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Ecological state of the Lake Durowskie during restoration measures

Macroinvertebrates Report

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1. INTRODUCTION

1.1. Research site

A lake is defined as a natural, permanent existing body of water with a relatively slow exchange of water; and whose functioning depends on several factors, among the most important ones we can name: area and shape of its basins, mixing intensity and amount of suspension and chemistry (Messayasz et al., 2014). For many people they are a preferred and suitable environment for experiencing nature through diverse activities such as: boating, camping, fishing, swimming, birdwatching, etc. (Singh & Bhatnagar, 2012). While in a natural area and depending on the legislation lakes are somewhat protected, for urban lakes the pressure can be sturdier. However, these lakes also possess a great value in aspects of the ecosystems services and the social values for a community (Singh & Bhatnagar, 2012).

Figure 1. Durowskie Lake and Wągrowiec town

The Durowskie Lake is a postglacial lake situated in Wągrowiec (Wielkopolska region, Poland) and it is a part of a chain of lakes connected with the river Struga Gołańska. With its surface of 143,7ha, the Durowskie Lake is an important part of touristic activities, such as recreation, sports and fishing (Gołdyn et al., 2013). Due to its economic and landscape value it is necessary to maintain a good quality of water in the lake. The lake in the northern region of the catchment area has mainly a forest character, but the wider surroundings include: agricultural land and the city itself (e.g. wastewater treatment plants); which resulted in an increase income of nutrients and changes in the littoral zone due to human activities. The overall situation brought eutrophication to the lake and a decrease in water quality. Therefore changes in land use and increasing human activity are continuous threats to the ecosystem.

Since 2008, restoration measures (2 aerators, biomanipulation and chemical treatment) are being taken in order to improve the water quality in the lake and maintain its ecological state in a condition which will improve biodiversity, but will still serve as a recreational zone at the same time. In order to evaluate the state of ecological restoration (trophic state of the Durowskie Lake), composition of changes in benthic macroinvertebrate communities were investigated.

1.2. Macroinvertebrates as indicators of water quality

Figure 2. Bentic biodiversity important in assessing water quality

Assessing the status of a lake, macroinvertebrates can serve as biological indicators and are the most common group of organism used to assess water quality (Rosenberg and Resh, 1993). They inhabit the sediment or live at the bottom substrates of lakes, streams, and rivers and reflect the biological integrity of the aquatic ecosystem (Rosenberg and Resh, 1993; Davies and Simon, 1995). Different macroinvertebrate species prevail depending on lake trophic status, which affects food quality and quantity, and oxygen status. Food is the main factor changing community composition when environmental conditions are not too severe. However, when organic pollution is more intense, it is oxygen concentration rather than food that limits the species survival and determines the community composition. Biological communities are highly influenced by site-specific conditions, and often these effects can be well synthesized by the seasonal dynamics and the depth distribution of benthic organisms (Bazzanti and Seminara 1987a, b). Potential threats to macroinvertebrate diversity are sedimentation, habitat loss and chemical pollution.

Lake morphometry affects community structure of macroinvertebrates. Generally, the benthic zone of lakes can be divided along the depth profile into the littoral, sub-littoral and profundal zones. The littoral zone is defined as the near shore lake bottom areas where emerged macrophytes grow. The sub-littoral zone is defined as the bottom area covered by submerged macrophyte or algal vegetation. Often, empty shells of molluscs are accumulated at its lower end (littoriprofundal) and thus form a specific sediment type. The lake bottom area extending deeper is called profundal zone, which consists of exposed fine sediment free of vegetation. Shores are often protected by rip-rap (stone surfacing), usually to avoid bank erosion due in urbanized areas. In general, any kind of shoreline development is considered to have detrimental impacts on the littoral zone through the alteration or loss of littoral habitats (Solimini et al., 2006).

Particular species assemblages of invertebrates have commonly been reported to be useful indicators of lake trophic state. These include: aquatic worms (Oligochaeta), midges (Chironomidae), snails (Gastropoda) and clams (Sphaeriidae). As species shifts occur with increasing eutrophication, chironomid species richness may decline; however, chironomid biomass and/or abundance increase. Chironomid emergence was recommended as an efficient indicator of secondary production in lakes (EPA, 2012; WFD, 2006). Some macroinvertebrates—for example, taxa within the order Diptera (true flies and mosquitoes) and the class Oligochaeta (segmented worms)—tend to be tolerant of poor water-quality conditions. Other organisms—for example, the orders Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies)—are more sensitive to pollution (Robinson, 2004).

Lake Durowskie has had decades of human use and abuse, during the second world war pine trees were planted around the lake to provide quick supplies for the war. Since then, these monocultures have gradually affected the state of existing ecosystem functions because of change in the natural vegetation structure. Another significant contribution to pollution was the sewage from the surrounding urban areas, and the chain of lakes upstream. Since 2006, the local government was able to stop direct sewage. Nevertheless, cyanobacteria blooms appeared in 2006, seriously affecting the tourism demand, a major income for the town of Wągrowiec (Interview to management group, 2014). As a consequence, the restoration process started in 2009 and is being monitored every year. The goal of this work is to provide an assessment of the ecological state of the lake using macroinvertebrates as indicators.

Together with other indicators it will allow the local government to identify the strengths of the restoration process and find adaptive measures in order to improve the condition.

