index of biosestone were excluded from biological indicators. The proposal to exclude these indicators was based on a mutual comparison of the data of biological quality elements exchanged so far, the determination and evaluation of which are based on national methodologies on both sides, as well as on the effort to exchange mutually comparable data. From among the biological indicators of surface water quality, the phytoplankton, phytobenthos and macrozoobenthos were monitored in the assessed year. Monitoring and evaluation of biological indicators on the Slovak side is carried out in relation to the long-term monitoring, taking into account the optimisation. After 2007, the Hungarian Party monitored and evaluated the biological indicators according to the gradually developed national methodology of evaluation according to the Water Framework Directive (WFD). By the Resolution No. 1155/2016 of the Hungarian Government, the revised Hungarian River Basin Management Plan 2 (RBMP2) from 2015 was adopted, which was prepared in order to fulfil the Member State's obligations contained in the Directive 2000/60/EC of the European Parliament and of the Council. The Background material No. 6.1 RBMP2 contains the methodology for determining the ecological status and limit values of the system for the assessment of biological, physico-chemical, hydromorphological and chemical parameters. On the Slovak side, the national methodology in the sense of the WFD is enshrined in the Regulation of the Government of the Slovak Republic No. 269/2010 Coll. as amended. Biological elements of surface water quality are evaluated according to the WFD at jointly monitored sampling points also within the Slovak-Hungarian Transboundary Waters Commission. According to the Water Framework Directive, the V. water quality class of the five-tier scale corresponds to a bad ecological status, the IV. class to a poor status, the III. class to a moderate status, the II. class to a good and the I. class to a high ecological status.

2.8.1. Biological indicators of surface water quality at sampling sites monitored by the Slovak Party

Monitoring and evaluation of biological indicators of surface water quality (phytoplankton, phytobenthos and macrozoobenthos) was carried out in the assessed year 2019 according to the methodology applied in previous years, partially considering the optimisation.

Phytoplankton

Phytoplankton was monitored on 10 sampling sites in 2019 (**Table 2-3**). In the period from March to October twelve samples were taken, six in the seepage channel. On several sites in the second half of June samples were not analyzed due to the high content of abiosestone. The vegetation period in 2019 can be characterized by the occurrence of several flow waves during the whole period, while the highest flow waves were in March and especially in the second half of May. The highest precipitation amount was recorded also in May. The average daily temperature of air and water in the Danube was mostly above the long-term daily average , except in May, when it fell significantly below the long-term average due to cooling and heavy precipitation. A slight decrease in temperatures was also recorded in July, September and early October, when the values decreased slightly below the long-term daily average. The main development of phytoplankton was registered only in May, when the highest values of phytoplankton abundance in 2019 were found, with a maximal value of 7756 cells.ml^{-1} in the river branch system on the sampling site No. 3376 at Dobrohošť. In June, due to high water levels at the end of May, the phytoplankton abundance decreased to its lowest values on most of sampling sites. The summer development of phytoplankton was only slight, the highest value (1818 cell.ml^{-1}) was recorded in July on the sampling site No. 311 in the lower part of the reservoir, the others ranged maximally up to 818 cell.ml^{-1}. Subsequently, the phytoplankton abundance was low until the end of the growing season. In none of the cases was the mass development of algae growth detected. A different development was documented at the end of the river branch system, where the phytoplankton abundance values belong to the lowest.

In general, the phytoplankton abundance ranged from 44 to 7756 cells.ml^{-1}. The lowest and the highest value occurred in the river branch system, the lowest in August on the sampling site No. 3528 in the Bačianske river arm and the highest in the second half of May on the sampling site No. 3376 at Dobrohošť. Exceedance of the limit for mass development (10000 cells.ml^{-1}) did not occur in the evaluated year. The annual average of phytoplankton abundance at individual sampling sites ranged from 201 to 1388 cells.ml^{-1}. The lowest value of the annual average occurred on the sampling site No. 3528 in the river branch system - Bačianske river arm, and the highest on the No. 311 in the lower part of the reservoir. Apart from two sampling sites, the values of the annual average (201 to 1388 cells.ml^{-1}) were similar or lower than in 2018 (284 to 1469 cells.ml^{-1}). A slight increase of the annual average occurred in the seepage channel at Čunovo (sampling site No. 3531) and a more significant increase was documented in the river branch system at Dobrohošť (No. 3376), from 682 cells.ml^{-1} to 1029 cells.ml^{-1}. The values of the average annual abundance of phytoplankton in 2019 were well below the limit for mass development.

Except the seepage channel, the largest portion in the phytoplankton composition in the evaluated year, had the cyclic diatoms (*Bacillariophyceae - Centrales*), the pennate diatoms (*Bacillariophyceae - Pennales*) were on the second place and the cellular green algae (*Chlorococcalles*) on the third. In the right-side seepage channel at Čunovo (sampling site No. 3531) in the assessed year, in contrast to the previous year, the highest portion had the cyclic diatoms (*Bacillariophyceae - Centrales*), a slightly lower portion had the golden-brown algae (*Chrysophyceae*) and the cellular green algae (*Chlorococcalles*). The portion of pennate diatoms (*Bacillariophyceae - Pennales*), that dominated in the previous year decreased significantly. Contrary to 2018, the cyanobacteria (*Cyanophyceae*) did not occur on this sampling site.

In the context of optimisation of the monitoring under the 1995 Agreement, the percentage of the phytoplankton baseline groups was selected for the evaluation: Cyanophyta, Chromophyta, Chlorophyta and Euglenophyta. These groups enter into the assessment of the ecological status, or ecological potential of surface water bodies together with the abundance and biomass of phytoplankton (chlorophyll-a). The limit values for the determination of the corresponding status/potential are set in the Governmental regulation No. 269/2010 Coll. as amended. The phytoplankton is monitored on sampling sites, one of which is located in a natural water body (No. 109) and the others are in significantly altered (No. 112, 3529, 3376, 3528, 3739, 3531) or artificial water bodies (No. 307, 311, 3530).

Based on the obtained percentages of the four main phytoplankton groups and their comparison with the limit values for the determination of ecological status or potential, it can be stated that according to this biological element of surface water quality the status or potential is high or maximum (I. class) on seven sites. On three localities higher percentage of cyanobacteria occurred. In the lower part of the reservoir, on the sampling site No. 311 the representation of cyanobacteria corresponded to the good potential (II. class) and on two localities (No. 307 in the upper part of the reservoir and No. 3529 in the Mosoni Danube) the values were at the level of moderate potential (III. class). On the sampling site in the reservoir, the cyanobacteria (Cyanophyta) were represented also by species forming the algal bloom, but they had only a low abundance. In the Mosoni Danube, species that produce harmful toxins did not participate in the abundance in the case of cyanobacteria.

By calculating the characteristic values from the phytoplankton abundance and chlorophyll-a data for the year 2019 and comparing them with the limit values, it can be concluded that they were at the level of high status or maximum potential (I. class) on all monitored localities.

Table 2-3: Basic groups of phytoplankton and characteristic values of phytoplankton abundance and chlorophyll-a in 2019 and their comparison wit limit values

Phytoplankton groups, abundance and biomass	**Sampling site**									
	109	**3739**	**112**	**307**	**311**	**3530**	**3529**	**3531**	**3376**	**3528**
Cyanophyta (%)	0.41	0	1.57	6.24	2.83	1.59	5.54	0	1.77	0
Chromophyta (%)	85.2	92.3	86.9	81.9	90.5	91.3	83.9	80.0	88.5	93.9
Chlorophyta (%)	14.4	7.7	11.6	11.8	6.7	7.1	10.5	19.9	9.7	6.1
Euglenophyta (%)	0.04	0.04	0	0	0	0.02	0.03	0.14	0.03	0
Abundance (cells.ml^{-1}), P(90)	441	515	648	721	1388	745	557	236	1029	201
Biomass - chlorophyll-a (μg.l^{-1}), P(90)	3.6	5.9	7.7	6.5	7.5	5.2	6.8	7.2	7.6	4.9

Legend:

I. class	II. class	III. class

Phytobenthos

Phytobenthos represents communities of photosynthetic microscopic and macroscopic cyanobacteria and algae living in the water loosely or attached to the substrate. It indicates short-term changes in water quality and responds directly to the presence of nutrients. In the area of Gabčíkovo Waterworks, the phytobenthos is monitored for a long time as part of periphyton. In the frame of hydrobiological analyses, determination of species and IPS (Indice de Polluo-Sensibilité Spécifique or Specific Pollution Sensitivity Index - Cemagref, 1982) and SID (Saprobic Index Diatoms or Rott's Saprobic Index - Rott et al., 1997) indices have been agreed for phytobenthos. The list of all identified species is a pat of the data exchange and is given in the Table Annex of the National Annual Report in 2019. In the assessed year, samples for determination of phytobenthos were taken in May, July and October on sampling sites listed in **Table 2-4**. Due to unstable hydrologic conditions, the spring sampling was not carried out in the Danube and in the river branch system at Dobrohošť. In the summer, the mass occurrence of the *Theodoxus fluviatilis*, which consumes the phytobenthos on the solid substrate, prevented the development of growths on the sampling site in the Mosoni Danube at Čunovo.

In terms of species diversity, the dominant part of phytobenthos in the evaluated year was formed by diatoms (*Bacillariophyceae - Pennales*) - 38 taxa, which always dominate in the periphyton. Other groups were represented by a lower number of taxa (from 1 to 16 taxa). The dominant species on the monitored sites were *Melosira varians*, *Diatoma vulgaris*, *Naviculla tripunctata, Nitzschia dissipata, Cymbella compacta, Naviculla recens*, *Synedra ulnaa* from the group of diatoms (*Bacillariophyceae*), *Bangia atropurpurea* from the red algae (*Rhodophyceae*), *Ulothrix zonata* from filamentous green algae (*Chlorophyceae - Ulotrichales*), *Spirogyra spp.* from the group of green conjugating algae (*Conjugathophyceae - Zygnematales*) and *Cladophora glomerata* from the siphonous green algae (*Chlorophyceae - Siphonocladales*).

Calculation of IPS and SID diatom indices was performed in OMNIDIA 6.0 software. The IPS index has been evaluated as the most suitable tool for water quality assessment in several European countries. The index values vary in the range from 1.1 to 20, with a higher value indicating better water quality. The IPS index limit values for individual types of water bodies are specified in the Governmental regulation No. 269/2010 Coll. as amended. The SID index characterizes the degree of saprobity and classifies the water to the appropriate quality class. It varies in a range from >1.3 to <3.5, when the higher value indicates worse water quality and vice versa, the lower value, the better water quality.

Table 2-4: Values of IPS index in 2019 (based on SVP-PD data)

ID	Sampling site	Month			Average	
		V.	VII.	X.	2019	*2018*
108	Danube, Bratislava, left side	x	12.3	12.7	**12.5**	*13.5*
110	Danube, Bratislava, right side	x	14.4	14.0	**14.2**	*13.3*
112	Danube, Medveďov, left side	x	13.8	14.4	**14.1**	*15.6*
3529	Mosoni Danube, Čunovo, left side	15.0	x	14.7	**14.9**	*15.9*
3376	Dobrohošť canal, Dobrohošť	x	14.6	15.3	**15.0**	*13.2*
3528	Bačianske river arm, weir J2	15.9	15.6	14.4	**15.3**	*14.7*

Table 2-5: Values of SID index in 2019 (based on SVP-PD data)

ID	Sampling site	Month			Average	
		V.	VII.	X.	2019	*2018*
108	Danube, Bratislava, left side	x	2.24	2.12	**2.18**	*2.08*
110	Danube, Bratislava, right side	x	1.93	2.06	**2.00**	*2.06*
112	Danube, Medveďov, left side	x	2.08	2.09	**2.09**	*2.06*
3529	Mosoni Danube, Čunovo, left side	2.05	x	2.03	**2.04**	*2.02*
3376	Dobrohošť canal, Dobrohošť	x	2.05	1.83	**1.94**	*2.03*
3528	Bačianske river arm, weir J2	2.03	1.98	2.07	**2.03**	*2.06*

Note: sampling sites No. 108 and 110 - left and right bank of the sampling site No. 109, x - sample not taken

The results obtained in 2019 (**Table 2-4**) show that according to the average value of IPS index, which characterizes the overall pollution of surface water, the water quality on sampling site in the Danube at Bratislava on the left side (No. 108) is worse than on the right-side and corresponds to III. quality class, IPS 12.5 - moderate quality. On other localities, according to the average values of IPS index (IPS 14.1 - 15.3), the quality in the evaluated year was good, so II. class. The least polluted water was in the river branch system (IPS 15.0 and 15.3). Compared to the previous year, a slight deterioration of the average value of IPS was documented on three sampling sites (No. 108 in the Danube at Bratislava - left side, No. 112 in the Danube at

Medveďov and No. 3529 in the Mosoni Danube at Čunovo). On the other three localities, there was a slight improvement in surface water quality.

Similarly, also in the case of the average values of the SID index (**Table 2-5**), the left side of the Danube at Bratislava (SID 2.18) shows a worse quality than the right side (SID 2.00). Values on the left side of the Danube at Bratislava already correspond to the range for β-mesosaprobity to α-mesosaprobity (II. to III. quality class). According to the SID index, the saprobity on the other sampling sites is the same (1.94 - 2.09). The values correspond to β-mesosaprobity, which represents II. quality class and therefore good water quality. The average values of SID index are comparable with the average values in 2018. A slight deterioration occurred only on the sampling site No. 108 in the Danube at Bratislava on the left side (2.18, while in 2018 it was 2.08) and a slight improvement in the river branch system at Dobrohošť (No. 3376) - **Table 2-5**.

Based on the results of surface water quality assessment according to diatom indexes IPS and SID (**Table 2-4** and **Table 2-5**) it can be stated that upstream of the waterworks in the Danube at Bratislava (left side) the water quality is slightly worse (IPS 12.5, SID 2.18) as in the Danube downstream of the waterworks at Medveďov (IPS 14.1, SID 2.09). In the case of the right side of the Danube at Bratislava, the water quality is similar to that of Medveďov. In the Danube at Bratislava (left side) the values correspond to the moderate quality (III. class) according to IPS and II. to III. class according to SID, while at Medveďov the values are at level II. class (good quality).

Macrozoobenthos

The macrozoobenthos represents benthic invertebrates - small microscopic to large macroscopic invertebrates, inhabiting the bottom of water bodies. From an ecological point of view, the monitoring of macrozoobenthos in flowing water bodies appears to be the most appropriate method for bioindication. Samples are relatively easy to access and quickly processable. In 2019, the macrozoobenthos samples were taken in May, July and October on the monitoring sites listed in **Table 2-6**. There was no spring sampling in the Danube and in the reservoir, and a summer one in the Mosoni Danube.

In sections with fast flowing water with gravely or rocky bottom (sampling sites No. 109 at Bratislava, No. 112 at Medveďov in the Danube and No. 4025 in the Danube old riverbed at Dobrohošť) rheophilic and oxybionic macroinvertebrate species prevail, indicating β-mesosaprobity. At these sampling sites in 2019 the following species dominated: *Theodoxus fluviatilis*, *Dikerogammarus bispinosus*, *Dikerogammarus villosus*, *Echinogammarus ischnus*, representatives of the family Lumbriculidae g. sp. div., and on the sampling site No. 109 also *Fredericella sultana*, and on No. 4025 also *Lithoglyphus naticoides*, *Limnomysis benedeni*, and representatives of the family Chironomidae g. sp. div.. On the sampling site at Sap (No. 3739), upstream of the confluence of the Danube with the tail-race canal, and in the Mosoni Danube at Čunovo (No. 3529), with a slower flow of water, stagnophilic and oligooxybionic species appear, which withstand a slight pollution. In this section the bottom is sandy or muddy. In the assessed year, the species *Lithoglyphus naticoides*, *Limnomysis benedeni*, *Corbicula fluminea*, *Theodoxus fluviatilis* and representatives of the families Lumbriculidae g. sp. div. and Chironomidae g. sp. div. dominated here. In the Mosoni Danube also the species *Bithynia tentaculata*, *Platycnemis pennipes* and *Physella acuta*.

There are places in the reservoir with different flow velocities and depending on that, also with different composition of the substrate. On the muddy sediment in the deeper parts of the reservoir (No. 307 and 311), species of the family Lumbriculidae g. sp. div. and the species *Lithoglyphus naticoides*, *Pisidium henslowanum, Chironomus plumosus* and *Corbicula fluminea* were the dominant species of macrozoobenthos in the evaluated year.

In the river branch system in the assessed year species *Dreissena polymorpha*, *Lithoglyphus naticoides*, *Physella acuta*, *Theodoxus fluviatilis*, *Bithynia tentaculata* and representatives of the families Lumbriculidae g. sp. div. and Chironomidae g. sp. div. dominated. At the beginning of the river branch system also the species *Platycnemis pennipes*, *Valvata piscinalis*, *Potamopyrgus antipodarum*, Tanytarsini gen. sp. div., *Calopteryx splendens*, and at the end of the river branch system also species *Simulium balcanicum*, *Simulium erythrocephallum*, *Corophium robustum*, *Echinogammarus ischnus* and *Simulium noelleri*.

Table 2-6: Values of saprobic index of macrozoobenthos in 2019

ID	Sampling site	Month			Yearly average		Saprobity in 2019
		V.	VII.	X.	2019	*2018*	
108	Danube, Bratislava, left side	x	1.89	1.91	**1.90***	**2.02**	β -mesosaprobity
110	Danube, Bratislava, right side	x	1.92	1.73	**1.83***	**1.95**	β -mesosaprobity
4025	Danube, Dobrohošť, left side	x	1.99	2.07	**2.03***	**2.15**	β -mesosaprobity
3739	Danube, Sap, left side	x	2.14	2.24	**2.19***	**2.16***	β -mesosaprobity
112	Danube, Medveďov, left side	x	2.11	2.28	**2.20***	**2.17***	β -mesosaprobity
307	reservoir, Kalinkovo, navigation	x	2.74	2.61	**2.68***	**-**	α -mesosaprobity
311	reservoir, Šamorín, left side	x	2.29	2.39	**2.34***	**-**	β -mesosaprobity
3529	Mosoni Danube, Čunovo	2.06	1.98	2.05	**2.03**	**2.08**	β -mesosaprobity
3376	Dobrohošť canal, Dobrohošť	2.07	2.03	2.04	**2.05**	**2.10**	β -mesosaprobity
3528	river branch system, Bačianske river arm, weir J2	2.12	2.00	2.07	**2.06**	**2.07**	β -mesosaprobity

Note: sampling sites No. 108 and 110 - left and right bank of the sampling site No. 109, x - sample not taken
* - average of two measurements

The saprobic indices of macrozoobenthos were calculated on the basis of determined species and varied in the range from 1.73 to 2.74, with the degree of saprobity at the level of β-mesosaprobity to α-mesosaprobity. The highest value (2.74) was recorded on the sampling site no. 307 in the upper part of the reservoir. Except the sampling site No. 307, the saprobic index values varied maximally up to 2.39. The average values of saprobic index ranged from 1.83 to 2.68. By comparing the average values of the saprobic index at individual sampling sites with the values from the previous year, it can be stated that the values were mostly similar or slightly decrease, only on two sampling sites in the Danube (No. 112 and 3739) they increased slightly. The values in the reservoir cannot be compared, as in 2018 only the autumn sampling in the lower part of the reservoir on the sampling site No. 311 was carried out, when the value of the saprobic index was 2.60. On this site, values of the saprobic index at the level of α-mesosaprobity occur most often.

Other aspects of the macrozoobenthos development are evaluated in Part 7 – Biological observations, where additional evaluation for molluscs (*Mollusca*) and dragonflies (*Odonata*) can be found.

2.8.2. Biological indicators and assessment of the ecological status of surface water at sampling sites monitored by the Hungarian Party

From among the biological quality elements, the Hungarian Party has been observing the phytoplankton, phytobenthos and macrozoobenthos for a long time. In 2019, the biological quality elements were only monitored on common sampling sites and on the newly included sampling site in the Mosoni Danube at Mecsér. In the case of other sampling sites, the assessment from 2017 was used. A summary of the results is presented in **Table 2-7**, the double asterisk indicate the results from 2017.

Table 2-7: Ecological status assessment for biological quality elements (Hungarian results)

ID	Sampling site	phyto-plankton	phyto-benthos	macro-zoobenthos
2306*	Danube, Medve	I	II	III
0001*	Danube old riverbed, Rajka	I	I	II
0042	Danube old riverbed, Dunakiliti, downstream of the submerged weir	II**	II**	III**
0002	Danube old riverbed, Dunaremete	II**	III**	IV**
1112	river branch system, Helena	III**	II**	III**
1114	river branch system, Szigeti river arm	II**	II**	III**
1126	river branch system, Ásványi river arm	III**	II**	III**
0082*	Mosoni Danube, Rajka	I	II	III
0084*	right-side seepage canal, Rajka	III	I	II
1141	Mosoni Danube, Mecsér	I	I	II

Note: * - jointly monitored sampling sites, ** - evaluation from 2017

The evaluation of biological indicators of water quality on the Hungarian side is carried out according to the Water Framework Directive within the ecological status of surface waters. The assessment of ecological status is carried out on the basis of a harmonized assessment of the results of biological quality elements, physico-chemical elements of water quality relevant from a biological point of view, hydromorphological indicators, as well as chemical parameters. The methodology of the determination of ecological status and the limit values of the system for evaluation of biological, physico-chemical, hydromorphological and chemical parameters is contained in the Background material No. 6.1 of the RBMP2. The evaluation of phytoplankton is based on the HRPI multimetric index (Hungarian River Phytoplankton Index), which characterizes the quantitative and qualitative conditions of phytoplankton. The phytobenthos evaluation is based on the IPSITI index, which is a combination of three diatom indices: the IPS index - Integrated Pollution Index, the SID index - saprobic index and the TID index - trophic index. The macrozoobenthos in 2019 was evaluated on the basis of the new national evaluation system HMMI (Hungarian Macroinvertebrate Multimetric Index - more details in the Hungarian National Annual Report in 2019). The classification of biological quality elements was performed on the basis of limit values for the types of water bodies determined within the RBMP2, taking into account the typology as follows: the Danube, the Danube old riverbed and the Mosoni Danube (9F), the river branch system (8N), seepage canal (5S).

According to the results from the monitoring of individual biological quality elements in 2019, it can be stated that according to phytoplankton a high status (I. quality class) was achieved in the Danube at Medveďov, in the Danube old riverbed at Rajka and in the Mosoni Danube at Rajka and Mecsér. In the right-side seepage channel at Rajka a moderate status was achieved (II. quality class).

According to phytobenthos, a high status (I. quality class) was achieved in the Danube old riverbed at Rajka, in the seepage channel at Rajka and in the Mosoni Danube at Mecsér. In the Danube at Medveďov and in the Mosoni Danube at Rajka good status was found (II. quality class).

In the case of macrozoobenthos, except the moderate status (III. quality class) in the Danube at Medveďov and in the Mosoni Danube at Rajka, on the other three localities observed in 2019 a good status (II. quality class) was achieved.

Concerning the overall ecological status, when, besides the biological quality elements, also the supporting elements (physico-chemical quality elements and other specific substances) are included in the assessment, on two sampling sites observed in 2019 (in the Danube old riverbed at Rajka and in the Mosoni Danube at Mecsér) a good ecological status (II. quality class) was determined and on three localities (in the Danube at Medveďov, in the Mosoni Danube at Rajka and in the right-side seepage channel at Rajka) the ecological status was moderate (III. quality class). Similarly, a moderate overall ecological status was also determined at other localities observed in 2017, except the sampling site in the Danube old riverbed at Dunaremete, where the achieved overall ecological status corresponded to a bad status (IV. quality class) (Hungarian National Annual Report in 2019).

2.8.3. Biological indicators and assessment of the ecological status of surface water at jointly monitored sampling sites

Biological indicators in 2019 on jointly monitored sampling sites were evaluated within the ecological status, or the potential of surface waters and in accordance with the methodology agreed in the frame of the Transboundary Water Commission (Assessment of the status of waters of the Slovak-Hungarian boundary watercourses in the year 2019).

According to the Transboundary Water Commission, the ecological status (or potential) in 2019 on the jointly observed localities, based on the biological quality elements, was determined as follows:

Danube at Bratislava - this sampling site according to Slovak results in 2019 was classified into the good status (II. quality class).

Danube at Medveďov - according to the Slovak and Hungarian results it was classified into the moderate status/potential (III. quality class).

Danube old riverbed at Rajka - according to the results of the Slovak Party, this sampling site was classified into a maximal potential (I. quality class), but only on the basis of the phytoplankton assessment, the results of the Hungarian Party corresponded to a good ecological status (II. quality class).

Right-side seepage channel at Čunovo/Rajka - based on the Slovak results it was classified into a good potential (II. quality class)), but only on the basis of phytoplankton assessment, and according to the Hungarian Party this sampling site was classified into a moderate status (IIII. quality class).

Mosoni Danube at Čunovo/Rajka - according to the results of the Slovak Party, this sampling site was classified into a high status (I. quality class), but from the biological quality elements only on the basis of phytoplankton assessment, the results of the Hungarian Party corresponded to a moderate ecological status (III. quality class).

For the determination of the overall ecological status/potential, supporting elements were also included in the assessment.

Besides the biological elements of quality, the Slovak Party also considered the physico-chemical quality elements and synthetic and non-synthetic substances relevant to Slovakia. The sampling sites in the Danube at Bratislava, in the Danube old riverbed at Rajka, in the Mosoni Danube at Čunovo and in the right-side seepage channel at Čunovo were classified into the II. quality class, so the overall ecological status/potential was also good (II. class). Only in the Danube at Medveďov, the overall ecological potential was moderate (III. quality class). The level of reliability of the ecological status assessment was high on three sampling sites, in the Danube old riverbed at Rajka and in the right-side seepage channel it was medium.

The Hungarian Party, after taking into account the results of the evaluation of physico-chemical quality elements and other specific substances (heavy metals), determined in the Danube old riverbed at Rajka good overall ecological status (II. class) and in the Danube at Medveďov, in the Mosoni Danube at Rajka and in the right-side seepage channel at Rajka on all sites a moderate overall ecological status (III. quality class).

When harmonizing the results of the Slovak and Hungarian Parties, there were one class differences in the overall assessment on two sampling sites (in the Mosoni Danube at Čunovo/Rajka and in the seepage channel at Čunovo/Rajka). The differences arose from that fact, that the Slovak Party on these localities observed only one biological quality element, while the Hungarian Party all relevant elements. Based on previous agreements, the overall ecological status in the Danube at Bratislava assessed only the Slovak Party (Assessment of the status of waters of the Slovak-Hungarian boundary watercourses in the year 2019).

2.9. Quality of sediments

The assessment of the level of sediment pollution within the frame of the Joint monitoring was carried out according to the „Canadian Sediment Quality Guideline for Protection of Aquatic Life" (CSQG) of 1999, modified in 2002. The comparison of measured values is performed against two limits - the Threshold Effect Level (TEL) and the Probable Effect Level (PEL). Sediment sampling was carried out at four sampling sites, both on the Slovak and the Hungarian sides. The situation of sampling sites is shown in **Fig. 2-1**. The Slovak Party took performed the sampling in autumn at the time of low flow rates (in September) and the Hungarian Party sampled in the spring (in April). Inorganic and organic micro-pollution was determined in the analysis of sediment samples. In the frame of inorganic pollution, eight heavy metals were analyzed (arsenic, cadmium, chromium, copper, nickel, lead, mercury and zinc) and from the organic contamination the analysis included substances from the PAH group and on the Hungarian side also the amount of total phosphorus and total nitrogen.

Inorganic micro-pollution of sediments at observed locations on the Slovak territory in 2019 generally slightly increased compared to the year 2018. Concentrations of arsenic and lead increased mainly, cadmium contents were similar. A slight decrease of concentrations was recorded only on two sampling sites in the case of copper and zinc (No. 307 and 4301), and on one site in the case of chromium (No. 307). Compared to the limits of the Canadian standard CSQG, the mercury concentration higher than the threshold limit (TEL=0.17 mg.kg^{-1}) occurred on only one site No. 4301 in the river branch system (0.18 mg.kg^{-1}). Concentrations of chromium, lead and zinc on two sampling sites (No. 311 in the lower part of the reservoir and No. 4301 in the river branch system) corresponded to a slightly contaminated sediment, at they slightly exceeded the lower limit of the range >TEL and <PEL. The measured concentrations of chromium reached 42.8 mg.kg-1 on No. 311 and 41.9 mg.kg^{-1} on No. 4301 (TEL=37,3 mg.kg^{-1}, PEL=90,0 mg.kg^{-1}), the lead concentrations reached 37.6 mg.kg^{-1} on No. 311 and 35.9 mg.kg^{-1} on No. 4301 (TEL=35,0 mg.kg^{-1}, PEL=91,3 mg.kg^{-1}), and in the case of zinc values of 128 mg.kg^{-1} on No. 311 and 133 mg.kg^{-1} on No. 4301 were found (TEL=123 mg.kg^{-1}, PEL=315 mg.kg^{-1}). In the case of copper, concentrations lower than the threshold limit was found only on the sampling site No. 307, on the other three locations the concentrations were from the range >TEL and <PEL (>35.7 mg.kg^{-1} - <197,0 mg.kg^{-1}), with a maximum of 45.2 mg.kg^{-1} on the site No. 311. In the case of arsenic and cadmium, all concentrations belonged to the range >TEL and <PEL (for arsenic: >5.9 mg.kg^{-1} - <17,0 mg.kg^{-1} and for cadmium: >0.6 mg.kg^{-1} - <3,5 mg.kg^{-1}), with maxima of 14.9 mg.kg^{-1} and 1.83 mg.kg^{-1} on the sampling site No. 311. Concentrations from the range >TEL and <PEL represent a level, when the adverse effects on biological life may be observed sometimes (occasionally) and they express the

potential for the occurrence of eco-toxicological effects and a moderate level of contamination. A danger to biological life associated with the aquatic environment is a pollution exceeding the PEL level. Such values of inorganic pollution did not occurred in the evaluated year.

