Ecological state of the lake during restoration measures using macro-invertebrates.

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INTRODUCTION

Restoration can be defined as “a complete structural and functional return to a pre-disturbance state” (Cairns, 1991). Pre-restoration monitoring is necessary to define the correct restoration project design and the desired state after restoration (Erwin, 1990). Long term post-restoration monitoring will determine when and to what degree the system has become self-maintaining and whether or not the restoration attempt was effective (Zedler and Weller, 1990). However, both pre- and post-restoration monitoring are seldom performed (Kusler and Kentula, 1990; National Research Council, 1992).

Physical, chemical and bacteriological measurements commonly form the basis of monitoring, because they provide complete spectrum of information for proper water management (Metcalfe, 1989). Aquatic organisms, such as benthic macroinvertebrates (Rosenberg and Resh, 1993; Metcalfe, 1989) can serve as bioindicators to integrate their total environment and their responses to complex sets of environmental conditions (Worf, 1980).

Benthic macroinvertebrates are key components of aquatic food webs that link organic matter and nutrient resources (e.g., leaf litter, algae and detritus) with higher trophic levels (Wallace. and Webster, 1999). These organisms have mostly sedentary habits (Cook, 1976) and are, therefore, representative of site specific ecological conditions. With the sensitive life stage (Hutchinson et al., 1998) and relatively long life span (Pratt and Coler, 1976), they have the ability to integrate the effects of short-term environmental variations. Besides, these assemblages are made up of many species among which there is a wide range of trophic levels and pollution tolerances (Cook, 1976, Pratt and Coler, 1976; France, 1990), therefore providing strong information for interpreting cumulative effects.

Studies on the potential use of benthic macroinvertebrates as bioindicators for river ecosystems have been widely reported in literatures (Rosenberg and Resh, 1993). Benthic macroinvertebrates, especially aquatic insects, have been traditionally used in the biomonitoring of stream and river ecosystems for various environmental stress types, such as organic pollution (Zelinka and Marvan, 1961), heavy metals (Winner et al., 1980), hydromorphological degradation (Friberg et al., 2009), nutrient enrichment (Johnson et al., 2006), acidification (Sandin and Johnson, 2000) and general stressors (Barbour et al., 1999). Indeed, the assemblages constitute the basis of most biomonitoring program currently in Europe and North America. Due to their relatively long life cycle and mobility, they can be good indicators of long-term (several years) effects and broad habitat conditions (Barbour et al., 1999).

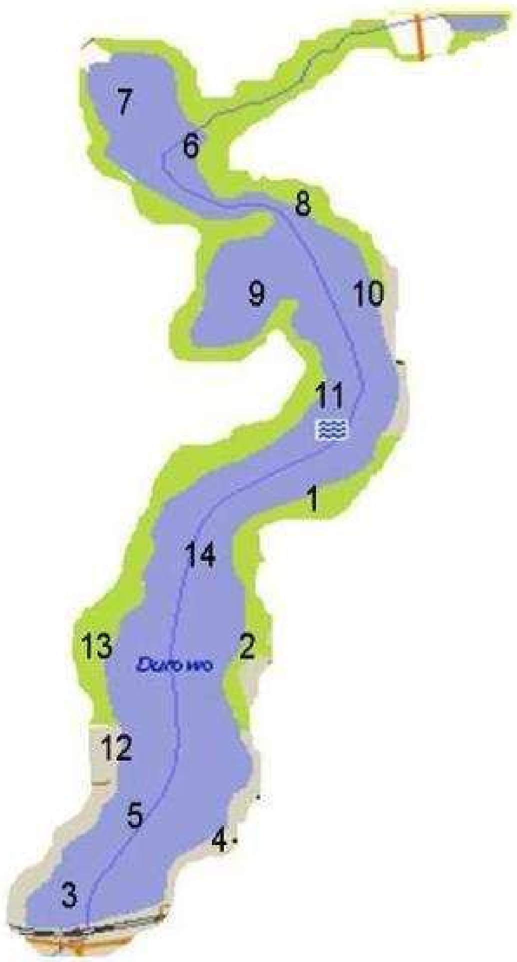
In view of this, current water quality auditing programmes in rivers use sampling of biological organisms, especially benthic component. Benthic communities in rivers are influenced by a large number of factors, with populations responding differentially in accordance with their specific ecological tolerances (Rosenberg and Resh, 1993). Benthic macroinvertebrates have also an important role in many ecosystem processes, including decomposition of allochthonous organic material, herbivory, and transport of energy from primary producers to secondary consumers (Sandin and Johnson, 2000). Because of their wide range of sensitivity to contaminants, benthic invertebrates are considered excellent indicators of river pollution (Rosenberg and Resh, 1993).

To better understand the state of ecological restoration in Lake Durowskie, we investigated macroinvertebrate density and richness in responses to restoration which aimed at determining habitat heterogeneity. Specifically, we asked whether habitat restoration increases macroinvertebrate density and richness and whether different ecological (e.g., land use, watershed size, recovery time) and methodological (e.g., restoration strategy, project size) variables influence the magnitude and direction of macroinvertebrate responses.

1. Methodology

Lake Durowskie is located in Wągrowiec, Poland. The lake is a part of chain of lakes connected by the river Struga Golaniecka. These rivers and lakes are at the exposure of nutrients and pollutant from agricultural lands and industrial areas.

In the study of macroinvertebrates on Lake Durowskie (Fig. 1) during July 4-9, 2011, samples were collected from 14 sites divided into 4 different categories, according to the similarity between other parameters. Four of the sampling sites are from the pelagial, two from each aerator, five from littoral zones near the forest and three from the littoral zones near urban area (Fig. 1). For each pelagial zone were taken 10 samples (grabs) and for each littoral zone were taken 17 samples (grabs).



Number of sites	Sites description
1	Littoral with reeds near forest cover
2	Littoral near urban area
3	Pelagial near dam
4	Littoral near urban area
5	Pelagial (aerator 1)
6	Littoral near Struga Golaniecka River
7	Pelagial
8	Littoral (bulrush near forest cover)
9	Pelagial
10	Pelagial (aerator 2)
11	Littoral with reeds
12	Littoral near urban area
13	Littoral with reeds near forest cover
14	Pelagial

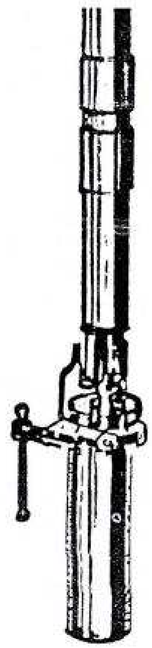
Fig. 1 – Distribution of sampling sites in Lake Durowskie

The lake has a surface of 143,7 ha, the depth can reach more than 14 meters and another important characteristic is the abrupt shore with fast growing steps.

In order to take the samples we used two different core samplers for sediments, including organisms.

