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Current Ecological State Assessment of Bulgarian part of the Trans-boundary Mesta River (South-West Bulgaria)

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Abstract: The water quality, physico-chemical and the ecological state assessment of the water bodies of the trans-boundary Mesta River during the period 2009-2010 were discussed. The MDS analysis illustrated that similarities between species composition of the macrozoobenthos at the studied sites are based on the level of the anthropogenic impact rather than the differences between the main river and its tributaries. Comparison with the last published data (1999-2000) demonstrated processes of stabilization of the aquatic ecosystem as a result of improvement of the water quality and the ecological state of the studied river ecosystem. During the last 25 years, shifts in species composition, decreases in species richness and reorganization in the trophic structure of the benthic fauna were detected in the referent site Demyanitsa.

Key words: Mesta River, macrozoobenthos, water quality, ecological state assessment

Introduction

In terms of the Water Framework Directive 2000/60/EC, the trans-boundary River Mesta is located in Eco-region 7 (Eastern Balkans). The ecological status of the Mesta (Nestos) River has been well studied for the last 30 years with relation to its hydrology and geology (Mimides *et al*., 2007; Diadovski *et al*., 2007, Hristova, 2012), water quality (Kovachev, Uzunov 1986; Varadinova, Uzunov 2002; Psilovikos *et al***.**, 2005), benthic invertebrate fauna (Kovachev 1991; Uzunov *et al*. , 2011**)**, community trophic structure (Varadinova *et al*., 2007, 2008) , and other ecological quality elements (Ivanov *et al*., 2006; Economidis *et al*., 2010). Because of the long range of hydrological, hydrochemical and hydrobiological data stored, Mesta River was selected as one of the seven Bulgarian sites included in the European LTER (Long Term Ecological Research) net.

After a period of heavy organic pollution until 1990 (when the relevant authorities banned the operation of the two polluting plants), improvements of the water quality within the river system of Razlozhka-Iztok-Mesta were registered (Kovachev 1991). In conditions where there was a lack of a considerable anthropogenic impact, processes of recovery and remarkable improvements of the ecological status were determined, especially for the sites loaded in previous periods with severe organic pollution (Varadinova, Uzunov 2002).

The aim of this paper is to assess the current ecological state of the water bodies of the Mesta River ten years after the last studied period (1999-2000). Changes in species composition and trophic structure for long-term periods at referent site Demyanitsa are considered.

Material and Methods

Macrozoobenthic samples from Summer-July 2009 and Autumn-October 2010 were taken. In addition, published data from 1986, 1987 and 2000 (Kovachev, Uzunov 1986; Varadinova, Uzunov 2002) and our own unpublished data from 1990, 1997, 2005 and 2007 were used in the analyses.

A total of 20 representative sites situated along the main river and its tributary systems were investigated (Fig. 1). From them, four sites (Cherna Mesta, Demianitsa Iztok and Momina Kula) were common for the two studied years.

During conducted investigations, twenty-five macrozoobenthic samples were collected (Table 1), using the adapted multi-habitat method (Cheshmedjiev *et al*., 2011) with different sampling