2. METHODOLOGY

2.1. Research area

Durowskie Lake, Wągrowiec (Wielkopolska region, Poland)

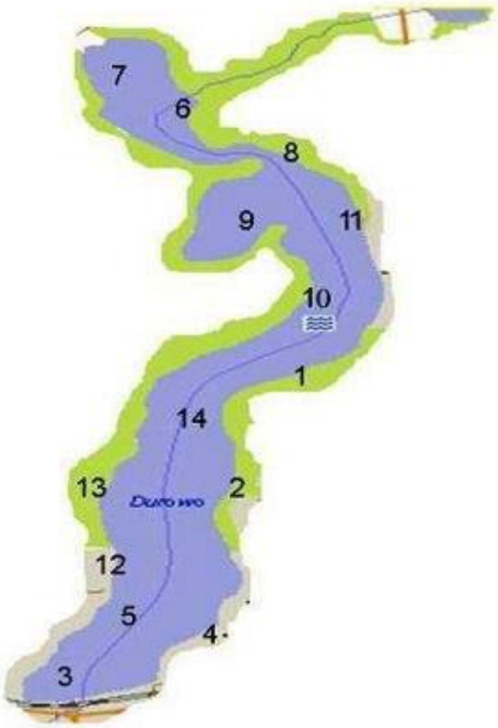
Surface area:	143,7 ha
Max depth:	14,6 m
Mean depth:	7,9 m
Main tributary:	Struga Gołaniecka River
Catchment area:	236,1 km^2

The Durowskie Lake is stratified, chain lake connected with the Kobyleckie Lake through the Struga Gołaniecka River (Gołdyn et al., 2013).

Figure 3. Satelite picture of Lake Durowskie (source: Google maps, 10/07/2014)

2.2. Sampling methods

The samples of benthic macroinvertebrates were collected in 14 different sites of the lake and 2 sites in the Struga Gołańska River (inflow and outflow). Sites are distributed around the lake and belong to different lake regions (Figure 4). All the samples were collected between 30th of June and 5th of July 2014.



Sites	Description
1 Littoral	Reed near forest cover
2 Littoral	Near urban area
3 Profundal	Near dam
4 Littoral	Near urban area
5 Profundal	(Aerator 1)
6 Profundal	
7 Littoral	
8 Littoral	Littoral
9 Profundal	Profundal
10 Profundal	(Aerator 2)
11 Littoral	With reed
12 Littoral	Near urban area
13 Littoral	Reed near forest cover
14 Profundal	

Figure 4. Distribution of the sampling sites at Durowskie Lake

Sampling sites were divided into four different zones:

1. Littoral - forest → stations 1, 7, 8, 11, 13
2. Littoral - urban → stations 2, 4, 12
3. AeratorI, II → stations 5, 10
4. Profundal → stations 3, 6, 9, 14

During sediment (including organism) sampling two core samplers (harvesters) were used:

- „Czapla” - samples from shallow waters (littoral part of the lake) with a depth of 2 meters or less (Figure 5). Overall 17samples were collected on each station.
- „Kajak” - samples from deeper parts of the lake including the part with the maximum depth of 14,6 meters (Figure 6). Overall 10 samples were collected on each station.

Figure 5. “Czapla”sampler

Figure 6. “Kajak” sampler

Samples of benthic macroinvertebrates from each site were washed on a sieve (Figure 7) and stored into separate plastic boxes filled with water.

Figure 7. Sieving of sediment samples

Laboratory work consisted from two parts. Organisms longer than 2 mm were first separated from the sediment and divided into taxa categories. Organisms from each taxa were dried, weighted and placed in a test tube with alcohol (70%), except for Oligochaeta which were placed in tubes with formaldehyde (4%). The macroinvertebrates were then identified to the species level using the key (Rybak, 2000; Kołodziejczyk and Koperski, 2000; Piechocki , Dyduch-Falniowska 1993, Tachet 2000) (Figure 8).

Figure 8. Laboratory work

2.3. Data analysis

According to the number of samples that were taken at each research site (10 with "Kajak" and 17 with "Czapla"), biomass and number of individuals per square meter was calculated.

The Shannon-Wiener Index was used as one of several diversity indices used to measure diversity in categorical data. It is simply the information entropy of the distribution, treating species as symbols and their relative population sizes as the probability. The advantage of this index is that it takes into account the number of species and the evenness of the species. The index is increased either by having additional unique species, or by having greater species evenness.

$$H_S = - \sum_{i=1}^{S} p_i \cdot \ln p_i$$

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).P_i is the proportion of individuals that is derived by dividing the number of individuals of one species found, with the number of all individuals of all species found.

The higher the values of H_s are, the better are the conditions of the water body.

Pielou's species evenness refers to how close in numbers each species in an environment is.

$$J' = \frac{H'}{H'_{\max}}$$

J' is constrained in the range between 0 and 1. The less variation in communities between species the higher J' is. In other words, the higher the value and the less the variation in communities between the species, the better the quality of the water.

The Margalef Index is used for measuring of species diversity. It is calculated from the total number of species present and the abundance or total number of individuals.

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

where

Da = Margalef Index

S = the number of species

N= the total number of individuals

The higher the index the greater the diversity.

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.

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.