The first core sampler called “Czapla” (Fig. 2), was used for the shallow waters near the littoral sites, with a depth no bigger than 2m. This sampler has a diameter of 5,7 cm and was used to take 17 samples from littoral zones.

The second sampler is called “Kajak” (Fig. 3) was used for deeper parts of the lake and 10 samples were taken from each of these sites.



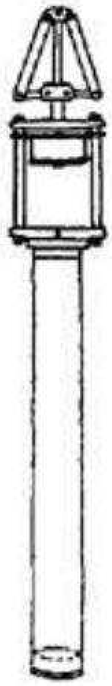


Fig. 2 – “Czapla” sampler **Fig. 3 – “Kajak” sampler**

After takeoff, the samples from each site were washed on a sieve and than stored into separate plastic boxes filled with water. The macroinvertebrates were identified to the species level using the key (Jan Igor Rybak, 2000; Adrzej Kołodziejczyk and Paweł Koperski, 2000; Chiriac and Udrescu, 1965). After this, every group of species was weighed.

In order to obtain the areal coverage of each species for 1 m^2 we multiplied by 23 the number of each species collected. In order to obtain the biomass of each species in mg/ m^2 we multiplied by 23 the mass of each species.

2.Data analysis

The Shannon-Wiener Index, Eveness and diversity indices were used to measure diversity for macroinvertebrates according to Shaw.(2003).

The Shannon-Wiener Index is calculated from the abundances of each species (abundance of the species/total abundances)

$$H' = -\sum_{i=1}^{S} p_i \log(p_i)$$

Where S is the total number of species and p_i is the frequency of the *i*th species (the probability that any given individual belongs to the species, hence p).

Equitability (E) or eveness index is calculated as:

$$E = \frac{H'}{H_{\max}} = \frac{-\sum p_i \ x \log(p)}{\log(S)}$$

where E is equitability (Eveness) and S is the number of species or lower taxonomic level used.

Margalef Index - a measure of species diversity

It is calculated from the total number of species presentand the abundance or total number of individuals. The higher the index the greater the diversity

Da = (S-1)/log to base e N

where

Da = Margalef Index

S = the number of species

N= the total number of individuals

The EPT Index is named for three orders of aquatic insects that are common in the benthic macroinvertebrate community: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies).

The EPT Index is based on the premise that high-quality streams usually have the greatest species *richness.* Many aquatic insect species are intolerant of pollutants and will not be found in polluted waters. The greater the pollution, the lower the species richness expected, as only a few species are pollutant tolerant.

Ratio of EPT and Chironomidae: The EPT/Chironomidae Index is calculated by dividing the sum of the total number of individuals classified as *Ephemeoptera*, *Plecoptera,* and *Trichoptera* by the total number of individuals classified as *Chironomidae.*

The biological monitoring working party (BMWP) is a procedure for measuring water quality using species of macroinvertebrates as biological indicators.

The method is based on the principle that different aquatic invertebrates have different tolerances to pollutants

Table 1 – The five classes of water quality according to BMWP score and diversity index

Class	BMWP score	Range	Diversity Index
I	>100	1	>5,5
II	70-99	2	4,0-5,4
III	40-69	3	2,5-3,9
IV	10-39	4	1-2,4
V	<10	5	<1

A numerical value has been attributed to each taxon based on its tolerance to organic pollution, one being tolerant and ten being intolerant. The BMWP score for a site is the sum of the values for each taxon present in a sample. The score is based on the presence of each taxon, regardless of the number of representatives of the taxon in the sample. The values assigned for each family are given in Annex 1.

The WFD classification scheme for water quality includes five status classes: high, good, moderate, poor and bad.

'High status' is defined as the biological, chemical and morphological conditions associated with **no** or **very low** human pressure. This is also called the 'reference condition' as it is the best status achievable - the benchmark. These reference conditions are type-specific, so they are different for different types of rivers, lakes or coastal waters so as to take into account the broad diversity of ecological regions in Europe.

Table 2 – The ecological status according to the water framework directive classification (WFD, 2000)

Ecological Status	Class
Very Good	**I**
Good	**II**
Moderate	**III**
Poor	**IV**
Bad	**V**

Simpson Index

Simpson's diversity index (also known as species diversity index) is one of a number of diversity indices, used to measure diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the relative abundance of each species. The Simpson index represents the probability that two randomly selected individuals in the habitat will not belong to the same species. The simplicity of Simpson's Diversity Index has led it to be use frequently.

$$\hat{D} = \frac{\sum_{i=1}^{S} n_i(n_i - 1)}{N(N - 1)}$$

Where n_i is the number of individuals of species i which are counted, and N is the total number of all individuals counted.

3. Results and discussion

Table 3 - Frequence of macroinvertebrate community in Durowskie lake from July 4-9.2011

Taxon	**S**													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Nematoda						+	+							
Hirudinea:														
Erpobdella octooculata (L.)		+		+										
Glossiphonia complanata (L.)				+										
Helobdella stagnalis (L.)		+		+				+			+	+		
Hemiclepsis marginata (O.F. Müller)												+		
Hirudo sp.				+										
Oligochaeta	+	+		+			+				+	+	+	
Bivalvia:														
Anodonta anatina (L.)	+											+	+	
Anodonta cygnea (L.)												+		
Unio pictorum (L.)							+							
Unio tumidus (L.)	+	+									+	+		
Gastropoda:														
Bitynia tentaculata (L.)								+						
Potamopyrgus antipodarum (E.A. Smith)	+	+										+	+	
Theodoxus fluvitatilis (L.)		+		+			+					+	+	
Viviparus contectus (Millet)							+							
Isopoda:														
Asselus aquaticus (L.)		+		+			+	+				+		
Megaloptera:														
Sialis sp.		+		+			+	+						
Ephemeroptera:														
Caenis sp.				+				+				+		
Odonata:														
Libellula sp.								+						
Trichoptera		+		+			+	+			+	+	+	
Ceratopogonidae:														
Bezzia sp.				+		+		+						
Leptoconopinae (subfam.)									+					
Chaoboridae:														
Chaoborus flavicans (Meig.)			+		+					+				+
pupae of *Chaoborus sp.*										+				
Chironomidae	+	+	+	+		+	+	+	+		+	+	+	
Hydracarina		+		+		+	+	+	+			+		

In the study of macroinvertebrates from Lake Durowskie in July 2011 a total of 26 taxa were identified from the all the 14 stations and except the taxa of Nematoda, Oligochaeta, Trichoptera, Leptoconopinae, Chironomidae and Hydracarina all remaining taxa were identified to the species level.

According to the map (Fig. 4) we can see higher richness in species diversity and in number of individuals between 2011 and the other two years.

In the sampling zones from Littoral urban area (2, 4, 12) we can observe that the number of species is slightly higher and the number of individuals is much bigger.

In the sampling zones from Littoral near forest we can see an obvious increase in number of species and also in number of individuals collected.

In the sampling zone from Pelagial we can observe a similarity between all the years.

