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METALS CONTENT IN THE SYSTEM WATER - SEDIMENTS - CHIRONOMIDAE - *PERCA FLUVIATILIS* - *PROTEOCEPHALUS PERCAE* FROM TOPOLNITSA DAM, BULGARIA

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Abstract

The study aims to examine the content of Cr, Mn, Fe and Al in liver and muscle samples of Perca fluviatilis Linnaeus, 1758 and its parasite Proteocephalus percae (Müller, 1780) Railliet, 1899, in samples of Chironomidae, water and sediments from the anthropogenically influenced ecosystem of Topolnitsa Dam (East Aegean Basin, Bulgaria). The highest exceedance was observed for Mn content (171.58 times) in Chironomidae samples. In the studied perch samples, the highest exceedances were recorded in liver samples for Cr (32.27 times), followed by Mn (5.68 times) and Fe (3.85 times) compared to the maximum permissible concentrations by national legislation. The exceedances in Al values were found only in Chironomidae samples (22.94 times). Bioaccumulation, bioconcentration, and biomagnification coefficients were analysed. The bioindicator significance of perch (Pr. percae), its parasite Pr. percae, and chironomids was assessed. The liver of European perch is a bioindicator of Cr pollution, and Chironomidae are bioindicators of Cr and Fe pollution, as well as Pr. percae, for Mn.

Key words: *benthos macroinvertebrates*, *bioindication, European perch, heavy metals, parasites.*

INTRODUCTION

Topolnitsa Dam is located in the southern part of a deep valley, on the border between Ihtimanska and Saschinska Sredna Gora, at the boundary between the Balkan Mountain and Vitosha-Ihtiman subregions of the Mountain biogeographic region, and the Upper Thracian Lowland subregion of the Central Bulgarian biogeographic region (Gruev & Kuzmanov, 1994). The Dam was built in 1963 on the Topolnitsa River, 600 m from the village of Muhovo, Ihtiman Municipality, Sofia Region and after the village of Poibrene, Panagyurishte Municipality, Pazardzhik Region. The Topolnitsa River is the longest in the Sredna Gora Mountain. Topolnitsa Dam belongs to type L11b: Large deep dams in Ecoregion 7: Eastern Balkans, with water body code BG3MA800L160. The area around the dam ecosystem is distinguished by rich biological diversity. For its protection, the Protected Area BG0001389 Sredna Gora and Protected Area BG0001039 Popintsi under the Habitats Directive (Directive 92/43/EEC), as well as the Protected Area BG0002054 Sredna Gora, under the Birds Directive (Directive 79/409/EEC), have been declared. In the immediate vicinity of the Dam Wall near the village of Muhovo, the Topolnitsa Hydroelectric Power Plant is located. The waters of the Topolnitsa Dam are used for electricity generation, irrigation of arable land, flood control, sport and industrial fishing, tourism, etc. At the same time, the Topolnitsa Dam is located in an area with significant historical and contemporary industrial activity, including mining, metallurgy, raw material processing, and agricultural pressure in the peripheral territories. This necessitates complex ecological studies to assess interactions among physicochemical, geochemical, biological, and hydrological factors. One of the main pollutants that negatively impacts organisms and ecosystems is metals/metalloids, which, in addition to being pollutants, are also natural components of rocks.

As a result of anthropogenic activities such as mining and metal smelting, these elements are removed from their natural environments and become pollutants (Walker et al., 2006). A characteristic feature of metals is that they are neither created nor destroyed by humans, and, at high concentrations, they can pose a threat to living organisms and ecosystems. The heavy metals are characterised by toxicity, persistence and accumulativeness (Sauer & Watabe, 1989; Castro-Gonzales & Méndez-Armenta, 2008).

Scientific publications indicate that dams under conditions similar to those at the Topolnitsa Dam often exhibit signs of eutrophication, elevated concentrations of toxic metals, disrupted biological structures, and unstable ecosystem processes.

Dams, as anthropogenically created water bodies, have complex dynamics that make them both strategic resources and environmentally sensitive systems (Walker et al., 2006; Li et al., 2019).

The Topolnitsa dam has been identified as a repository of pollutants, with high As and Cu concentrations in the bottom sediments (Kolchakov et al., 1994). Exceedances of Fe, Mn, Ni, Cu, Ba, Mo, Al, Zn, Cd, Pb, Co, Ti, Sr have been reported (Dak et al., 2008).

Other authors have examined elements of the Dam ecosystem, such as water and fish (Velcheva, 2001; Velcheva & Nikolov, 2009; Georgieva et al., 2015; Valkova et al., 2022).

However, the majority of studies concern the state of the waters of the Topolnitsa River (Yancheva et al., 2011; Varbanov & Gartsiyanova, 2015; Gartsiyanova et al., 2021; Mihaylova et al., 2021; Park et al., 2022).

The studies characterise the state of one or another element in freshwater ecosystems, but do not track the circulation of heavy metals between the abiotic and biotic environments.

