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MONITORING OF THE STATE OF THE ELSHISHKA AND MEDETSKA RIVERS FROM THE TOPOLNITSA RIVER SUB-BASIN

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Abstract

The study aims to monitor the state of two rivers from the Topolnitsa River sub-basin – the Elshishka and Medetska Rivers. For the study, samples of macrozoobenthos and waters from the lower reaches of both rivers were collected. The monitoring was carried out in the spring, summer and autumn of 2024 according to a methodology approved for the country and the European Union. A total of 14 taxa of macroinvertebrate organisms belonging to 9 orders (Amphipoda, Coleoptera, Decapoda, Diptera, Ephemeroptera, Hemiptera, Odonata, Sphaeriida, Trichoptera) were collected. The main metrics are presented, including the total number of taxa, EPT taxa, species diversity indices, trophic index, saprobic index, and biotic index. During the study period, no macroinvertebrate taxa were detected in the Medetska biotope. During the spring, no macroinvertebrate organisms were detected in the Elshishka biotope. The dominant macrozoobenthos taxon in spring and summer in the Elshishka biotope is *Gammarus pulex* (Linnaeus, 1758), indicating χ - β -mesosaprobic conditions. In both seasons, the Elshishka biotope is dominated by macroinvertebrate taxa belonging to group C (relatively tolerant forms) and no organisms belonging to groups A and E (sensitive forms and most tolerant forms, respectively) were found. Based on the calculated indices and metrics, the ecological state of the Elshishka River in spring is very bad, while in summer and autumn it varies from very good to very bad. The comprehensive ecological assessment for the two studied biotopes shows a very bad ecological state for the entire period of the study.

Keywords: Bulgaria, comprehensive ecological assessment, indices, Maritsa River basin, metrics

INTRODUCTION

The Topolnitsa River rises from the Sashtinska Gredna Gora Mountain, flows for 155 km and flows from the left into the Maritsa River, in the region of the Pazardzhik town. The Topolnitsa River's catchment area is 1789 km² (Kiradzhiev, 2013; Varbanov et al., 2020). The river's catchment area is subject to long-term anthropogenic impact, as a result of the development of mining and metallurgical activities in the region (Mihaylova et al., 2021). The main sources of anthropogenic load in the Topolnitsa River basin are mines, tailings dams and metallurgical plants (Yancheva et al., 2011; Kancheva et al., 2018; Gartsyanova et al., 2021a; Mihaylova et al., 2021). Heavy metals enter the environment from natural and anthropogenic sources (weathering of the earth's crust, soil erosion, mining, industrial water discharge, etc.). Heavy metal pollution in most cases follows the order: industry - atmosphere - soils - waters - food - people (Morais et al., 2012). Heavy metals are toxic, persistent and accumulate in the environment (Yancheva et al., 2011). Aquatic organisms absorb pollutants either from the aquatic environment or through nutrition. Heavy metals have a number of negative effects on aquatic organisms, expressed in developmental abnormalities, growth suppression, increased mortality (Khayatzadeh & Abbasi, 2010). More pollutants (heavy metals) accumulate in sediments than in waters (Pradit et al., 2010). Sediments contaminated with heavy metals and metalloids pose a risk to the bottom macroinvertebrates present in them, and can lead to their death (Khayatzadeh & Abbasi, 2010). Macroinvertebrates are good bioindicators. A change in the environment leads to a change in their communities (Rashid & Pandit, 2014). Few authors have studied the concentrations of heavy metals and metalloids in the waters of the Medetska River (Kancheva et al., 2018; Gartsyanova et al., 2021b; Mihaylova et al., 2021). Kancheva (2016); Kancheva & Dinev (2023) examine the ecological state along the Topolnitsa River.