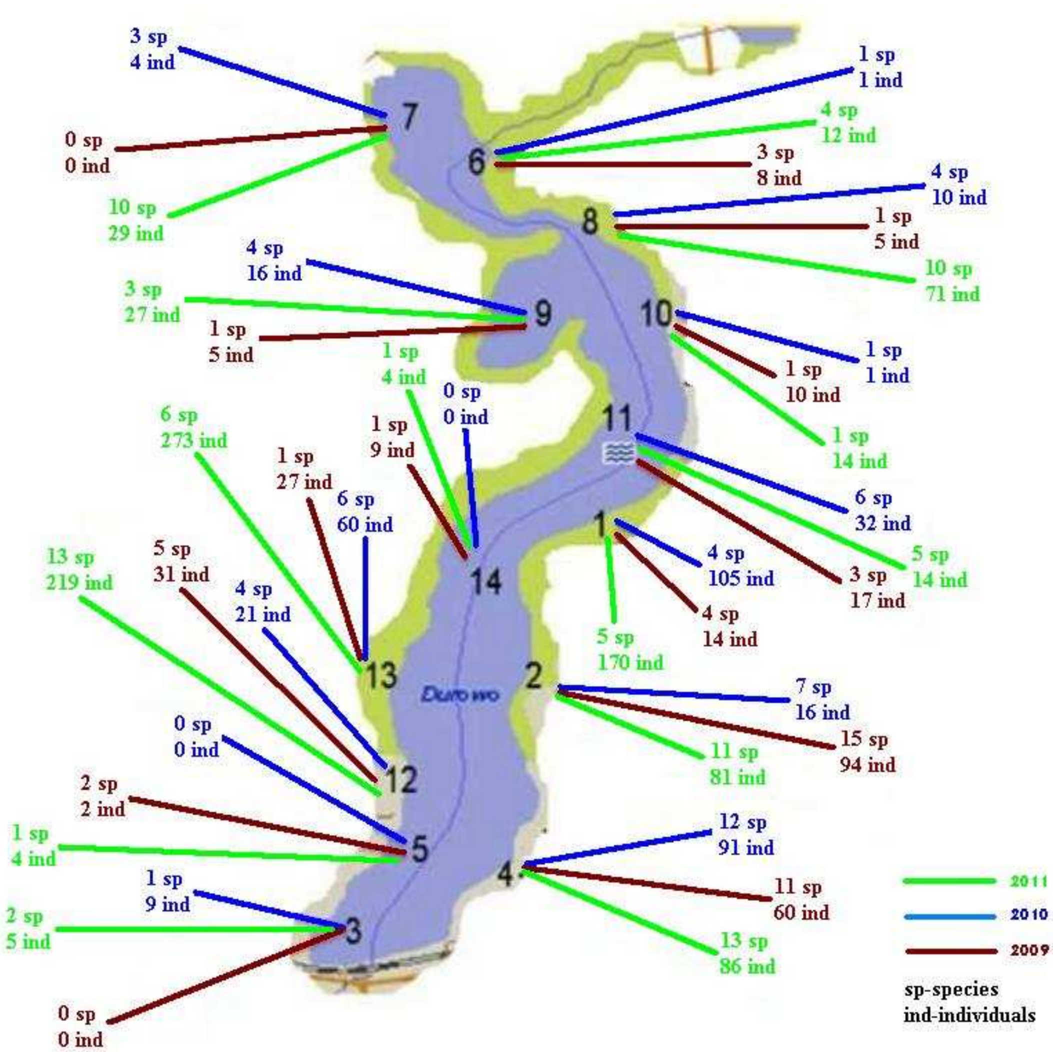


Fig. 4 - Total number of species and individuals identified in 2009, 2010 and 2011 sampling season in Lake Durowskie

Table 4 - Number of macroinvertebrates collected from the sampling stations in Lake Durowskie ($1m^2$)

Taxon	S													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Nematoda						23	23							
Hirudinea:														
Erpobdella octooculata (L.)		23		23										
Glossiphonia complanata (L.)				23										
Helobdella stagnalis (L.)		69		23				23			23	46		
Hemiclepsis marginata (O.F. Müller)												23		
Hirudo sp.				46										
Oligochaeta	92	92		92			92				23	184	69	
Bivalvia:														
Anodonta anatina (L.)	23											23	138	
Anodonta cygnea (L.)												23		
Unio pictorum (L.)							23							
Unio tumidus (L.)	92	23									69	69		
Gastropoda:														
Bithynia tentaculata (L.)								23						
Potamopyrgus antipodarum (E.A. Smith)	1403	161										1702	3910	
Theodoxus fluvitatilis (L.)		138		69			23					23	46	
Viviparus contectus (Millet)							23							
Isopoda:														
Asselus aquaticus (L.)		253		207			23	23				23		
Megaloptera:														
Sialis sp.		23		184			46	230						
Ephemeroptera:														
Caenis sp.				115				437				23		
Odonata:														
Libellula sp.								23						
Trichoptera		69		138			92	46			92	138	161	
Ceratopogonidae:														
Bezzia sp.				46		115		92						
Leptoconopinae (subfam.)									230					
Chaoboridae:														
Chaoborus flavicans (Meig.)			23		92					299				92
pupae of *Chaoborus sp.*										23				
Chironomidae	2300	920	92	966		92	230	621	322		115	2691	1955	
Hydracarina		92		46		46	92	115	69			69		
TOTALS	3910	1863	115	1978	92	276	667	1633	621	322	322	5037	6279	92

In the Littoral urban area (2, 4, 12) we can observe the highest biodiversity of macroinvertebrates, however the species that are included are not necessarily indicators for higher quality waters (Hirudineea). From the Littoral near forest (1, 6, 8, 11, 13) the highest biodiversity was registered in Station 8 (10 species with 1633 individuals/m^2) that are good indicators of water quality.

In the Pelagial area (3, 7, 9, 14) the highest biodiversity is in station 7 (10 species with 667 individuals/ m^2).

In the Aerator area (5, 10) the biodiversity in very low due to depth of water (>14m).

The biomass of macroinvertebrates (Table 5) calculated for the sampling sites indicate that the highest biomass (638503 mg/ m^2) is in Station 11 and is represented mostly by Bivalvia (*Unio tumidus L.*).

The lowest biomass of macroinvertebrates was registered in Stations 5 and 14 (529 mg/ m^2) due to the presence only of Chaoboridae taxa.

