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WATER QUALITY ASSESSMENT FROM THE ARIEŞ RIVER CATCHMENT AREA BASED ON BENTHIC INVERTEBRATES

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SUMMARY. The present study represents the assessment of the Arieş River water quality in its headwaters, an area heavily affected by intensive tourism activities from the Arieşeni resort. The water quality was assessed using three biotic indices based on benthic invertebrate communities: the Extended Biotic Index (E.B.I.), the Biological Monitoring Working Party adapted for Poland (B.M.W.P.-PL) and the Average Score Per Taxon (A.S.P.T.). Seven sampling sites were considered, located both on the main river course and on its main tributaries from the Arieş River headwaters. The structure of the benthic invertebrate communities, together with their indicative values for water quality showed polluted waters at the source of the Arieş River, an area characterized by intense tourism. However, on going downstream, the river exhibited good and high water quality, due to its self-cleaning capacity.

Keywords: A.S.P.T., B.M.W.P.-PL, E.B.I.

Introduction

Assessing river water quality based on benthic invertebrate communities represents one of the methods recommended by the Water Framework Directive 2000/60/EC of the European Parliament.

Benthic invertebrates play a key role in aquatic ecosystems, representing the link between autotrophs, allochthonous input and top predators (Wetzel, 2001). Benthic invertebrates are a heterogeneous group in terms of their feeding behaviour, habitat preferences or development, including both tolerant and intolerant taxa to pollution, habitat alteration or other human impacts (Wetzel, 2001; Verberk *et al.*, 2002). Benthic communities have long been used as bioindicators for monitoring water quality of streams, considering not only pollution but also other anthropogenic influences (Hering *et al.*, 2006).

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The Arieș River catchment area represented the subject for many hydrobiological studies, focused on algae, benthic invertebrates or fish communities (Momeu and Peterfi, 2007; Momeu *et al.*, 2007; 2009; Cupșa, 2009), but also on interstitial fauna (Moldovan *et al.*, 2011). These studies showed the major negative impact caused by mining in Roșia Montană and Roșia Poieni areas. The present paper focuses on the headwaters of the Arieș River, upstream of these mining regions, where a prosperous touristic resort developed in the past 20 years. Thus, the objectives of the present paper are: (1) to analyze the structure of the benthic invertebrate communities from the Arieș River headwaters and its tributaries in the area; (2) to present their dynamics and distribution; and (3) to assess the water quality from the study area.

Materials and methods

The Arieș River flows through the Apuseni Mountains (Transylvania, Romania), having its source on the North-Eastern part of the Cucurbăta Massif (1761 m altitude) and a length of 164 km (Ujvari, 1972).

The study area is located in the upper Arieș River catchment area, in the Arieșeni Commune, Alba county, which consists of 18 smaller villages, with a total surface of 6310 ha. The Arieșeni commune is traversed by the springs of the Arieșul Mare River, flowing eastwards on a distance of 14.2 km (Ghinea, 2002). In fact, the Arieșul Mare River is formed in the Arieșeni Commune, and its main tributaries from this area are: the Cobleș River (with a length of 8.5 km), the Ștei River (2 km in length) and the Galbena River (6 km in length).

Benthic invertebrates were sampled from seven sites: three located on the main river course and four located on its main tributaries from the area (The Galbena, the Ștei and the Cobleș Rivers) (Tables 1, 2).

Table 1.

The seven sampling sites with their codes used for the present paper

Sampling site name	Sampling site code
The Arieș River – source	S1
The Arieș River – upstream Arieșeni	S2
The Arieș River – downstream Arieșeni	S3
The Galbena River – source	S4
The Galbena River – upstream the junction with the Arieș River	S5
The Ștei River – upstream the junction with the Arieș River	S6
The Cobleș River – upstream the junction with the Arieș River	S7