From among the heavy metals in the sediment samples taken on the Hungarian territory, compared to the previous year, the contents of cadmium, copper and zinc increased and the contents of lead, mercury and chromium decreased. Arsenic concentrations decreased in the river branch system and increased in the Danube old riverbed. Contents corresponding to the unpolluted environment were recorded on all sampling sites in the case of copper (less than 35,7 $mg.kg^{-1}$), arsenic (less than 5,9 $mg.kg^{-1}$) and lead (less than 35,0 $mg.kg^{-1}$). In the case of chromium, one slight exceedance of the threshold level (37,3 $mg.kg^{-1}$) occurred in the river branch system, on the sampling site No. 1126 in the Ásványi river arm with a concentration of 38.2 $mg.kg^{-1}$. In the case of mercury, the measured values exceeded the threshold value (0,17 $mg.kg^{-1}$) in the Szigeti river arm (0,40 $mg.kg^{-1}$), in the Danube old riverbed upstream of the bottom weir (0,42 $mg.kg^{-1}$) and in the Ásványi river arm (0,36 $mg.kg^{-1}$). Pollution exceeding the PEL value (0,486 $mg.kg^{-1}$) was not detected on any sampling site, although the mentioned mercury values were closer to the PEL that to the threshold value. The PEL limit value represents a level when the adverse effects on biological life bounded to the aquatic environment may occur frequently. In the case of zinc and cadmium, all concentrations found were in the range >TEL and <PEL, but were closer to the lower limit of the range (for zinc: >123 $mg.kg^{-1}$ - 315 $mg.kg^{-1}$, for cadmium: >0,6 $mg.kg^{-1}$ -3,50 $mg.kg^{-1}$). The highest concentration of zinc (198 $mg.kg^{-1}$) and cadmium (1.20 $mg.kg^{-1}$) occurred on the sampling site No. 1126 in the Ásványi river arm. In the assessed year, the highest contents of observed heavy metals were documented in the river branch system, mainly on the sampling site No. 1126 in the Ásványi river arm, similarly to 2018.

Organic pollution of sediments on the Slovak territory decreased slightly compared to the previous year. Exceptions were the concentrations of fluoranthene and chrysene found on the sampling site No. 311, which slightly increased compared to 2018 and also exceeded the threshold limit: in the case of fluoranthene with a value of 149 $\mu g.kg^{-1}$ (TEL=111 $\mu g.kg^{-1}$, PEL=2355 $\mu g.kg^{-1}$) and in the case of chrysene by a concentration of 82.9 $\mu g.kg^{-1}$ (TEL=57,0 $\mu g.kg^{-1}$, PEL=862 $\mu g.kg^{-1}$). On three sampling sites (No. 307, 311 and 4301) the threshold concentrations for phenanthrene and benzo(a)pyrene were exceeded. Exceedances of the threshold limit were only slight. The highest concentrations occurred on the sampling site No. 311 in the reservoir: in the case of phenanthrene - 76.7 $\mu g.kg^{-1}$ (TEL=41,9 $\mu g.kg^{-1}$, PEL=515 $\mu g.kg^{-1}$) and in the case of benzo(a)pyrene - 63,1 $\mu g.kg^{-1}$ (TEL=31,9 $\mu g.kg^{-1}$, PEL=782 $\mu g.kg^{-1}$). The contents of naphthalene and anthracene corresponded to the natural environment without anthropogenic impact, thus they were lower than 34,6 $\mu g.kg^{-1}$ for naphthalene and lower than 46.9 $\mu g.kg^{-1}$ for anthracene. All measured concentrations of organic micro-pollution of sediments were from the range >TEL and <PEL, which corresponds to a slight pollution, and were closer to the lower limit of the given range and thus closer to an uncontaminated environment, than to the level, when the adverse effect on biological life is often expected.

The pollution of sediments with organic substances on the Hungarian territory was similar or lower than in 2018. The contents of monitored organic substances mostly corresponded to an uncontaminated environment and only on the sampling site No. 0042 in the Danube old riverbed downstream of the bottom weir, there occurred concentrations of two substances that slightly exceeded the threshold limit (TEL). It was the case of benzo(a)anthracene with the value of 35.2 $\mu g.kg^{-1}$ (TEL=31,7 $\mu g.kg^{-1}$ PEL=385 $\mu g.kg^{-1}$) and benzo(a)pyrene with the value of 38.1 $\mu g.kg^{-1}$ (TEL=31,9 $\mu g.kg^{-1}$ PEL=782 $\mu g.kg^{-1}$). On this sampling site also the highest sum of concentrations of organic substances from the group of PAH (300.8 $\mu g.kg^{-1}$) was documented, similarly to previous year, although it was lower (in 2018 the sum of PAH was 417.5 $\mu g.kg^{-1}$).

The lowest inorganic pollution of sediment in 2019 on the Slovak territory was documented on the sampling site No. 307 in the upper part of the reservoir and the lowest organic micro-pollution was found on the locality No. 4016 in the Danube old riverbed river upstream of the bottom weir. The most contaminated sediment was the sample from the sampling site No. 311 in the lower part of the reservoir. On the Hungarian territory, the lowest inorganic pollution was found on the sampling site No. 0042 in the Danube old riverbed downstream of the bottom weir, but here the highest organic pollution occurred. And conversely, on the sampling site No. 1126 in the Ásványi river arm, the inorganic pollution was the highest, but the organic was the lowest.

The Hungarian Party also analysed the total phosphorus and total nitrogen contents in sediments. The total phosphorus content in 2019 ranged in the interval from 200 $mg.kg^{-1}$ (Szigeti river arm - No. 1114) to 566 $mg.kg^{-1}$ (Ásványi river arm - No. 1126). The lowest concentration of total nitrogen (216 $mg.kg^{-1}$) occurred on the sampling site No. 0042 in the Danube old riverbed downstream of the bottom weir at Dunakiliti, and the highest value (2183 $mg.kg^{-1}$) was found on the sampling site No. 1126 in the Ásványi river arm. Compared to 2018, the total phosphorus contents decreased on three sites and only in the Danube old riverbed downstream of the bottom weir at Dunakiliti (No. 0042) slightly increased. Similarly, the concentrations of the total nitrogen decreased on three localities and an increase was documented only on the sampling site No. 1126 in the Ásványi river arm.

Overall, it can be stated that the inorganic pollution of sediments in 2019 on the Slovak territory was slightly higher than in 2018 and the organic micro-pollution slightly decreased. All contents of evaluated indicators of inorganic and organic micro-pollution, which were from the range >TEL and <PEL, were next to the lower limit. On the Hungarian territory, the organic micro-pollution of sediments was similar to that in 2018 or slightly decreased. From among the monitored heavy metals, the contents of cadmium, copper and zinc increased and the contents of lead, mercury and chromium decreased. The concentrations of arsenic decreased in the river branch system and increased in the Danube old riverbed. In none of the cases there was a concentration exceeding the limit of probable adverse effect (PEL). Concentrations of monitored heavy metals from the range >TEL and <PEL were next to the lower limit, except the mercury, where the values on three localities approached the value of the probable adverse effect (PEL). The contamination of sediment above the PEL level poses a danger to biological life associated with the aquatic environment.

2.10. Indicative assessment of surface water quality indicators according to agreed limit values for the classification of surface water quality

In **Table 2-8** an indicative classification of selected sampling sites and selected surface water quality indicators was done according to the agreed limit values for the classification of surface water quality.

The indicative classification was performed using the limit values of the five-class system, according to the trans-boundary water quality classification adopted by the Slovak-Hungarian Trans-boundary Water Commission at its LXV. session, and referred in the „Directive for surface water quality monitoring of the Slovak-Hungarian boundary waters and for extended water quality monitoring on the Danube”.

Certain part of the observed indicators show seasonal fluctuation, which subsequently affects the classification into the quality classes. In the case that a range is given (e.g. I-II), this means natural seasonal fluctuation of individual indicators or their dependence on climatic conditions. If a value from another quality class occurred once or twice during the evaluated period (mostly during higher flow rates or flood waves), it is indicated by a cross mark in the colour of the relevant class. In the case of two values, which fall into different quality classes, the colour of the cross corresponds to the worst class. The range with asterisks (e.g. I*-II*) represents a situation, when each recorded value was below the determination limit of the applied analytical method, but the two Parties have different limits of determination.

Based on a comparison of water quality entering the affected area (sampling site at Bratislava) and water quality, which leaves the affected area (sampling site at Medveďov) it is evident, that the water quality that leaves the system is very similar.

Table 2-8: Indicative assessment of surface water quality indicators

Parameter	Sites situated on the Danube			Mosoni Danube		Seepage canal	Right-side river branch system
	Bratislava	Rajka	Medveďov	Čunovo/ Rajka	Mecsér	Čunovo/ Rajka	Helena, Szigeti, and Ásványi river arm
temperature	I $^{+}$	I $^{+}$	I $^{+}$	I $^{+}$	I-II	I $^{+}$	I-II
pH	II-III	I-II	I-II $^{+}$	I-II $^{+}$	I-II	I-II $^{+}$	I-II $^{+}$
conductivity	I-II	I-II	I-II	I-II	I-II	I-II	I-II
suspended solids	I-V	I-III $^{+}$	I-III $^{+}$	I-IV $^{+}$	I-III $^{+}$	I	I-II $^{+}$
Fe	-	I $^{+}$	I $^{+}$	I $^{+}$	-	I $^{+}$	I $^{+}$
Mn	-	I-III $^{+}$	I-III $^{+}$	I-II $^{+}$	-	I-III	I-III $^{+}$
Cl^-	I	I	I	I	I	I	I
SO_4^{2-}	-	I	I	I	I	I	I
NO_3^-	I-II $^{+}$	II	II	II	I-II	I-II	II $^{+}$
NH_4^+	I	I	I	I	I $^{+}$	I	I
NO_2^-	I-II	I-II	I-II	I-II	I-II $^{+}$	I-II	I-II $^{+}$
total nitrogen	I-II $^{+}$	I-II	I-II	I-II	I-II	I-II	I-II
PO_4^{3-}	I-II	I $^{+}$	I $^{+}$	I	I-II	I	I-II
total phosphorus	I-II	I-II	I-II	I-II $^{+}$	I-II $^{+}$	I	I-II
O_2	I	I	I	I	I	I $^{+}$	I
COD_{Mn}	I	I	I	I	I $^{+}$	I	I $^{+}$
BOD_5	I	I-II $^{+}$	I-II	I-II $^{+}$	I-II $^{+}$	I $^{+}$	I-II $^{+}$
chlorophyll-a	I $^{+}$	I $^{+}$	I $^{+}$	I $^{+}$	I $^{+}$	I $^{+}$	I-II
As	II**-III	II**-III** $^{+}$	II**-III*	III*	III**-IV	III-IV	III**-IV
Cr	I*	I*	I*	I** $^{+}$	I*	I*	I*
Cd	I*	I*-II*	I*-II*	II*	II** $^{+}$	II*	II*
Cu	II	I-II $^{+}$	I-II $^{+}$	I-II $^{+}$	I-II $^{+}$	I-II $^{+}$	I-III $^{+}$
Ni	II*	II**-III	II**-III	II**-III	II-III	II** $^{+}$	II-III
Pb	I**-III $^{+}$	I**-III $^{+}$	I*-II** $^{+}$	II**-III $^{+}$	II**-III $^{+}$	II** $^{+}$	II**-III $^{+}$
Hg	I*	I*	I*	I*	I*	I*	I*
Zn	II** $^{+}$	I-III	I-II** $^{+}$	I-III $^{+}$	I-III $^{+}$	I-III	I-III $^{+}$

Quality classes: **I. class** **II. class** **III. class** **IV. class** **V. class**

* all the data below the limit of determination ** most of the data below the limit of determination

\+ one or two values of different quality class and the colour represents the worst quality class/the highest value

2.11. Conclusions

The quality of surface water at sampling sites monitored under the Agreement did not change significantly in 2019 compared to the previous year and in long-term is balanced. The increase or decrease in the concentrations of individual indictors during the observed period appears already in Bratislava on the sampling site No. 109, which is located upstream of the Gabčíkovo Waterworks, and monitors the surface water quality entering the Slovak territory. Some monitored indicators of surface water quality in the Danube, in the reservoir and in the river branch system show seasonal changes, some indicators depend mainly on the flow rate, others are influenced by biochemical processes in the surface waters. The fluctuation of quality indicators in the Mosoni Danube and in the seepage channel reflects the different characteristics of these water bodies. The water quality in the Mosoni Danube is influenced by the Danube water and in the seepage canal mainly by the leaking groundwater. Typical for the seepage water are fairly balanced time series data of quality indicators, which fluctuate only in narrow ranges.

From among the basic physical and chemical indicators of surface water quality, the water temperature on most monitored sampling sites in 2019 reached lower values than in the previous year. Exceptions were two locations: No. 1126 in the Ásványi river arm and No. 3531/0084 in the right-side seepage channel, where the achieved maxima were slightly higher. The values of pH and specific conductivity were similar to the previous year, but mostly fluctuated in wider ranges with lower minima. The contents of suspended solids, iron and manganese were affected by the actual hydrological regime. High contents at individual locations were found in connection with the highest flow wave at the end of May or the flow wave in March. The highest value of suspended solids was measured in May in the Danube at Bratislava (202 $mg.l^{-1}$). The annual maximum in the case of iron was found in the river branch system (Helena weir) at the end of February and in the case of manganese in the Danube old riverbed at Rajka in March. Compared to the previous year, the contents of suspended solids, iron and manganese were higher or similar.

The development of concentrations of basic cations and anions at particular sampling sites was similar. Compared with long-term measurements, their values show high stability. Higher contents of some ions (sodium, calcium, chlorides and sulphates) were documented in 2019 on the sampling site No. 1141 in the Mosoni Danube at Mecsér. The most stable ionic composition is characteristic for the seepage water. Concentrations of cations and anions fluctuate here in narrower ranges. The highest values of individual cations and anions on the monitored sites occurred at the beginning of January or in February, in connection with a significant cooling in the mentioned period. The lowest values were documented in June and July. Compared to the previous year, the contents of sodium and chlorides at sampling sites observed by the Slovak Party fluctuated in wider ranges and reached higher maxima. The contents of calcium, magnesium, sulphates and bicarbonates mostly decreased or were similar to those in 2018.

Some nutrients show seasonal variation. Higher concentrations are characteristic for the colder months; decrease in values is recorded in the spring after warming. Seasonal fluctuation is related to temperature-dependent biochemical processes in the water. Contents of phosphates and total phosphorus may increase at higher flow rates. Low values of phosphates are typical for the growing season, when there is an intensive growth of algae and their contents often fall below the limit of determination. In the assessed year, low contents of phosphates occurred at the beginning of April and in May in connection with the main wave of phytoplankton development, on some localities also in July (in connection with milder summer development of phytoplankton). The highest contents of total phosphorus occurred during the period of flow waves (at the end of May, in the first half of June or in March). The highest contents of nutrients with seasonal fluctuation in 2019 were recorded in January or February, the lowest in the summer. In connection with cooling and high water levels, a temporary increase of values occurred in early April, late May and early June. In general, it can be stated that the amount of nutrients in surface water in the evaluated year was higher or similar to that in 2018. Higher were mainly the contents of total nitrogen and nitrites. Concentrations of nitrates at most of sampling sites were higher compared to the year 2018, on the sampling site in the Danube old riverbed they were similar and a slight decrease as recorded only on two sampling sites in the right-side river branch system (Helena weir and the Ásványi river arm). Contents of phosphates were similar, but without high values recorded on some sampling sites in 2018 (above 30 $mg.l^{-1}$). Similar were also the contents of total phosphorus, except the site in the Mosoni Danube at Mecsér, where the total phosphorus concentrations increased compared to the previous year. The lowest and the most balanced nutrient values can be found in seepage water, what results from its groundwater origin. The seasonality is not as strong here as elsewhere. The content of nutrients in the Danube water is, among other suitable conditions, potentially sufficient for the development of eutrophication processes.

Oxygen conditions in 2019 can be classified as good. The dissolved oxygen content on the monitored sites basically did not change. Contamination by organic substances, expressed by the COD_{Mn} indicator increased on most sampling sites, a slight decrease was documented only in the Danube at Medveďov, in the Danube old riverbed at Rajka and in the Mosoni Danube at Rajka. The pollution expressed by the BOD_5 indicator was similar to that in 2018, only in the Danube at Medveďov and in the Mosoni Danube at Mecsér it decreased slightly. In the case of the BOD_5 indicator, significant differences in the values measured by the Slovak and Hungarian Party were registered again on common sampling sites. The values obtained by the Hungarian Party were higher. The lowest pollution in the evaluated year was characteristic for the sampling site in the right-side seepage canal at Čunovo/Rajka.

Concentrations of heavy metals, which were determined from the filtered samples, were low during the evaluated year. Most of the measured values were below the limits of determination of applied analytical methods. Such concentrations were characteristic mainly for mercury, cadmium and chromium. The highest frequency of values above the limit of determination was characteristic for copper. Compared to the previous year, the pollution of surface water by the observed heavy metals was similar, except of zinc, contents of which decreased. In the case of arsenic, lower annual maximum was found than in 2018, and conversely, slightly higher in the case of copper and lead. Based on the comparison of heavy metal concentrations with the limits pursuant to the Directive of the European Parliament and of the Council No. 2008/105/EC on environmental quality standards, as amended, and limits according to the national standards (Decree of the Hungarian Ministry of Rural Development No. 10/2010 (VIII.18.) and the Slovak Government Regulation No. 269/2010 Z.z., as amended) it can be stated, that in 2019 the concentrations of heavy metals were in compliance with environmental quality standards.

Based on long-term observations of the water quality entering the affected area and the water quality, which leaves the affected area, it can be stated that the physico-chemical composition of the Danube water by passing through the Gabčíkovo Waterworks does not change substantially. The situation in the quality of individual indicators is similar.

The chlorophyll-a content refers to the amount of phytoplankton and provides information on the eutrophic status of the water. In the evaluated year, the chlorophyll-a content was similar to the previous year. An exception was the sampling site in the right-side seepage channel, where chlorophyll-a contents slightly increased and at some sampling sites higher or lower maxima reached then in 2018. The highest values were recorded at the end of April or in May during the main wave of phytoplankton development.

From among the other biological indicators of the surface water quality, the phytoplankton, phytobenthos and macrozoobenthos were monitored in the evaluated year. The evaluation of these quality elements on the Slovak side was carried out in relation to the previous period, taking into account the optimisation. In the evaluated year, a similar development of phytoplankton was observed as in 2018. The limit for mass development was not exceeded in any case. Considering the hydrological and climatic conditions, the main wave of phytoplankton development was not recorded until May. The highest abundance of phytoplankton (7756 cells.ml^{-1}) occurred on the sampling site No. 3376 in the river branch system at Dobrohošť. he summer development of phytoplankton as only slight and subsequently the abundance values were low until the end of the vegetation period. The highest average annual abundance value of 1388 cells.ml^{-1} was recorded on the sampling site No. 311 in the lower part of the reservoir. Compared to the previous year, the annual average phytoplankton abundance increased more significantly only at the locality in the river branch system at Dobrohošť

(No. 3376), other values of the annual average were similar as in 2018 or slightly decreased. The phytoplankton consisted mainly of small cyclic diatoms, pennate diatoms and cellular green algae, even in the right-side seepage channel the largest portion had the cyclic diatoms in the evaluated year, slightly lower was the portion of yellow-brown and cellular green algae. The share of pennate diatoms, that dominated this locality in 2018 decreased significantly. The percentage representation of the basic groups of phytoplankton (Cyanophyta, Chromophyta, Chlorophyta and Euglenophyta) in the evaluated year corresponded to the level of high status (or maximum potential) at seven sites. In the lower part of the reservoir, the representation of cyanobacteria corresponded to a good potential, and in the upper part of the reservoir and in the Mosoni Danube at Čunovo the values were at the level of moderate potential. On the sampling sites in the reservoir, the cyanobacteria were represented also by species forming a water flower, but they had only a low abundance.

In terms of species diversity, the dominant part of phytobenthos in the evaluated year was formed by diatoms. The calculation of IPS and SID diatomic indices was performed in OMNIDIA 6.0 software. Based on the results in 2019, it can be stated that according the average value of IPS index, which characterizes the overall pollution of surface waters, the water quality in the Danube at Bratislava on the left side was worse than on the right side and corresponded to the III. class, so moderate quality. On other localities, the water quality according the average values of IPS was good, so II. class. The least polluted water as in the river branch system. Compared to the previous year, a slight deterioration of the average value of IPS was documented on three sampling sites (in the Danube at Bratislava, at Medveďov and in the Mosoni Danube at Čunovo). Similarly, also in the case of the average values of the SID index, the left-side of the Danube at Bratislava was of lower quality than the right-side. The values on the left-side corresponded to the range for β-mesosaprobity to α-mesosaprobity (II. to III. quality classes). On other localities, the saprobity according to the average value of SID corresponded to β-mesosaprobity, what represents II. quality class and thus good water quality. The average values of SID were comparable with values in 2018. A slight deterioration occurred only in the Danube at Bratislava on the left-side and a slight improvement in the river branch system at Dobrohošť.

In macrozoobenthos, in the sections with more flowing water with gravelly or rocky bottom rheophilic and oxybionic species prevail, indicating β-mesosaprobity. In sections with slow flowing water, stagnophilic and oligooxybionic species increase, which tolerate a slight pollution. In these sections, the bottom is sandy to muddy. The saprobic index of macrozoobenthos in 2019, reached the level of β-mesosaprobity to α-mesosaprobity, while the α-mesosaprobity was found in the upper part of the reservoir, where also the average value of saprobic index corresponded to this level. This level of saprobity already represents a water with more significant pollution. The average values of the saprobic index of macrozoobenthos on other localities were at the level of β-mesosaprobity. By comparing the average values at particular sampling sites with the values from the previous year, it can be stated that the values were mostly similar, improvement occurred on two sites (in the Danube at Bratislava and in the Danube old riverbed at Dobrohošť), and they can not be compared in the reservoir due to missing measurements in 2018.

Monitoring and evaluation of biological indicators on the Hungarian side has been carried out since 2007 according to the Water Framework Directive (WFD) within the ecological status of surface waters according to the gradually evolving national methodology. According to the results of individual biological quality elements, it can be stated that in 2019, according to phytoplankton, high status (I. quality class) was achieved on sites in the Danube at Medveďov, in the Danube old riverbed at Rajka and in the Mosoni Danube at Rajka, good status (II. quality class) was found in the Mosoni Danube at Mecsér and an average status (III. quality class) in the seepage channel at Rajka. According to the phytobenthos, high status (I. quality class) was achieved in the Danube old riverbed at Rajka, in the right-side seepage channel at Rajka and in the Mosoni Danube at Mecsér. Good status (II. quality class) was found in the Danube at Medveďov and in the Mosoni Danube at Rajka. In the case of macrozoobenthos, apart from the moderate status (III. quality class) in the Danube at Medveďov and in the Mosoni Danube at Rajka, good status (II. quality class) was achieved on the three other localities observed in 2019. Concerning the overall ecological status, when besides the biological quality elements, supporting elements (physico-chemical quality elements and other specific substances) are also included into the evaluation, good ecological status (II. quality class) was determined on two sampling sites observed in 2019 (in the Danube old riverbed at Rajka and in the Mosoni Danube at Mecsér) and moderate ecological status (III. quality class) on three localities (in the Danube at Medveďov, in the Mosoni Danube at Rajka and in the right-side seepage channel at Rajka). Similarly, the moderate overall ecological status was determined at other localities monitored in 2019, except the sampling site in the Danube old riverbed at Dunaremete, where the achieved overall ecological status corresponded to poor status (IV. quality class).

Biological indicators in 2019 on jointly monitored sampling sites were evaluated also in the frame of Transboundary Water Commission. Based on biological quality elements the Slovak Party determined a maximal ecological potential (I. quality class) in the Danube old riverbed at Rajka and in the Mosoni Danube at Rajka, a good ecological status or potential (II. quality class), in Danube at Bratislava and in the right-side seepage canal at Čunovo. According to the Slovak results, the moderate ecological potential (III. quality class) was achieved only in the Danube at Medveďov. The overall ecological status/potential, when supporting elements are also included into the assessment, corresponded to the good ecological status/potential, except the sampling site in the Danube at Medveďov, where the overall ecological potential was moderate (III. quality class). On the Hungarian side, based on the evaluation of the biological quality elements, and also after taking into account the supporting elements, a good overall ecological status (II. quality class) was achieved in the Danube old riverbed at Rajka and on the other jointly observed localities the Hungarian Party determined a moderate ecological status (III. quality class). When harmonizing the results of the Slovak and Hungarian Parties, there were one class differences in the overall assessment on two localities (in the Mosoni Danube and in the right-side seepage channel at Čunovo/Rajka). The reason were mainly the differences in the methodology of the ecological status/potential assessment. The differences in assessment arose from the fact, that the Slovak Party observed and evaluated only one biological quality element on these localities, and the Hungarian Party all relevant elements.

The sediment quality in 2019 for the purposes of the Agreement was assessed according to the Canadian standard „Canadian Sediment Quality Guidelines for the Protection of Aquatic Life”. In none of the cases in the evaluated year, a concentration exceeding the limit of probable adverse effect (PEL) occurred. On the Slovak territory, the inorganic micro-pollution of sediments was slightly higher than in 2018 and the organic micro-pollution decreased slightly. All contents of the evaluated indicators of inorganic and organic micro-pollution from the range >TEL and <PEL were closer to the lower limit. On the Hungarian territory, most concentrations of observed organic substances corresponded to an uncontaminated environment. From the inorganic pollution, such low contents have been documented in the case of copper, arsenic and lead. The contents of other observed heavy metals on some sites slightly exceeded the threshold limit and the values corresponded to a slightly polluted environment. Only in the case of mercury did they approach the upper limit of the range (PEL) on three sampling sites (in the Szigeti river arm, in the Ásványi river arm and in the Danube old riverbed upstream of the bottom weir at Dunakiliti). The PEL limit represents a level when the adverse effects on biological life associated with the aquatic environment may occur frequently. The most polluted sediment on the Slovak side was the sediment from sampling site No. 311 in the lower part of the reservoir. On the Hungarian territory, the highest concentrations of inorganic pollution were found on the

sampling site No. 1126 in the Ásványi river arm and the highest concentrations of organic substances from the PAH group were recorded on the sampling site No. 0042 in the Danube old riverbed downstream of the bottom weir at Dunakiliti.

PART 3

Groundwater Levels

In 2019, the monitoring of groundwater levels continued according to the optimized monitoring programme approved in November 2017. The modified monitoring network consists of 186 observation wells (98 on the Slovak territory and 88 on the Hungarian territory). The list of observation wells is given in the respective National Annual Reports on environmental monitoring and the situation of observation networks on both sides of the Danube is shown in **Fig. 3-1**. The groundwater level data were used for evaluation of impacts of technical measures and discharges into the Danube and the Mosoni branch of the Danube and impact of water supply on the groundwater regime. The evaluation in the local scale was done by the Parties separately and is given in their National Annual Reports. In this Joint Report, a regional evaluation was jointly elaborated according to computed groundwater level equipotential lines. In accordance with the optimization, it is possible to use additional data from other monitored objects for the creation of maps of equipotential and difference lines. If such data were used, they were provided to the other Party in the National Annual Report. The equipotential lines were constructed in order to compare groundwater levels in the influenced area in the current year and in the period before construction of submerged weir and introducing the water supply into the river branches on the Hungarian side.

3.1. Joint evaluation of groundwater regime

Groundwater levels in the observed area (Žitný ostrov and the Szigetköz area) are primarily influenced by surface water levels in the Danube and in the reservoir. Besides this, the groundwater level in the inundation area is strongly influenced by the drainage effect of the Danube old riverbed. This impact, which adversely influences groundwater levels in the inundation area, is being mitigated by water supply into the river branch system on both sides of the Danube. Regarding the flow rates in the Danube, the year 2019 was one of the average years, but the flow rate regime was again not typical. As in the previous year, there were no significant flow or flood waves of longer duration that would cause a significant rise and fluctuation of groundwater levels. The groundwater levels were the most significantly affected by the May flow waves, when the flow rate twice exceeded 5000 $m^3.s^{-1}$ during a week. Larger flow waves, which exceeded 3000 $m^3.s^{-1}$ during the culmination, occurred also in January, March, June and at the end of July. However, the duration of these waves was short and, with the exception of the flow wave at the turn of May and June, they affected groundwater levels only in the close surroundings of the Danube. Changes in groundwater levels in the inundation, but also in the adjacent inland area of the Žitný ostrov and Szigetköz, were related to increased discharges into the Danube old riverbed and to the implementation of artificial floods in the right- and left-side river branch systems. The flooding of the right-side river branch system was realized in the first half of May. The artificial flooding of the left-side river branch system began in the second half of May and took place during the passage of the highest flow wave on the Danube, which had a synergistic effect on the groundwater level, which was in addition enhanced also by above-average precipitations. In most objects, the highest groundwater levels were recorded during discharging increased flow rates into the Danube old riverbed and during implementation of artificial floods. In the Szigetköz area it was in the middle of May, in the Žitný ostrov area it was at the end of May, or in the first half of June. The highest levels around the reservoir, despite the long lasting low flow-rates on the Danube, occurred during September and October. The minimal levels occurred in some objects during February and early March, but in objects under the direct influence of the Danube it was mainly at the end of October, during low flow rates on the Danube. Groundwater levels in the upper part of the inundation increased mostly by 0.8 to 1.3 m, but in objects near the Danube the increase reached 1.5 to 2.1 m. In the area of the central Szigetköz and the middle and lower part of the inundation area on the Slovak territory, the course of the groundwater levels was similar. The rise of groundwater levels reached 0.5 to 2.4 m. In the vicinity of the confluence of the Danube old riverbed and the tail-race channel, the rise in levels was even more pronounced and reached 3.0 to 4.8 m. In contrast to the upper part of the inundation, the minimal groundwater level in objects near the Danube occurred at the end of the year. The highest groundwater levels were recorded during the passage of the flow waves in the second half of May, with maximum levels occurring in late may or early June. In the area below the confluence of the Danube old riverbed and the tail-race channel, the minimal levels were linked to low flow rates on the Danube at the end of the year. Groundwater levels in this period decreased below the levels recorded at the beginning of the year. Close to the Danube, the rise of groundwater levels reached up to 4.6 m, but with increasing distance from the Danube it rapidly decreased to values around 1.0 m. The situation was different in the area of the reservoir, where maximal levels, despite the low flow rates in the Danube, occurred from September to November. The lowest groundwater levels occurred at most of observation objects in February or in the first half of March. The amplitude of groundwater level fluctuation in this area reached 0.26 to 0.76 m, at a greater distance from the Danube only up to 0.5 m.