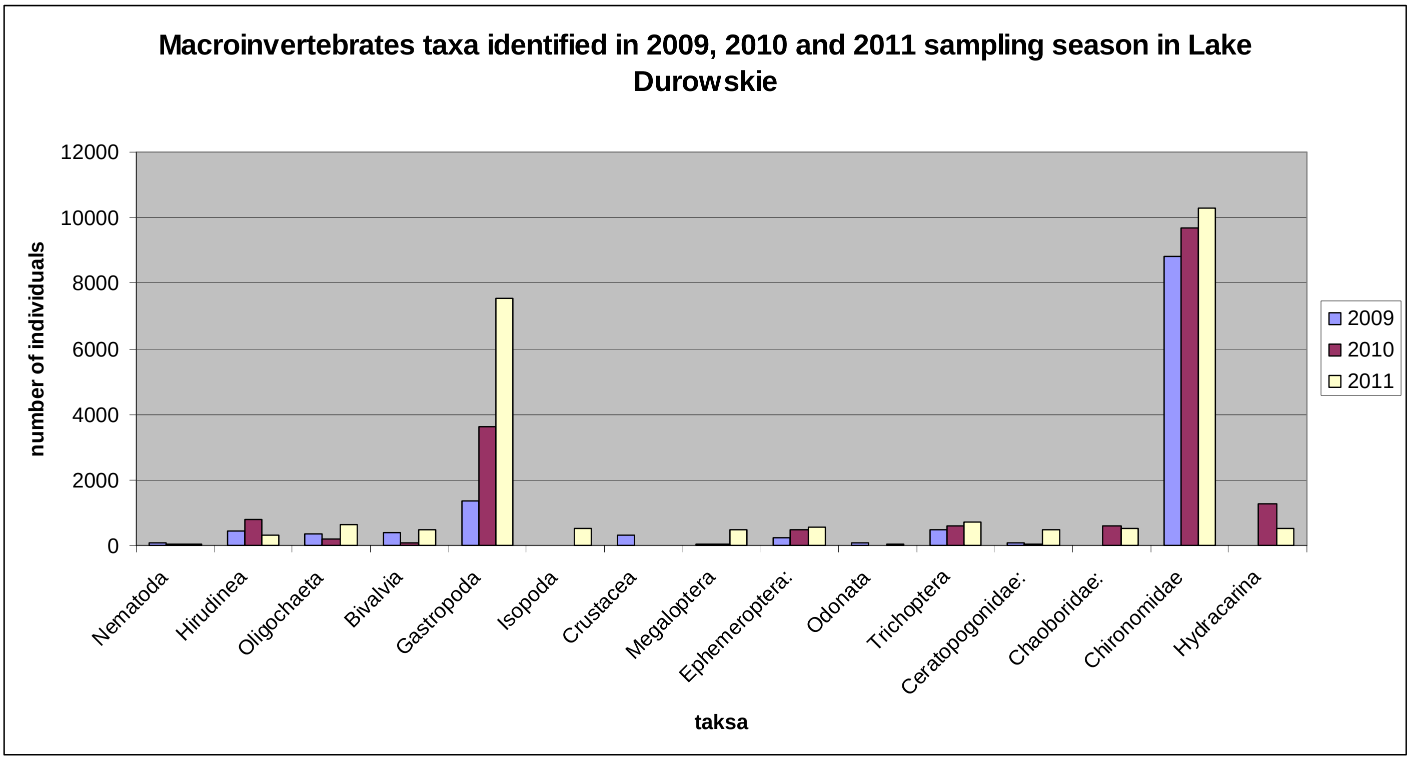


Fig. 5 – Macroinvertebrates taxa identified in 2009, 2010 and 2011

Table 5 - Biomass of macroinvertebrates calculated for the sampling stations in lake Durowskie (mg/ m^2)

Taxon	**S**													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Nematoda						**207**	**92**							
Hirudinea:														
Erpobdella octooculata (L.)		**230**		**1495**										
Glossiphonia complanata (L.)				**46**										
Helobdella stagnalis (L.)		**368**		**92**				**69**			**115**	**184**		
Hemiclepsis marginata (O.F. Müller)												**46**		
Hirudo sp.				**276**										
Oligochaeta	**299**	**115**		**115**			**184**				**46**	**483**	**184**	
Bivalvia*:														
Anodonta anatina (L.)	**297390**											**564,88**	**520950**	
Anodonta cygnea (L.)												**204,24**		
Unio pictorum (L.)							**76130**							
Unio tumidus (L.)	**77050**	**269560**									**634570**	**26910**		
Gastropoda*:														
Bithynia tentaculata (L.)								**2806**						
Potamopyrgus antipodarum (E.A. Smith)	**8717**	**874**										**13524**	**26151**	
Theodoxus fluvitatilis (L.)		**18078**		**5796**			**2277**					**1863**	**6877**	
Viviparus contectus (Millet)							**132480**							
Isopoda:														
Asselus aquaticus (L.)		**759**		**391**			**161**	**92**				**115**		
Megaloptera:														
Sialis sp.		**115**		**1495**			**920**	**5313**						
Ephemeroptera:														
Caenis sp.				**69**				**805**				**46**		
Odonata:														
Libellula sp.								**1426**						
Trichoptera**		**713**		**22448**			**966**	**161**			**966**	**36317**	**552**	
Ceratopogonidae:														
Bezzia sp.				**115**		**138**		**23**						
Leptoconopinae (subfam.)									**575**					
Chaoboridae:														
Chaoborus flavicans (Meig.)			**138**		**529**					**989**				**529**
pupae of *Chaoborus sp.*										**92**				
Chironomidae	**2300**	**3358**	**1035**	**5175**		**1035**	**3335**	**460**	**9223**		**2806**	**6118**	**1794**	
Hydracarina		**46**		**115**		**23**	**92**	**23**	**46**			**69**		
TOTALS	**385756**	**294216**	**1173**	**37628**	**529**	**1403**	**216637**	**11178**	**9844**	**1081**	**638503**	**86444,12**	**556508**	**529**

Littoral zones contain more species than pelagial zones (Fig. 6). The pelagial zone consist of 12 taxa belonging to Nematoda, Oligochaeta, Bivalvia (Unio pictorum), Gastropoda (Theodoxus fluviatilis, Viviparus contectus), Isopoda (Asselus aquaticus), Megaloptera (Sialis sp.), Trichoptera, Ceratopogonidae (Leptoconopinae), Chaoboridae (Chaoborus flavicans), Chironomidae and Hydracarina.

