ECOLOGICAL STATE OF LAKE DUROWSKIE BASED ON PHYSICO-CHEMICAL PROPERTIES AND ALGAE IN JULY 2014

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Introduction

Lake Durowskie is the identity of the town of Wagrowiec and also the main attraction for tourists and locals. There is a long history of events which led to an increased level of contaminants in this lake. The direct disposal of sewage into the lake until 1999 is among the most important. Agricultural run-off, carrying loads of fertilizers, herbicides and pesticides, brought additional nutrients such as phosphates and nitrates into the Lake. The ultimate outcome of the increased level of contaminants in the lake appeared in the form of cyanobacteria bloom, which invaded the whole Lake

The cyanobacteria bloom in Lake Durowskie brought changes to the properties of the water, reduced transparency of the water and the high pH values made the lake turn into a graveyard for fish and other aquatic organisms. Furthermore, the beaches around the lake were closed, because they failed to fulfil hygienic requirements due to abundance of toxic cyanobacteria. As a result, tourism activities around the lake also stopped.

The local government of Wagrowiec, which is keen on modernizing the town and promoting the tourism industry, decided to initiate the Lake restoration project in 2009. The important measures that have been taken so far include installation of aerators for the oxygenation of hypolimnion, addition of Iron sulphate (PIX) to sediment phosphorus and introduction of pike and pike-perch for biomanipulation.

In addition to this the local Government engaged Adam Mickiewicz University from Poznan for periodic monitoring of the Lake to assess the effectiveness of restoration measures. The monitoring process is taking into consideration many aspects of lake quality assessment including hydrology, physic-chemical parameters, algae, macrophytes and micro-invertebrates communities etc.

This report aims to contribute to the monitoring of Lake Dubrowskie, to assess the present ecological state and its changes during the last four years based on physico-chemical parameters of the water, phytoplankton analysis and phytobenthos community.

Material and Methods

Study area

The study was conducted in Lake Dubrowskie, situated in Wielkopolska Region (central Poland) by the city of Wangrowiec between June 29 and July 9, 2014.

The geographic coordinates of Lake Durowskie are N 52°49’6’’ and E 17°12’1’’. This lake is arelatively shallow postglacial lake (14,6m depth) with the whole catchment area measuring 236.1 km^2 (table 1).

Lake Morphometry	
Surface	143.7 ha
Volume	11,322,900 m^3
Maximum depth	14.6 m
Average depth	7.9 m
Main tributary	Struga Golaniecka
Surface of the entire catchment area	236.1 km^2
Surface of the direct catchment area	1.581 ha
Share of agricultural area	58.26 %
Share of forests	33.52 %
Urban area	8.25 %

Table 1 Morphometry of Lake Wagrowiec

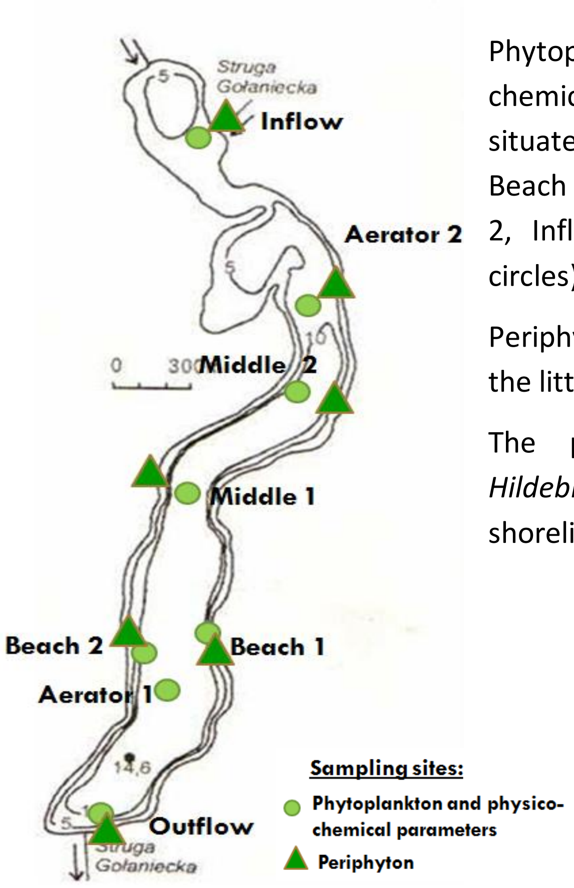

Figure 1 Sampling stations

Phytoplankton and water samples for physico-chemical parameters were taken from 8 stations, situated in different parts of the lake: Beach 1, Beach 2, Aerator 1, Aerator 2, Middle 1, Middle 2, Inflow and Outflow of the lake (fig.1, in circles).

Periphyton was sampled in 8 stations situated in the littoral zone of the lake (fig.1, in triangles).

The presence or absence of red algae *Hildebrandia rivularis* was observed along the shoreline during all sampling period.

Methods

Physico-chemical parameters

We measured basic physico-chemical parameters (temperature, conductivity, concentration of oxygen, water saturation with oxygen, electrical conductivity and pH level) at the stations in the depth profile, using YSI 556 Multi-Parameter Water Quality Meter and a Hanna Combo-Meter. Water transparency was estimated using a Secchi disk.

Water samples for chlorophile *a* analysis were collected at the same sites, on the surface and at a depth of 1 to 2 meters. Later, they were processed in the laboratory according to ISO Standards (Elbanowska et al, 1999).

The trophic state of the lake was estimated using Carlson's Trophic State Index (TSI) based on Chlorophil *a* and a Secchi disk transparency (Carlson and Simpson 1996), according to the following formulas:

$$TSIM(Chl\ a) = 9.81\ ln(Chla) + 30.6;$$
$$TSIM(Sd) = 60 - 14.41\ ln(Sd);$$

Where Chl a is Chlorophyll a (µg/L) and Sd is transparency (m)

Water quality class was estimated based on Chlorophyll *a*, oxygen concentration, conductivity and Secchi disc transparency values according to the Ordinance of Enviromental Ministery of Poland (2008) which is compatible with the Water Framework Directive (Rozporządzenia Ministra Środowiska z dnia 9 listopada 2011 r. w sprawie sposobu klasyfikacji stanu jednolitych części wód powierzchniowych oraz środowiskowych norm jakości dla substancji priorytetowych (Dz. U. 2011 r. Nr 257, poz. 1545)

Phytoplankton analysis

Phytoplankton samples were collected from the surface water at Inflow, beach 1 and 2, Outflow; and from 0, 1 and 2 meters depth in all Middle and Aerator stations. The samples were concentrated using a plankton net. Taxonomical analysis was performed during the same day of sampling. Biomass of the algae was estimated based on cell counts and specific volumes, according to Rott, 1981.

Trophic status of the lake was estimated using the mixed index of Nygaard (Nygaard, 1949), following the equation:

$$Mixed\ index\ of\ Nygaard = \frac{Cyanobacteria + Chlorococcales + Centric\ diatoms + Euglenoids}{Desmids}$$

The Jaccard Index was used to compare the similarity and diversity of the number of species between the years. We calculated it according to the formula (Jaccard, 1912):

$$J = \frac{c}{a + b - c} \times 100\ \%,$$

Where J is index of Jaccard (percentage of species in common)
a – number of species in one year
b – number of species in another year
c – number of species in common

In order to measure evenness and diversity of the species between different sites we used Shannon-Wiener and Evenness Indices according to Shaw (2003):

$$H' = -\ {}_{i=1}^{s} p_i \log(p_i);$$

$$E = \frac{-\ \ p_i \times \log(p)}{\log(S)};$$

Where H' is the Shannon index, p_i – percentage of individuals of certain species in the community; E – evenness (equitability); S – number of species in the community.

Periphyton analysis

Periphyton species were collected from submerged stones in the 8 stations using a brush. The samples were conserved using Lugol solution and the species were identified in the laboratory.

Van Dam's ecological indicator values were used to estimate oxygen saturation, trophy and alkalinity in lake Durowskie (van Dam, 1994).

The diatom index was used to estimate the ecological state of the lake. In order to calculate the diatom index, we first had to calculate the trophy index (TJ), the index of referential species (pGR) and their standardization, according to formulas:

$$TJ = \frac{(TJi \times wTJi \times Li)}{(wTJi \times Li)};$$

Where TJi is the sensitivity of species for the trophic state;
wTJi - range of the tolerance of the algal species;
Li - number of specimens of the determined species divided by the number of all identified individuals in the sample

$$pGR = \frac{NB - (NC + ND)}{NB + NC + ND};$$

Where pGR is the index of referential species;

NB is number of referential species for all lakes;

NC - number of referential species for deep lakes and of degradation species in shallow lakes;

ND - number of degradation species for both kinds of lakes;

$$ZTJ = 1 - ((TJ - 1) \times 0.25))$$
$$ZpGR = \quad pGR + 1 \quad \times 0.5$$

Diatom Index is calculated according to the equation:

$$DI = \frac{ZTJ + ZpGR}{2};$$

The assigned value corresponds to ecological state of the lake according to the table 2.

DI	Ecological state
>0,83	Very good
0,55	Good
0,30	Moderate
0,15	Poor
<0,15	Bad

Table 2 Ecological state according to the Diatom index (DI)

Dominating species in both groups of algae were defined as those which exceeded 10% of the total number of individuals.

Results and discussion

Physico-chemical parameters

The patterns of temperature and dissolved oxygen in the vertical profile were similar (fig. 2). In most of the stations there is a drop in the temperature (from 20 to 11°C) around 4-6 m from the surface. This thermocline corresponds to the metalimnion and the amount of dissolved oxygen decreases abruptly at this point.

The Epilimnion (first strata in the water column from the surface towards the thermocline) is characterized by the highest temperature (around 20 °C) as well as the highest amount of dissolved oxygen (6-10 mg/L) whereas the Hypolimnion (>6 m depth) is characterized by having low amounts of oxygen available (<2 mg/L). However, it is important to point out that even in the deepest point of the lake (fig. 2-right, Aerator 1) there is at least 1 mg/L of dissolved oxygen. This amount is enough to help prevent the orthophosphates, which are abundant in the sediment, from moving up the water column. In this way, fewer nutrients are available for the phytoplankton to consume and grow and this contributes to higher transparency of the water.

The inflow of the lake, (Struga Gołaniecka river) has a higher amount of dissolved oxygen compared to the average amounts from the other sampling sites.

