Annex 1 Assessment of ecological status according to WFD

In North Macedonia, ecological assessment of rivers is mostly based on water quality and biological classification systems adopted from other Mediterranean countries. With the exception of macroinvertebrates, physicochemical quality, benthic diatoms and aquatic macrophytes are assessed using methods developed in other Member States. Nevertheless, following the intercalibration exercises, all the national assessment methods and the respective quality classes boundaries are comparable across the Member States.

In this study, ecological classification is based on the following decision making diagram, suggested by the WFD (EC 2007) guidance documents.

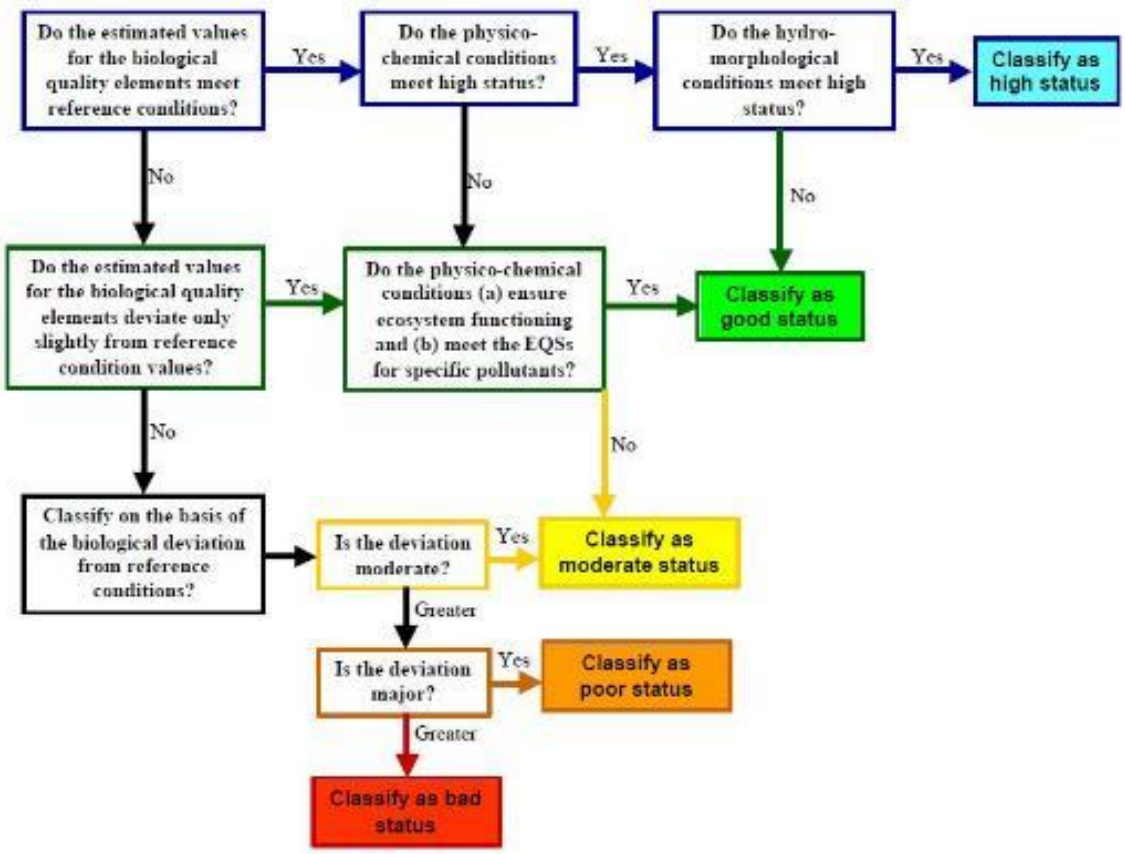


Figure 1 Indication of the relative roles of biological, hydro morphological and physicochemical quality elements in ecological status classification according the normative definitions in Annex V:1.2

- **Results of water quantity characteristic**

Water quantity characteristics are measured in one hydrological station r. Lepenec – Mouth MP2.

River Lepenec – Hydrological Station – Mouth

Identification number 63139

Latitude $42^0 00' 47''$

Longitude $21^0 22' 56''$

Altitude 260 m

Cota Zero "O" 260.00 mnm

Length from source 74,7 m

Catchment Area F = 770.00 km^2

Annual view of daily flow for 2018, 2019 and 2020 are given in the following tables.

Table 1 Annual view of daily flow (m^3/s) 2018 year river Lepenec - Mouth

Annual view of daily flow (m^3/s) 2018 year river Lepenec – Mouth												
Month / **Day**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
1	6.15	9.48	15.52	36.19	14.97	9.03	16.08	16.08	6.15	2.56	2.84	4.04
2	6.15	9.48	15.52	24.66	15.52	8.59	15.52	15.52	5.77	2.56	2.84	3.72
3	6.53	16.64	36.97	23.35	14.43	8.59	14.97	14.97	6.15	2.56	2.84	3.12
4	6.53	53.01	45.97	20.19	14.97	8.16	12.86	12.86	5.77	2.84	2.56	3.12
5	6.15	43.44	35.42	23.35	16.08	11.36	12.86	12.86	5.40	2.84	2.84	3.12
6	6.15	28.07	91.66	24.66	23.35	7.33	15.52	10.41	5.40	2.56	2.84	2.84
7	6.15	21.43	60.44	30.93	18.97	7.33	36.19	9.48	5.05	2.56	2.84	2.84
8	6.15	20.19	30.21	28.78	17.79	6.93	36.19	9.03	4.70	2.56	2.84	3.12
9	5.77	17.79	28.78	24.00	14.97	8.16	20.19	9.03	4.36	2.56	2.84	3.72
10	5.77	16.08	26.69	24.66	15.52	9.48	19.58	7.74	4.36	2.56	2.56	4.04
11	5.77	20.19	24.00	22.70	14.97	11.36	18.38	7.33	4.36	2.56	2.56	4.36
12	5.40	15.52	24.00	21.43	13.38	11.85	17.21	6.53	4.04	2.84	2.84	5.05
13	5.77	15.52	33.90	20.80	12.35	12.35	14.97	6.15	4.04	2.84	2.84	4.36
14	6.15	19.58	28.07	20.19	11.85	11.85	13.38	6.15	4.04	2.56	2.84	5.77
15	6.15	15.52	28.78	19.58	13.38	13.38	12.86	6.15	3.42	2.56	3.12	6.15
16	6.53	15.52	23.35	19.58	18.38	14.97	10.88	9.48	3.42	2.84	3.12	6.53
17	17.21	14.97	21.43	19.58	14.43	13.90	9.94	9.48	3.12	2.84	3.72	5.77
18	18.97	14.97	33.15	19.58	12.86	12.86	9.48	9.03	3.42	2.56	4.04	5.05
19	14.43	15.52	28.78	18.38	11.85	11.85	8.16	8.59	3.12	2.56	4.36	5.77
20	11.85	16.64	28.07	17.21	11.36	10.88	7.33	8.16	3.12	2.84	2.56	5.40
21	10.88	16.08	26.69	17.21	12.35	11.36	6.53	5.40	2.84	2.84	3.72	4.36
22	10.41	25.33	25.33	16.08	12.86	10.88	6.53	3.72	3.12	3.72	2.56	4.36
23	9.94	21.43	24.66	15.52	13.38	12.86	6.15	3.42	3.12	3.12	4.04	4.04
24	10.88	19.58	24.00	12.35	14.43	11.36	9.48	3.12	2.84	2.84	3.42	4.04
25	9.94	18.38	22.70	14.43	15.52	11.85	10.88	2.84	2.84	2.84	3.12	4.70
26	9.03	16.64	30.21	14.43	16.08	13.90	7.74	10.88	2.56	2.84	4.36	5.77
27	9.03	15.52	28.07	13.90	15.52	10.88	36.19	10.41	2.56	2.84	4.36	5.40
28	9.03	15.52	26.69	14.43	14.97	12.35	45.97	9.94	2.84	2.56	5.77	5.05
29	9.03		24.66	14.97	12.35	12.35	20.19	7.33	2.56	3.12	5.77	4.36
30	9.48		22.70	14.97	10.41	18.38	17.79	6.15	2.56	2.84	6.15	12.86
31	9.48		22.06		33.90		18.97	5.05		2.84		9.94
Qav	**8.61**	**19.57**	**30.27**	**20.27**	**15.26**	**11.22**	**16.42**	**8.49**	**3.90**	**2.76**	**3.44**	**4.93**
Qmin	**5.40**	**9.48**	**15.52**	**12.35**	**10.41**	**6.93**	**6.15**	**2.84**	**2.56**	**2.56**	**2.56**	**2.84**
Qmax	**18.97**	**53.01**	**91.66**	**36.19**	**33.90**	**18.38**	**45.97**	**16.08**	**6.15**	**3.72**	**6.15**	**12.86**

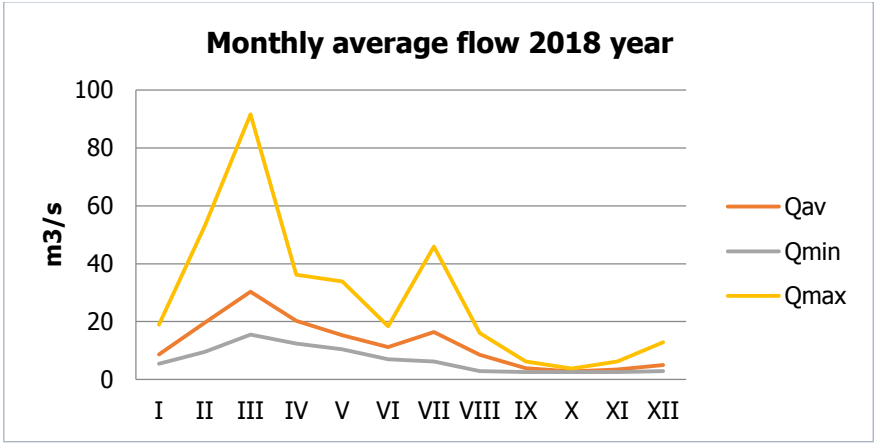


Table 2 Annual view of daily flow (m^3/s) 2019 year river Lepenec - Mouth

Annual view of daily flow (m^3/s) 2019 year river Lepenec - Mouth												
Month **Day**	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
1	4.04	9.94	6.15	6.53	9.48	/	5.77	2.84	1.37	1.37	1.37	4.70
2	3.72	11.85	5.77	6.15	9.48	/	5.77	2.56	1.37	1.37	1.37	4.36
3	3.72	10.88	5.77	5.77	9.48	/	4.70	2.56	1.37	1.37	1.37	3.42
4	3.72	11.85	5.77	6.15	9.48	/	3.72	2.56	1.37	1.81	1.37	3.72
5	4.04	16.08	5.77	5.40	9.94	21.43	4.04	2.30	1.17	1.58	1.58	3.12
6	3.72	16.08	5.77	5.40	10.88	/	3.42	2.30	1.17	1.37	1.37	4.04
7	3.42	23.35	6.53	5.40	10.41	/	3.12	2.30	4.04	1.37	1.81	4.70
8	3.42	11.85	6.93	5.77	9.94	/	2.84	2.30	3.12	1.37	2.84	4.04
9	3.12	9.48	9.03	8.59	9.94	/	2.84	2.05	2.56	1.37	2.05	3.72
10	3.12	8.59	9.03	10.41	9.03	14.43	4.04	1.81	2.05	1.37	1.58	4.36
11	3.12	8.16	9.48	17.21	8.59	13.38	9.03	1.58	1.58	1.17	1.58	4.70
12	3.42	7.74	10.41	16.08	8.59	12.86	5.40	1.58	1.37	1.17	1.58	4.36
13	3.72	7.33	10.88	15.52	9.94	11.85	4.04	1.37	1.37	1.17	11.36	4.04
14	3.72	7.33	9.94	9.48	24.00	11.36	6.15	1.37	1.37	1.17	5.77	4.70
15	3.12	6.93	9.48	16.64	23.35	10.41	5.77	1.37	1.37	1.17	3.42	4.36
16	3.12	6.93	8.59	17.21	26.69	7.74	6.15	1.37	1.37	1.17	2.56	4.70
17	3.42	6.53	9.03	16.08	16.64	6.93	6.93	1.37	1.37	1.17	2.05	4.70
18	3.12	6.53	9.03	14.97	16.08	9.94	5.05	1.17	1.37	1.17	2.05	4.36
19	3.12	6.53	9.48	12.86	15.52	11.36	4.70	1.37	1.37	1.17	1.81	4.36
20	3.42	6.93	9.48	11.85	13.90	10.41	4.04	1.37	1.81	1.17	3.12	4.36
21	3.72	6.93	9.48	10.88	12.86	8.59	4.04	1.17	1.81	1.17	6.53	4.36
22	3.72	6.93	9.03	10.41	12.35	9.48	3.72	1.17	1.81	1.17	2.84	6.15
23	4.04	7.74	8.16	9.48	11.36	7.74	3.72	1.17	1.81	1.17	2.56	9.03
24	4.04	7.74	8.16	9.48	10.88	6.53	3.42	1.17	2.30	1.17	2.56	7.74
25	4.36	7.33	8.16	9.94	10.41	9.48	2.84	1.17	3.72	1.17	3.12	6.15
26	4.70	6.53	8.16	8.59	9.94	6.93	2.84	1.17	3.12	1.17	2.30	5.05
27	5.05	6.15	7.33	9.03	9.94	6.15	2.56	1.17	2.84	1.37	2.05	4.70
28	5.05	6.15	6.93	9.48	9.48	6.15	2.56	1.17	2.05	1.37	2.56	4.70
29	5.40		7.33	9.03	9.48	5.77	2.56	1.17	1.37	1.17	4.04	4.70