The study aims to present results on the content of aluminum (Al), chromium (Cr), manganese (Mn) and iron (Fe) in samples of water, sediments, bottom macroinvertebrates from Chironomidae, in muscles and liver of perch (*Perca fluviatilis* Linnaeus, 1758) and its parasite *Proteocephalus percae* (Müller, 1780) Railliet, 1899, for ecological characterisation and conservation of natural resources.

MATERIALS AND METHODS

The research was carried out in the tail of the Dam after the village of Poibrene, designated as the Poibrene Biotope, with coordinates $42^0$27’38.88’’ N $23^0$59’20.81’’ E (Figure 1).

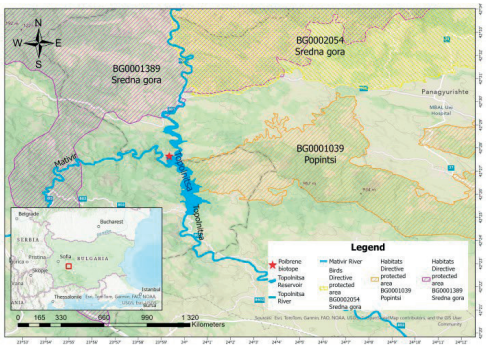


Figure 1. Topolnitsa Dam, Poibrene Biotope

The content of the heavy metals Al, Cr, Mn and Fe was monitored in samples of water, sediments and Biological Quality Elements (BQE) - macrozoobenthos, fish and fish parasites. The studies on BQE macrozoobenthos have been carried out in accordance with the standard BSS EN ISO 10870:2012. The samples were collected using a standard hydrobiological net and a Van Veen dredger in the littoral zone of the Dam ecosystem (Belkinova et al., 2013). The fish were collected after obtaining personal permits for scientific research fishing from the Executive Agency for Fisheries and Aquaculture of the Ministry of Agriculture and Food, in compliance with the BSS EN 14757:2015 standard. The ecological structure, condition and assessment of the condition of the ichthyofauna were analysed based on the indicators number of specimens, abundance (A), percentage of abundance (A%), weight (W g), percentage of weight (W%), maximum body width (TW cm), maximum body length (TL cm), and absolute dominance (D):

$$D = \frac{(A\%+W\%)}{2},$$

where A% is abundance in % and W% is weight of fish in % (Belkinova et al., 2013; Regulation H-4, 2012), Fulton condition coefficient (K):

$$K = 100.\frac{W}{L^3},$$

where W is the weight of fish, and L is the maximal body length (Golub et al., 2019).

Water sampling was carried out in accordance with BSS EN ISO 5667-1:2026, and sediment sampling in accordance with BSS ISO 5667-12:2017. The main Physicochemical Quality Elements: temperature (0C), pH, dissolved O2 mg/l, electrical conductivity (μS/cm), hardness (ppm), N-NH4 mg/l, N-NO3 mg/l, N-NO2 mg/l, TOC mg/l, P-Ortho-PO4 mg/l, BOD5 mg/l and Secchi transparency m, were monitored according to Regulation H-4/2012 from National legislation. A portable system for rapid analysis of organic pollutants in water, the ENOVA Insta Sense O2 model, and a HANNA HI83399 Photometer were used to determine physicochemical water quality indicators under field conditions.

Among the Biological Quality Elements, dominant groups and representatives have been selected. Among the established macrozoobenthos, the dominant Chironomidae were studied for the contamination of Al, Cr, Mn, and Fe. In the ichthyocomplexes, the dominant fish species is the European perch, Perca fluviatilis Linnaeus, 1758 (30 specimens). Samples of perch muscle and liver were isolated. The digestive system was examined for endoparasites. The studies on parasites were conducted in accordance with Zashev & Margaritov (1966) and Moravec (2013). Species differentiation was carried out according to the criteria of Bauer (1987) and Moravec (2013). Dominant helminth species in the helminth communities of perch is the cestode species Proteocephalus percae (Müller, 1780) Railliet, 1899. Pr. percae was also examined for contamination of the four heavy metals. The samples were collected from April to October 2025.

In total, 9 samples each of water, sediment, Pr. percae and Chironomidae, 10 samples each of fish muscle and liver were processed and analysed for Al, Cr, Mn, and Fe content. Sample pretreatment and acid digestion were performed according to EPA- and ISO-approved procedures: BSS EN ISO 21424:2020 for biological samples, BSS EN ISO 5667-14:2016 for water samples, and US EPA Method 3051A for sediment samples. After collection, water samples were stored at 4°C in dark glass bottles before transportation to the laboratory. For ICP-MS analysis, 50 mL of each water sample was filtered through a 25 mm sterile PES syringe filter with a pore size of 0.45 μm. The filtrates were acidified with 0.05 mL concentrated nitric acid to pH 2 and subsequently subjected to instrumental analysis.