The invertebrate communites were sampled seasonally in 2012: in spring on May the 13th, in summer on August the 5th and in autumn on September the 23rd. The samples were collected in plastic vessels, using a 250 μm mesh net, and then preserved in 4% formaldehyde. Subsequently, the samples were sorted in the laboratory, under a dissecting microscope. Taxonomical identifications were made to the genus level for Plecoptera (stoneflies), Ephemeroptera (mayflies), Turbellaria and Hirudinea; and to the family level for Oligochaeta, Copepoda, Amphipoda, Trichoptera (caddisflies), Diptera, Coleoptera, Odonata and Heteroptera. Based on these analyses, the following

biotic indices were calculated: the Extended Biotic Index (E.B.I.) (Ghetti, 1997), the Biological Monitoring Working Party, adapted for Poland (B.M.W.P.-PL) and the Average Score Per Taxon (A.S.P.T.) (Walley and Hawkes, 1996; 1997).

Table 2.

Location of the seven sampling sites from the upper Arieș catchment area, with their major characteristics (sp – spring 2012; su – summer 2012; au – autumn 2012)

Sampling site	Altitude (m a.s.l.)	GPS coordinates	Riverbed width (m)			Maximum depth (m)		
			sp	su	au	sp	su	Au
S1	1172	N 46º30'54.43" E 22º40'51.67"	1.5	1	0.7	0.25	0.25	0.20
S2	1099	N 46º30'29.60" E 22º41'36.93"	3	3	2	0.30	0.30	0.30
S3	799	N 46º27'25.52" E 22º47'40.40"	9	9	6	0.30	0.30	0.40
S4	1419	N 46º28'18.19" E 22º41'07.07"	2	2	2	0.15	0.15	0.15
S5	921	N 46º28'36.53" E 22º44'52.55"	3	2.5	3	0.40	0.40	0.20
S6	908	N 46º28'28.62" E 22º44'25.05."	5	4	3	0.50	0.40	0.60
S7	878	N 46º28'35.50" E 22º45'39.34"	8	8	8	0.40	0.40	0.30

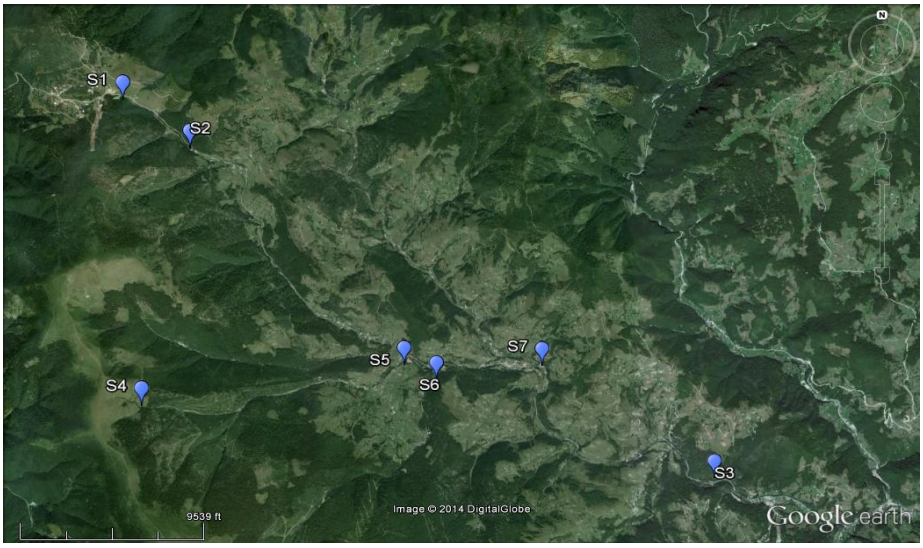

Figure 1. Location of the seven sampling sites from the Arieș catchment area (S1 -The Arieș River – source; S2 -The Arieș River – upstream Arieșeni; S3 -The Arieș River – downstream Arieșeni; S4 -The Galbena River – source; S5 -The Galbena River – upstream the junction with the Arieș River; S6 -The Ștei River – upstream the junction with the Arieș River; S7 -The Cobleș River – upstream the junction with the Arieș River) (source: GoogleEarth)

Results and discussion

The relative percentage abundance was calculated in order to illustrate the structure and dynamics of aquatic invertebrate communities from all the sites sampled in spring, summer and autumn 2012 (Fig. 2 – 4).