EPT Index = Σ(EPT / Chironomidae)

The greater the number of taxa from the EPT orders, the higher the value and the better the water quality.

The Simpson index is used to measure the degree of concentration when individuals are classified into type.

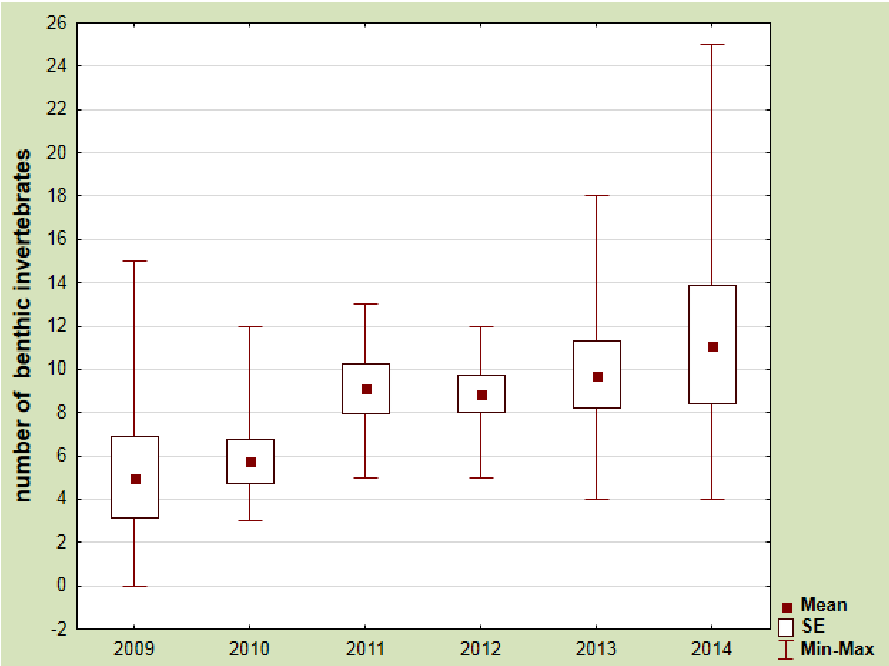
$$\lambda = \sum_{i=1}^{R} p_i^2$$

Small values in datasets are indicating a high diversity and large values in datasets indicating a low diversity.

3. RESULTS AND DISCUSSION

3.1. Number of benthic invertebrates and Species Density

Overall 34 different taxa were found in 2014 during the field work, in 14 stations (Appendix, Table 1), with 38 772 individuals (Appendix, Table 2), and a total biomass of 2 025 072 mg (Appendix, Table 3). The following classes and orders were documented: Plathelminthes, Nematoda, Hirudinea, Oligochaeta, Bivalvia, Gastropoda, Isopoda, Megaloptera, Coleoptera , Ephemeroptera , Odonata , Trichoptera, Diptera and Hydracarina. For our analyses and comparisons with the previous years, six profundal stations were discarded since all of them recorded only one species (*Chaoborus flavicans* (Meig.)), something to be expected due to the dearth of oxygen in this part of the lake.

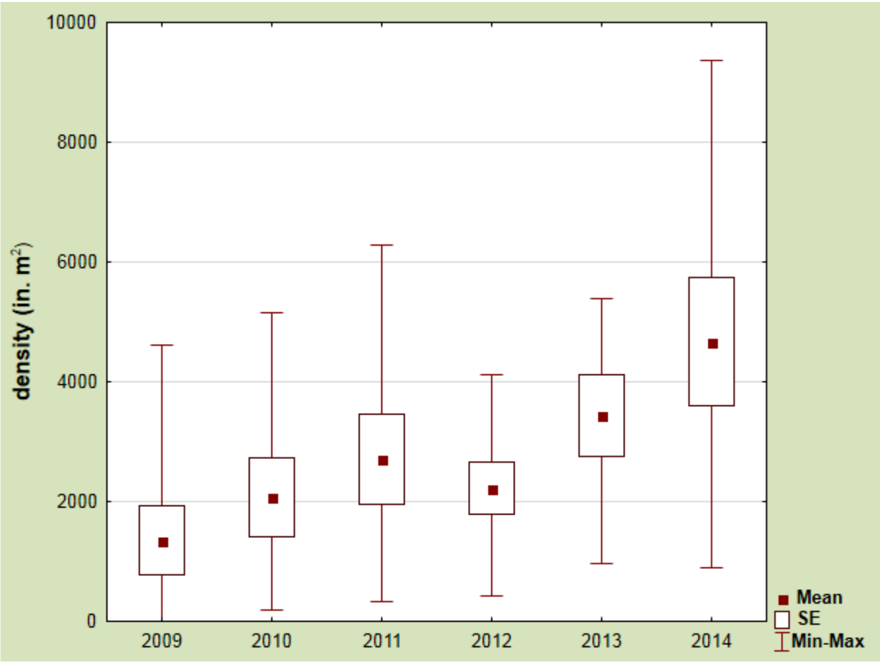


Graph 1. Number of bentic invertabres in Durowskie Lake

Considering only the eight littoral sites and in relation to previous years, the number of benthic invertebrate's taxa in Lake Durowskie in 2014 was the highest since the beginning of the restoration process five years ago. The mean value for littoral sites increased to 11 taxa per station, one more than in 2013 and six more than in 2009. The boxplot (Graph 1) depicts the stable increase in the lake during the restoration process. The two urban sites in the south-west of the Lake hold the main concentration of biodiversity (Site 2 with 18, and site 4 with 25 taxa respectively). Another habitat with a remarkable number of taxa was forest with macrophyte cover in the lake, namely site

7 (16 taxa) in the north end of the lake and site 11 (10 taxa) a couple of hundred meters north of Aerator 2.