Biological samples were dissolved with concentrated HNO_3 and then appropriately diluted before analysis. Sediment sample preparation was performed in accordance with US EPA Method 3051A. The aqua regia digestion was performed using 0.5 g of the sediment sample and an acid mixture containing 9 mL of HNO_3 and 3 mL of HCl. After the digestion, the supernatant was decanted and diluted to a final volume of 50 mL with double-deionised water. Before ICP-MS analysis, 1 mL of each sample solution was diluted to 10 mL with double-deionised water. Elemental analysis was performed using a PerkinElmer SCIEX ELAN DRC-e ICP-MS system (MDS Inc., Concord, ON, Canada).

Bioconcentration factors have been determined:

$$BCF=\frac{Cb}{Cw},$$

where *Cb* was the concentration of examined heavy metals in the biological samples and *Cw* - concentrations in the water samples, and

$$BCF=\frac{Cb}{Cs},$$

where *Cb* was the concentration of the examined heavy metals in the biological samples and *Cs* - concentrations in the sediment samples.

Bioacumulation factor was determined for the fish parasite *Pr. percae* for the accumulation of examined heavy metals:

$$BAF=\frac{CPr.percae}{Cfish\ muscle \text{ or } Cfish\ liver},$$

The biomagnification factor was determined as:

$$BMF=\frac{Cfish\ muscle \text{ or } Cfish\ liver}{CChironomidae},$$

Statistical processing of the results was performed using MS Excel (Microsoft, 2010).

RESULTS AND DISCUSSIONS

Macrozoobenthos

The samples of bioindicator macrozoobenthos collected in 2025 are distinguished by the presence of 5 taxa in the Poibrene Biotope.

Representatives of Chironomidae Newman, 1834, larvae (Insecta, Diptera) dominate, followed by Baetidae (*Baetis* Leach 1815, larvae; Insecta, Ephemeroptera) and Gerridae (*Gerris* Fabricus, 1794; Heteroptera). Coleoptera is represented by two taxa (Gyrinidae and Haliplidae). 286 specimens of Chironomidae were isolated and studied. Representatives of Chironomidae are bioindicators for p-saprobic conditions and belong to the sensitivity group D (tolerant forms) (Belkinova et al., 2013). Scientific studies by other authors show reduced biodiversity in the benthos, dominance of tolerant groups (Chironomidae) and periodic "blooms" of cyanobacteria - typical of reservoirs with combined pressure from toxic metals and eutrophication (Li et al., 2019), also found in this study. Modern methods for complex assessment include physicochemical analyses and biological indicators (Li et al., 2019).

Fish and basic biological indices

Freshwater fish in the Poibrene biotope are represented by 5 species: European perch *Perca fluviatilis* Linnaeus, 1758 (Percidae); Roach *Rutilus rutilus* (Linnaeus, 1758) (Cyprinidae); Bleak *Alburnus alburnus* (Linnaeus, 1758) (Cyprinidae); Orpheus dace *Squalius orpheus* Kottelat & Economidis, 2006 (Cyprinidae); Pumpkin seeds *Lepomis gibbosus* (Linnaeus, 1758) (Centrarchidae).

P. fluviatilis in the Poibrene Biotope is distinguished by the highest abundance (A%=46.0; 30 specimens) and absolute dominance (D=26.5). It is eudominant in the ichthyocomplexes from the researched biotope of the Topolnitsa Dam. The main metric data of the studied perch specimens were also determined (TL cm 13.58±2.17 (10.4-17.5); TW cm 3.42±0.67 (2.2-4.5); W/W% 28.14±12.28 (11.0-51.0)/7.0). The European perch, *P. fluviatilis*, is distributed throughout Europe and is found across almost all of Bulgaria. It inhabits rivers, lakes, brackish and semi-saline waters. It prefers reservoirs overgrown with aquatic vegetation. It is tolerant of high-water acidity. Young feed on zooplankton, and the adults feed on bottom invertebrates and small fish. The species is the subject of sport fishing.

The perch (*P. fluviatilis*) is recommended as an indicator species for assessing the degree of pollution of aquatic ecosystems (Karapetkova & Zhivkov, 2006; Kottelat & Freyhof, 2007). The species is not threatened (LC, IUCN).

The Fulton condition coefficient for P. fluviatilis in this study was K=1.20, indicating fat fish in the studied biotope of Topolnitsa Reservoir. The Fulton condition coefficient is a widely used indicator for assessing the health, fitness or completeness of fish populations. This tool is vital for monitoring fish health, assessing the impact of the environment on wild populations and for the sustainable management of fish resources. At K values around 1, K indicates an average condition. When K>1.2 indicates fat fish, and K<0.8 indicates slim fish. Furthermore, K>1 values indicate favourable environmental conditions (Radkhan & Eagderi, 2015; Zaharieva et al., 2024). Similar studies were conducted by Stavrescu-Bedivan et al. (2023) on Lake Mostiștea in Romania. They found K values above unity for Prussian carp (*Carassius gibelio*), indicating a favourable state of the species in the ecosystem.

