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Benthic Macroinvertebrate Communities in Agriculturally Impaired Streams

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This work presents research into the taxonomic composition of macroinvertebrate communities in streams that are under the influence of agricultural pollution A total of 67 macroinvertebrate taxa (including 61 identified species) belonging to 40 families have been identified in the explored streams. The greatest species richness is recorded for the Trichoptera (18 species/1 taxa) and Mollusca (12 species). The molluscs *Gyraulus albus,* amphipods *Gammarus pulex,* caddisflies *Hydropsyche pellucidula* and oligochaetes are detected in all examined streams. There, the number of total benthic macroinvertebrate taxa is highly variable, ranging from 16 to 40. Results show that the examined streams depending on the benthic macroinvertebrate taxonomic composition and predominance of seperate macroinvertebrate groups undergo different pollution. Intolerant to pollution taxa such as Plecoptera, which are the most sensitive to pollution insects, have been found only in 5 of 12 examined streams and in low abundances. The richness and diversity of macrozoobenthos in some streams appear to respond to the water quality deterioration. The present study has found out that in the stream where the total macroinvertebrate taxa, EPT taxa richness are the lowest and a relative abundance of gatherers is the highest, the values of NH_4-N, NO_3-N, total N, PO_4-P and total P in the stream water are the highest, too.

Key words: *Streams, macroinvertebrates species richness, pollution.*

1. Introduction

Rivers in agricultural and urban landscapes suffer from considerable inputs of organic and inorganic compounds. Human-induced changes in streams may affect physical structure of the streambed, concentrations of dissolved chemicals in water, living organisms, and ecosystem functioning. The structure of biotic communities and ecosystem function do not always equally respond to the anthropogenic stress (Azrina et al. 2006).

Freshwater macroinvertebrate species vary in sensitivity to organic pollution and, thus, their relative abundances have been used to make inferences about pollution loads. In natural pristine rivers, high diversity and richness of species could be found, however a high impact due to human activities caused many changes to the assemblages and biodiversity of the river fauna (Nedeau et al. 2003, Miserendino et al. 2008).

Macroinvertebrates are good indicators of environmental variation because of easy samples collections and taxa identification, and their relatively long life cycle, limited migration ability, and different sensitivity to the different environment (Barbour et al. 1999, Liu et al. 2004). Aquatic macroinvertebrates have been widely used as indicators of water quality because they have several attributes not possessed by other water quality indicators (Rosenberg&Resh 1993).

Macroinvertebrates are ideal indicator organisms also as various taxa are associated with different levels of water quality. The analysis of macroinvertebrate assemblages is time and cost efficient compared to the chemical and physical assessments of water quality (Bode 1996).

Data on dynamics of the macroinvertebrates species composition in streams of Lithuania are scarce. Two-year data on seasonal dynamics of macroinvertebrates in the coldwater (Pliūraitė 2001) and mixed thermal regime rivers in Lithuania (Pliūraitė 2002) have shown that the taxonomic composition of macroinvertebrate depends on the season and the type of the river substratum. According to Višinskienė (2005), diversity and number of species of caddisfly larvae in small Lithuanian rivers depend on different environmental factors of their habitats and seasonal changes in zoobenthos.

Detailed seasonal studies of macroinvertebrate abundance and biomass were carried out in the stone substratum of the medium-sized coldwater Lithuanian rivers (Pliūraitė 2007). The results show that seasonal trends in the macroinvertebrate community composition are related to the changes in the environmental characteristics of the river, especially water temperature and discharge.

The objective of this study has been to present a comparative account of physicochemical parameters and species diversity of macrobenthic invertebrates among 12 streams that are under the influence of agricultural pollution.

2. Materials and methods

Site description

Characteristics of the examined streams are presented in Table 1 (Gailiušis et al. 2001). All these streams are medium-sized (Council.... 1997). Agriculture was an important land use category within the streams examined. Consequently, many streams received substantial agricultural input.

During the research five water parameters (temperature, dissolved oxygen, pH, and conductivity) were studied in the streams.

Sampling methods

Research was carried out in 12 streams in May, 2008. Benthic organisms were studied in May because of their greatest diversity at that time.