Moreover new groups and families were recorded this year; among those, it is noteworthy to mention *Hydroporus sp.* in Site 1 (forest cover), the first Coleoptera ever found since restoration started. However, urban sites have also provided important findings; many individuals in the family Batidae were recorded in Sites 2 and 4, an encouraging sign considering that Ephemeropterans are pollution-sensitive species.

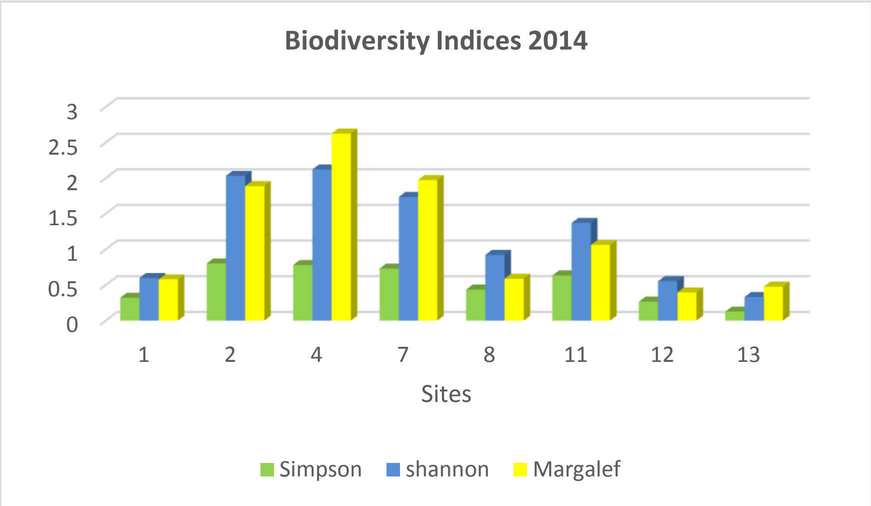


Graph 2. Species density in Durowskie Lake

Similarly as the number of taxa, species density shows an important and steady increment since 2009; when the recorded mean of individuals per m^2 was 1,349 to more than threefold in 2014 when the mean density reached 4,671 individuals per m^2. Except for a slight decrease in 2012, species density in Lake Durowskie has been continuously in the rise, as illustrated clearly in the boxplot below (Graph. 2). The highest density is again concentrated in urban sites 2 (8 173) and 4 (9 361); nevertheless, two sites with forest cover also display a considerably high density (Site 1 with 5 681; and site 13 with 4 459 individuals per m^2).These results support the trend of a gradual increase in biodiversity, which could be the result of an improvement in the ecological state of the lake.

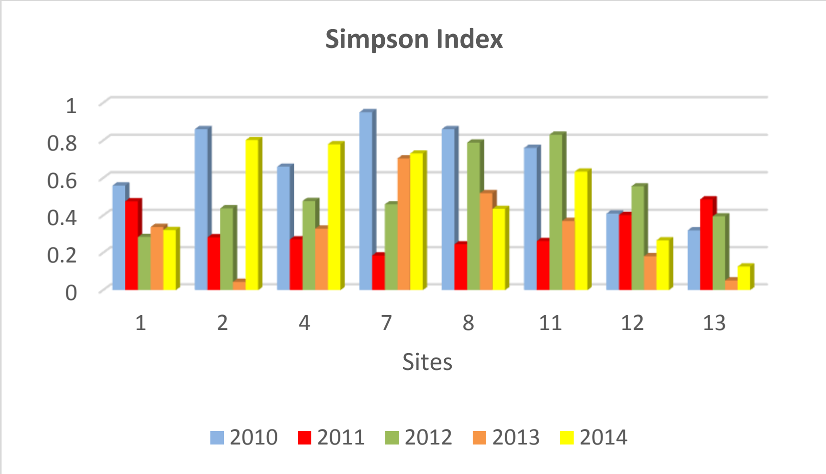
3.2. Biodiversity

The results of various biodiversity indices (Graph 3) confirmed the trend of highest concentration located in urban sites 2 and 4. The reason may be due to a number of pollution tollerant species that survive in this habitat, and may be even benefited from human activities such as bait contributed by fishermen inside the Lake. In addition to that, sites with forest cover and macrophytes (7, 11) appear again second in biodiversity concentration. Perhaps, this could be a positive sign of recovery of the more shallow areas north of Aerator 2.