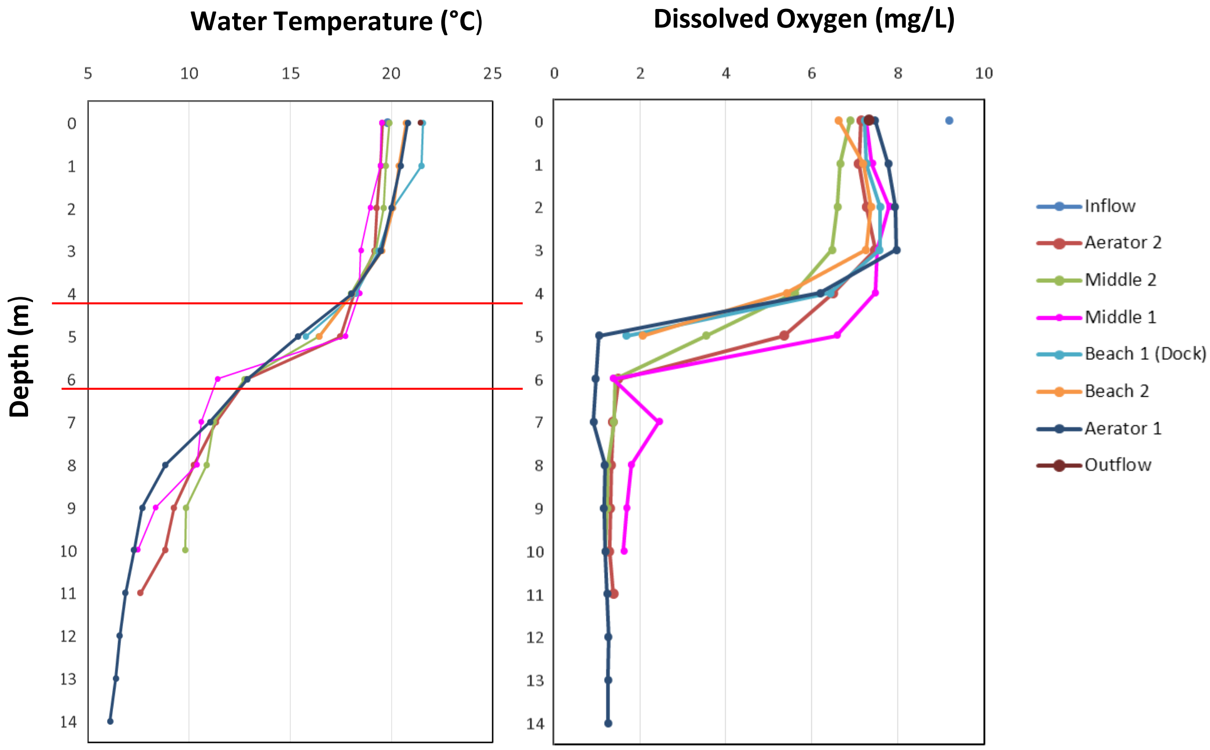

Fig 2. Vertical profile of sampling sites in Lake Durowskie: (left) Water temperature °C, (right) Dissolved oxygen (mg/L).

Overall, the pH of the lake varied between 7,3 and 8,5 and decreased deeper in the lake (fig. 3). The latter is likely due to the predominance of respiration over photosynthesis in the deeper layers of the lake. Furthermore, higher values of pH in the epilimnion can be due to the removal of CO_2 via photosynthesis by the greater amount of algae living in the surface.

The conductivity is high and varies from 652 µS/cm to 730 µS/cm. If the water displays a conductivity above 1.200 µS/cm, it no longer comes under the category of freshwater. For all the sites in the lake there is an increase of the conductivity from the epilimnion to the hypolimnion (fig. 3). This pattern suggests that the sediments at the bottom of the lake are contributing the most to the ions available in the water column instead of other factors (e.g., surface run-off). Furthermore, the fact that the inflow has the lowest conductivity value supports this idea.

The average water transparency in Lake Durowskie is 1.4 m (fig.4). However, the transparency for the Inflow is 0,6 m less. This difference is due to the lower depth of this sampling site rather than a change in the actual transparency of the water.

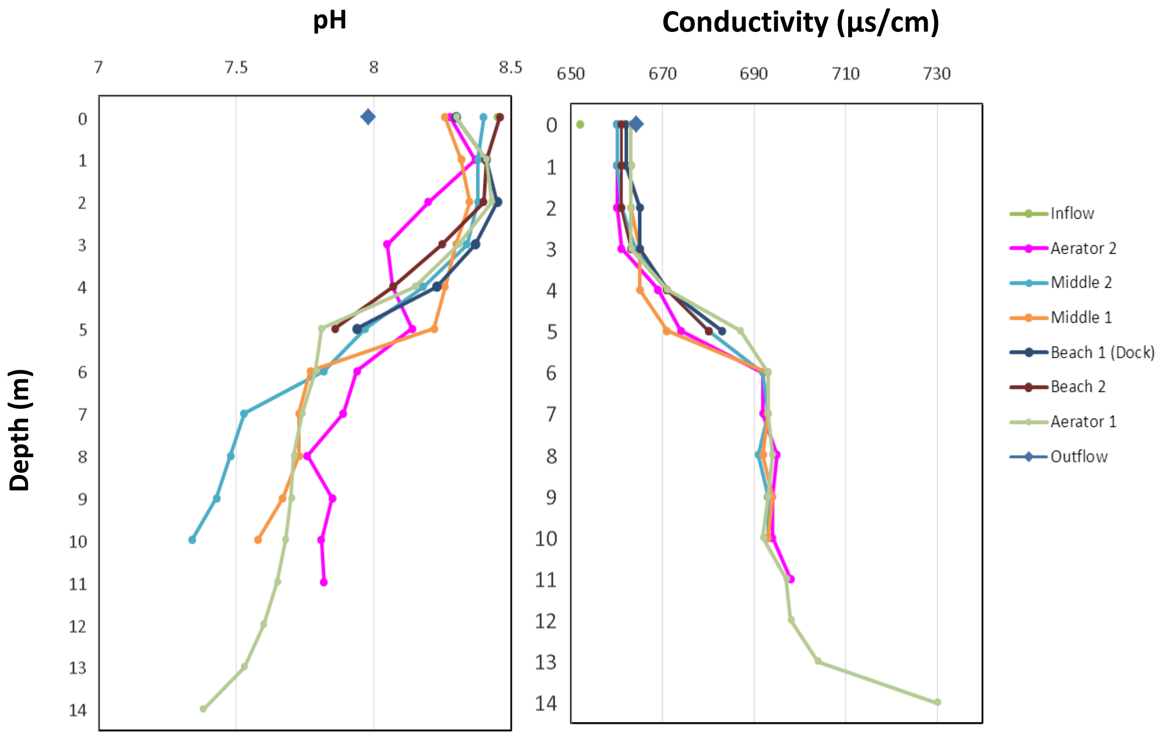

Fig 3. Vertical profile of sampling sites in Lake Durowskie: (left) pH, (right) Conductivity (µs/cm).

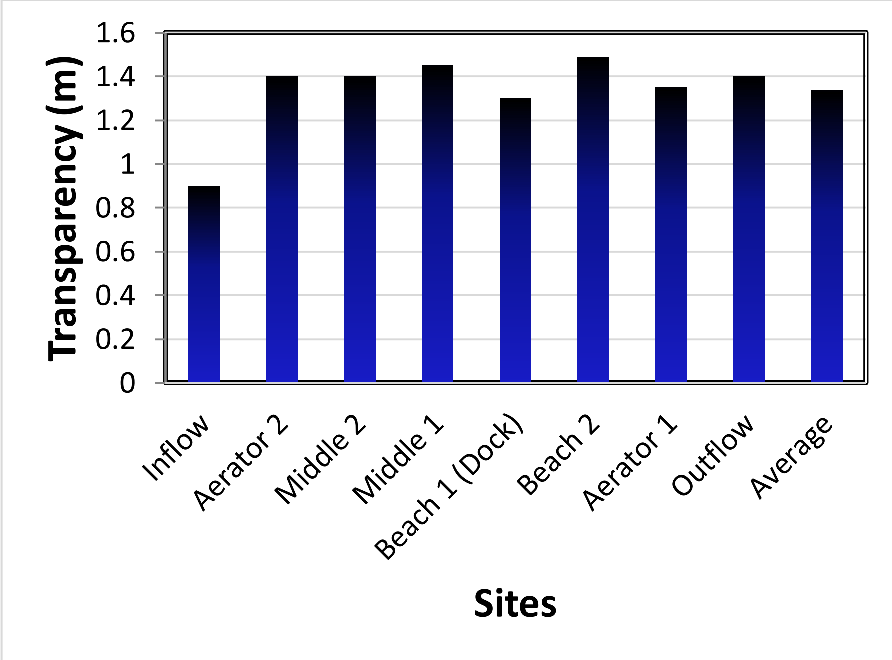

Fig 4. Water transparency (m) in different sites of Lake Durowskie.

The trophic state index (TSI), based on both the Secchi disk (SD) and the Chorophyll *a* pigments (CHL), indicates that the state of the lake is eutrophic with a localized hypereutrophic situation in the Inflow of the lake (fig. 5).

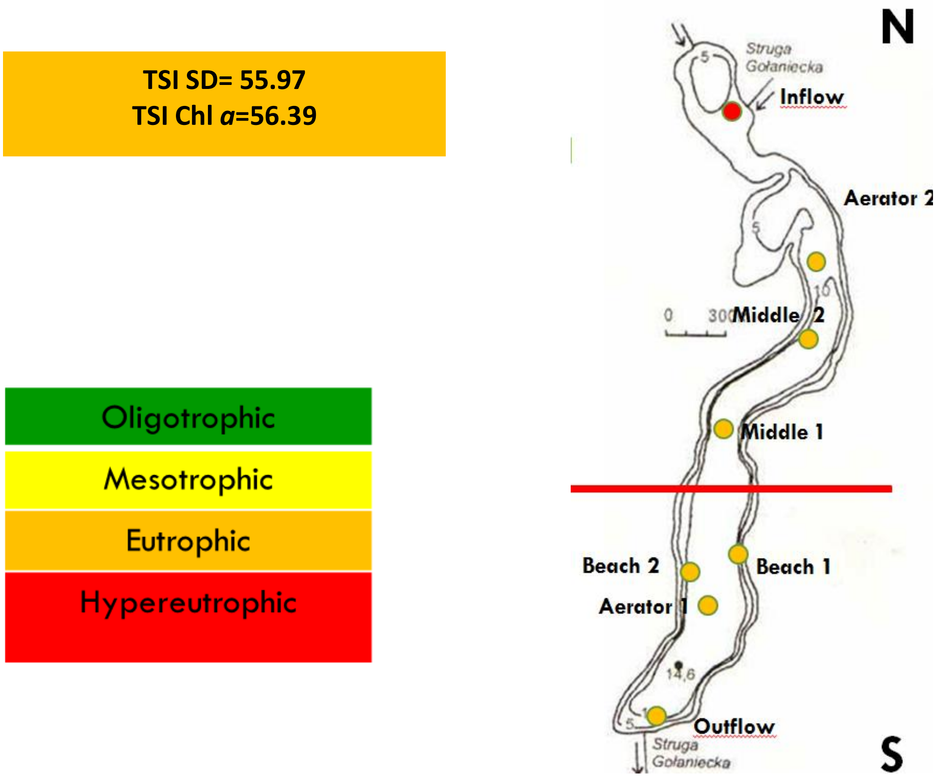

Fig 5. Trophic state index in different sites of lake Durowskie.

According to the Ordinance of Enviromental Ministery of Poland (2008) which is compatible with the Water Framework Directive, the parameters conductivity and transparency are still classified below good (table 3). Therefore, more efforts need to be done in order to improve these aspects.

