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Studies upon the benthic macroinvertebrate community from Ormanului Valley (Bihor County, Romania)

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Abstract. The benthic macroinvertebrate community was investigated in Ormanului Valley in three sample sites situated along the rivulet. The samples were taken monthly in the cold season, between September 2006 and February 2007. The species were determined and the ecological indexes were calculated (density, abundance, frequency, constancy, diversity, evenness). We observed the variation of the community structure along the months and the differences between the three sample sites due to the differences of the nature of substrata and the speed of the water flow.

Keywords: benthos, macroinvertebrates, benthic community, streams.

Introduction

Uileacu de Beius Village is situated in the western part of Romania in the south-western part of Bihor County in a hilly region with an altitude between 400 and 800 m near Codru Moma Mountains. The relief is hilly with high peaks and deep valleys. Through the village flows the Crisul Negru River. Ormanului Valley is a left side tributary of Crisul Negru and flows into the river on the territory of Uileacu de Beius.

The average temperatures are around 10^0C, in the winter often occur thermic inversions. In the spring the temperatures are smaller than in autumn because the snow melting and in the summer the temperatures are high. The mountain sector rivulets are high speed flowing and with small water quantity. The riverbed is usually covered by stones and boulders. The water has high solved oxygen content and a small amount of organic debris.

The benthic organisms from these habitats adapted to these conditions especially to the high speed of the water (Cooksey & Hyland 2007, Cupsa et al. 2002, Cupsa et al. 2003a,b, Cupsa & Banyai 2006). Here we can find with great abundance 4 invertebrate groups: Turbelariata, Plecoptera larvae, Ephemeroptera larvae and Trichoptera larvae (Curtean-Bănăduc et al. 2006, Ilut et al. 2006, Kazanci & Dugel 2000, Robert & Curtean-Bănăduc 2005). Together with them there are also other groups as Gastropoda, Gammarida, etc. (Duran 2007). The benthic invertebrates found here are perfectly adapted to the high speed of the water, the low organic content, low temperature of the water and high oxygen content (Principe et al. 2007).

The small streams and rivulets with good quality water are a natural refuge for many exacting species, which can't live in the bigger rivers because of their pollution or hydrodynamic modifications (Dobre & Tatole 2000, Florea & Grigoraş 2000, Fleituch 2003, Tullos & Neumann 2006).

The aim of this paper is to explore the benthic macroinvertebrate fauna in this valley which flows in Crisul Negru River. The valley can offer good habitat for macrozoobenthic species which find in this unpolluted water a refugee. The macrozoobenthic community represents a species reserve (Finn et al. 2011) which can populate the nearby Crisul Negru River which is affected by domestic pollution by the city of Beius situated upstream.

Material and methods

The samples were collected monthly during September 2006 – February 2007, from three habitats along the Ormanului Valley one situated near the spring of the Valley, the second in the middle course and the third near the confluence with Crisul Negru River.

Study area

Ormanului Valley is a stream which has its spring in Codru Moma Mountains, Urberial forest situate on the territory of Uileacu de Beius Village. It flows through the forest along appreciatively 8 kilometers. The direction of the flow is south-east to north-east. The debit of the stream is small and inconstant. The valley is supplied by the melted snow in the spring and the rain during the rest of the year. During the torrential rains flash floods can occur along the valley.

Sample sites

S1 is situated near the spring of the valley. The water has a high speed flow, the substratum made up from boulders and gravels. The depth of the water is appreciatively of 5 cm, with small level variations during the rainy periods. The temperature of the water is relatively constant and low. The riverbed is narrow. The riverbanks are covered with herbaceous vegetation and trees.

S2 is in the middle part of the valley. The substratum is covered by gravels and has a lot of holes; the average depth of the water is 10-15 cm in the study period. The riverbed is broader than at S1, the river flow has a higher speed. The river banks are steep.

S3 is situated at the river mouth at the confluence with Crisul Negru River. The riverbed is broader; the depth is variable depending on the quantity of the fell precipitation. The substratum is made up from stones and sand. The temperature of the water modifies depending on the temperature of the air. The vegetation is formed by trees and herbs.