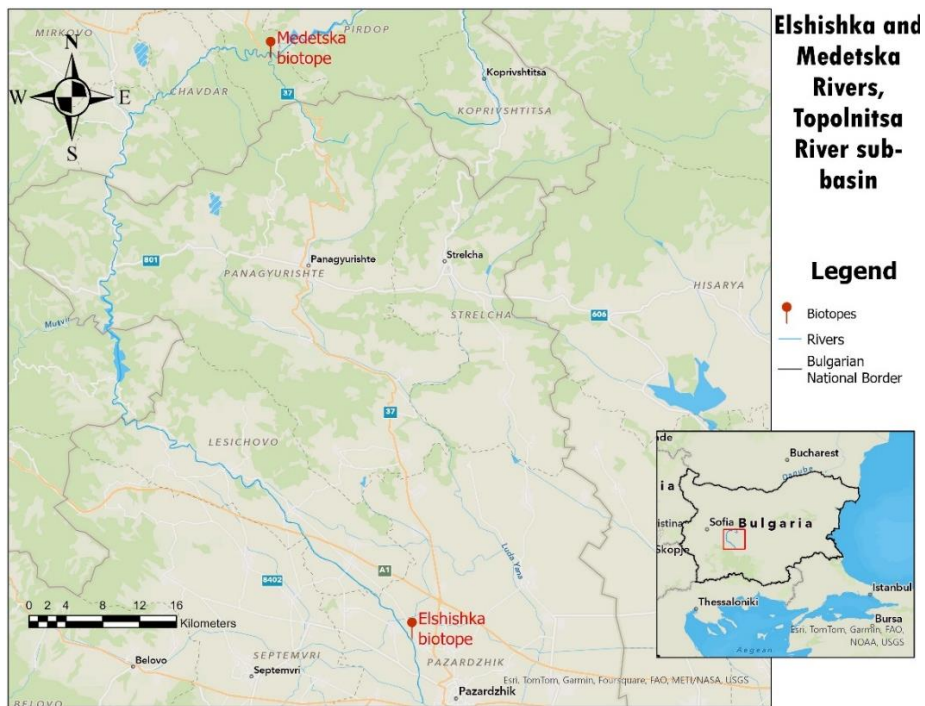
Although supporting the biological elements characterizing the ecological state of river waters, physicochemical quality elements additionally reveal the sources and forms of anthropogenic impact on the waters. The latter can act independently or in combination, in bursts or continuously. In addition to the above sources of pollution, various agricultural activities are also carried out in the Topolnitsa River basin, which exert pressure on the waters both diffusely (fertilization) and pointwise (discharge of wastewater from livestock farms). Domestic wastewater also plays a significant role in water pollution due to the fact that the majority of settlements do not have a sewage system, as well as the lack of urban wastewater treatment plants (Varbanov et al. 2020; Gartsyanova et al., 2021a).

The aim of the study is to monitor the state of the Elshishka and Medetska Rivers, based on the biological quality element (BQE) macrozoobenthos and physicochemical quality elements (PhQEs).

MATERIALS AND METHODS

In the spring, summer and autumn of 2024, the lower reaches of the Elshishka and Medetska Rivers were visited. The selected sampling sites (designated as biotopes) are located before the confluence of both rivers into the Topolnitsa River (42°14'01.0"N 24°17'21.2"E; 42°39'05.7"N 24°09'05.0"E) (Map 1;

Photos 1-2). The Elshishka River is of Type R5 “Semi-mountainous rivers” in Ecoregion 7. The studied section of the river (Elshishka biotope) is characterized by slow flow and rocky bottom.



Map 1. Location of selected biotopes



Photo 1. Biotope Elshishka (spring 2024)

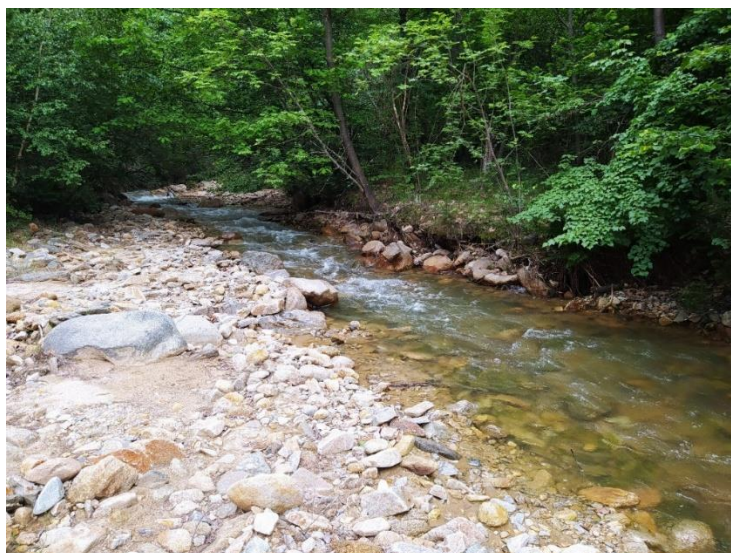


Photo 2. Biotope Medetska (spring 2024)

The Medetska River is of Type R3 “Mountainous rivers” in Ecoregion 7. The selected section of the river (Medetska biotope) is characterized by fast flow and rocky bottom.