Table 3. Classification of Lake Durowskie under the Water Framework Directive

Parameter	Value	Classification
Chlorophyll *a*	≈ 11.65 µg/L	Good (II class)
Oxygen concentration	≈ 7.40 mg/L	Good
Conductivity	≈ 660.63 µS/cm	Below good
Transparency (Secchi disc)	≈ 1.33 m	Below good

The different measured parameters have varied across the years. The Chlorophyll *a* shows an increase since 2012 onwards, the surface pH is being alkaline since 2011, around the same value (>8) and Electric conductivity, transparency and dissolved oxygen show a more fluctuating trend (Table 4)

Table 4. Values for different parameters across the years (2011-2014)

Parameter	2011	2012	2013	2014
Chlorophyll *a*	≈ 14.00 µg/L	≈ 2.20 µg/L	≈ 8.45 µg/L	≈ 11.65 µg/L
Electric conductivity	≈ 400.00 µS/cm	≈648.20 µS/cm	≈601.38 µS/cm	≈ 660.63 µS/cm
Surface pH	≈ 8.70	≈8.87	≈8.13	≈ 8.30
SD (Transparency)	≈ 2.00 m	≈ 0.88 m	≈1.68 m	≈ 1.33 m
Dissolved oxygen (surface)	≈ 10.00 mg/L	≈ 13.50 mg/L	≈5.47 mg/L	≈ 7.40 mg/L

Phytoplankton

Number of species

In total we found 73 species of phytoplankton during the laboratory analysis (Fig. 6). The Number of species in 2014 remained at a similar level as in 2013. There was a continuous increase in the number of species between 2008 and 2011 with a drop in 2012. Because most algae prefer warm and clean water , such a decrease could be due to the exceptionally cold and rainy weather during the time the sampling took place that year (June).

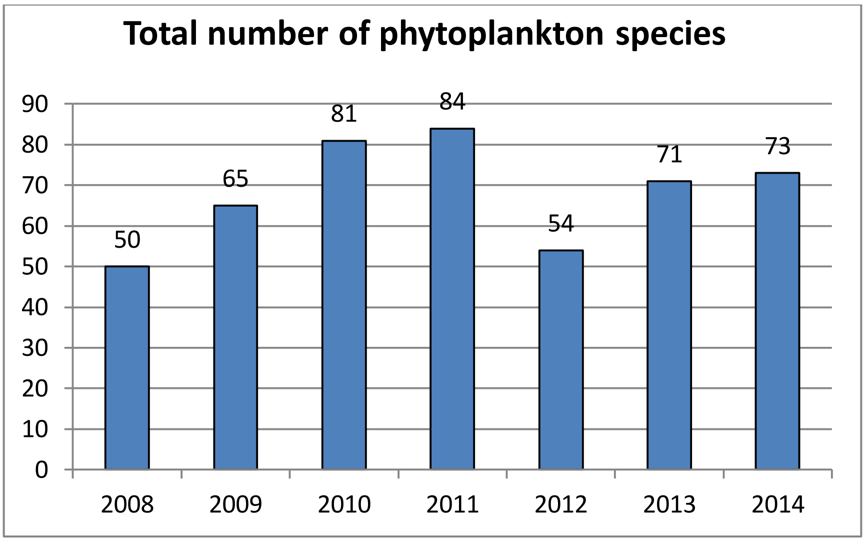

Figure 6. Total number of phytoplankton species in 2008-2014.

The total number of phytoplankton species differed between stations (Fig. 7). The highest number of phytoplankton appeared in the site at Aerator 2 (Fig. 7). This number could be due to the fact that water in this site has the highest amount of dissolved oxygen and that this kind of environment is preferred by most algae. Another reason is that Aerator 2 is located close to the inflow, which brings a high number of additional species along with the river water. The lowest number we found was on both Beach 1 and Beach 2.

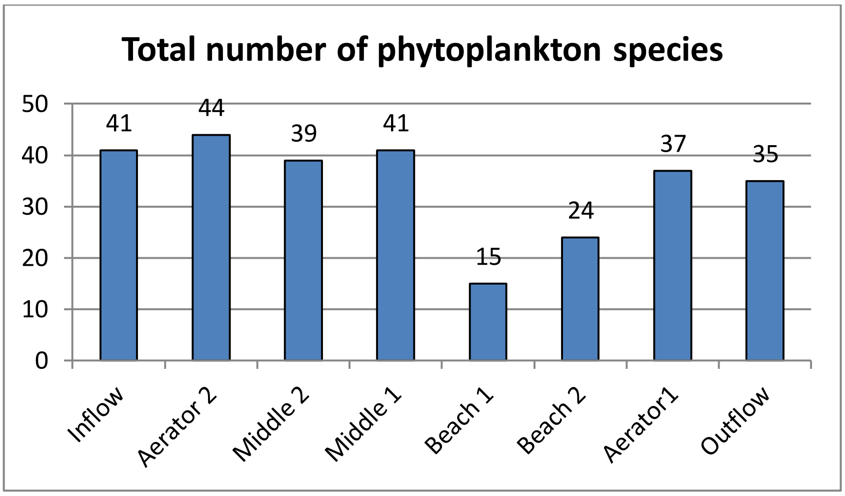

Figure 7 Total number of phytoplankton species in each site.

Dominance of Algae Groups

Chrysophyce was a dominant group of algae in all stations, except for the inflow(Fig. 8). The most abundant species was *Dinobryon divergens*. At the inflow, Cyanobacteria were eudominating, with high numbers of *Limnothrix redekei* (70%) and *Aphanizomenon flos-aquae* (13%) (Table 5). In the rest of the stations this group occurred only in small quantities. Lake Kobyleckie which is located above Lake Durowskie is very rich in nutrients. Phosphorus and nitrogen flow with the Struga Gołaniecka stream to Lake Durowskie. The reason for the high abundance at the inflow is due to Cyanobacterias preference for nutrient rich waters. Blooms of species from this group might be dangerous for human health because of their toxicity. Moreover, high abundance of Cyanobacteria is characteristic of the eutrophic and hypertrophic states of the water.

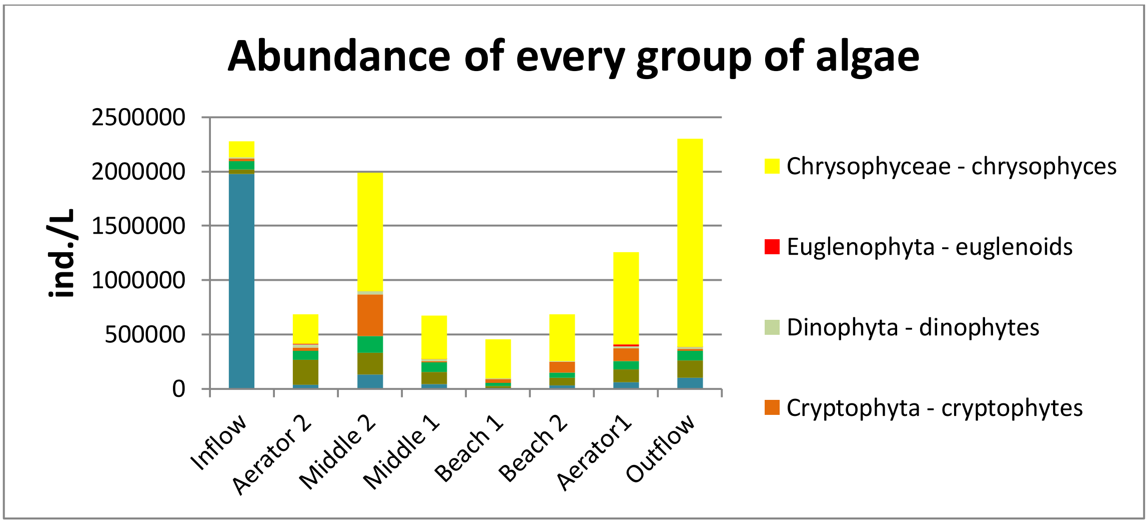

Figure 8 Abundance of every group of algae [ind./L].

Table 2 Dominant species [%] of phytoplankton in the epilimnion layer (0-2m) of Lake Durowskie

Depth	0m	0-2m	0-2m	0-2m	0-2m	0m	0m	0m
Station	**Infl**	**A2**	**M2**	**M1**	**A1**	**Outfl**	**B1**	**B2**
Aphanizomenon flos-aquae (L.) Ralfs	13%	0%	0%	0%	0%	0%	0%	0%
Cryptomonas marssonii Skuja	0%	0%	13%	0%	2%	0%	0%	13%
Dinobryon divergens Imhof	0%	37%	61%	63%	67%	8%	77%	1%
Fragilaria crotonensis Kitton	0%	13%	0%	3%	1%	2%	0%	0%
Limnothrix redekei (Van Goor) Meffert	70%	4%	6%	4%	4%	3%	0%	3%

Biomass of Algae Groups

We calculated the biomass of every group of algae sampled from each study site. As shown in figure 9, high abundance was not necessarily reflected in high biomass. Dinophytes which were not very noticeable as individuals, contributed significantly to the total biomass of phytoplankton in different sites. This can be explained by the large cells of this group of Algae. On the other hand, chrysophyce are very numerous as individuals, but after conversion of the number into biomass their significance was reduced. This is caused by the small biomass of a chrysophyce cell.

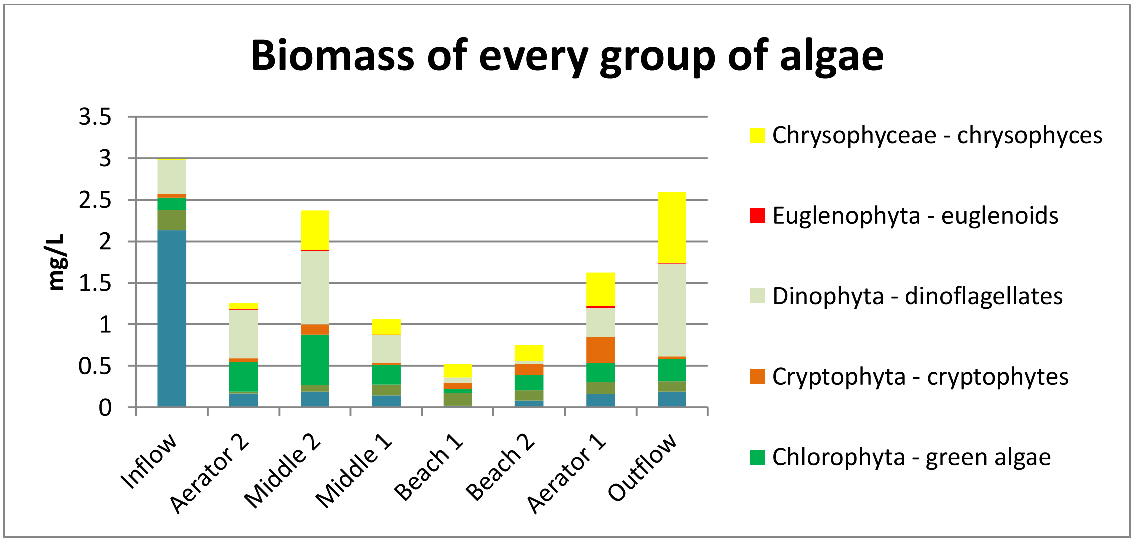

Figure 9 Biomass of every group of algae [mg/L].

Jaccard Index

We calculated the biomass of every group of algae sampled. Table 6 analyses the results of Jaccard Index and indicates how many species in percentage are common in the previous years. According to this we can see that 52% of the species from 2013 re-emerged in 2014.

Table 6 Jaccard Index

YEAR	2009	2010	2011	2012	2013	2014
2008	84	51	43	33	40	52
2009	-	48	28	20	29	35
2010	-	-	42	42	62	47
2011	-	-	-	34	58	47
2012	-	-	-	-	77	49
2013	-	-	-	-	-	52

Nygaard`s Mixed Index

According to the Nygaard's Mixed Index, most stations were in a hypertrophic state (table 7). Only in the inflow we observed Eutrophic state. It is more likely that this is due to higher number of centric diatoms which are more abundant in the river stream that in the lake.