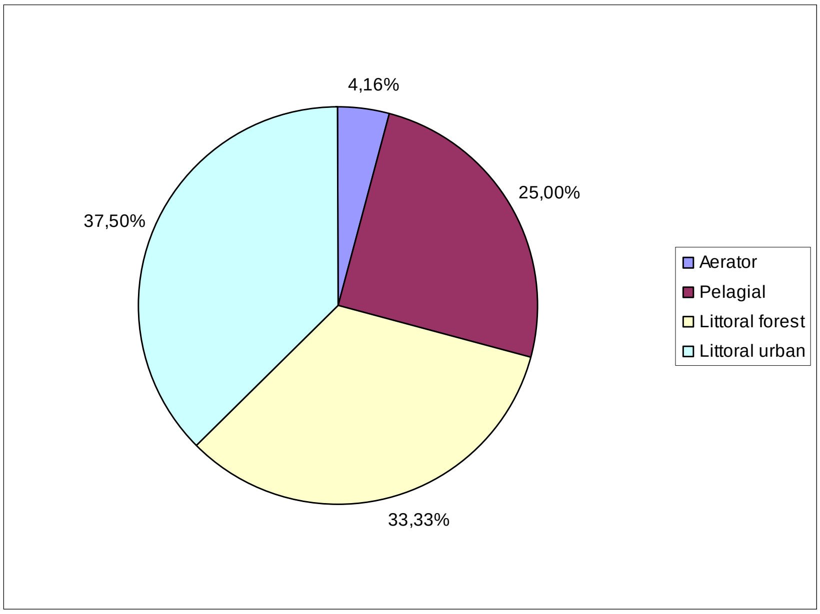


Fig. 6 - The distribution of species in the 4 different zones of Lake Durowskie

From the total of 23.207 individuals collected we can observe that the Littoral near forest was the most abundant (Fig. 7). This fact is due to the physico-chemical parameters (transparency, oxygen dissolved) and to macrophytes influence on the water quality. The lowest number of individuals is correlated to the low number of species from the Aerator sites.

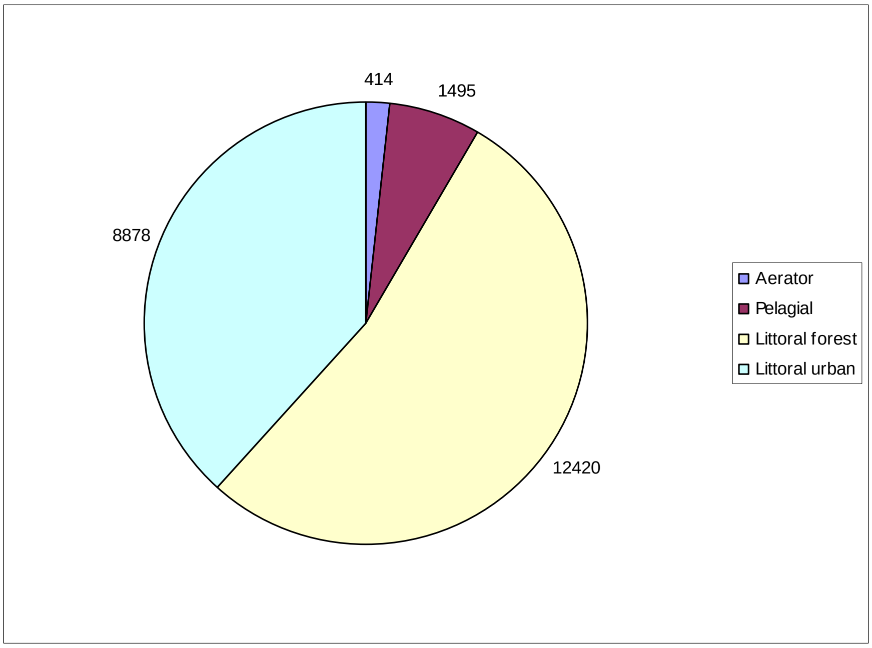


Fig. 7 - Total number of individuals collected at the four different sampling zones of Lake Durowskie

Table 6 – Indices and BMWP score of sampling sites of Lake Durowskie (1m^2)

Indices	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Simpson index	2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2011	0,4758	0,2830	0,6772	0,2714	1,0000	0,3170	0,1855	0,2453	0,4174	0,8669	0,2630	0,4021	0,4859	1,0000
Shannon index	2010	0,3400	0,7200	0,0000	0,7100	0,0000	0,0000	0,4500	0,5200	0,4500	0,0000	0,5900	0,2500	0,2500	0,0000
	2011	0,8866	1,7280	0,5004	1,8359	0,0000	1,2367	1,9519	1,6861	0,9526	0,2573	1,4328	1,2291	0,9217	0,0000
Species evenness	2010	0,5600	0,8600	0,0000	0,6600	0,0000	0,0000	0,9500	0,8600	0,7500	0,0000	0,7600	0,4100	0,3200	0,0000
	2011	0,5509	0,7206	0,7219	0,7157	0,0000	0,8921	0,8477	0,7323	0,8671	0,3712	0,8902	0,4792	0,5144	0,0000
Margalef	2010	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2011	0,6045	1,4608	0,4215	1,7128	0,2212	0,7117	1,5378	1,3517	0,4665	0,3463	0,8659	1,5250	0,6861	0,2212
BMWP	2010	12,0000	28,0000	0,0000	50,0000	0,0000	0,0000	4,0000	12,0000	5,0000	0,0000	26,0000	15,0000	15,0000	0,0000
class	2010	IV	IV	V	III	V	V	V	IV	V	V	IV	IV	IV	V
BMWP	2011	24,0000	36,0000	0,0000	30,0000	0,0000	0,0000	32,0000	26,0000	0,0000	0,0000	19,0000	54,0000	27,0000	0,0000
class	2011	IV	IV	V	IV	V	V	IV	IV	V	V	IV	III	IV	V
EPT %	2010	0,0000	6,2500	0,0000	12,0879	0,0000	0,0000	0,0000	10,0000	0,0000	0,0000	25,0000	0,0000	1,6666	0,0000
	2011	0,0000	3,7037	0,0000	6,9767	0,0000	0,0000	13,7931	2,8169	0,0000	0,0000	28,5714	2,7397	2,5641	0,0000
EPT Chironomidae	2010	0,0000	0,1700	0,0000	0,2200	0,0000	0,0000	0,0000	0,2500	0,0000	0,0000	0,5000	0,0000	0,0200	0,0000
	2011	0,0000	0,0040	0,0000	0,0072	0,0000	0,0000	0,0600	0,0045	0,0000	0,0000	0,2484	0,0010	0,0013	0,0000

The calculation of EPT index doas not include Plecoptera family since no species was found during our sampling in Lake Durowskie.