Table 1. Characteristics of the examined streams (Gailiušis et al. 2001)

N	Streams basin	Streams	Area of stream basin, km^2	Length, km	Data on Localities
1.	Lielupės	Daugyvenė	487.8	61.1	55⁰16´04"N, 23⁰95´77"E
2.		Kulpė	263.3	30.8	56⁰02´37"N, 23⁰43´12"E
3.		Mažupė	162.3	37.5	55⁰98´07"N, 24⁰10´53"E
4.		Orija	117.3	30.5	55⁰99´65"N, 24⁰47´75"E
5.		Pyvesa	501.6	92.6	56⁰02´70"N, 24⁰42´70"E
6.		Sidabra	185.1	45.6	56⁰33´63"N, 23⁰60´77"E
7.		Šiladis	123.1	28.3	56⁰07´08"N, 23⁰65´52"E
8.		Tatula	453.4	64.7	56⁰12´64"N, 24⁰46´30"E
9.	Nevėžio	Liaudė	183.5	39.2	55⁰50´82"N, 23⁰95´68"E
10.		Linkava	163.4	36.8	55⁰48´55"N, 24⁰12´130E
11.		Obelis	673.8	53.3	55⁰28´43"N, 24⁰25´85"E
12.		Upytė	252.0	39.5	55⁰58´60"N, 24⁰17´60"E

Samples of macrozoobenthos have been collected from the stone substratum as this type of substratum contains the highest diversity of macroinvertebrate species. The samples were dredged from four 0.1 m² areas by the kick-sampling method (national Board...1993). The samples were fixed in formalin solution (4%). A total of 48 samples were collected and analyzed in the laboratory.

We have analyzed taxa richness which measures the overall variety of the macroinvertebrate assemblage and Ephemeroptera, Plecoptera and Trichoptera (EPT) richness. The systematic groups of Oligochaeta were not determined.

We also calculated the Shannon-Weaver diversity index (H') (Shannon&Weaver 1949). Similarities in the abundance of taxa among invertebrate samples collected from the stone substratum of streams were calculated using a Bray-Curtis similarity measure (Bray&Curtis 1957).

Five macroinvertebrate functional feeding groups (gatherers, shredders, filters, scrapers and predators) were assigned to the recorded taxa in accordance with the standard methods (An introduction...1984, Fauna Aquatica...1995, Wright et al. 2002).

Statistical analysis

Bray-Curtis similarity index calculations were done with the CLUSTER program of the PRIMER 5.2.3 package. A standard statistical approach was used for data comparison

Pearson's correlation coefficient (r) was applied to analyze relationships among the total number of macroinvertebrate taxa, H', and separate macroinvertebrate species and water quality values. To determine differences in the abundance of macroinvertebrates taxa among streams General Linear Model ANOVA was used. All species data were log (1+x)] transformed prior to the analysis.

Calculations were done with Statistica for Windows's version 6.0 (StatSoft, 2001).

3. Results

3.1. Environmental and chemical variables

Conductivity examined across 12 streams was relatively high, ranging within the limits from 753 to 2740µS cm^{-1} (Table 2). The water temperature ranged from 10.1 to 15.7^{0}C, while the dissolved oxygen concentration fluctuated in a wide range from 7.35 to 12.78 mg l^{-1}. pH in examined streams changed from 6.80 to 8.48.

The values of chemical variables in the examined streams are presented in Table 3. In all streams at least one chemical variable exceeded the highest permissible concentration.

3.2. Composition of the macroinvertebrate community

A total of 67 macroinvertebrate taxa (including 61 identified species) belonging to 40 families were identified in the examined streams (Apendix. Table). The greatest species richness was recorded for the Trichoptera (18 species/1 taxa) and Mollusca (12 species). They were followed by the Ephemeroptera (8 species) and Chironomidae (8 species). The other identified groups (Spongia, Nematomorpha, Oligochaeta, Hirudinea, Amphipoda, Isopoda, Odonata, Plecoptera, Heteroptera, Coleoptera, other Diptera) were represented by a small number of taxa (Appendix. Table). The molluscs *Gyraulus albus*, amphipods *Gammarus pulex*, caddisflies *Hydropsyche pellucidula* and oligochaetes were detected in all examined streams. Caddisflies *Hydropsyche angustipennis* were detected in 91.7 %, *Anabolia soror* 91.7%, mayflies *Cloneon dipterum* 91.7%, *Caenis macrura* 83.3%, molluscs *Sphaerium corneum* 83.3%, *Bithynia tentaculata* 75.0%, leeches *Erpobdella octoculata* (83.3%), chironomids *Cricotopus algarum* 91.7%, beetles larvae *Limnius volckmari* 83.3%, *Elmis aenea* 75% of examined streams. 14 species of macroinvertebrate were found only in one stream, 7 species - in two streams.