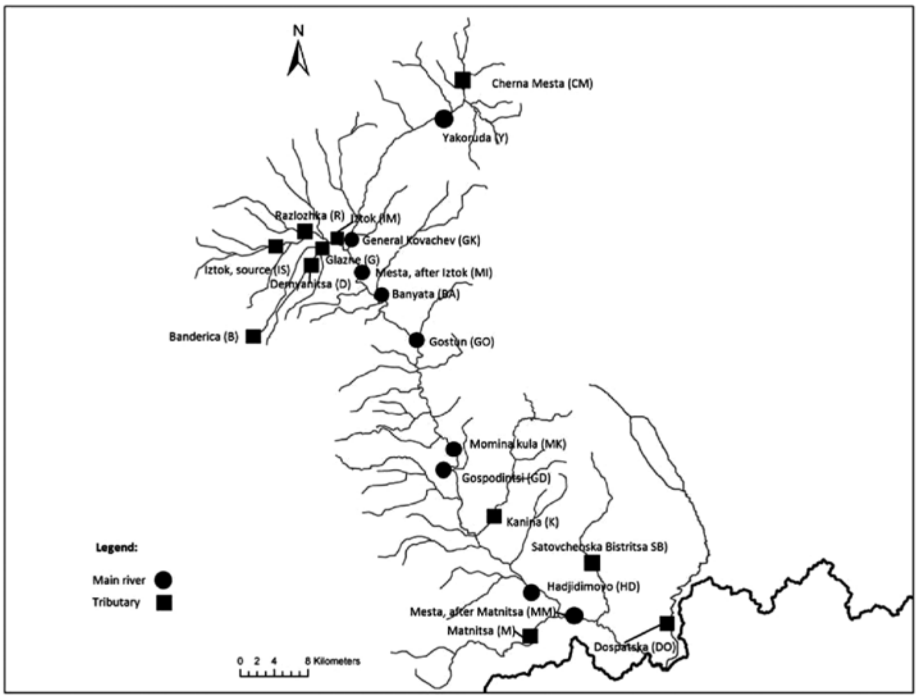

Fig. 1. River Mesta basin and location of the sampling points

Table 1. Sampling points, altitude, longitude, latitude ranges, and years of sampling

Sampling points/years	Altitude (m)	Longitude	Latitude	Data 2009	Data 2010
Cherna Mesta (CM)	980	23º43’39,9”	42º03’27,5”	*	*
Yakoruda (Y)	933	23º41’35,5”	42º01’53,1”		*
General Kovachev (GK)	744	23º34’18,2”	41º53’10,1”	*	*
Iztok, source (IS)	771	23º31’37,9”	41º54’04,4”	*	
Razlozhka (R)	769	23º31’45,8”	41º53’59,3”		*
Banderitsa (B)	1949	23º25’45,8”	41º46’03,4”	*	
Demyanitsa (D)	1115	23º28’16,6”	41º48’39,4”	*	*
Glazne (G)	775	23º32’17,3”	41º53’39,2”		*
Iztok (IM)	762	23º33’53,6”	41º53’10,4”	*	*
Mesta, after Iztok (MI)	741	23º34’14,4”	41º53’13,2”	*	
Banyata (BA)	745	23º35’31,3”	41º52’07,8”		*
Gostun (GO)	674	23º40’35,5”	41º47’00,1”		*
Momina Kula (MK)	614	23º42’08,3”	41º42’35,0”	*	*
Gospodintsi (GD)	571	23º43’48,7”	41º39’20,3”		*
Hadzhidimovo (HD)	476	23º51’24,3”	41º31’48”		*
Kanina (K)	537	23º47’28,5”	41º36’14,1”	*	
Matnitsa (M)	494	23º51’52,4”	41º29’43,0”	*	
Satovchenska Bistritsa (SB)	576	23º57’07,7”	41º32’22,8”	*	
Dospatska (DO)	1043	23º07’21,5”	41º33’30,7”	*	
Mesta, after Matnitsa (MM)	458	23º53’32,9”	41º30’05,2”	*	

techniques (ISO 7828:1985/EN 27828:1994 ISO 8265:1988/EN 28265:1994).

Physico-chemical parameters (water temperature, oxygen concentration, EN 25814 mg/l and saturation (%), conductivity (µS/cm, EN 27888), alkalinity (pH, ISO 10523) were measured on site by means of portable Windaus Labortechnik Package and HANNA multi-parameter instruments.

The water quality and the ecological state (EQR) of water bodies at studied sites were determined in accordance with the WFD requirements (2000/60/EC) transposed in national legislation – Ordinance №1/2011 and Ordinance № H-4/2012. The water quality was assessed by using Pantle & Buck's saprobic index (SPUB) (Pantle, Buck, 1955). The ecological status was defined by means of the Irish Biotic Index (BI) (Clabby, Bowman, 1979) and Rhithron Feeding Type Index (RETI) (Schweder 1990), and its adapted version (Varadinova 2006).

The Sorensen coefficient was calculated, and the Cluster dendogram (Statistica 7: Hill, T., P. Lewicki, 2007) was used to display the similarity between species composition of the macroinvertebrate fauna for different studied periods.

Multidimensional Scaling (MDS) analysis (Primer 6.1.6: Clarke, K. R. , R. M. Warwick, 2001) was applied to visualize similarities amongst sampling sites.

Results and Discussion

In accordance with the WFD requirements, physico-chemical parameters play a supporting role to biological elements in the ecological status assessment of the water bodies. Fig.s 2 – 5 present