30	9.94		6.53	9.03	9.48	5.77	2.56	1.17	1.37	1.17	5.77	4.70
31	9.03		6.53		9.48		3.12	1.58		1.37		4.36
Qav	**4.14**	**9.16**	**8.01**	**10.30**	**12.16**	**9.76**	**4.24**	**1.64**	**1.87**	**1.27**	**2.88**	**4.73**
Qmin	**3.12**	**6.15**	**5.77**	**5.40**	**8.59**	**5.77**	**2.56**	**1.17**	**1.17**	**1.17**	**1.37**	**3.12**
Qmax	**9.94**	**23.35**	**10.88**	**17.21**	**26.69**	**21.43**	**9.03**	**2.84**	**4.04**	**1.81**	**11.36**	**9.03**

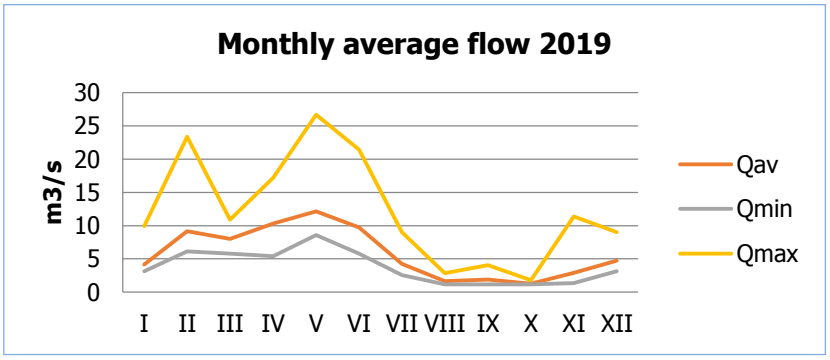
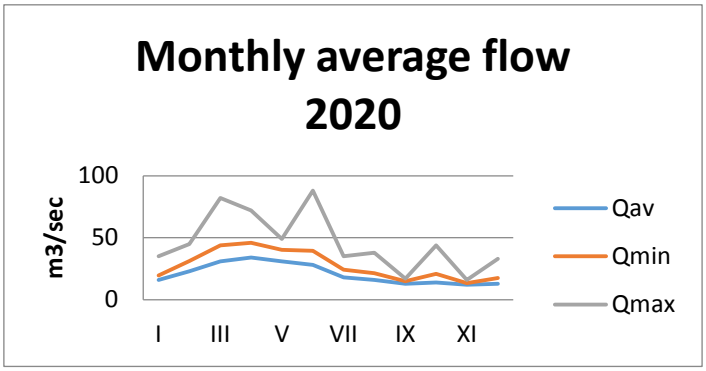


Table 3 Annual view of daily flow (m^3/s) 2020 year river Lepenec - Mouth

Annual view of daily flow (m^3/s) 2020 year river Lepenec - Mouth												
Month	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
Day												
1	22	24	33	34	42	42	35	17	15	15	16	13
2	22	23	32	35	41	40	32	16	15	14	15	13
3	17	26	33	37	47	39	30	16	16	15	15	13
4	17	25	52	45	46	38	30	16	16	14	14	14
5	17	31	69	63	43		31	17	16	14	13	15
6	17	29	53	72	42		35	29	15	14	15	14
7	17	27	51	43	41		29		15	17	14	17
8	17	25	82	41	41	36	28	38	15	18	14	18
9	16	25	70	42	39	35	26	33	16	16	13	22
10	18	26	59	44	37	38	26	29	16	15	13	33
11	17	26	50		36	42	26	27	15	15	13	24
12	18	45	45		36	36	25	24	14	15	13	25
13	21	41	46	42	32	34	24	22	14	44	12	21
14	21	39	49	42	31	33	24	21	13	33	13	19
15	20	41	48	46	38	32	22	20	14	28	13	16
16	20	38	46	44	45	32	19	20	13	35	13	15
17	20	36	39	43	46	31	18	19	14	29	13	15
18	19	34	37		44	30	19	23	14	27	13	15
19	19	35	39		41	29	25	21	14	25	12	15
20	18	33	38		39	29	24	23	14	21	12	15
21	16	31	36	43	41	28	22	20	13	21	14	15
22	16	30	35	61	39	28	21	19	14	20	14	15
23	17	31	38	56	37	35	20	18	14	21	13	14
24	16	31	34	49	35	88	22	17	15	20	13	14
25	16	31	33	48		70	21	17	15	23	13	14
26	18	29	31		35	59	22	24	14	21	13	16
27	24	31	32	45	38	48	21	22	17	21	12	17
28	22	31	38	44	39	41	20	20	17	20	12	22
29	24	34	39	43	41	39	19	18	17	20	12	20
30	35		38	42	49	37	18	17	16	19	13	19

31	27		35		45		18	16		17		23
Qav	16	23	31	34	31	28	18	16	13	14	12	13
Qmin	19	31	44	46	40	40	24	21	15	21	13	17
Qmax	35	45	82	72	49	88	35	38	17	44	16	33



- **Results of biological and general physico-chemical elements and heavy metals**

The results of analysis of biological and general physico-chemical elements and heavy metals is performed according to Regulation on the classification of surface water, which was adopted pursuant to Article 90 (2) of the Low on Water. The assessment of the ecological status is in accordance with the classification of surface water provided in Annex V of the WFD.

Limit value is in accordance with Decree for classification of water and for Cd (cadmium) and Pb (lead) according with Directive 39/13/EC for Priority Substances.

Results of Biological Elements

➢ *Results of phytobentos*

In the following text are presented only the data on the values of the IPS/5 index, which is considered to be the most representative and is one of the most frequently used in dices in the monitoring of natural waters in the European Union. Its limit values for the corresponding ecological status are presented in the following table.

Table 4 Limit values of the IPS index for ecological status assessment

Ecological status	IPS values
High	17 ≤ IPS ≤ 20
Good	13 ≤ IPS < 17
Moderate	9 ≤ IPS <13
Poor	5 ≤ IPS <9
Bed	IPS < 5

a) Lepenec - Border

ID 63135, Catchment area 699.3 km^2, Altitude 360 m

2018 year: At the measuring point MP1 Lepenec - Border (border with Kosovo), the Epiliton and Epiphyton communities according to the IPS index show moderate ecological status. This result is expected given the impact of the Cement Factory in the upper part of the river, as well as the agricultural activities of the surrounding population and communal wastewater from the surrounding houses. The situation is expected to worsen in the summer.

May 2019: At the measuring point MP1 Lepenec-Border (border with Kosovo), the Epiliton communities according to the IPS index show good ecological status. This result is expected given the rising water at this time of year. Worse ecological status is expected due to the impact of the Cement Factory in the upper part of the river, as well as the agricultural activities of the surrounding

population and communal wastewater from the surrounding houses. Particular deterioration is expected in the summer.

September 2019: According to the IPS index, for the epilipton and epipelon diatom communities, the MP1-Lepenec measuring point (on the border with Kosovo) has a poor ecological status, just like the epipelon diatom communities last year in the same period. The result is expected, due to the impact of the Cement Factory in the upper part of the river as well as the pollution from the agricultural activities of the surrounding population and the communal wastewater from the surrounding houses.

February 2020: At the measuring point MP1 Lepenec-Border (border with Kosovo), the diatom communities from the preparation with a sample of epiliton, the preparation with a sample of thread algae, as well as the preparations with epiliton and epipelon, as well as moss with epipelon, according to the IPS index show acceptable ecological status. The water was flooded. The stones were covered with silt, as well as the moss sample.

This result is due to the impact of the Concrete plant in the upper part of the river (R.Kosovo), as well as municipal waste waters from the surrounding areas. Agricultural activities in the summer period of the year, further increase the ecological status of the river, so it is expected deterioration of the ecological situation in this period of the year.

b) Lepenec – Mouth MP2 (inflow into the river Vardar)

ID 63139, Catchment area 770 km^2, Altitude 260 m

2018 year: According to the IPS index for the epilipton, epipelon communities in May, the measuring point MP2 Lepenec - Mouth (at the inflow into Vardar) has a good ecological status. This result is expected given the freshly flooded water from the heavy rains during that period. In conditions of freshly flooded water, the diatoms film is washed from the substrate, making it impossible to take a representative sample.

May 2019: According to the IPS index for the epilipton, epipelon communities in May, the measuring point MP2Lepenec - Mouth (at the inflow into Vardar) has a moderate ecological status. The water was flooded during the heavy rains.

September 2019: The measuring point MP2 Lepenec – Mouth (on the inflow in Vardar), according to the IPS index for the sample of epiliton, macrophytes and mixed sample of epilipton and macrophytes has moderate ecological status. It should not be overlooked that the values for the index are on the verge of poor ecological status. This result is expected given that industrial and communal wastewater flows into this part of the river.

February 2020: According to the IPS index for the epilithic, epiphytic and epipelonic communities in February, at the measuring point MP2 Lepenec – Mouth (on the inflow in Vardar), has an acceptable ecological status. The stones were covered with mil. The water was swollen and fast. Industrial and communal wastewater flows into this part of the river.

In the following tables are presented the results by the assessment of ecological status according to the biotic index IPS for 2018, 2019 and 2020 year in measurement point MP1 and MP2.

Table 5 Ecological status according to the biotic index IPS 2018 year

Measurement point	Date	Substrate	IPS
MP1 - Lepenec– Border	28.05.2018	Epilipton	12.6
MP1 - Lepenec– Border	28.05.2018	Macrophytes	10.5
MP1 - Lepenec– Border	19.09.2018	Epilipton	11.4
MP1 - Lepenec– Border	19.09.2018	Macrophytes	10
MP1 - Lepenec– Border	19.09.2018	Sludge	6.5
MP2 - Lepenec– Mouth	28.05.2018	Epilipton	13.1
MP2 - Lepenec– Mouth	28.05.2018	Macrophytes	13.6
MP2 - Lepenec– Mouth	28.05.2018	Epipelon	14.3
MP2 - Lepenec– Mouth	19.09.2018	Epilipton	12.9
MP2 - Lepenec– Mouth	19.09.2018	Macrophytes	11.3
MP2 - Lepenec– Mouth	19.09.2018	Sludge	8.4

Table 6 Ecological status according to the biotic index IPS 2019 year

Measurement point	Date	Substrate	IPS
MP1 - Lepenec - Border	22.05.2019	Epipelon	13.7
MP1 - Lepenec - Border	02.09.2019	Epiliton	7.3
MP1 - Lepenec - Border	02.09.2019	Epipelon	6.9
MP2 - Lepenec– Mouth	22.05.2019	Epiliton	10.7
MP2 - Lepenec - Mouth	22.05.2019	Conical algae	11.1
MP2 - Lepenec - Mouth	22.05.2019	Epipelon	10.5
MP2 - Lepenec - Mouth	02.09.2019	Epiliton	9.7
MP2 - Lepenec - Mouth	02.09.2019	Macrophytes	9
MP2 - Lepenec - Mouth	02.09.2019	Epipelon + Macrophytes	9.3

Table 7 Ecological status according to the biotic index IPS 2020 year

Measurement point	Date	Substrate	IPS
MP1 - Lepenec - Border	03.02.2020	Epiliton	10.0
MP1 - Lepenec - Border	03.02.2020	Epiliton + Epipelon	10.1
MP1 - Lepenec - Border	03.02.2020	Epipelon + moss	11.9
MP1 - Lepenec - Border	03.02.2020	Conical algae	12.8
MP2 - Lepenec - Mouth	03.02.2020	Epiliton	11.2
MP2 - Lepenec - Mouth	03.02.2020	Macrophytes	9.8

- ***Results of invertebrates***

a) Lepenec – Border MP1

2018 year: The results from the macroinvertebrate survey conducted in 2018 at the sampling site MP1 (May/June and September/October) showed that during the spring period (May and beginning of June) the diversity of macroinvertebrates is relatively low (11 taxa), which is mostly obvious when it comes to EPT taxa (only 4 taxa registered). The macroinvertebrate community is characterized by taxa tolerant to high concentrations of dissolved nutrients in the water, such as the larvae of four mayfly taxa; *Baetisspp.* (7,0%), *Ephemerellaignita* (60,5%), *Oligoneurellarhenana* (4,7%), *Rhitrogenasp.* (2,3%), some chironomid species within the subfamilies Ortocladiinae and Tanypodinae, as well as the amphipod crustacean *Gammarus balcanicus* (4.7%). Tolerant mollusks such as the aquatic snail *Gyraulusalbus* (2,3%) present a significant element of the macroinvertebrate community. The ecological status of MP1 in this period of the year is estimated to be **moderate**