Table 2. Water parameters of examined streams

Streams	Water temperature, ^{0}C	Dissolved oxygen, mg/l	pH	Conductivity µS/cm
Daugyvenė	11.8	8.42	7.83	781
Kulpė	12.3	11.08	8.48	1058
Mažupė	13.5	9.98	8.16	838
Orija	15.7	8.93	8.16	2740
Pyvesa	14.6	9.49	8.00	872
Sidabra	12.3	11.08	8.48	1058
Šiladis	10.1	8.34	8.35	904
Tatula	13.3	12.78	8.08	1802
Liaudė	12.2	7.35	7.66	759
Linkava	15.1	7.50	8.01	840
Obelis	14.9	7.78	6.80	753
Upytė	15.1	7.96	7.28	803

Table 3. The values of chemical variables in the examined stream (Data from the Environmental Protection Agency of Lithuania)

Stream	BOD mg l^{-1}	NH_4-N mg l^{-1}	NO_3-N mg l^{-1}	N total mg l^{-1}	PO_4-P mg l^{-1}	P total mg l^{-1}
Daugyvenė	1.9	0.03	**6.25**	**7.68**	0.04	0.08
Kulpė	**4.0**	0.06	1.5	2.2	**0.12**	**0.21**
Mažupė	**4.9**	0.00	0.30	0.92	0.06	0.07
Orija	**3.4**	0.00	0.24	1.20	0.01	0.01
Pyvesa	**1.7**	0.06	1.72	2.36	**0.099**	**0.118**
Sidabra	**6.0**	**11.21**	**3.13**	**16.17**	**1.92**	**2.27**
Šiladis	**3.1**	0.09	1.80	**2.90**	**0.25**	**0.28**
Tatula	1.7	**0.27**	**3.72**	**5.00**	**0.09**	**0.10**
Liaudė	**3.1**	0.06	1.20	2.10	0.05	0.06
Linkava	2.0	0.07	**5.30**	**7.40**	0.02	0.03
Obelis	**4.4**	0.06	1.6	**3.4**	**0.084**	**0.17**
Upytė	**3.0**	0.06	**4.1**	**4.3**	0	0

(bold type marks the values that exceed the highest permissible concentration)

The number of total benthic macroinvertebrate taxa was highly variable across the examined streams ranging from 16 (Sidabra) to 40 (Pyvesa) (Table 4).

The numbers of EPT taxa were the highest in four examined streams and the lowest in the Sidabra stream (Table 4).

The Shannon biodiversity index fluctuated from 2.2 to 4.07. It was obtained that in the Sidabra stream with its lowest total macroinvertebrate taxa number the Shannon biodiversity index was low too (Table 4).

Results of the percent similarity analysis for individual macroinvertebrate taxa classified the benthic invertebrate samplings of 12 streams into VIII groups (to show the pattern of species distribution) (Fig. 1). Group I includes macroinvertebrate samples collected in the Sidabra and group II – in the Upyte, streams. Macroinvertebrate of these groups were dominated by *Asellus aquaticus* and *Pisidium supinum*, *Crisotopus algarum* , respectively (Table 5). The abundance of isopod *Asellus aquaticus* in the Sidabra stream was significantly greater compared to the other streams (ANOVA: F=7.52, p= 0.014). The abundance of isopod *Asellus aquaticus* was positively correlated with NH_4 (r=0.99, p=0.000001), total N (r=0.84 p=0.001), PO_4 (r=0.99, p=0.000001), total P (r=0.99, p=0.000001) values. Samples of benthic invertebrate collected in the Šiladis and Kulpė streams comprised group III. The macroinvertebrate of this group was dominated by mayflies *Caenis macrura* and oligochaetes. The Mažupės stream with dominating species of caddisflies *H. angustipennis* forms IV group. Samples of macroinvertebrate collected in the Liaudė and Daugyvenė streams comprised group V.