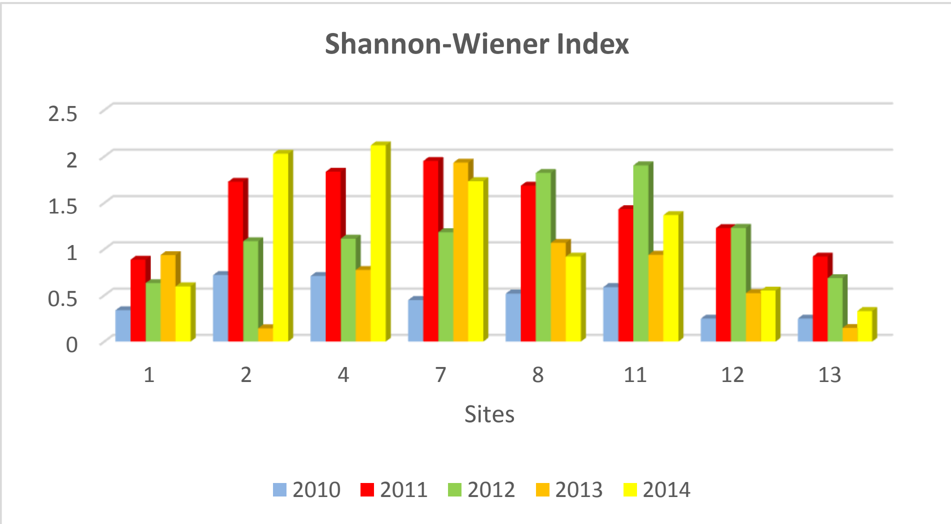


Graph 3. Biodiversity indices in Durowskie Lake

Compared to the data of 2013, only sites 1, 8 and 13 indicate a slight decrease. Site 7 has barely maintained its biodiversity, while the remaining five littoral sites has a major increase according to the biodiversity indices in Graphs 4 and 5. Nevertheless, the trend that was suggested by our two previous boxplots (Graphs 1 and 2) of a steady increase in biodiversity is not observable anymore. It is important to keep in mind that these indices catalogue not only abundance of taxa and species, but also evenness in number of species. The appraisal available with the Shannon-Wiener and Simpson since 2010 do not show a clear pattern and more time may be necessary to have more clear results.

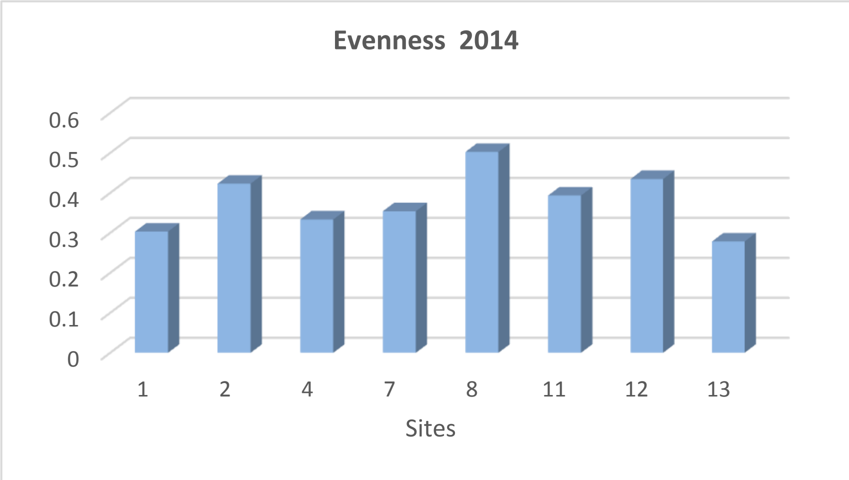


Graph 4. Simpson biodiversity index in Durowskie Lake 2010-2014



Graph 5. Shannon-Wiener biodiversity index in Durowskie Lake 2010-2014

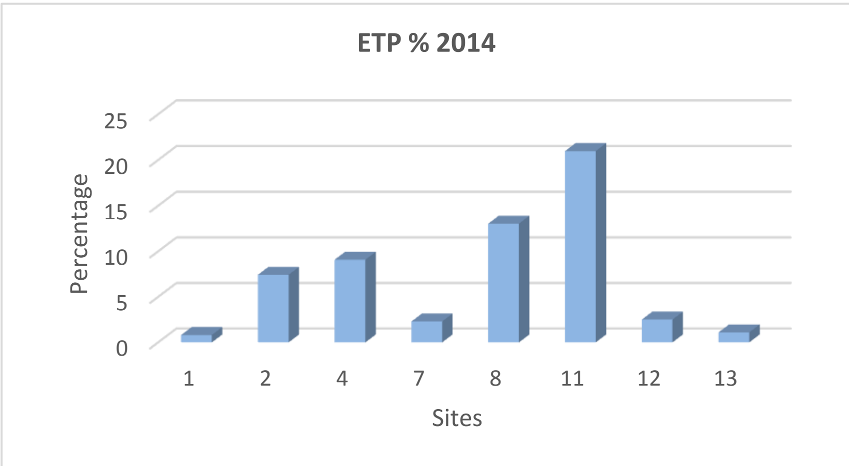
Taking evenness as a separate parameter, Graph 6 shows that the most even site is 8, where the dominance of Chironomidae is not as marked as in other sites. On the other hand, the most biodiverse sites (urban 2, 4) have a strong dominance of Chironomidae and Isopoda. However, possible indicators of a cleaner environment in these two sites include: two families of Ephemeroptera, at least two species of Thricoptera, and Bivalvia. Meanwhile, on site 11 one of the most biodiverse forested areas have Chironomidae and Ephemeroptera as dominant groups, with Bivalvia and Thricoptera as other indicators of a healthy ecosystem, and without the presence of Oligochaeta. To complete the top four sites in biodiversity, site 7 has three dominant groups: Chironomidae, Oligochaeta and Helobdella stagnalis, a species of Hirundinae.