Parasites of *Perca fluviatilis* from Topolnitsa reservoir, Poibrene Biotope

The parasite communities of perch are represented by two species: *Proteocephalus percae* (Müller, 1780) Railliet, 1899 (Proteocephalidae, Cestoda) and *Contracaecum* sp., larvae (Nematoda). The dominant species is *Pr. percae*. In the study, the species was represented by a prevalence of P%=43.34, a mean intensity of MI=7.85, and a mean abundance of MA=3.4. The species is the core for the parasitic communities of perch. The definitive hosts of *Pr. percae* are European perch (*P. fluviatilis*), Ruffe (*Gymnocephalus cernua*, Linnaeus, 1758), Northern pike (*Esox lucius*, Linnaeus, 1758), and others. Intermediate hosts are crustaceans of the genus *Cyclops* Müller, 1785 (Kakacheva-Avramova, 1983; Bauer, 1987).

Physicochemical Quality elements

Under field conditions, the main physicochemical quality elements were determined according to Regulation H-4/2012 for dams of type L11b in Ecoregion 7: Eastern Balkans, to which the studied dam ecosystem, Poibrene Biotope, also belongs (Table 1).

According to Regulation No. H-4/2012, for lakes of type L11b, the obtained quality elements indicate a moderate water state in the studied biotope.

Table 1. Physicochemical quality elements, Topolnitsa Dam, Poibrene Biotope

Physicochemical elements	Water stateL11b/ Regulation № H-4/2012			Topolnitsa dam L11b
	Excellent	Good	Moderate	
Temperature, ^{0}C				20.08
pH	-	6.7-8.7	-	9.00
dissolved O_2mg/l	10.5-8.00	8.00-6.00	<6.00	6.80
Electroconductivity µS/cm	<650	650-750	>750	410
Hardness				270Class 5
N-NH_4mg/l	<0.03	0.03-0.08	>0.08	0.49
N-NO_3mg/l	<0.06	0.06-1.80	>1.80	0.60
N-NO_2mg/l	<0.01	0.01-0.025	>0.025	0.058
TOCmg/l				1.00
P-Ortho-PO_4mg/l	<0.016	0.016-0.035	>0.03	0.37
BOD_5mg/l	<1	1-2.5	>2.5	0.50
Secchi transparency, m	>3	3-2	<2	<2

Heavy metal content

The prepared samples of water, sediments, fish muscles and liver, and samples of *Pr. percae* and Chironimidae were subjected to chemical analyses for the contents of Al, Cr, Mn, and Fe (Table 2). According to Regulation H-4/2012 and Regulation EQS/2010 of national legislation, the maximum permissible values for Al in surface waters are 25 µg/L at pH < 6.5; for Cr, 32 µg/L. The annual average norm for Mn in surface waters is 50 µg/L, and for Fe, 100 µg/L. For fish muscle, according to FAO/WHO (1972), the maximum permissible limit is Mn e 0.5 mg.kg-1, and for Cr – 0.15 mg.kg^{-1} wet weight. According to WHO (1996), the maximum permissible limit of Fe in fish muscles is 0.05 mg.kg^{-1} dry weight. For Al content, the maximum permissible limit of 0.2 mg kg^{-1} wet weight is accepted for marine fish muscles, because there are no officially approved norms by FAO, WHO, and others for freshwater fish (Ranau et al., 2001). The highest concentrations of Al, Mn, and Fe were found in the Chironomidae samples, while the highest concentrations of Cr were found in the liver samples of perch. The change in the concentrations of the trace elements in the studied samples (wet weight) is in the following descending order: CAl_Fe_Chironomidae>CAl_Fe_Liver>CAl_Fe_*Pr.percae*>CAl_Fe_Muscle>CAl_Fe_Water; CCr_Liver>CCr_Chironomidae>CCr_Muscle>CCr_*Pr.percae*>CCr_Water;CMn_Chironomidae>CMn_*Pr.percae*>CMn_Liver>CMn_Muscle>CMn_Water (Table 2).

Higher excesses in Al concentrations were recorded in water samples (80.67 times) than in Chironomidae (22.94 times). In the liver and muscle samples of perch, as well as in the samples from *Pr. percae*, no excesses in Al concentrations were recorded. Regarding the Cr content, excesses were not found only in water samples.