The autumn sampling of 2018 (September/October) did not show big differences in the macroinvertebrate community structure, although the number of EPT taxa slowly escalated from 4 to 6. The macroinvertebrate community contains the larvae of the mayflies *Baetisspp.*(19.8%), *Ephemerellaignita* (12.3%) and *Caenismacrura* (1,2%), indicative to the relatively high concentrations of dissolved nutrients, as well as few species from the subfamily Orthocladiinae(13,6). Although the moderately sensitive *G. Balcanicus* (1,2%) is still present on the sampling locality, the community contains some new taxa which were not registered in the spring season, as the larvae of *Hydropsyche*sp. (Trichoptera). In this period of the year the presence of the aquatic worms (Oligochaeta) is also bigger (43,2%). The detailed analysis of the results from the calculation of the biotic indices (SaprobicIndex, ASPT, Number of Taxa and BMWP) showed that the ecological status of the sampling site is worse in the autumn than in the spring period, therefore it is estimated as **poor.**

Table 8 Lepenec – Border MP1 2018

INDICES / WATER BODIES	MP1 May/June	MP1 Sept./Oct.
Saprobic Index (German new version)	2.1	2.0
ASPT	6.2	5.0
Number of taxa	11	10
BMWP Score	56	40

Ecological status	**M**	**P**

2019 year: The results obtained from the macroinvertebrate survey conducted during 2019, showed relatively high diversity of the macroinvertebrate fauna (11 taxa) in the spring period (May/June) on the locality MP1. However, the number of EPT taxa was noted to be low (3 taxa). The community is characterized by indicators of waters with moderately high nutrient concentrations, such as larvae of the mayfly (Ephemeroptera) *Baetis*sp. (33.6%), non-biting midgets (Chironomidae) from the subfamilies Ortocladiinae, Tanypodinae (12,5%) and the tribes Tanytarsinii and Chironominii. Tolerant isopod crustaceans such as *Asellus aquaticus* (Isopoda, 0,7%), aquatic worms (Oligochaeta, 21,1%), and the caddisflies *Hydropsychepellucidula* (7,2%) and *Hydropsycheinstabilis* (2,0%) were also recorded. The presence of some filter feeders as *Simulium*sp. (Diptera, 15,8%) means that there are high portions of suspended organic materials in the water on the sampling locality MP1.

Taking all this into consideration, the ecological status of this locality in the spring period of 2019 is estimated as **bad**.

The autumn sampling conducted in September 2019 year show a bigger variety of macroinvertebrate taxa (16). The number of EPT taxa is has also escalated (7 taxa) in comparison with the spring period. The community involves mayflies (*Baetis*sp., 25,9%;*Ephemerellaignita*, 4,6%); *Caenis*sp., 11,3%), non-biting midgets (Orthocladinae, 11,9%; TanypodinaeandTanytarsinii) indicative to waters with moderately high nutrient concentrations. Caddisfly larvae (*Hydropsychepellucidula*, 10,7%);*Hydropsyche sp.*) and amphipod crustaceans are also present (*Gammarus balcanicus*, 2,4%). Although the population density of aquatic worms (Oligochaeta, 1,5 %) is lower than in the spring period, the community contains β-mesosaprobic species as larvae of *Onychogomphusforcipatus* (0,6%, Odonata). The ecological status assessment which employed the SaprobicIndex, ASPT, Number of Taxa and BMWP showed that in the autumn period this sampling locality has better ecological status, than in the spring period **moderate.**

Table 9 Lepenec Border MP1 2019 year

INDICES / WATER BODIES	MP1 May/June	MP1 September
Saprobic Index (German new version)	2.0	1.7
ASPT	3.6	5.1
Number of taxa	11	16
BMWP Score	25	51
Ecological status	**B**	**M**

2020 year: The analysis of the results obtained during the research year 2020 (May/June and October), showed that in the campaign conducted at the end of May and the beginning of June, there is a relatively higher diversity of macroinvertebrates (16 taxa) and low number of EPT taxa (7). The community is represented by macroinvertebrates indicative of the presence of moderately high concentrations of nutrients in the water, such as mayflies *Baetis spp.* (23.7%) and *Ephemerella ignita* (17.8%) (Ephemeroptera), as well as moderately sensitive amphipod shrimp *Gammarus balcanicus* with (0.7%) and *Gammarus roeseli* (1.0%). The presence of the more tolerant aquatic snails *Physa sp.* (0.3%) (Gastropoda) is characteristic. Also, the presence of *Trichoptera larvae* was observed mostly with the representatives of *Hydropsyche pellucidula* (8.2%), *Hydropsyche fulvipes* (4.9%), *Psychomia pussila* (0.7%) as well as increased presence of aquatic worms from the group *Oligochaetae sp* (31.6%). The presence of larval filters of the genus *Simulium sp.* (5.3%) (Diptera), is indicative of increased content of suspended solids in water. In this period of the year the sampling point is characterized by **good** environmental status.

In October 2020 there is a relatively lower macroinvertebrate assay (12 taxa) and a low number of EPT taxa (5). The community is represented by the mayflies *Baetis spp.* (29.4%) and *Ephemerella*

ignita (5.9%) which are indicative of the presence of moderately high concentrations of nutrients in the water, as well as the presence of tolerant chironomides represented by *Orthocladinae s.* (5.9%) and *Tanypodinae sp.* (2.9%). The presence of *Trichoptera larvae* was also observed, mostly with representatives of *Hydropsyche spp.* (2.9%), *Hydropsyche pellucidula* (11.8%), *Hydropsyche fulvipes* (8.8%), as well as the moderately sensitive amphipod shrimp *Gammarus balcanicus* (2.9%). In this period of the year, a large presence of aquatic worms from the group *Oligochaetae sp* (20.6%) was recorded. The analysis of the data obtained by calculating the Saprobic Index, ASPT, number of taxa and BMWP showed that the ecological status at the measuring point during the research period shows deterioration and is **poor**.

Table 10 Lepenec Border MP1 2020 year

INDICES / WATER BODIES	MP1 May/June	MP1 October
Saprobic Index (German new version)	2.0	1.7
ASPT	5.4	4.9
Number of taxa	16	12
BMWP Score	75	44
Ecological status	**G**	**P**

b) Lepenec Mouth MP2

Lepenec – Mouth MP2 - inflow in r. Vardar

2018 year: The large amount of rain right before the sampling campaign in the spring period of 2018 (May/June) resulted with worsening the hydrological characteristics of the sampling site which led to a variety of difficulties during sampling. Consequently, the obtained results showed that there are only 4 registered EPT taxa, which means that the macroinvertebrate diversity is extremely low. The macroinvertebrate community is presented with the larvae of *Baetis sp.* (3,6%), *Ephemerellaignita* (82.1%), *Oligoneurella sp*. (3.6%) and the family Pothamantidae(10,7%).

Taking into account the fragmented diversity, the ecological status of river Lepenec at the sampling locality MP2 in the spring period is estimated as **bad.**

The macroinvertebrate community was shown to be more diverse (8 taxa) during the autumn period. The results from the macroinvertebrate sampling at the end of September and the beginning of October, showed that along the larvae of *Caenismacrura* (45.7%) and *Ephemerellaignita* (11.4%), the community contains also moderately sensitive species such as *Gammarus roesel i*(5,7%), tolerant chironomid species from the Tanypodinae subfamily (11,4%), as well as β-mesosaprobic caddisfly (*Hydropsyche instabilis* (8,6%), *Hydropsychecontubernalis* (5,7%), *Hydropsychefulvipes* (2,9%)) and dragonfly larvae (*Onychogomphusforcipatus* (8.6%)). Based on the macroinvertebrate community structure as well as the values of the biotic indices, ecological status on the MP2 in the autumn period was estimated as **poor**.

Table 11 Lepenec Mouth MP2 2018 year

INDICES / WATER BODIES	MP2 May/June	MP2 Sept./Oct.
Saprobic Index (German new version)	2.1	2.0
ASPT	8.0	6.3
Number of taxa	4	8
BMWP Score	24	38
Ecological status	**B**	**P**

2019 year: The comprehensive analysis of the results from the spring sampling in 2019 showed poor biodiversity of macroinvertebrates (4 taxa) and EPT taxa (1) on the sampling site WB_2.

The macroinvertebrate community contains mayfly larvae from the genus *Baetis* (33,6) and dense population of aquatic worms (Oligochaeta, 31,3%). Because of the poor diversity of EPT taxa, the ecological status of MP2 in the spring period is estimated as **bad.**

On the other hand, the autumn sampling in 2019 showed slightly different results as a total number of 13 taxa were detected, out of which 5 were EPT taxa. The macroinvertebrate community involves mayflies (*Baetis*sp., 2,8%;*Caenis*sp., 39,4% and*E. ignita,* 18,3%), amphipod crustaceans as *G. Roeselii* (0,7%), caddisflies *(H. instabilis,* 0,7% and *Hydropsychefulvipes,* 4,2%) and non-biting midgets (Tanypodinae, 3,5% and Orthocladinae, 12,7%). The presence of tolerant aquatic snails such as *Ancylusfluviatilis* (2,1%) and*Physa fontinalis*, as well as aquatic worms (Oligochaeta, 12,0%) was also noted. Based on the macroinvertebrate community structure and the biotic indices values, the ecological status on the sampling site MP2 in the autumn period is assessed as **moderate.**

Table 12 Lepenec Mouth MP2 2019

INDICES / WATER BODIES	MP2 May/June	MP2 September
Saprobic Index (German new version)	/	1.8
ASPT	3.0	4.9
Number of taxa	4	13
BMWP Score	12	54
Ecological status	**B**	**M**

2020 year: The analysis of the results obtained during the May/June 2020 campaign showed that the MP2 is characterized by relatively high species richness (15) and EPT taxa (7). The community is represented by macroinvertebrates such as mayflies *Baetis sp.* (8.6%), *Ephemerella ignita* (55.9%) and *Oligoneurella rhenana* (0.9%) (Ephemeroptera) as well as a large presence of *Oligochaetae sp.* (1.7%). Moderately sensitive amphipod shrimp *Gammarus roeselii* (1.2%), as well as beta-mesosaprobic larvae of *Hydropsyche instabilis* (1.7%), *Hydropsyche fulvipes* (3.4%) and *Hydropsyche contubernalis* (0.9) (*Trichoptera*) are present within the community. The presence of the larvae of the tolerant *chironomides Tanypodinae spp.* (9.5%), Orthocladinae (4.3%), Chironominii spp. (6.0%) and Tanytasinii spp. (2.6%) has also been observed. Based on the structure of the community and the values of the applied indices, namely SI, ASPT, number of taxa and BMWP, the ecological status of MP2 during the research period shows a significant improvement and is assessed as **poor.** In the campaign October 2020, a test was taken on MP2, but the heavy rains that has been in the previous period, conditions with very poor condition of this water body, the water was flooded and no macroinvertebrate units were found in the test.

Table 13 Lepenec Mouth MP2 2020

INDICES / WATER BODIES	MP2 May/June	MP2 October
Saprobic Index (German new version)	2.0	/
ASPT	5.3	/
Number of taxa	15	/
BMWP Score	48	/
Ecological status	**P**	/

Results of general physico-chemical parameters and heavy metals

The results of the physico-chemical elements and heavy metals in two water bodies, respectively in two measurement points: MP1 Lepenec-Border and MP2 Lepenec-Mouth – inflow in river Vardar are presented below.