The samples of BQE macrozoobenthos were collected according to EN ISO 10870:2012; EN 16150:2012; Regulation No. H-4 of 14.09.2012; Belkinova et al. (2013); Cheshmedjiev et al. (2011) using a kick net sampler. In laboratory conditions, the taxonomic affiliation of the collected macroinvertebrates was determined under Stereo Zoom Microscope, KERN OZL 464T24 and microscope KERN OBN 135T241. Basic metrics for number and abundance (total number of taxa; number of taxa from Ephemeroptera, Plecoptera and Trichoptera (EPT); % (Oligochaeta & Diptera); % Filter feeders; % EPT taxa) and basic indices (German trophic index RETI; Pantle & Buck saprobic index (SPUB); Shannon-Weaver species diversity index (H'); Pielou's evenness index (E); Simpson's dominance index (C); Adapted Biotic Index according to Regulation No. H-4 of 14.09.2012; Belkinova et al. (2013)) were calculated.

To carry out the physicochemical monitoring of the waters of the Elshishka River, sampling was carried out in the same biotope in June and November. Sampling was carried out at low water levels due to low water levels throughout 2024.

The analysis of the water samples was carried out on site using a field combined pH/EC/TDS-Meter MW-802 and a CO-411 oximeter. In laboratory conditions, the analyses were carried out with a Multiparameter Photometer HI83399. For the quantitative determination of Al, As, Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn, two samples were taken fixed on the ground with nitric acid. The analyses were carried out with an Inductively Coupled Plasma Mass Spectrometer

(ICP-MS DRC-e, Perkin Elmer) in the educational and scientific laboratory of the Faculty of Chemistry and Pharmacy of Sofia University “St. Kliment Ohridski”.

No samples were collected from the Medetska River during the specified period, but data from previous field studies conducted by some of the authors were used to characterize the ecological state of the river.

RESULTS AND DISCUSSION

Ecological state by biological quality element macrozoobenthos

A total of 14 taxa of macroinvertebrates belonging to 9 orders (Amphipoda, Coleoptera, Decapoda, Diptera, Ephemeroptera, Hemiptera, Odonata, Sphaeriida, Trichoptera) were collected for the entire study period. Nine (69 specimens) and 10 taxa (284 specimens) of macroinvertebrates were collected from the Elshishka biotope, respectively, in summer and autumn, which defines the studied section of the river as having a moderate ecological state. The dominant taxon in both seasons is *Gammarus pulex* (Linnaeus, 1758). No macroinvertebrates were found in the Elshishka biotope (in the spring season) and in the Medetska biotope (in the three seasons of the study), indicating a very bad ecological state. In the Elshishka biotope (summer and autumn) 3 taxa of Ephemeroptera, Plecoptera and Trichoptera (*Baetis* sp., nymph; *Hydropsyche* sp., larva; *Hydropsyche ornatula* McLachlan, 1878 larva) were found. According to the EPT taxa metric, the ecological state of the waters in the Elshishka biotope is determined as moderate for summer and autumn, and very bad for spring. According to this metric, the ecological state of the waters in the Medetska biotope is very bad (Table 1).