Table 2. Concentration of heavy metals

Concentration of heavy metals, wet weight					
µg/g	*Perca fluviatilis* µg/g		*Pr.percae* µg/g	Chironomidae µg/g	Water µg/ml
	Liver	Muscle			
Al	14.13±7.50 (8.83-19.44)	3.48±0.72 (2,97-3.99)	5.07±0.27 (4.92-5.3)	688.21±5.25 (684.49-691.92)	1.21±0.03 (1.19-1.23)
Cr	9.68±2.41 (7.98-11.39)	2.64±0.25 (2.46-2.82)	1.62±0.01 (1.61-1.63)	8,45±4,49 (11.62-5.27)	0,004±0,001 (0,003-0,005)
Mn	5.68±0.13 (5.78-5.59)	0.85±0.63 (0.40-1.29)	10.21±0.03 (10.19-10.23)	171.58±2.16 (170.05-173.10)	0.24±0.03 (0.22-0.26)
Fe	385.2±123.32 (298.0-472.4)	13.55±1.48 (12.5-14.6)	28.22±0.03 (28.20-28,24)	1248.75±197.21 (1388.2-1109.3)	0.84±0.03 (0.82-0.86)
Concentration of heavy metals, dry weight					
µg/g	*Perca fluviatilis* µg/g		*Pr.percae* µg/g	Chironomidae µg/g	Sediments µg/g
	Liver	Muscle			
Al	47.12±25.00 (29.44-64.80)	13.92±2.80 (11.88-15.96)	20.30±0.03 (20.28-20.32)	1593.06±12.17 (1584.46-1601.67)	20131.19±1390.31 (19148.09-21114.29)
Cr	32.29±8.04 (26.60-37.97)	10.56±1.02 (9.84-11.28)	6.51±0.03 (6.49-6.53)	19,55±10.39 (12.20-26.89)	57.65±7.84 (52.11-63.20)
Mn	18.96±0.44 (19.27-18.64)	3.38±2.52 (1.60-5.16)	40.87±0.03 (40.85-40.89)	397,16±4,99 (393.63-400.69)	758.86±130.48 (666.60-851.13)
Fe	1284.00±41 1.06 (993.34-1574.67)	54.2±5.94 (50.00-58.40)	112.9±0.49 (112.8-112.11)	2890.63±456,52 (2567.82-3213.43)	24852.91±4364.32 (21766.87-27938.95)

Of the biological samples, the highest Cr exceedances were found in perch liver samples (32.27 times), followed by Chironomidae samples (28.17 times) and perch muscle samples (8.8 times). The lowest Cr exceedances were observed in samples from *Pr. percae* (5.4 times). Mn concentrations showed exceedances in all the studied samples, but were highest in those from Chironomidae (171.58 times), followed by those of *Pr. percae* (10.21 times), of perch liver samples (5.68 times), and in water samples (4.80 times). The lowest exceedances are of perch muscle samples (0.85 times). Regarding Fe content, the highest exceedances were found in Chironomidae samples (12.49 times), followed by water (8.4 times), and were lowest in perch liver samples (3.85 times). No exceedances were found in perch muscle samples and in *Pr. percae* (Table 2).

There are no uniform standard values for heavy metals in sediments in the environmental legislation of Bulgaria and the European Union. For the presented studies, we used Regulation

3/2008 of the national legislation and those approved by the US Environmental Protection Agency (US EPA). Other authors have also used these regulatory documents to assess heavy metal content in sediments in Bulgaria (Cholakova, 2021). When comparing the concentrations of the studied elements to those in the sediment samples (dry weight, μg/g), the highest concentrations of Al, Cr and Mn were recorded for the sediments, the lowest in the muscle samples for Al, Mn, and in Pr. percae for Cr, respectively. The highest values for Fe were recorded in the Chironomidae, followed by those in the sediments, in the perch liver, and in Pr. percae. They were the lowest again in the perch muscle. The change in the concentrations of the studied elements in the samples (wet weight) is in the following descending order:

CAl_Fe_Sediments>CAl_Fe_Chironomidae>CAl_Fe_Liver>CAl_Fe_*Pr.percae*>CAl_Fe_Muscle;CCr_Liver>CCr_Sediments>CCr_Chironomidae>CCr_Muscle>CCr_*Pr.percae*;CMn_Sediments>CMn_Chironomidae>CMn_*Pr.percae*>CMn_Liver>CMn_Muscle;CFe_Chironomidae>CFe_Sediments>CFe_Liver>CFe_*Pr.perca.*

In aquatic environments, Al is present in inorganic and organic complexes. Given its abundance, studying its impact on aquatic organisms and the aquatic environment, especially in dam ecosystems, is of great importance. In the National legislation (Regulation 3/2008), as well as in the ERL (Effect Range-Low; Long et al., 1995) no limit values for the content of this element are determined. The total Al concentration should not exceed 74.4 μg/L to protect freshwater organisms (Botté et al., 2021). Studies have shown that sedimentary forms of Al can be toxic to freshwater organisms, especially fish. Potentially hazardous concentrations of dissolved Al in the environment are considered more harmful to freshwater organisms (Botté et al., 2021). The impact of Al on freshwater organisms is reported to depend on pH, habitat type, total hardness, and DOC (US EPA, 2018).