Sampling method and data analysis

The samples were collected with a Surber bottom dredge, were preserved in 4% formalin in field. In lab the samples were sorted under a 40X magnifying stereomicroscope and transferred in 70% ethylic alcohol. In lab the specimens were sorted and identified to species level using the recommendations of AQEM manual. Taxonomic identification was based on specific identification keys (Godeanu, 2002).

For each sample site we analyzed the density of the individuals (N/m^2), the relative abundance (A%) the Shanonn-Wiener Diversity Index (H), the evenness (E), the frequency (F%) and the constancy (C) (Sîrbu & Benedek 2004).

Results

From the benthic samples we determined the invertebrate groups and species. We have identified a number of 8 invertebrate groups (Table 1) and 21 species. The number of species in the samples was between 11 and 15. In the sample site S3 we found the highest number of species (15). The highest density has *Dugesia lugubris* (Turbelariata), *Gammarus balcanicus* (Amphipoda) and *Rhabdiopteryx* (Plecoptera) in all three sample sites. The density of Ephemeropteran larvae was the highest from all benthic invertebrate groups (Fig 1).

The highest average abundance has *Gammarus balcanicus* (27.17) followed by *Dugesia lugubris* (23.99) and *Heptagenia sulphurea* (23.48).

The monthly dynamics of the benthic invertebrate groups in S1 shows that in February the number of the species was the highest, followed by September with 6 species (Table 2). The smallest number of species we found in December (4).

The Amphipoda are the most frequent, *Dugesia lugubris* was found in all the study period except September.

The Ephemeroptera larvae are present in each month

Table 1. The density (nr. of specimens/m^2) of the macrozoobenthic invertebrate species from the sample sites.

Taxonomic group	Species	S1	S2	S3
Turbelariata	*Dugesia lugubris*	45	39	63
Amphipoda	*Gammarus balcanicus*	55	17	72
Ephemeroptera	*Ecdyonurus dispar*	48	15	56
	Heptagenia sulphurea	39	23	37
	Habrophlebia fusca	0	17	1
	Oligoneuriela rhenana	0	0	1
	Siphlonurus aestivalis	0	0	1
	Polimytarcis sp.	1	0	0
	Total Ephemeroptera	88	55	96
Plecoptera	*Leuctra fusca*	8	10	6
	Perla marginata	1	0	0
	Rhabdiopteryx sp.	15	11	15
	Total Plecoptera	24	21	21
Trichoptera	*Limnephilus rhombicus*	1	1	1
	Hidropsyche pellucidula	14	3	4
	Berea pulata	2	0	0
	Rhyacophila fasciata	0	2	0
	Total Trichoptera	17	6	5
Coleoptera	*Gyrinus distinctus*	5	0	7
	Brychius elevatus	3	10	5
	Total Coleoptera	8	10	12
Diptera	*Chironomida larvae*	0	0	1
	Simulium columbaczense	0	0	1
	Total Diptera	0	0	2
Neuroptera	*Osmylus filophalus*	0	1	0
Total no of species		12	11	15
Diversity		1.98	2.12	1.89
Evenness		0.77	0.85	0.70

Table 2. Monthly dynamics of the invertebrate groups in sample site S1, the frecquency of occurance (f%) and constancy.

Taxonomic group	Species	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	f%	C
Turbelariata	*Dugesia lugubris*	_	13.79	21.05	33.33	25	27.5	83.33	Euconstant
Amphipoda	*Gammarus balcanicus*	76.59	6.89	10.52	4.16	11.53	13.79	100	Euconstant
Ephemeroptera	*Ecdyonurus dispar*	4.25	_	_	_	48.07	36.20	50	Constant
	Heptagenia sulphurea	_	24.13	69.23	45.83	_	1.72	66.66	Constant
	Polimytarcis sp.	2.12	_	_	_	_	_	16.66	Accidental
	Total Ephemeroptera	6.37	24.13	69.23	45.83	48.07	37.92	100	Euconstant
Plecoptera	*Leuctra fusca*	_	_	_	_	3.84	10.34	33.33	Accessory
	Perla marginata	_	_	5.26	_	_	_	16.66	Accidental
	Rhabdyopteryx sp.	_	_	15.78	8.33	11.53	6.89	66.66	Constant
	Total Plecoptera	0	0	21.04	8.33	15.37	17.23	66.66	Constant
Trichoptera	*Limnephilus rhombicus*	2.12	_	_	_	_	_	16.66	Accidental
	Hidropsyche pellucidula	_	48.27	_	_	_	_	16.66	Accidental
	Berea pulata	4.25	-	-	-	-	-	16.66	Accidental
	Total Trichoptera	6.37	48.27	0	0	0	0	33.33	Accessory
Coleoptera	*Gyrinus distinctus*	11.06	_	_	_	_	_	16.66	Accidental
	Brychius elevatus	_	3.44	_	_	_	3.44	33.33	Accessory
	Total Coleoptera	11.06	3.44	0	0	0	3.44	50	Constant
Total species		6	5	5	4	5	7	13	