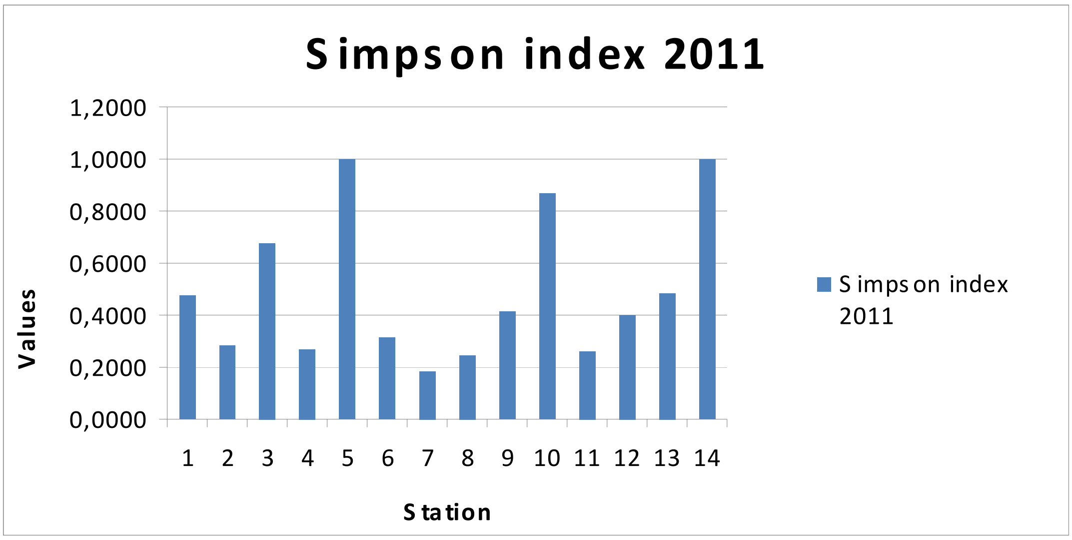


Fig. 8 – Simpson index

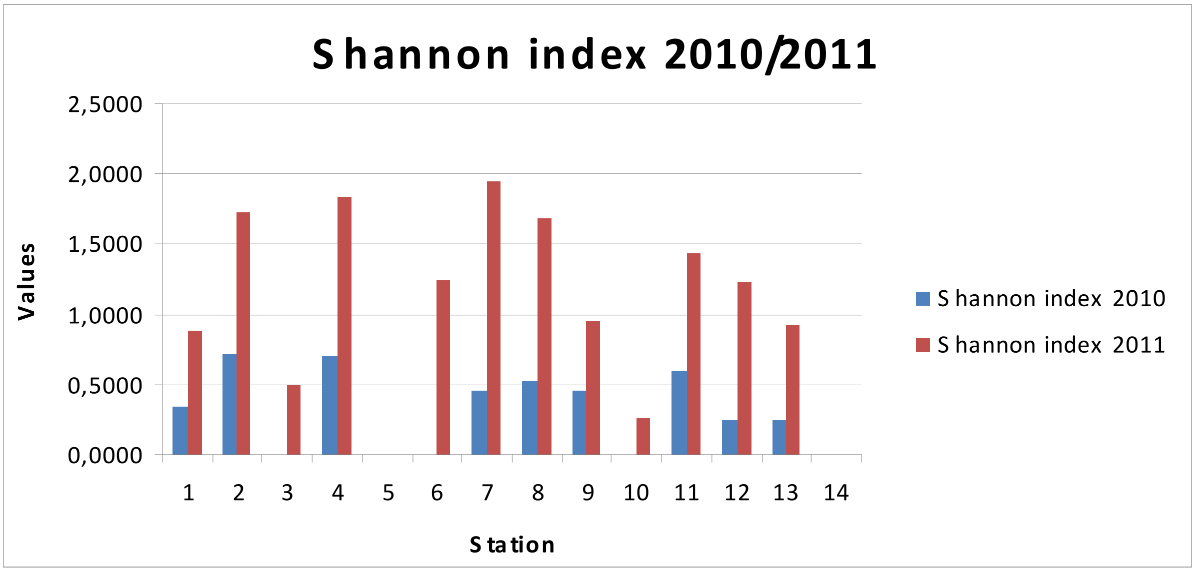


Fig. 9 – Shannon index

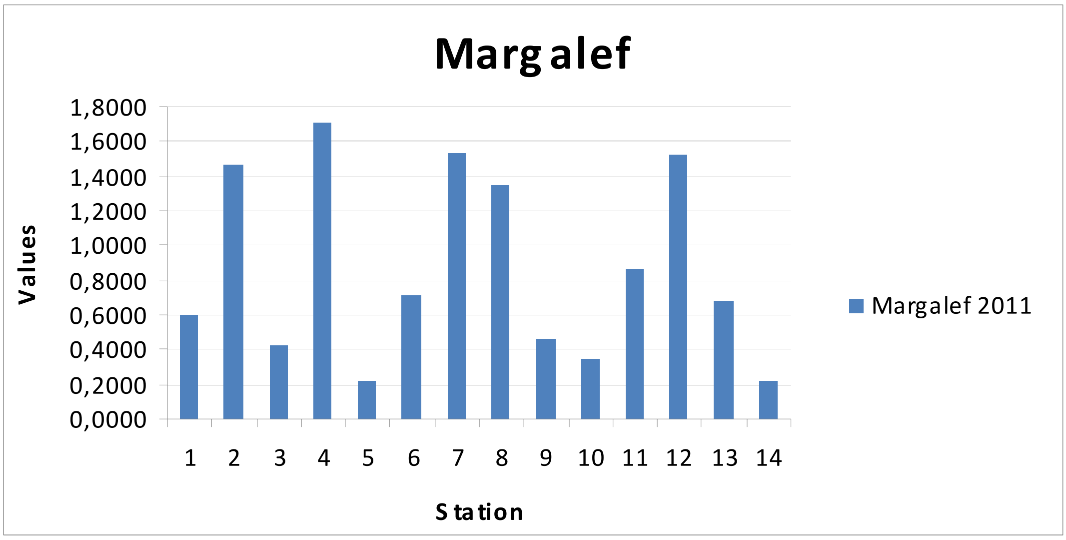


Fig. 10 – Margalef index

Shannon, Simpson and Margalef indices refflect the diversity of species. Simpson and Margalef indices were not calculated for previous years but we can say that the values show high diversity.

For Shannon index we had the possibility to compare the data with the one from previous year. The graphic (Fig. 9) reveals that the diversity of species has grown obviously in every station.

Even though not all the species are very relevant regarding sensitivity to pollution it is a good thing for our research because any increase of biodiversity shows that the water quality has improved.

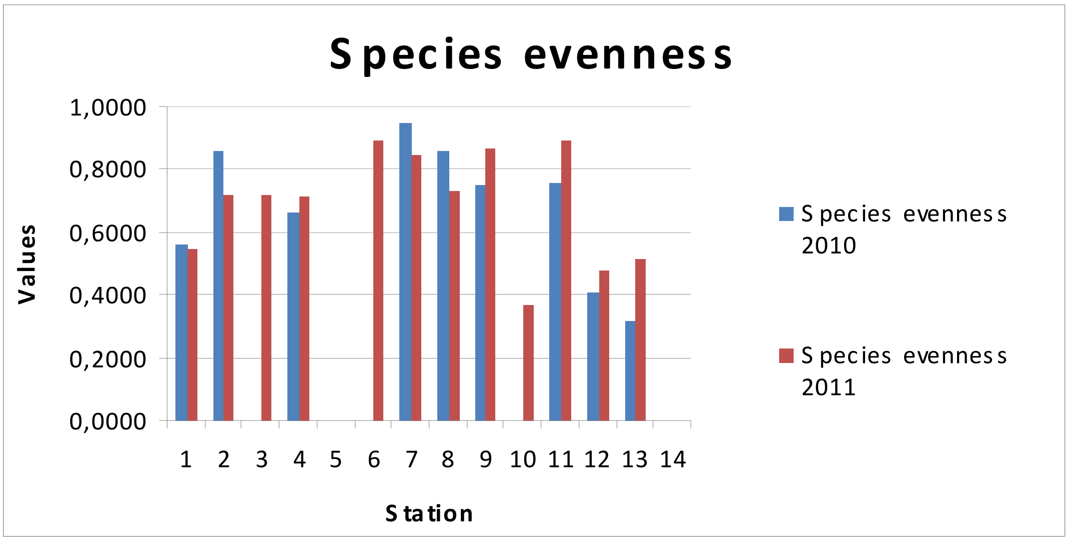


Fig. 11 – Species evenness index

Comparing the Evenness index (Fig. 11) between 2010 and 2011 we can observe that there are some differences between the stations as following: in stations 1 and 4 the biodiversity doesn't show major changes; in station 3 and 10 we can see that in the previous year no species was found but in 2011 we were able to takeoff individuals of Chaoboridae (*Chaoborus sp.*) and Chironomidae; in stations 9, 11, 12, 13 we can see that the biodiversity has increased.