Chromium (Cr) is a widespread metal in soils and waters. Cr^{3+} accumulates poorly in organisms and is excreted mainly in the urine. Much more toxic is Cr^{6+}, which accumulates in much higher concentrations. It accumulates mainly in the liver, spleen and bone marrow. Cr6+ in the body is reduced to Cr3+ , which forms complexes with biomolecules, explaining the long retention of Cr in cells. It is excreted in the urine. According to Regulation 3 of the national legislation, the maximum permissible concentration is 200 μg/L, against which no excesses were found in the sediment samples we examined. According to the ERL US EPA, the norm is 81 mg/kg Cr, against which we also found no exceedances in the sediment samples we examined. Manganese (Mn) plays an important role in the development of aquatic plants. At high concentrations in water, Mn is toxic to fish. Iron (Fe) occurs in the form of inorganic and organic compounds. Fe deficiency leads to anaemia, including in fish. Organisms can accumulate Fe, which is why it is found in them at higher concentrations. At a concentration of 0.2 $mg \cdot l^{-1}$ in water, mass fish deaths have been reported (Yablanski & Petkov, 2011).

BCF values from 1000 to 5000 indicate that the corresponding chemical element is bioaccumulating (European Chemicals Agency, 2017). Such values were found for BCFCr-Liver-Water, BCFCr-Chironimidae-Water and BCFFe-Chironimidae-Water (Table 3). BAF showed higher bioaccumulation values in *Pr. percae* than in perch muscles for Al, Mn and Fe.

Table 3. Bioconcentration factor (BCF), Bioaccumulation factor (BAF), and Biomagnification factor (BMF)

BCF[C_b/C_w] wet weight	**BCF_Al**	**BCF_Cr**	**BCF_Mn**	**BCF_Fe**
Liver - Water	11.68	2420.00	23.67	458.57
Muscle - Water	2.87	660.00	3.54	16.13
Pr. percae - Water	4.19	405.00	42.54	33.59
Chironomidae - Water	568.77	2112.50	714.92	1486.61
BCF [C_b/C_s] dry weight	**Al**	**Cr**	**Mn**	**Fe**
Liver - Sediments	0.002	0.56	0.02	0.05
Muscle - Sediments	0.0006	0.18	0.004	0.0001
Pr. percae - Sediments	0.001	0.09	0.05	0.004
Chironomidae - Sediments	0.079	0.34	0.52	0.12
BAF $C_{Pr.\ percae}/C_{fish}$ wet weight	**BAF_Al**	**BAF_Cr**	**BAF_Mn**	**BAF_Fe**
Liver	0.36	0.17	1.79	0.07
Muscle	1.46	0.61	12.01	2.08
BMF $C_{fish}/C_{Chironomidae}$ wet weight	**Al**	**Cr**	**Mn**	**Fe**
Liver	0.02	1.15	0.03	0.31
Muscle	0.005	0.31	0.005	0.01

Highest BAFMn-*Pr.pertsae*_Muscle=12.01 gives reason *Pr. percae* to be determined as a bioindicator for Mn. When the values of BCF and BAF are < 250, the risk is low; the risk is moderate from 250 to 1000; and the risk is high and bioaccumulative from 1000 to 5000 (European Chemicals Agency, 2017). When

BMF>1, the contaminant increases and accumulates much more (biomagnification) (Fremlin et al., 2025), in this case, in perch than in food, Chironomidae. We establish it for the accumulation of Cr in the perch liver. The results obtained provide reason to declare the European perch a bioindicator of Cr pollution and Chironomidae bioindicators of Cr and Fe pollution (Table 3).

CONCLUSIONS

The results obtained for the Topolnitsa Dam, Poibrene Biotope, show poor species diversity in the benthic macroinvertebrate fauna, ichthyocenoses, and parasitic communities of perch. According to the study, the liver of European perch is a bioindicator of Cr pollution, and Chironomidae are bioindicators of Cr and Fe pollution. BAF showed higher bioaccumulation values in *Pr. percae* than in perch muscles for Al, Mn and Fe. The highest BAFMn-*Pr. percae*_Muscle=12.01 determined *Pr. percae* as a bioindicator for Mn.

REFERENCES

Bauer, O.N. (Ed.) (1987). Opredelitel parazitov presnovodnih rib SSSR *[Key to the Parasites of Freshwater Fishes of the USSR*]. Leningrad, RU: Nauka Publishing House. [In Russian]

BSS EN ISO 10870:2012 Waterquality – Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters (ISO 10870:2012). [In Bulgarian]

BSS EN 14757:2015 Water quality - Sampling of fish with multi-mesh gillnets. [In Bulgarian]

BSS EN ISO 5667-14:2016 Water quality - Sampling - Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling (ISO 5667-14:2014)

BSS ISO 5667-12:2017. BDS. Water quality. Sampling. Part 12: Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas

BSS EN ISO 21424:2020 Milk, milk products, infant formula and adult nutritionals - Determination of minerals and trace elements - Inductively coupled plasma mass spectrometry (ICP-MS) method (ISO 21424:2018)

BSS EN ISO 5667-1:2026. BDS. Water quality. Sampling. Part 1: Guidance on the design of sampling programmes and techniques for sediment sampling (ISO/DIS 5667-1).