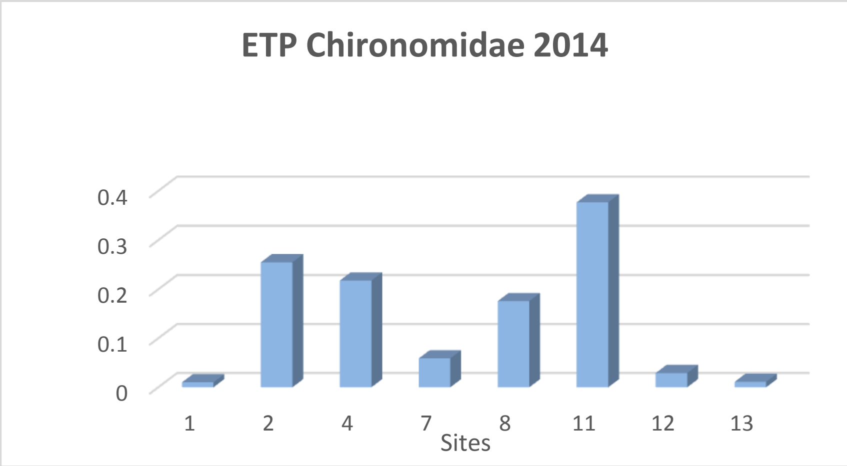
Graph 6. Evenness in Durowskie Lake 2014

3.3. Water Quality

ETP and ETP Chironomidae indices results (Graphs 7 and 8) are utterly low in certain sites, specifically 1, 7, 12 and 13; opening the possibility that the water quality in these areas have a much slower recovery than other parts of the lake and it may be necessarily to pay special focus on these areas. Sites 12 and 13 for instance are located in an area of heavy erosion.

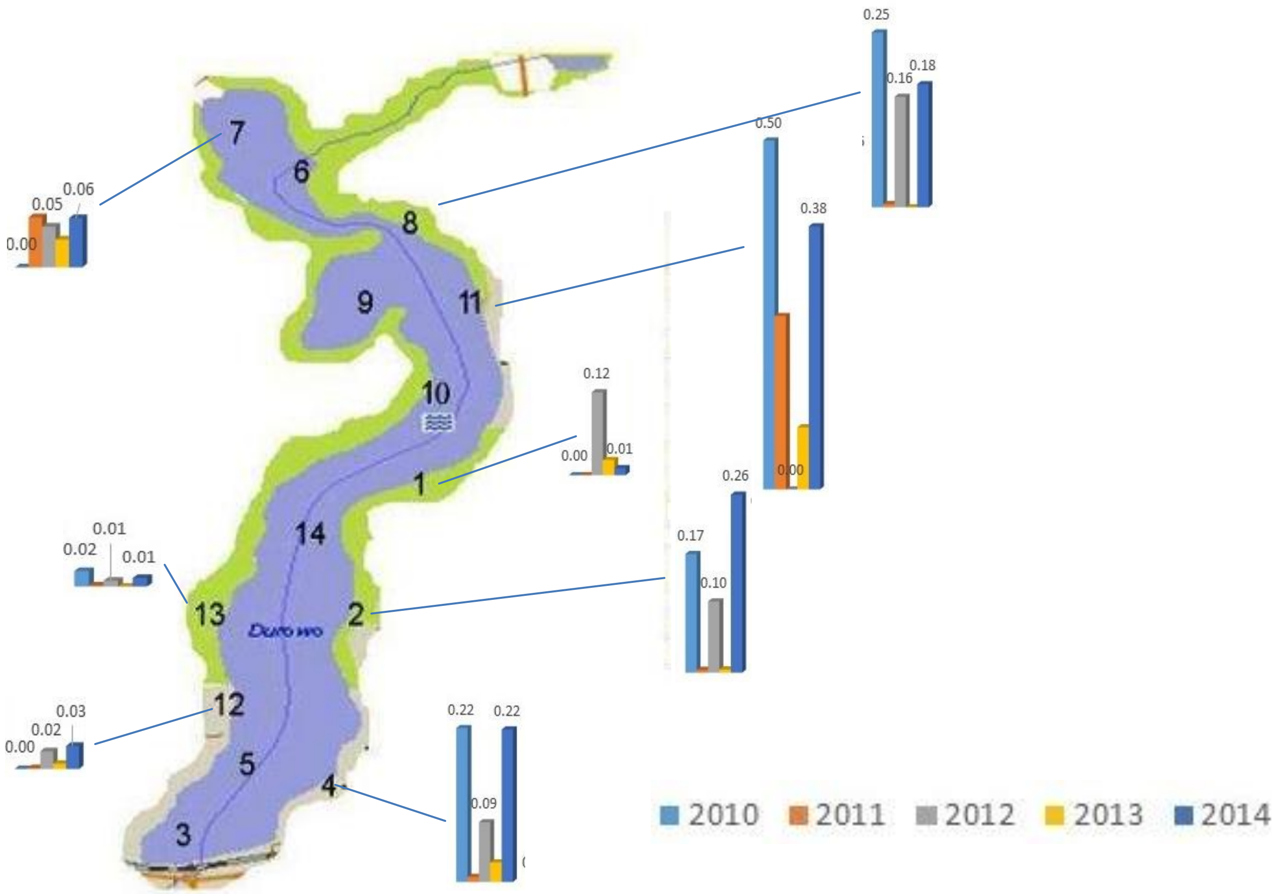


Graph 7. EPT Percentage in Durowskie Lake



Graph 8. EPT Chironomidae in Durowskie Lake

On the other hand, the analysis of Graph 9 allows us to observe an improvement in the presence of Ephemeroptera and Tricoptera taxa compared to 2011 in sites 2, 4, 8 and 11. Plecoptera species have not been recorded in Lake Durowskie. Batidae, a new family of Ephemeropterans, was found this year in sites 2 and 4.