Table 4. Total number of macroinvertebrate taxa (SR), EPT (Ephemeroptera,Plecoptera Trichoptera) richness and Shannon biodiversity index (H')

Streams	SR	EPT	H'
Daugyvenė	32	12	3.88
Kulpė	24	8	3.68
Mažupė	26	10	3.67
Orija	28	9	3.28
Pyvesa	40	16	2.96
Sidabra	16	6	2.20
Šiladis	26	11	3.72
Tatula	35	15	3.97
Liaudė	24	9	3.55
Linkava	37	17	3.78
Obelis	26	14	3.86
Upytė	28	11	4.07

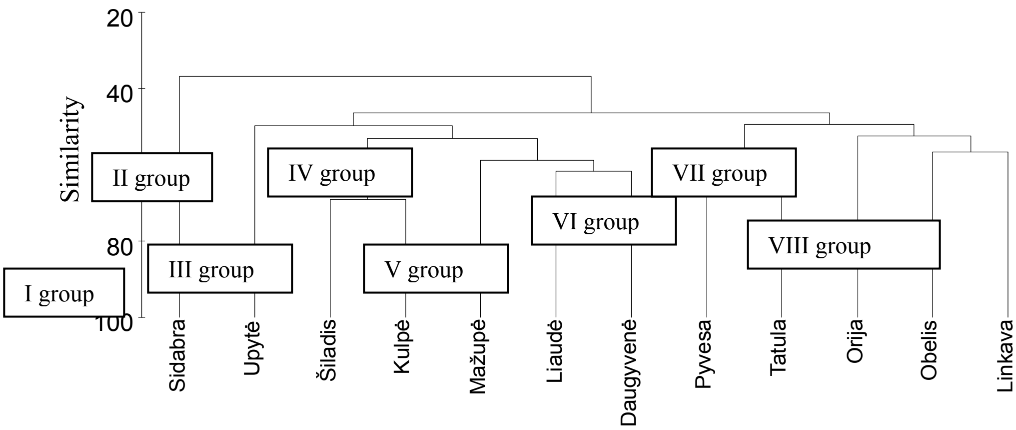

Fig. 1. Cluster diagram by group-average clustering based on the Bray-Curtis similarity index using the abundance of species

Group VI includes macroinvertebrate samples collected in the Pyvesa and Tatula. Caddisflies *Cheumatopsyche lepida* and molluscs *Theodoxus fluviatilis* were found only in this group.

Macroinvertebrate samples collected in the Orija stream made up group VII. In this group the abundance of the caddisflies *Hydropsyche angustipennis*, *H. pellucidula* was the highest compared to the other groups.

The abundance of caddisflies *Hydropsyche anngustipenis* in the Orija stream was significantly greater compared to the other streams (ANOVA: F=11.69, p= 0.014) and was positively correlated with conductivity (r=0.86, p=0.001), which in the Orija stream was the greatest, too.

Macroinvertebrate samples collected in the Obelis and Linkava streams with dominating species of chironomids *Cricotopus algarum* comprised group VIII.

Functional feeding groups

Our results suggest that the relative abundance of gatherers in the Kulpė and Sidabra streams was the greatest in comparison with the other examined streams (Table 6). Gatherers in the Sidabra stream were represented by isopods *Asellus aquaticus* and in the Kulpė stream by oligochaetes and mayflies *Caenis macrura*. The greatest relative abundance of filterers was recorded in the Orija stream in which the relative abundance of gatherers was the lowest. Filterers in this stream were represented by the species of caddisflies belonging to the family Hydropsychidae. A relative abundance of scrapers in the Pyvesa stream was the highest among the examined streams. Scrapers in the Pyvesa stream were represented by caddisflies *Hydroptila* sp.

Table 5. Occurrence of the most typical macrozoobenthos taxa in the stone substratum of the medium-sized streams

Streams	Dominating species
Daugyvenė	*Cloneon dipterum* 17.0%, Oligochaeta 8.5%, *Rheotanytarsus exiguus* 9.5%, *Gyraulus albus* 6.2%, *Gammarus pulex* 5.9%
Kulpė	*Caenis macrura* 19.3%; Oligochaeta 17.9%
Mažupė	*Hydropsyche angustipennis* 30.1%, *Cloneon dipterum* 12.2%
Orija	*Hydropsyche angustipennis* 35.1%, *H.pellucidula* 27.3%
Pyvesa	*Hydroptila* spp. 24.9%, *Gyraulus albus* 11.8%, *Elmis aenea* 9.8%
Sidabra	*Asellus aquaticus* 58.0%
Šiladis	Oligochaeta 16.3%; *Caenis macrura* 16.3%, *Asellus aquaticus* 7.0%
Tatula	*Cheumatopsyche lepida* 19,3%; *Hydroptila* spp. 13,4%
Liaudė	*Cricotopus algarum* 15.8%, *Hydropsyche.pellucidula* 15.3%, Oligochaeta 15.3%, Anabolia soror 12.2%
Linkava	*Cricotopus algarum* 24.4%, Elmis aenea 8.3%
Obelis	*Cricotopus algarum* 24.9%, *Gammarus pulex* 10.0%;
Upytė	*Pisidium supinum* 13.3%, *Cricotopus algarum* 12.8%