Table 1. Main metrics for the ecological state of the Elshishka and Medetska Rivers

Metrics	Elshishka			Medetska		
	Spring	Summer	Autumn	Spring	Summer	Autumn
total number of taxa	0 very bad	9 moderate	10 moderate	0 very bad	0 very bad	0 very bad
number of taxa EPT	0 very bad	3 moderate	3 moderate	0 very bad	0 very bad	0 very bad
% (Oligochaeta & Diptera)	0	1.45	13.38	0	0	0
% Filter feeders	0	0	1.06	0	0	0
% EPT taxa	0	30.44	23.24	0	0	0
RETI	0 very bad	0.11 very bad	0.19 very bad	0 very bad	0 very bad	0 very bad
SPUB	0 very bad	1.04 very good	1.39 very good	0 very bad	0 very bad	0 very bad
Shannon-Weaver species diversity index (H')	-	1.27 α	1.67 α	-	-	-
Pielou's evenness index (E)	-	0.577 α	0.723 0	-	-	-
Simpson's dominance index (C)	-	0.419 α	0.257 β	-	-	-
BI (nEQR)	-	2.5(0.5) moderate	3(0.6) moderate	-	-	-

In the Elshishka biotope, an increase in % (Oligochaeta & Diptera) and % Filter feeders was observed from summer to autumn, and a decrease in % EPT taxa, which are more sensitive to anthropogenic load on aquatic ecosystems (Table 1).

In summer and autumn, in the benthic communities of macroinvertebrates of the Elshishka biotope, according to the type of feeding, taxa from the group of scrapers, which are characteristic of the semi-mountainous zone of river ecosystems, dominate. The calculated trophic index RETI shows an imbalance in the studied sections of the river ecosystems and a very bad ecological state (Table 1).

Of the identified bioindicator macroinvertebrate organisms in the Elshishka biotope, the taxa responsible for β - α , χ - β and 0- β -mesosaprobic conditions (2 taxa each) dominate in the summer, and for β - α -mesosaprobic conditions (3 taxa) in the autumn. The calculated SPUB index indicates a very good ecological state in the Elshishka biotope during these two seasons (Table 1).

The values obtained in the Elshishka biotope for the Shannon-Weaver species diversity index (H') during the summer and autumn seasons indicate α -mesosaprobic conditions. The Pielou's evenness index (E) has higher values in the autumn, and the Simpson's dominance index (C) has a lower value, which indicates more favorable conditions in the autumn in the Elshishka biotope (Table 1).

During the summer season, 8 taxa of macroinvertebrate organisms belonging to group C (relatively tolerant forms) were identified in the Elshishka biotope. During the autumn season, 5 taxa belonging to group C, 2 taxa – to group B (less sensitive forms) and 1 taxa – to group D (tolerant forms) were identified in the same biotope. The biotic index (BI) shows a moderate ecological state for the Elshishka biotope during both seasons (Table 1).

Ecological state by physicochemical quality elements

The physicochemical state of the rivers at the specified monitoring points was assessed according to the requirements of Regulation No. H-4 of 14.09.2012 (amended and supplemented 2023) and the Environmental Quality Standards (EQS) Regulation of 2010 (amended and supplemented 2015). The Medetska River is of Type R3, and the Elshishka River is of Type R5.

The data from the chemical analysis of the waters of the Elshishka River before the mouth show that in 2024 the river waters were in good ecological state according to most of the physicochemical quality elements (Table 2). Deviations are registered for the quality elements ammonium nitrogen, nitrite nitrogen and orthophosphates, indicating the emission into the waters of untreated wastewater from livestock farms upstream and direct discharge of domestic wastewater from settlements located near the river. These results, although with lower values, correspond to previous studies (Varbanov et al. 2023), as well as to the analysis of operational data from the National System for Environmental Monitoring (NSEM) at this point for a longer period. The nature of the impact shows that the discharge of wastewater from livestock farming has a burst nature and is associated with the release of contaminated water from fecal lagoons. They are usually discharged during periods of higher water levels in the river to ensure their faster dilution or the

volumes depend on the number of animals raised. Previous studies have found contents of nitrite nitrogen, ammonium nitrogen exceeding the reference values for good ecological state under Regulation No. H-4 of 14.09.2012 by a thousand times (Varbanov et al., 2023). The contents of heavy metals, registered in 2024 (Table 3) show that deviations are observed in the quality elements copper (Cu), cadmium (Cd) and chromium (Cr). These quality elements are also characterized by a significant excess of the values in previous years (Gartsiyanova et al., 2021a).