The following tables (present the values of basic statistics of the general physico-chemical parameters that were measured along the sampling sites in river Lepenec 2018, 2019 and 2020 aggregated respectively in two measurement points: Lepenec-Border MP1 and Lepenec - Mouth MP2 – inflow in river Vardar. The values are typical of the season whereas the mean dissolved oxygen concentrations indicate high physicochemical quality for all the dates.

a) Lepenec – Border MP1

Table 14 Statistical analyses Lepenec-Border MP1 2018 year

	Lepenec (Border) MP1 2018						
Parameter	**Unit**	**N**	**Min**	**5%-ile**	**Avg**	**95%-ile**	**Max**
Alkalinity_CaCO3	mg/l CaCO3	11	95	98	138	183	190
Alkalinity_mEq	mEq/l	11	1.9	2.0	2.8	3.7	3.8
Alkalinity_Phenolphtalein	mEq/l	11	0.00	0.05	0.15	0.28	0.35
BOD5	mg O2/l	11	2.4	2.5	5.4	10.2	10.8
Ca2+	mg/l	11	30	33	50	69	71
Cd	µg/l						
Cl-	mg/l	11	6.7	7.3	10.1	12.9	13.1
CO_2_free	mg/l	11	0	0	0	0	0
CO_3^{2-}	mg/l	11	0.0	3.0	9.0	16.5	21.0
COD_Mn	mg O2/l	11	1.2	1.5	3.7	7.5	8.3
COD_Mn_Kmn	mg/l KMnO4	11	4.8	6.0	14.7	29.7	32.7
Colour_Pt	Pt_Co	11	1.2	2.2	5.3	7.3	7.4
Conductivity	µS/cm	11	226	228	303	410	416
DO	mg/l	11	9.3	9.5	10.9	13.2	13.4
DO_sat	%	11	84	85	97	110	111
Dried residue_filtrable	mg/l	11	124	137	198	259	260
Dried residue_non-filtrable	mg/l	11	172	180	272	407	470
Fe	µg/l	11	27.0	28.5	55.5	96.0	110.0
Fixed residue_filtrable	mg/l	11	72	74	121	174	175
Fixed residue_non-filtrable	mg/l	11	106	107	165	249	264
Hardness_carbonate_CaCO3	mg/l	11	69	76	107	149	155
Hardness_carbonate_odH	mg/l	11	3.8	4.3	6.0	8.3	8.7
Hardness_non-carbonate_CaCO3	mg/l	11	39	47	65	81	83
Hardness_non-carbonate_odH	mg/l	11	2.19	2.61	3.62	4.52	4.66
Hardness_total_CaCO3	mg/l	11	132	135	171	225	229
Hardness_total_odH	mg/l	11	7.4	7.5	9.6	12.6	12.8
HCO3-	mg/l CaCO3	11	104	107	150	204	214
K+	mg/l	11	1.5	1.5	2.9	5.6	6.5
Mg2+	mg/l	11	7.2	7.7	10.6	13.1	14.3
Mn	µg/l	11	1.6	3.3	23.3	59.0	59.0
Na+	mg/l	11	4.7	4.9	8.8	15.0	15.7
NH4_N	µg N/l	11	107	122	385	810	973
NO2_N	mg N/l	11	0.012	0.014	0.090	0.226	0.243
NO2_N_µg	µg N/l	11	12	14	90	226	243
NO3_N	mg N/l	11	0.82	0.85	1.89	4.10	4.75

NO3_N_µg	µg N/l	11	816	848	1891	4103	4750
OH-	mg/l	11	0	0	0	0	0
pH	-	11	7.6	7.6	7.9	8.2	8.2
PO_4	mg PO4/l	11	0.09	0.09	0.27	0.59	0.60
PO_4	mg P/l	4	0.03	0.03	0.09	0.19	0.20
PO4_µg	µg PO4/l	11	88	89	268	590	603
Redox	mV	11	-55	-54	-45	-36	-34
Residue volatile_filtrable	mg/l	11	52	53	77	104	107
Residue volatile_non-filtrable	mg/l	11	65	68	107	194	275
SO4_2-	mg/l	11	10.7	12.6	22.3	30.9	30.9
SS_Mineral	mg/l	11	8	9	43	101	113
SS_Organic	mg/l	11	2	3	30	114	183
SS_Total	mg/l	11	15	16	73	191	247
T_air	oC	11	4.0	5.0	16.7	26.0	26.0
T_water	oC	11	4.0	4.5	11.0	17.3	18.5
Turbidity_NTU	NTU	11	14.0	15.0	76.5	189.5	246.0
Turbidity_SiO2	mg SiO2/l	11	5.0	6.3	7.7	10.0	10.0
Zn	µg/l	11	0.2	0.2	7.3	21.3	28.2

Table 15 Statistical analyses Lepenec_Border MP1 2019 year

	Lepenec (Boreder) MP1 2019						
Parameter	**Unit**	**N**	**Min**	**5%-ile**	**Avg**	**95%-ile**	**Max**
Alkalinity_$CaCO_3$	mg/l $CaCO_3$	10	85	104	152	200	208
Alkalinity_mEq	mEq/l	10	1.7	2.1	3.0	4.0	4.2
Alkalinity_Phenolphtalein	mEq/l	10	0.05	0.07	0.18	0.41	0.50
BOD5	mg O_2/l	10	3.1	3.2	4.7	7.0	8.2
Ca^{2+}	mg/l	10	32	33	50	68	69
Cd	µg/l	10	0.005	0.010	0.039	0.094	0.098
Cl^-	mg/l	10	6.6	7.1	12.2	18.3	18.8
CO_2_free	mg/l	10	0	0	0	0	0
CO_3^{2-}	mg/l	10	3.0	4.4	10.8	24.6	30.0
COD_Mn	mg O2/l	10	1.1	1.2	5.7	21.0	35.2
COD_Mn_Kmn	mg/l KMnO4	10	4.2	4.6	22.5	83.0	139.0
Colour_Pt	Pt_Co	10	4.8	5.3	8.3	15.9	21.5
Conductivity	µS/cm	10	208	223	331	427	429
Cr_VI	µg/l	10	0.17	0.19	0.55	1.01	1.05
Cu	µg/l	10	0.26	0.52	3.24	9.14	9.18
DO	mg/l	10	9.1	9.2	10.6	12.5	13.1
DO_sat	%	10	85	87	95	101	103
Dried residue_filtrable	mg/l	10	121	134	209	279	288
Dried residue_non-filtrable	mg/l	10	151	168	253	386	460
Fe	µg/l	10	14.0	16.3	46.1	105.9	150.0
Fixed residue_filtrable	mg/l	10	78	87	126	166	170
Fixed residue_non-filtrable	mg/l	10	103	107	149	201	222
Hardness_carbonate_$CaCO_3$	mg/l	10	50	56	107	160	167

Hardness_carbonate_°dH	mg/l	10	2.8	3.1	6.0	8.9	9.3
Hardness_non-carbonate_$CaCO_3$	mg/l	10	51	53	76	119	146
Hardness_non-carbonate_°dH	mg/l	10	2.85	2.98	4.25	6.63	8.16
Hardness_total_$CaCO_3$	mg/l	10	114	121	184	235	236
Hardness_total_°dH	mg/l	10	6.4	6.8	10.3	13.2	13.2
HCO_3^-	mg/l CaCO3	10	85	112	163	194	195
K^+	mg/l	10	2.0	2.1	3.4	5.2	5.7
Mg^{2+}	mg/l	10	7.7	7.9	14.2	24.0	28.1
Mn	µg/l	10	1.6	5.8	19.5	38.0	47.0
Na^+	mg/l	10	4.9	5.4	10.1	16.6	17.1
NH_4_N	mg N/l	10	0.005	0.010	0.039	0.094	0.098
NH_4_N_µg	µg N/l	10	19	55	319	783	1011
NO_2_N	mg N/l	10	0.024	0.024	0.135	0.310	0.315
NO_2_N_µg	µg N/l	10	24	24	135	310	315
NO_3_N	mg N/l	10	0.19	0.24	1.24	2.01	2.13
NO_3_N_µg	µg N/l	10	190	240	1240	2008	2132
OH^-	mg/l	9	0	0	0	0	0
Pb	µg/l	10	0.25	0.25	0.28	0.43	0.57
pH	-	10	7.7	7.7	7.9	8.2	8.2
PO_4	mg PO_4/l	10	0.16	0.17	0.40	0.76	0.85
PO4	mg P/l	10	0.05	0.05	0.13	0.25	0.28
PO4_µg	µg PO_4/l	10	165	166	405	764	855
Redox	mV	10	-58	-58	-42	-31	-30
Residue volatile_filtrable	mg/l	10	43	47	83	114	127
Residue volatile_non-filtrable	mg/l	10	48	62	104	189	238
SO_4^{2-}	mg/l	10	10.9	13.6	22.6	30.8	31.4
SS_Mineral	mg/l	10	5	5	23	79	124
SS_Organic	mg/l	10	1	1	22	105	186
SS_Total	mg/l	10	8	8	45	184	310
T_air	°C	10	5.0	7.0	16.2	24.5	25.0
T_water	°C	10	4.2	4.8	11.5	17.8	18.0
Turbidity_NTU	NTU	10	7.0	7.0	42.1	183.0	309.0
Turbidity_SiO_2	mg SiO_2/l	10	5.0	5.5	7.5	10.0	10.0
Zn	µg/l	10	0.2	0.2	2.5	7.3	8.2

Table 16 Statistical analyses Lepenec_Border MP1 2020 year

Parameter	**Lepenec (Boreder) MP1 2020**				
	Unit	**N**	**Min**	**Avg**	**Max**
Alkalinity_$CaCO_3$	mg/l $CaCO_3$	8	90.08	145.88	192.7
Alkalinity_mEq	mEq/l	8	1.80	2.92	3.85
Alkalinity_Phenolphtalein	mEq/l	8	0.00	0.11	0.20
BOD5	mg O_2/l	8	2.81	5.68	9.36
Ca^{2+}	mg/l	8	31.26	48.74	60.32
Cd	µg/l	8	0.005	0.082	0.130
Cl^-	mg/l	8	7.99	12.62	22.79

CO_2_free	mg/l	8	0.00	0.00	0.00
CO_3^{2-}	mg/l	8	0.00	6.60	12.0
COD_Mn	mg O2/l	8	1.23	4.09	10.63
COD_Mn_Kmn	mg/l KMnO4	8	4.86	16.17	42.0
Colour_Pt	Pt_Co	8	5.8	11.7	46.3
Conductivity	µS/cm	8	178.0	289.7	372.0
Cr_VI	µg/l	8	0.40	0.71	1.56
Cu	µg/l	8	0.63	2.68	4.73
DO	mg/l	8	8.03	9.95	12.03
DO_sat	%	8	63.39	90.97	108.4
Dried residue_filtrable	mg/l	8	125	192	250
Dried residue_non-filtrable	mg/l	8	134	468	2537
Fe	µg/l	8	12.0	74.7	364.0
Fixed residue_filtrable	mg/l	8	76	114	149
Fixed residue_non-filtrable	mg/l	8	84	231	1038
Hardness_carbonate_$CaCO_3$	mg/l	8	40.04	97.57	155.1
Hardness_carbonate_°dH	mg/l	8	2.24	5.46	8.68
Hardness_non-carbonate_$CaCO_3$	mg/l	8	49.15	75.23	117.6
Hardness_non-carbonate_°dH	mg/l	8	2.75	4.21	6.58
Hardness_total_$CaCO_3$	mg/l	8	110.10	172.31	215.2
Hardness_total_°dH	mg/l	8	6.16	9.64	12.04
HCO_3^-	mg/l CaCO3	8	97.63	164.44	222.7
K^+	mg/l	8	1.030	2.468	5.022
Mg^{2+}	mg/l	8	6.08	11.49	15.81
Mn	µg/l	8	1.6	41.4	295.0
Na^+	mg/l	8	4.742	8.723	14.820
NH_4_N	mg N/l	8	0.0791	0.2901	0.7442
NH_4_N_µg	µg N/l	8	79.10	290.06	744.2
NO_2_N	mg N/l	8	0.0396	0.0943	0.2502
NO_2_N_µg	µg N/l	8	39.60	94.31	250.2
NO_3_N	mg N/l	8	0.0464	0.7741	2.2600
NO_3_N_µg	µg N/l	8	46.40	774.09	2260.0
OH^-	mg/l	8	0.00	0.00	0.00
Pb	µg/l	8	0.25	0.29	0.61
pH	-	8	7.55	7.97	8.26
PO_4	mg PO_4/l	8	0.0497	0.3447	0.8270
PO4_µg	µg PO_4/l	8	49.70	344.65	827.0
Redox	mV	8	-56.0	-41.2	-18.0
Residue volatile_filtrable	mg/l	8	49	79	111
Residue volatile_non-filtrable	mg/l	8	50	237	1499
SO_4^{2-}	mg/l	8	11.51	23.05	41.66
SS_Mineral	mg/l	8	7	117	952
SS_Organic	mg/l	8	1	158	1429
SS_Total	mg/l	8	9	276	2381