Graph 9. ETP Chironomidae for Lake Durowskie 2010 – 2014

4. CONCLUSIONS

Our research for this year shows the highest number of taxa groups since the beginning of monitoring. In total, 34 taxa were identified, among those new groups such as Coleoptera. There is also an observable trend that the taxa number as well as species density are steadily increasing in the last five years.

According to the biodiversity indices, urban sites (2, 4) have the highest species concentration followed by forest sites with macrophytes (7, 11). In the case of urban sites, they seem to be healthier than expected despite of human disturbance. While Biomass of Chironomidae is quite high, there is also the presence of taxa with little and/or no pollution tolerance. Perhaps identifying the exact species of Tricoptera and Ephemeroptera would help elucidate the current state of these sites.

Overall the very low values of EPT in some sites (1, 7, 12, 13) may be considered as a sign of concern of the water quality in these areas. Therefore, it is necessary to confirm the main causes which could potentially be: proximity to inflow or urban areas.

The various indices reflect an improvement compared to the past three years which means that the overall quality of the water is improving gradually.

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6. Appendix

Table 1. Frequency of macroinvertebrates collected from the sampling stations in Lake Durowskie (1m²)

Taxon S	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plathelmintes														
Tricladida				+										
Nematoda							+							
Hirudinea:														
Erpobdella octooculata (L.)				+										
Glossiphonia complanata (L.)				+										
Helobdella stagnalis (L.)		+		+			+				+			
Hemiclepsis marginata (O.F. Müller)		+		+								+		
Piscicola geometria (L.)											+			
Oligochaeta		+		+			+					+		
Bivalvia:														
Anodonta anatina (L.)		+		+			+				+			
Unio pictorum (L.)	+													
Unio tumidus (L.)	+						+						+	
Pisidium sp.		+		+							+			
Gastropoda:														
Bitynia tentaculata (L.)	+	+		+			+				+			
Lymnaea peregra (O. F. Müller)							+							
Potamopyrgus antipodarum (E.A. Smith)							+						+	
Theodoxus fluvitatilis (L.)		+		+										
Viviparus contectus (Millet)				+			+							
Valvata piscinalis (O.F. Muller)		+												
Isopoda:														
Asellus aquaticus (L.)		+		+										
Megaloptera:														
Sialis lutaria (L.)				+										
Sialis fuliginosa Pictet				+										
Coleoptera														
Hydroporus sp.	+													
Ephemeroptera:														
Caenidae	+	+		+			+	+			+	+	+	
Beatidae		+		+										
Odonata:														
Coenagrioniidae		+		+										
Cordulidae							+							
Lestidae				+										
Trichoptera														
Apatania sp.		+		+				+						
Trichoptera sp.		+		+			+				+			
Ceratopogonidae				+			+	+						
Chaoboridae:														
Chaoborus flavicans (Meig.)			+		+	+			+	+				+
pupae of *Chaoborus sp.*					+		+			+				
Chironomidae														
Larvae	+	+		+			+	+	+		+	+	+	
Pupae		+		+									+	
Hydracarina														
Hydrachna sp.		+		+							+			
Hydracarina sp.		+		+			+	+			+			
TOTAL TAXA PER SITE	6	18	1	25	2	1	16	5	2	2	10	4	5	1

Table 2.Number of macroinvertebrates collected from the sampling stations in Lake Durowskie (1m²)

Taxon S	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plathelmintes														
Tricladida				69										
Nematoda							23							
Hirudinea:														
Erpobdella octooculata (L.)				69										
Glossiphonia complanata (L.)				115										
Helobdella stagnalis (L.)		273		414			644				546			
Hemiclepsis marginata (O.F. Müller)		390		69								49		
Piscicola geometria (L.)											39			
Oligochaeta		780		368			207					196		
Bivalvia:														
Anodonta anatina (L.)		39		23			23				78			
Unio pictorum (L.)	46													
Unio tumidus (L.)	23						23						98	
Pisidium sp.		312		115							39			
Gastropoda:														
Bitynia tentaculata (L.)	966	195		207			69				39			
Lymnaea peregra (O. F. Müller)							23							
Potamopyrgus antipodarum (E.A. Smith)							23						49	
Theodoxus fluvitatilis (L.)		468		184										
Viviparus contectus (Millet)				46			46							
Valvata piscinalis (O.F. Muller)		39												
Isopoda:														
Asselus aquaticus (L.)		2535		2254										
Megaloptera:														
Sialis lutaria (L.)				23										
Sialis fuliginosa Pictet				115										
Coleoptera														
Hydroporus sp.	23													
Ephemeroptera:														
Caenidae	46	156		322			23	78			936	49	49	
Beatidae		39		69										
Odonata:														
Coenagrioniidae		39		69										
Cordulidae							23							
Lestidae				23										
Trichoptera														
Apatania sp.		78		69				39						
Trichoptera sp.		334		391			23				78			
Ceratopogonidae				46			23	39						
Chaoboridae:														
Chaoborus flavicans (Meig.)			338		104	104			130	182				78
pupae of *Chaoborus sp.*					26		23		52	26				
Chironomidae														
Larvae	4577	2340		3657			782	663	364		2691	1666	4165	
Pupae		39		253									98	
Hydracarina														
Hydrachna sp.		78		207							39			
Hydracarina sp.		39		184			23	78			351			
TOTAL	5681	8173	338	9361	130	104	2001	897	546	208	4836	1960	4459	78