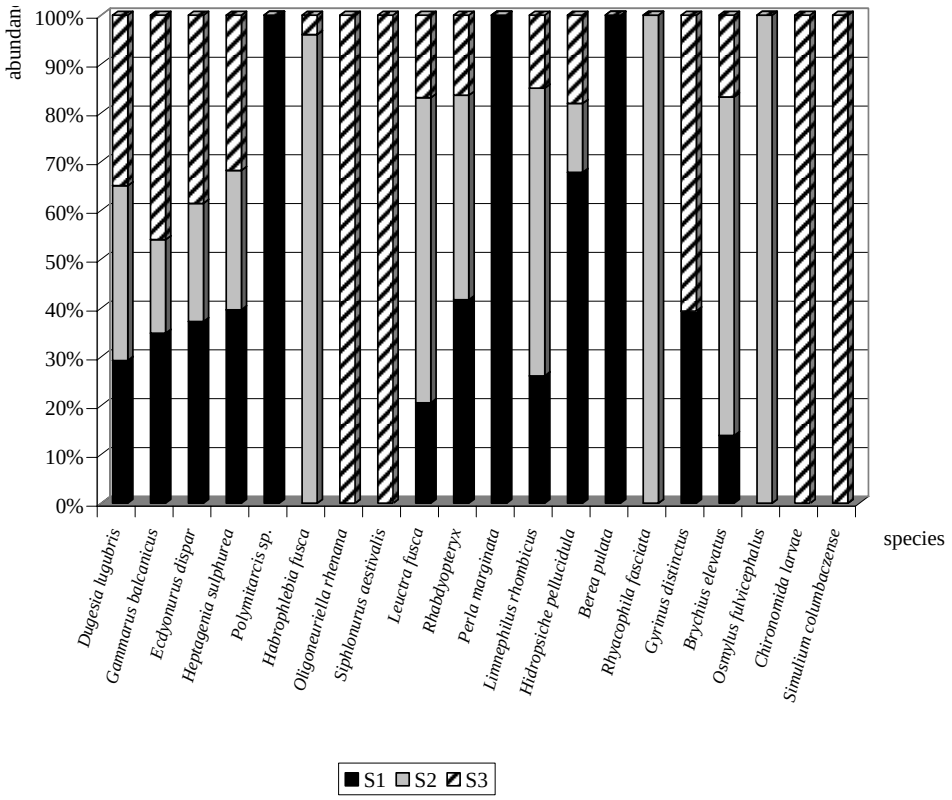

Figure 1. Average abundance of the species at the three sample sites.

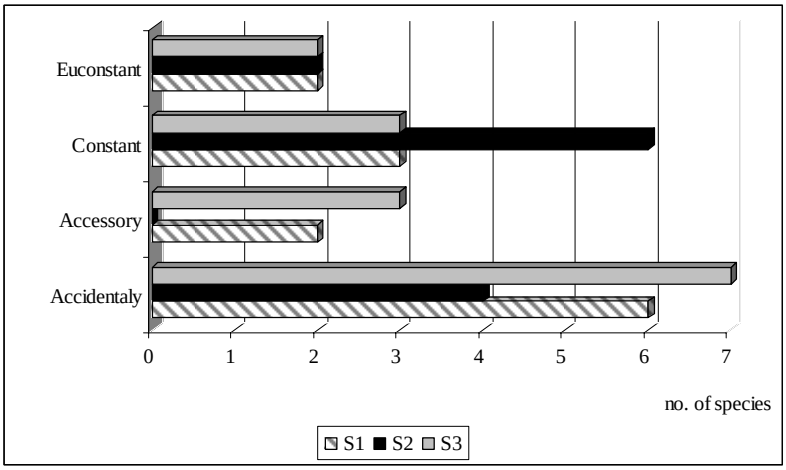

Figure 2. The constancy of the benthic invertebrates in the investigated sample sites.

but not the same species. The most frequent is *Heptagenia sulphurea* and it is also very abundant in November and December (69.23% in November), its frequency is 50 %. *Ecdyonurus dispar* has the maximum abundance in January (48.07 %) and February (36.20 %). It is present only in three months from the studied period. *Polymitarcis* larva was sampled only in September with a low abundance.