As in the previous years, a comparison of changes in groundwater levels for three hydrological situations in the period prior to the introduction of water supply (1993) and in the evaluated year (2019) was performed. The selected hydrologic situations characterise the low, average and high flow rate conditions in the Danube, corresponding to flow rates approximately 1000, 2000 and 3000 m^3s^{-1}.

Due to the course of flow rates in the Danube, the low flow rates period was chosen only at the beginning of December, when on October 9, 2019 the flow rates decreased to 1000 m^3s^{-1}. The hydrological situation can be considered similar to the situation that preceded the selected date in 1993. The date for the average flow rate conditions was chosen at the end of the first decade of May, on May 9, 2019, similarly to the year 1993. Hydrological situations as well as climatic conditions in 1993 and 2019 can be considered comparable. The most unfavourable situation in terms of comparability of flow rates and previous hydrological situations was in the case of high flow rates. For the high flow rate conditions in 2019 it was possible to choose a date only after the passage of higher flow waves in the first half of June. The hydrological situation could by considered comparable to the hydrological situation in 1993.

The selected dates and the corresponding flow rates in the Danube at Bratislava-Devín gauging station are the following (**Table 3-1, Fig. 3-2, Fig. 3-3a, b**):

Table 3-1: Selected dates and the corresponding flow rates in the Danube at Bratislava-Devín gauging station

hydrologic situation	before the water supply 1993		after the water supply 2018	
	date	Q ($m^3.s^{-1}$)	date	Q ($m^3.s^{-1}$)
low flow rate	09.03.1993	976	09.12.2019	995
average flow rate	09.05.1993	1937	09.05.2019	2072
high flow rate	25.07.1993	2993	10.06.2019	3136

Jointly constructed maps of equipotential lines for selected dates, using measured groundwater levels, are shown in **Figs. 3-4 to 3-6**. In wells where the water level is measured once a week, the groundwater level for the selected dates was calculated by linear interpolation. In all other wells the average daily values were used. Altitudes of the groundwater levels are given on maps for each observation object that was used for calculating of equipotential lines. Additional groundwater level data were also used to calculate equipotential lines on the Slovak territory,. In the case of surface water, only the computed surface water level data in the Danube were used, other surface waters were not used for the calculation of equipotential lines. The equipotential lines represent general groundwater levels and flow direction, and do not show the local influences of channels or river branch systems. Differences between groundwater levels for the selected hydrologic situations in years 1993 and 201 are shown in **Figs. 3-7 to 3-9**.

The evaluation is focused mainly on the area influenced by technical measures and discharges according to the intergovernmental Agreement and by the water supply realised on the Hungarian side. In this sense, the influenced area is represented by the inundation and the flood-protected area on the Hungarian side, and partly by the inundation area on the Slovak side.

Low flow rate conditions

On the map of groundwater level equipotential lines for low flow rates conditions (**Fig. 3-4**) it can be seen that the groundwater flow direction in the upper part of the river up to the line Dunakiliti - Šamorín shows infiltration from the river and from the reservoir into the surrounding area. Just downstream of Bratislava, the groundwater on the left side of the Danube flows to the east and gradually turns to the east-southeast direction. On the right side of the Danube, it flows south to south-southeast and when it enters the Hungarian territory it turns to southeast, maintaining this general direction through the entire Szigetköz area. In the inundation area along the Danube old riverbed from Dunakiliti to the confluence with the tail-race channel, the groundwater flow direction turns towards the Danube old riverbed and the groundwater is drained by the river. In the case of low levels, the groundwater is drained by the Danube even downstream the confluence of the Danube old riverbed and the tail-race channel.

Changes in groundwater levels between 1993 and 2019 for low flow rate conditions are shown on a map of groundwater level differences (**Fig. 3-7**). On the major part of the Žitný ostrov and Szigetköz the green and blue colours prevail, which indicates insignificant changes or a slight rise in groundwater levels. The increase of groundwater levels in the Bratislava area and the upper part of the reservoir is related to the water level impoundment in the Danube at low flow rates. The increase of groundwater levels in the central part of Szigetköz, including the floodplain, is related to the implementation of water supply under the Agreement. A slight rise in groundwater levels can also be seen in the area at Ásványráró, which is the result of the completion of the technical measures in the lower part of the Hungarian inundation area, which was previously characterized by a decrease. The completion of the Hungarian water supply system partially mitigates the ground water level decrease also on the Slovak territory upstream the confluence of the Danube old riverbed and the tail-race channel. The decrease in groundwater levels in the lower part of the reservoir is caused by a decrease in permeability of the reservoir bottom as compared with the situation just after its filling in 1993. Observation results in recent years show that the decline of groundwater levels has almost stopped and the area with groundwater level decrease does not change significantly. The decrease in groundwater level on the right-side of the Danube is manifested mainly in the part of the originally planned reservoir and extends maximally up to Dunakiliti. The decline in groundwater levels along the river Váh is related to lower surface water level in the river Váh in the compared period.

The change of groundwater levels in the area influenced by technical measures and discharges according to the Agreement in 2019 is still defined by a range between -0.7 and

+0.7 m in comparison to groundwater levels in 1993. The decrease of groundwater levels around the lower part of the reservoir in 2019, reflecting the decrease in the permeability of the reservoir bottom was -0.2 to -0.7 m, on the left side below Šamorín up to -2.0 m. The completion of the water supply system in the lower part of the Hungarian river branch system helped to restore the groundwater levels in the river branch system at Ásványráró and in the Bagoméri river arm system to their previous height. However, at the end of 2019, the low flow rates in the Danube were more pronounced in the Bagoméri river arm system, what can be seen in the slight decline in groundwater levels. The decrease of the groundwater level along the tail-race canal and around its confluence with the Danube old riverbed in the Slovak territory reaches maximally up to -1.2 m. The increase of groundwater levels, which was caused by the water supply, in the central part of the Slovak and Hungarian inundation area reaches +0.25 to +0.7 m.

<u>Average flow rate conditions</u>

The groundwater flow direction under the average flow rate conditions (**Fig.3-5**) is very similar to the flow direction in the case of low flow rate conditions. Along the upper part of the Danube up to Dunakiliti it shows infiltration from the river and the reservoir into the surrounding area. The groundwater in the upper part of the Žitný ostrov flows to east, in the vicinity of the lower part of the reservoir near Šamorín it gradually turns to the east-southeast. This direction is maintained by the groundwater also in the central part of the Žitný ostrov and in the lower part it again turns eastward and flows parallel to the Danube. The groundwater on the right side of the Danube flows mainly to the south-southeast, in the vicinity of the upper part of the reservoir it sometimes turns to the south. Also when entering the Hungarian territory, the groundwater flow direction predominantly has the south or southeast direction, which remain preserved throughout the whole Szigetköz area outside the inundation. Along the inundation area from Dunakiliti to Dunaremete, the groundwater flows in the southeast direction, but near the old Danube it turns into the riverbed and the river drains the adjacent area. However, within the inundation on both sides of the Danube, the groundwater flow also shows an infiltration from the river branch system. In the lower part of inundation the groundwater flow prevailingly has southeast direction, parallel to the flow of the Danube.

The map of the groundwater level differences for the average flow rate conditions in the Danube (**Fig. 3-8**), The Žitný ostrov area is dominated by a green colour, which represents insignificant changes. On the right side of the Danube in the area of the upper and central Szigetköz, a significant increase of groundwater levels can be observed, compared to 1993. This increase is related to the implemented water supply according to the Agreement and completely eliminates the decrease around the lower part of the reservoir on the Hungarian territory. The water supply into the Mosoni Danube and into the inundation is reflected in increases of groundwater level mainly in the middle and partially in the lower part of the Szigetköz area, including the inundation area from Dunakiliti to Bagoméri river arm system. The decrease of groundwater levels around the reservoir is caused by a decreased in the permeability of the reservoir bottom. The size of the area with a decrease in groundwater levels does not change substantially. Unlike the previous year, it does not affect the Hungarian territory. Even in the case of average flow rate conditions, it can be stated that in recent years the decline in groundwater levels has almost stopped. The increase of groundwater levels in the inundation area, especially in its central part, reaches up to +1.7 m, in the area of Kisbodak up to the +2,2 m. Thanks to the completion of the water supply system in the lower Szigetköz, the decrease of the groundwater level in this area has practically disappeared. A slight decrease can be observed only on the Slovak territory downstream of the Gabčíkovo Power Plant. Compared to the low flow rate conditions, the decrease is smaller, which reflects the greater vulnerability of this area at low flow rates. A slight decrease can also be seen in the lower part of the Žitný ostrov area near the

Little Danube and along the river Váh, which results from different surface water levels in rivers in the compared periods.

High flow rate conditions

The groundwater flow direction for high flow rate conditions (**Fig. 3-6**) are almost identical to the flow directions in the case of average flow rate conditions. Also in this case the flow directions along the upper part of the Danube show the infiltration of water from the river and from the reservoir into the surroundings. In the area of the upper and central Žitný ostrov, the direction of groundwater flow to east and east-southeast prevails. In the lower part, it turns east again, but in contrast to the average state, the water from the river infiltrates into the surrounding area. Also in the case of groundwater flow on the right side of the Danube, the south-southeast direction remained mainly preserved. In the vicinity of the upper part of the reservoir and in the area of the Bagoméri river arm system in the lower part of Szigetköz, the groundwater flow direction in some places turns to the south. Along the floodplain from Dunakiliti to Dunaremete, the groundwater flows in a south-east direction, but due to the significant drainage effect in the vicinity of the old Danube, it turns towards the riverbed. As in the case of the average flow rate condition, the groundwater flow in the inundation also shows the infiltration from the river branch system.

The groundwater level differences map for high flow rate conditions (**Fig. 3-9**), there are three areas when comparing levels between 2019 and 1993. The area with a decrease in the groundwater level is located in the upper part of the Žitný ostrov in the vicinity of the reservoir and partially extends into the Hungarian territory, where it spreads approximately to Rajka and Dunakiliti municipalities. The decline in groundwater levels in this area is related to the gradual reduction of the permeability of the reservoir bottom and in its lower part it is magnified by the drainage effect of the Danube old riverbed. The interaction of these factors is most pronounced below Šamorín, where the decrease of the groundwater level exceeds -2.5 m, compared to the state in 1993. On the Hungarian side, the largest decrease can be observed in the area of the originally planned reservoir, when it can reach up to -0.7 m. At greater distance from the reservoir the decline decreases and at Rajka and Dunakiliti it reaches -0.25 m. The second area are the part of the Szigetköz and of the central Žitný ostrov, where the changes in groundwater level are insignificant and are expressed by the green colour. On the Hungarian side, this concerns the area, which stretches from the border with Slovakia to the Bagoméri river arm system and is roughly bounded by a line between the town of Mosonmagyaróvár and the municipalities of Ásványráró and Vámosszabadi in the lower part of the Szigetköz. The third effect is the increase of groundwater levels, which can be seen on the outer side of the Szigetköz, as well as on the greater part of the lower Žitný ostrov area. The increase of groundwater levels in these areas mostly does not exceeds +0.25 to +0.7 m. The increased groundwater levels in these areas are probably related to the above-average precipitations, that fell during May, as well as to higher surface water levels in the channel system in both areas.

3.2. Conclusions

Based on the results obtained by the groundwater level observations, it can be stated that the water supply into the right-side river branch system and into the Mosoni Danube plays an important role in influencing groundwater levels in the entire Szigetköz area. Measures implemented under the intergovernmental Agreement, as well as measures realized in the right-side inundation, caused a significant rise in groundwater levels in the upper, middle and, after completion the water supply system, also in the lower part of the Szigetköz. In the case of conditions of low and especially average flow rates in the Danube, it is possible to se a significant increase of groundwater levels in the upper and middle part of the inundation. The groundwater level increase in the upper part of the Szigetköz area and around the reservoir is reduced due to the decrease of the permeability of the reservoir bottom. In the period 2009-2013, a huge amount of sediments was transported into the reservoir, what intensified the colmatation of the reservoir bottom. However, observations in recent years show that the decline of groundwater levels has significantly slowed down or even stopped, and the area with groundwater level decrease has not changed significantly. The decline around the lower part of the reservoir and in the upper part of Szigetköz is magnified by the drainage effect of the Danube old riverbed. Since 2015, the most significant change in relation to the groundwater level has been the completion of the water supply system in the lower part of the Hungarian inundation area. Since completion the water supply system, in the case of low, average, and even high flow rate conditions, a significant increase in ground water levels can be seen in the lower part of inundation area, which had previously been characterized by a decrease. The completion of the Hungarian water supply system partially mitigates the ground water level decrease also on the Slovak territory upstream the confluence of the Danube old riverbed and the tail-race channel. The decrease in groundwater levels on the Slovak territory can still be observed especially in the vicinity of the tail-race channel and below its confluence with the Danube old riverbed, which is most pronounced at low flow rates. The groundwater level in this area is adversely affected by the erosion of the riverbed.

The monitoring results in the period after the completion of the water supply system on Hungarian territory show that appropriate technical interventions in the river branch system and the application of an effective water supply can significantly affect the groundwater levels in the floodplain area. The discharge of increased flow rates into the Danube old riverbed during flood and flow waves has a significant effect on groundwater levels in the inundation. From the vegetation point of view, the annual implementation of artificial floods is also important, as far as possible, by which it is possible achieve greater dynamics in fluctuation of groundwater levels. On the other side, the monitoring results point to the fact that it is necessary to solve the water supply in the lower part of the inundation area on the Slovak territory, particularly in the case of low and average flow rate conditions. The positive impact of water supply can be further efficiently supported by measures implemented in the Danube old riverbed (raising the water level with bottom weirs), which would ensure an increase of groundwater levels in the strip along the Danube old riverbed on both sides. By measures in the Danube old riverbed the overall situation in the entire inundation area on the Slovak and Hungarian territory could be improved.

PART 4

Groundwater Quality

The groundwater quality on the Slovak and Hungarian territories is assessed separately. The list of objects included in the joint monitoring is given in **Table 4-1** and **4-2**, and their position is shown in **Fig. 4-1**. For evaluation in the Joint Report representative objects for groundwater quality observation were selected on both sides. A detailed evaluation of groundwater quality for each object included in the joint monitoring was done in the Slovak and Hungarian National Annual Reports on environmental monitoring in 2019. The national reports include the monitoring data for the year 2019 in tabular form and the long-term graphical development of observed quality indicators for the period 1992-2019. The data from monitored objects are interpreted in relation to limits for groundwater quality assessment agreed within the intergovernmental Agreement from 1995. The limits are listed in **Table 4-3**.

4.1. Evaluation of groundwater quality on the Slovak territory

The groundwater quality on the Slovak territory is monitored at 11 objects (6 water supply sources and 5 observation objects). Their list is given in **Table 4-1**. For the purposes of the Slovak-Hungarian monitoring, data from the Western Slovakia Water Company (ZsVS), the Bratislava Water Company (BVS), the Slovak Hydrometeorological Institute (SHMÚ) and the Ground Water Consulting Ltd. (GWC) were used. The assessment in the Joint Report is focused mainly on groundwater quality in water supply sources, which are more representative because of their continuous pumping. From among the assessed objects the water supply source No. 102 at Rusovce is situated on the right side of the Danube and the others are situated on the left side of the Danube: the water supply source N. 119 at Kalinkovo, No. 105 at Šamorín, No. 353 at Gabčíkovo, No. 467 at Vojka and No. 485 at Bodíky. The latter two are located between the Danube old riverbed and the derivation channel. The groundwater quality in the water supply sources is stable for a long time.

Table 4-1: List of monitoring objects on the Slovak territory

No.	ID	Name	Location
1	**102**	Rusovce	Rusovce, water supply source, right side of the reservoir
2	**119**	S-10	Kalinkovo, water supply source, left side of the reservoir
3	**105**	S-2	Šamorín, water supply source, left side of the reservoir
4	**467**	HV-1	Vojka, water supply source
5	**485**	HB-2	Bodíky, water supply source
6	**353**	HAŠ-4	Gabčíkovo, water supply source
7	**872**	603091	Čunovo, right side of the reservoir
8	**329**	726591	Šamorín, left side of the reservoir
9	**262**	736591	Sap
10	**87**	PZ-13/7	Kalinkovo, left side of the reservoir
11	**3**	PZ-1/3	Kalinkovo, left side of the reservoir

Right side of the Danube

The water supply source at Rusovce – No. 102

The water supply source No. 102 at Rusovce is a local water supply source, that is situated in the wider vicinity of the upper part of the Hrušov reservoir and represents the groundwater quality on the right side of the Danube. The groundwater chemistry of the water source indicates stable conditions of water quality formation. The water temperature fluctuates slightly and sometimes exceeds the agreed limit (such a case did not occurred in the evaluated year). The electric conductivity reaches the highest values from among the observed water sources, with a decreasing tendency in the last three years (from 56,4 $mS.m^{-1}$ in October 2015 to 48,9 mSm^{-1} in December 2019). The highest are also the concentrations of hydrogen carbonates, chlorides, calcium and magnesium. Since 2014, the hydrogen carbonates fluctuate in a wider range (from 241.0 $mg.l^{-1}$ to 348.4 $mg.l^{-1}$) with a maximum in 2015, while in the previous period they did not exceeded 300 $mg.l^{-1}$. In the evaluated year, the highest content of hydrogen carbonates was 289.8 $mg.l^{-1}$. For the last ten years, the concentrations of chlorides vary mostly in the range from 20 to 30 $mg.l^{-1}$, the concentrations of calcium in the range from 65 to 85 $mg.l^{-1}$ and magnesium in the range from 15 to 25 $mg.l^{-1}$. In the evaluated year, the contents of basic cations and anions were balanced, fluctuating in even more narrower ranges than in 2018, with a slight indication of a decrease in values in the case of chlorides and sulphates. The nitrate concentrations, after the increase of the limit of determination in 2011 to 5.0 $mg.l^{-1}$, mostly vary below this level. The oxygen content shows seasonal variation and was higher than in 2018, the values fluctuated in a wider range, from 3.0 to 9.0 $mg.l^{-1}$, while in the year 2018 it was from 2.8 to 3.8 $mg.l^{-1}$. The organic pollution, the contents of manganese, iron, ammonium ions and phosphates are low, and for a long time meet the limits according to the **Table 4-3**. On the water source No. 102 at Rusovce in 2019, no exceedances of limit values of the observed indicators were found.

Left side of the Danube

Water supply sources at Kalinkovo No. – 119

The water supply source No. 119 at Kalinkovo lies near the upper part of the reservoir, just behind the flood-protection dyke. The groundwater quality in this object was, and is mainly influenced by the change of infiltration areas and by the technical measures in the Hrušov reservoir. The specific conductivity is relatively balanced, in the period from 2011 to 2019 it fluctuates in a narrow range (43,6-50,2 mSm^{-1}). The time series of calcium contents (varying mostly between 60 to 70 $mg.l^{-1}$) and chloride concentrations (oscillating around 19 $mg.l^{-1}$) are also balanced. The contents of other observed cations and anions are more fluctuating, in the case of magnesium and sulphates with a slight sign of a decrease. The water temperature occasionally exceeds the recommended value of 12 °C. The oxygen conditions are good on this object. In the assessed year, the dissolved oxygen contents fluctuated in a wider range (1,3 to 9,1 $mg.l^{-1}$) than in 2018 (3,9 to 7,6 $mg.l^{-1}$). The nitrates concentrations decreased below the limit of quantification (5 $mg.l^{-1}$). The organic pollution, phosphates and iron contents have been low for a long time. The concentrations of ammonium ions are around 0.1 mg.l-1, with occasionally higher values, but in the long term they meet the agreed limit for this indicator (0,5 $mg.l^{-1}$). In the time series of manganese contents, a gradual increase in the values can be observed, which since 2014 exceeded the limit value in each determination. In the evaluated year they ranged from 0.12 to 0.16 $mg.l^{-1}$. By comparing the measured values of the observed parameters with the agreed limits, it can be stated that apart from manganese, no other exceedances of limit values were detected. Low content of nitrates and increasing manganese content indicate reducing conditions.

Water supply source at Šamorín –No. 105

The water supply source No. 105 at Šamorín is located at the lower part of the Hrušov reservoir. The groundwater quality is similar to the water quality in the object No. 119 at Kalinkovo. The contents of basic cations and anions, the values of water temperature and electric conductivity are similar. The conductivity values, contents of calcium, chlorides and sulphates have been balanced for a long time, in the assessed year a slight decrease in chlorides is visible. Concentrations of magnesium and hydrogen carbonates fluctuate, but their content did not changed significantly in the evaluated year. The water temperature occasionally exceeds the limit value of 12 °C, twice in the evaluated year (in August 17.6 °C and in September 12.2 °C). From the nutrients, the concentrations of nitrates are similar as in the object No. 119, but the time series are less fluctuating. The values of ammonium ions, unlike the Kalinkovo, have long been below the limit of determination (0.03 $mg.l^{-1}$). The iron and manganese contents, which oscillate around the limit of determination of 0.007 $mg.l^{-1}$, are also low. In the assessed year, a higher concentration of iron occurred in August (0.23 $mg.l^{-1}$), which exceeded also the limit value for this indicator (0.2 $mg.l^{-1}$). The organic pollution is low, since 2016 the values have been at the level of the determination limit (0.5 $mg.l^{-1}$). The concentrations of dissolved oxygen increased slightly over the last four years to 3.5 - 8.5 $mg.l^{-1}$, and are slightly higher than at the Kalinkovo water source, although the maximum recorded in the year 2019 was lower (at Kalinkovo it was 9.1 $mg.^{l-1}$). In the assessed year in the water source No. 105 at Šamorín, exceedances of limit values occurred in the case of two parameters: twice in the case of water temperature and once in the case of iron. The development of chemistry on this object points to stable conditions for the creation of groundwater quality.

Water supply source at Gabčíkovo –No. 353

The water supply source No. 353 at Gabčíkovo is situated on the left side of the Danube, southeast of Gabčíkovo, at a distance approximately 2 km from the tail race channel. The vicinity of the source is made up mostly of agricultural land. The groundwater quality in the water supply source Gabčíkovo differs from the groundwater quality in the water supply sources at Kalinkovo and Šamorín because of the different groundwater flow direction. The values of several quality indicators are relatively balanced in this object: the water temperature, pH, the concentrations of calcium, sodium, chlorides, sulphates hydrogencarbonates and also conductivity values fluctuate only in a narrow ranges. The conductivity is the lowest of all monitored water sources. (in he evaluated year it fluctuated from 44.2 to 45.2 mSm^{-1}). The lower conductivity value is also associated with lower contents of basic cations and anions. The concentrations of sodium (about 5 $mg.l^{-1}$), potassium (about 1 $mg.l^{-1}$) and chlorides (about 10 $mg.l^{-1}$) are among the lowest of all other monitored objects. The sodium and potassium concentrations reach only half of the values recorded in the water supply sources at Šamorín or Kalinkovo. The contents of hydrogencarbonates are also low, that oscillate around 216 $mg.l^{-1}$. The contents of nitrates are relatively balanced, mostly fluctuate around 3.5 $mg.l^{-1}$ (in the year 2019 in the range from 3.4 to 3.8 $mg.l^{-1}$). The dissolved oxygen concentrations are one of the lowest, in the assessed year they ranged from 0.19 to 0.43 $mg.l^{-1}$. The contents of ammonium ions, phosphates, iron and manganese, and also the COD_{Mn} values have been low in long-term, and mostly oscillate around the level of determination of the analytical methods used. By comparing the measured contents of observed parameters in 2019 with the agreed limit values for groundwater quality assessment (**Table 4-3**), it can be stated that on the object No. 353 at Gabčíkovo no exceedances occurred.

Water supply sources at Vojka – No. 467

The water supply source No. 467 at Vojka is a typical local water source, which is situated in the area between the Danube old riverbed and the derivation channel. The groundwater quality may be affected by local conditions. From the long term point of view, the groundwater in the water supply source at Vojka (No. 467) has a satisfactory quality for drinking purposes. The water temperature sometimes exceeds the recommended value of 12 °C. No such temperature occurred in the evaluated year. The conductivity values fluctuate in a relatively narrow range (in the period from 2011 to 2019 from 44.5 to 49.2 mSm^{-1}). The time series of cations and anions are relatively balanced and also fluctuate in a narrow ranges. In the assessed year, however, in the case of potassium increased concentrations from 2.8 to 3.2 $mg.l^{-1}$, which represents the highest values in this water source since the beginning of monitoring. The content of nitrates decreased slightly, it fluctuated from 2.4 to 2.8 $mg.l^{-1}$, while in 2018 it was in the range from 2.7 to 3.2 $mg.l^{-1}$. The dissolved oxygen content is low (in the year 2019 fluctuated from 0.24 $mg.l^{-1}$ to 0.54 $mg.l^{-1}$), but it does not belong to the lowest among the observed water sources, lower contents are at water sources at Gabčíkovo and Bodíky. The concentrations of ammonium ions, phosphates, organic pollution, manganese and iron in Vojka have been low for a long time and are often below the limits of determination. In 2019, on the water supply source No. 467 at Vojka, no exceedances of limit values occurred. On this water supply source there are favourable conditions for the creation of groundwater quality.

Water supply sources at Bodíky – No. 485

Similarly to the water supply source at Vojka, the water supply source No. 485 at Bodíky is a typical local water source, which is situated close to the sealed derivation channel and its water quality is influenced by local conditions. In this object, slight reduction conditions are documented. From among the monitored water supply sources, this object is characterized by the lowest contents of dissolved oxygen, nitrates and sulphates, and conversely the highest values of water temperature, ammonium ions and especially manganese. The water temperature in this object has been above the limit value in long term, in 2019 at ach sampling with a maximum of 14.1 °C. The concentrations of manganese exceed the agreed limit value at each determination. In the assessed year they varied in the range from 0.38 to 0.67 $mg.l^{-1}$, which meant a slight decrease compared to the values from the previous year (0.27 to 0.82 $mg.l^{-1}$). Concentrations of ammonium ions ranged up to 0.27 $mg.l^{-1}$, which was below the limit for this parameter (0.50 $mg.l^{-1}$), similarly to the previous period of monitoring. In the case of iron, a higher concentration rarely occurs at Bodíky, and most of the values are below the limit of determination (0.04 $mg.l^{-1}$), in the evaluated year the maximum was 0.07 $mg.l^{-1}$. Similarly to the water source at Vojka, several water quality indicators fluctuate in narrow ranges (conductivity, water temperature, pH, calcium, magnesium, chlorides, sulphates and hydrogencarbonates), and their time series are relatively balanced. For the last three years, however, the sodium and potassium concentrations have an increasing tendency, and conversely the magnesium and chlorides have a decreasing tendency. Both, the organic pollution and the contents of phosphates are low, the values are often below the limits of determination. The dissolved oxygen content decreased, compared to 2018, fluctuating from 0.07 to 0.31 $mg.l^{-1}$ (in 2018 it was from 0.15 to 0.82 $mg.l^{-1}$). The concentrations of nitrates have long been below the limit of determination, so they are lower than 1 $mg.l^{-1}$. In the evaluated year, in the Bodíky water supply source (No. 485), from among the observed indicators of groundwater quality, the agreed limits in the case of manganese and water temperature were not met at each determination.

4.2. Conclusions regarding the Slovak territory

The chemical composition of groundwater in water supply sources indicates stable conditions for groundwater quality formation. In the water supply source at Rusovce (No. 102), the groundwater quality has improved since damming the Danube, and the groundwater chemistry is influenced only by the changes in the chemical composition of the Danube water and the conditions of pumping. In the water supply sources at Kalinkovo (No. 119) and Šamorín

(N. 105), the groundwater quality is influenced by the infiltration of surface water from the Danube and the reservoir. The quality of groundwater in the water supply source at Gabčíkovo (No. 353) differs due to the inflow of groundwater also from the inland of Žitný ostrov. In the water supply sources at Vojka (No. 467) and Bodíky (No. 485), the groundwater quality can be significantly affected by local conditions. Concentration of observed groundwater quality indicators mostly fluctuate in narrow and similar to each other ranges. The exception is the Gabčíkovo water supply source, where the contents of sodium, potassium and chlorides are about half lower than in other water supply sources.