Legend	Result
Dystrophic	0 - 0.3
Oligotrophic	< 1.0
Mesotrophic	1.0 - 2.5
Eutrophic	3 - 5
Hypertrophic	5 - 43

Table 7 The mixed index of Nygaard based on the number of species from all sorts taxonomical groups of algae.

Station	2008	2009	2010	2011	2012	2013	2014	Trophyc State
Aerator 1	9,67	16	8,3	9	7	8	9	Hypertrophy
Aerator 2	-	26	11,5	5	8	14	20	Hypertrophy
Middle 1	-	9	12,5	13	3	5,5	11	Hypertrophy
Middle 2	-	-	8,3	18	9	7,5	20	Hypertrophy
Inflow	-	-	1,8	17	9	19	3,75	Eutrophy
Outflow	-	-	6,5	5	-	12	8	Hypertrophy
North	-	-	11,5	5,3	-	-	-	Hypertrophy
Beach 1	-	-	-	3	9	7	5	Hypertrophy
Beach 2	-	-	-	-	5	6	10	Hypertrophy

Evenness and Shannon-Weaver Index

The Highest diversity was noticed on station Areator 2, which is likely due to its geographical position, allowing it to encompass both the species of the river and the lake, as well as the species of the shallow northern part of the lake and the deeper part in the south (fig.10). It could also be related to good oxygenation of the water. The Lowest diversity was observed at station Beach 1, which was possibly due to high anthropogenic pressure such as erosion.

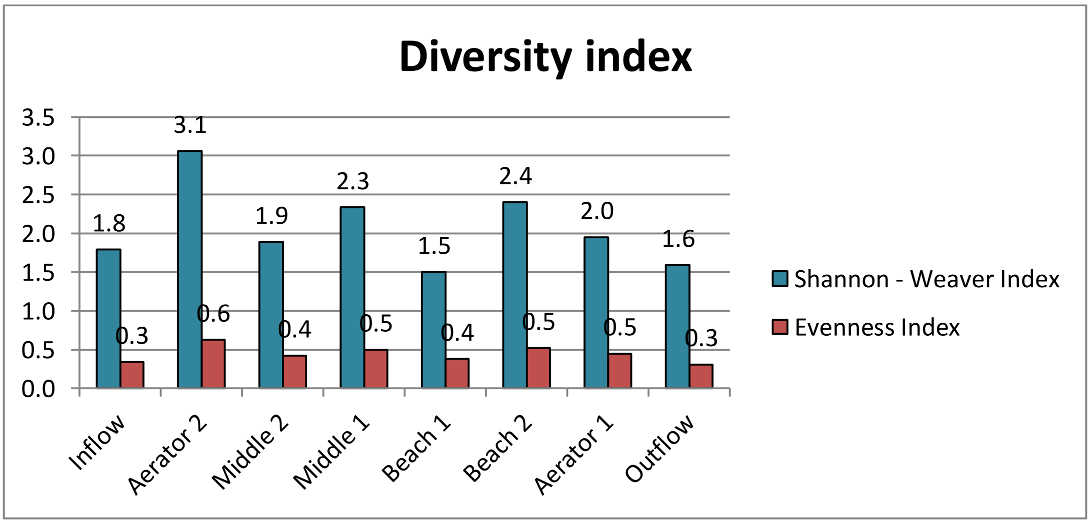

Figure 8 Evenenness and Shannon-Weaver Index.

Periphyton

Dominant species

One hundred and ten species of periphyton were found in Lake Durowskie, its inflow and outflow. Different species dominated every site of sampling, with the exception of *Achnanthes minutissima,* which was dominating in six out of nine sites (table 8). *Gomphonema olivaceum* is the dominating species at two sites (site 4 and 5), and the other six species were dominating at only one out of eight sites.

Two sites had high evenness of species distribution (site 2 and 6), as there were three dominant species. Diversity at site 1 was very low, as a single species, *Achnantes minutisima*, was dominating (>45%).

Table 8. Dominating periphyton species. Values presented in % of the total number of species.

	Site							
Species	1	2	3	4	5	6	7	8
Achnanthes minutissima Kütz	45.36	14.11	23.96	27.47		11.39	13.23	
Achnanthes minutissima var. affinis (Grun.) Lange-Bertalot						10.89		
Amphora pediculus (Kütz.) Grun.			20.22					
Cymbella affinis Kütz.		11.19						
Cymbella minuta Hilse						15.84		
Cocconeis pediculus Ehr.		10.67						
Cocconeis placentula Ehr.								16.52
Gomphonema olivaceum (Horn.) Breb.				14.66	21.54			

Figure 9 *Achnanthes minutissima*

Achnanthes minutissima Kütz is a hypereutraphentic species, therefore it can easily adapt to any trophic conditions. This is probably the reason why it was abundant in the majority of the sites (fig.9). However, it requires high oxygen saturation (>75%) and circumneutral pH (van Dam et al, 1994).

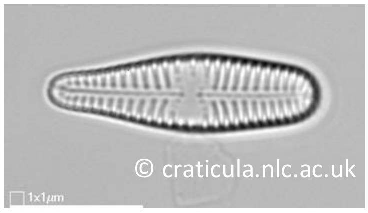

figure 10 *Gomphonema olivaceum*

Gomphonema olivaceum (Horn.) Breb. was a dominant species at sites 4 and 5 (fig.10). It exclusively occurs at pH >7, and prefers high oxygen saturation. *Gomphonema olivaceum* is a eutraphentic species (van Dam et al, 1994).

figure 11 *Achnanthes minutissima var. affinis*

Achnanthes minutissima var. affinis (Grun.) Lange-Bertalot was an eudominant species at the site 6. It is an alkaphilous species (fig.11)(van Dam et al, 1994). It‘s preferences of oxygen concentration and eutrophic state of water are not known.

Amphora pediculus (Kütz.) Grun. is an eutraphentic species, which prefers alkaline waters. However, it also requires high oxygenation (>75%).

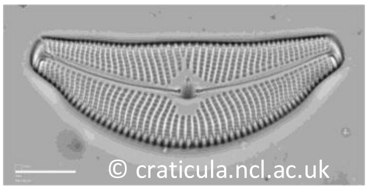

figure 12 *Cymbella affinis*

Cymbella affinis Kütz. (fig.12) was found to be the dominant species at site 2. It is an alcaphilous and eutraphenic species, with a preference for waters highly saturated in oxygena.

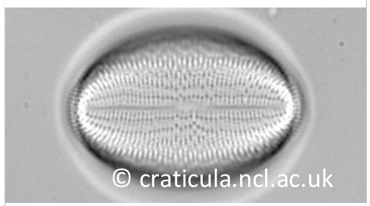

figure 13 *Cocconeis pediculus*

Cymbella minuta Hilse occurs in lakes with neutral pH. It is a common species of Central Europe. *Cymbella minuta* is not a sensitive species to habitat alteration, as it also occurs in antropogenicaly disturbed areas.

Cocconeis pediculus Ehr. is an eutraphentic species, preferring high oxygen saturation (>75%) and alcalinic waters (fig.13)(van Dam et al, 1994).

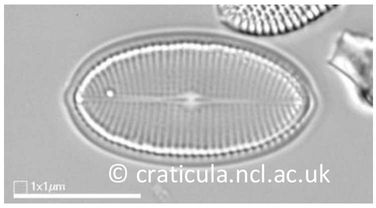

figure 14 *Cocconeis placentula*

Cocconeis placentula Ehr. requires only moderate levels of dissolved oxygen (>50%)(fig.14). It is eutraphentic and alcanophilous. *Cocconeis placentula* is the only dominating species at site 8, which is close to the inflow of the lake.

Van Dam's Ecological indicators

Some periphytic algae species are restricted to certain environmental conditions, which makes them good indicators of the state of the water body where they live. Based on the ecological indicator values of freshwater diatoms by van Dam et al, 1994 we estimated the conditions of oxygen saturation, trophy and alkalinity in the lake Durowskie.

High number of species found in Lake Durowskie indicates very oxygenated water (47 out of 74 species prefers saturation higher than 75-100%) (fig.15). High saturation of oxygen in the shoreline of Lake Durowskie is likely due to motor boat activities and as a result of increased waving.

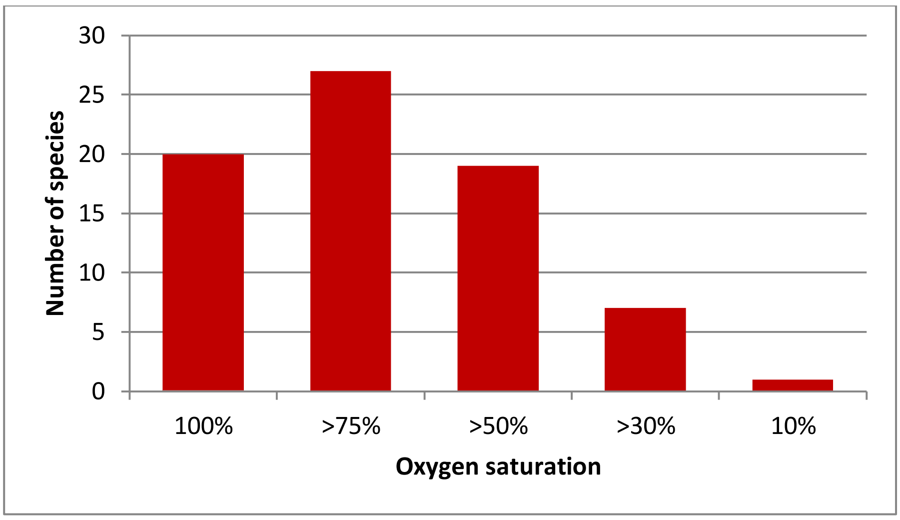

Figure 15 Oxygen saturation based on Van Dam's indicators

The trophic state of Lake Durowskie is eutrophic according to the Van Dam's indicator species. A High number of species found are restricted to eutrophic waters (34 out of 80)(fig.16). Some of the species (n=13) indicate meso-eutrophic state; and some are generalists and therefore bad indicators of the trophic state (n=15).

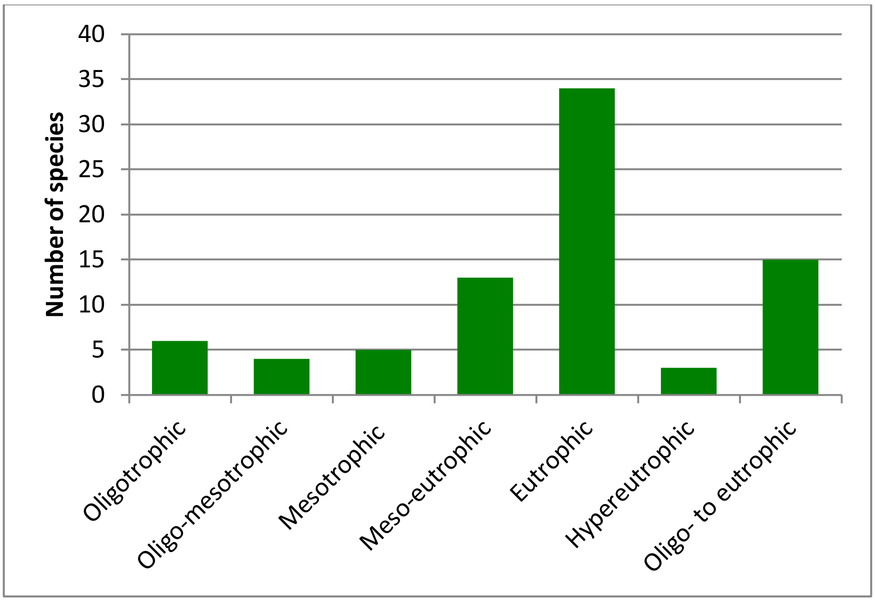

figure 16 Trophic state based on Van Dam's indicators

Periphyton species indicate alkaline water of the lake (fig. 17). 54 out of 84 species were alkaphilous, mainly occurring at the pH>7. This is not surprising as Lake Durowskie is eutrophic, and eutrophy is characterised by high alkalinity.