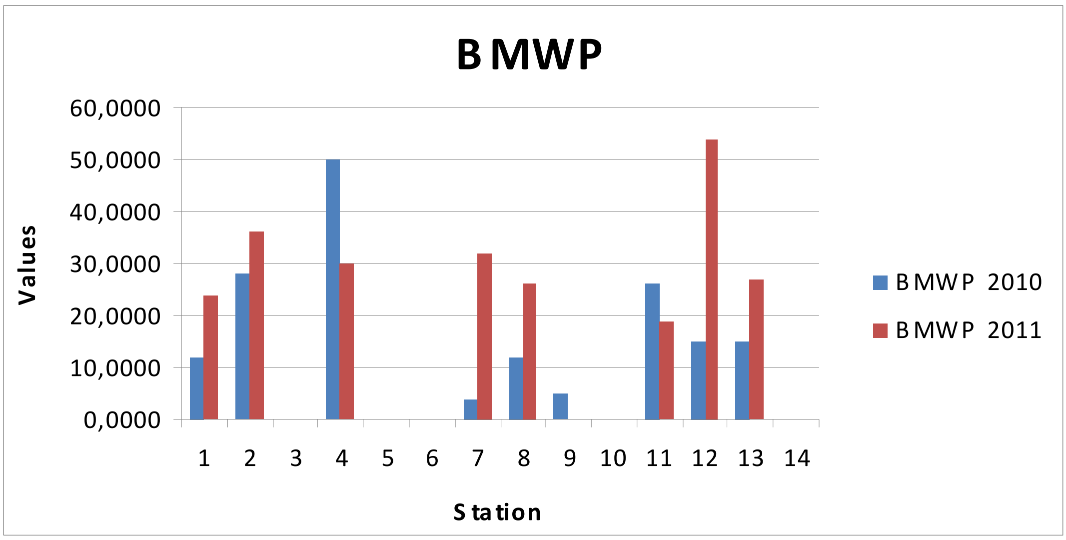


Fig. 12 – BMWP index

After calculating the BMWP index we can notice that in station 4 the water quality decreased from class III to class IV due to anthropogenic input of organic substances. We also observed that in stations 7 and 12 the water quality improved from class V to class IV, respective from class IV to class III.

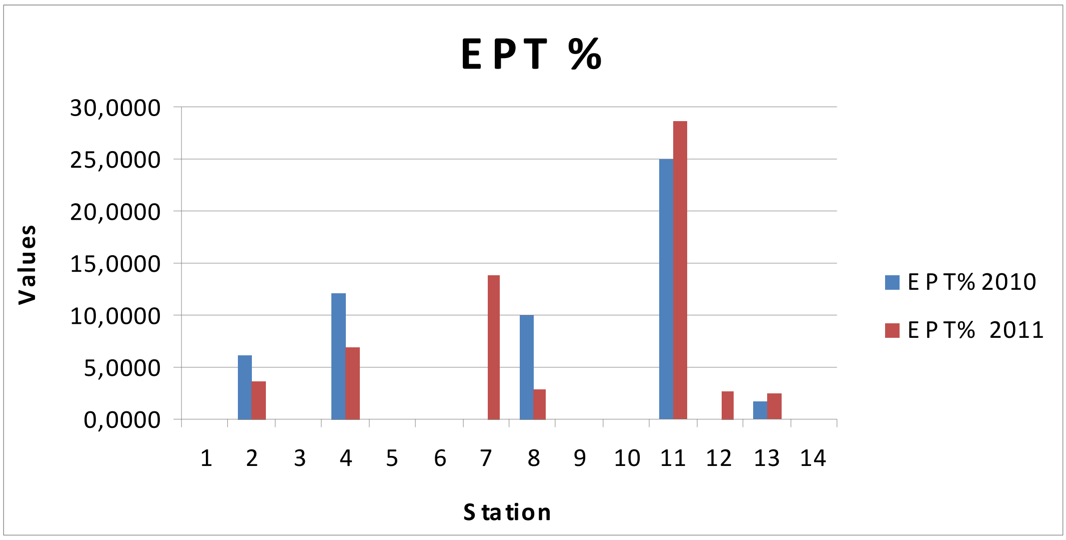


Fig. 13 – EPT % index

Table 7 – Comparisation of EPT/Chironomidae ratio between 2009, 2010 and 2011 sampling season

EPT/Chironomidae	Stations													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
2009	**0,09**	**0,125**	**0**	**0,176**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
2010	**0**	**0,17**	**0**	**0,22**	**0**	**0**	**0**	**0,25**	**0**	**0**	**0,5**	**0**	**0,02**	**0**
2011	**0**	**0,004**	**0**	**0,007**	**0**	**0**	**0,06**	**0,005**	**0**	**0**	**0,25**	**0,001**	**0,001**	**0**