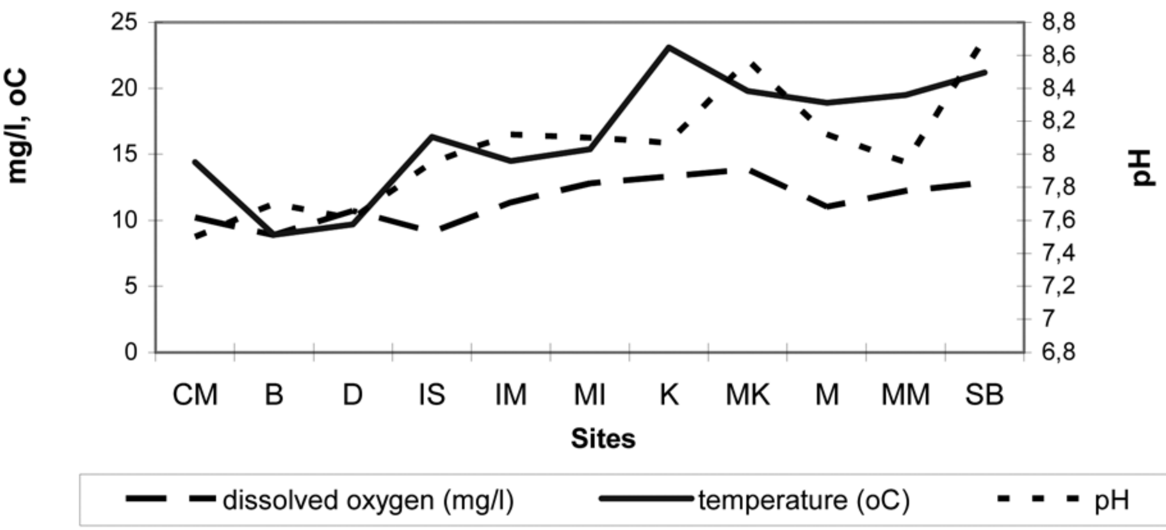

Fig. 2. Longitudinal dynamics of the values of physico-chemical parameters (dissolved oxygen, pH and temperature) in the studied sites during 2009

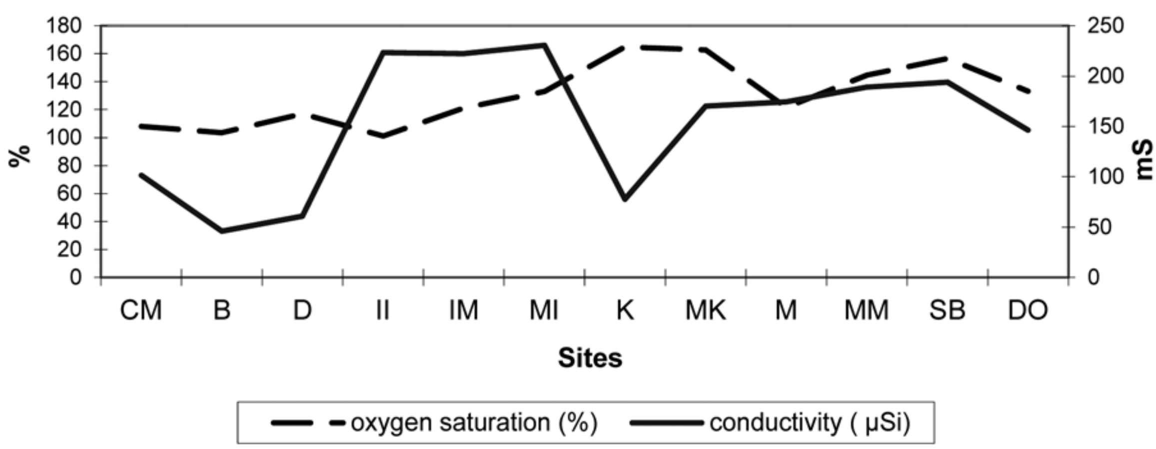

Fig. 3. Longitudinal dynamics of the values of physico-chemical parameters (oxygen saturation and conductivity) in the studied sites during 2009