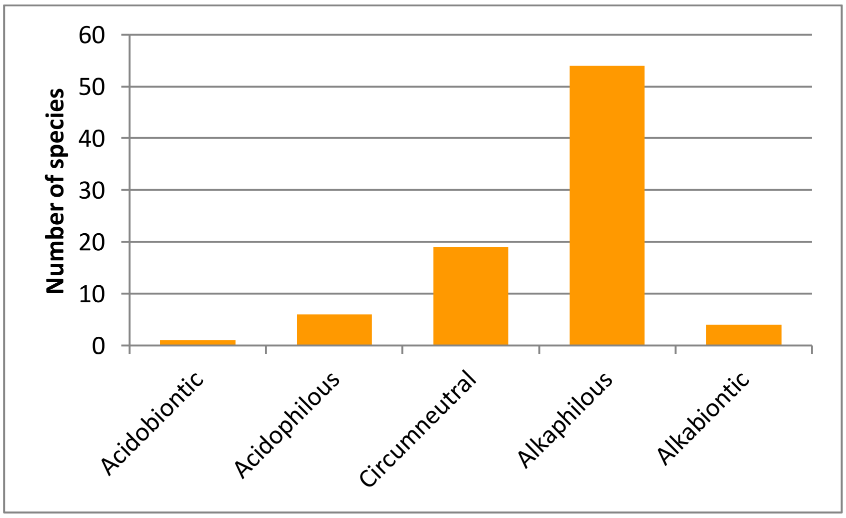

figure 17 Alkalinity based on Van Dam's indicators

Diatom index

Diatoms are a group of algae, which have a shell made of silica (fig.18). Many species of diatoms are sensitive to the trophic state of the water; therefore this group is used to calculate a diatom index to estimate the ecological state of water bodies.

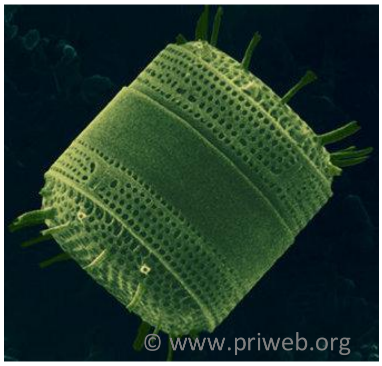

figure 18. Diatom cell in its silica frustule

The ecological state of Lake Durowskie varied from bad to moderate within different stations (fig.19). In some stations (i.e. 6, 7, 9) the state had improved since 2010-2011. However, in other stations, the ecological state had worsened. This is especially noteworthy for station 3, where the quality had been deteriorating annually, and this year it was poor for the first time during the 5 years of monitoring.

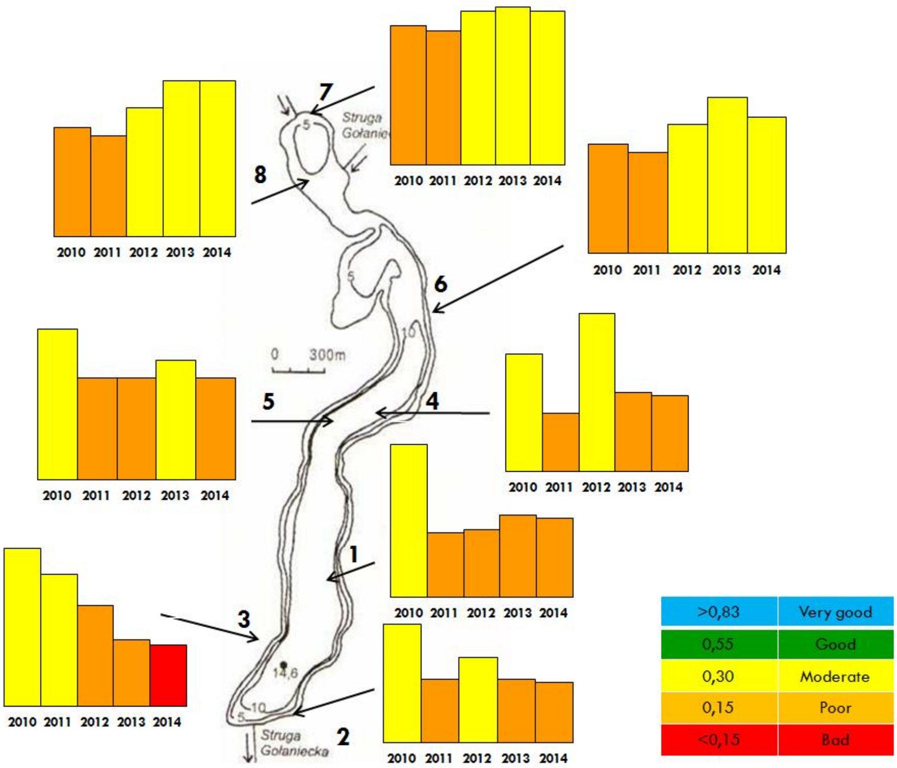

figure 19 Ecological state of the lake in different stations based on Diatom Index

We noticed that the ecological state of the lake differed geographically. Taking into account the average values for Northern (stations 4,5,6,7,8) and Southern stations (stations 1,2,3), we could see that the ecological state is better in the North, when compared to the South (Fig.20). We hypothesised that this could be due to higher anthropogenic pressure in the littoral zone in the Southern part of the lake. The town of Wagrowiec is situated in the southern part; meanwhile forest covers most of the shores in the north. The coverage of macrophytes is less disturbed here, which results in higher absorbtion of nutrients by water plants. This might be the reason why the ecological state of the Northern shores is better than of the South.

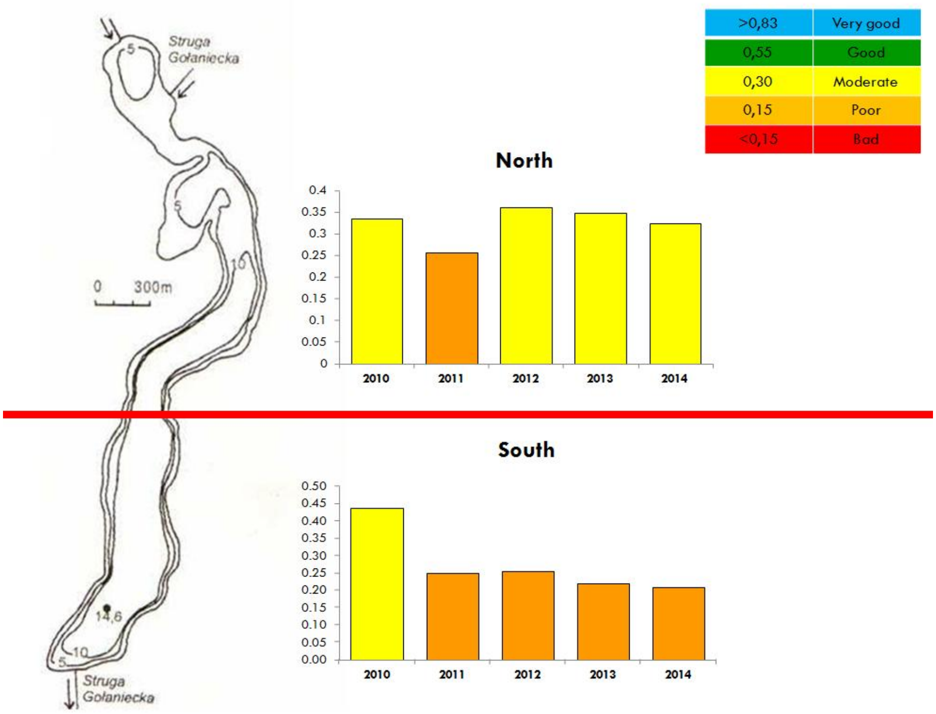

figure 20 Ecological state of Southern and Northern part of the lake based on Diatom Index

Hildenbrandia rivularis

Hildenbrandia rivularis is a cosmopolitan red algae species which prefers fresh flowing water habitats, but also occurs in standing water (fig.21). It is considered to be a bioindicator of good water quality. However, it occurs right across the nutrient gradient, and the presence of stable substrata and clear water is probably more important than the nutrient concentration per se (Kelly&King, 2007).

figure 21 *Hildenbrandia rivularis*

Since 2010 an increasing abundance of these algae had been observed in Lake Durowskie, especially in the south-eastern part (fig.22). The dominant wind direction in this area is from the west, and this creates constant wave erosion and oxygenation of the water in the south-east region. As *Hildenbrandia rivularis* prefers lotic water habitats, it is likely that this, together with high motorboat activity, is the reason for high abundance of *this species* in the south-eastern part of the lake.

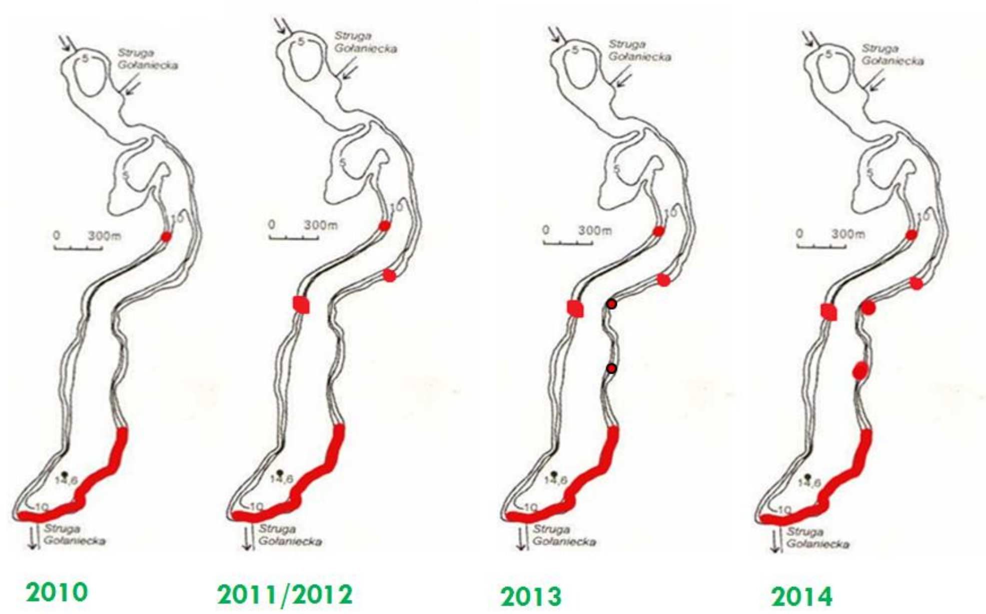

figure 3 Changes in the abundance of *Hildebrandia rivularis*

New sites of *Hildebrandia rivularis* have been reported until 2013. However, this year we did not find any new sites, which indicates that the situation has likely stabilised (fig.22).