Chironomid larvae represended the group with the dominant percentage abundance in all sampling sites, in all three seasons.

At the sampling site S1 - The Arieș River – source, chironomids and oligochaetes recorded the highest values of percentage abundance, because of their ability to survive in very low dissolved oxygen conditions (Abel, 2002). These high percentages indicated organic pollution caused by domestic wastes coming from the touristic guest houses near the Arieșeni ski track. These results differ from the data published by Cupșa (2009), who found low numbers of oligochaetes at the Arieș River source in 2005. These higher oligochaete percentages in the river headwaters could be caused by the increasing number of guest houses, appeared in the past few years, directly related to waste waters and thus organic pollution.

Invertebrates characteristic to clean mountainous rivers: stoneflies, mayflies and caddisflies appeared together with oligochaetes and chironomids at the other sampling sites located on the main river course (S2-The Arieș River – upstream Arieșeni, S3-The Arieș River – downstream Arieșeni), but also at the sites situated on the three tributaries (S4-The Galbena River – source, S5-The Galbena River – upstream the junction with the Arieș River, S6-The Ștei River – upstream the junction with the Arieș River, S7-The Cobleș River – upstream the junction with the Arieș River) (Fig. 2 - 4).

In spring, chironomid larvae dominated the invertebrate communities from the sampling sites S2 and S3, but stoneflies and mayflies became abundand in summer and autumn. Thus, after the organic pollution indicated by tolerant taxa like chironomids, the river was able to recover and intolerant groups returned probably from the tributaries.

Invertebrate communities found in the main tributaries: the Galbena, the Cobleș and the Stre Rivers included the following groups: Plecoptera, Ephemeroptera, Trichoptera and Amphipoda (Fig. 3 and 4), all represended by a small number in S1, the Arieș River source. Thus, the tributaries acted as an important sink of biodiversity, used to repopulate the regions affected by pollution.

For the assessment of water quality, the benthic invertebrates were identified to the taxonomical level required by each of the three indices: the E.B.I. (Ghetti, 1997), the B.M.W.P.-PL and the A.S.P.T. (Walley and Hawkes, 1996; 1997).

A total number of 64 taxa were identified at the seven sampling sites (Table 3). The lowest number of taxa (28) was found at sampling site S1. The taxa richness increased on going downstream, with 31 at S2 and 33 at S3, respectively. Higher numbers of taxa were found on the tributaries: 37 on the Galbena River (sites S4 and S5), 38 on the Ștei River and 39 on the Cobleș River.