T_air	°C	8	4.0	16.1	25.0
T_water	°C	8	5.0	12.0	19.0
Turbidity_NTU	NTU	8	8.0	274.9	2380.0
Turbidity_SiO_2	mg SiO_2/l	8	5.0	6.4	10.0
Zn	µg/l	8	0.22	0.28	0.80

b) Lepenec – Mouth MP2

Table 17 Lepenec – Mouth MP2 2018

Parameter	**Lepenec (Mouth) MP2 2018**						
	Unit	**N**	**Min**	**5%-ile**	**Avg**	**95%-ile**	**Max**
Alkalinity_$CaCO_3$	mg/l $CaCO_3$	11	90	90	138	184	185
Alkalinity_mEq	mEq/l	11	1.8	1.8	2.8	3.7	3.7
Alkalinity_Phenolphtalein	mEq/l	11	0.10	0.10	0.15	0.25	0.30
BOD5	mg O_2/l	11	2.4	2.5	5.0	9.0	11.0
Ca^{2+}	mg/l	11	30	30	51	70	71
Cd	µg/l						
Cl-	mg/l	11	7.5	7.7	11.0	14.0	14.7
CO2_free	mg/l	11	0	0	0	0	0
CO3_2-	mg/l	11	6.0	6.0	9.3	15.0	18.0
COD_Mn	mg O2/l	11	1.1	1.4	3.3	6.7	6.9
COD_Mn_Kmn	mg/l KMnO4	11	4.1	5.6	13.0	26.4	27.4
Colour_Pt	Pt_Co	11	3.7	4.1	7.0	10.2	10.6
Conductivity	µS/cm	11	236	240	317	421	426
DO	mg/l	11	9.5	9.6	10.8	12.7	13.6
DO_sat	%	11	78	82	98	107	107
Dried residue_filtrable	mg/l	11	126	138	204	255	258
Dried residue_non-filtrable	mg/l	11	185	211	277	345	377
Fe	µg/l	11	28.0	33.5	62.5	101.5	127.0
Fixed residue_filtrable	mg/l	11	72	80	127	175	187
Fixed residue_non-filtrable	mg/l	11	112	120	180	257	288
Hardness_carbonate_CaCO3	mg/l	11	78	78	112	149	155
Hardness_carbonate_odH	mg/l	11	4.4	4.4	6.2	8.3	8.7
Hardness_non-carbonate_CaCO3	mg/l	11	44	46	64	76	78
Hardness_non-carbonate_odH	mg/l	11	2.46	2.60	3.59	4.25	4.38
Hardness_total_CaCO3	mg/l	11	137	137	176	225	229
Hardness_total_odH	mg/l	11	7.7	7.7	9.8	12.6	12.8
HCO3-	mg/l CaCO3	11	98	98	149	198	207
K+	mg/l	11	1.5	1.6	2.9	5.1	6.0
Mg2+	mg/l	11	7.2	7.2	11.0	13.7	14.3
Mn	µg/l	11	1.6	1.6	21.2	48.0	57.0
Na+	mg/l	11	5.1	5.4	9.3	14.3	14.5
NH4_N_µg	µg N/l	11	44	62	296	702	760
NO2_N	mg N/l	11	0.013	0.015	0.101	0.239	0.304

NO2_N_µg	µg N/l	11	13	15	101	239	304
NO3_N	mg N/l	11	0.81	0.89	2.02	4.61	5.75
NO3_N_µg	µg N/l	11	807	890	2016	4606	5750
OH-	mg/l	11	0	0	0	0	0
pH	-	11	7.6	7.6	7.9	8.1	8.2
PO4	mg PO4/l	11	0.01	0.05	0.27	0.57	0.58
PO4	mg P/l	11	0.00	0.02	0.09	0.18	0.19
PO4_µg	µg PO4/l	11	13	47	267	565	585
Redox	mV	11	-55	-54	-43	-32	-31
Residue volatile_filtrable	mg/l	11	49	51	77	104	104
Residue volatile_non-filtrable	mg/l	11	72	75	97	122	128
SO4_2-	mg/l	11	10.4	12.1	21.8	33.5	37.5
SS_Mineral	mg/l	11	12	14	53	101	102
SS_Organic	mg/l	11	5	7	20	38	40
SS_Total	mg/l	11	34	35	72	132	141
T_air	oC	11	6.0	6.0	17.0	25.0	25.0
T_water	oC	11	3.4	4.1	11.0	17.3	18.0
Turbidity_NTU	NTU	11	33.0	33.5	70.8	131.0	140.0
Turbidity_SiO2	mg SiO2/l	11	5.0	6.3	7.7	10.0	10.0
Zn	µg/l	11	0.2	2.4	12.1	25.8	27.7

Table 18 Lepenec–Mouth MP2 2019 year

Parameter	**Lepenec (Mouth) MP2 2019**						
	Unit	**N**	**Min**	**5%-ile**	**Avg**	**95%-ile**	**Max**
Alkalinity_CaCO3	mg/l CaCO3	10	95	114	158	208	210
Alkalinity_mEq	mEq/l	10	1.9	2.3	3.2	4.2	4.2
Alkalinity_Phenolphtalein	mEq/l	10	0.10	0.10	0.19	0.28	0.30
BOD5	mg O2/l	10	3.0	3.2	4.6	7.3	8.7
Ca2+	mg/l	10	30	33	53	73	76
Cd	µg/l	10	0.005	0.014	0.066	0.139	0.151
Cl-	mg/l	10	7.0	8.0	13.3	17.9	17.9
CO2_free	mg/l	10	0	0	0	0	0
CO3_2-	mg/l	10	6.0	6.0	11.4	16.7	18.0
COD_Mn	mg O2/l	10	1.6	1.7	7.2	28.2	47.6
COD_Mn_Kmn	mg/l KMnO4	10	6.4	6.5	28.6	111.4	188.0
Colour_Pt	Pt_Co	10	5.3	5.8	8.2	13.7	17.2
Conductivity	µS/cm	10	215	229	345	457	463
Cr_VI	µg/l	10	0.47	0.49	0.77	1.27	1.34
Cu	µg/l	10	0.84	1.12	2.72	4.84	4.94
DO	mg/l	10	8.7	8.9	10.4	12.2	13.1
DO_sat	%	10	88	89	96	103	104
Dried residue_filtrable	mg/l	10	133	142	215	285	293
Dried residue_non-filtrable	mg/l	10	179	197	306	473	550
Fe	µg/l	10	2.5	13.1	59.0	122.1	127.0
Fixed residue_filtrable	mg/l	10	84	93	132	170	174

Fixed residue_non-filtrable	mg/l	10	120	127	184	249	263
Hardness_carbonate_CaCO3	mg/l	10	45	56	113	177	178
Hardness_carbonate_odH	mg/l	10	2.5	3.2	6.3	9.9	9.9
Hardness_non-carbonate_CaCO3	mg/l	10	51	51	75	129	151
Hardness_non-carbonate_odH	mg/l	10	2.85	2.85	4.22	7.21	8.44
Hardness_total_CaCO3	mg/l	10	124	127	189	247	248
Hardness_total_odH	mg/l	10	6.9	7.1	10.6	13.8	13.9
HCO3-	mg/l CaCO3	10	98	121	171	220	226
K+	mg/l	10	2.0	2.2	3.3	4.3	4.6
Mg2+	mg/l	10	8.3	8.6	14.0	25.0	29.3
Mn	µg/l	10	8.0	9.8	24.5	42.7	44.0
Na+	mg/l	10	5.1	6.1	10.3	15.9	16.4
NH4_N	mg N/l	10	0.005	0.014	0.066	0.139	0.151
NH4_N_µg	µg N/l	10	10	13	245	645	884
NO2_N	mg N/l	10	0.032	0.032	0.099	0.235	0.286
NO2_N_µg	µg N/l	10	32	32	99	235	286
NO3_N	mg N/l	10	0.06	0.13	1.36	2.23	2.39
NO3_N_µg	µg N/l	10	61	125	1359	2230	2392
OH-	mg/l	9	0	0	0	0	0
Pb	µg/l	10	0.25	0.25	0.25	0.25	0.25
pH	-	10	7.7	7.7	8.0	8.3	8.3
PO4	mg PO4/l	10	0.12	0.14	0.35	0.61	0.62
PO4	mg P/l	10	0.04	0.04	0.11	0.20	0.20
PO4_µg	µg PO4/l	10	117	138	351	610	618
Redox	mV	10	-65	-61	-44	-34	-33
Residue volatile_filtrable	mg/l	10	49	49	83	118	128
Residue volatile_non-filtrable	mg/l	10	59	70	122	226	287
SO4_2-	mg/l	10	11.5	14.4	22.6	32.3	35.2
SS_Mineral	mg/l	10	7	15	52	121	158
SS_Organic	mg/l	10	4	4	40	151	238
SS_Total	mg/l	10	13	20	92	264	396
T_air	oC	10	5.5	7.8	16.9	25.6	26.0
T_water	oC	10	5.5	5.7	12.4	19.3	19.5
Turbidity_NTU	NTU	10	10.0	10.9	87.3	263.2	395.0
Turbidity_SiO2	mg SiO2/l	10	7.5	7.5	8.8	12.8	15.0
Zn	µg/l	10	0.2	0.2	6.3	13.7	14.2

Table 19 Statistical analyses Lepenec (Mouth) MP2 2020 year

Parameter	**Lepenec (Mouth) MP2 2020**				
	Unit	**N**	**Min**	**Avg**	**Max**
Alkalinity_$CaCO_3$	mg/l $CaCO_3$	9	105.09	154.14	205.2
Alkalinity_mEq	mEq/l	9	2.10	3.08	4.10
Alkalinity_Phenolphtalein	mEq/l	9	0.00	0.15	0.30
BOD5	mg O_2/l	9	2.42	4.55	7.79
Ca^{2+}	mg/l	9	31.29	49.13	64.21

Cd	µg/l	9	0.058	0.086	0.148
Cl^-	mg/l	9	9.55	13.42	18.57
CO_2_free	mg/l	9	0.00	0.00	0.00
CO_3^{2-}	mg/l	9	0.00	8.70	18.0
COD_Mn	mg O2/l	9	1.40	3.83	8.21
COD_Mn_Kmn	mg/l KMnO4	9	5.53	15.15	32.4
Colour_Pt	Pt_Co	9	4.7	9.6	17.7
Conductivity	µS/cm	9	208.0	307.5	393.0
Cr_VI	µg/l	9	0.55	0.89	2.29
Cu	µg/l	9	0.85	3.41	5.54
DO	mg/l	9	8.39	10.16	12.16
DO_sat	%	9	70.56	94.76	105.3
Dried residue_filtrable	mg/l	9	149	205	262
Dried residue_non-filtrable	mg/l	9	178	396	1634
Fe	µg/l	9	14.0	48.9	199.0
Fixed residue_filtrable	mg/l	9	91	122	161
Fixed residue_non-filtrable	mg/l	9	116	216	732
Hardness_carbonate_$CaCO_3$	mg/l	9	70.07	111.46	165.2
Hardness_carbonate_°dH	mg/l	9	3.92	6.24	9.24
Hardness_non-carbonate_$CaCO_3$	mg/l	9	49.15	73.73	121.5
Hardness_non-carbonate_°dH	mg/l	9	2.75	4.13	6.80
Hardness_total_$CaCO_3$	mg/l	9	135.13	185.19	230.8
Hardness_total_°dH	mg/l	9	7.56	10.36	12.91
HCO_3^-	mg/l CaCO3	9	115.93	170.24	231.9
K^+	mg/l	9	0.094	2.536	4.158
Mg^{2+}	mg/l	9	9.73	14.10	20.67
Mn	µg/l	9	1.6	22.2	96.0
Na^+	mg/l	9	5.868	10.067	16.589
NH_4_N	mg N/l	9	0.0345	0.3090	0.8680
NH_4_N_µg	µg N/l	9	34.50	309.0	868.0
NO_2_N	mg N/l	9	0.0413	0.0673	0.1010
NO_2_N_µg	µg N/l	9	41.30	67.28	101.0
NO_3_N	mg N/l	9	0.1092	0.8131	2.3200
NO_3_N_µg	µg N/l	9	109.20	813.07	2320.0
OH^-	mg/l	9	0.00	0.00	0.00
Pb	µg/l	9	0.25	0.31	0.85
pH	-	9	7.41	7.96	8.20
PO_4	mg PO_4/l	9	0.194	0.342	0.536
PO4_µg	µg PO_4/l	9	194.20	342.32	536.0
Redox	mV	9	-53.0	-41.2	-10.0
Residue volatile_filtrable	mg/l	9	58	83	116
Residue volatile_non-filtrable	mg/l	9	62	182	902
SO_4^{2-}	mg/l	9	15.71	24.66	36.50
SS_Mineral	mg/l	9	14	94	640
SS_Organic	mg/l	9	4	99	832

SS_Total	mg/l	9	26	193	1472
T_air	°C	9	5.0	9.6	15.0
T_water	°C	9	5.5	12.8	19.0
Turbidity_NTU	NTU	9	24.0	190.5	1470.0
Turbidity_SiO_2	mg SiO_2/l	9	5.0	9.6	15.0
Zn	µg/l	9	0.22	0.51	2.10

Table 20 Water body status according to the general physico-chemical elements 2018, 2019 and 2020 year

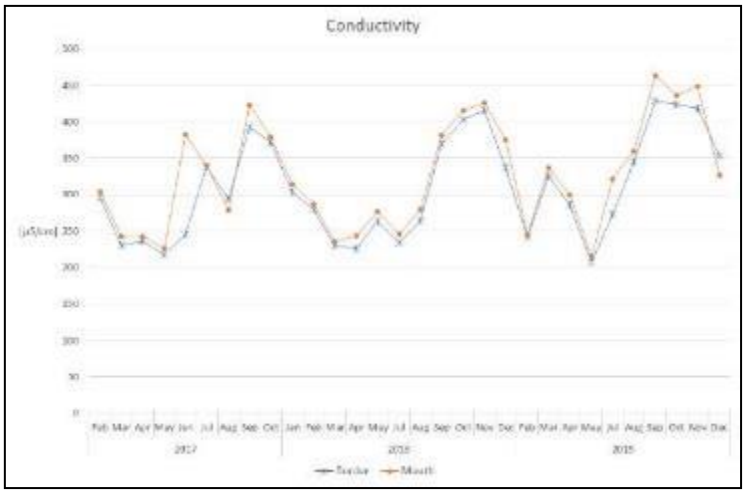
Measurement point	Water Body	pH	Alkalinity	El. Conductivity	Dissolved Oxygen	BOD5	COD	Phosphate (PO_4)	Ammonium (NH_4 – N)	NitrateNO_3–N)	Nitrite(NO_2 – N)	General PH-CH WB status
1. Lepenec– Border MP1 2018	WB_1	H	G	M	H	M	G	P	G	G	G	**P**
2. Lepenec– Mouth MP2 2018	WB_2	H	G	M	H	M	G	P	G	G	G	**P**
1. Lepenec– Border MP1 2019	WB_1	G	G	M	H	P	M	P	G	G	P	**P**
2. Lepenec– Mouth MP2 2019	WB_2	G	G	M	H	M	M	P	G	M	G	**P**
1. Lepenec– Border MP1 2020	WB_1	H	G	H	H	M	G	M	G	H	G	**M**
2. Lepenec– Mouth MP2 2020	WB_2	H	G	H	H	M	G	M	G	H	G	**M**