The Plecoptera larvae were present in a relatively small number of individuals except *Rhabdiopteryx*, which was abundant in November and January. The other two Plecoptera species were sampled in one or two months from the study period.

The Coleoptera species are present only accidentally with very low abundances.

The benthic community in S1 is not very constant, as we can see from Fig. 2 the most species are accessory or accidental. The greatest number of species we found in November (7) (Table 3) and the smallest number of species in September (4).

In sample site S2 are many are constant (*Dugesia lugubris* and *Gammarus balcanicus*) or euconstant (*Leuctra fusca,* and *Rhabdiopteryx*) species (Table 3). There are 4 Trichoptera species accidental or accessories in this sample site.

In S3 the highest number of species were found in December and January (7 species – Table 4), and in September we found only 2 species *Gammarus balcanicus* and *Gyrinus distinctus.*

The greatest abundance is reached by the *Gammarus bal-*

Table 3. Monthly dynamics of the invertebrate groups in sample site S2, the frequency of occurance (f%) and constancy.

Taxonomic group	Species	Sept	Oct	Nov	Dec	Jan	Feb	f%	C
Turbelariata	*Dugesia lugubris*	_	19.35	25	43.33	52.38	7.69	83.33	Euconstant
Amphipoda	*Gammarus balcanicus*	26.13	6.45	17.85	10	_	7.69	83.33	Euconstant
Ephemeroptera	*Ecdyonurus dispar*	_	_	_	_	_	57.69	16.66	Accidental
	Heptagenia sulphurea	26.13	41.95	_	33.33	_	_	50	Constant
	Habrophlebia fusca	42.10	_	28.57	_	4.76	_	50	Constant
	Total Ephemeroptera	68.23	41.95	28.57	33.33	4.76	57.69	100	Euconstant
Plecoptera	*Leuctra fusca*	5.26	_	7.14	_	19.04	11.53	66.66	Constant
	Rhabdyopteryx sp.	_	_	10.71	10	14.28	7.69	66.66	Constant
	Total Plecoptera	5.26	0	17.85	10	33.32	19.22	83.33	Euconstant
Trichoptera	*Limnephilus rhombicus*	_	_	_	_	4.76	_	16.66	Accidental
	Hidropsiche pellucidula	_	3.22	3.57	3.33	_	_	50	Constant
	Rhyacophila fasciata	_	6.45	_	_	_	_	16.66	Accidental
	Brychius elevatus	_	19.35	7.14	_	_	7.69	50	Constant
	TotalTrichoptera	0	29.02	10.71	3.33	4.76	7.69	83.33	Euconstant
Neuroptera	*Osmylus fulvicephalus*	_	_	_	_	4.76	_	16.66	Accidental
Total species		4	6	7	5	6	6	12	

Table 4. Monthly dynamics of the invertebrate groups in sample site S3, the frequency of occurance (f%) and constancy.