Table 6. Abundance (%) of macroinvertebrates functional feeding groups in the examined streams

Streams	Gatherers	Predators	Scrapers	Shredders	Filterers	Other
Daugyvenė	53.6	3.8	11.0	9.2	20.2	2.2
Kulpė	75.6	8.6	5.8	6.0	4.0	
Liaudė	49.0	2.0	3.6	18.6	26.8	
Linkava	47.3	8.9	25.0	10.2	8.2	0.4
Mažupė	40.3	6.0	4.0	3.2	46.5	
Obelis	68.0	2.5	11.6	7.1	10.8	
Orija	21.1	1.5	10.4	0.3	66.3	0.4
Pyvesa	22.4	4.3	55.6	7.2	4.3	6.2
Sidabra	75.8	8.9	1.0	6.8	7.5	
Šiladis	51.8	3.5	22.9	16.8	4.4	1.5
Tatula	30.0	2.9	30.1	3.6	27.1	6.3
Upytė	49.1	6.5	25.5		18.9	

4. Discussion

Benthic macroinvertebrates are known to be sensitive to habitat characteristics and responsive to the water quality (Rosenberg&Resh 1993). For these reasons, benthic macroinvertebrates have been used worldwide as biological changes indicators for assessment of water quality in rivers and streams (Barbour et al. 1999).

Lenat (1984) showed that streams receiving the agricultural run off had greater suspended solids and sedimentation, increased particulate organic matter, elevated nutrient concentrations, and lower abundance of Ephemeroptera, Plecoptera and Trichoptera.

Data obtained in this work show that according to the benthic macroinvertebrate taxonomic composition and predominance of separate macroinvertebrate species the examined streams undergo different pollution. The observed differences among the examined streams were probably associated not only with agricultural activities but with pollution from the town sewage, too. The richness, diversity of macrozoobenthos in streams appeared to respond to the water quality deterioration (Table 3, 4). A lower species biodiversity often signified the environmental stress due to human activities.

In this study it has been determined that the total macroinvertebrate taxa and EPT taxa richness were the lowest in the Sidabra (6) stream. The values of NH_4-N, NO_3-N, total N, PO_4-P and total P were also the highest in the Sidabra stream. The latter is polluted not only from agriculture but also from the town sewage. Macroinvertebrate community of the Sidabra stream was dominated by isopod *Asellus aquaticus* (58.0%). According to Graca et al (1994) the European *Gammarus pulex* L. is replaced by isopod *Asellus aquaticus* L. as dominant species in the situations of organic pollution. As proved scientifically, good and poor water quality can be perfectly indicated by numerous occurrences of *Gammarus pulex* and *Asellus aquaticus,* respectively (Jurajda et al. 2007).

In the Kulpe stream, EPT taxa richness was higher in comparison with the Sidabra stream and there dominated mayflies *Caenis macrura* and Oligochaeta. An increase in caenid mayflies in agriculturally impacted streams has been explained by their adaptability to fine substrata and slow currents, removal of riparian vegetation may have benefited this taxon (Dudgeon 1999, Iwata et al. 2003). Kasangaki et al. (2008) suggest that mayflies (Caenidae, Trichorythiidae, Oligoneuridae) are the best bioindicators of agriculturally impacted sites. The order Oligochaeta also has a high tolerance to a variety of stresses and their presence in high abundances is a good indicator of pollution (Barbour et al. 1996). The streams Šiladis and Liaudė are dominated by Oligochaeta, too.

Intolerant to pollution taxa such as Plecoptera, which are the most sensitive to pollution insects (Hawkes 1998, Galdean et al. 2000), were found in only 5 (Linkava, Pyvesa, Tatula, Obelis, Orija) of 12 examined streams and in low abundances. As shown in the earlier research stoneflies are abundant in clean cold-water Lithuanian streams (Pliūraitė 2008).