From the long term point of view, the quality of groundwater in the monitored water supply sources mostly meets the agreed limits for drinking water (**Table 4-3**). Exceedances of limits occur only on some objects in the case of water temperature, manganese and occasionally also in the case of iron. In the evaluated year 2019, the limit value for water temperature was twice exceeded in the Šamorín water supply source and four times at Bodíky (No. 485). The manganese content exceeded the limit value on the water supply sources at Bodíky (No. 485) and Kalinkovo (No. 119) in each determination, while at Kalinkovo the manganese contents are lower than at Bodíky. In the case of iron, there was one exceedance in the water supply source No. 108 at Šamorín. There were no other exceedances in water supply sources in 2019.

The water temperature in water supply sources at Rusovce (No. 102), Kalinkovo (No. 119) and Šamorín (No. 105) is fluctuating and sometimes exceeds the recommended limit value, in the water supply source at Gabčíkovo (No. 353) it is balanced. The highest values are characteristic for the water source at Bodíky (No. 485), where the water temperature fluctuate above the limit value in long term. The pH values on the observed water supply sources in the last ten years ranged from 7.5 to 8, and the conductivity values between 40 and 60 mSm^{-1}, while the highest conductivity is documented on the water source at Rusovce (No. 102) and the lowest at Gabčíkovo (No. 353). From among nutrients, the phosphates and ammonium ions at observed water sources have long been present in low concentrations an are currently mostly lower than the limits of determination of the analytical methods used. Only at Bodíky and Kalinkovo is the concentration of ammonium ions slightly higher, but it does not achieve the limit value agreed for this groundwater quality indicator. Except the water supply source at Bodíky, the contents of nitrates have recently ranged from 3 to 9 $mg.l^{-1}$. The highest concentrations are recorded at the water sources at Kalinkovo and Šamorín and the lowest are documented at Bodíky, where they have been lower than 1 $mg.l^{-1}$ since 2009. The values of organic pollution, characterized by COD_{Mn}, has decreased in all water sources during the observed period and in the last four years fluctuate around the level of 5 $mh.l^{-1}$. At water sources at Gabčíkovo and at Bodíky, low concentrations of dissolved oxygen are characteristic for a long time (up to about 1 $mg.l^{-1}$). In the water supply source at Vojka, a slight improvement in oxygen conditions was recorded in the years 2007 to 2017 (values varied from 0.8 to 3.6 mg.l-1), but in the last two years the dissolved oxygen content dropped below 1 $mg.l^{-1}$. On the other water sources the dissolved oxygen content fluctuates mostly in the range from 2 to 8 $mg.l^{-1}$. The long-term high manganese content is typical for the local water source at Bodíky (No. 485), where exceedances of the limit value occur in each determination. The situation has been similar since 2014 at the Kalinkovo water source (No. 119), although the manganese concentrations do not reach such high values as in the object at Bodíky.

The chemical composition of groundwater in observation objects is similar to the chemical composition of groundwater in nearby water supply sources. The groundwater quality in observation objects is in a greater extent affected by local influences, which may be reflected in a higher number of exceedances of the limit values. In the assessed year, exceedances were found for three groundwater quality indicators: for manganese and iron in one object (No. 262) and in the case of water temperature in three objects (No. 3, 87, 329). In selected observation objects

(No. 872, 329 and 262), inorganic and organic micro-pollution is also monitored. In 2019, no single exceedance of limit values for groundwater quality assessment according to **Table 4-3** was recorded. However, the measured concentrations of arsenic, chromium, mercury and zinc in some observation objects indicate a low pollution. The contents of observed indicators of organic pollution, as well as the contents of cadmium, copper and nickel in the evaluated year did not reach the level of determination limits.

4.3. Evaluation of the groundwater quality on the Hungarian territory

The groundwater quality observation continued in 2019 on the basis of the optimized program. The subject of the joint monitoring of groundwater quality on the Hungarian side consist of 22 objects, composed of 16 observation objects and 6 wells, which are used for drinking water supply (water supply sources). While the observation wells have the screens situated in the upper part of the gravel sediments, the water supply wells draw water from deeper horizons. The list of monitored objects is given in **Table 4-2**.

Table 4-2: List of monitoring objects on the Hungarian territory

No.	ID	Name.	Location
1	**3544**	9310	Rajka
2	**3546**	9327	Dunakiliti
3	**3548**	9331	Dunakiliti
4	**3549**	9368	Rajka
5	**3550**	9379	Rajka
6	**3555**	9413	Dunasziget
7	**3559**	9418	Mosonmagyaróvár
8	**3561**	9430	Kisbodak
9	**5656**	9544	Halászi
10	**3564**	9456	Ásványráró
11	**3565**	9457	Ásványráró
12	**3566**	9458	Ásványráró
13	**3569**	9475	Győrzámoly
14	**3570**	9480	Győrzámoly
15	**3571**	9484	Vámosszabadi
16	**3572**	9536	Püski
17	**3595**	DA-I	Darnózseli, water supply source
18	**3592**	25-E	Győr - Szőgye, water supply source
19	**3594**	DK-I	Dunakiliti, water supply source
20	**3596**	T-II	Mosonmagyaróvár - Feketeerdő, water supply source
21	**3593**	6E	Győr - Szőgye, water supply source
22	**3591**	K-5	Győr - Révfalu, water supply source

Data from wells that are used for drinking water supply were provided by Regional Water Companies. The groundwater quality monitoring in observation wells is performed by the Government Office of Győr-Moson-Sopron County. The frequency of monitoring on water sources was four times a year, on observation objects it was twice a year. Four observations objects (No. 9327, 9413, 9430 and 9456) were selected for the evaluation of groundwater quality on the Hungarian territory in the Joint report, which are mentioned below.

Observation object No. 9327, site: Dunakiliti

Based on long-term data, in the object No. 9327 a seasonal, periodic fluctuation of some water quality indictors is clearly observable. Periodicity appears primarily in the changes of water temperature, pH and concentrations of nitrates. The water temperature from time to time exceeds the limit value of 12 °C. The pollution by organic matter, expressed by COD_{Mn}, has been relatively balanced since 2010, and the measured values meet the agreed limit in long-term. The content of nitrates is low, permanently below the limit value. The concentrations of ammonium ions have been showing a significant increase since 2010, and since 2017 there have also been values exceeding the limit value (0.5 $mg.l^{-1}$). However, the concentration measured in the second half of the assessed year (0.09 $mg.l^{-1}$) significantly dropped below the limit value. Contents of manganese, iron and phosphates show seasonal fluctuation since 2010. In the case of manganese and iron, concentrations significantly exceeding the agreed values occur. In the case of phosphates, from 2010 an increase of concentrations can be observed, which from the year 2015 sometimes exceed also the limit value for this parameter (0.5 $mg.l^{-1}$).

Based on the results of measurement in 2019, it can be stated that the water temperature (12.7 °C), the iron contents (3.26 and 1.84 $mg.l^{-1}$), the concentrations of manganese (0.82 and 0.23 $mg.l^{-1}$), and ammonium ions (0.75 $mg.l^{-1}$) exceeded the agreed limit values for groundwater quality assessment according to **Table 4-3**.

Observation object No. 9413, site: Dunasziget

The water temperature in this object is relatively balanced, because it is only to a small extent affected by meteorological conditions. The measured values fluctuate in the area of the limit value. The conductivity, indicating a water with moderate salt content show fluctuations in the long term. Concentrations of ammonium and phosphate ions and the contamination by organic matter have been low for a long time. Since 2007, the nitrates concentrations show a significant increase with values occasionally exceeding the limit of 50 $mg.l^{-1}$. In the long-term, the calcium content quite often varies above 100 $mg.l^{-1}$, which is the limit value for this indicator. In the evaluated year, also in the case of magnesium there occurred a concentration that exceeded the limit value, similarly to 2018. This object is characteristic by high manganese concentrations, which are mostly higher than the limit value of 0.05 $mg.l^{-1}$. The measured concentrations show a large variance. In the case of iron, a value exceeding the limit of 0.2 $mg.l^{-1}$ occurs occasionally. However, no such concentration has occurred in the last five years.

Based on the data from 2019 it can be stated that from among the observed groundwater quality parameters slight exceedances were documented in the case of water temperature (12.3 °C and 12.4 °C), calcium (106 $mg.l^{-1}$), magnesium (35.5 $mg.l^{-1}$) and the limit value was significantly exceeded in the case of manganese (0.56 and 0.26 $mg.l^{-1}$). The measured values of other parameters complied with the agreed limits.

Observation object No. 9430, site: Kisbodak

The groundwater in object No. 9430 has a moderate salt content. The water temperature shows a slight seasonal fluctuation. The pH values have been balanced for a long time and fluctuate in the range of 7.0-7.5 for the last ten years. The electric conductivity has been relatively balanced since 2001, and the time series of the basic cations and anions have also been relatively balanced. The exception are sulphates, which have a declining tendency in the long-term. The organic matter content shows seasonal fluctuation and, apart from one value of 3.3 $mg.l^{-1}$ in 2015, has long been below the limit value for this indicator (3.0 $mg.l^{-1}$). Phosphates and nitrates have long been characterized by low concentrations. The ammonium ions contents have shown a slight increase since 2007, but the concentrations are below the limit value of 0.5 $mg.l^{-1}$. The groundwater pollution by iron and manganese is high in the long run. Their concentrations in this object significantly exceed the limit values. However, the evaluated year was an exception in the case of iron, as no such concentration occurred. In the time series of manganese, a decreasing tendency can be observed.

In 2019, exceedances of limit values in the object No. 9430 at Kisbodak were documented only in the case of water temperature (14.0 °C and 12.7 °C) and manganese (0,12 $mg.l^{-1}$).

Observation object No. 9456, site: Ásványráró

The groundwater has a moderate mineralization and a stable water temperature with a slight seasonal fluctuation. The pH values show fluctuations within the range of limit values (6.5-9.5). In the time series of conductivity, it was possible to observe an increasing tendency until 2015, subsequently the conductivity dropped significantly to the level of values at the beginning of monitoring and in the evaluated year reached values of 44.3 and 42.1 $mS.m^{-1}$. The decrease in conductivity is also associated with the decrease of calcium, hydrogen carbonates and sulphates concentrations. From the long-term point of view, the content of ammonium ions is high, and even after a significant decrease of concentrations in the years 2015 to 2019, they remain higher than the limit value for this indicator (0.5 $mg.l^{-1}$). The high content ammonium ions in this object is considered as background pollution from agricultural activities. Concentrations of other observed nutrients (the nitrates and phosphates) have been low in long-term. The organic matter content, expressed by COD_{Mn}, does not show significant changes and is below the limit value in long-term. Groundwater has a high content of iron and manganese, with seasonal fluctuations. Concentrations of these parameters significantly exceed the drinking water limit values.

From the observed water quality data in 2019 result that the values of water temperature (12.6 °C and 12.3 °C) , concentrations of ammonium ions (0.54 $mg.l^{-1}$), iron (0,53 $mg.l^{-1}$) and manganese (0,42 $mg.l^{-1}$) exceeded the agreed limit values. Concentrations of other monitored indicators were below the level of the respective limit values.

4.4. Conclusions regarding the Hungarian territory

The above results show that groundwater in the shallow horizons of gravel sediments is enriched with iron and manganese. This also applies to other observation wells, which were evaluated in the National Annual Report in 2009. Iron and manganese concentrations in most observation objects permanently exceed the limit values.

Increased contents of nutrients and organic pollution are mainly related to local pollution, which is of agricultural origin or, in some cases, comes from wastewater ponds. In general, it can be stated that their content in observation objects did not change significantly in comparison with the previous year. High contents exceeding the limit values are recorded only on some objects. For example, the water quality in object No. 9368 at Rajka is still affected by local pollution. High ammonium ion contents occur here in long-term, which are the highest from among the 16 monitored observation objects. The measured values of phosphates and nitrates fluctuate around the limit values. High concentrations of potassium are also present in this object, which exceed the highest limit value according to the **Table 4-3**. At present, higher concentrations of ammonium ions exceeding the limit value are measured also on objects No. 9456 and 9327. Obsolete animal breedings gradually being disposed of, what is reflected in the groundwater quality improvement, e.g. on the object No. 9458 at Ásványráró, where no signs of fresh pollution were found. Concentrations of ammonium ions do not reach the limit value, but the content of nitrates have increased again and in the evaluated year exceeded the limit and were the highest from among the 16 observation objects (76.7 and 105 $mg.l^{-1}$). The content of phosphates is still the highest. It is several times higher than the limit value (in 2019 3.0 and 20.3 $mg.l^{-1}$). In this object in the assessed year, were also measured the highest concentrations of calcium (171 $mg.l^{-1}$), conductivity values (114.1 $mS.m^{-1}$), contents of potassium (17.2$mg.l^{-1}$), sodium (29.5 $mg.l^{-1}$) and hydrogen carbonates (510 $mg.l^{-1}$). The measured concentrations of potassium (17.2$mg.l^{-1}$) and magnesium (57.3$mg.l^{-1}$) exceeded even the highest limit values.

Change in the concentration of nitrates in object No. 9418 at Mosonmagyaróvár points to the impact of background pollution. From the long-term point of view, the measured values fluctuate around the limit value. In comparison with other monitored objects, the highest concentrations of sulphates (204 $mg.l^{-1}$), chlorides (59 $mg.l^{-1}$) and magnesium (63.5 $mg.l^{-1}$) were measured in this object. Organic pollution, expressed by COD_{Mn}, mostly meets the agreed limit value. During the monitoring, from time-to-time in some objects higher values occurred, that exceeded the limit value (3 $mg.l^{-1}$) or even the highest limit value (5 $mg.l^{-1}$). In the current year, the limit value was exceeded on the object No. 9475 at Győrzámoly (3.9 $mg.l^{-1}$), No. 9458 at Ásványráró (3.3 $mg.l^{-1}$) and in object No. 9536 at Püski (4.8 $mg.l^{-1}$). On objects close to pollution sources, that are located in the direction of groundwater flow (objects at Rajka and Ásványráró), changes in groundwater quality related to livestock farming can be well and sensitively observed.

Inorganic and organic micro-pollution is monitored on selected objects (No. 9379, 9413, 9536, 9536, 9456 and 9480). In the year 2019, organic micro-pollution was found in concentrations below the limit values for groundwater quality assessment (**Table 4-3**). Except one measured concentration of atrazine (0.022 $\mu g.l^{-1}$) on the object No. 9379 at Rajka, the other concentrations of observed organic substances did not reach the limits of determination. From among the inorganic micro-pollutants, the concentrations of mercury, chromium and nickel in the evaluated year did not reach the limit of determination in any of the monitored objects. In the case of arsenic and cadmium, concentrations above the limit of determination were measured only on one object (No. 9356 at Püski), while the concentration of arsenic (35.9 $\mu g.l^{-1}$) exceeded even the highest limit value (10 $\mu g.l^{-1}$) according to the **Table 4-3**. The measured concentrations of zinc, lead and copper do not reach the limit values, but indicate a slight groundwater pollution.

The groundwater quality in deeper horizons of gravel sediments in the Szigetköz is monitored by production wells in water supply sources. Wells in the region at Győr have a higher content of ammonium ions, organic matter, manganese and iron in comparison with the other monitored wells. Manganese and iron concentrations exceed the limit values or approach them. Concentrations are lower in wells where the water is pumped from greater depth. The water extracted in water supply sources Dunakiliti I, Mosonmagyaróvár - Feketeerdő T-II and Darnózseli I is of satisfactory quality and is characterized by high stability. In general, the groundwater quality in wells producing potable water (occasionally after pre-treatment) is suitable for drinking water supply.

From among the six substances of organic micro-pollution of groundwater, that were monitored in three water supply sources (DA1 - Darnózseli, T-II - Mosonmagyaróvár - Feketeerdő, DK-I - Dunakiliti), only the atrazine contents were slightly above the limit of determination in objects DA-1 and T-II. From among the inorganic micro-pollution, six heavy metals (Ni, Pb, Hg, Cu, Cd, Cr) were observed. Only the concentrations of mercury in two objects (T-II and DK-I) indicate a slight pollution of groundwater, other concentrations of the observed heavy metals did not reach the limits of determination.

Table 4-3: Groundwater quality limits for drinking purposes

Basic parameters - physical and chemical parameters

parameter	unit	limit value	highest limit value
temperature	°C	12	25
pH	-	6.5-9.5	
conductivity at 25 °C	$mS.m^{-1}$	250	
O_2	$mg.l^{-1}$	-	
COD_{Mn}	$mg.l^{-1}$	3	5
NH_4^+	$mg.l^{-1}$	0.5	
NO_3^-	$mg.l^{-1}$	50	
PO_4^{3-}	$mg.l^{-1}$	0.5	
Mn	$mg.l^{-1}$	0.05	
Fe	$mg.l^{-1}$	0.2	
Na^+	$mg.l^{-1}$	200	
K^+	$mg.l^{-1}$	10	12
Ca^{2+}	$mg.l^{-1}$	100	
Mg^{2+}	$mg.l^{-1}$	30	50
HCO_3^-	$mg.l^{-1}$	-	
Cl^-	$mg.l^{-1}$	250	
SO_4^{2-}	$mg.l^{-1}$	250	

Supplemental parameters – inorganic and organic micropollutants

parameter	unit	limit value	highest limit value
Inorganic micropollutants - heavy metals			
As	$\mu g.l^{-1}$		10
Cd	$\mu g.l^{-1}$		5
Cr	$\mu g.l^{-1}$		50
Cu	$\mu g.l^{-1}$	200	2000
Hg	$\mu g.l^{-1}$		1
Ni	$\mu g.l^{-1}$		20
Pb	$\mu g.l^{-1}$		10
Zn	$\mu g.l^{-1}$	200	3000
Organic micropollutants			
pesticides – sum	$\mu g.l^{-1}$		0.5
pesticides – individually	$\mu g.l^{-1}$		0.1
aldrin	$\mu g.l^{-1}$		$\Sigma \leq 0.03$
dieldrin	$\mu g.l^{-1}$		
heptachlor	$\mu g.l^{-1}$		0.03
heptachlor epoxide	$\mu g.l^{-1}$		0.03
trichloroethylene	$\mu g.l^{-1}$		$\Sigma \leq 10$
tetrachloroethylene	$\mu g.l^{-1}$		
DDT/DDD/DDE	$\mu g.l^{-1}$	1	5
HCH – sum	$\mu g.l^{-1}$		$\Sigma \leq 0.1$

HCH – hexachlorciclohexane

PART 5

Soil Moisture

5.1. Data collection methods

The soil moisture monitoring under the 1995 Agreement continued in 2019 on the Slovak and Hungarian Territories in accordance with the approved monitoring optimization. The Slovak Party performs the soil moisture measurements using a neutron probe on 13 monitoring sites, all of which are located in the inundation. Measurements are performed at 10 cm depth intervals down to the groundwater level. The monitoring of soil moisture on the Hungarian side was interrupted in the years 2013 to 2017. Since 2018, the monitoring has continued on 12 localities, 6 of which are located in the agricultural area. Most of monitoring sites on the Hungarian side needed to be restored or rebuilt, so the soil moisture monitoring was introduced gradually during 2018. Also on the Hungarian side, the monitoring is carried out according to the existing methodology, thus by the capacitive probe, in 10 cm depth intervals to a maximum depth of 3 m or to the groundwater level. The Hungarian Party at some sites has also installed devices for continuous recording of soil moisture changes of the Campbell CS616 type. At these localities, measurements with the capacitive probe will be carried out at the same time. On both sides, the measured values of soil moisture are expressed by the total soil moisture content in volume percentage. The list of monitoring sites are given in **Tables 5-1** and **5-2** and their situation is shown in **Fig. 5-1**.

5.2. Data presentation methods

The method of presentation of soil moisture data remained unchanged. The soil moisture content is shown in graphs showing the average volume percentage of moisture for the depth interval from 0 to 100 cm and from 110 to 200 cm. The measured soil moisture content at selected monitoring sites is presented in colour charts with the time distribution of soil moisture for the entire monitoring period and for the entire measured depth. The monitored data are comprehensively processed in the National Annual Reports and the graphical presentation of each monitoring site is given in the Annexes.

Table 5-1: List of monitoring stations on the Slovak side

No.	ID	Name	Locality	Area
1	**2703**	MP-6	Dobrohošť	inundation, biological area
2	**2704**	MP-9	Bodíky	inundation, biological area
3	**2705**	MP-10	Bodíky	inundation, biological area
4	**2706**	MP-14	Gabčíkovo	inundation, biological area
5	**2707**	MP-18	Kľúčovec	inundation, biological area
6	**2755**	L-3	Sap	inundation, forest stand
7	**2757**	L-5	Baka	inundation, forest stand
8	**2758**	L-6	Trstená na Ostrove	inundation, forest stand
9	**2759**	L-7	Horný Bar - Šuľany	inundation, forest stand
10	**2760**	L-8	Horný Bar - Bodíky	inundation, forest stand
11	**2763**	L-11	Vojka nad Dunajom	inundation, forest stand
12	**2764**	L-15	Dobrohošť	inundation, forest stand
13	**3804**	L-25	Medveďov	inundation, forest stand

Table 5-2: List of monitoring stations on the Hungarian side

No.	ID	Name	Location	Area
1	**3601**	T-16	Dunasziget 15D	inundation, forest stand
2	**3602**	T-17	Dunasziget 22B	inundation, forest stand
3	**3603**	T-18	Lipót 4A	inundation, forest stand
4	**3604**	T-19	Ásványráró 27C	inundation, forest stand
5	**3634**	T-21	Kisbodak F26	inundation, biological area
6	**3635**	T-22	Györzámoly 6B2	inundation, forest stand
7	**3756**	T-10	Ásványráró A19	agricultural area
8	**3757**	T-04	Dunaremete	agricultural area
9	**3758**	T-12	Lipót L18	agricultural area
10	**3759**	T-02	Halászi H15	agricultural area
11	**5579**	T-03	Dunakiliti 16	agricultural area
12	**5580**	T-09	Püski P14	agricultural area

5.3. Hydrological and climatic conditions of the year 2019

The moisture content of the soil is mainly influenced by the amount of precipitation and, in the case of favourable conditions, also by the level of groundwater that can rise capillary into the soil profile. The influence of the submerged weir in rkm 1843 and the increased flow rate into the Danube old riverbed on the soil moisture can manifest itself only through changes in the groundwater level. The height of the groundwater level, its position in relation to the boundary between the gravel sediments and the soil profile and the character of the soil play a crucial role.

In terms of the precipitation amount, the year 2019 can be considered as below-average (**Fig. 5-2**) The total annual precipitation at the Bratislava-airport meteorological station, reached 524.6 mm and was the eight lowest since 1992. It was similar in the upper part of the Szigetköz, where on the precipitation measuring station in Mosonmagyaróvár the total annual precipitation reached 548.7 mm. In the central part of the Žitný ostrov, the total annual precipitation at the Gabčíkovo station was lower and reached 482.5 mm, which was the sixth lowest precipitation amount since 1992. Also in the lower part of the Szigetköz the total annual precipitation was lower and reached 476.2 mm at the station in Győr (**Fig. 5-2**). At all four meteorological stations, the highest monthly precipitation total was recorded in May (**Fig. 5-3**), when there were significantly above-average precipitation totals - 118.2 mm at the Bratislava-airport station, 135.0 at the Mosonmagyaróvár station, 113.8 mm at The Gabčíkovo station and 111.4 mm at the Győr station. Higher monthly precipitation totals (30.1-79.3 mm) also occurred in January, August, September, November and December. The lowest monthly precipitation total was recorded in the upper half of the Žitný ostrov in June (17,5 mm), in the upper part of the Szigetköz it was in Marc, when only 12.7 mm was recorded at the station in Mosonmagyaróvár. In the central part of the Žitný ostrov at the Gabčíkovo station, the lowest monthly precipitation total occurred in February and reached only 12.0 mm. In February, very low monthly totals (13.7-17.9 mm) were also recorded on other precipitation measuring stations. The lowest monthly precipitation total in the lower part of the Szigetköz was recorded in July and reached 16.5 mm. Lower monthly precipitation totals (15.7-27.3 mm) also occurred in March, April and October. From the above it follows, that although the time distribution of precipitation within the year was not very favourable (**Fig. 5-3**, **Fig. 5-4**), the fact that higher precipitation totals occurred in January and especially in May had a positive effect on creation of soil moisture reserves as well as on their supply. Higher flow waves during May and higher flow rates in the first half of June also played an important role in replenishing the soil moisture content in the first half of the year.

In terms of air temperature, the year 2019 as a whole was very warm (**Fig. 5-5**, **Fig. 5-7**). Although, similarly as in the previous year, no extremely high average daily temperatures above 30 °C occurred, the average annual temperature was the highest at all four meteorological stations for the entire monitoring period. Since the previous year was also very warm, it can be stated that the last two years were the warmest in terms of the average annual temperature in the entire observed period. The lowest average daily temperatures were recorded at the beginning of the third decade of January (January 21-23, 2019), while the lowest average daily temperature occurred on January 22, 2019 (**Fig. 5-6**), when it dropped to -5.6 °C at the station Bratislava-airport, at the station Mosonmagyaróvár to -5.9 °C, at the station Gabčíkovo to -4.8 °C and at the station Győr to -5.7 °C. The highest average daily temperatures occurred in June, July and August (**Fig. 5-6**), when the highest average daily temperatures at stations Bratislava-airport and Gabčíkovo were recorded on June 26, 2019 with values of 28.1 °C and 27.9 °C, at the station in Győr it was on June 27, 2019 with a value of 28.3 °C and at the station in Mosonmagyaróvár was the highest average daily temperature recorded on July 26, 2019 with a value of 27.8 °C. There were up to 28 days at the Bratislava-airport station with an average daily temperature of 25 °C and more, while three very warm periods with an average daily temperature above 25 °C were recorded, which, however, did not last long (**Fig. 5-6**). The first lasted 6 days (10.6-15.6.2019), the second lasted 5 days (22.7.-26.7.2019) and the third also lasted 5 days (28.8.-1.9.2019), although the average daily temperature on one day fell slightly below 25 °C. At the station Mosonmagyaróvár, in the upper part of the Szigetköz there were only 21 days with an average daily temperature of 25 °C and above, but similarly as in Bratislava there were three continuous very warm periods. The first lasted 5 days (11.6.-15.6.2019), the second lasted 4 days (23.7.-26.7.2016) and the third lasted 3 days (18.8.-20.9.2019). There were 23 days with an average daily temperature of 25 °C and above at the Gabčíkovo station, but there was only one continuous very warm period and it lasted 6 days (10.6.-15.6.2019). Similarly, also at the Station in Győr there were 23 days warmer than 25 °C, but contrary to Gabčíkovo there were three very warm periods. The first lasted 5 days (11.6.-15.6.2019), the second lasted 4 days (23.7.-26.7.2019), although one day the average temperature fell slightly below 25 °C, and the third lasted 3 days (18.8.-20.8.2019). At all four meteorological stations, the coldest month was January and the warmest month was June (**Fig. 5-6**).

The creation of soil moisture reserves started only at the beginning of the year, and was caused in particular by the heavy rainfall, especially in the first half of January (**Fig. 5-2**). These precipitations affected mainly the upper part of the soil profile and on some localities the highest soil moisture contents were recorded during January or in the first half of February. In the lower part of the soil profile, the creation of soil moisture reserves began also in January, which was caused by the passage of a flow wave and a slight increase of groundwater levels. However, the most significant influence on the soil moisture in both depth intervals had the flow waves during May (**Fig. 1-2**, **Fig. 1-3**) and the realisation of artificial flooding, in the right-side river branch system in the first half of May (**Fig. 1-4**, **Fig. 1-6**), and in the left-side river branch system in the second half of May a in the first half of June. On most of observed sites, maximal values in both depth intervals occurred during this period. During artificial floods, the soil moisture content on the affected sites was maintained at a higher level, although it did not reached the maximal values. After reaching the highest values, the soil moisture content on all localities began to decline steadily and decreased until the end of October. The decline in the lower part of the soil profile continued until the end of the year, but in the upper parts of the soil profile the soil moisture content began to rise again during November and December due heavy precipitations. The minimal values in the upper part of the soil profile were recorded on most localities during October, only on some it was during August. In the lower part of the soil profile, the minimal values were most often recorded at the beginning of the year, but low values and on some localities even minima, occurred in November and December. In general, it can be stated that the soil moisture content at the end of the year in the upper part of the soil profile was higher than at its beginning, but in the lower part of the soil profile on all localities it was similarly low as at the beginning of the year.

5.4. Evaluation of results on the Slovak side

The thickness of the soil profile in the upper part of the inundation area is small (monitoring sites No. 2703, 2764, 2763 and 2760). The groundwater level at these locations fluctuates only in the gravel layer (**Fig. 5-8a**). In 2019, the groundwater level on the site No. 2703 fluctuated from 3.2 to 5.1 m. On sites No. 2764, 2763 and 2760, the groundwater level ranged from 1.2 to 4.8 m. Layers to 1 m depth are almost exclusively dependent on climatic conditions. Only high flood waves can influence the soil moisture content by increasing the groundwater level. Layers in the depth 1-2 m are also mostly dependent on climatic conditions, but the lower part of this depth range may be slightly influenced by the groundwater level during the passage of large flow waves. Maximal average soil moisture contents on localities No. 2703 and 2763 in the depth interval up to 1 m occurred already in the middle of February. On the other two sites, it was during the culmination of the flow wave and the simultaneous culmination of the artificial flood in the left-side river branch system at the turn of May and June. At the depth from 1 to 2 m, the maximal values on sites No. 2703, 2760 and 2763 occurred in early June. After reaching the maximal values, the soil moisture content on these localities decreased almost continuously (**Fig. 5-8b**). At a depth interval to 1 m, the minimal values were recorded at the end of October. Due to precipitation in November and December, the soil moisture content started to rise again and at the end of the year it reached significantly higher values than at its beginning. In the depth interval from 1 to 2 m, precipitations at the end of the year were not manifested and the soil moisture content continued to decrease until the end of the year, when the lowest values were recorded during November or December, while they were mostly lower than at the beginning of the year. Due to the low flow rates in the Danube in the second half of the year, a relatively significant drying of the soil profile was recorded on these sites.