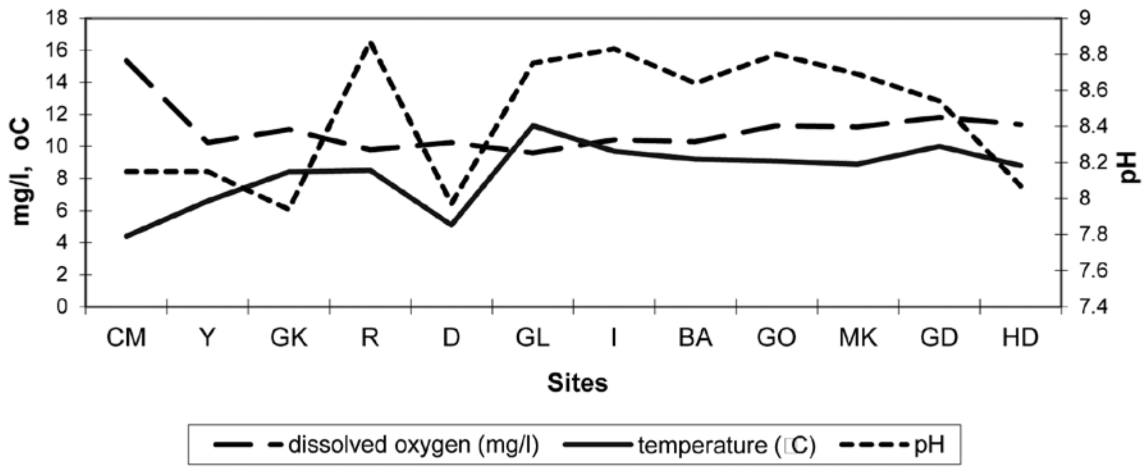

Fig. 4. Longitudinal dynamics of the values of physico-chemical parameters (dissolved oxygen, pH and temperature) in the studied sites during 2010

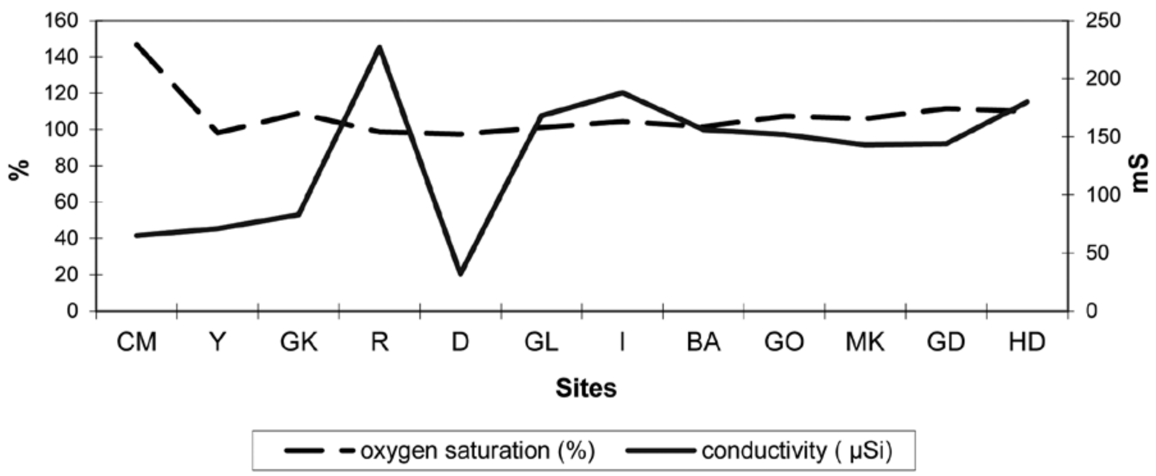

Fig. 5. Longitudinal dynamics of the values of physico-chemical parameters (oxygen saturation and conductivity) in the studied sites during 2010

the dynamics of pH, conductivity, temperature, dissolved oxygen and saturation at studied sites during 2009 and 2010.

The results demonstrated that all measured values of oxygen parameters and conductivity characterized the state of the studied water bodies as high (Ordinance № H-4/2012). Comparative analyses between the years 1999 and 2010 showed that even at the most impacted site, Razlozhka, which was heavily polluted from industrial sources, the situation was considerably improved. Thus, while at the aforementioned site, in autumn 1999, oxygen concentration respectively saturation values showed very low value – (September – 3,4mg/l/37%, October 2,36mg/l/23%), the values of the same parameters (9,79 mg/l/98,8% measured in October 2010 demonstrated very good state, according Ordinance № H-4/2012. Slight deviations from the standards for good state for pH were observed at the some of the studied sites (Fig. 2 and 4). Use of fertilizers and detergents which through the surface runoff fall into the Mesta River is a likely cause for the alkalinity of the waters.

The SPUB indices, which are characterized water quality described saprobiological situation in the Mesta River and its tributaries as oligo- (predominantly at the upper part) and beta-mezosaproby (Fig. 6 and 7). There was one exception determined at site Glazne where the SPUB value assessed the studied site as transitional between beta-mezosaprobity and poly-saprobity (SPUB=2.583). This situation might be a result of the discharge of untreated