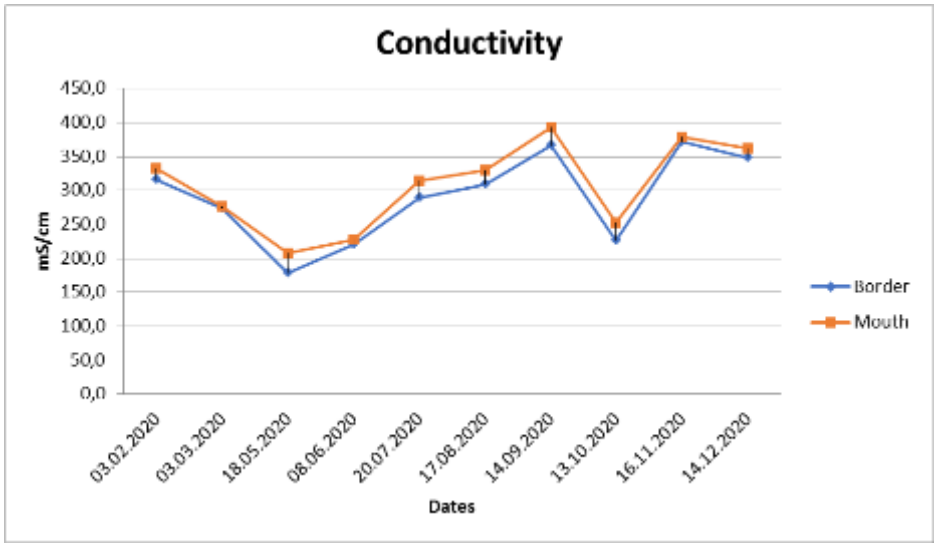
Analysis of the general physico-chemical elements shows that pH, dissolved oxygen are with high status, alkalinity, COD, Ammonium (NH_4), nitrate (NO_3) and nitrite (NO_2) with good status, Conductivity and BOD5 with moderate status and Phosphate (PO_4) with poor status in Lepenec - Border MP1 and Lepenec – Mouth MP2 in 2018 year.

Analysis of the general physico-chemical elements in 2019 year shows lower status (poor) for BOD, Phosphate (PO_4) and Nitrite (NO_2) at MP1 Lepenec-Border. MP2 has poor status only for the phosphates (PO_4). Moderate status is achieved at both measuring points for conductivity and COD. MP2 additionally has moderate status for BOD5 and nitrate (NO_2). The concentrations of pH, alkalinity and ammonium (NH_4) show good status for both measuring points MP1 and MP2. Good status also is achieved for nitrate (NO_3) for MP1 and good status for nitrite (NO_2) for MP2.

Analysis of the general physico-chemical elements in 2019 year shows medium status for BOD and Phosphate (PO_4) for both MP1 and MP2. Good status is achieved for alkalinity, COD, Ammonium (NH4) and nitrite (NO_2). High status is achieved at both measuring points for the following parameters pH, dissolved oxygen, conductivity and nitrate (NO_3).

High nitrite concentrations indicate fecal pollution. The general status of the water in River Lepenec for 2018 and 2019 is assessed as poor and in 2020 with moderate status. Graphs of some phisico-chemical elements and heavy metals are given bellow.


Conductivity


Conductivity
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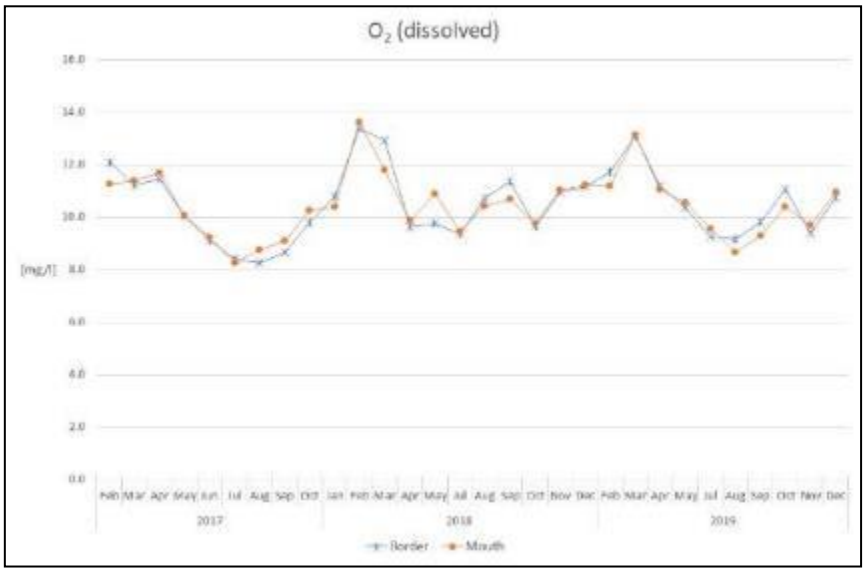
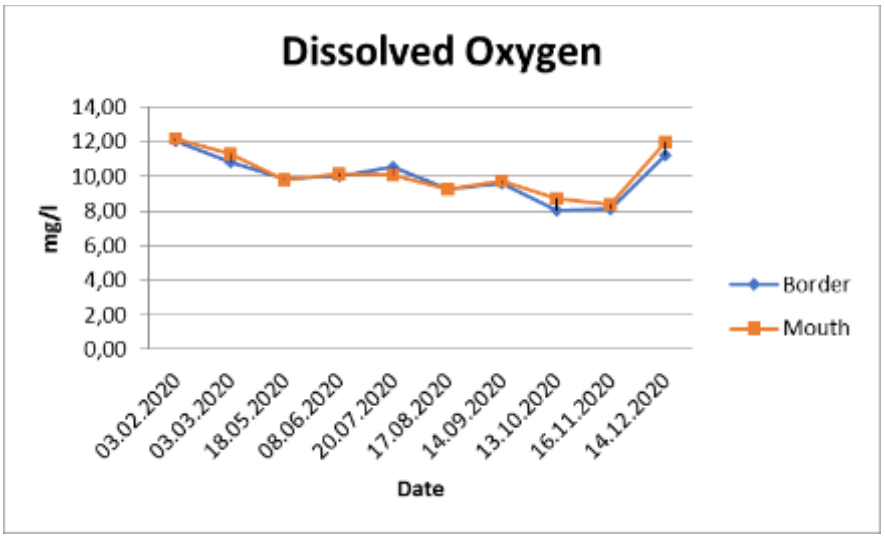
300,0
250,0
200,0
150,0
100,0
50,0
0,0
mS/cm
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Dates
Border
Mouth


O2 (dissolved)


Dissolved Oxygen
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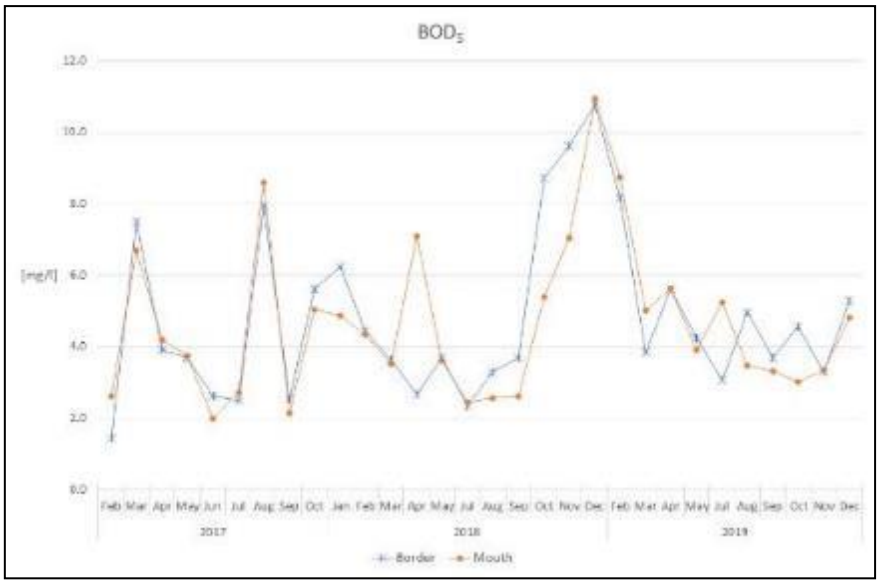
12,00
10,00
8,00
6,00
4,00
2,00
0,00
mg/l
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Date
Border
Mouth


BOD5
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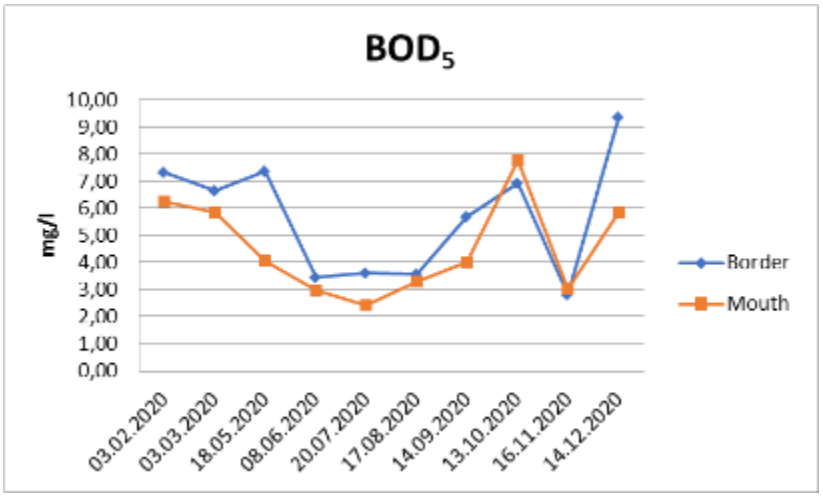
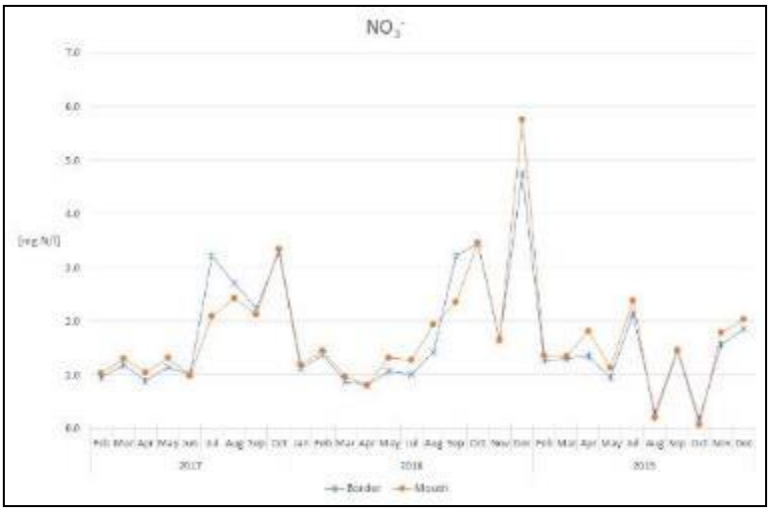
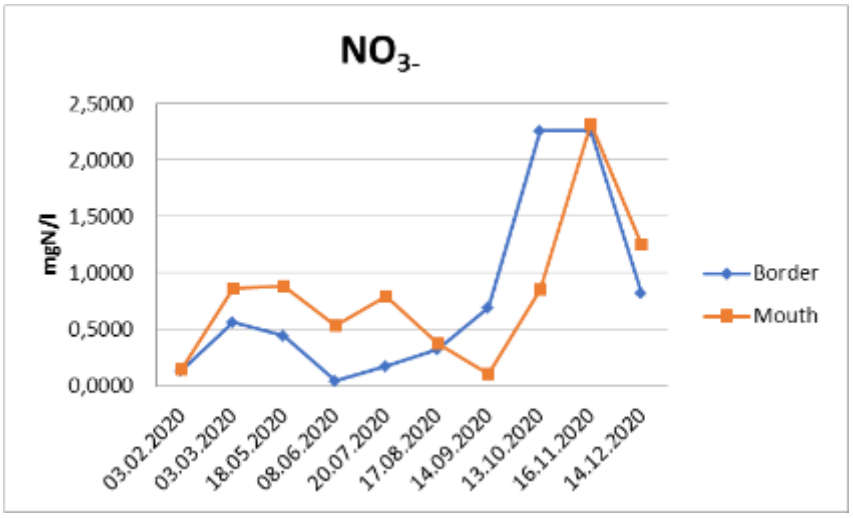
10.0
8.0
6.0
4.0
2.0
0.0
[mg/l]
2017
2018
2019
Border
Mouth