The thickness of the soil profile in the middle part of the inundation area gradually increases. In general, the groundwater regime in this area is influenced by the water supply to the river branch system, introduced in May 1993. Moreover, the groundwater level is significantly affected by natural floods or flow waves. The groundwater level in 2019 fluctuated slightly below or around the boundary between the soil profile and gravel layers - monitoring sites No. 2704, 2705, 2757, 2758, 2759 - and during the flow waves in March and especially in May it partially supplied the soils with water. During the year, the groundwater level on the site No. 2704 varied from 2.7 to 3.9 m, while it permanently influences only the lowest part of the soil profile (**Fig. 5-9a**). On the sites No. 2705, 2757 and 2759, the groundwater level ranged from 1,7 to 3.6 m. The highest groundwater level was on the site No. 2758, where it ranged in the depth from 1.2 to 2.5 m. The maximal values of the average soil moisture content in the layer down to a depth of 1 m, according to the prevailing influence, occurred at the end of January or the beginning of June, when the soil moisture values were affected by above-average precipitation totals or increased flow rates into the river branch system. A slight increase was also recorded at the end of August due to heavy rainfall. The minimal values, due to the low flow rates , occurred either at the beginning of the year (No. 2705), during August or at the end of October. At the end of the year, the soil moisture content in the upper layer began to rise again in November and December due to precipitation, reaching higher values than at its beginning. In the depth from 1 to 2 m, the minimal values occurred either at the beginning or at the end of the year, in November and December. The maximal values in the depth from 1 to 2 m were most often related to the passage of flow wave and to the discharge of increased flow rate during the artificial flooding of the left side inundation at the turn of May and June (**Fig. 5-9b**).

In the lower part of the inundation area, downstream of the confluence of the river branch system and the Danube old riverbed (monitoring sites No. 2706 and 2755), the groundwater level usually fluctuates around the boundary between the soil profile and the gravel layer (**Fig. 5-10a**). Based on the comparison of the course of the groundwater level before and after putting the waterworks into operation, it can be stated that due to the deepening of the bottom of the tail race channel, there is a decrease in the average and minimal groundwater levels. The occurrence of minima is linked to the minimal water levels in the Danube old riverbed. At maximal water levels, the monitored area is flooded. However, during the last six years, the Istragov area has not been flooded. The groundwater level in the upper part of Istragov in 2019 fluctuated in the depth between 1.0 and 4.6 m, at the confluence of the Danube old riverbed and the tail-race channel it was between 0.0 to 4.3 m, while during the flow waves in March and in May, some terrain depressions could be flooded for a short time. Maximal soil moisture values in both depth intervals were registered at the turn of May and June. For the second half of the year, gradual decrease of soil moisture content was characteristic in both depth intervals, while minima inn the upper part of the soil profile occurred at the end of October, in the lower part of the soil profile it was at the beginning of the year (**Fig. 5-10b**).

The soil moisture contents at monitoring sites No. 2707 and 3804, that are located in the inundation below the confluence of the tailrace channel and the Danube old riverbed, are strongly influenced by the flow rate regime in the Danube. The development of soil moisture values over the year was similar as on the previous locations. Maximal average values of soil moisture in 2019 in the depth to 1 m at both localities were recorded at the turn of May and June. In the depth interval of 1-2 m, the maximal values were recorded either before or after the passage of the flow wave in May, because during it the lower part of the soil profile was saturated with groundwater, The lowest values in the depth interval to 1 m were recorded on both localities at the end of October In the lower part of the soil profile, the lowest values occurred at the beginning of the year. After reaching the maximal values, the soil moisture contents decreased until the end of the year, but they were significantly higher than the values from the beginning of the year. The Danube riverbed erosion negatively affects also these monitoring areas. During low flow rates in the Danube, as was the case during the second half of the year, the groundwater level does not supply the soil profiles sufficiently.

The minimal and the maximal average soil moisture contents on the mentioned monitoring sites in the inundation area for both depth intervals are given in the **Table. 5-3**.

Table 5-3: The minimal and maximal average soil moisture contents in depth intervals of 0-1 m and 1-2 m on the Slovak side in 2019

ID	Depth interval 0-100 cm		Depth interval 110-200 cm	
	Lowest average value	Highest average value	Lowest average value	Highest average value
Upper part of inundation area				
2703	9,89	25,97	10,75	17,75
2764	11,40	32,68	5,78	20,83
2763	5,73	20,66	2,97	3,85
2760	13,19	27,41	8,55	26,07
2704	16,12	28,04	17,62	24,97
Central part of inundation area				
2759	15,96	25,74	29,06	40,21
2705	39,44	52,20	41,20	47,23
2758	34,97	42,66	17,42	45,28
2757	26,67	36,05	14,49	40,39
Lower part of inundation area				
2706	10,89	34,38	3,30	42,33
2755	16,62	52,14	7,65	41,79
3804	33,06	53,66	33,74	49,45
2707	9,11	32,63	12,76	32,27

5.5. Evaluation of results on the Hungarian side

The soil moisture measurements in accordance with the optimisation approved in 2017 are performed on 12 localities, 6 of which are located in the inundation and 6 on agricultural area. After the reconstruction, optionally after the site renewal, the measurements began to be gradually implemented from the end of the first half of 2018, while 9 to 12 measurements were carried out at individual sites. In 2019, the first measurements started at the end of February and the last ones took place at the beginning of October, with 8 to 12 measurements being carried out. One of the reconstructed localities (No. 3602, T-17) was destroyed during modification of the water supply system at the beginning of 2019, at two other localities (No. 3634 - T-21 and 3635 - T-22) the measuring equipment was damaged in the second half of the year at the wood logging. During the restoration of monitoring sites in 2018, devices for continuous recording of soil moisture changes were of the Campbell CS616 type were also installed at four sites (No. 5579 - T-03, 5580 - T-09, 3601 - T-16 and 3603 - T-18). During the installation of devices, soil samples were taken from the soil profile for calibration. Measurements with Campbell type instruments are affected by settling and changes in the soil bulk density in the first several months, so the comparison and harmonisation of the two types of measurements will take longer time and require further research.

Similarly to the Slovak side, the thickness of the soil profile is relatively small in the upper part of the inundation area, gradually increasing towards the middle part (monitoring sites No. 3601 - T-16, 3602 - T-17). In 2019, the groundwater level on the locality No. 3601 fluctuated from 2.5 to 4.0 m below ground (**Fig. 5-11a**). On the site No. 3602 it was from 2.2 to 4.8 m. Although the layers down to depth of 1 m on these localities are almost exclusively dependent on climatic conditions, they are also affected by increased groundwater level during higher flow rates in the Danube old riverbed and during increased flow rates into the right-side river branch system. The minimal soil moisture contents in the depth interval 0-100 cm on the sites in the upper part of the inundation occurred from the end of August until the end of measurements at the beginning of October. On one of the sites, the lowest value was recorded in April, which, however, resulted from the fact that the measurements were completed in the first half of the year. The maximal values of the average soil moisture content in the upper part of the inundation occurred at the beginning of the year. Thanks to the relatively high sand content, the layers at a depth of 1-2 m are also favourably influenced by the capillary rise from the groundwater level. At the beginning of the year, however, the groundwater level was relatively deep and therefore minimum values of soil moisture content were recorded in this period. The maximal average contents of soil moisture in the upper part of the inundation at a depth of 1 to 2 m were recorded at the beginning of June in connection with the passage of the flow wave at the turn of May and June, which caused a significant rise of groundwater levels. After reaching the maximal values, the soil moisture content decreased almost continuously (**Fig. 5-11b**).

A similar course of soil moisture values could be observed also in the middle and in the lower part of the inundation (localities No. 3603 - T-18, 3604 - T-19, 3634 - T-21 and 3635 - T-22). In 2019, the groundwater level in the middle part of the inundation (locality No. 3634) fluctuated from 1.0 to 4.1 m below the ground (**Fig. 5-12a**). In the lower part of the inundation (localities No. 3604 and 3635) it was from 1.8 to 4.5 m. The minimal average contents of soil moisture in the depth interval 0-100 cm, similarly to the upper part of the inundation, also occurred at the beginning of October. At one site, the lowest values were recorded in April, but measurements were also completed in the first half of the year. The maximal values of the average soil moisture content on the monitored localities occurred most often in the second half of May and the beginning of June, which in these parts of the inundation is related to the discharge of increased flow rates into the inundation and the passage of flow waves on the Danube. In general, the average values of soil moisture content at the beginning of the year were higher than at the end of measurements at the beginning of October (**Fig. 5-12b**). It can be assumed that in the upper layers of the soil due to increased precipitation totals during November and December, the soil moisture contents at the end of the year also increased. In the depth interval 110-200 cm, the minimal average soil moisture contents were recorded at the beginning of the observation (February-March), in one case it was in the first half of April. Similarly to the upper part of the inundation, the maximal values occurred most often at the end of May and the beginning of June, in connection with the passage of flow waves on the Danube in the second half of May (**Fig. 5-12b**).

Courses of soil moisture content on sites on the flood-protected side - agricultural land (sites No. 3756 - T-10, 3757 - T-04, 3758 - T-12, 3759 - T-02, 5579 - T-03 and 5580 - T- 09), differed slightly depending on the location of the site to the Danube. The dependence of soil moisture content on climatic conditions was more pronounced, including layers at greater depths. In the upper part of Szigetköz (localities No. 3759 - T-02 and 5579 - T-03) the groundwater level ranged from 3.0 to 4.3 m. Layers down to the depth of 1 m are exclusively dependent on climatic conditions (**Fig. 5-13a**). Even layers at a depth of 1-2 m are mostly dependent on climatic conditions, but the lower part of this depth interval can be slightly affected by the groundwater level during the passage of large flow waves.

In the central part of Szigetköz (sites No. 3757 - T-04, 3758 - T-12 and 5580 - T-09) the groundwater level fluctuated from 1.5 to 3.8 m. Also in this part of the Szigetköz, the layers down to a depth of 1 m depend on climatic conditions. Soil layers at a depth of 1 to 2 m, however, are already affected by the groundwater level, which on sites closer to the Danube old riverbed, in the case of higher flow waves, also rises into these layers.

In the lower part of Szigetköz (locality No. 3756 - T-18) the groundwater level in 2019 ranged from 0.5 to 2.3 m. In this part of Szigetköz, the soil moisture content in the soil profile is also significantly affected by the groundwater level.

The minimal soil moisture contents in layers of 0-1 m on agricultural sites occurred mainly in the second half of the year, in the period from the end of August to the beginning of October. Only at locality No. 3759 (T-02), the minimal soil moisture content was recorded at the beginning of July and at site No. 5579 (T-03) in the second half of April. The maximal soil moisture values occurred at different times during the first half of the year, most often in late May and early June, which in the upper half of Szigetköz was associated with above-average precipitation, but in the lower half also joined the effect of flow waves in the second half of May.

In the soil layers in the depth interval from 1 to 2 m, the minimum values of soil moisture in most localities also occurred at the end of the monitoring period (end of August to the beginning of October). Concerning the maximal average values of soil moisture, as in the upper part of the soil profile, they mostly occurred at different times during the first half of the year. However, at one of the sites, the maximum in this depth interval was recorded at the beginning of October (**Fig. 5-13b**), when minima occurred on most sites. This is related to the relatively deep groundwater level and the low and balanced soil moisture content throughout the monitoring period. In general, it can be stated that in the second half of the year there was a gradual drying of the soil profile. Nevertheless, at most sites, the soil moisture content at the end of the measurements in 2019 (early October) was similar or slightly higher than at the beginning of the year.

The minimum and maximum average soil moisture contents at monitoring sites for both depth intervals are given in **Tab. 5-4**. As basically only two measurements were performed in the second half of the year, the basic characteristics obtained from the measured data (minima, maxima and average values) again cannot be considered as fully representative (**Tab. 5-4**).

Table 5-4: The minimal and maximal average soil moisture contents in depth intervals of 0-1 m and 1-2 m on the Hungarian side in 2019 (February - October)

ID	Depth interval 0-100 cm		Depth interval 110-200 cm	
	Lowest average value	**Highest average value**	**Lowest average value**	**Highest average value**
Right-side inundation				
3601 (T-16)	16.6	26.3	13.1	34.2
3602 (T-17)	-	-	-	-
3603 (T-18)	5.4	8.5	9.8	30.1
3604 (T-19)	14.3	22.4	8.4	35.2
3634 (T-21)	28.3*	34.9*	29.0*	41.0*
3635 (T-22)	12.7*	18.9*	13.4*	35.5*
Flood-protected area - agricultural land				
3756 (T-10)	24.6	35.9	36.4	45.6
3757 (T-04)	22.6	27.3	10.5	30.0
3758 (T-12)	14.8	21.6	30.7	35.4
3759 (T-02)	2.5	7.1	11.4	14.8
5579 (T-03)	18.5	29.7	19.3	31.2
5580 (T-09)	25.3	34.1	17.0	31.8

Note: * - data only for the first half of 2019

PART 6

Forest stands

The development of forest stands, as well as plant and animal communities assessed in the Part 7 - Biological observations, are influenced by hydrological and climatic conditions. In 2019, these conditions were generally more favourable than in the previous year, although the flow regime of the Danube was not typical again.

- In terms of water richness, the year 2019 belonged to moderately water rich years, with the occurrence of extremely water rich and moderately water rich months in the first half of the year and dry and extremely dry months in the second half of the year. The largest flow wave occurred at the end of May, but it did not cause flooding of the inundation. Only in the area at the confluence of the Danube old riverbed and the tail-race channel could the increasing groundwater fill the dry riverbeds of old river arms and terrain depressions, and below the confluence the low-lying parts of inundation could be flooded for a short time. In the inundation area from Dobrohošť to the mouth of the river branch system into the Danube old riverbed, the groundwater levels were also affected by the implementation of artificial flooding, which lasted from mid-May to almost mid-June. As the above-mentioned flow wave also occurred during this period, it is not possible to clearly distinguish their impact on groundwater levels. However, it can be stated that their synergistic effect had a positive impact on the soil moisture content, which was also helped by the above-average precipitation totals during May.
- Also in 2019, the replenishment of the soil profile by moisture was dependent mainly on precipitation. At the beginning of the vegetation period, the soil moisture reserves were mostly at the average, or slightly below average level. Precipitations in May, together with increased water levels, improved this situation. The decrease of soil moisture has occurred since June, and the lowest values occurred by the end of the year.
- In terms of the annual precipitation total, the assessed year was below average, but in terms of the time distribution of precipitations it developed relatively favourably. In terms of the spatial distribution of precipitations, relatively different values were again recorded in the individual parts of the inundation (more precipitation in the upper part). In terms of the average daily air temperature, the evaluated year was marked as very warm (similarly to the previous year), but very warm periods lasted shorter.

6.1. Evaluation of the Slovak territory

Monitoring sites on the Slovak side are located in the inundation area. The list of monitored sites is given in **Table 6-1** and their situation is shown in **Fig. 6-1**. In accordance with the monitoring optimisation approved in 2017, the Slovak Party evaluated the development of basic growth parameters of forest stands on eight monitoring plots. The aerial imagery of the health of forest stands is carried out at three-year intervals, the next one should take place in 2021. On the monitoring areas, the most productive stands of cultivated poplars are monitored. At present, the Pannonia poplar clone is grown on all monitoring areas, by which the initially observed stands of cultivated poplars I-214 and Robusta, as well as the white willow stand, were replaced

Table 6-1: List of the forest monitoring areas on the Slovak side

No.	ID	Name	Locality	Tree species	Age
1	**2681**	L-3	Sap	poplar - *Populus x euroamericana Pannonia*	17
2	**2683**	L-5	Baka	poplar - *Populus x euroamericana Pannonia*	13
3	**2684**	L-6	Trstená na Ostrove	poplar - *Populus x euroamericana Pannonia*	16-(18)
4	**2685**	L-7	Horný Bar – Bodíky	poplar - *Populus x euroamericana Pannonia*	21
5	**2686**	L-8	Horný Bar – Šuľany	poplar - *Populus x euroamericana Pannonia*	14
6	**2689**	L-11	Vojka nad Dunajom	poplar - *Populus x euroamericana Pannonia*	(18)-20
7	**2690**	L-12	Dobrohošť	reforestation in 2015	(4)-5
8	**3802**	L-25	Medveďov	poplar - *Populus x euroamericana Pannonia*	25

- the number in brackets represents the age of the group of trees that are in the minority in the case of additional planting

The development of forest stands in the assessed year mostly continued in the trend of previous years, significant deviations were recorded only in stands in which forest management interventions - improvement cutting - were carried out.

Based on the evaluation of growth parameters for the year 2019, it can be stated that the height increment quality classification of the observed stands shows only smaller, slow fluctuations on most areas. These stands are characterized by intense, or moderately intensive growth. A significant improvement of the height increment has been registered in recent years on area No. 2683 (after improvement cutting), less intensively also on areas No. 2684 and 2681. These stands are just over 15 years old. After the previous decline, the growth of poplars on the area No. 2686 in the last two years improved by one quality class and has stabilized. A clear decrease of the height increment is noticeable in the last four on the areas No. 2689, and to some extent also on the most intensively growing stands on areas No. 2685 and 3802, which are of 20 years of age or older, approaching the culmination age. On areas No. 2684 and 2681, the development of the thickness increment values in the evaluated year remained approximately at the level of the previous year. A slight decrease in the current annual thickness increment was recorded on areas No. 2685 and 3802 (age of culmination), more pronounced is on the area No. 2686. Compared to the previous year, the values of the current annual thickness increment on areas No. 2683 and 2689, after the improvement cutting, were several times higher.

In terms of the duration of the growth period, it can be stated that due to the artificial flooding, an earlier onset of more intense growth was recorded from mid-May. The September above-average precipitation totals were reflected in the prolongation of the growing season.

From the forestry management point of view, it can be stated that the implementation of hydrotechnical measures in most areas ensured suitable conditions for the existence, growth and production of floodplain forest. in most areas. The unfavourable development of habitat conditions is more pronounced in the years with below-average precipitation, what in the assessed year was partially mitigated by the implementation of the artificial flood lasting from mid-may to mid-June. Improvement in sensitive areas could be expected after construction of submerged weirs in the Danube old riverbed, or by restructuring the species composition of existing stands towards hardwood communities. The results of the monitoring also point to the need for more efficient use of the existing weirs in the river branch system to mitigate the effects of the groundwater level decline, which is manifested especially in the vicinity of the Danube old riverbed. The effects of unfavourable climatic conditions could also be mitigated by replenishing the soil moisture in periods of low precipitation amount and extreme temperatures.

6.2. Evaluation of the Hungarian territory

Monitoring of forest stands in the Szigetköze area was interrupted after 2014. In line with the monitoring optimisation, the Hungarian side resumed the monitoring of forest stands in 2018 and implemented it in accordance with the approved monitoring program, but deviations were noted in the monitoring methodology.

Measurements of dendrometric characteristics of forest stands (tree heights and thickness) were performed on eight monitoring plots by terrestrial laser scanner, which enables the acquisition of more accurate data on the height and thickness of trees. The monitoring areas are located in the inundation area (**Fig. 6-1**) and are listed in **Table 6-2**.

Aerial imagery of the stands health state, which was planned in 2018, was not carried out on the Hungarian side, but on the basis of MODIS satellite imagery the photosynthetic activity of forest stands in the Szigetköz was evaluated. With this method it was possible to obtain information about the vitality of the forests and to detect the presence of possible biotic or abiotic stressors. In the assessed year, this evaluation was experimentally extended by including data obtained from ESA Sentinel 2 satellite images, which gives a significantly more precise resolution (10x10 m). Evaluation of the health state was performed using the normalized vegetation and water indices (NDVI, NDII, EVI, NDWI) on a monthly basis. The mentioned vegetation indices enable the evaluation of the level of (vegetation) photosynthetic activity of the stand and the level of stress resulting from the lack of water (water content in plant tissues).

On the observed areas poplar stands dominate, which corresponds to the current tree composition in the Szigetköz area. The cultivated poplar "Pannonia" forms the largest part of the forest stands. Based on satellite images, it is also possible to add that a relatively high percentage of forest areas of the observed region is overgrown with willows and the third most common tree species is the non-native black locust (*Robinia pseudoacacia*). A relatively large area (14%) is formed by non-forest areas, which are however under forestry managed.

Table 6-2: List of the forest monitoring areas on the Hungarian side

No.	ID	Name	Locality	Tree species	Age
1	**3614**	22C	Dunasziget	oak-ash stand	65
2	**3615**	4A	Lipót	poplar - *Populus x euroamericana I-214*	35
3	**4236**	15B	Dunakiliti	poplar - *Populus x euroamericana Pannonia*	33
4	**4226**	26C	Dunasziget	poplar - *Populus x euroamericana Pannonia*	31
5	**4228**	6B	Dunasziget	poplar - *Populus x euroamericana Pannonia*	24
6	**4230**	6B2	Győrzámoly	poplar - *Populus x euroamericana Pannonia*	24
7	**4231**	18M	Kisbodak	poplar - *Populus x euroamericana Kornik*	25
8	**4232**	19E	Kisbodak	grey poplar - *Populus x canescens* - not evaluated	3-4

The evaluation of the development of dendrometric characteristics of forest stands in the vegetation period 2018-2019 could not be evaluated in the current report, as due to the unavailability of the area at Kisbodak at the end of 2019, measurements were performed only at the beginning of 2020. The comprehensive annual assessment of the development of forest stands will be performed only in the next annual report.

The areal assessment of the health status of the stands on the basis of satellite images was based on four vegetation and water indices - NDVI, NDII, EVI, NDWI. Based on their comparison between the years 2017-2018 and 2018-2019, it is possible to state a decrease in all four indices in the mentioned periods. Although the variance of values is considerable, the data point to a decrease of photosynthetic activity of the forest and of the water supply, thus indicating a deterioration of the status of the forest. The differences in the values of the indices were the largest in the case of the water index (NDWI), in the period between the years 2018-2019.

Based on additional hydrological data, it can be summarized that the groundwater levels of Szigetköz depend on the water stages in the Danube, which subsequently affects the growth and the health state of forest stands. The comparison of the potential evaporation and the monthly amount of precipitation during the vegetation period shows that the rate of potential evaporation exceeded the amount of precipitation totals, except of May and the first half of September. The difference recorded in the months of June and July was particularly critical. This finding is confirmed by the statement from the previous year, according to which the water replenishment in the summer months are of primary importance from the forest stand growth increments point of view.

PART 7

Biological Observations

Since 2018, biological observations have been carried out according to the optimisation of the joint Slovak-Hungarian monitoring approved on November 29, 2017. Biological observations are divided into three parts. The first part includes terrestrial groups, which are made up of terrestrial plants, molluscs and the strictly protected Northern Pannonian vole (*Microtus oeconomus mehelyi*). The second part is the aquatic group represented by macrozoobenthos and additional qualitative samples of aquatic molluscs and dragonfly larvae. The third part is also represented by aquatic groups including fishes, zooplankton and macrophytes. The list of observed sites together with the monitored biological groups on the Slovak and Hungarian sides is given in **Table 7-1a, b, c**. The situation of the monitored localities is shown on **Fig. 7-1.** The location of individual observed localities needs to be précised by joint field surveys.

A brief description of climatic, hydrological and moisture conditions in the evaluated year, which influenced the development of the monitored groups of fauna and flora, is given in Part 5 - Soil Moisture, Chapter 5.3 and in Part 6 - Forest stands.

Table 7-1a: The list of monitoring areas - terrestrial groups

No.	ID	Name	Location	Monitored groups		
				Phytocoenology	Molluscs	Pannonian vole
Slovak side						
1	**2600**	B-6	Dobrohošť – Dunajské kriviny	●	●	
2	**2603**	B-9	Bodíky – Bodícka brána	●	●	
3	**2604**	B-10	Bodíky – Kráľovská lúka	●	●	●
4	**2608**	B-14	Gabčíkovo – Istragov	●	●	●
5	**2609**	B-15	Sap – Erčéd	●	●	
6	**2612**	B-18	Kľúčovec – Sporná sihoť	●	●	
Hungarian side						
1	**5722**	B-01	Dunasziget – hardwood floodplain forest	●		
2	**5723**	B-02	Dunasziget – meadow	●		
3	**5742**	B-03	Halászi - Derék forest	○		
4	**5725**	B-04	Lipót – poplar forest, Gombócos closure	●		
5	**5726**	B-05	Dunaremete - willow forest	●		
6	**5727**	B-06	Vámosszabadi - willow forest	●		
7	**5728**	F19	Dunaremete - Danube old riverbed, rkm 1824		●	
8	**5729**	F26	Kisbodak - Pálffy Island		●	●
9	**5730**	F31	Lipót - Zsejkei channel		●	
10	**5732**	H06	Lipót, Lipóti dead river arm, Danube river arm		●	●
11	**5740**	X2	Ásványráró - Lake Öntés		●	
12	**5741**	X3	Ásványráró - Bagoméri river arm		●	

Legend: ○ - not evaluated in 2019
- Phytocoenology (Braun-Blanquet)
- Terrestrial molluscs (Gastropoda)
- Pannonian root vole (*Microtus oeconomus mehelyi*)

Table 7-1b: The list of monitoring areas - aquatic groups - Macrozoobenthos

No.	ID	Name	Location	Monitored groups		
				Macrozoobenthos	Aquatic Molluscs	Dragonflies
Slovak side - macrozoobenthos						
1	**3529**		Čunovo - Mosoni Danube	●		
2	**1203**		Rajka - Danube old riverbed	○		
3	**4025**		Dobrohošť - Danube old riverbed	●		
4	**3739**		Sap - Danube old riverbed	●		
5	**112**		Medveďov - Danube	●		
6	**3376**		Dobrohošť - river arm system, Dobrohošť channel	●		
7	**3528**		Bodíky - river arm system, Bačianske river arm	●		
Slovak side - additional qualitative samples						
8	**2600**	B-6	Dobrohošť – Dunajské kriviny, Danube old riverbed		●	●
9	**2603**	B-9	Bodíky - Bodícka brána, river arm system		●	●
10	**2604**	B-10	Bodíky - Kráľovská lúka, river arm system		●	●
11	**2608**	B-14	Gabčíkovo - Istragov, Danube old riverbed, river branch system - Foki weir		●	●
12	**2612**	B-18	Kľúčovec - Sporná sihoť, Danube, river arm system		●	●
Hungarian side - macrozoobenthos						
1	**5739**	X1	Dunakiliti - Danube old riverbed, upstream of weir, rkm 1843 (DUN_3528)	●		
2	**5735**	H11	Doborgaz - Danube old riverbed. rkm 1839 (DUN_3260)	●	●	
3	**5728**	F19	Dunaremete - Danube old riverbed, rkm 1825 (DUN_136)	●	●	
4	**5737**	GAZ	Dunasziget - Gázfűi Danube (GAZ_507)	●		
5	**5729**	F26	Kisbodak - Pálffy Island	●	●	
6	**5730**	F31	Lipót - Zsejkei channel	●		
7	**5740**	X2	Ásványráró - Lake Öntés	●	●	
8	**5741**	X3	Ásványráró - Bagoméri river arm	●	●	
9	**5738**	MOS	Dunaszeg - Mosoni Danube, dead river arm (MOS_512)	●		
Hungarian side - additional qualitative samples						
10	**5732**	H06	Lipót, Lipóti dead river arm (LIP_494)	●	●	

Legend: ○ - not evaluated in 2019

- Macrozoobenthos at least Bivalves (Bivalvia), Gastropods (Gastropoda), Leeches (Hirudinea) Crustaceans (Malacostraca), Dragonflies (Odonata), Mayflies (Ephemeroptera), Caddisflies (Trichoptera), True bugs (Heteroptera), Beatles (Coleoptera)
- Aquatic Molluscs (Mollusca), Dragonflies (Odonata - on the Slovak side larvae + imagines as a suppl.)

Table 7-1c: The list of monitoring areas - fishes, zooplankton, macrophytes

No.	ID	Name	Location	Monitored groups		
				Fishes	Zooplankton	Macrophytes
Slovak side						
1	**2600**	B-6	Dobrohošť – Dunajské kriviny, Danube old riverbed	●	●	
2	**2603**	B-9	Bodíky – Bodícka brána, river arm system	●	●	●
3	**2604**	B-10	Bodíky – Kráľovská lúka, river arm system, dead river arm	●	●	●
4	**2608**	B-14a	Gabčíkovo – Istragov, Danube old riverbed, river arm system	●	●	●
5	**2608**	B-14b	Gabčíkovo – Istragov, river arm system	●		
6	**2612**	B-18	Kľúčovec – Sporná sihoť, river arm system	●	●	●

Hungarian side						
1	**5739**	X1	Dunakiliti - Danube old riverbed, upstream of weir, rkm 1843	●		
2	**5735**	H11	Doborgaz - Danube old riverbed, rkm 1839	●		○
3	**5731**	H04	Dunasziget - Schisler dead river arm	●	●	●
4	**5734**	H09	Dunasziget - Csákányi Danube	●	●	●
5	**5736**	H12	Halászi - Zátonyi Danube	●	●	●
6	**5728**	F19	Dunaremete - Danube old riverbed, rkm 1825	●	●	
7	**5732**	H06	Lipót - Lipóti dead river arm	●	●	●
8	**5740**	X2	Ásványráró - Lake Öntés	●		●
9	**5741**	X3	Ásványráró - Bagoméri river arm	●	●	
10	**5737**	GAZ	Dunasziget - Gázfűi Danube		●	
11	**5730**	F31	Lipót - Zsejkei channel		●	
12	**5738**	MOS	Dunaszeg - Mosoni Danube, dead river arm		●	
13	**5733**	H07	Kisbodak – Danube old riverbed, rkm 1828			○
14	**5732**	X4	Bagoméri Danube	●	●	

Legend: - ○ - not evaluated in 2019
- Fishes (Osteichthyes)
- Zooplankton: Cladocerans (Cladocera), Copepods(Copepoda)
- Macrophytes (according to Kohler, also Braun-Blanquet)

7.1. Terrestrial groups

7.1.1. Phytocoenology

The left-side river branch system

On the area No. 2600 there is a community of the driest type of floodplain forest. After the revitalization interventions (the peripheral river arm and the central depression in the area are permanently supplied with water from the Dobrohošť channel), it was possible to observe light positive changes and stabilisation in previous years, but currently disintegration of the poorly developed tree layer was recorded. Under it there is a well-developed shrub layer, which gives the character to the vegetation. In the shrub and the herb layer, the bloody dogwood (*Swida sanquinea*) dominates and intensively rejuvenates. In addition to it, the dense herb layer consists mainly of nitrophilous species, while in the evaluated year a slight retreat of hygrophilous species was recorded (weak precipitation totals).