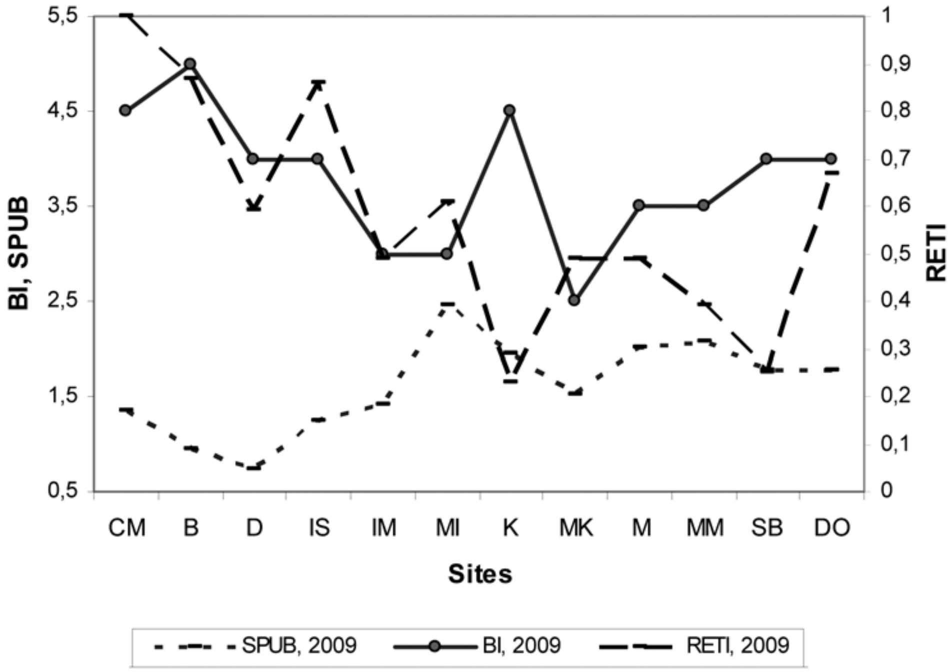

Fig. 6. Longitudinal dynamics of SPUB, BI and RETI along the Mesta River in 2009

Fig. 7. Longitudinal dynamics of SPUB, BI and RETI along the Mesta River in 2010

wastewaters from the Bansko resort situated above the studied site. The actual state was compared with the last published data (Varadinova, Uzunov 2002). The results showed improvement and stabilization of the ecological situation after 1999-2000. This tendency was most clearly expressed at the polluted sites (Razlozhka, Iztok and Banyata) where due to secondary saprobic succession a more favorable conditions were registered and betterment of the water quality was observed.

The MDS plot illustrated that similarities between species composition of the macrozoobenthos