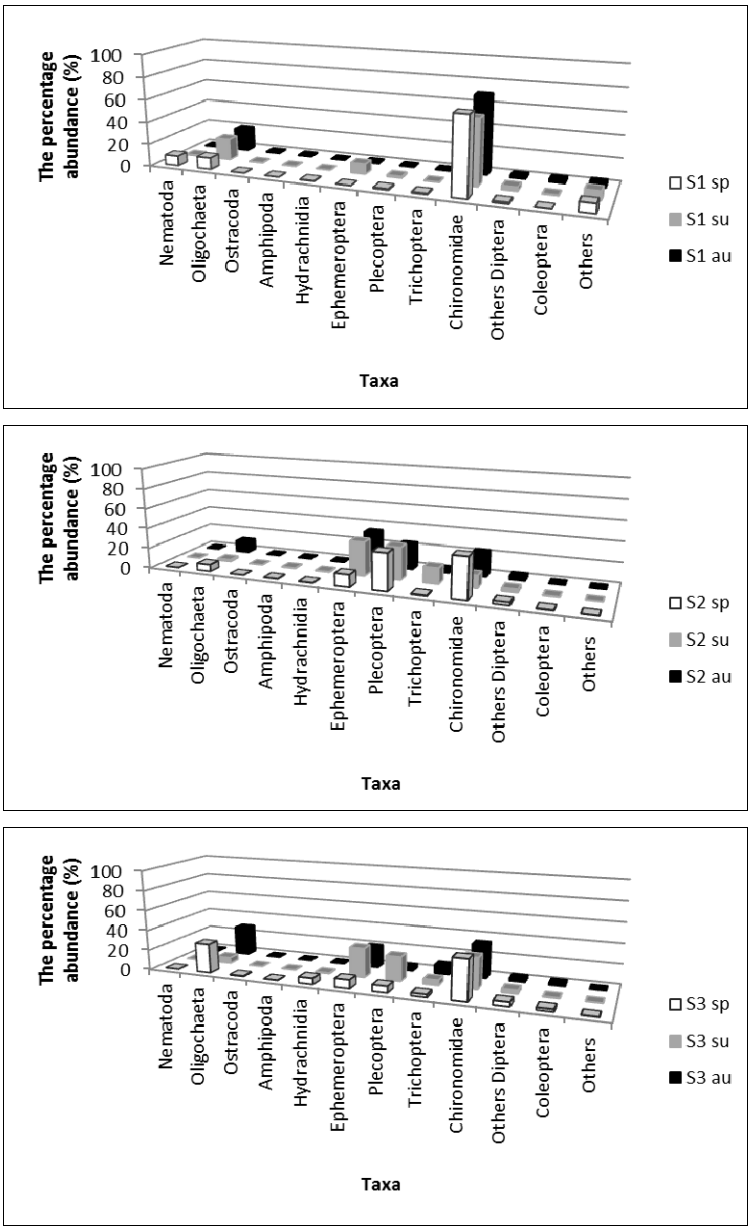

Figure 2. The percentage abundance (%) of benthic invertebrate groups from three sampling sites: S1-The Arieș River – source, S2-The Arieș River – upstream Arieșeni, S3-The Arieș River – downstream Arieșeni, in three different seasons (sp- spring, su- summer, au- autumn)

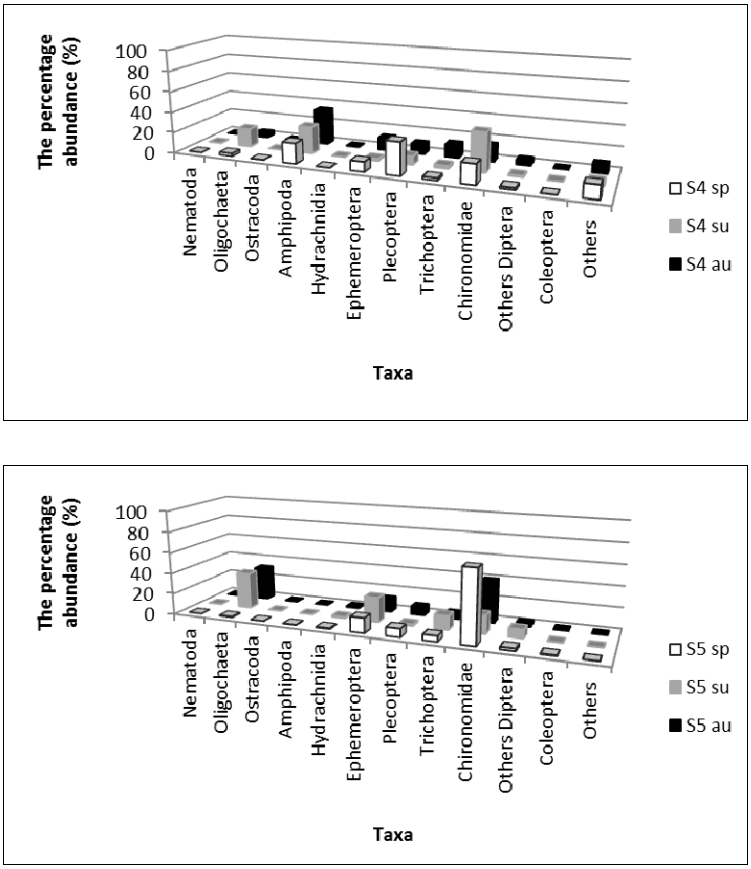

Figure 3. The percentage abundance (%) of benthic invertebrate groups from two sampling sites: S4-The Galbena River – source, S5-The Galbena River – upstream the junction with the Arieș River, in three different seasons (sp- spring, su- summer, au- autumn)

The lowest number of Ephemeroptera, Plecoptera, Trichoptera and Diptera was recorded at sampling site S1, while the sites located on the tributaries (S4 – S7) were characterized by a higher biodiversity, acting as a source for river repopulation after pollution.