Conclusion

Our study has identified that the trophic state of the Lake Durowskie is still eutrophic, and even hypertrophic in the inflow. The largest amount of cyanobacteria was also found in the inflow station. Thus, we could infer that this source still carries the highest amount of nutrients that affect the water quality in Lake Durowskie.

The diversity of phytoplankton was found to be higher than before restoration, and it has been increasing since 2012, when bad weather conditions affected the populations. This may be due to the effective restoration measures taken.

The ecological state of the lake has improved and reached moderate level during the last 4 years, but only in the Northern part of the lake. In the South the ecological conditions are still poor, and in some sites (i.e. the site Beach 1) it has been annually deteriorating and reached bad state this year. We can hypothesize that the reason may lie in the anthropogenic pressures such as: motorboat activities, fishing, and erosion among others.

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ANNEX 1. Comparison of phytoplankton species composition in different investigated years in July in Lake Durowskie.

Phytoplankton taxa	2008	2009	2010	2011	2012	2013	2014
***Cyanoprokaryota* - cyanobacteria**							
Anabaena affinis Lemm.							+
Anabaena flos-aquae Brebisson		+				+	
Aphanizomenon aphanizomenoides (Forti) Hort. & Kom.	+				+		
Aphanizomenon flos-aquae (L.) Ralfs	+	+	+	+			+
Aphanizomenon gracile Lemmerman	+						
Aphanizomenon isatschenkoi (Usacc.) Pros. - Lavrenko	+	+	+				
*Aphanocapsa grevillei (*Ber.) Rabenhorst		+					
Aphanocapsa incerta (Lemm.) Cronberg et Komarek	+	+	+			+	
Arthrospira massartii Kuff.		+					
Chroococcus limneticus Lemm.	+	+		+			
Chroococcus turgidus (Kűtz.) Naeg.		+		+			+
Cyanogranis feruginea (Wawrik) Hind.		+	+				
Gloeocapsa minuta Lemm.							+
Jaaginema pseudogeminatum (Schmid) Anagn. et Kom.			+	+			
Limnothrix lauterbornii(Schmidle) Anagn.		+					
Limnothrix redekei (Van Goor) Meffert	+		+	+	+	+	+
Lyngbya hieronymusii Lemm.		+					
Microcystis aeruginosa Kützing	+			+	+	+	+
Microcystis flos-aquae (Wittrock) Kirchner			+			+	
Jaaginema gracile (Bocher) Anagn. et kom.		+					
Phormidium granulatum Gardn. Anagn.	+	+	+		+		

Phormidium tenue (Agards ex Gomont) Anagn. et kom.		+					
Planktolyngbya limnetica (Lemm.) Kom. – Legn. Et Cronenberg		+	+	+	+	+	+
Planktothrix agardhii (D.C. ex Gom.) Anagn. et Kom.	+	+	+	+	+	+	+
Pseudanabaena limnetica (Lemm.) Kom.	+	+	+				+
Spirulina laxissima (W. West)			+				
Spirulina mior Kütz.					+		
Oscillatoria grossegranulata Skuja						+	
Bacillariophyceae - diatoms							
Achnanthes exigua Grun.			+				
Achnanthes minutissima Kützing	+		+	+		+	
Amphora ovalis Kützing	+	+	+	+			
Amphora pediculus (Kütz.) Grun.			+				
Asterionella formosa Hasall		+		+	+	+	+
Cocconeis euglypta (Ehr.) Clevei	+						
Cocconeis placentula Ehr.	+		+	+	+	+	
Cyclotella atomus Hustedt		+					
Cyclotella meneghiniana Kütz.	+	+	+			+	
Cyclotella ocellata Pant.	+		+	+	+	+	+
Cyclotella operculata (Ag.) Kützing	+	+	+			+	
Cyclotella radiosa (Grun.) Lemm.	+	+	+	+	+	+	+
Cymatopleura solea (Breb.) W. Smith							+
Cymbella affinis Kützing				+			
Cymbella microcephala Grun.				+		+	
Cymbella minuta Hilse ex Rabenhorst	+		+	+	+	+	+
Diatoma vulgare Bory				+			
Fragilaria capucina (Desm.) Rabenhorst				+		+	
Fragilaria crotonensis Kitton	+	+		+	+	+	+

Fragilaria pinnata Ehr.	+			+			+
Fragilaria ulna (Nitzsch) Lange-Bertalot	+	+	+	+	+	+	+
Fragilaria ulna var. *angustissima* Sippen	+	+	+	+	+	+	+
Gomphonema acuminatum Ehr.					+	+	+
Gomphonema olivaceum (Horn.) Breb.			+	+			+
Gomphonema parvulum (Kütz.) Kütz.				+			
Melosira varians Ag.	+						
Hippodonta capitata (Ehr.) L-B, Metz. et Witk.						+	
Navicula cincta (Ehr.) Ralfs	+	+	+			+	+
Navicula mensiculus Schumann	+						
Navicula radiosa Kützing			+	+	+	+	+
Naviula tripunctata (O.F. Muller) Bory de Sain. Van.			+			+	
Nitzschia palea (Kütz.) W. Smith				+	+	+	+
Nitzschia recta Hantzsch ex Rabenh.						+	
Nitzschia sigmoidea (Ehr.) W. Smith				+			+
Nitzschia sinuata (W. Sm.) Grunow				+			
Pinnularia viridis (Nitzsch) Ehr.				+			+
Placoneis gastrum(Ehr.) Meresch.		+					
Rhopalodia gibba (Ehr.) Muller						+	
Staurosira construens Ehr.		+					
Chlorophyta- green algae							
Ankistrodesmus falcatus (Corda) Ralfs		+					
Botryococcus braunii Kütz.						+	+
Characium aqngustatum A. Braun		+		+	+	+	+
Chlamydomonas globosa Snow	+	+	+	+		+	
Chlamydomonas passiva Skuja			+			+	+
Chlamydomonas reinchardtii Dangeard		+					

Closterium acutum var. *variabile* (Lemm.) Krieg.	+		+	+			
Coelasrum astroideum De Notaris			+	+	+	+	
Coelastrum microporum Naegel.			+				
Coelastrum reticulatum (Dang.) Senn	+	+					+
Cosmarium abbreviatum Raciborski	+		+	+	+	+	+
*Cosmarium exiguum*W. Archer		+					
Cosmarium margaritatum (Turp.) Ralfs				+			
Cosmarium phaseolus Brebisson in Ralfs	+		+	+		+	+
Cosmarium laeve Rabenhorst					+		
Cosmarium regnellii Wille	+	+	+		+		+
Crucigeniella rectnagulrais (Naeg.) Kom.						+	
Crucigenia tetrapedia (Kirchner) W. et G.S. West			+				
Desmodesmus communis (Hegew.) Hegew.	+	+	+	+	+	+	+
Desmodesmus grahneisii (Heynig) Fott				+			
Desmodesmus naegellii (Meyen) Hegew.			+				
Desmodesmus opoliensis (Rchter) Hegew.			+			+	
Desmodesmus subspicatus (Chod.) Hegew. et Schmidt	+		+			+	+
Dictyosphaerium pulchellum Wood	+	+	+	+			
Didymocystis planctonica Korsikov				+			
Elkatothrix gelatinosa Wille			+	+		+	+
Franceia ovais (France) Lemm.							+
Golenkinia radiata Chodat	+		+	+	+	+	+
Kirchneriella contorta var. *elegans* (Schmidle) Bohlin	+					+	+
Koliella longiseta (Vischer) Hindak	+						
Lagerheimia ciliata(Lag.) Chodat							+
Micractinium crassisetum Hortobagyi				+			
Micractinium pusillum Fresenius				+			

Mougeotia sp.				+	+		
Monoraphidium arcuatum (Kors.) Hindak	+						
Monoraphidium circinale (Nyg.) Nygaard	+						
Monoraphidium contortum (Thur.) Kom.-Legn.	+	+	+	+	+	+	+
Monoraphidium griffithii (Berk.) Kom.-Legn.	+		+				+
Monoraphidium irregulare (G.M. Sm.) Kom.-Legn.	+		+				
Monoraphidium komarkovae Nygaard	+	+	+				+
Monoraphidium minutom (Nageli) Kom. - Legn.		+					
Monoraphidium obtusum (Kors.)Kom. - Legn.	+						
Nephrocytium limneticum (G. M. Sm.) G. M. Sm.				+			
Oocystis lacustris Chodat	+	+	+	+	+		+
Palmelochette tenerrima Kors.				+			
Pandorina morum (O.F. Müller) Bory			+			+	
Pediastrum boryanum (Turpin) Meneg.			+	+	+	+	+
Pediastrum simplex Meyen						+	
Pediastrum duplex Meyen						+	+
Pediastrum tetras (Ehr.) Ralfs			+				+
Phacotus lendneri Chodat.				+			
*Phacotus lenticularis (*Ehr.) Stein	+			+	+	+	+
Provasoliella saccata (Skuja) Ettl					+		
Provasiorella sp.							+
Pteromonas angulosa (Carter) Lemm.		+	+				
Pteromonas cordiformis Lemm.			+				
Scenedesmus acuminatus (Lager.) Chodat			+		+		+
Scenedesmus bicaudatus Dedusenko			+	+	+		
Scenedesmus dimorphus (Turp.) Kütz.		+		+			
Scenedesmus ecornis (Ehr.) Chod.			+	+	+		+

Scenedesmus obtusus Meyen				+			
Scenedesmus regularis Swirenko		+					
Scenedesmus verucosus Roll				+			
Sphaerocystis planctonica (Korsikov) Bourrelly				+	+	+	+
Staurastrum gracile Ralfs			+	+	+	+	+
Staurastrum paradoxum Meyen							+
Tetraedron caudatum (Corda) Hansgirg	+		+				
Tetraedron minimum (A. Br.) Hansgirg	+	+	+	+	+	+	+
Tetraedron triangulare (Chod.) Kom.	+	+		+		+	
Tetrastrum glabrum (Roll) Ahlstr. et Tiff			+	+			+
Tetrastrum staurogeanieforme (Schroed.) Lemm.			+	+		+	+
Treubaria schmidlei (Schroeder) Fott et Kovacik		+	+	+		+	+
Cryptophyta - cryptophytes							
Chroomonas acuta Uterm.	+						+
Cryptomonas erosa Ehrenberg	+	+	+	+	+	+	+
Cryptomonas gracilis Skuja		+					
Cryptomonas marssonii Skuja	+	+	+	+	+	+	+
Cryptomonas ovata Ehrenberg	+	+	+	+	+	+	+
Cryptomonas rostrata Troitzskaja emend I. Kiselev	+		+	+	+	+	+
Rhodomonas minuta Skuja	+	+	+	+	+	+	+
Dinophyta - dinophytes							
Ceratium hirundinella (F. B. Müller) Bergh	+	+		+	+	+	+
Gymnodinium aeruginosum Stein	+					+	
Peridiniopsis cuningtonii Lemm.	+	+	+	+	+	+	+
Peridinium cinctum (O.F. Müller) Ehrenberg	+	+	+	+	+	+	+
Peridinium gatunense Nygaard						+	
Peridinopsis berolinense (Lemm.) Bourrelly	+	+	+	+	+	+	+