According to Maul et al. (2004), in streams with the lowest total phosphorus concentration the greatest abundance of mayflies and caddisflies is found. The data of this study conform to the above mentioned results. The Orija and Mažupė streams with the lowest values of total phosphorus have the greatest abundance of caddisflies. Caddisfly *Hydropsyche* dominates in the Orijos, Mažupės streams, while in cold-water Lithuania streams their abundance is low (Pliūraitė 2006). It has been also determined that in cold-water streams caddisflies *Hydropsyche pellucidula* prevail (Višinskienė 2005, Pliūraitė 2007, 2008, Bernotienė&Višinskienė 2008). The researches show that not all genera of caddisflies are intolerant to pollution. The caddisflies *Cheumatopsyche, Hydropsyche* have been found in organically polluted waters (Whiles&Dodds 2002). An increase in conductivity could markedly reflect macroinvertebrate standing stocks in stream ecosystems (Koetsier et al. 1996). In our study *H. angustipennis* exhibited a significantly positive correlation with the values of conductivity. It was concluded that in cold-water streams the abundance of caddisflies *Hydropsyche* was associated with conductivity (Pliūraitė 2008). According to the erlier obtained data caddisflies *Rhyacophila nubila* prevail in cold-water Lithuania streams (Pliūraitė 2008). In this study caddisflies *Rhyacophila nubila* have been found only in two streams (Linkava and Tatula).

It is determined that in clean Lithuanian rivers mayflies *Baetis rhodani, Serratella ignita* (Pliūraitė 2007, 2008) predominate, while in the examined streams mayflies *Caenis macrura* do. According to Bode (1988), the cold-water streams were dominated by sensitive stonefly, caddisfly, mayfly taxa, while the warmer streams were dominated by more tolerant snails, leaches, isopods, dragonflies.

High densities of *Chironomus* larvae have been regarded as excellent bioindicators of poor quality waters (Hooper et al. 2003) in which an increase in its density in response to organic enrichment by antropic actions frequently eliminates all other Chironomidae genera (Marques&Barbosa 2001). Chironomid *Cricotopus algarum* predominate in the Liaudė, Linkava, Upytė streams and their predominance show that these streams suffer from pollution.

Kerans & Karr (1994) hypothesized that with increasing human impacts the proportions of gatherers and filterers would increase and the proportions of scrapers, shredders and predators would decrease. The results obtained in this research agree with the above mentioned data. The Kulpė and Sidabra streams have the highest proportions of gatherers and the Orija, Mažupė - of filterers as compared to the other streams. A relative abundance of collectors-gatherers provides an indication of organic enrichment (Plafkin et al. 1989). A relative abundance of scrapers is the highest in the Pyvesa and the lowest in the Sidabra streams. Specialized feeders such as scrapers or shredders are regarded as more sensitive, while generalists as collectors or filter feeders are more tolerant to impairment, able to use a wider range of available food materials (Barbour et al. 1996). According to Oberböck et al. (2004) shredders show a reliable response to organic pollution declining with increasing pollution. As determined by Ormerod (2002) predators are susceptible to human disturbance because their trophic position causes them to be affected by biomagnified pollutants and disturbances that affect prey populations.

5. Conclusions

1. A total of 67 macroinvertebrate taxa (including 61 identified species) belonging to 40 families were identified in the examined streams. The greatest species richness was recorded for the Trichoptera (18 species/1 taxa) and Mollusca (12 species). The molluscs *Gyraulus albus,* amphipods *Gammarus pulex,* caddisflies *Hydropsyche pellucidula* and oligochaetes were detected in all examined streams.
2. Intolerant to pollution taxa such as Plecoptera, which are the most sensitive to pollution insects were found in low abundances only in 5 of 12 examined streams.
3. The examined streams undergo different pollution levels depending on the benthic macroinvertebrate taxonomic composition and predominance of separate macroinvertebrate groups.

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Appendix. Table. Distribution of macroinvertebrate taxa in 12 examined streams