Studies in previous years of the physicochemical state of the Medetska River characterize its waters in bad ecological state. It is associated exclusively with significantly higher than the reference values of the quality elements (copper (Cu), manganese (Mn) and zinc (Zn)), as well as iron (Fe), cadmium (Cd) and nickel (Ni). Of the general physicochemical quality elements, deviations from the reference values are observed in pH (between 3.4 and 4.9), electrical conductivity (between 1143 and 2560 $\mu\text{S}/\text{cm}$). Respectively, dissolved substances also have high values (between 653 and 1720 mg/l).

Table 2. General physicochemical quality elements of the waters of the Elshishka River for 2024

Month	T°C	pH	DO(mg/l)	O ₂ %	Cond	NH ₄ -N	PO ₄ ³⁻	NO ₃ -N	NO ₂ -N /mg/l	Note
Elshishka River before the mouth										
June	22.0	7.7	7.6	87.6	650	0.24	0.08	0.8	0.03	slightly muddy fast current
November	6.4	7.5	10.3	87	710	0.03	0.01	0	0.003	clear-low water

Table 3. Values of heavy metals content in the waters of the Elshishka River for 2024

Month	Al	Cr	Mn	Fe	Co	Ni	Cu	Zn	As	Cd	Pb
Elshishka River before the mouth											
June	12.8	2.45	2.30	38.2	0.23	2.81	5.82	7.99	3.50	0.070	0.200
November	1.56	9.38	6.33	52.40	0.44	0.56	7.53	5.85	0.38	0.77	0.006

Petrova et al. (2011) reported high levels of heavy metals in waters from the Medetska River. Kancheva (2016) reported a very bad ecological state according to the BQE macrozoobenthos for the Medetska and Elshishka Rivers, which is also confirmed by the present study. Kancheva et al. (2018) reported significant Cu pollution of the waters at the mouth of the Medetska River (413 times above the maximum permissible concentrations). Gartsiyanova et al. (2021b) studied the pollution of the waters of the Medetska River with heavy metals and metalloids (Cu, Fe, Mn, Pb, As, Zn, Cd and Ni) and reported high concentrations of Cu, Mn, Fe and Zn. Mihaylova et al. (2021) studied the concentrations of heavy metals and metalloids (Fe, Al, Cd, Co, Cu, Pb, Zn, Cr, Mn, Ni, As) in waters from the Medetska River and the Topolnitsa River (before and after the confluence of the Medetska River). The authors reported that the Medetska River pollutes the Topolnitsa River.

Kancheva & Dinev (2023) reported a very bad ecological state for the Medetska River according to the BQE macrozoobenthos.

According to the data provided in the reports on the state of water bodies in the territory of the East Aegean Region by the East Aegean River Basin Directorate (EARBD) for the period 2021-2023, the ecological state of the Elshishka River and the Medetska River is very bad (Table 4). The comprehensive ecological assessment carried out in this study in 2024 confirms the assessment made in previous years of a very bad ecological state of both rivers.

Table 4. Comprehensive ecological assessment for the period 2021-2023 (EARBD) (BQEs – biological quality elements; PhQEs – physicochemical quality elements)

	Ecological state on the BQEs	Ecological state on the PhQEs	Ecological state	Chemical status
River Elshishka				
2021	very bad	moderate	very bad	bad
2022			very bad	unattainable good
2023	very bad	moderate	very bad	unattainable good
River Medetska				
2021	very bad	moderate	very bad	bad
2022			very bad	unattainable good
2023	very bad	moderate	very bad	unattainable good

CONCLUSIONS

During the entire period of study in the Medetska biotope, no bioindicator macrozoobenthos was established, as well as in the spring in the Elshishka biotope. The comprehensive ecological assessment, according to the study conducted for both biotopes, shows a very bad ecological state.

A heterogeneous anthropogenic impact has been established, and depending on the sources of pollution it is single-variant or combined. For the Elshishka River, it is the result of the mixed imitation in the waters of wastewater from operating livestock farms, domestic wastewater from settlements and wastewater from former copper ore mining operations. The first ones have an episodic, burst discharge character, while the others have a constant impact. The waters of the Medetska River experience constant pressure from waste mine waters, which over time have led to a specific rusty coloration of the stones in the river bed.

We recommend deepening ecological monitoring research in both river ecosystems, aimed at taking measures to improve the living conditions of hydrobionts.

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