Peridinopsis elpatiewskyi (Ostenf.) Bourrelly	+		+	+	+	+	+
Euglenophyta - euglenoids							
Colacium vesiculosum Ehr.		+		+		+	
Euglena caudata Hübner					+		
Euglena pisciformis Klebs		+		+			
Phacus orbicularis Hubner	+	+					
Trachelomonas hispida (Perty) Stein	+		+	+	+	+	+
Trachelomonas planctonica Swirenko	+		+	+			
Trachelomonas volocina Ehrenberg	+		+	+	+	+	+
Chrysophyceae - chrysophyces							
Chrysococcus rufescens Klebs				+			
Dinobryon bavaricum Imhoff		+	+	+	+	+	+
Dinobryon crenulatum W. et G.S. West		+	+	+			
Dinobryon divergens Imhof		+	+		+	+	+
Dinobryon sociale Ehrenberg	+		+	+		+	
Erkenia subaequiciliata Skuja	+	+	+		+	+	+

ANNEX 2. List of phytoplankton species from different taxonomical algal groups and their frequency in Lake Durowskie from 30 th to 05th July 2014 (Inf – inflow; A2 – Aerator 2; Mid. 2 – Middle 2; Mid.1 – Middle 1; Outf – outflow; B1 – Beach 1; B2 – Beach 2; F – frequency).

	n=1	n=3	n=3	n=3	n=3	n=1	n=1	n=1	n=16
Depth	**0m**	**0-2m**	**0-2m**	**0-2m**	**0-2m**	**0m**	**0m**	**0m**	**%**
Site	**Inf**	**A2**	**M2**	**M1**	**A1**	**Outf**	**B1**	**B2**	**F**
Cyanoprokaryota - cyanobacteria									
Aphanizomenon flos-aquae (L.) Ralfs	+	+	+	+	+	+	.	.	44

Anabaena affinis Lemm.	+	.	.	.	.	.	.	.	6
Chroococcus turgidus (Kűtz.) Naeg.	.	.	.	.	.	.	.	+	6
Gloeocapsa minuta Lemm.	.	.	.	+	.	.	.	.	6
Limnothrix redekei (Van Goor) Meffert	+	+	+	+	+	+	+	+	100
Microcystis aeruginosa Kützing	+	.	.	.	.	.	.	.	6
Planktolyngbya limnetica (Lemm.) Kom. – Legn. Et Cronenberg	+	+	.	+	+		.	+	31
Planktothrix agardhii (D.C. ex Gom.) Anagn. et Kom.	+	+	+	+	+	+	.	+	81
Pseudanabaena limnetica (Lemm.) Kom.	.	.	.	+	.	.	.	.	6
Bacillariophyceae - diatoms									
Asterionella formosa Hasall	.	+	+	+	+	+	.	.	69
Cyclotella ocellata Pant.	.	+	+	+	+	+	+	+	88
Cyclotella radiosa (Grun.) Lemm.	+	+	+	+	+	+	+	+	94
Cymatopleura solea (Breb.) W. Smith	+	.	.	.	.	.	.	.	6
Cymbella minuta Hilse ex Rabenhorst	+	.	.	.	+	.	.	.	13
Fragilaria crotonensis Kitton	+	+	+	+	+	+	+	+	88
Fragilaria pinnata Ehr.	+	+	.	.	.	.	.	+	13
Fragilaria ulna (Nitzsch) Lange-Bertalot	+	+	+	+	+	+	.	+	88
Fragilaria ulna var. *angustissima* Sippen	+	+	.	+	+	+	.	+	44
Gomphonema acuminatum Ehr.	+	.	.	.	.	.	.	.	6
Gomphonema olivaceum (Horn.) Breb.	+	+	.	.	.	.	.	.	13
Navicula cincta (Ehr.) Ralfs	+	.	+	+	.	.	.	.	19
Navicula radiosa Kützing	+	+	+	.	.	+	.	.	25
Nitzschia palea (Kütz.) W. Smith	+	+	.	.	.	.	.	.	13
Nitzschia sigmoidea (Ehr.) W. Smith	.	.	+	.	.	.	.	.	6
Pinnularia viridis (Nitzsch) Ehr.	+	.	.	.	.	.	.	.	6
Chlorophyta - green algae									
Botryococcus braunii Kütz.	+	+	+	+	.	+	.	+	44

Monoraphidium komarkovae Nygaard	.	+	.	.	.	.	.	.	6
Characium angustatum A. Braun	.	.	.	.	+	.	.	.	6
Chlamydomonas passiva Skuja	.	+	.	.	+	.	.	+	19
Coelastrum astroideum De Notaris	.	.	+	.	+	+	.	+	25
Coelastrum reticulatum (Dang.) Senn	.	+	+	+	.	+	+	+	63
Cosmarium abbreviatum Raciborski	.	.	.	+	.	+	+	.	19
Cosmarium phaseolus Brebisson in Ralfs	+	.	.	.	+	.	.	.	13
Cosmarium regnellii Wille	+	.	.	.	.	.	.	.	6
Desmodesmus communis (Hegew.) Hegew.	+	+	+	+	+	.	.	.	56
Desmodesmus subspicatus (Chod.) Hegew. et Schmidt	+	.	.	+	.	.	.	.	13
Elkatothrix gelatinosa Wille	.	+	+	+	.	+	.	.	25
Franceia ovalis (France) Lemm.	.	.	.	+	.	.	.	.	6
Golenkinia radiata Chodat	+	+	+	+	+	.	.	.	44
Kirchneriella contorta var. *elegans* (Schmidle) Bohlin	.	+	.	.	+	+	.	.	25
Lagerheimia ciliata (Lag.) Chodat	.	.	+	.	.	.	.	.	6
Monoraphidium contortum (Thur.) Kom.-Legn.	.	.	+	.	+	.	.	.	13
Monoraphidium griffithii (Berk.) Kom.-Legn.	+	.	.	.	.	.	.	.	6
Monoraphidium komarkovae Nygaard	+	.	.	.	.	.	.	.	6
Oocystis lacustris Chodat	.	.	+	+	+	+	.	.	56
Pediastrum boryanum (Turpin) Meneg.	.	+	+	+	+	+	.	+	63
Pediastrum duplex Meyen	+	.	+	+	.	.	.	.	25
Pediastrum tetras (Ehr.) Ralfs	.	+	.	.	.	.	.	.	6
*Phacotus lenticularis (*Ehr.) Stein	.	+	+	+	+	+	+	+	88
Scenedesmus acuminatus (Lager.) Chodat	.	.	+	.	.	.	.	.	6
Scenedesmus ecornis (Ehr.) Chod.	.	.	.	+	.	.	.	.	6
Sphaerocystis planctonica (Korsikov) Bourrelly	.	+	+	+	+	+	+	+	94
Tetraedron minimum (A. Br.) Hansgirg	.	+	+	.	+	+	.	.	25

Tetrastrum glabrum (Roll) Ahlstr. et Tiff	.	+	.	.	.	.	.	.	6
Tetrastrum staurogeanieforme (Schroed.) Lemm.	.	.	.	+	+	+	.	.	19
Treubaria schmidlei (Schroeder) Fott et Kovacik	+	.	.	.	.	.	.	.	6
Staurastrum gracile Ralfs	+	+	+	+	+	+	.	.	44
Provasiorella sp.	.	+	.	.	.	.	.	.	6
Staurastrum paradoxum Meyen	+	.	.	.	.	.	.	.	6
Cryptophyta - cryptophytes									
Chroomonas acuta Uterm.	+	.	.	.	.	.	.	.	6
Cryptomonas erosa Ehrenberg	+	+	+	+	+	+	+	.	88
Cryptomonas marssonii Skuja	.	+	+	+	+	+	.	+	56
Cryptomonas ovata Ehrenberg	+	.	.	.	+	.	.	.	13
Cryptomonas rostrata Troitzskaja emend I. Kiselev	+	+	+	+	+	+	+	+	75
Rhodomonas minuta Skuja	+	+	+	+	+	+	+	+	69
Dinophyta - dinoflagellates									
Peridinopsis berolinense (Lemm.) Bourrelly	.	+	.	.	.	.	.	.	6
Ceratium hirundinella (F. B. Müller) Bergh	+	+	+	+	.	+	.	.	38
Peridiniopsis cuningtonii Lemm.	+	+	+	+	+	+	+	.	75
Peridinium cinctum (O.F. Müller) Ehrenberg	.	+	+	+	+	+	+	+	81
Peridinopsis elpatiewskyi (Ostenf.) Bourrelly	+	+	+	+	.	+	.	.	63
Euglenophyta - euglenoids									
Trachelomonas hispida (Perty) Stein	.	+	+	+	+	+	.	.	44
Trachelomonas volocina Ehrenberg	.	+	.	.	.	.	.	.	6
Chrysophyceae - chrysophyces									
Erkenia subaequiciliata Skuja	+	+	+	+	+	+	+	+	88
Dinobryon divergens Imhof	+	+	+	+	+	+	+	+	100
Dinobryon bavaricum Imhoff	.	+	+	+	+	+	.	+	56

ANNEX 3. Average number of phytoplankton species cells (ind./L) from different depth in Lake Durowskie from 30th to 05th July 2014 (Inf – inflow; A2 – Aerator 2; Mid. 2 – Middle 2; Mid.1 – Middle 1; Outf – outflow; B1 – Beach 1; B2 – Beach 2).

Depth	0-2m	0-2m	0-2m	0-2m	0-2m	0-2m	0-2m	0-2m
Site	**Inf**	**A2**	**Mid.2**	**Mid.1**	**A1**	**Outf**	**B1**	**B2**
***Cyanoprokaryota* - cyanobacteria**								
Aphanizomenon flos-aquae (L.) Ralfs	292800	1600	12800	1600	4000	9600	.	.
Anabaena affinis Lemm.	6400	.	.	.	.	.	.	.
Chroococcus turgidus (Kűtz.) Naeg.	.	.	.	.	.	.	.	6400
*Gloeocapsa minuta*Lemm.	.	.	.	1600	.	.	.	.
Limnothrix redekei (Van Goor) Meffert	1598400	28267	106667	26133	42667	78400	6400	20800
Microcystis aeruginosa Kützing	6400	.	.	.	.	.	.	.
Planktolyngbya limnetica (Lemm.) Kom. – Legn. Et Cronenberg	24000	3200	.	1600	3200	.	.	1600
Planktothrix agardhii (D.C. ex Gom.) Anagn. et Kom.	49600	1600	9600	6400	11733	12800	.	3200
Pseudanabaena limnetica (Lemm.) Kom.	.	.	.	3200	.	.	.	.
Total	**1977600**	**34667**	**129067**	**40533**	**61600**	**100800**	**6400**	**32000**
***Bacillariophycee* - diatoms**								
Asterionella formosa Hasall	.	25067	81067	17600	8000	38400	.	.
Cyclotella ocellata Pant.	.	8533	28000	10133	11200	35200	3200	4800
Cyclotella radiosa (Grun.) Lemm.	1632	16000	40000	36800	43733	24000	9600	24000
Cymatopleura solea (Breb.) W. Smith	1600	.	.	.	.	.	.	.
Cymbella minuta Hilse ex Rabenhorst	1600	.	.	.	3200	.	.	.
Fragilaria crotonensis Kitton	17600	105600	27200	19733	21333	38400	6400	11200
Fragilaria pinnata Ehr.	.	41600	.	.	.	.	.	6400
Fragilaria ulna (Nitzsch) Lange-Bertalot	4800	18400	17600	16800	25600	12800	.	12800
Fragilaria ulna var. *angustissima* Sippen	1600	5600	.	11200	3200	6400	.	6400
Gomphonema acuminatum Ehr.	1600	.	.	.	.	.	.	.