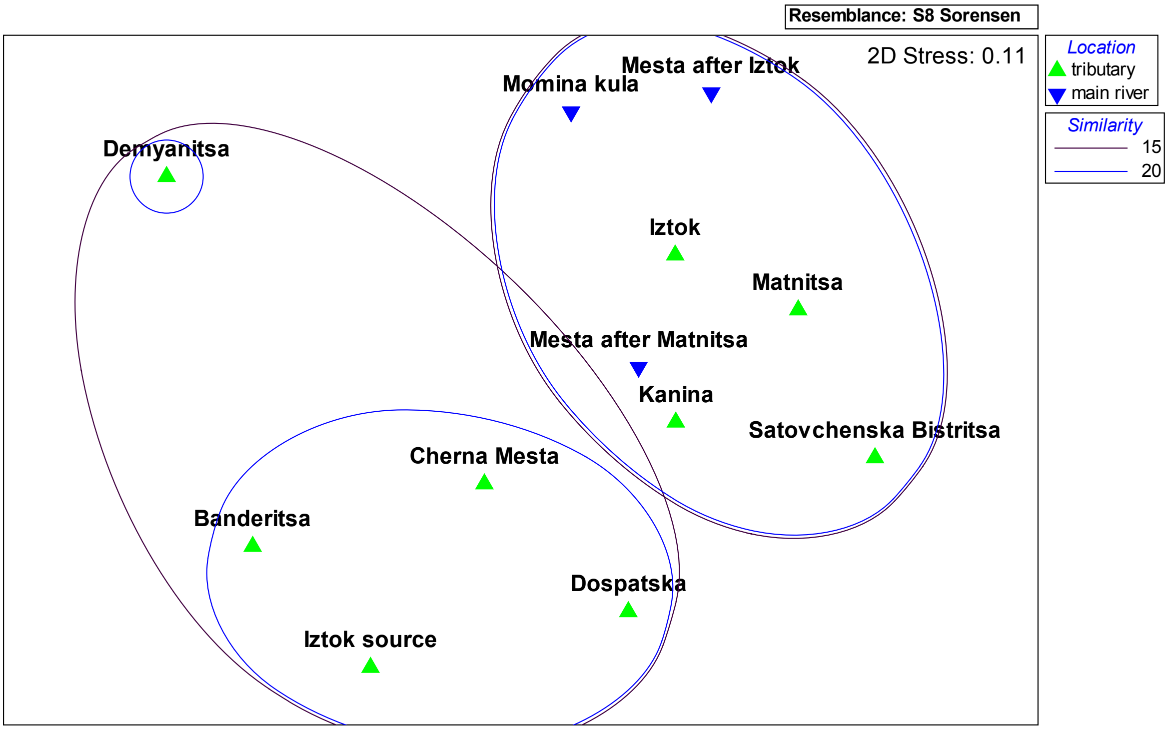

Fig. 8. MDS plots visualizing the similarity of benthic macroinvertebrate community composition between studied sites in 2009

at the studied sites during 2009 were based on the level of the anthropogenic impact rather than the differences between the main river and the tributaries (Fig. 8). The first group combines the clean, unaffected stations Cherna Mesta, Iztok sources, Banderitsa, Demyanitsa and Dospatska. The second group includes sites, subjected to different kinds of impact (Kerakova, 2009; Ihtimanska, 2010). In comparison with the other clean sites, the species composition determined at sites Demyanitsa and Dospatska demonstrated low resemblance level. Different hydromorphological conditions – high slope, velocity and substrate (river bottom is covered by rocks and large boulders) – are probably the reason for the formation of benthic fauna adapted to the more extreme specific environment – typical for the Demyanitsa site. The sampling point Dospatska is situated downstream of the Dospat Reservoir where the environment creates living conditions for the development of specific macrozoobenthic fauna (Filinova *et al*., 2008).

The EQR assessment (Table 2) determined by BI values (Fig. 6 and 7) showed high and good state at the upper parts of the river system Moderate status is determined at the sites General Kovachev and Glazne.

Comparison between 2009 and 2010 presented a worsening of the ecological status at the sites Cherna Mesta (from high to good) and Iztok (from good to moderate). A possible reason for the unfavorable EQR values could be local point and/or diffuse sources of pollution (agriculture, farming, waste waters). An improvement of the ecological situation at the Momina Kula site (from moderate to good) was registered. Downstream, because of the powerful self-purification capacity of the river ecosystem stimulated by slope, velocity and lack of potential sources of human impact, high and good ecological state was observed.

As far as BI is leading in benthosological assessment, according to the current assessment of the Mesta site, downstream Matnitsa (last studied site before border crossing), the Mesta River leaves the Bulgarian territory and enters Greece in a good ecological state (Ordinance № H-4/2012).

The Trophic index RETI values have a supporting role in the ecological state assessment of running water bodies. EQR assessment based on trophic structure declines downstream mainly because of the fact that trophic indices are very sensitive towards hydro-morphological degradation. We considered that in the case of the Mesta River, the main reason for the deterioration of the trophic index assessment could be due to the location of the last five sites (excluding Dospatska) described in Table 2. It should be noted that three of them (tributaries Kanina, Matnitsa

Table 2. Ecological state assessment, based on BI and RETI, at studied sites for two studied years – 2009 and 2010

Sampling points	EQR/BI		EQR/RETI	
	2009	2010	2009	2010
Cherna Mesta	High	Good	High	Good
Yakoruda		High		Good
General Kovachev		Moderate		Good
Iztok, source	Good		High	
Razlozhka		Good		Good
Banderitsa	High		High	
Demyanitsa	Good	High	Good	High
Glazne		Moderate		Good
Iztok	Good	Moderate	Moderate	Good
Mesta, after Iztok	Good		Good	
Banyata		Good		Good
Gostun		Good		Good
Momina kula	Moderate	Good	Moderate	Good
Gospodintsi		High		Moderate
Hadzhidimovo		Good		High
Kanina	High		Bad	
Matntsca	Good		Moderate	
Satovchenska Bistritsa	Good		Moderate	
Dospatska	Good		Good	
Mesta, after Matnitsa	Good		Moderate	

and Satovchenska Bistritsa) are situated before the influx in the main Mesta River and the last one is located immediately after entering the Kanina River. These sites can be defined as transitional and often are more heterogeneous (Mac Nally 2005). They are characterized as mixing/boundary zones where changes in physical habitat, organic matter and inorganic sediments, alteration in food availability and habitat for aquatic organisms are happening (Wallis *et al*., 2009). Confluences are biodiversity 'hotspots' in river systems (Clarke *et al*., 2008) where restructuring of the proportions of the functional feeding groups and transformations of the trophic structure are happening. In our opinion, this is one of the main reasons for discrepancy between the assessments based on BI and the trophic index downstream.