Taxonomic group	Species	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	f%	C
Turbelariata	*Dugesia lugubris*	_	10.34	40.62	45	27.17	20.83	83.33	Euconstant
Amphipoda	*Gammarus balcanicus*	82.92	20.68	15.62	_	27.17	16.66	83.33	Euconstant
Ephemeroptera	*Ecdyonurus dispar*	_	_	_	_	35.36	56.25	33.33	Accessory
	Heptagenia sulphurea	_	51.72	31.25	30	_	_	50	Constant
	Habrophlebia fusca	_	_	3.12	_	_	_	16.66	Accidental
	Oligoneuriella rhenana	_	_	_	2.5	_	_	16.66	Accidental
	Siphlonurus aestivalis	_	_	_	2.5	_	_	16.66	Accidental
	Total Ephemeroptera	0	51.72	34.37	35	35.36	56.25	83.33	Euconstant
Plecoptera	*Leuctra fusca*	_	3.44	_	_	6.09	2.08	50	Constant
	Rhabdyopteryx	_	_	9.37	_	7.31	_	33.33	Accessory
	Total Plecoptera	0	3.44	9.37	0	13.4	2.08	66.66	Constant
Trichoptera	*Limnephilus rhombicus*	_	_	_	_	1.21	_	16.66	Accidental
	Hidropsiche pellucidula	_	10.34	_	2.5	_	_	33.33	Accessory
	Total Trichoptera	0	10.34	0	2.5	1.21	0	50	Constant
Coleoptera	*Gyrinus distinctus*	17.03	_	_	_	_	_	16.66	Accidental
	Brychius elevatus	_	_	_	2.5	3.65	2.08	50	Constant
	Total Coleoptera	17.03	0	0	2.5	3.65	2.08	66.66	Constant
Diptera	*Chironomida larvae*	_	_	_	2.5	_	_	16.66	Accidental
	Simulium columbaczense	_	3.44	_	_	_	_	16.66	Accidental
	Total Diptera	0	3.44	0	2.5	0	0	33,33	Accessory
Total species		2	6	5	7	7	5	15	

canicus in September, followed by the Ephemeroptera larve which are the most abundant every month except September and *Dugesia lugubris* in December.

Species as: *Habrophlebia fusca, Oligoneuriella rhenana, Siphlkonurus aestivalis, Limnephilus rhombicus, Gyrinus distinctus* and *Simulium columbaczense* were found only in one month in the studied period, so they are accidental in the habitat.

In September we found only two species: *Gammarus balcanicus* and *Gyrinus distinctus*, the former with a very high abundance.

In October and February the most abundant are the Ephemeroptera larvae *Heptagenia sulphurea* (51.72%) and *Ecdyonurus dispar* (56.25%).

Limnephilus rombicus (1,25%) is the less abundant and less frequent in this sample site.

The diversity has very similar values between the three sample sites, the highest diversity is reached by S2.

Discussions

During our study we found that the benthic invertebrate community in this ecosystem is very alike in the three sample sites because the relative constant type of habitats, the lack of pollution and anthropic impact.

In the valley we have identified many Plecoptera larvae species which are indicator organisms for the good quality of the water; these species are adapted to high oxygen content in the water and high velocity of the current (Curtean-Bănăduc 2005, Korte 2010).

The Efemeroptera larvae species are well represented also, the majorities of them is specific to the mountainous river courses, and are adapted to low temperature waters (Petrovici & Tudorancea 2000).

The low organic content in the substratum determine a small number of species in the investigated sites. The biotope can't support by the scarce trophic base a richer bio-

cenosis (Adamek et al. 2010). The trophic chains in the ecosystem are few and short due to the small diversity.

The presence of the Plecoptera larvae from three species *(Leuctra fusca, Perla marginata, Rabdiopteryx sp*) shows the high oxygen content in the water, because these three species are strictly adapted to clean waters with a high dissolved oxygen content (Celik 2002, Curtean-Bănăduc 2005, Petrovici & Tudorancea 2000).

The low temperature of the water during the whole year ensures the existence of the exacting species over the year.

Some species were found only in one sample site: *Polimytarcis sp., Perla marginata, Berea pulata* in S1. The first two species are Plecoptera larvae which are very exacting to the environmental conditions; they prefer clean waters with high speed, high oxygen content and low organic content. In S2 we found *Rhyacophila fasciata* and *Osmylus filophalus* two species which are relatively rare in the region. In S3 we found *Oligoneuriela rhenana, Siphlonurus aestivalis,* Ephemeroptera larvae which are not as exacting to the environmental factors as the other species, so they can support greater environmental variations(Petrovici & Tudorancea 2000). Also we found Diptera larvae *Chironomida larvae, Simulium columbaczense* which are common in the lower sector of the streams and rivers and are characteristic to water rich in organic content.

The Amphipoda are the most frequent, we found *Gammarus balcanicus* in each month. This species live in the entire life cycle in the water, so it's presence around all year is expectable (Duran 2007). *Dugesia lugubris* was found in all the study period except September. This absence is due probably to the fact that the species is maybe not very frequent in September and it wasn't sampled (Ilut et al. 2006).