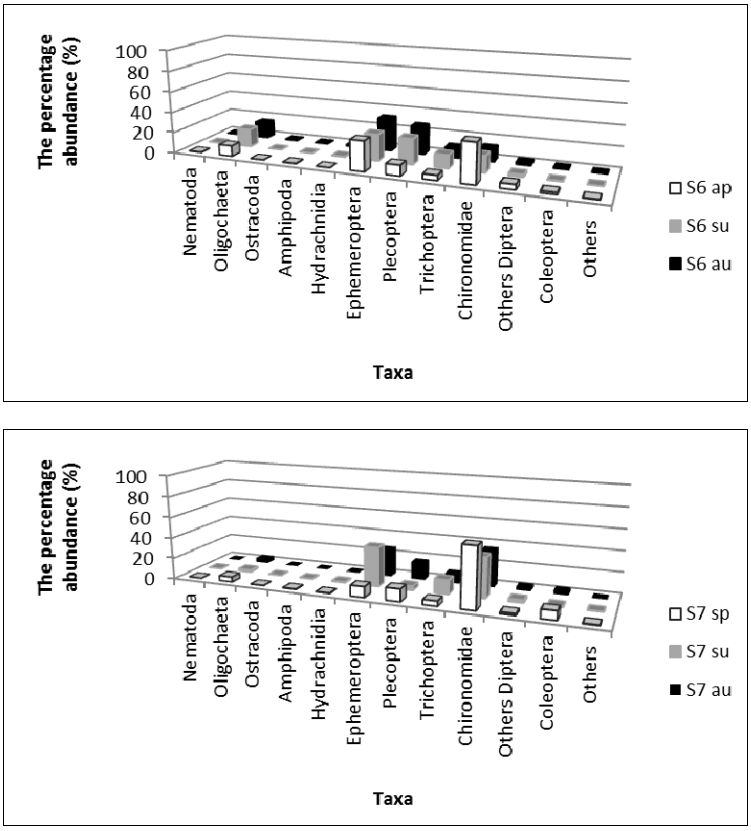

Figure 4. The percentage abundance (%) of benthic invertebrate groups from two sampling sites: S6-The Ştei River – upstream the junction with the Arieş River, S7-The Cobleş River – upstream the junction with the Arieş River, in three different seasons (sp- spring, su- summer, au- autumn)

The three water quality indices (E.B.I., B.M.W.P.-PL and A.S.P.T.) were calculated based on the structure of benthic invertebrate communities from the seven sampling sites. The water quality classes were calculated for each season separatelly (Table 4).

Table 3.

List of benthic invertebrate taxa identified in the seven sampling sites located on the main river course and the main tributaries of the Arieș River (S1-The Arieș River – source, S2-The Arieș River – upstream Arieșeni, S3-The Arieș River – downstream Arieșeni, S4-The Galbena River – source, S5-The Galbena River – upstream the junction with the Arieș River, S6-The Ștei River – upstream the junction with the Arieș River, S7-The Cobleș River – upstream the junction with the Arieș River)