Table 3. Biomass of macroinvertebrates collected from the sampling stations in Lake Durowskie (1m²)

Taxon S	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Plathelmintes														
Tricladida				138										
Nematoda							46							
Hirudinea:														
Erpobdella octooculata (L.)				3404										
Glossiphonia complanata (L.)				2484										
Helobdella stagnalis (L.)		1911		2645			2093				2340			
Hemiclepsis marginata (O.F. Müller)		5187		207								98		
Piscicola geometria (L.)											156			
Oligochaeta		1014		655,5			345					441		
Bivalvia:														
Anodonta anatina (L.)		13845		22540			125580				55653			
Unio pictorum (L.)	246560													
Unio tumidus (L.)	38410						49680						947660	
Pisidium sp.		10764		19090							2067			
Gastropoda:														
Bitynia tentaculata (L.)	7245	15639		16652			6670				3354			
Lymnaea peregra (O. F. Müller)							276							
Potamopyrgus antipodarum (E.A. Smith)							138						196	
Theodoxus fluvitatilis (L.)		56862		28106										
Viviparus contectus (Millet)				46690			103500							
Valvata piscinalis (O.F. Muller)		390												
Isopoda:														
Asselus aquaticus (L.)		5499		4324										
Megaloptera:														
Sialis lutaria (L.)				345										
Sialis fuliginosa Pictet				1725										
Coleoptera														
Hydroporus sp.	23													
Ephemeroptera:														
Caenidae	46	273		414			23	156			5950	49	49	
Beatidae		39		115										
Odonata:														
Coenagrioniidae		1404		2300										
Cordulidae							2208							
Lestidae				552										
Trichoptera														
Apatania sp.		858		2369				275						
Trichoptera sp.		390		25197			230				234			
Ceratopogonidae				46			23	39						
Chaoboridae:														
Chaoborus flavicans (Meig.)			1326		572	494			572	754				390
pupae of *Chaoborus sp.*					104		23		182	104				
Chironomidae														
Larvae	14766	11856		15157			8924	3549	8632		37518	5880	12985	
Pupae		312		1863									1568	
Hydracarina														
Hydrachna sp.		195		557							507			
Hydracarina sp.		78		69			92	39			117			
TOTAL	307050	126516	1326	197645	676	494	299851	4058	9386	858	107896	6468	962458	390

Table 4. Simpson Biodiversity index 2010-2014 (Only littoral stations)

SIMPSON INDEX								
	1	**2**	**4**	**7**	**8**	**11**	**12**	**13**
2010	0.56	0.86	0.66	0.95	0.86	0.76	0.41	0.32
2011	0.4758	0.283	0.2714	0.1855	0.2453	0.263	0.4021	0.4859
2012	0.2849	0.438	0.4771	0.4596	0.7885	0.8304	0.5555	0.3952
2013	0.3379	0.04444	0.3293	0.7042	0.5193	0.3706	0.1813	0.05217
2014	0.3219	0.8018	0.7797	0.7303	0.4353	0.6342	0.2664	0.1263

Table 5. EPT Chronomidae 2010-2014 (Only littoral stations)

EPT CHIRONOMIDAE								
	1	**2**	**4**	**7**	**8**	**11**	**12**	**13**
2010	0	0.17	0.22	0	0.25	0.5	0	0.02
2011	0	0.004	0.0072	0.06	0.0045	0.2484	0.001	0.0013
2012	0.1182	0.102	0.0853	0.0488	0.1579	0	0.0222	0.0075
2013	0.0217	0.0046	0.0278	0.0333	0	0.0889	0.0066	0
2014	0.01	0.255	0.218	0.059	0.176	0.377	0.029	0.011

Table 6. Shannon-Wiener Biodiversity index 2010-2014 (Only littoral stations)

SHANNON-WIENER INDEX								
	1	**2**	**4**	**7**	**8**	**11**	**12**	**13**
2010	0.34	0.72	0.71	0.45	0.52	0.59	0.25	0.25
2011	0.8866	1.728	1.8359	1.9519	1.6861	1.4328	1.2291	0.9217
2012	0.6331	1.086	1.114	1.184	1.823	1.905	1.231	0.6877
2013	0.9375	0.1439	0.7766	1.934	1.069	0.9405	0.5253	0.148
2014	0.598	2.0297	2.1202	1.7342	0.9208	1.3693	0.5528	0.3307