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ECOLOGICAL QUALITY ASSESSMENT OF LUDA RIVER, BULGARIA

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SYNOPSIS

The benthic community of Luda River is influenced by both uranium loaded sediments and infiltrate water from the abundant mine in the vicinity of the Senokos Village. Water quality of Luda River (Bulgaria) is assessed by use of structural (Margalefs' diversity index, Simpson dominance index and Shannon-Weaver diversity index) biotic (BMWP, MIBI, BGBI, EPT) and saprobic (Pantle-Buck) indices of the benthic communities. The low values of the BMWP, MIBI, BGBI, EPT and Margalefs' diversity index at stations two, six (during the spring) and seven (during the autumn) mark the problem sections of the river. The saprobic index varied between olygosaproby and olygo – β-mesosaproby and shows the lack of significant organic pollution.

INTRODUCTION

Streams and rivers are under various changes due to anthropogenic activities in their catchment areas (Qadir & Malik, 2009). The effects of human activities have resulted in degradation of stream and riverine ecosystem (Schleiger, 2000) which ultimately alter the structure and function of stream biota (Stoddard et al., 2006).

The biological response and sensitivity of different organisms to physical and chemical changes of aquatic system can be used as an indicator for the assessment of habitat quality (Karr, 1991). Biological indicators may reflect the intensity of anthropogenic stress and have been used as a tool in risk assessment and evaluation of human induced changes in freshwater ecosystem (Toham & Teugels, 1999). Benthic macroinvertebrates are sensitive to changes in their environment and habitat characteristics (Chakona et al., 2008), and have been widely used as biological indicators of river health (Russev et al., 1981; Yaneva, 1987; Yaneva & Russev, 1993; Yaneva et al., 1997; Balcombe et al., 2005; Moskova et al., 2009).

Diverse biotic indices have been used to assess the water quality in rivers (Yaneva, 1979; Uzunov & Kovachev, 1985; Uzunov et al., 1991; De Pauw & Hawkes, 1993; Knoben et al., 1995). The most widely used are those based on the benthic invertebrates (Metcalfe, 1989; Cairns & Pratt, 1993). The qualitative and quantitative changes in the benthic communities have also been used as a tool for checking pollution.

The aim of the study is to assess the water quality of Luda River (Bulgaria), a left tributary to the Struma River.

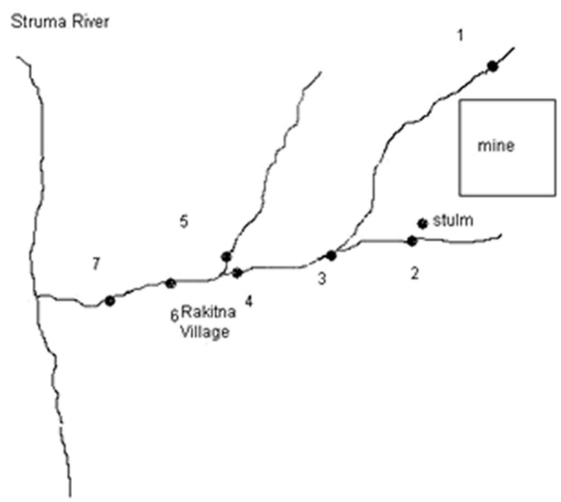

Figure 1: Scheme of the Luda River basin with relative position of the mine and the sampling stations.

MATERIAL AND METHODS

Luda River is a left tributary to the Struma River – one of the biggest rivers in Bulgaria. The predominant substrate on the river bed is sand and gravel. In the upper reaches of Luda River is located uranium mine Senokos (Pirin Mountain, Bulgaria). The mining started in 1988 and continued until 1991 as an open mine ore extraction. In the beginning of the 90's the mine was rehabilitated, but the lack of maintenance has led to intense surface erosion of the protective layer and washout of radioactive material toward Luda River. In the lower reaches, waters are diverted for irrigation, thus enhancing the negative effect of the uranium mine on the benthic invertebrates and posing a health risk for the local community. During the low water-level period, the over exploitation of the river leads to almost complete dry off of the river. The small tributaries and the hyporeal of the river act as refuge for the benthic communities at low water flows. Macrozoobenthic communities make a quick recovery with the beginning of the autumnal precipitation. Macrozoobenthic samples were collected by the standard method ISO 7828/1985 from seven stations during spring and autumn of 2009 (Fig. 1). All samples were fixed in 4 % formaldehyde and after laboratory sorting by systematic groups are kept in 70% alcohol.