Coverage values and the species composition of the tree and the shrub layer of the poplar stand on the monitoring area No. 2603 were similar to the previous year. Slightly lower coverage values were registered in the herb layer, but the species diversity was increased. The increased representation of hygrophilous species from the last year remained also preserved, what was reflected also in increase of the ecological moisture index. The representation of the invasive himalayan balsam (*Impatiens glandulifera*) is maintained at low level, but the invasive ash-leaved maple tree (*Negundo aceroides*) achieves higher coverages in all layers.

The monitoring area No. 2604 is characterized by a stabilized willow stand. Willows were again favourably supplied with moisture, they were in a state of full foliage even during the summer. The shrub layer remains insignificant (up to 10 % of the coverage). The developed herb layer is dominated by the original nitrophilous species - European dewberry (*Rubus caesius*), common nettle (*Urtica dioica*) and goosegrass (*Galium aparine*), along with the long-term presence of the rare summer snowflake (*Leucojum aestivum*). However, after the lightening of the stand by cutting out the neighbouring trees in 2016, there is an increase in the coverage of the invasive himalayan balsam (*Impatiens glandulifera*), which already reaches coverage up to 25 %.

The woody vegetation on the monitoring area No. 2608 is created by young poplars, whose coverage gradually increases (above 30 %). The coverage of the shrub layer, consisting of rejuvenating native woody plants and shrubs, is at the level of 20 %, but the invasive ash-leaved maple tree (*Negundo aceroides*) also thrives in it. The character of the dense and closed herb layer was determined by the nitrophilous European dewberry (*Rubus caesius*) - coverage above 75 %, a weaker representation is achieved by other native nitrophilous species. The proportion of the invasive giant goldenrod (*Solidago gigantea*) is relatively high, but stable in recent years. The absence of the rare summer snowflake (*Leucojum aestivum*) continues for the fourth year, but hydrophytes have appeared in the undergrowth during the spring.

The tree layer on the monitoring area No. 2609 is created by young poplars, that reach a relatively high coverage, but use to be influenced by a long-lasting summer moisture deficit. This was insignificant in the assessed year. The shrub layer is absent for a long time. The developed herb layer in the stabilised stand was formed by the monodominant white panicle aster (*Aster lanceolatus*), the strong dominance of which decreased significantly after being flooded in 2016 and after lightening of the stand and this tendency is every year more pronounced. The representation of other native nitrophilous species, the common nettle (*Urtica dioica*) and European dewberry (*Rubus caesius*), in the assessed year already exceeds the representation of the aster. The protected summer snowflake (*Leucojum aestivum*) was absent, but the hydrophyte, greater pond sedge (*Carex riparia*), has been forming conspicuous tufts for several years. The representation of two invasive herbs is negligible.

The species composition, as well as the coverage values of the particular layers on the area No. 2612 are at similar level in recent years. Some difference was registered in the reduced coverage of the herb layer in the spring of the assessed year, due to flooding. The flood decimated the growths of nettle and grasses, the character of the stand was given by the ground ivy (*Glechoma hederacea*) and European dewberry (*Rubus caesius*). The presence of invasive herbs has not been registered, a slight presence in the herb and shrub layers achieves the invasive ash-leaved maple tree (*Negundo aceroides*). However, its presence in the tree layer is considerable, but stabilized.

The right-side river branch system

The tree layer of the hardwood floodplain forest of *Fraxino pannonicae - Ulmetum* on the area B-01 Dunasziget - forest (original designation No. 28a) is significantly closed. The herb layer was developed only mosaically due to the flooding in June, the high June temperatures, and the disturbance of the surface and eating by high game. Wider representation from the herb species achieves only the non-native invasive small balsam (*Impatiens parviflora*). Similar results were registered also before the interruption of monitoring on 2013.

The gradual transformation of the meadow character of the stand on the area B-02 Dunasziget - meadow (original designation No. 28b) into a forest stand is observed since 2013. At present, most of the former homogeneous meadow has been transformed into a maple forest. The stand was closed during the summer survey, in the autumn there was a surface disturbance on a part of the area (cutting on the adjacent area), what slightly decreased the coverage of particular layers. Under the close tree layer, the height of the herb layer is insignificant and is also disturbed by high game. The nitrophilous common nettle (*Urtica dioica*), invasive giant goldenrod (*Solidago gigantea*) and European dewberry (*Rubus caesius*) dominate.

The Derék oak-hornbeam forest near Halászi (area B-03, original designation No. 31) has not been evaluated after the resumption of monitoring (2018 and 2019).

The poplar stand on the area B-04 Lipót, Gombócos closure (original designation No. 30) was cut-out in 2011 and the area was subsequently reforested with seedlings of pedunculate oak (*Quercus robur*). The trees are currently prospering, the layer is almost closed. The shrub layer has not yet been developed, but the abundance of the bloody dogwood (*Swida sanquinea*) specimen in the herb layer indicates that a shrub layer may be formed from them in the coming years. In the undergrowth the nitrophilous common nettle (*Urtica dioica*) and the ground ivy (*Glechoma hederacea*) dominate.

The willow stand on the B-05 Dunaremete area was cut-out in 2010 and later replaced by cultivated grey poplar. Young poplars are currently prospering well, some already reaching a height of 5 meters. Closure of their crowns was at the level of 35 %, what means an increase of 10 % compared to the previous year. In the herb layer, the decline of weed species, typical after an anthropogenic disturbance - cutting-out, was confirmed. Significant dominance of European dewberry (*Rubus caesius*) is registered, followed by the more abundant white panicle aster (*Aster lanceolatus*) and common nettle (*Urtica dioica*). The presence of the bloody dogwood (*Swida sanquinea*) specimens in the herb layer indicates its future dominance in the shrub layer.

The white willow stand on the area B-06 near Vámosszabadi is almost fully closed. The coverage of the herb layer reaches 90 % (in the previous year only 60 %), although there were also mud spots and tree deposits after the June flood. In the previous year, the presence of the protected summer snowflake (*Leucojum aestivum*) was recorded in this area for the first time in this area, its occurrence was not repeated in the assessed year, but this could also be caused by the late date of phytocoenological survey. The dominant representation also in this area was achieved by the white panicle aster (*Aster lanceolatus*) and the invasive giant goldenrod (*Solidago gigantea*) also occurred relatively abundantly.

7.1.2. Terrestrial molluscs

The left-side river branch system

The malacocoenosis on the area No. 2600 still has the character of the driest type of the soft (or transient) lowland forest. In recent years, a gradual increase of the moisture value is registered, that is calculated on the basis of the moisture demand of the species present. The malacocoenosis is dominated by mesohygrophilous species - the true glass snail (*Aegopinella nitens*) and the incarnate or forest snail (*Monachoides incarnatus*), or the euryecious *Punctum pygmaeum*. The presence of hygrophilous species, e.g. hairy snail (*Trichia hispida*) is also considerable, while the proportion of species of loose vegetation decreases. Probably due to greater distance and higher position of the location, the effects of revitalizing interventions in the malacocoenosis began to be visible with a multi-year delay.

The terrestrial malacocoenosis on the area No. 2603 is observed in a young poplar stand, in which it has developed into a taxocoenosis of drier type of soft lowland forest. In the period after the flood in 2013, hygrophilous species together with mesohygrophilous representatives dominate - the white-lipped snail (*Cepaea hortensis*), hairy snail (*Trichia hispida*), bush snail (*Fruticicola fruticum*), the true glass snail (*Aegopinella nitens*). Besides them, the proportion of the polyhygrophilic short-toothed herald snail (*Carychium minimum*) also increased in the assessed year.

The terrestrial malacocoenosis on the area No. 2604 still has a strong wetland character with a dominance of forest hygrophilous and polyhygrophilous species - shiny glass snail (*Zonitoides nitidus*), short-toothed herald snail (*Carychium minimum*), amber snail (*Succinea putris*) and glossy pillar (*Cochlicopa lubrica*). The presence of rare and scarce wetland species, e.g. Alder's tawny glass snail (*Euconulus alderi*) is stable, as is the absence of anthropotolerant representatives. The moisture value of the habitat, calculated on the basis of the moisture requirements of the species present, is also consistently high.

The malacocoenoses on areas No. 2608 and 2609 re observed in young 11- and 13-year old stands, in which the native communities, registered before the clear-cut, regenerate only slowly. Signs of the malacocoenosis regeneration on the area No. 2608 began to appear 8-9 years after reforestation of the area. Due to the closure of the young stand the species number and abundance of forest hygrophilous species, e.g. amber snail (*Succinea putris*) and glossy pillar (*Cochlicopa lubrica*), is gradually increasing. At present, the return of several polyhygrophilous species of German hairy snail (*Pseudotrichia rubiginosa*) and short-toothed herald snail (*Carychium minimum*) is recorded. However, the dominant representation is still achieved by the euryecious and undemanding forest species *Punctum pygmaeum* and the true glass snail (*Aegopinella nitens*). The community has not yet been restitued to the structure before the clear-cut. The situation in terrestrial malacocoenosis on the area No. 2609 appears to be significantly favourable, the community is formed by hygrophilous and polyhygrophilous species - the shiny glass snail (*Zonitoides nitidus*), glossy pillar (*Cochlicopa lubrica*) and the copse snail (*Arianta arbustorum*). At present, the malacocoenosis is located in a distinctly hygric part of the moisture gradient, the representation of the xerophilous species is already stably insignificant - the Viennese banded snail (*Caucasotachea vindobonensis*).

The malacocoenosis on the area No. 2612, due to regular flooding, is in long-term formed by a mixture of hygrophilous, mesohygrophilous and euryecious species. In the assessed year, the mesohygrophilous and polyhygrophilous species dominated - the incarnate or forest snail (*Monachoides incarnatus*) and amber snail (*Succinea putris*). The site is located on the boundary between the mezic and more hygric part of the ordination diagram, so it has relatively good moisture conditions.

The right-side river branch system

The monitoring of terrestrial malacocoenosis is carried out in on six areas by random collecting (sifting of riparian deposits and soil, raking the undecomposed litter, collecting from undergrowth and some trees). Because the samples are not collected in a targeted manner but by random collection, capture of rare species is less frequent. In the assessed year, the occurrence of almost half of the species living in the Szigetköz was confirmed, but the populations were mostly very poor. Increased numbers were recorded in the case of some hygrophilous terrestrial species - the short-toothed herald snail (*Carychium minimum*), bush snail (*Fruticicola fruticum*), the copse snail (*Arianta arbustorum*), and on several sites the glossy pillar (*Cochlicopa lubrica*). Besides them, however, the dominant representation on three sites is achieved also by the euryecious *Punctum pygmaeum*. The greatest species richness was registered on the area No. F26 on the Pálffy island, on the area No. X2 at the Lake Öntés and on the area No. X3 at the Bagoméri river arm, but most of species reached the abundance only at the level of a few individuals. Re-occurrence of protected species from the last year - the strawberry snail (*Trichia striolata*) and endemic Danubian blind snail (*Bythiospeum oshanovae*), has not been confirmed. The malacological results of the evaluated year indicate a long-lasting drought. The terrestrial snails did not stay on the plants at all, they hid under the undecomposed litter due to the intense sunlight. In addition, it is true, that practically the whole Szigetköz is influenced by anthropogenic activity.

7.1.3. Northern Pannonian vole (*Microtus oeconomus mehelyi*)

The introduction of monitoring of the northern vole was agreed by experts of both Parties, who also agreed on a common monitoring methodology. Monitoring in 2019 was carried out for five days (4 nights) in mid-October and in November. However, due to the spatial differences of monitoring sites, a higher number of animal traps was used on the Hungarian side - 55 pieces, while on the Slovak side 44 pieces. On the site No. 2604, due to the changed hydrological conditions in the evaluated year, it was necessary to adjust the distribution of traps. These differences, as well as the changed hydrological conditions, need to be taken into account when evaluating the results of monitoring.

The left-side river branch system

Monitoring of the Northern Pannonian vole (*Microtus oeconomus mehelyi*) began in 2018 and is carried out on two sites

On the first site, 44 traps were placed in a terrain depression on the area No. 2604, overgrown with sedges (*Carex sp.*) with irregular occurrence of self-seeding shrubs and dense growth of common reed (*Phragmites australis*). After cleaning the pipeline under the road on the line F, the site during the autumn of 2019 was flooded already for a long time, the traps were distributed in non-flooded parts of the area as close as possible to the sedges. During 5 days, a total of 200 small terrestrial mammals were captured, but the presence of the Northern Pannonian vole was not registered. Even the reposition of traps to the waterlogged part of the habitat, after a further decrease of the water level, did not lead to the capture of the Northern Pannonian vole. It is probable, that the changed hydrological condition during most of the year caused the population to move to another part of the habitat. Among the captured individuals of small terrestrial mammals, the striped field mouse (*Apodemus agrarius*) and the yellow-necked field mouse (*Apodemus flavicolis*) dominated.

In mild depression on the area No. 2609, which is a remnant of a dead arm, 11 traps were placed in four lines (a network of 44 traps). Most traps were located in the central part of the depression, which is overgrown with sedges (*Carex sp.*). One side of the marginal part of the depression is overgrown with common reed (*Phragmites australis*), on the other side willows grow. During the five day monitoring, a total of 188 small terrestrial mammals were captured, of which the striped field mouse (*Apodemus agrarius*) dominated. The Northern Pannonian vole (*Microtus oeconomus mehelyi*) was caught in 22 cases. Based on the marking of captured individuals, it can be stated that 15 different specimens were captured, consisting of 6 females, 7 males and 2 juvenile individuals, some of which were captured repeatedly. Compared to the previous year, it can be stated that with the increase in the total number of caught individuals of the small terrestrial mammals by about 80 % (from 103 to 188), the population of the Northern Pannonian vole was almost fourfold.

The right-side river branch system

The monitoring of the Northern Pannonian vole on the Hungarian side in 2018 and 2019 was carried out in the flood-protected area on the site H-06 at Lipót, the Lipóti marsh and in the floodplain on the site F26 at Kisbodak on the Pálffy Island. Based on the results of two years, it can be stated that the species forms stable populations in the monitored area, but the results of captures are different on both sites. The gender ratio was relatively balanced. The results in the case of both sites indirectly point to a favourable water supply , as well as to a high groundwater level in the recent period.

A total of 17 catches of the Northern Pannonian vole (*Microtus oeconomus mehelyi*) were recorded on the site at the Lipóti marsh, including repeated catches, which is a significant decrease compared to the previous year (70 individuals). However, this was partly caused by the earlier decline of waterlogged parts of the reed stand due to low Danube water levels, as well as the onset of the winter regime in the water supply system and the subsequent transfer of a part of the population to the inner part of the reed stand. From the 17 captured specimens of the Northern Pannonian vole (*Microtus oeconomus mehelyi*), 7 different individuals were identified, consisting of 4 females and 3 males. A total of 240 small terrestrial mammals were captured on the site, dominated by the invasive striped field mouse (*Apodemus agrarius*) and the common vole (*Microtus arvalis*).

On the Pálffy Island, 31 catches of the Northern Pannonian vole (*Microtus oeconomus mehelyi*) were recorded (39 in the previous year), of which the repeated catches accounted a larger share than on the site at Lipóti marsh. From the captured individuals, 12 different specimens were identified, consisting of 6 females and 6 males. A total of 189 small terrestrial mammals were captured by traps. The dominant species was the invasive striped field mouse (*Apodemus agrarius*) and the bank vole (*Myodes glareolus*) was also abundant. In he previous year, the population of the Northern Pannonian vole (*Microtus oeconomus mehelyi*) on this site was significantly smaller than in the flood-protected area (Lipóti marsh site), with a significant female predominance.

7.2. Aquatic groups - Macrozoobenthos

The Danube

The macrozoobenthos in the upper part of the Danube old riverbed is assessed at locality No. 4025 - Dobrohošť, approximately in rkm 1839.6. Based on the species composition, it can be stated that rheophilic and oxybiotic species indicating β-mesosaprobity prevail in macrozoobenthos. The dominant species in 2019 were from aquatic molluscs the gravel snail (*Lithoglyphus naticoides*) and the invasive river nerite (*Theodoxus fluviatilis*), however, it could be stated that the malacocoenosis of the Danube was relatively rich in species, but the representatives achieved low abundance. Furthermore, the *Limnomysis benedeni* from crustaceans and representatives of Chironomidae gen. sp. div. and Lumbriculidae gen. sp. div. were abundant, and with low number of representatives the relatively rich in species *Amphipoda* community was present. The current results in terms of communities of mayflies, caddisflies and dragonflies document only a rare occurrence of representatives.

Site No. 3739 is situated in the Danube old riverbed at area of Sap, approximately 1 km upstream of the confluence with the tail-race channel. In this section of the Danube old riverbed, the flow of water is slowed down and in the composition of macrozoobenthos the stagnophilic and oligooxybionic species increase, withstanding milder pollution. Macrozoobenthos samples were generally poor in the assessed year. Relatively rich in species community was formed by crustaceans (*Amphipoda*), which consisted mainly of *Dikerogammarus sp.* and *Echinogammarus sp.*. From among the other groups abundant occurrence achieved representatives of Lumbriculidae and Chironomidae gen. sp. div. and two non-native mollusc species (*Theodoxus fluviatilis, Corbicula fluminea*). The mayflies communities in the samples of the evaluated year were absent, caddisflies and dragonflies were represented very weakly, mainly by rheophilic species.

The site No. 112 is situated by the bridge at Medveďov and macrozoobenthos samples are taken from the left bank of the Danube, approximately in rkm 1806.4. The macrozoobenthos samples taken in the assessed year were poor. From among the aquatic molluscs, mostly the invasive species were recorded: the river nerite (*Theodoxus fluviatilis*) and the zebra mussel (*Dreissena polymorpha*) with sparse abundance. In a very large abundance, two species of crustaceans from the amphipods were registered in the macrozoobenthos sample: *Dikerogammarus villosus* and *Echinogammarus ischnus*. Mass occurrence was found during the autumn sampling in the case of Lumbriculidae gen. sp. div.. In the samples, similarly to the previous year, a rare occurrence of larvae of semi-rheophilic to typical Danube mayflies and caddisflies was detected. Dragonflies were not caught in the assessed year.

The evaluation of the Danube macrozoobenthos on the Hungarian side was to be carried out in three profiles in terms of the optimization - in rkm 1843 (monitoring area X1), rkm 1839 (monitoring area H11) and in rkm 1825 (monitoring area F19). In the Hungarian National Report, however, the ecological status of the Danube is assessed on sites Dun_3258 in rkm 1843, Dun_3260 in rkm 1840 and Dun_123 in rkm 1823. The results indicate a moderate ecological status of the river, with the exemption of the area at Dunasziget with a poor ecological status. During the sampling, rich communities of aquatic molluscs were recorded in old riverbed, besides the ubiquistic - invasive species, there were also several native Danube species and species preferring weaker water flow and muddy bottom. From among leeches and crustaceans, mainly the widespread rheophilic species were registered, but coastal habitats with autochthonous organic deposit were inhabited also by stagnicolous and marshy species. From the point of view of the dragonfly community, the presence of a very poor community was recorded on all areas, consisting of eurytopic and common Danube species, or the community was missing in the sample. Mayflies and caddisflies were not registered in the samples.

The left-side river branch system

Based on the evaluation results of macrozoobenthos samples taken on the site No. 3376 in the Dobrohošť channel, it can be stated that the communities of aquatic molluscs and dragonflies are richer in species in the branches of the upper part of the inundation, while a more significant representation is achieved mainly by undemanding or rheophilic species. From the aquatic molluscs the bladder snail (*Physella acuta*), gravel snail (*Lithoglyphus naticoides*), river nerite (*Theodoxus fluviatilis*) and tentacled bithinia (*Bithynia tentaculata*) dominated, while from among the dragonflies they were the blue featherleg (*Platycnemis pennipes*) and banded demoiselle (*Calopterix splendens*). From the other groups, these were mainly representatives of the families Chironomidae gen. sp. div. and Lumbriculidae gen. sp. div.. Only a rare occurrence of several mayflies and caddisflies species were captured in the samples.

The macrozoobenthos in the inundation area is observed at site No. 3528, in the through-flowing Bačianske river arm before its mouth into the Danube old riverbed. Based on the evaluation of the samples, it can be stated that there is a relatively rich community of aquatic molluscs in the arm, but invasive species achieve a more significant representation. In the malacocoenosis the zebra mussel (*Dreissena polymorpha*), river nerite (*Theodoxus fluviatilis*), tentacled bithinia (*Bithynia tentaculata*) and bladder snail (*Physella acuta*) dominated. From the crustaceans abundant occurrence achieved species *Corophium curvispinum* and *Echinogammarus ischnus*. From among the other groups, they were mainly representatives of the family Lumbriculidae gen. sp. div. and four species of the family Simuliidae, which achieved a mass occurrence in the spring. Communities of mayflies and dragonflies were very poor, but a total of three species from both communities were captured in this year's samples. Although from the species diversity point of view, a relatively large number of caddisflies species (9) was registered, the species occurred only rarely or scattered, and species of various ecological demands were represented, from rheophilic to species bind to macrophyte growth.

The right-side river branch system

The composition of macrozoobenthos on the site F26 Kisbodak in the deep river arm above the closure on the Pálffy Island is similar to the Danube fauna in both years assessed. In 2018, 24 species registered, in the evaluated year it was 22 species. In the case of molluscs, the invasive river nerite (*Theodoxus fluviatilis*) reached a higher abundance, and in August also the New Zealand mud snail (*Potamopyrgus antipodarum*) indifferent to the flow. Another non-native species - the Asian clam (*Corbicula fluminea*) shows a permanent presence, but with slight abundance. In the case of dragonfly and caddisfly communities, some rheophilic and semi-rheophilic representatives were characteristic: the banded demoiselle (*Calopterix splendens*), blue featherleg (*Platycnemis pennipes*) and the caddisfly *Anabolia furcata*.

On the site F31 near Lipót, in the overgrown Zsejkei channel, 28 species were captured in 2018 and in the assessed year only 19. The representation of molluscs was again sporadic, the crustaceans (mass abundant the non-native species *Dikerogammarus villosus*) and aquatic insects dominated. With higher abundance, especially in the spring, one semi-rheophilic and one rheophilic dragonfly species were registered - the blue featherleg (*Platycnemis pennipes*) and banded demoiselle (*Calopterix splendens*).

In the stagnant water of the Lake Öntés, on the site X2 near Ásványráró 33 species of macrozoobenthos were captured in 2018, and only 25 in the assessed year. Representatives of aquatic molluscs, except the tentacled bithinia (*Bithynia tentaculata*) indifferent to the flow, showed slight abundance, including the non-native ubiquistic acute bladder snail (*Physella acuta*), the invasive Asian clam (*Corbicula fluminea*) and the Chinese pond mussel (*Sinanodonta woodiana*). The last year's richer odonatocoenosis became impoverished, only sporadic occurrence of four species was recorded. The most abundant were species of the chiromonids family (*Chironomidae*).

The deep water of the Bagoméri river arm, on the site X3 site near Ásványráró, can be considered a richly inhabited habitat. In the river arm, the presence of 31 species was confirmed in the previous year, in the assessed year it was 33 representatives. The proportion of aquatic molluscs was relatively large, there were both rheophilic and stagnicolous species. The most abundant were the populations of tentacled bithinia (*Bithynia tentaculata*) and gravel snail (*Lithoglyphus naticoides*). From among the aquatic insects the presence of the mayfly community was confirmed, formed by the undemanding mayfly *Cloeon dipterum*, the community of dragonflies was composed of four species - the more abundant eurytopic blue-tailed damselfly (*Ischnura elegans*) and the rheophilous blue featherleg (*Platycnemis pennipes*), while the caddisfly community was recorded only in spring and consisted of the only semirheophilous species *Anabolia furcata*. Most of the captured species are common in the Szigetköz. Similar conclusions can be also stated on the basis of a sample taken from the Bagoméri river arm for the purpose of evaluating the watercourse ecological status, but it should be added that no protected species was detected in the arm. The water quality in the assessed year appeared to be average.

The assessment of macrozoobenthos in the frame of biological monitoring was further planned at the sites Gazfűi Danube (GAZ) and the dead arm of the Mosoni Danube (MOS) at Dunasziget. In the Hungarian National Report, sites that are evaluated in terms of ecological status of waters are marked as GAZ_507 and MOS_512, and similarly is evaluated also the site in the Lipót dead river arm (LIP_494). The observed section of the Gazfűi Danube shows a very poor ecological status, while in the previous year it showed a poor status, as it was also before the interruption of monitoring in 2013. These results stem from the low number and abundance of type-specific species, as well as from the overall poor inhabitancy of the arm. The odonatocoenosis consisted of four species, the presence of three species of crustaceans and a single semi-rheophilic mayfly, an ubiquistic mollusc specie and river caddisfly was further confirmed in the macrozoobenthos sample. The ecological status of the assessed section of the Mosoni Danube was good in the previous year, similarly as in the period between the years 2006-2013 (with the exception of the year 2007, when it was assessed as high status). This level was maintained only until the summer of 2019, in the later autumn term the ecological status was assessed as poor. In terms of individual communities, the highest number of species was recorded in the case of molluscs and crustaceans. In the malacofauna, species of more flowing sections are mixed with typical species of almost stagnant waters. The crustaceans were dominated by characteristic Danube species. The mayfly, caddisfly and dragonfly communities were very poor in species. From among molluscs several protected species were present (*Fagotia daudebartii acicularis, Fagotia esperi, Borysthenia naticina*). The Lipóti dead arm, which is located on the flood-protected area, provides a diverse habitat structure and is characterized by the richest macrozoobenthos fauna from among all areas. As the dead arm is considered as standing water, it cannot be included into the category of flowing waters, for which the ecological status has been assessed. As in the previous year, the highest species richness was registered in the communities of molluscs and dragonflies. The malacofauna consisted mainly of species of stagnant waters and swamps. In the case of dragonflies, besides marshy species also species with a wide ecological valence were captured. In the river arm, the presence of an endangered mollusc species was proved - the little whirlpool ramshorn snail (*Anisus vorticulus*), and the European medicinal leech (*Hirudo medicinalis*).

7.2.1. Aquatic molluscs

The Danube

The evaluation of aquatic malacocoenoses of the Danube in the previous years was based on data provided by the Slovak Party (Slovak observation areas No. 2600, 2608 and 2612). Based on these data, the entire stretch of the Danube (derived section and the section downstream of the confluence of the tail-race canal with the Danube old riverbed) in the period 2005-2013 was characterized by a poor malacofauna. The turning point of decline in species number and abundance recorded in 2005 was evoked by an extraordinary expansion of the non-native, invasive river nerite (*Theodoxus fluviatilis*). The gradual disappearance of most species in the following years was probably caused by interaction of another factors (hydrological, trophic, physical and chemical). The malacofauna of the Danube has been regularly supplemented only by the ubiquistic zebra mussel (*Dreissena polymorpha*). After the flood in 2013, the communities were significantly enriched with species that were flushed out from the arms in the inundation (species dependent on stagnant or slow-flowing water). Similar species richness of malacofauna persists on the area No. 2600 in the diverted section (12 species), but with an alarming increase in abundance of the invasive theodox in the assessed year (more than 5700 individuals.m^2). The dominant representation in the Danube old riverbed is achieved by non-native and eurytopic species, most of the present representatives do not form stable populations, their occurrence depends on the connectivity of river habitats upstream of the studied profile during increased water levels. The malacocoenosis on the area No. 2608 (in the area upstream from the confluence) was also characterized by an increased number of representatives, which was not observed in the previous year. Besides the stable occurrence of two non-native species, the river nerite (*Theodoxus fluviatilis*) and the zebra mussel (*Dreissena polymorpha*), the presence of four others representatives as recorded, including the rheophilic taxon *Esperiana sp.*. Downstream of the confluence, on the area No. 2612, a turning point occurred in the assessed year, when only a few specimens of an invasive and ubiquistic species were captured - the river nerite (*Theodoxus fluviatilis*) and the zebra mussel (*Dreissena polymorpha*).

After the resumption of monitoring on the Hungarian side in 2018, data from the localities H-11 in rkm 1839 and F-19 in rkm 1824 are also available. In the evaluated year, due to the low autumn water levels at the time of sampling, a significant decline of species was observed. Higher abundance on the gravel bed achieved only the invasive river nerite (*Theodoxus fluviatilis*), and shells of the *Corbicula* genus on the muddy bottom. Even, no ubiquistic zebra mussel (*Dreissena polymorpha*) was observed. The Hungarian Party also took a macrozoobenthos sample to determine the water quality at Dunakiliti, At Lipót and At Dunasziget. These samples showed the presence of a richer mollusc fauna in the Danube, which, besides the rheophilic species, was formed also by species preferring weak water flow and muddy bottoms. The presence of several protected species (*Fagotia daudebartii acicularis, Borysthenia naticina, Pseudanodonta complanata*) was also confirmed.