The Ephemeroptera larvae are present in each month but not the same species. The most frequent is *Heptagenia sulphurea* and it is also very abundant in November and December (69.23% in November), its frequency is 50 %. *Ecdyonurus dispar* has the maximum abundance in January (48.07 %) and February (36.20 %). It is present only in three months from the studied period. *Polymitarcis* larvae were sampled only in September with a low abundance, so this species is rare in this sample site.

The Plecoptera larvae were present in a relatively small number of individuals except *Rhabdiopteryx*. They are present in a mall number of species in each sample site and they are not very abundant. This fact can be due to the low capacity of support of the habitat and also to their great mobility which permit the escaping from sampling.

The Coleoptera species are present only accidentally with very low abundances. The Coleoptera species are not typically benthic because they can swim in the body of the water.

In streams which are not very deep they can often rest on the substratum, especially if they do not have submerged vegetation. The benthic community in S1 is not very constant, the most species are accessory or accidental. This situation is due to the fact that the sample site is near the spring, the water is not very deep and broad and the trophic base is scarce (Krno, 2010).

In S2 sample site *Dugesia lugubris* and *Gammarus balcanicus* are also euconstant (*Dugesia lugubris* wasn't found in September and *Gammarus balcanicus* in January). The abundance of these two species is relatively high in each month except february, when are less abundant. *Ecdyonurus dispar* was found only in one month – February, but with a very high abundance (57, 69%) *Heptagenia sulphurea* is accessory; it was found in the half of the total number of samples from S2 and has high abundances in the community. *Habrophlebia fusca* is also present in only 3 months with high abundances. Except December and January when they are less abundant, the Ephemeroptera larvae are the most abundant in the benthic community.

In this sample site we found 2 Plecoptera species *Leuctra fusca,* and *Rhabdiopteryx* which are constant with a frequency of 50%. The Plecoptera species are lacking in October. There are 4 Trichoptera species *Limnephilus rhombicus*, *Rhyacophila fasciata, Hidropsiche pellucidula, Brychius elevatus* the first two are accidental and the last two accessories in this sample site. They lack in September and have low abundances in the rest of the months. So it seems that the environmental conditions are not very favorable for this group of benthic invertebrates (Robert & Curtean-Bănăduc 2005)

In this sample site we found accidentally a Neuroptera larva *Osmylus fulvicephalus* in January.

From the point of view of constancy the benthic community in S2 is different from S1, the most species are constant or euconstant (Table 3), which shows a more stable community because the decrease of the water speed and a better trophic base for the benthic invertebrates.

In S3 the highest number of species were found in December and January (7 species – Table 4), and in September we found only 2 species *Gammarus balcanicus* and *Gyrinus distinctus.*

The greatest abundance is reached by the *Gammarus balcanicus* in September, followed by the Ephemeroptera larve which are the most abundant every month except September and *Dugesia lugubris* in December.

The Plecoptera and Trichoptera larvae are less abundant at this sample site than in S2, they usually are found rarely in the lower sectors of the rivers (Curtean-Bănăduc et al. 2006, Chakona et al. 2009). Also are well represented the Coleoptera and Diptera larvae. These two groups are more often in the lower sector of the streams and rivers.

Species as: *Habrophlebia fusca, Oligoneuriella rhenana, Siphlkonurus aestivalis limnephilus Rhombicus, Gyrinus distinctus and Simulium Columbaczense* were found only in one month in the studied period, so they are accidental in the habitat.

In September we found only two species: *Gammarus balcanicus* and *Gyrinus distinctus*, the former with a very high abundance.

In October and February the most abundant are the Ephemeroptera larvae *Heptagenia sulphurea* (51.72%) and *Ecdyonurus dispar* (56.25%).

Limnephilus rombicus (1.25%) is the less abundant and less frequent in this sample site.

The benthic community in streams is made up especially from insect larvae (Ribeiro & Uieda 2005) accessory and accidental species, the number of constant and euconstant species is lower. This fact suggests that the community is not very constant at this sample site (Fig. 2)

Because of the low content of the organic content in the sediments the diversity and evenness are low because the

trophic base can't support a very diverse benthic community in the investigated sample sites.

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