Taxa		**Sites**						
		S1	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**
Nematoda		x	x	x	x	x	x	x
Oligochaeta	Enchytraeidae	x	x	x	x	x	x	x
	Gordiidae				x			
	Haplotaxidae	x	x	x	x	x	x	x
	Lumbricidae	x	x	x	x	x	x	x
	Lumbriculidae	x		x	x	x	x	x
	Naididae	x	x	x	x	x	x	x
	Tubificidae	x	x	x	x	x		x
Copepoda		x						x
Ostracoda		x		x	x			
Amphipoda			x	x	x	x	x	x
Hydrachnidia		x	x	x	x	x		x
Ephemeroptera	*Acentrella*				x	x	x	
	Baetis	x	x	x	x	x	x	x
	Caenis			x			x	x
	Centroptilum							x
	Cloeon	x						
	Echdyonurus		x	x	x	x	x	x
	Epeorus			x			x	x
	Ephemera			x				x
	Habroleptoides		x	x		x	x	x
	Habrophlebia					x		x
	Seratella		x	x		x	x	x
	Rhithrogena		x	x	x	x	x	x
	Torleya		x	x		x		x
Plecoptera	*Arcynopteryx*			x	x	x	x	
	Besdolus				x			
	Brachyptera						x	
	Isoperla		x		x		x	
	Leuctra	x	x	x	x	x	x	x
	Nemoura	x	x		x	x	x	x
	Perla		x	x		x	x	x
	Perlodes		x	x		x	x	x
	Protonemura		x		x	x	x	
	Taeniopteryx						x	

Table 3. continued

Trichoptera	Brachycentridae	x						
	Goeridae					x	x	
	Hydropsychidae		x	x		x	x	x
	Hydroptilidae					x		
	Lepidostomatidae						x	
	Limnephilidae	x	x	x	x	x	x	x
	Polycentropodidae		x		x		x	x
	Rhyacophilidae		x	x	x	x	x	x
Diptera	Athericidae			x	x	x	x	x
	Blephariceridae					x	x	
	Ceratopogonidae	x	x	x	x		x	x
	Chironomidae	x	x	x	x	x	x	x
	Dixidae				x			
	Empididae	x	x	x	x	x	x	x
	Limoniidae	x	x	x	x	x	x	x
	Psychodidae				x			
	Simuliidae	x	x		x	x	x	x
	Syrphidae				x			
	Tabanidae	x						
	Tipulidae	x						
Coleoptera	Dytiscidae	x				x		
	Elminthidae		x	x	x	x	x	x
	Hydrophilidae							x
Altele	Aeshnidae	x						
	Ancylus				x			x
	Dugesia	x		x	x	x		x
	Helobdella				x			
	Lymnaeidae	x						
	Sphaeriidae	x	x					

According to E.B.I., the water quality classes were higher for all seven sampling sites, while B.M.W.P.-PL and A.S.P.T. assigned lower quality classes to all sites. An ”accepted quality class” was considered, averaging the quality classes showed by all the three indices. Only sampling site S1 was rated with moderate water quality (class III); the rest of the sites were considered of good and high water quality (class I-II) (Table 4).

Table 4.

The quality classes calculated according to the three biotic indices, and the accepted quality classes, for the sampling sites considered in the Arieș catchment area (E.B.I. – Extended Biotic Index, B.M.W.P. – Biological Monitoring Working Party, A.S.P.T. – Average Score Per Taxon, S1-The Arieș River – source, S2-The Arieș River – upstream Arieșeni, S3-The Arieș River – downstream Arieșeni, S4-The Galbena River – source, S5-The Galbena River – upstream the junction with the Arieș River, S6-The Ștei River – upstream the junction with the Arieș River, S7-The Cobleș River – upstream the junction with the Arieș River)

Sites	E.B.I. quality classes	B.M.W.P. quality classes	A.S.P.T. quality classes	Accepted quality classes
S1	II-III	III-IV	III	III
S2	I	II	II	I-II
S3	I	II	II	I-II
S4	I	II	II	I-II
S5	I	I-II	II	I-II
S6	I	I-II	I-II	I-II
S7	I	I-II	II	I-II

Conclusions

A total of 64 taxa were identified in the study area, with a minimum richness of 28 at the Arieș River source, a region heavily affected by tourism. The highest number of taxa was found on the three river tributaries from the area, so they might represent an important biodiversity source in repopulating affected river stretches.

In 2012, the water quality from the upper Arieș river catchment area, based on benthic invertebrate communities, was good and high (class I-II), except for the touristic region near the ski track from Arieșeni (where sampling site S1 was located). The severe pollution from this area could be caused by intensive tourism, massive deforestation, overgrazing, but also by the prolonged drought that led to low river discharges, decreasing the self-cleaning capacity of the river.

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