Margalefs' diversity index (d) (1958), Simpson dominance index (c) (1949) and Shannon-Weaver diversity index (H) (1963) were used to assess the river. These indices reflect the changes in the community structure with pollution, and are used to measure stress in the environment. The richness of the community is reduced with pollution.

Biotic indices which were used in this study are Biological Monitoring Working Party (BMWP) (Armitage et al., 1983), Modified Irish Biotic Index (MIBI) (Yaneva & Cheshmedjiev, 1999), Bulgarian Biotic Index (BGBI) (Uzunov et al., 1998), EPT Index based on presence of *Ephemeroptera*, *Plecoptera*, *Trichoptera* (Lenat, 1988). The saprobiological analysis was accomplished through saprobic index of PANTLE & BUCK (1955) (SPB). The index is based on the total tolerance of the species composing the community to a certain saprobic level. BMWP assigns scores to different families of aquatic organisms based on their sensitivity to pollution. The greater their sensitivity towards pollution, the higher the BMWP score. This scoring system provides an excellent early warning of deteriorating water quality. MIBI and BGBI place groups of animals into five broad classes A-E, of which group A includes the most tolerant forms. Using combinations of the relative abundance of these groups the water quality is expressed as a Q value where Q1 is bad and Q5 is excellent quality. The EPT Index is the total number of distinct taxa within the groups, *Ephemeroptera*, *Plecoptera* and *Trichoptera*. These orders of macroinvertebrates are highly sensitive to pollution and they are often used as water quality indicators. Their presence indicates a high quality of water, while their absence suggests water may be polluted. The EPT index increases with increases in water quality while reductions are commonly used to infer environmental decline.

RESULTS AND DISCUSSION

Margalefs' diversity index (d) is in the range 5.8 – 12.6 (Table 1). In non influenced conditions the values of this index are above 8 (Russev, 1993). According to that, stations one, four and five (during the both studied seasons) are in excellent state. The state of station six is a very good during the autumn. The values under 6.3 correspond to a slight change in the conditions at stations two (during the spring) and seven (during the autumn). According Margalefs' diversity index, the benthic community of station three gradually recovers after the influence at station two.

The Shannon-Weaver diversity index (H) in Luda River is with the same dynamic. The high values of this index (3.0 and above) at stations one, three, four and five (in all seasons) and at station six (during the autumn) assessed the benthic communities as a stable and functionally compete. Comparatively lower is the diversity of benthic communities at stations two (during the spring) and seven (during the autumn). The minimal diversity (1.3) is at station six during the spring.

The low values of Simpson index (c) (0.1 – 0.2) show a lack of many dominants among the groups of the benthic communities at stations one, three, four, five and six (during the autumn). Slightly higher is the dominance of the communities at stations two (during the spring) and seven (during the autumn). An exception to this tendency is found at station six (during the spring), when the dominance is 0.6.

Table 1: Values of structural indices at different stations along Luda River.

Sampling stations	Indices					
	d		c		H	
	spring	autumn	spring	autumn	spring	autumn
1	9.2	9.9	0.2	0.2	3.2	3.4
2	5.8	-	0.3	-	2.3	-
3	7.4	7.6	0.2	0.1	2.9	3.6
4	-	8.8	-	0.1	-	3.5
5	-	12.6	-	0.1	-	3.7
6	3.5	9.1	0.6	0.2	1.3	3.3
7	-	6.3	-	0.3	-	2.4

The values of saprobic index (S_{PB}) characterized the studied parts of the river as olygosaproby (stations one, three, six and seven) and olygo – β mesosaproby (stations two, four and five) and show the lack of significant organic pollution from the villages in the watershed (Table 2).

Table 2: S_{PB} values at different stations along Luda River.

	stations						
	1	2	3	4	5	6	7
spring	0.9	1.5	0.8	-	-	1.3	-
autumn	1	-	1.2	1.5	1.5	1.2	1.3

The ecological state of Luda River is well illustrated by the values of BMWP, MIBI, BGBI and EPT. The low values of the these indices at station two marks the direct inflow of seepage waters from the stulm to the river (Tab. 3, Fig. 1, Fig. 2). The confluence to the main river of a number of small unimpacted tributaries determines the quick recovery of the benthic communities below the mine (from station three to station five) (Fig. 1). The steeper slope of the upper reaches leads to transportation and accumulation of eroded materials downstream bellow the Rakitna Village. The observed deterioration of the water quality at stations six and seven are due to the synergetic effect of the mine and the diversion of river waters for irrigation on the benthic invertebrates (Fig. 2).