Kovachev and Uzunov (1986) pointed out that during the first years after the elimination of heavy industrial impact, processes of adaptation, readjustment and enrichment of the macrozoobenthos fauna in the Mesta River were observed. In this aspect, the benthic community in the studied river basin is consecutively altering, parallel with the environmental conditions. Most of the changes within the invertebrate species diversity are recognized to be driven by human activities on a local and regional (basin) scale (i.e. discharge regulation) but some could be of global importance (i.e. climate change) (Uzunov *et al.,* 2005). Changes in the precipitation and hydrologic regime of regions could potentially result in directional trends in species assemblages. These effects are much more pronounced at unpolluted, clear rivers. A typical example in this aspect is Demyanitsa River. The site is located in the Pirin Mountain National Park and recognized as a referent site in terms of the WFD normative definitions. The assessment is confirmed with the dynamics of SPUB and BI values over the course of a 25-year period (Fig. 9).

During this period, shifts in species compositions of the benthic fauna were detected at Demyanitsa River (Fig. 10). A similar tendency was determined at other referent sites located in the upper part of the Glasne River during 1986-2000 (Uzunov *et al.,* 2005). These processes could be described as „regime shift"- reorganizations of communities from one relatively stable status to another.

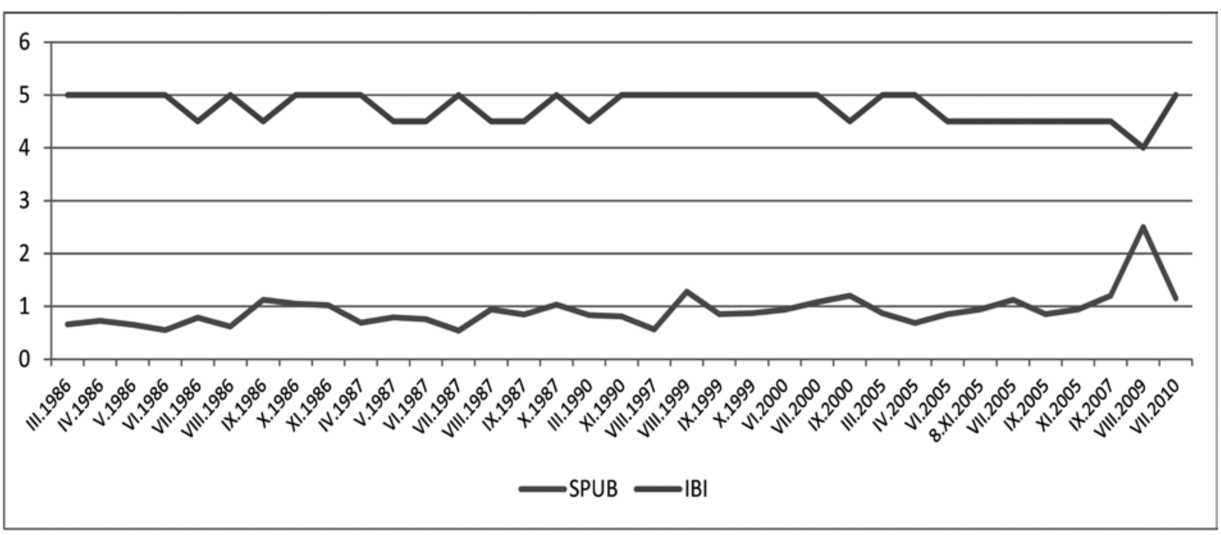

Fig. 9. Dynamics of saprobic SPUB and biotic indices BI values during the studied periods at Demyanitsa River referent site