Belkinova, D., Gecheva, G., Cheshmedzhiev, S., Dimitrova-Dyulgerova, I., Mladenov, R., Marinov, M., Teneva, I., Stoyanov, P., Ivanov, P., Mihov, S., Pehlivanov, L., Varadinova, E., Karagyozova, Ts., Vassilev, M., Apostolu, A., Velkov, B., & Pavlova, M. (2013). *Biological analysis and ecological assessment of surface water types in Bulgaria*. Plovdiv, BG: University "P. Hilendarskii" Publishing House (in Bulgarian).

Botté, A., Zaidi, M., Guery, J., Fichet, D., & Leignel, V. (2022). Aluminium in aquatic environments: abundance and ecotoxicological impacts. AquatEcol. 56(3), 751–773.

Castro-Gonzales, M.I., & Méndez-Armenta, M. (2008). Heavy metals: Implicationsassociated to fish consumption. *Environmental Toxicology and Pharmacology*, 26(3). 263-271.

Cholakova, Z. (2021). Peculiarities in the content of heavy metals in the bottom sediments of some tributaries of the Iskar River in the Stara Planina Mountains (Iskretska River and Batuliyska River). – In: *Yearbook of the Sofia University, Faculty of Geology and Geography, book 2 – Geography*, 113. 140–160.

Dak, T., Velcheva, I., & Todorova, B. (2008). A Study on the Processes of Distribution, Accumulation and Transfer of Cadmium and Zink in the Organisms of Fishes. *Proceedings of the Anniversary Scientific Conference on Ecology.* Plovdiv, 503-513. [In Bulgarian]

Directive 92/43/EEC of 21 May 1992 on the conservation of naturalhabitats and of wild fauna and flora. *Retrieved from* https://assets.publishing.service.gov.uk/media/5a7ce7bee5274a2c9a484d58/Annex-A-Habitats-Directive.pdf

Directive 2009/147/EC on the conservation of wild birds. Retrieved from https://www.npws.ie/directive-2009147ec-conservation-wild-birds-codifiedversion

European Chemicals Agency. (2017). *Guidance on information requirements and chemical safety assessment – Chapter R.7a – Endpoint specific guidance*, European Chemicals Agency, https://data.europa.eu/doi/10.2823/337352

FAO/WHO (1972) Evaluation of Certain Food Additives and the Contaminants Mercury, Lead and Cadmium. WHO Technical Report Series No. 505.

Fremlin, K. M., Elliott, J.E., & Gobas, F.A.P.C. (2025). Guidance for measuring and evaluating biomagnification factors and trophic magnification factors of difficult substances: application to decabromodiphenylethane. *Integrated Environmental Assessment and Management*. 21(2): 263–278

Gartsiyanova, K., Varbanov, M., Kitev, A. & Genchev, S. (2021). Water quality analysis of the rivers Topolnitsa and Luda Yana, Bulgaria using different indices. *Journal of Physics: Conference Series*. 1960. 012018.

Georgieva, E., Vesela Yancheva, V., Velcheva, I., Maria Becheva, M., & Stoyanova, S. (2015). Histological alterations under metal exposureIn gills of European perch (*Perca fluviatilis* l.) from Topolnitsa Reservoir (Bulgaria). *Arch. Biol. Sci*., 67(2). 729-737.

Golub, D., Bukva, M. & Dekić, R, (2019). Morphological Characteristics and Condition of Bleak Alburnus alburnus (Teleostei; Cyprinidae) from the Bosna River. SKUP, 10(1): 16-28. https://doi: 10.7251/SKPEN191001016G

Gruev, B., & Kuzmanov, B. (1994). *General*

biogeography. Sofia, BG: Univ. Publishing House "St. Kliment Ohridski".

Kakacheva-Avramova, D. (1983). *Helminths of freshwater fishes in Bulgaria*. Sofia, BG: Bul. Acad. Sci. Publishing House. [in Bulgarian]

Karapetkova, M., & Zhivkov, M. (2010). *Fish in Bulgaria*. Sofia, BG: GeaLibris.

Kolchakov, I., Stanchev, A., Brashnarova, A., & Stanislavova, A. (1994). Research on arsenic and copper contamination of soils and plant production in the Pazardzhik field through irrigation water from the Topolnitsa dam. *Soil science, agrochemistry and ecology*. 29, 88-90.

Kottelat, M., & Freyhof, J. (2007). *Handbook of European freshwater fishes*. Berlin, DE: Publications Kottelat, Cornol and Freyhof.

Li, Z., Huo, J., & Bricker, J. D. (2019). Ecological risk assessment for eutrophication and heavy metal pollution of Suyahu Reservoir sediments. *Biotechnology & Biotechnological Equipment*, *33*(1), 1053–1062.