BOD5
10,00
9,00
8,00
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
mg/l
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Border
Mouth


NO3-
[mg N/l]
2017
2018
2019
Border
Mouth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mgN/l
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2,0000
1,5000
1,0000
0,5000
0,0000
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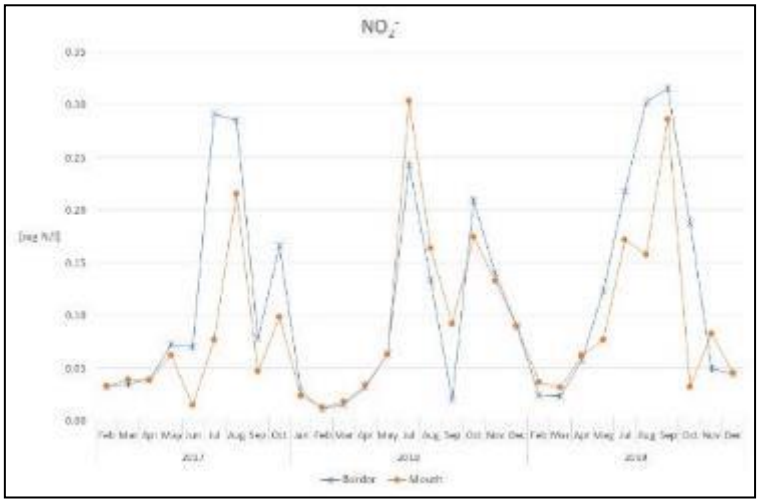
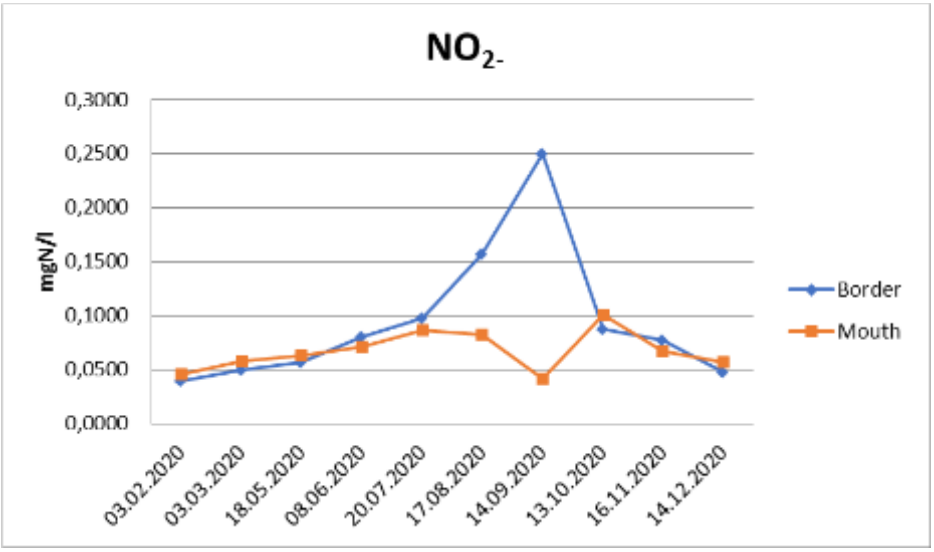
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Border
Mouth


NO2-
[mg N/l]
2017
2018
2019
Border
Mouth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0,2000
0,1500
0,1000
0,0500
0,0000
mgN/l
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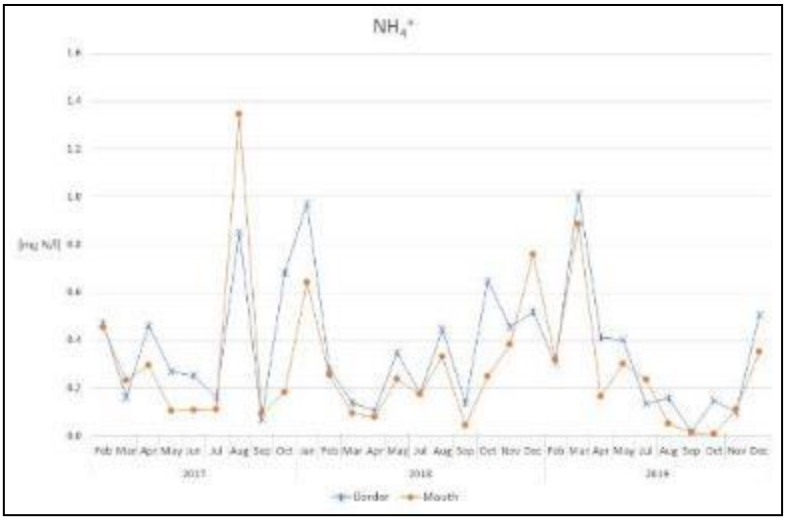
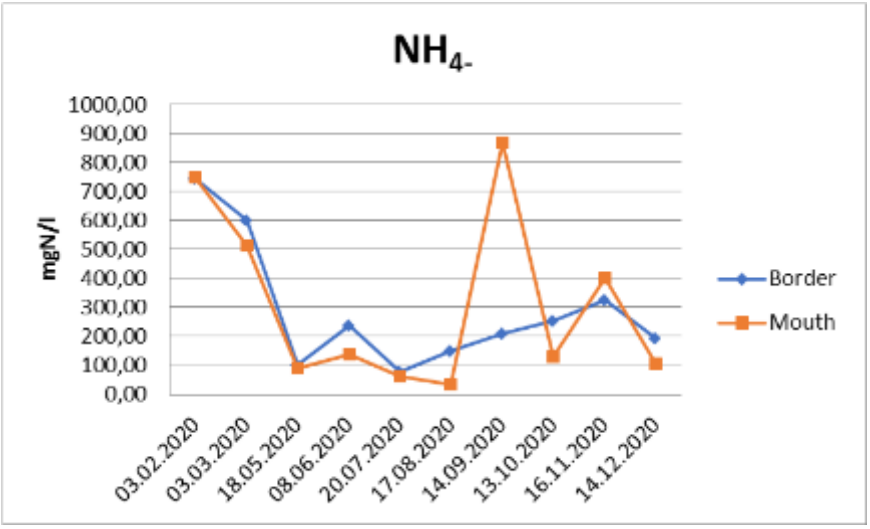
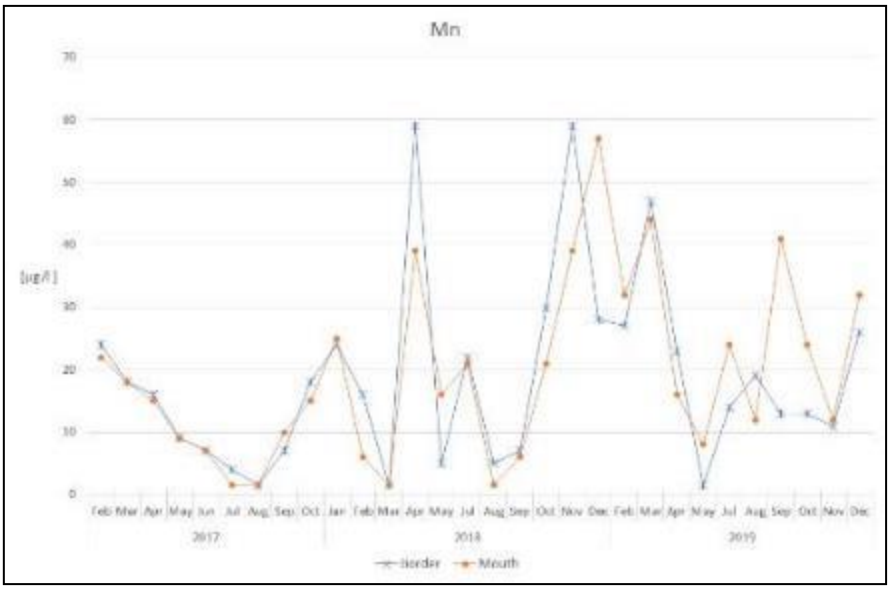
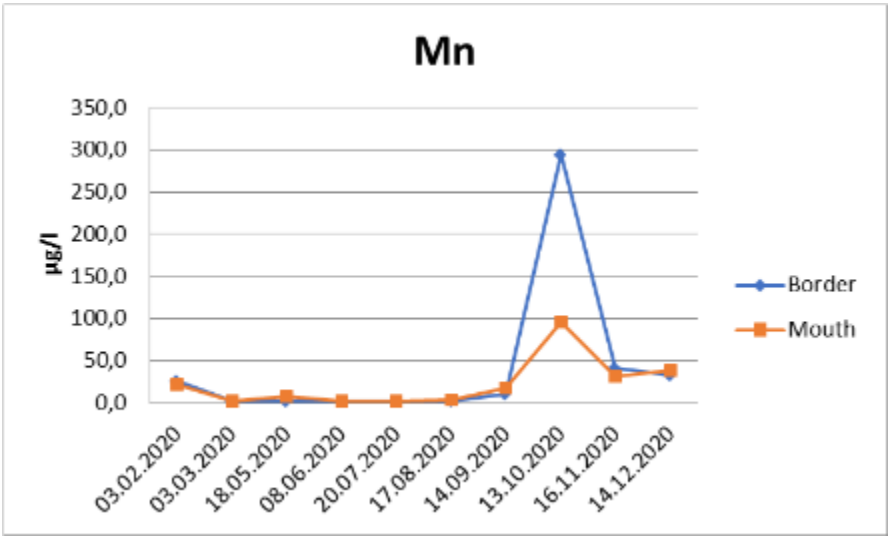
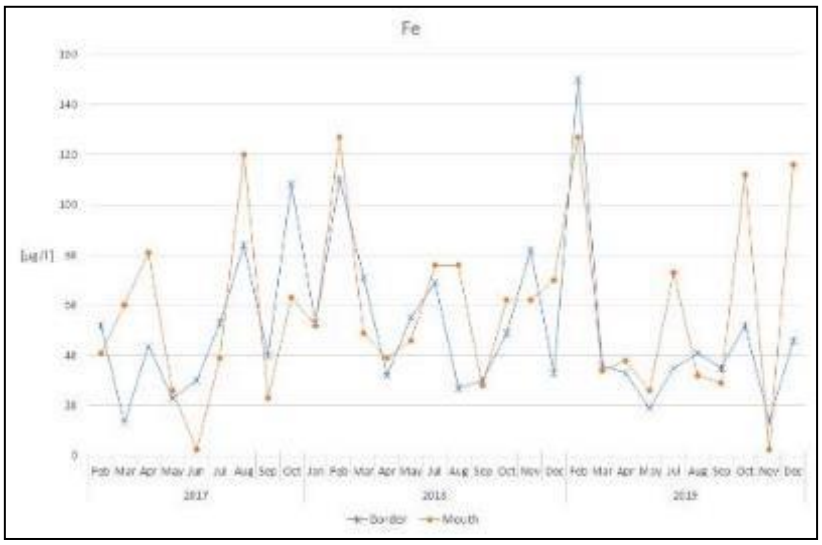
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Border
Mouth