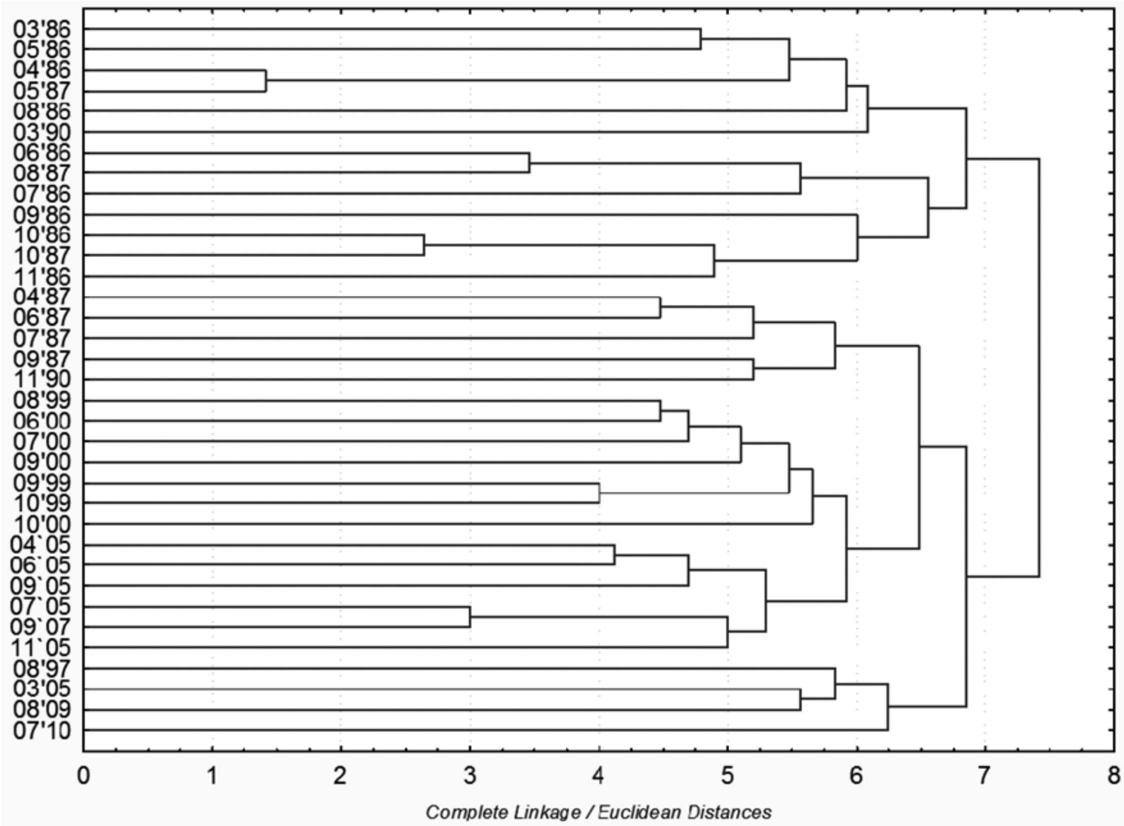

Fig. 10. Cluster analysis of species similarity of the invertebrate fauna in the Demyanitsa River for several periods of study.

High-mountain ecosystems are controlled by abiotic rather than biotic factors (Reice 1985) and this site is free of human impacts, so a possible reason for the long-term changes of species diversity of the benthic invertebrate communities could be the water discharge decline at the Mesta River over the last fifty years, as revealed by Diadovski *et al.* (2007). In comparison with 1986, a decrease in the species richness was observed in 2010. Sorensen similarity coefficient between the first and last studied period is only 21%.

Furthermore, changes in the trophic structure were determined. The long-term functional feeding group's analyses at Demyanitsa site showed that the deposit feeder share remained relatively persistent and an increase of the percentage share of the scrapers was observed. The most sensitive functional group shredders demonstrated a decrease during the period 1986-2010. According to the River continuum concept in a typically natural, undisturbed environment such as Demyanitsa River, the number of shredders should decrease markedly downstream through the middle reaches (Vannote *et al.,* 1980). Shredder populations' invertebrates seem to play a key role in litter breakdown in headwaters, and tend to decrease downstream largely because of physical factors, such as increasing width and decreasing riparian vegetation (Manuel *et al*., 2006). On other occasions, shredder reduction could be detected in disturbed rivers, because the shredder trophic group is very susceptive towards different kinds of human impacts, including organic pollution (Varadinova *et al.,* 2007).

Taking into account the above-mentioned outcomes, our future investigations will focus on the reasons and more detailed analyses of the changes in species and trophic structure of the macrozoobehtos at clean, undisturbed river sites and stretches.

Conclusion

The values of physico-chemical parameters, current assessment of water quality of the Mesta River, and indices based on macrozoobenthos demonstrated processes of stabilization of the aquatic ecosystem and improvement of the ecological state of the riverine water bodies.

Similarities between species composition of the macrozoobenthos at the studied sites during 2009 are formed on the basis of the level of the anthropogenic impact rather than the differences between the main river and the tributaries.

Shifts in species composition and changes in the species richness and reorganization in the trophic structure of the benthic fauna in high-mountain (free of human impact) ecosystems could be caused by global climate processes which are reflected in the local scale.

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2. Developing the identification system and assessment of the ecological state and potential of certain types of surface waters (rivers & lakes) in the territory of the Republic of Bulgaria (based on the typology of system “B).

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