The left-side river branch system

Aquatic mollusc communities in the river branch system on the Slovak side are monitored on areas No. 2603 and 2604. In the previous period, signs of destruction of the malacocoenosis were registered on both areas, but after the flood in 2013, positive changes have been observed in terms of the development of communities. Their persistence were also confirmed in the assessed year. The area No. 2603 is characterized with suitable conditions for the development of a stabilized mollusc community, the presence of 20 species was recorded, most of which achieve multiple occurrence in samples during the year. Non-native species indifferent to the flow, eurytopic and ubiquistic species - the tentacled bithinia (*Bithynia tentaculata*), acute bladder snail (*Physella acuta*), the New Zealand mud snail (*Potamopyrgus antipodarum*), continue to achieve a high abundance. Several rare species, that were absent in previous years, were also recorded - *Ferrisia fragilis*, *Musculium lacustre*, the bladder snail (*Physa frontinalis*), the Flat valve snail (*Valvata cristata*). The malacofauna of the dead arm on the area No. 2604 as made up of 9 representatives due to the relatively favourable hydrological situation, while the community was rich also from the abundance point of view. It is also possible to evaluate positively the persistent return of large snails, the great ramshorn snail (*Planorbarius corneus*) and the great pond snail *Lymnaea stagnalis*.

<u>The right-side river branch system</u>

The monitoring of aquatic malacofauna was last performed in 2013, when only samples from the Pálffy Island (site F-26) were evaluated. Since 2018, the monitoring of aquatic molluscs in the river branch system was extended by another 3 areas (X2 - Lake Öntés, X3 - Bagoméri river arm, H06 - Lipóti dead arm). Although the recorded communities were relatively rich in species at the time of sampling, only the big-ear radix (*Radix auricularia*), Flat ramshorn snail (*Planorbis planorbis*) and the Flat valve snail (*Valvata cristata*), which prefer overgrown waters, achieved more significant number of individuals. Most species occurred in the abundance up to 10 individuals in samples. Rare and protected species have not been recorded. It should be noted that aquatic malacocoenosis was affected by long-lasting low water levels, when snails died after exposing the river arm bottoms, or retreated to the deeper parts of river arms. Due to the absence of significant changes of water levels during the year, no sediment deposits were formed on the banks of the river arms, which usually hide the shells of species present. The reproduction of molluscs was further inhibited by the widespread common duckweed, forming large spots on the water surface.

Further information on the development of aquatic malacocoenoses of the Danube floodplain are also provided by macrozoobenthos samples from another 3 sites (GAZ - Gazfűi Danube, F31 - Lipót, Zsejkei channel, MOS - dead arm of the Mosoni Danube), which are evaluated by the hydrobiological assessment of surface water quality. Only 2-3 mollusc species were captured in the Gázfűi Danube and the Zsejkei channel at Lipót. The species diversity of the malacocoenosis of the Mosoni Danube was similar to that in the areas evaluated above, but it decreased in the autumn.

7.2.2. Dragonflies (*Odonata*)

Additional qualitative monitoring of the dragonfly community is carried out only by the Slovak Party. Monitoring is carried out on two complex monitoring areas in the Danube and on four complex monitoring areas in the river branch system.

<u>The Danube</u>

The macrophyte vegetation in the coves of the riparian zone of the Danube old riverbed on areas No. 2600 and 2608 theoretically provide suitable habitat for the occurrence of dragonfly community. However, the odonatocoenoses are poor in species and abundance in long-term, with frequent absence of representatives, or the whole community in individual samples. In the evaluated year, the rheophilous banded demoiselle (*Calopterix splendens*) with low abundances was captured on both observed Danube sites. Besides it, also the semi-rheophilous blue featherleg (*Platycnemis pennipes*) and eurytopic blue-tailed damselfly (Ischnura elegans) were recorded on the area No. 2600.

The left-side river branch system

Diverse and species rich dragonfly community was registered again in the river arm on the area No. 2603, what indicates the diversity of the habitat. In the odonatocoenosis also in the evaluated year eurytopic and stagnicolous species dominated, but only the blue-tailed damselfly (*Ischnura elegans*)achieved an abundant occurrence.

After flushing of the dead arm on the area No. 2604 in 2013, the odonatocoenosis was enriched and the high number of species remains preserved also in the present (18 species in 2018, 17 species in the assessed year). In terms of abundance, the most significant are he stagnicolous species demanding overwarmed waters with plenty of macrophytes, e.g. the small red-eyed damselfly (*Erythromma viridulum*), besides which a higher abundance achieved also the blue-tailed damselfly (*Ischnura elegans*). The river arm is one of the most valuable habitats.

The monitoring of dragonflies at the Foki weir on the area No. 2608 was resumed in 2014. At present, the results document the presence of rich in species and abundant odonatocoenosis (20 species captured in 2018, 15 species in the assessed year), in which mostly the stagnicolous and eurytopic species dominate. A mass occurrence in the summer showed the stagnicolous small red-eyed damselfly (*Erythromma viridulum*) and the eurytopic black-tailed skimmer (*Orthetrum cancellatum*).

Diverse habitats (periodic waters, smaller and larger river arms) on the area No. 2612 provide relatively favourable conditions for the occurrence of dragonflies with different ecological demands, with the dominance of eurytopic and stagnicolous species - e.g. the azure damselfly (*Coenagrion puella*) and the green emerald damselfly (*Lestes viridis*). A total of 14 species were recorded, but only the spring sample was rich in species.

7.3. Aquatic groups - Fishes *(Osteichthyes)*

The Danube

The evaluation of the ichthyofauna of the Danube old riverbed is based on the results of the Slovak observations on monitoring areas No. 2600 at Dobrohošť and No. 2608 at Gabčíkovo, and the results of the Hungarian observation on the monitoring site X1 at Dunakiliti, upstream of the submerged weir, on the site H11 at Doborgaz, downstream of the submerged weir, and on the site F19 at Dunaremete. Based on the results from Slovak monitoring areas (which partially already do not correspond to eupotamal) it can be stated that the ichthyocoenoses in this section of the Danube is stabilized in recent years, with medium-high species diversity (usually 8-13 species), and with a relatively low abundance. Based on the Hungarian results, the species richness of the ichthyofauna is more than doubled. During 2019, 22 to 24 species were recorded at individual localities, a total of 28 different species (similar to the previous year). The regular presence of rheophilic and semirheophilic representatives has been confirmed on both sides, but eurytopic fishes dominate. The highest abundance was achieved by the common bleak (*Alburnus alburnus*) and common roach (*Rutilus rutilus*). The proportion of invasive species as lower compared to the previous year, the species do not behave invasively (species of the genus *Neogobius* and the common sunfish (*Lepomis gibosus*)). Endangered, vulnerable and rare species such as *Zingel zingel*, *Zingel streber* and vimba (*Vimba vimba*), occurred as well.

The left-side river branch system

In the stabilized, rich in species and abundant ichthyocoenosis on the area No. 2603 (water supplying river arm) has long-been dominated by eurytopic and indifferent fishes. At present, it is mainly the eurytopic common bleak (*Alburnus alburnus*), which accounts up to a half of the total fish abundance. In previous years, there has been recorded an increase in the proportion of invasive species of the genus *Neogobius sp.* and the common sunfish (*Lepomis gibosus*). However, this tendency was interrupted in the previous year and in the assessed year their representation only slightly exceeded 10 %.

The ichthyocoenosis of the dead arm on the area No. 2604 was temporarily enriched after its flushing in 2012-2013. In the following years, a gradual decline of species was observed. In the previous year, however, this tendency reversed again, higher species richness (11 species) and double to triple abundance of ichthyocoenosis was recorded. This tendency is probably related to the recovering of the shallow arm supplying water from the river branch system during higher water levels. The dominant position achieve undemanding species: the goldfish (*Carassius auratus*), common roach (*Rutilus rutilus*) and common sunfish (*Lepomis gibosus*), but still occur species that are able to survive at higher water temperature and lack of oxygen.

The development of ichthyocoenosis in river arms on two sub-sites on the area No. 2608 (upstream and downstream of the Foki weir) is significantly influenced by the current water regime. If the observed parts of the river branch communicate with the main stream, the number of species and the abundance of fishes is stable and high. When the water level decreases, fishes are receding and also the influence of fish-eating birds becomes stronger. In recent years, enrichment of the species diversity of ichthyocoenosis can be registered during increased water stages. The part of the river arm upstream of the Foki weir is usually connected with the main stream by a shallow, grounded connection channel. The part of the river arm downstream of the Foki weir communicates with the Danube through its lower outlet. Both fish communities were rich in species also in the evaluated year, the presence of 19 species were recorded upstream of the weir and downstream there were 15 representatives. On both sites several rheophilic species were present, but eurytopic fish species dominated - the common bleak (*Alburnus alburnus*) and common roach (*Rutilus rutilus*). Significantly higher abundance of fishes was captured downstream of the weir. Invasive species have been present in both parts of the river arm for a long time with a relatively low abundance. The species of the genus *Neogobius* show a retreat, the common sunfish (*Lepomis gibosus*) reaches a dominance of about 13 %.

The ichthyocoenosis of the shallow, muddy river arm on the area No. 2612 is poor in species and abundance in recent years. Its temporary enrichment usually occurs after flushing the river arm, but the fishes subsequently die in conditions with lack of oxygen and the influence of fish-eating birds. During the spring and autumn of the evaluated year, the river arm was dried, fishes were registered only during the summer sampling. The abundance of the non-native, undemanding goldfish (*Carassius auratus*) was extremely increased and abundant was also the eurytopic common rudd (*Scardinius erythrophthalmus*).

The right-side river branch system

Monitoring of the ichthyofauna on the Hungarian side was resumed in 2018 after a four-year suspension, and at the same time, in accordance with the approved optimization, the number of monitored areas also increased from four to seven. In the area of inundation, the ichthyofauna was assessed in the Csákányi river arm (H09), in the Schisler river arm (H04), in the Lake Öntés (X2), in the inner Bagoméri river arm (X3) and in the Bagoméri river arm (X4). thanks to various habitats in the inundation, a total of 27 fish species were confirmed in these localities. Abundant occurrence in all sites (similarly to the previous year) show the eurytopic or limnophilic species - the common bleak (*Alburnus alburnus*), common roach (*Rutilus rutilus*) and bitterling (*Rhodeus sericeus*). In the flowing sections, stable populations of rheophilous species were also formed: the common barbel (*Barbus barbus*), common nase (*Chondrostoma nasus*), common orfe (*Leuciscus idus*) and common chub (*Squalius cephalus*). In the evaluated year the water levels were low during sampling, the portion of flowing sections was lower, therefore the abundance of rheophilic species was reduced.

In very slow flowing or stagnant waters on the flood-protected side (on the areas of Zátonyi Danube - H12 and the Lipóti dead arm - H06) the species richness of the ichthyofauna is lower (16 species in total) and consists of limnophilous and eurytopic species, e.g. the common roach (*Rutilus rutilus*) and common bleak (*Alburnus alburnus*). The abundance of the common rudd (*Scardinius erythrophthalmus*) decreased and the abundance of the common sunfish (*Lepomis gibosus*) increased.

7.4. Aquatic groups - Zooplankton (Water fleas - *Cladocera*, Copepods - *Copepoda*)

The Danube

The evaluation of the development of water fleas and copepods communities has long been based on the results of the Slovak Party on the monitoring areas No. 2600 and 2608, which are situated on the diverted stretch of the Danube. After the resumption of Hungarian observations, the list of monitoring areas in this section was expanded by two areas (F19, H07).

Based on Slovak results, the cladocerans and copepods communities have been unstable in the recent years and poor in species and abundance, but after the strong flood in 2013 they were enriched. Increased numbers of species were partially maintained at higher levels also in the following years. In the last two years, however, both taxocoenoses are very poor in species and abundance, in several samples the communities were absent. On the area No. 2600, cladocerans were missing in all three samples, while on the site No. 2608 they formed a relatively rich community during the summer, consisting mainly of phytophilic species. The copepods communities on both areas were formed by only 1-2 non-native species, while the populations were created by only few individuals.

After the resumption of monitoring, the Hungarian results also confirm the existence of communities very poor in species (1-4 cladocerans and copepods species) and abundance (often only 1-7 individuals). Water flees in the spring samples of the assessed year completely absent, in the summer the presence of the only pelagic species (*Bosmina longirostris*) was confirmed. Two species were registered from the copepods, mainly juveniles, with very low abundances.

The left-side river branch system

As for the cladocerans community on the area No. 2603, the existence of species rich community can be stated, especially in the littoral of the river arm (the autumn sample from the medial did not contain any representatives). The medium-rich copepods community is stabilized, while inhabited is mainly the littoral part of the river, overgrown by various vegetation. In both communities, the tychoplanktonic species, typical for the Danube region, continued to dominate (cladocerans: *Scapholeberis mucronata*, *Alona sp.*, *Pleuroxus sp.*, copepods: *Eucyclops sp.*).

After interrupting the isolation of the dead river arm on the area No. 2604, as a result of the flood in 2013, the cladocerans and copepods communities were enriched, but from 2018 onwards impoverishment is observed again. Poor plankton was recorded mainly in the medial of the river arm, the littoral was inhabited slightly richer. The previous dominants of the communities were the euplanktonic species, which, however, retained their dominance in the assessed year only in the community of copepods in the medial of the river arm. The site is considered a faunistically important habitat in terms of planktonic crustaceans.

The tendency of the last year's impoverishment of planktonic crustaceans in the arm on the site No. 2608 did not continued in the assessed year. Both communities were moderately rich, mainly in the spring. However, there is an increase in the proportion of tychoplanktonic species, while in the previous years the euplanktonic species usually dominated in the communities (in the case of cladocerans: *Chydorus sphaericus*, *Scapholeberis sp.*, in then case of copepods: *Eucyclops sp.*, *Macrocyclops sp.*).

After the intensive flushing of the river arm on the area No. 2612 in 2013 and the probable communication of the river arm with the inundation, the cladocerans and copepods communities were enriched in the following years. The tendency of shallowing and gradual terrestrification of the river arm was interrupted, but in the previous year, due to low water stages, impoverishment of water fleas community was recorded. Although the total species diversity registered during 2019 was slightly higher (14 species with a predominance of tychoplanktonic species), it should be emphasized that the summer sample was very poor and the community in the autumn sample was absent. In the case of copepods, the relatively low species richness (8 species in 2018 and 2019), as well as the atypical slight dominance of euplanktonic representatives (*Mesocyclops leucarti*, *Eurytemora velox, Cyclops strenuus*) have been preserved.

<u>*The right-side river branch system*</u>

Until 2013, the sampling of planktonic crustaceans was carried out on four areas. After the resumption of monitoring in 2018, the list of areas was expanded by another six areas in the floodplain, but also on the flood-protected area. The number of samples was increased to two per year. Last year's results confirmed the justification for taking three parallel samples at both sampling dates to capture more complete communities, on the basis of which they were carried out also during sampling in the evaluated year.

In the Schisler river arm (site H-04 - floodplain), 27 species of planktonic crustaceans were registered, which means significantly richer communities compared to the previous year (10 species). The communities showed the highest abundance from among the observed areas. The euplanktonic water flea species *Bosmina longirostris* and in the spring the euplanktonic cladoceran *Eurytemara velox* showed a mass occurrence.

The stable ecological conditions of the Lipóti marsh (site H-06) were characterized by a long-term relatively balanced number of species of planktonic crustaceans. In the year 2013, 12 species were recorded, after resumption of the monitoring in 2018 11 species, but in the assessed year the species richness increased to 21 species. Communities continued to consist mainly of species typical for stagnant waters, bound to macrophytes. Slightly higher was the abundance of species *Chydorus sphaericus*, *Pleuroxus denticulatus*, *Eucyclops serrulatus*, the other species in the samples were represented by only a few individuals (1-4).

The occupancy of the Csákányi Danube (site H-09) has been weak for a long time, which may be related to a stronger water flow. In 2018, the presence of seven species of planktonic crustaceans was recorded, while in the assessed year ten species was registered. Their representation was very insignificant, mostly 1-3 individuals in the samples.

The monitoring site in the Zátonyi Danube (site H-12) is located in the flood-protected area. The number of registered species of planktonic crustaceans was 20 in the previous and also in the assessed year. It should e noted, that in 2013 no occurrence of cladocerans or copepods was recorded. In the assessed year, besides the last year's phytophilous species and species of stagnant waters associated with macrophyte stands (*Chydorus sphaericus*, *Simocephalus vetulus*, *Ceriodaphnia quadrangula*), euplanktonic and benthic species (*Acanthocyclops robustus*, *Alona affinis*) were also recorded.

Monitoring on the site X2 - Lake Öntés was started only in the year 2018, when the samples showed the presence of 5 species of water fleas and 3 species of copepods, while the abundance of species was low. In the evaluated year, the species richness of communities increased to 18 species, of which bout half (mainly the tychoplanktonic representatives) showed also a higher abundance.

In summary it can be stated, that the species richness of planktonic crustaceans was increase in the evaluated year. The presence of several rare species of Szigetköz has been confirmed. On the other hand, it have to be stated that the non-native water flea *Pleuroxus denticulatus* and the non-naive copepod *Eurytemora velox* have been domesticated in the Szigetköz.

After the resumption of monitoring the following areas have been observed since the previous year: X3 - Ásványráró, X4 - Bagoméri river arm, GAZ - Gazfűi Danube, F-31 - Zsejkei channel and MOS - dead river arm of the Mosoni Danube, where the sampling is performed with a 30-litre bucket or a transparent sampling tool. A total of 42 species of planktonic crustaceans were captured, what means a more significant increase compared to the previous year (28 species), especially in the case of copepods. From among the cladocerans, the most frequently detected were the tychoplanktonic water flea *Chydorus sphaericus* and the euplanktonic water flea *Bosmina longirostris*, as well as the species of the genera *Alona* and *Pleuroxus*. In the case of copepods, the juvenile stages of tychoplanktonic species of *Eucyclops serrulatus* and *Macrocyclops albidus* dominated. The number of species and the abundance of individual representatives in the monitoring areas showed a relation to the speed of water flow current. At higher speeds, a decrease in the species number and abundance was registered. At several sampling sites, changes in species composition were observed during the year. Current experience suggests that by the sampling tool it is possible to take a sample from the entire water column, which eliminates the differences associated with the vertical dispersion of individual species. However, for a more representative sample, more water would need to be filtered in the future.

7.5. Aquatic groups - Macrophytes

The Danube

The Slovak Party does not observe macrophytic growths in the Danube old riverbed. The Hungarian Party suspended the macrophyte monitoring in 2011. Based on the approved optimisation, two areas were again included in the monitoring: H-11 in rkm 1839 and H-07 in rkm 1828. However, the occurrence of macrophytes was not confirmed in any of these areas, so in 2019 they were excluded from monitoring.

The left-side river branch system

Usually rich vegetation in the deep through-flowing river arm on the area No. 2603 were formed by hydrophytes and marsh species in the assessed year, along with persistent presence of the rare flowering rush (*Butomus umbellatus*). Higher coverage values were achieved only by the undemanding hornwort (*Ceratophyllum demersum*), the invasive waterweed is absent.

The development of macrophytic vegetation in the dead river arm on the area No. 2604 proceeded under more favourable hydrological conditions. The marginal reed growths from previous years have been enriched with hydrophytes. The richest were the growths of the true aquatic vegetation in the central section, but even here there were also population of marsh plants. This locality is still rich in scarce species - yellow water lily (*Nuphar lutea*), white water lily (*Nymphaea alba*), floating fem (*Salvinia natans*) and water caltrop (*Trapa natans*).

On sections No. 1 and 2 of the river arm on the area No. 2608 favourable moisture conditions were again observed for development of richer macrophyte growths (on the section No. 1 up to 14 species), which consisted mainly of marsh species, with a strong dominance of reed canary grass (*Phalaroides arundinacea*). In addition to them, the section No. 1, which is often exposed, is inhabited again by several chamaephytes (bushes) forming even a shrub layer -

white willow (*Salix alba*), invasive ash-leaved maple (*Negundo aceroides*), black elderbarry (*Sambucus nigra*) and white ash (*Fraxinus americana*). In the final section of the river arm (No. 3), a permanent hydroecophase remains maintained due to revitalisation measures and the backwater, this section is inhabited mainly by species of the true aquatic vegetation.

On all three observed sections of the river arm on the area No. 2612, rich in species and abundant macrophyte vegetation was registered again (mostly on the section No. 2 - up to 21 species). In the deepest section No. 1, species of the true aquatic vegetation dominated - the hornwort (*Ceratophyllum demersum*) and the invasive Nuttal's waterweed (*Elodea nuttalii*), whose representation as maintained at the level of the previous year, about 50 % of the water column. The rich growths on the other two shallower sections (No. 2 and 3) continued to be mainly formed by wetland species, as these sections, after the May flood subsided, were exposed until the end of the vegetation period. Protected and scarce species continue to survive in the river arm - the water caltrop (*Trapa natans*), club rush (*Scirpus radicans*).

The right-side river branch system

The observation of macrophyte vegetation in right-side river branch system had been interrupted since 2012. In the assessed year macrophyte growths in the inundation were again evaluated in the Csákányi Danube (H-09), in the Schisler dead river arm (H-04) and on the newly included site in the Lake Öntés (X2). The monitoring on the flood-protected area was resumed on the site in the Lipóti marsh (H-06) and in the Zátonyi Danube (H-12).

In summary, it can be stated that the vegetation growths of river arms after several-year of interruption of monitoring show a similar character also in years 2018 and 2019. The richest are the growths in the Lipóti marsh (H-06), where several protected species are more abundantly represented, while the occurrence of the invasive Canadian pondweed (*Elodea canadensis*) was not recorded after the resumption of monitoring. Macrophytes in the Zátonyi Danube (H-12) were of a similar composition in the previous year. The water surface was covered with large spots of protected white water lily (*Nymphaea alba*) and shining pondweed (*Potamogeton lucens*). Smaller spots were formed by the yellow water lily (*Nuphar lutea*), from among the submerged species the hornwort (*Ceratophyllum demersum*) and the arrowhead (*Sagittaria sagittifolia*) were abundant. The absence of invasive Canadian pondweed (*Elodea canadensis*) also persists.

The amount of water released into the active inundation during the year is very similar in the long run. A large part of the river arms in the inundation is characterized by a greater depth of water, to which the stabilized species composition of macrophytes has adapted. The water level in the Schisler arm (H-04) was again covered by European water milfoil (*Myriophyllum spicatum*) and submerged species of the pondweed family (*Potamogeton sp.*), while the invasive Canadian pondweed (*Elodea canadensis*) was absent in the evaluated year. The occurrence of this species was significantly weaker also in the Csákányi Danube (H-09), where it occurred very rarely. Only the shinning pondweed (*Potamogeton lucens*) retained its mass occurrence and the water surface was also covered with green filamentous algae of the genus *Cladophora*. After several years, the whorl-leaf water milfoil (*Myriophyllum verticulatum*) reappeared in the Schisler river arm, but the invasive Carolina azolla (*Azolla caroliniana*) appeared as a new species in the Csákányi Danube. The Lake Öntés (X2) was also relatively abundantly overgrown with macrophytes, while the eastern and southern parts of the lake was dominated by the shinning pondweed (*Potamogeton lucens*) and the holly leaved naiad (*Najas marina*). Basically, spots of filamentous algae were present in all of these water bodies.

PART 8

8.1. Conclusion Statements

Based on the results of environmental monitoring in 2019 the following conclusions can be stated:

1. The average annual flow rate in the year 2019 at the gauging station Bratislava-Devín, that plays a key role in determining the actual amount of water to be released into the Danube old riverbed downstream of Čunovo weir, reached 1962 $m^3.s^{-1}$. This value represents a slightly below-average flow rate on the Danube. The flow regime of the Danube in 2019 was again not typical. The first half of the year was significantly more water bearing, the average daily flow rates were around the long-term average daily values and there were also three more significant flow waves. January and March were extremely water bearing. From the third decade of March to the end of second decade of May, flow rates were mostly below the long-term daily averages. Thanks to the higher flow rates, May and June were also above-average water bearing months, while at the end of May also the highest flow wave in 2019 occurred. However, even this flow wave did not cause significant flooding. The second half of the year, unlike the first, was less water bearing and the average daily flow rates were rather well below the long-term average daily values for almost the entire period. The exceptions were several insignificant flow waves, which were caused by higher precipitation totals in the Danube basin. However, even the highest of them did not significantly exceeded the long-term average daily values. Low flow rates, which use to be typical for the winter months, occurred in the period from September to December. In addition, at the end of July and in late September there occurred such flow rates that were close to the lowest recorded average daily flow rates. The annual minimum was recorded on September 23, 2019 at 903.0 $m^3.s^{-1}$, the annual maximum occurred on May 30, 2019 culminating at 5490 $m^3.s^{-1}$.

   Taking into consideration the obligations envisaged in the intergovernmental Agreement, the Slovak Party, in the case of average annual flow rate of 1962 $m^3.s^{-1}$ at Bratislava-Devín, was obliged to release an average annual discharge of 387.6 $m^3.s^{-1}$ into the Danube riverbed downstream of the Čunovo dam. Based on measurements carried out at the Doborgaz and Helena gauging stations, the total average annual discharge released to the Danube downstream of Čunovo in the year 2019 was 396 $m^3.s^{-1}$. During the year 2019 there did not occurred such an average flow rate (more than 5400 $m^3.s^{-1}$ at Bratislava-Devín gauging station) when it would be necessary to release into the Danube old riverbed increased discharges (over 600 $m^3.s^{-1}$). However, higher discharge due to technical maintenance on the Gabčíkovo Hydropower Plant was released during one day in September. If, in accordance with the methodology for calculating the average annual flow rate, reduction of the flow rate to 600 $m^3.s^{-1}$ is applied for this day, an average annual flow rate of 395 $m^3.s^{-1}$ (101,9 %) is obtained, what means that the Slovak Party fulfilled the average annual discharge jointly agreed in the intergovernmental Agreement. As far as the daily flow rate management table is concerned, it can be stated that this was fulfilled as well. In regard to the minimal flow rates in non-vegetation period, there was not a single case, when the deficit of the average flow rate would exceed the acceptable deviation. Even in the case of the minimal values for the summer regime, in 2019 there was no case when the deficit of flow rate would exceed the acceptable deviation. The hydrological conditions in the spring of 2019 were favourable, so at the request of the Hungarian Party it was possible to release a higher amount of water into the Danube old riverbed and to realize partial artificial flooding of the right-side river branch system.

Concerning the water amount released into the Mosoni Danube the average annual discharge in 2019 was 34.1 $m^3.s^{-1}$. During 2019, there were several periods when the flow rate into the Mosoni Danube was reduced. Due to technical maintenance, the flow rate was reduce to about 20 $m^3.s^{-1}$ on three occasions, in the first half of April for 16 days, in mid-October for 4 days and 2 days in the first half of December. However, a more significant reduction of the flow rate into the Mosoni Danube took place at the request of the Hungarian Party, due to reconstruction works on the objects on the Mosoni Danube and the right side seepage canal. The reduction of the flow rate to approx. 25 $m^3.s^{-1}$ lasted 112 days. Due to the above limitations, the average annual flow rate into the Mosoni Danube in the year 2019 reached only 35.7 $m^3.s^{-1}$, which is 83.0 % of the agreed amount. However, for the above reasons, it can be stated that the Slovak Party fulfilled the obligation set out in the Intergovernmental Agreement. Both Parties informed each other about the above restrictions.

2. The quality of surface water at sampling sites monitored in the frame of Joint monitoring has not changed significantly in 2019 in comparison with previous years and in long-term is balanced. The increase or decrease in concentrations of individual indicators during the observed period appears already in Bratislava, where the quality of water entering the Slovak territory is monitored. Some monitored indicators of surface water quality in the Danube, in the reservoir and in the river branch system show seasonal changes, some indicators depend mainly on the flow rate, others are influenced by biochemical processes in the surface water.

   The year 2019 was a year with a slightly below-average flow rate. The highest flow waves occurred during May, higher flow waves were also in mid-January, during March and at the end of July, which affected the content of certain indicators that are influenced by flow rates (suspended solids, iron, manganese, phosphates, total phosphorus and COD_{Mn}). Compared to the previous year, the water temperature in 2019 decreased slightly on most sampling sites. The pH and the specific conductivity values were similar to the previous year, but mostly fluctuated in wider ranges with lower minima. Due to the flow regime, the highest contents of suspended solids, iron and manganese were found in June in connection with the highest flow wave culminating at the end of May. Compared to the previous year, the suspended solids contents were higher at most sampling sites. Concentrations of basic cations and anions show high stability in comparison with long-term measurements. The content of nutrients shows seasonal fluctuations and in 2019 their contents was slightly higher than in 2018. The highest contents of nutrients were recorded in January and February, the lowest in the summer period. The dissolved oxygen content on sampling sites basically did not changed. Organic pollution, expressed by the COD_{Mn} indicator, increased on most sampling sites, the BOD_5 values were mostly similar as in the year 2018. Compared to the previous year, the pollution of surface water by observed heavy metals was similar, except of zinc, the contents of which decreased. As in 2018, a large part of the measured values were below the quantification limits of applied analytical methods. The highest number of concentrations above the limit of quantification was characteristic for copper, as it was in previous years.