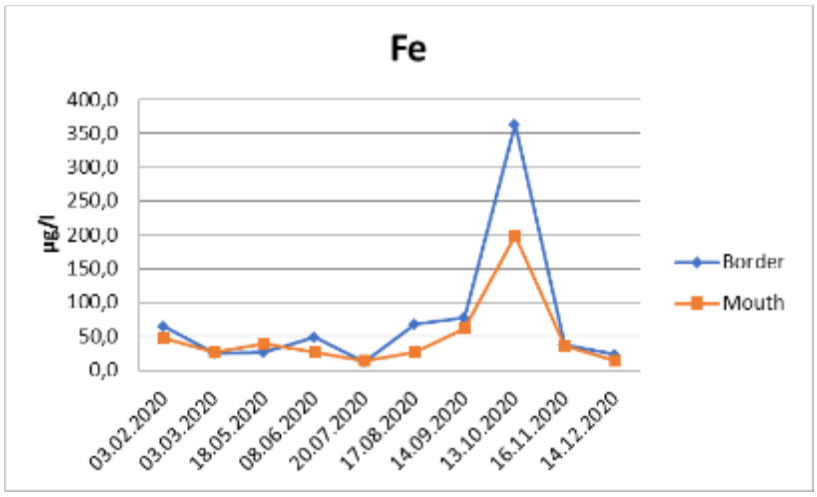

NH4+
Border
Mouth

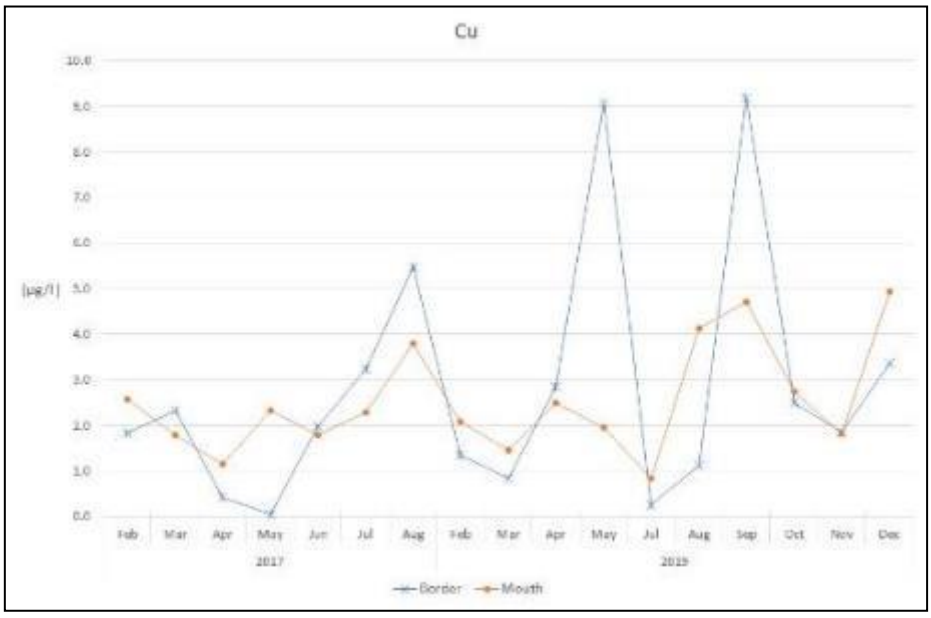

NH4-
1000,00
900,00
800,00
700,00
600,00
500,00
400,00
300,00
200,00
100,00
0,00
mgN/l
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Border
Mouth

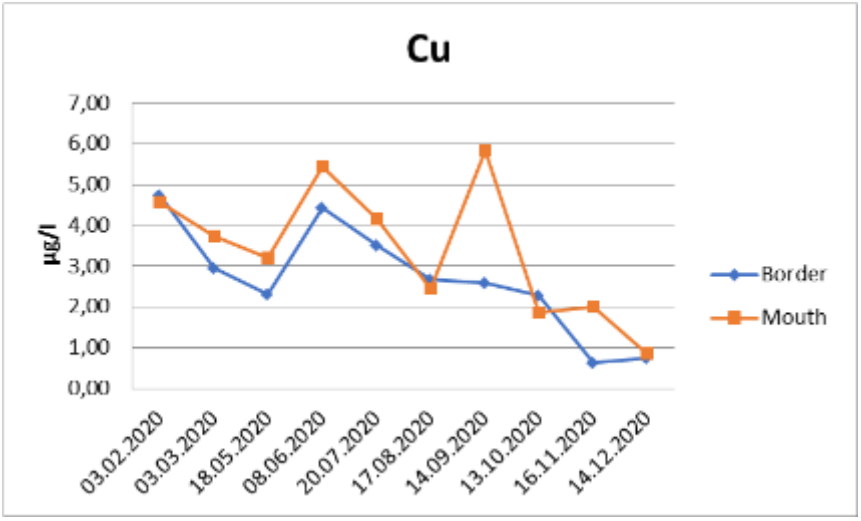

Mn
[ug/l]
2017
2018
2019
Border
Mouth

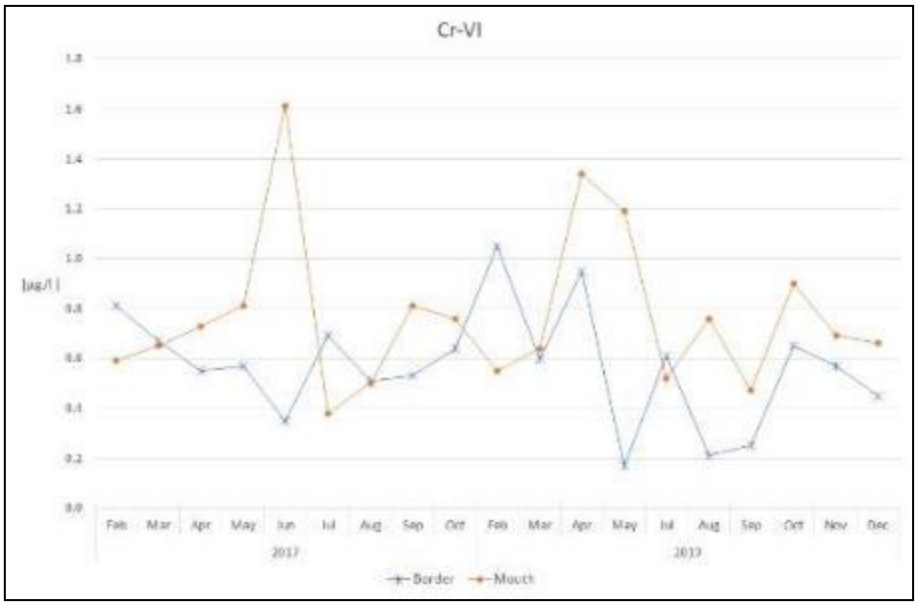

Mn
µg/l
350,0
300,0
250,0
200,0
150,0
100,0
50,0
0,0
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Border
Mouth

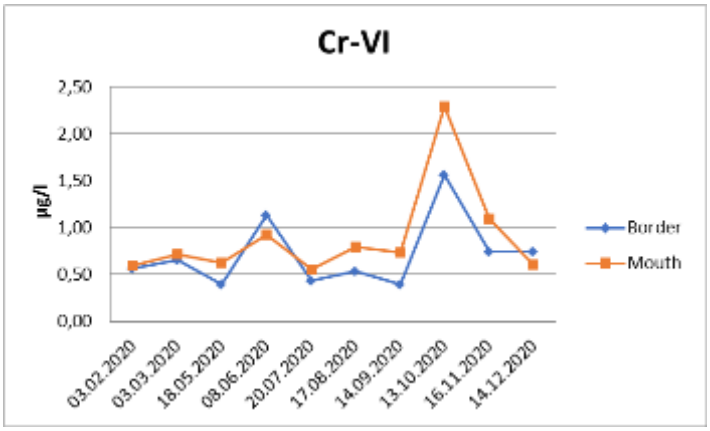

Fe
[ug/l]
2017
2018
2019
Border
Mouth

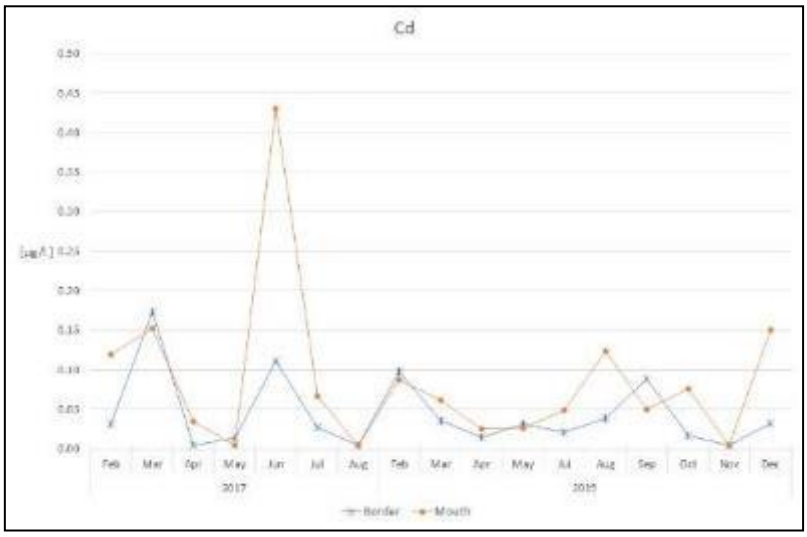

Fe
400,0
350,0
300,0
250,0
200,0
150,0
100,0
50,0
0,0
µg/l
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Border
Mouth

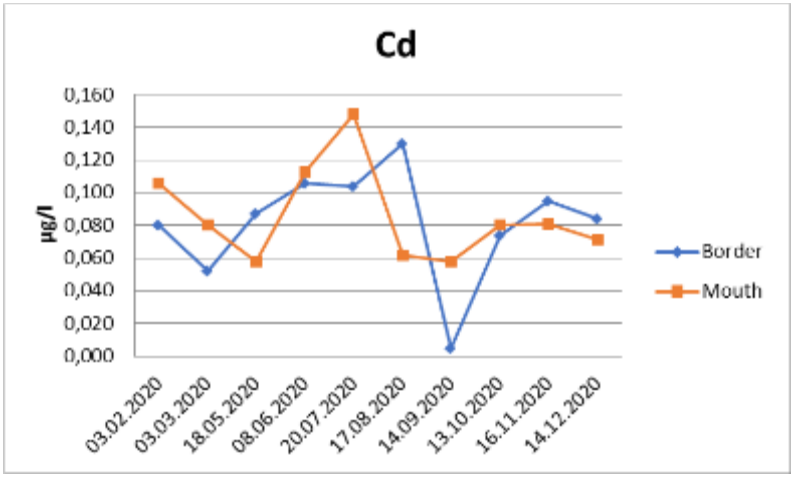

Cu
(µg/l)
Feb
Mar
Apr
May
Jun
Jul
Aug
Feb
Mar
Apr
May
Jul
Aug
Sep
Oct
Nov
Dec
2017
2019
Border
Mouth


Cu
7,00
6,00
5,00
4,00
3,00
2,00
1,00
0,00
µg/l
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020
Border
Mouth


Cr-VI
[µg/l]
Border
Mouth


Cr-VI
µg/l
2,50
2,00
1,50
1,00
0,50
0,00
Border
Mouth
03.02.2020
03.03.2020
18.05.2020
08.06.2020
20.07.2020
17.08.2020
14.09.2020
13.10.2020
16.11.2020
14.12.2020


Cd
Border
Mouth



Discussion:

- **Lepenec – Border MP1**

Algae: At the measuring point MP1 Lepenec - Border (border with Kosovo), the Epiliton and Epiphyton communities according to the IPS index show **moderate** ecological status in 2018 and **poor** status in 2019 and 2020.

Invertebrate: The ecological status of MP1 in this period of the year (May/June 2018 year) is estimated to be **moderate.** The detailed analysis of the results from the calculation of the biotic indices (Saprobic Index, ASPT, Number of Taxa and BMWP) showed that the ecological status of the sampling site is worse in the autumn 2018 year than in the spring period, therefore it is estimated as **poor.**

Taken all into consideration, the ecological status of this locality in the spring period of 2019 is estimated as **bad.** The ecological status assessment which takes in consideration the Saprobic Index, ASPT, Number of Taxa and BMWP showed that in the autumn period 2019 year this sampling locality has better ecological status, than in the spring period which is **moderate.**

The ecological status of MP1 for period May-June 2020 is assessed as **good.** The ecological assessment of Saprobic Index (German new version), ASPT, number of taxa and BMWP **s**owed that in the autumn period 2020 year this sampling locality has worse ecological status, than in the spring period which is **poor.**

Physico-chemical elements and heavy metals: The General physico-chemical status in Lepenec – Border MP1 is **poor** in 2018 and 2019 year and moderate in 2020.

- **Lepenec – Mouth MP2**

Algae: According to the IPS index for the epilipton, epipelon communities in May 2018 year, the measuring point MP2 Lepenec - Mouth (at the inflow into Vardar) has a **good** ecological status. According to the IPS index for the epilipton, epipelon communities in May 2019 year, have **moderate** ecological status. The water was flooded during the heavy rains. According to the IPS index for the sample of epiliton, macrophytes and mixed sample of epilipton and macrophytes has **moderate** ecological status in September 2019 year. According to the IPS index for the epilithic, epiphytic and epipelonic communities in February 2020, at the measuring point MP2 Lepenec – Mouth (on the inflow in Vardar), has an **acceptable** ecological status.

Invertebrate: Taken into account the fragmented diversity, the ecological status of river Lepenec at the sampling locality MP2 in the spring period 2018 year is estimated as **bad.** Based on the macroinvertebrate community structure as well as the values of the biotic indices, ecological status on the MP2 in the autumn period 2018 year was estimated as **poor**.

Because of the poor diversity of EPT taxa, the ecological status of MP2 in the spring period 2019 year is estimated as **bad.** Based on the macroinvertebrate community structure and the biotic indices

values, the ecological status on the sampling site MP2 in the autumn period 2019 year is assessed as **moderate.**

Based on the structure of the community and the values of the applied indices, namely SI, ASPT, number of taxa and BMWP, the ecological status of MP2 during the research period in 2020 shows a significant improvement and is assessed as **poor.** In the campaign October 2020, a test was taken on MP2, but the heavy rains that has been in the previous period, conditions with very poor condition of this water body, the water was flooded and no macroinvertebrate units were found in the test.

Phisico-chemical elements and heavy metals: The General physico-chemical status in Lepenec – Mouth MP2 is **poor** on 2018 and 2019 year and moderate for 2020 year.