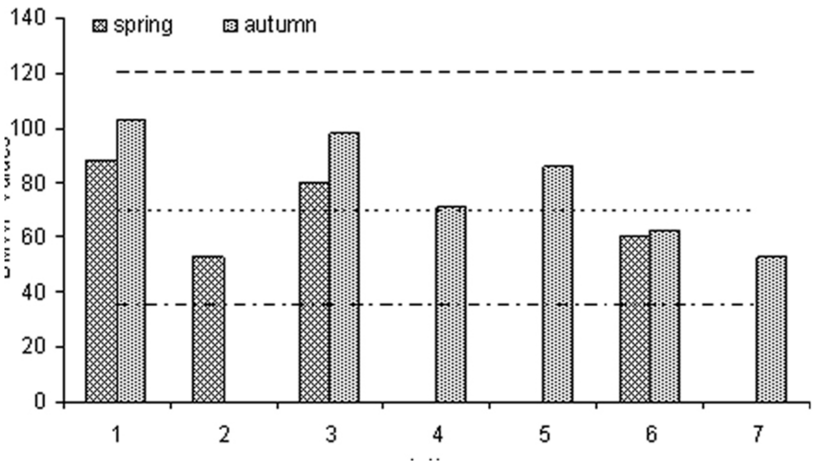

Figure 2: BMWP values at different stations along Luda River during the spring and autumn of 2009. Horizontal lines mark the border value between water quality classes: - - - - between excellent to good; ……. good to moderate; -˙-˙-˙- moderate to bad.

According the values of MIBI and BGBI the water quality at stations two and six (during the spring) is good to moderate which correspond to II - III category according to Bulgarian State Standard (Act # 7/ 08.08. 1986). The water quality at all other stations along the river is excellent to good (Table 3).

Table 3: MIBI and BGBI values at different stations along Luda River.

Sampling stations	Biotic indices			
	MIBI		BGBI	
	spring	autumn	spring	autumn
1	Group A 5	Group A 4-5	Class A 9	Class A 10
2	Group B 3-4	-	Class B 8	-
3	Group A 4-5	Group A 5	Class B 9	Class B 9
4	-	Group A 5	-	Class B 9
5	-	Group A 5	-	Class B 9
6	Group A 3-4	Group A 5	Class B 6	Class B 9
7	-	Group A 4-5	-	Class B 8

The EPT Index also proves that the problem sections of the Luda River are stations two, six and seven (Fig. 3). In all other stations EPT Index increases with the improving of water quality.

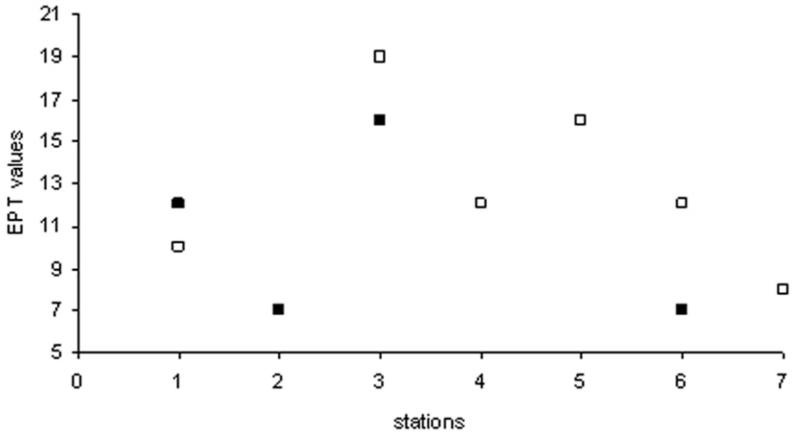

Figure 3:
EPT values at different stations along Luda River during the spring (■) and autumn (□) of 2009.

The abandoned uranium mine Senokos continues to affect locally the benthic communities of Luda River and its ecological state. The negative effect of the mine is enhanced by the diversion of river waters. Downstream the benthic invertebrates make a quick recovery. During the driest period of the years, the over exploitation of the river leads to almost complete dry off of the river.

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