   Based on the results obtained from the monitoring of biological quality elements (phytoplankton, phytobenthos and macrozoobenthos) in 2019 at sampling sites monitored by the Hungarian Party, it can be stated that according to biological elements good ecological status (II. quality class) was achieved in the Danube old riverbed at Rajka and in the Mosoni Danube at Mecsér, and a moderate ecological status (III. quality class) on three other sites (in the Danube at Medveďov, in the Mosoni Danube at Rajka and in the right-side seepage channel at Rajka). The assessment of biological quality elements on the Slovak side in 2019 was carried out in connection too the previous period, taking into account the optimization. The development of phytoplankton was similar to that in 2018 and the threshold for mass development was not exceeded in no single case. The percentual representation of the basic groups of phytoplankton (Cyanophyta, Chromophyta, Chlorophyta a Euglenophyta) in the assessed year corresponded to the level of high status, or the maximal potential (I. quality class) on seven sites. In the lower part of the reservoir, the representation of cyanobacteria corresponded to a good potential (II. quality class), and on two localities (in the upper part of the reservoir and in the Mosoni Danube at Čunovo) the values were at the level of moderate potential (III. quality class). The dominant part of phytobenthos was formed by diatoms, and on the basis of diatom indexes IPS and SID the water quality corresponds to the level of β-mesosaprobity, thus good water quality (II. quality class). Only on the sampling site in the Danube at Bratislava on the left side, the water quality corresponded to III. quality class, so moderate quality. In the case of macrozoobenthos, the average values of the saprobic index on monitored sites corresponded to the level of β-mesosaprobity, with the exception of the sampling site in the upper part of the reservoir, where the values was at the level of α-mesosaprobity.

The sediment quality in 2019 was assessed for the purposes of the Agreement according to the Canadian standard „Canadian Sediment Quality Guidelines for the Protection of Aquatic Life". In none of the cases in the evaluated year, a concentration exceeding the limit of probable adverse effect occurred. On the Slovak territory, the inorganic micro-pollution of sediments was slightly higher than in 2018 and the organic micro-pollution slightly decreased. All contents of the assessed indicators of inorganic and organic micro-pollution from the range >TEL - <PEL were closer to the lower limit. On the Hungarian territory, most concentrations of observed organic substances corresponded to an uncontaminated environment. From the inorganic pollution, such low contents have been documented in the case of copper, arsenic and lead. The contents of other observed heavy metals on some sites slightly exceeded the threshold limit and the values corresponded to a slightly polluted environment. Only in the case of mercury did they approach the upper limit of the range (PEL) on three sampling sites. The PEL limit represents a level when the adverse effects on biological life associated with the aquatic environment may occur frequently. The most polluted sediment on the Slovak side was the sediment from sampling site in the lower part of the reservoir. On the Hungarian territory, the highest concentrations of inorganic pollution were found on the sampling site in the Ásványi river arm and the highest concentrations of organic substances from the PAH group were recorded on the sampling site in the Danube old riverbed downstream of the bottom weir at Dunakiliti.

Based on long-term observations of the water quality entering the affected area and the water quality, which leaves the affected area, it can be stated that the physico-chemical composition of the Danube water by passing through the Gabčíkovo Waterworks does not change substantially. The situation in the quality of individual indicators is similar in long-term.

3. In 2019, the monitoring of groundwater levels continued according to the optimized monitoring programme approved in November 2017. Groundwater levels in the observed area are primarily influenced by surface water levels in the Danube and in the reservoir. Besides this, the groundwater level in the inundation area is strongly influenced by the drainage effect of the Danube old riverbed. This impact, which adversely affects groundwater levels in the inundation area, is being mitigated by the water supply into the river branch system on both sides of the Danube. Regarding the flow rates in the Danube, the year 2019 was one of the average years, but the flow rate regime was again not typical. As in the previous year, there were no significant flow or flood waves of longer duration that would cause a significant rise and fluctuation of groundwater levels. The groundwater levels were the most significantly affected by the May flow waves, when the flow rate twice exceeded 5000 $m^3.s^{-1}$ during a week. Larger flow waves, which during the culmination exceeded 3000 $m^3.s^{-1}$, were reflected on groundwater levels only in the close surroundings of the Danube. In most objects, the highest groundwater levels were recorded during discharging increased flow rates into the

Danube old riverbed and during implementation of artificial floods. In the Szigetköz area it was in the middle of May, in the Žitný ostrov area it was at the end of May, or in the first half of June. The highest levels around the reservoir, despite the long lasting low flow-rates on the Danube, occurred during September and October. The minimal levels occurred in some objects also during February and early March, but in objects under the direct influence of the Danube it was mainly at the end of October, during low flow rates on the Danube. Groundwater levels in the upper part of the inundation increased mostly up to 1.3 m, but in objects near the Danube the increase reached up to 2.1 m. In the area of the central Szigetköz and the middle and lower part of the inundation area on the Slovak territory, the course of the groundwater levels was similar. The rise of groundwater levels reached up to 2.4 m. In the vicinity of the confluence of the Danube old riverbed and the tail-race channel, the rise in levels was even more pronounced and reached up to 4.8 m.

Based on the results obtained by the groundwater level observations, it can be stated that the water supply into the right-side river branch system and into the Mosoni Danube plays an important role in influencing groundwater levels in the entire Szigetköz area. Measures implemented under the intergovernmental Agreement, as well as measures realized in the right-side inundation, caused a significant rise in groundwater levels in the upper, middle and, after completion the water supply system, also in the lower part of the Szigetköz. In the case of conditions of low and especially average flow rates in the Danube, it is possible to see a significant increase of groundwater levels in the upper and middle part of the inundation. The groundwater level increase in the upper part of the Szigetköz area and around the reservoir is reduced due to the decrease of permeability of the reservoir bottom. In the period 2009-2013, a huge amount of sediments was transported into the reservoir, what intensified the colmatation of the reservoir bottom. However, observations in recent years show that the decline of groundwater levels has significantly slowed down or even stopped, and the area with groundwater level decrease do not change significantly. The decline around the lower part of the reservoir and in the upper part of Szigetköz is magnified by the drainage effect of the Danube old riverbed. Since 2015, the most significant change is the completion of the water supply system in the lower part of the Hungarian inundation area. Since completion the water supply system, in the case of low, average, and even high flow rate conditions, a significant increase in ground water levels can be seen in the lower part of inundation area, which had previously been characterized by a decrease. The positive impact of the water supply in the lower part of the Hungarian river branch system partially mitigates also the ground water level decrease on the Slovak territory upstream the confluence of the Danube old riverbed and the tail-race channel. However, at low flow rates on the Danube, the decrease of groundwater levels in the vicinity of the tail-race channel and below the confluence with the Danube old riverbed on the Slovak territory is still significant.

Monitoring results in the period after the completion of the water supply system on the Hungarian territory show that appropriate technical interventions in the river branch system and the application of an effective water supply can significantly affect groundwater levels in the floodplain area. The discharge of increased flow rates into the Danube old riverbed during flood or flow waves on the Danube also has a significant effect on groundwater level in the inundation. On the other side, the results also point to the fact that it is necessary to solve the water supply in the lower part of the inundation area on the Slovak territory, particularly in the case of low and average flow rate conditions. The positive impact of water supply can also be efficiently supported by measures implemented in the Danube old riverbed (raising the water level with bottom weirs), which would ensure an increase of groundwater levels in the strip along the Danube old riverbed on both sides. By measures in the Danube old riverbed the overall situation in the entire inundation area on the Slovak and Hungarian territory could be improved.

4. The chemical composition of groundwater in water supply sources on the Slovak territory indicates stable conditions for groundwater quality formation. From the long-term point of view, the quality of groundwater in the monitored water supply sources mostly meets the agreed limits for drinking water. Exceedances of limits occur only on some objects in the case of water temperature, manganese and occasionally also in the case of iron. In the assessed year 2019, the limit value for water temperature was twice exceeded in the water supply source at Šamorín and four times at Bodíky. The manganese content exceeded the limit value on the water supply sources at Bodíky and Kalinkovo in each determination, while the manganese contents at Kalinkovo are lower than at Bodíky. In the case of iron one exceedance occurred in the water source at Šamorín. There were no other exceedances in water sources in 2019. The groundwater quality in observation objects is influenced to a greater extent by local influences, which may be reflected in a higher number of exceedances of limit values. Exceedances usually occur in the case of ammonium ions, manganese, iron and water temperature. In the assessed year, exceedances were found for three indicators of groundwater quality: in the case of manganese and iron on one object and in the case of water temperature on three objects. On selected objects the inorganic and organic micro-pollutants are also observed. In 2019, no single exceedance of the limit values was recorded.

   The monitoring of groundwater quality on the Hungarian territory in 2019 confirms the long-term results. The groundwater in shallow horizons of gravel sediments is enriched with iron and manganese and in most observation wells their contents permanently exceed the limit values. On observation objects, increased contents of nutrients and organic pollution also occur, that are related to local pollution that is of agricultural origin or in some cases come from wastewater ponds. However, high contents exceeding the limit values are registered only at some observation objects. Exceedances occur in the case of ammonium ions, phosphates and occasionally also nitrates. From the long-term point of view, the organic pollution mostly meets the limit value, but from time-to-time higher values occur in some objects. In the year 2019, organic pollution expressed by COD_{Mn} exceeded the limit value in three objects. From among the other observed groundwater quality indicators, exceedances of limit values occurred on some objects also in the case of potassium, magnesium, calcium and water temperature. The inorganic and organic micro-pollutants observed on selected objects were detected in 2019 in concentrations below the limit values for the assessment of groundwater quality, except for one concentration of arsenic on object No. 9536 at Püski that exceeded the highest limit value for this indicator. The groundwater quality in the deeper horizons of gravel sediments in the Szigetköz is monitored by production wells in water supply sources. The wells in the region at Győr have a higher content of ammonium ions, organic matter, manganese and iron in comparison with the other monitored wells. Manganese and iron concentrations exceed or approach the limit values for drinking water quality. Concentrations are lower in wells where the water is pumped from greater depth. The water pumped in the northern part of the Szigetköz is of satisfactory quality and the groundwater quality is characteristic by high stability. In the case of inorganic and organic micropollutants, the contents of observed indicators are mostly below the limit of quantification. In general, the quality of groundwater in wells producing potable water (occasionally after pre-treatment) is suitable for drinking water supply.

5. Monitoring of soil moisture continued in 2019 on the Slovak and the Hungarian territory in accordance with the approved monitoring optimization. The Slovak party performs soil moisture measurements using a neutron probe at 13 monitoring sites, all of which are located in the inundation. Since 2018, the soil moisture monitoring on the Hungarian side has continued on 12 localities, 6 of which are located in the agricultural area. In terms of the

precipitation amount, the year 2019 can be considered as below average, with the highest monthly precipitation total being recorded in May. Although the time distribution of precipitation within the year was not very favourable, higher precipitation totals in January and especially in May had a positive effect on the creation of soil moisture reserves and supply. Higher flow waves during May and higher flow rates in the first half of June also played an important role in replenishing of soil moisture content in the first half of the year. While precipitations mainly affected the upper part of the soil profile, the lower part of the soil profile was mainly affected by flow waves during May. In terms of air temperature, the year 2019 as a whole was very warm. Although, as in the previous year, there were no extremely high average daily temperatures above 30 °C, the average annual temperature in the whole territory was the highest for the whole monitoring period. As the previous year was also very warm, it can be stated that the last two years were the warmest in terms of the average annual temperature for the entire observed period. The above-mentioned climatic conditions were also reflected in the development of soil moisture content during the year.

The thickness of the soil profile on the Slovak side is small in the upper part of the inundation area. The groundwater level in this area fluctuates only in the gravel layer. Layers down to a depth of 1 m are almost exclusively dependent on climatic conditions. Layers at a depth of 1-2 m are also largely dependent on climatic conditions, but the lower part of this depth interval may be slightly affected by the groundwater level when large flow waves passes. Soil moisture reserves are created in the winter or spring months. In the upper part of the soil profile, the maximal average contents of soil moisture occurred after the above-average precipitations in January or May, in the deeper parts it was at the beginning of June after the passage of the flow wave. Subsequently, the soil moisture content gradually decreased and in the depth interval of down to 1 m the minimum values were recorded at the end of October. Due to precipitation in November and December, the soil moisture content started to rise again and at the end of the year it reached significantly higher values than at the its beginning. In the depth interval from 1 to 2 m, the precipitations at the end of the year were not manifested and the soil moisture content continued to decrease until the end of the year. The thickness of the soil profile in the middle part of the inundation gradually increases. In general, the groundwater regime in this area is influenced by the water supply to the river branch system. In addition, the groundwater level is significantly affected by natural flood or flow waves. The groundwater level in 2019 fluctuated slightly below or around the boundary between the soil profile and the gravel layers. The maximal values of the average soil moisture content in the layer to a depth of 1 m occurred according to the predominant effect at the end of January or at the beginning of June, when the soil moisture values were affected by the above-average precipitation totals or by the increased flow rates into the river branch system. Due to flow rates, the minimal values occurred either at the beginning of the year, at the end of August or at the end of October. In the depth from 1 to 2 m, the minimal values occurred either at the beginning or at the end of the year, in November and December. The maximal values at the depth from 1 to 2 m were most often related to the passage of the flow wave and to the discharge of increased flow rates during the artificial flooding of the left-side inundation at the turn of May and June. In the lower part of the inundation area, below the confluence of the river branch system and the Danube old riverbed, the groundwater level usually fluctuates around the boundary between the soil profile and the gravel layer. Due to the deepening of the bottom of the tail-race channel, the average and the minimal groundwater levels decreased. The occurrence of minima are tied to the minimal water levels in the Danube old riverbed. At maximal water levels, the monitored area is flooded. The maximal values of soil moisture in both depth intervals were registered at the turn of May and June. The second half of the year was characterized by a gradual decrease of the soil moisture content in both depth ranges, while the minima in the upper part of soil profile occurred at the end of October, in the lower part of the soil profile it was at the beginning of the year.

In the right-side inundation on the Hungarian territory, the thickness of the soil profile, similarly to the Slovak side, is relatively small in the upper part, gradually increasing towards the middle part. The minimal average contents of soil moisture in the depth interval of 0-1 m on localities in the upper part of the inundation occurred from the end of August until the end of measurements at the beginning of October. The maximal values of average soil moisture content occurred at the beginning of the year. Thanks to the relatively high sand content, the layers at a depth from 1 to 2 m are favourably influenced also by capillary rise from the groundwater level. At the beginning of the year, however, the groundwater level was relatively deep and therefore minimal values of soil moisture content were recorded during this period. The maximal average contents of soil moisture in the upper part of the inundation at a depth from 1 to 2 m were recorded in early June in connection with the passage of the flow wave at the turn of May and June, which caused a significant rise of groundwater levels. After reaching the maximal values, the soil moisture content decreased almost continuously. A similar course of soil moisture values could be observed also in the middle and the lower part of the inundation. The minimal average soil moisture contents in the depth interval of 0 to 1 m, similarly to the upper part of the inundation, also occurred at the beginning of October. The maximal values of the average soil moisture content on the monitored sites occurred most often in the second half of May and at the beginning of June, which in these parts of the inundation was related to the discharge of increased flow rates into the inundation and the passage of flow waves on the Danube. In general, the average values of soil moisture content at the beginning of the year were higher than at the end of measurements at the beginning of October. The courses of soil moisture content on agricultural land slightly differed, depending on the location of the site in relation to the Danube. The dependence of soil moisture content on climatic conditions, including layers at greater depths, was more pronounced here. In the central part of Szigetköz, the soil layers at a depth of 1 to 2 m are already affected by the groundwater level, which in localities closer to the Danube old riverbed, in the case of higher flow waves, also rises into these layers. In the lower part of Szigetköz, the moisture content in the soil profile is significantly influenced by the groundwater level. The minimal soil moisture contents in layers of 0-1 m on agricultural sites occurred mainly in the second half of the year, in the period from the end of August to the beginning of October. The maximal soil moisture values most often occurred at the end of May and the beginning of June, which in the upper half of Szigetköz was related to the above-average precipitation amount, but in the lower half the influence of flow waves in the second half of May was added. In the soil layers in the depth interval from 1 to 2 m, the minimal values of soil moisture on most sites also occurred at the end of the monitoring period. Concerning the maximal average values of soil moisture, they occurred at different times during the first half of the year. In general, it can be stated that in the second half of the year there was a gradual drying of the soil profile. Nevertheless, in most localities, the soil moisture content at the end of the measurements in the year 2019 was similar or slightly higher than at its beginning.

6. In 2019, the monitoring of the development of basic growth indicators of forest stands continued in accordance with the monitoring optimisation approved in 2017. The Slovak Party evaluated the growth indicators on eight monitoring plots. The health status of forest stands is carried out at three-year period on the basis of aerial imagery. The last evaluation was carried out in the report for the year 2018. On the Slovak side, the Pannonia poplar clone is currently grown on all monitoring plots, which replaced the initially observed stands of cultivated poplars I-214 and Robusta, as well as the white willow stand. The development of forest stands in the assessed year mostly continued in the trend from previous years, most significant

deviations were recorded only in stands in which forest management interventions were implemented. Based on the evaluation of growth indicators for the year 2019, it can be stated that the height increment quality classification of the monitored stands shows only smaller, slow fluctuations on most areas. Improvement of growth was observed on plots where forestry management interventions were carried out. Decrease in the height increment in the last four years is noticeable in stands whose age is approaching the peak age.

Monitoring of forest stands in the Szigetköze area was interrupted after 2014. In line with the monitoring optimisation, the Hungarian Party resumed forest monitoring in 2018 and implemented it in accordance with the approved monitoring program, however some deviations were noted in the monitoring methodology. The observed areas are dominated by poplar stands, what corresponds to the current tree composition in the Szigetköz area. The cultivated poplar „Pannonia" creates the largest part of forest stands, a relatively high percentage of the forest stands is formed by willows and the third most common tree species is the non-native black locust. Measurements of dendrometric characteristics of forest stands were performed on eight monitoring plots, that are located in the inundation area. The evaluation of the development of dendrometric characteristics of forest stands in the vegetation period 2018-2019 could not be carried out in the current report, as due to the inaccessibility of the Kisbodak area, the measurements were performed only before the beginning of the vegetation period 2020. A comprehensive annual assessment of the development of forest stands will be carried out in the next annual report.

7. Since 2018, biological observations have been carried out according to the optimisation of the joint Slovak-Hungarian monitoring. Biological observations are divided into three parts. The first part includes terrestrial groups, which are made up of terrestrial plants, molluscs and the strictly protected Northern Pannonian vole (*Microtus oeconomus mehelyi*). The second part is the aquatic group represented by macrozoobenthos and additional qualitative samples of aquatic molluscs and dragonfly larvae. The third part is also represented by aquatic groups including fishes, zooplankton and macrophytes.

   The development of phytocoenosis on the monitoring areas on the Slovak side has stabilized in recent years, including slight positive changes in the uppermost part of the inundation. The character of the stand is represented by a well-grown shrub layer, under which there was a dense herb layer, consisting mainly of nitrophilous species. However, due to weak precipitation totals, continuing decay of the tree layer and a slight retreat of hygrophilous representatives in the herb layer was observed. In the middle part of the inundation, where the water supply is sufficient, hygrophilous species reached a more significant representation. The observed willow stand was in a state of full foliage even during the summer. In the lower part of the inundation, where there is a decrease in groundwater levels, the original nitrophilous species strengthened its position and the presence of the rare summer snowflake (*Leucojum aestivum*) is no longer registered. On the site at the confluence of the Danube old riverbed with the tail-race channel, the growth of monodominant aster prevailed in the herb layer. However, after flooding in 2016 and the subsequent lightening of the stand, the representation of the native nitrophilous species increased and in the evaluated year they already prevailed. In all areas, the presence of invasive species was also recorded, some of which reach a relatively large, but stable representation. In the Szigetköz area, the development of phytocoenoses continued in a similar way on most of the monitored sites. The observed forest stands are mostly well closed, the shrub layer is missing and the herb layer in such stands is usually insignificant and developed only mosaically. The forest stands are more diverse on the Hungarian side, the tree layers are formed by oak, ash-alder, maple, poplar and willow stands. In the herb layer nitrophilous species prevail, but invasive species are also abundant in some localities. The young stands in the lower part of the inundation gradually become closed and the herb layer also develops well, in which the European dewberry (*Rubus caesius*), the white panicled aster (*Aster lanceolatus*) and the common nettle (*Urtica dioica*) are abundant.

The development of the terrestrial mollusc community in the uppermost part of the left-side inundation points to improved moisture conditions. This is reflected in the stabilisation of the terrestrial mollusc community of the driest type of the soft floodplain forest and the gradual increase of abundance of more moisture-demanding species with a significant proportion of hygrophilous species. In the central part of the inundation area, the hygrophilous and meso-hygrophilous species have a dominant representation in the malacocoenosis. In the evaluated year, the representation of one polyhygrophillic species also increased. The protected site of marshy character is even dominated by forest hygrophilous and polyhygrophilous species, with a stable presence of rare and protected wetland species. Malacocoenoses on areas with young poplar stands in the lower part of the inundation are still affected by the clear-cut. Signs of regeneration of the malacocoenosis began to appear only 8-9 yeas after reforestation. As a result of the closure of young stands, the number and abundance of forest hygrophilous species are gradually increasing. At present, the return of several polyhygrophilous species is also registered. The situation in the terrestrial malacocoenosis on the site at the confluence of the Danube old riverbed and the tail-race channel is much more favourable, the community is formed by hygrophilous and polyhygrophilous species. The monitoring of terrestrial malacocoenosis on the Hungarian side has been carried out on six sites since 2018. Samples are collected by random collection, in which capture of rare species is less frequent. In the assessed year, the occurrence of almost half of the species living in the Szigetköz was confirmed, but the populations were mostly very poor. Increased abundance have been recorded in some hygrophilous terrestrial species. However, the occurrence of protected species from the previous year was not confirmed. The malacological results of the evaluated year generally indicate a long-lasting drought.

The monitoring of the protected Northern Pannonian vole (*Microtus oeconomus mehelyi*) in 2019 was carried out for five days (4 nights) in mid-October and in November. Due to the spatial differences of the monitoring sites, a higher number of animal traps was used on the Hungarian side - 55 pieces, while on the Slovak side 44 pieces. The monitoring on both sides was carried out at two sites, but on the Slovak side it was necessary to adjust the distribution of traps at one of the sites due to changed hydrological conditions. On the Slovak side, a total of 388 small terrestrial mammals were captured. However, the Northern Pannonian vole occurred only on one of the sites and was captured in 22 cases, of which 15 different specimens were identified. The absence of the Northern Pannonian vole on the second site was caused by significantly changed hydrological conditions, the site was flooded until late autumn. Both localities were dominated by the striped field mouse (*Apodemus agrarius*), and the yellow-necked field mouse (*Apodemus flavicolis*) was also abundant. On the Hungarian side, one of the sites is located in the flood-protected area. A total of 429 small terrestrial mammals were captured, of which the Northern Pannonian vole was captured in 48 cases and 19 different individuals were recorded. The dominant species in both localities was the invasive striped field mouse (*Apodemus agrarius*) and in the inundation the bank vole (*Myodes glareolus*) was also abundant. On he site at Lipóti marsh, the second most common species was the common vole (*Microtus arvalis*), what may be related with the lower water levels in this locality.

Based on the species composition of macrozoobenthos, it can be stated that rheophilous and oxybionic species indicating β-mesosaprobity predominate in the Danube old riverbed. The communities of aquatic molluscs and planktonic crustaceans were relatively rich in species, but the representatives had low abundance. On the contrary, the monitoring results of mayfly, caddisfly and dragonfly communities in the evaluated year document only a rare occurrence of representatives. At the confluence of the Danube old riverbed and the tail-race channel, where the water flow is slowed down, stagnophilous species and species tolerating milder pollution increase in the composition of macrozoobenthos. Similar results in the Danube old riverbed were also confirmed by the Hungarian side, which assessed the ecological status of the stream from moderate to poor. Similarly to the Slovak side, relatively rich communities of aquatic molluscs were recorded, also with the presence of several native Danube species and species preferring weaker water flow. The crustaceans community was dominated by rheophilous species, but coastal habitats were also inhabited by stagnicolous and marshy species. In the case of the dragonfly community, only a very poor community was recorded and mayflies and caddisflies were not recorded at all. In the Danube section downstream of the confluence with the tail-race channel, the macrozoobenthos samples of the assessed year were poor. From among the aquatic molluscs invasive species were mainly recorded, the crustaceans community was richer in species, of which two species also had a higher abundance. The occurrence of mayflies and caddisflies larvae was only rare, dragonflies were not recorded at all. In the left-side river branch system a species rich community of aquatic molluscs has been identified, but the invasive species had more significant representation. The communities of mayflies and dragonflies were very poor, the community of caddisflies was richer, but species of various ecological demands occurred only rarely on individual sites. In the right-side river branch system, the composition of macrozoobenthos is more similar to the composition in the Danube old riverbed. Most of the species captured within macrozoobenthos are common in Szigetköz. The community of aquatic mollusc is characterized by rheophilous and semi-rheophilous species, protected and endangered species occurred as well, but invasive species reached higher abundance. In the case of dragonfly and caddisfly communities, rheophilous and semi-rheophilous representatives were characteristic. In the lower part of the river branch system, the presence of the mayfly community was also confirmed. In terms of the ecological status of waters in individual sections, the evaluations ranged from poor to bad ecological status, which means a deterioration of the status compared to the previous year.

The ichthyofauna in the Danube old riverbed is observed on five monitoring sites, two are located on the Slovak side and three on the Hungarian side. Based on the results from the Slovak monitoring plots, it can be stated that the ichthyocoenoses in this section of the Danube are stabilized in recent years, with medium-high species diversity (8-13 species) and relatively low abundance. In 2019, a total of 16 different species were registered. The species richness of the ichtyofauna according to Hungarian results use to be more than double. In 2019, a total of 28 different species were recorded, similarly to the previous year. The regular presence of rheophilous and semirheophilous representatives has been confirmed on both sides, but eurytopic and non-native invasive fish species, which still do not behave invasively, are dominant. Endangered, vulnerable and rare species have also occurred. The development of ichthyocoenoses in the left-side inundation area is also stable. The communities are rich in species and rather abundant. In long-term the eurytopic and indifferent species dominate, but the abundance of two invasive species is also relatively high, however, in the evaluated year only slightly exceeded 10 % . In 2019, a total of 23 species were recorded, including endangered and rare species. On the Hungarian side, the ichthyocoenosis has been observed on seven localities since 2018, five of which is in the inundation area. In 2019, a total of 27 species of fish were confirmed, that consisted of rheophilous, eurytopic or limnophilous species. In the flood-protected area, a total of 16 species were recorded on two localities, which consisted of limnophilous and eurytopic species.

Planktonic crustaceans (cladocerans and copepods communities) were observed within the zooplankton. Based on the Slovak results from the previous years, the cladocerans and copepods communities have been unstable and poor in species and abundance, but after the strong flood in 2013 they were enriched. The increased number of species was maintained at a higher level in the next few years, but in the last two years both communities were poor in species and abundance, in several samples the communities were missing. In 2019, they consisted of phytophilous species. The Hungarian results in 2019 also confirm communities poor in species and abundance. The cladocerans were absent in the spring samples, only one species was recorded in the summer, and the copepods community was represented only by two species. In the left-side river branch system rich or medium rich in species zooplankton communities were found. The species composition was formed by euplanktonic and tychoplanktonic species, while on some localities an increase of tychoplanktonic species was recorded. After resumption of monitoring in the right-side river branch system, the zooplankton is observed at 10 sites. Compared to 2018, significantly richer communities of planktonic crustaceans were recorded on individual localities. The species diversity was lower in the river branches with higher flow velocity. The number of species recorded in river branches in the inundation area has more than doubled in some localities. The highest number of species of planktonic crustaceans, up to 27, was recorded in the Schisler river arm, where they also showed the highest abundance. Communities are formed by euplanktonic and tychoplanktonic species. In the flood-protected area, an increase in species was recorded only on the sampling site at the Lipóti marsh, where also the highest number of species was recorded in 2019, up to 21. The communities in the flood-protected area consist mainly of phytophilous species and species typical for stagnant waters linked to macrophytic growths. The presence of several rare species of the Szigetköz has also been confirmed.

The Slovak Party does not observe aquatic macrophytes in the Danube old riverbed. Following the resumption of monitoring, the Hungarian Party selected two sampling sites in the Danube. However, the occurrence of macrophytes was not confirmed in any of these places, so in 2019 they were excluded from monitoring. The development of aquatic macro-vegetation in the left-side river branch system was carried out in various habitats. The macrophytic vegetation was formed by hydrophytes and marshy species (up to 21 species), along with persistent presence of protected rare species. Monitoring of macrophytic growths in the right-side river branch system was interrupted since 2012. In the assessed year, the monitoring has been resumed on five sites, two of which are located in the flood-protected area. In summary, it can be stated that the vegetation growths in river arms in the years 2018-2019, after several years of interruption of monitoring, show similar character with a relatively abundant representation of protected species. The richest are the growths in the Lipóti marsh, where several protected species are more abundantly represented.

8.2. Proposals

Proposals given in this chapter will be obligatory for both Parties and do not require further approval when the actual Joint Annual Report is approved and signed by Nominated Monitoring Agents.

1. Due to anti-pandemic constraints, no planned negotiations were held between experts aimed at harmonizing the sampling schedule, specifying monitoring methodologies and identifying renewed or newly established monitoring sites. For this reason, the experts continue to recommend to hold these negotiations when the measures will be relaxed, while the field inspections will also be part of the negotiations.
2. Subsequently, on the basis of the above-mentioned negotiations, the experts of both parties will jointly prepare an update of the current Statute on the activities of the Nominated Monitoring Agents, which will contain a more detailed list and designation of monitored sites and methodologies in the sense of the approved monitoring optimization.