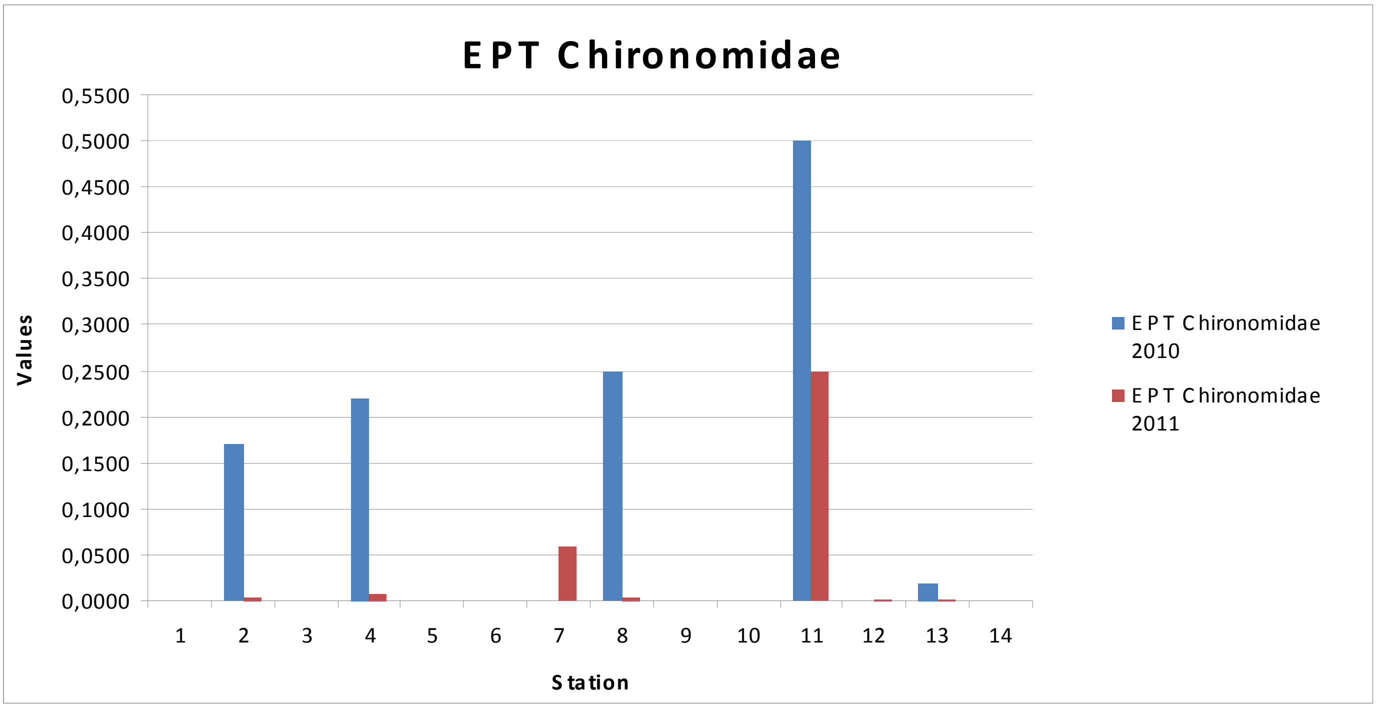


Fig. 14 – EPT Chironomidae index

After calculating EPT indices we can say that in stations 7, 11, 12, 13 the water quality has improved due to the additional oxygen pumped by the aerators.

Even thought the EPT has shown some improvements, the EPT Chironomidae index is lower, meaning that this family still populates the benthic zone of Lake Durowskie.

4. Conclusions

The biodiversity has increased from 19 taxa in 2010 to 26 taxa in 2011. All the indices of biodiversity indicate that the measures of restoration are effective. However, the success of restoration can he assessed by the replacement of eutrophic species by mesotrophic ones (Claude and Christophe; 2002).

In the littoral stations the diversity was found to be higher than in pelagic and aerators stations. This rapid re-colonization of macroinvertebrate was similar to results from other studies of river restoration (Friberg et al.,1994; Biggs et al., 1998; Laasonen et al., 1998). In the 3 stations of Littoral urban area we found the highest number of species (18 species) followed by the 5 station of Littoral near forest area (16 species). Although in Littoral urban area the number of species is higher, many of them is adapted to more polluted ecosystems (e.g Hirudinea), so we can say that Littoral near forest area has the most important biodiversity. In station 4 (Littoral near urban area) the water quality decreased from class III to class IV due to anthropogenic input of organic substances. We also observed that in stations 7 and 12 the water quality improved from class V to class IV, respective from class IV to class III.

The Pelagic zone (12 species) has a higher biodiversity than the Aerators zone (2 species) due to the differences in water depth.

Hirudinea taxa was observed to have the highest number of species (5) followed by Bivalvia and Gastropoda with 4 species. The highest density is revealed in Station 13 by the species Potamopyrgus antipodarum with 3910 individuals/m^2.

The only taxon to show a significant decrease to the restoration was the Chironomidae. This clearly indicates an improved water quality; this also corresponds with the findings of Saether 1970, 1979, Saether and McLean, 1972.

The analyses of biological communities are necessary part in the total evaluation of a lake. They may give information which cannot be approximately obtained by merely chemical methods. From the results and judging from the measures of restoration and land use change from 2010 to 2011 in the Lake Durowskie it is observed that the water quality has improved.

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6. Appendix

Standard table of BMWP – PL

Families		Score
Ephemeroptera	Ameletidae	10
Trichoptera	Glossosomatidae, Molannidae, Beraeidae, Odontoceridae, Leptoceridae	
Diptera	Blephariceridae, Thaumaleidae	
Ephemeroptera	Behningiidae	9
Plecoptera	Taeniopterygidae	
Odonata	Cordulegastridae	
Trichoptera	Goeridae, Lepidostomatidae	
Crustacea	Astacidae	8
Ephemeroptera	Oligoneuriidae, Heptageniidae (only genus Epeorus and Rhithrogena)	
Plecoptera	Capniidae, Perlidae, Chloroperlidae	
Trichoptera	Philopotamiidae	
Diptera	Athericidae	
Ephemeroptera	Siphlonuridae, Leptophlebiidae, Potamanthidae, Ephemerellidae, Ephemeridae, Caenidae,	7
Plecoptera	Perlodidae, Leuctridae	
Odonata	Calopterygidae, Gomphidae,	
Trichoptera	Rhyacophilidae, Brachycentridae, Sericostomatidae, Limnephilidae	
Coleoptera	Elmidae	
Heteroptera	Aphelocheiridae	
Gastropoda	Viviparidae	
Bivalvia	Unionidae, Dreissenidae	
Hirudinea	Piscicolidae	6
Crustacea	Gammaridae, Corophiidae	
Ephemeroptera)	Baetidae, Heptageniidae (except for genus Epeorus and Rhitrogena)	
Plecoptera	Nemouridae	
Odonata	Platycnemididae, Coenagrionidae	
Trichoptera	Hydroptilidae, Polycentropodidae, Ecnomidae	
Diptera	Limoniidae, Simuliidae, Empididae	
Gastropoda	Neritidae, Bithyniidae	
Crustacea	Cambaridae	5
Trichoptera	Hydropsychidae, Psychomyidae	
Coleoptera	Gyrinidae, Dytiscidae, Haliplidae, Hydrophilidae	
Heteropera	Mesoveliidae, Veliidae, Nepidae, Naucoridae, Notonectidae, Pleidae, Corixidae	
Diptera	Tipuliidae	
Gastropoda	Hydrobiidae	
Diptera	Ceratopogonidae	4
Gastropoda	Valvatidae, Planorbidae	
Bivalvia	Sphaeriidae	
Hirudinea	Glossiphonidae, Erpobdellidae, Hirudinidae	3
Crustacea	Asellidae	
Megaloptera	Sialidae	
Diptera	Chironomidae	
Gastropoda	Ancylidae, Physidae, Lymnaeidae	
Oligochaeta	All Oligochaeta	2
Diptera	Culicidae	
Diptera	Syrphidae, Psychodidae	1