Moravec, F. (2013). *Parasitic Nematodes of Freshwater fishes of Europe*. Praha, CZ: Academia Publishing House.

Mihaylova, B., Valchev, S., Benderev, A., Dobrev, H., Dachev, K., & Bardarska, G**.** (2021). Influence of Medetska River on the pollution of Topolnitsa River**.** *National Conference with International Participation "GEOSCIENCES 2021". ReviewoftheBulgarianGeologicalSociety*, 82(3), 177–179.

Park, J., Sakelarieva, L., & Varadinova, E. (2022). Comparative Analysis of the Water Policies and the Systems for Ecological Status Assessment of the Running Waters in Bulgaria and South Korea: Case study on Maritsa River and Han River. *EcologiaBalkanica*, 14(2). 171-189.

Statsoft Inc. (2011) (n.d.). STATISTICA (data analysis software system), version 10. Retrieved from www.statsoft.com.

Stavrescu-Bedivan, M-M., Sandu, M., Scaeteanu, G.V., Virsta, A., Majar, R.M., & Baicu, S. (2023). Preliminary report on the water quality, ichthyophauna and biometric indices for Prissian carp from Iezerul Mostiștea lake, Romania. *Scientific Paper. Series E. Land Reclamation, Earth Obsrvation & Surveying, Environmental Engineering*, XII. 309-319.

Radkhan, A., & Eagderi, S. (2015). Length-weight and length-length relationship and condition factor of six cyprinid fish species of Zarrineh River (Urmia Lake basin, Iran). *Iranian Journal of Ichthyology*, 2(1). 61-64.

Ranau, R., Oehlenschläger, J. & Steinhart, H. (2001). Aluminium content in edible parts of seafood. *Eur Food Res Technol*, 212(4). 431-438.

Regulation 3/2008 on the norms for permissible content of harmful substances in soils. State Gazette, 71/2008

Regulation on environmental quality standards for priority substances and certain other pollutants of 01.11.2010 (Regulation EQS/2010)

Regulation No. H-4 of 14.09.2012 on the characterization of surface waters. Promulgated in the Official Gazette, No. 22 of 5.03.2013, amended and supplemented, No. 67 of 04.08.2023 amended and supplemented, No.97 of 11 December 2015.

Sauer, G.R., & Watabe, N. (1989). Temporal and metal-specific patterns in the accumulation of heavy metals by the scales of *Fundulus heteroclitus*. *Aquatictoxicology*, 14(3). 233-248.

US EPA. 2007. "Method 3051A (SW-846): Microwave Assisted Acid Digestion of Sediments, Sludges, and Oils," Revision 1. Washington, DC. *Retrieved from https://www.epa.gov/sites/default/files/2016-12/documents/3051a.pdf*

US EPA (Environmental Protection Agency) (2018) Aquatic Life Ambient Water Quality Criteria for Aluminum in Freshwater, Federal Register, 83, 245.

Valkova, E., Atanasov, V., Tzanova, M., Atanassova, S., Sirakov, I., Velichkova, K., Marinova, M.N., & Yakimov, K. (2022). Content of Pb and Zn in Sediments and Hydrobionts as Ecological Markers for Pollution Assessment of Freshwater Objects in Bulgaria - A Review. *Int. J. Environ. Res. PublicHealth*, 19(5). 9600.

Varbanov, M., & Gartsiyanova, K. (2015). Comparative Analysis of water quality indexes. *Papers of Scientific Conference "The Science in service of the Society", 30 October 2015*, *Varna*. 3–10. [In Bulgarian]

Velcheva, I. (2001). Contents and transfer of copper in freshwater fish. BIOS. *Scientific annals of the school of biology*. 6. 49-60.

Velcheva, I., & Nikolov, B. (2009). A Study on the Processes of Distribution, Accumulation and Transfer of Copper (Cu) in the Organisms of Fishes. *Ecologia Balkanica*. 1. 15-20.

Walker, C.H., Hopkin, S.P., Sibly, R.M., & Peakball, D.B. (2006). *Principles of Ecotoxicology*. FL: CRC Press, Boca Raton.

WHO 1996. Trace elements in human nutrition and health. ISBN 92-4-156173-4 (NLM Classification: QU 130). Geneva.

Yablanski, T., & Petkov, G (Eds.) (2011). *Hand book of Applied Ecology*. Stara Zagora, BG: Alfamarket.

Yancheva, V., Petrova, S., Velcheva, I., & Georgieva, E. (2011). A review of ecological status of Topolnitsa River catchment area and Topolnitsa Dam. *Scientific papers University of Plovdiv* (In Bulgarian).

Zashev, G., & Margaritov, N. (1966). *Diseases of fish. Sofia*, BG: Nauka i izkustvo (In Bulgarian).

Zaharieva, P., Zaharieva, R., & Kirin, D. (2024). Species diversity of the Ichthyofauna of the Stryama River. *Problems of Geography*, 1-2. 119-130.