Order/Family/ Subfamily	Taxon	Mažupė	Orija	Upytė	Liaudė	Obelis	Linkava	Pyvesa	Šiladis	Tatula	Daugyvenė	Kulpė	Sidabra	Frequently %
Spongia														
Spongilidae	*Spongilla lacustris* (Linnaeus, 1758)		+	+			+			+				33.3
Nematomorpha														
Gordiidae	*Gordius aquaticus* Linnaeus, 1758		+						+		+	+		33.3
Oligochaeta undet		+	+	+	+	+	+	+	+	+	+	+	+	100
Hirudinea														
Erpobdellidae	*Erpobdella octoculata* (Linnaeus, 1758)	+		+	+	+	+	+	+	+	+		+	83.3
Glossiphonidae	*Glossiphonia complanata* (Linnaeus, 1758)							+	+	+				25.0
	Helobdella stagnalis (Linnaeus, 1758)												+	8.3
Mollusca														
Sphaeriidae	*Pisidium supinum* Schmidt, 1851	+		+	+			+	+	+	+			58.3
	Sphaerium corneum *(Linnaeus, 1758)*	+	+		+		+	+	+	+	+	+	+	83.3
	Sphaerium rivicola (Lamarck, 1818)	+		+	+		+				+			41.7
Planorbidae	*Ancylus fluviatilis* O.F. Müller, 1774)					+	+	+						25.0
	Planorbarius corneus (Linnaeus, 1758)				+			+				+	+	33.3
	Gyraulus albus (O.F. Müller, 1774)	+	+	+	+	+	+	+	+	+	+	+	+	100
Bithynidae	*Bithynia tentaculata* (Linnaeus, 1758)	+	+	+	+		+	+	+	+	+			75.0
Lymnaeidae	*Radix auricularia* (Linnaeus, 1758)							+						8.3
	Radix pereger O.F. Müller, 1774						+				+			16.7
Physidae	*Physa fontinalis* (Linnaeus, 1758)					+		+						16.7
Valvatidae	*Vavata (Cincinna) piscinalis* (O.F. Müller, 1774)							+						8.3
Neritidae	*Theodoxus fluviatilis* (Linnaeus, 1758)							+			+			16.7
Isopoda	*Asellus aquaticus* (Linnaeus, 1758)	+	+	+	+			+	+	+	+	+	+	83.3
Amphipoda	*Gammarus pulex* (Linnaeus, 1758)	+	+	+	+	+	+	+	+	+	+	+	+	100
Odonata														
Gomphidae	*Gomphus vulgatissimus* (Linnaeus, 1758)		+					+				+		25.0
Calopterigida***e***	*Calopteryx splendens* (Harris, 1782)										+			8.3
Ephemeroptera														
Baetidae	*Baetis rhodani* (Pictet, 1843)					+	+	+			+			33.3
	Cloeon dipterum (Linnaeus, 1761)	+	+	+	+	+		+	+	+	+	+	+	91.7
	Procloeon bifidum (Bengtsson, 1912)	+	+		+	+	+			+		+		58.3
Caenidae	*Caenis macrura* Stephens, 1835		+	+		+	+	+	+	+	+	+	+	83.3
Heptageniidae	*Ecdyonurus dispar* (Curtis, 1834)						+							8.3
Ephemeridae	*Ephemera danica* O.F Müller, 1764			+						+				16.7
Ephemerellidae	*Serratella ignita* (Poda, 1761)		+			+	+	+	+	+	+	+		66.7
Leptophlebidae	*Habrophlebia fusca* (Curtis, 1834)	+		+		+	+						+	33.3
Plecoptera														
Leuctridae	*Leuctra* spp.		+					+		+				25.0
Perlodidae	*Isoperla grammatica* (Poda, 1761)					+	+							16.7
Heteroptera														
Aphelocheiridae	*Aphelocheirus aestivalis* (Fabricius, 1794)							+		+	+			25.0
Coleoptera larvae														
Elmidae	*Elmis aenea* (O.F. Müller, 1806)	+	+	+		+	+	+	+	+		+		75.0
	Limnius volckmari (Panzer, 1793)	+	+	+		+	+	+	+	+	+	+		83.3
Gyrinidae	*Orectochilus villosus* (O.F. Müller, 1776)		+				+	+		+				33.3
Trichoptera														
Hydropsychidae	*Cheumatopsyche lepida* (Pictet, 1834)							+		+				16.7
	Hydropsyche angustipennis (Curtis, 1834)	+	+		+	+	+	+	+	+	+	+	+	91.7
	Hydropsyche pellucidula (Curtis, 1834)	+	+	+	+	+	+	+	+	+	+	+	+	100
	Hydropsyche ornatula McLachlan, 1878	+	+		+		+		+	+	+			58.3
Hydroptilidae	*Hydroptila* spp.	+	+	+		+	+	+	+	+	+	+		83.3
	Ithytrichia lamellaris Eaton, 1873									+				8.3
Goeridae	*Silo pallipes* (Fabricius, 1781)			+										8.3
Lepidostomatidae	*Lepidostoma hirtum* (Fabricius, 1775)							+						8.3
Leptoceridae	*Leptocerus tineiformis* Curtis, 1834							+						8.3
Limnephilidae	*Anabolia soror* McLachlan, 1875	+		+	+	+	+	+	+	+	+	+	+	91.7

Order/Family/ Subfamily	Taxon	Mažupė	Orija	Upytė	Liaudė	Obelis	Linkava	Pyvesa	Šiladis	Tatula	Daugyvenė	Kulpė	Sidabra	Frequently %
	Grammotaulius nigropunctatus (Retzius, 1783)					+								8.3
	Potamophylax latipennis (Curtis, 1834)			+		+	+	+						33.3
	Limnephilus stigma Curtis, 1834	+		+		+	+		+		+			50.0
	Limnephilus flavicornis (Fabricius, 1787)	+							+		+			25.0
	Halesus digitatus (Schrank, 1781)				+									8.3
Mollannidae	*Molanna angustata* Curtis, 1834						+		+					16.7
Polycentropodidae	*Polycentropus flavomaculatus* (Pictet, 1834)			+				+		+	+			33.3
Rhyacophilidae	*Rhyacophila nubila* Zetterstedt, 1840						+	+		+				33.3
Sericostomatidae	*Sericostoma personatum* (Kirby&Spence, 1826)						+	+						16.7
Diptera														
Limoniidae	*Dicranota bimaculata* (Schummel, 1829)	+	+	+	+	+	+							50.0
Athericidae	*Atherix* spp.									+				8.3
Ceratopogonidae	*Bezzia* spp.							+	+	+	+	+		41.7
Simuliidae	*Simulium* spp.		+	+	+	+					+			41.7
Tabanidae	*Tabanus* spp.						+							8.3
Chironomidae														
Chironominae	*Cladotanytarsus mancus* (Walker, 1856)	+	+											16.7
	Glyptotendipes gripekoveni Kieffer, 1913		+											8.3
	Polypedilum scalaenum (Schrank, 1803)		+	+	+		+					+		41.7
	Rheotanytarsus exiguus (Johannsen, 1905)			+			+		+	+	+	+	+	58.3
Orthocladiinae	*Cricotopus algarum* (Kieffer, 1911)	+	+	+	+	+	+	+	+	+	+	+		91.7
	Eukiefferiella coerulescens (Kieffer, 1926)	+												8.3
	Orthocladius saxicola Kieffer, 1911		+			+	+	+		+		+		50.0
Tanypodinae	*Thienemannimyia lentiginosa* (Fries, 1823)	+	+	+			+	+		+	+	+	+	75.0

Bentoso bestubūrių bendrijos žemės ūkio veiklos veikiamose upėse

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Šio darbo tikslas – ištirti taksonominę makrozoobentoso bendrijų sudėtį žemės ūkio veiklos veikiamose upėse. Dvylikoje ištirtų upių nustatyta 67 makrozoobentoso taksonų (įskaitant nustatyta 61 rūšį) priklausančių 40 šeimų. Didžiausia rūšių įvairovė nustatyta tarp apsiuvų (18 rūšių) ir moliuskų (12 rūšių). Visose tirtose upėse rasta moliuskų *Gyraulus albus,* šoniplaukų *Gammarus pulex,* ankstyvių *Hydropsyche pellucidula* ir oligohetų. Nustatyta, kad makrozoobentoso taksonų ištirtose upėse rasta nuo 16 iki 40. Makrozoobentoso taksonominės sudėties ir atskirų grupių dominavimo upėse rezultatai rodo, kad ištirtos upės patiria nevienodą taršą. Jautrios taršai ankstyvės, kurios rastos tik 5 iš 12 ištirtų upių. Jų gausumas nedidelis. Nustatyta, kad bendras makrozoobentoso taksonų skaičius, įvairovė, atskirų makrozoobentoso rūšių gausumas koreliavo su vandens fizikiniais cheminiais rodikliais. Tyrimų rezultatai parodė, kad upėje, kurioje rasta mažiausiai makrozoobentoso taksonų ir EPT taksonų, nustatytas mažiausias Šenono indeksas, didžiausias mitybinės funkcinės grupės – rinkėjų santykinis gausumas, NH4-N, NO3-N, bendro N, PO4-P, bendro P reikšmės upėje taip pat didžiausios.