Gomphonema olivaceum (Horn.) Breb.	1600	3200	.	.	.	.	.	.
Navicula cincta (Ehr.) Ralfs	1600	.	1600	3200	.	.	.	.
Navicula radiosa Kützing	1600	3200	1600	.	.	3200	.	.
Nitzschia palea (Kütz.) W. Smith	1600	1600	.	.	.	.	.	.
Nitzschia sigmoidea (Ehr.) W. Smith	.	.	1600	.	.	.	.	.
Pinnularia viridis (Nitzsch) Ehr.	1600	.	.	.	.	.	.	.
Total	**38432**	**228800**	**198667**	**115467**	**116267**	**158400**	**19200**	**65600**
***Chlorophyta* - green algae**								
*Botryococcu braunii*Kütz.	1600	1600	6400	3200	.	4800	.	17600
Characium aqngustatum A. Braun	.	.	.	.	1600	.	.	.
Chlamydomonas passiva Skuja	.	6400	.	.	6400	.	.	3200
Coelastrum astroideum De Notaris	.	.	3200	.	8000	3200	.	1600
Coelastrum reticulatum (Dang.) Senn	.	4000	11200	5333	.	14400	1600	1600
Cosmarium abbreviatum Raciborski	.	.	.	6400	.	4800	1600	.
Cosmarium phaseolus Brebisson in Ralfs	1600	.	.	.	3200	.	.	.
Cosmarium regnellii Wille	1600	.	.	.	.	.	.	.
Crucigenia quadrata Morren	.	.	.	.	.	.	.	.
Desmodesmus communis (Hegew.) Hegew.	3200	6933	8000	6400	6400	.	.	.
Desmodesmus subspicatus (Chod.) Hegew. et Schmidt	1600	.	.	19200	.	.	.	.
Elkatothrix gelatinosa Wille	.	3200	1600	3200	.	1600	.	.
Franceia ovalis(France) Lemm.	.	.	.	1600	.	.	.	.
Golenkinia radiata Chodat	43200	4800	1600	1600	2400	.	.	.
Kirchneriella contorta var. *elegans* (Schmidle) Bohlin	.	4000	.	.	1600	3200	.	.
Lagerheimia ciliata(Lag.) Chodat	.	.	4800	.	.	.	.	.
Monoraphidium contortum (Thur.) Kom.-Legn.	.	.	6400	.	1600	.	.	.
Monoraphidium griffithii (Berk.) Kom.-Legn.	6400	.	.	.	.	.	.	.
Monoraphidium komarkovae Nygaard	.	1600	.	.	.	.	.	.

Monoraphidium komarkovae Nygaard	1600	.	.	.	.	.	.	.
Oocystis lacustris Chodat	.	.	3200	2667	2400	6400	.	.
Pediastrum boryanum (Turpin) Meneg.	.	8000	7467	3200	3200	3200	.	1600
Pediastrum duplex Meyen	1600	.	4800	1600	.	.	.	.
Pediastrum tetras (Ehr.) Ralfs	.	1600	.	.	.	.	.	.
*Phacotus lenticularis (*Ehr.) Stein	.	4800	41600	4267	9067	19200	9600	3200
Provasiorella sp.	.	1600	.	.	.	.	.	.
Scenedesmus acuminatus (Lager.) Chodat	.	.	3200	.	.	.	.	.
Scenedesmus ecornis (Ehr.) Chod.	.	.	.	4800	.	.	.	.
Sphaerocystis planctonica (Korsikov) Bourrelly	.	16533	33600	13867	23467	16000	12800	19200
Staurastrum gracile Ralfs	1600	6400	12800	3200	4800	4800	.	.
*Staurastrum paradoxum*Meyen	1600	.	.	.	.	.	.	.
Tetraedron minimum (A. Br.) Hansgirg	.	4800	6400	.	1600	1600	.	.
Tetrastrum glabrum (Roll) Ahlstr. et Tiff	.	6400	.	.	.	.	.	.
Tetrastrum staurogeanieforme (Schroed.) Lemm.	.	.	.	3200	3200	3200	.	.
Treubaria schmidlei (Schroeder) Fott et Kovacik	16000	.	.	.	.	.	.	.
Total	**81600**	**82667**	**156267**	**83733**	**78933**	**86400**	**25600**	**48000**
***Cryptophyta* - cryptophytes**								
Chroomonas acuta Uterm.	1600	.	.	.	.	.	.	.
Cryptomonas erosa Ehrenberg	3200	22400	28000	8000	18133	8000	3200	.
Cryptomonas marssonii Skuja	.	2667	331200	1600	75200	1600	.	86400
Cryptomonas ovata Ehrenberg	8000	.	.	.	1600	.	.	.
Cryptomonas rostrata Troitzskaja emend I. Kiselev	3200	2400	8000	5600	16000	4800	35200	4800
Rhodomonas minuta Skuja	3200	5867	16000	1600	4800	4800	1600	12800
Total	**19200**	**33333**	**383200**	**16800**	**115733**	**19200**	**40000**	**104000**
***Dinophyta* - dinophytes**								
Peridinopsis berolinense (Lemm.) Bourrelly	.	6400	.	.	.	.	.	.

Ceratium hirundinella (F. B. Müller) Bergh	3200	1600	3200	1600	.	1600	.	.
Peridiniopsis cuningtonii Lemm.	6400	9600	10133	3200	10400	8000	1600	.
Peridinium cinctum (O.F. Müller) Ehrenberg	.	7467	12000	3200	8800	3200	1600	1600
Peridinopsis elpatiewskyi (Ostenf.) Bourrelly	3200	3733	1600	7467	.	3200	.	.
Total	**12800**	**28800**	**26933**	**15467**	**19200**	**16000**	**3200**	**1600**
***Euglenophyta* - euglenoids**								
Trachelomonas hispida (Perty) Stein	.	4800	2400	1600	17600	1600	.	.
Trachelomonas volocina Ehrenberg	.	1600	.	.	.	.	.	.
Total	**0**	**6400**	**2400**	**1600**	**17600**	**1600**	**0**	**0**
***Chrysophyceae* - chrysophyces**								
Dinobryon bavaricum Imhoff	.	27200	26400	3200	44800	46400	.	6400
Dinobryon divergens Imhof	12800	219733	1019733	385600	779733	1835200	350400	416000
Erkenia subaequiciliata Skuja	137600	22400	46400	12267	24000	38400	11200	12800
Total	**150400**	**269333**	**1092533**	**401067**	**848533**	**1920000**	**361600**	**435200**

ANNEX 4. Average biomass of phytoplankton species (mg/L) from different depth in Lake Durowskie from 30th to 05th July 2014 (Inf – inflow; A2 – Aerator 2; Mid. 2 – Middle 2; Mid.1 – Middle 1; Outf – outflow; B1 – Beach 1; B2 – Beach 2).

Site	Inf	A2	Mid.2	Mid.1	A1	Outf	B1	B2
Cyanoprokaryota - cyanobacteria								
Aphanizomenon flos-aquae (L.) Ralfs	0,505	0,003	0,025	0,003	0,0045	0,019	.	.
Anabaena affinis Lemm.	0,029	.	.	.	.	.	.	.
Aphanizomenon isatschenkoi (Usacc.) Pros. - Lavrenko	.	.	.	.	.	.	.	0,001
Aphanocapsa incerta (Lemm.) Cronberg et Komarek	.	.	.	.	.	.	.	.
Asterionella formosa Hasall	.	0,006667	0,006	0,003	0,0015	0,007	.	.
Chroococcus turgidus (Kűtz.) Naeg.	.	.	.	.	.	.	.	0,001

Cyclotella ocellata Pant.	.	0,009	0,0295	0,011	0,011333	0,037	0,003	0,005
Cyclotella radiosa (Grun.) Lemm.	0,004	0,02	0,05	0,046	0,057333	0,03	0,012	0,03
Cymatopleura solea (Breb.) W. Smith	0,159	.	.	.	.	.	.	.
Cymbella minuta Hilse ex Rabenhorst	0,001	.	.	.	0,005	.	.	.
Fragilaria crotonensis Kitton	0,016	0,0475	0,0125	0,009	0,009	0,017	0,003	0,005
Fragilaria pinnata Ehr.	.	0,01	.	.	.	.	.	0,001
Fragilaria ulna (Nitzsch) Lange-Bertalot	0,014	0,034333	0,023667	0,023	0,034333	0,017	.	0,017
Fragilaria ulna var. *angustissima* Sippen	0,009	0,013	.	0,026	0,007	0,015	.	0,015
Gloeocapsa minuta Lemm	.	.	.	0,0002	.	.	.	.
Gomphonema acuminatum Ehr.	0,002	.	.	.	.	.	.	.
Gomphonema olivaceum (Horn.) Breb.	0,002	0,004	.	.	.	.	.	.
Limnothrix redekei (Van Goor) Meffert	1,278	0,008667	0,009333	0,008333	0,013333	0,025	0,002	0,007
Microcystis aeruginosa Kützing	0,006	.	.	.	.	.	.	.
Navicula cincta (Ehr.) Ralfs	0,002	.	0,004	0,003	.	.	.	.
Navicula radiosa Kützing	0,003	0,008	0,004	.	.	0,008	.	.
Nitzschia palea (Kütz.) W. Smith	0,007	0,004	.	.	.	.	.	.
Nitzschia sigmoidea (Ehr.) W. Smith	.	.	0,017	.	.	.	.	.
Pinnularia viridis (Nitzsch) Ehr.	0,027	.	.	.	.	.	.	.
Planktolyngbya limnetica (Lemm.) Kom. – Legn. Et Cronenberg	0,008	0,002	.	0,0005	0,001	.	.	0,001
Planktothrix agardhii (D.C. ex Gom.) Anagn. et Kom.	0,062	0,002	0,012	0,008	0,014667	0,016	.	0,004
Pseudanabaena limnetica (Lemm.) Kom.	.	.	.	0,001	.	.	.	.
Total:	**2,134**	**0,172167**	**0,193**	**0,142033**	**0,159**	**0,191**	**0,02**	**0,087**
Bacillariophyceae - diatoms								

Achnanthes exigua Grun.	.	.	.	.	.	.	.	.
Achnanthes minutissima Kützing	.	.	.	.	.	.	.	.
Amphora ovalis Kützing	.	.	.	.	.	.	.	.
Amphora pediculus (Kütz.) Grun.	.	.	.	.	.	.	.	.
Asterionella formosa Hasall	.	.	.	0,007	0,006	0,0015	0,006667	0,003
Cocconeis euglypta (Ehr.) Clevei	.	.	.	.	.	.	.	.
Cocconeis placentula Ehr.	.	.	.	.	.	.	.	.
Cyclotella meneghiniana Kütz.	.	.	.	.	.	.	.	.
Cyclotella ocellata Pant.	.	0,003	0,005	0,037	0,0295	0,011333	0,009	0,011
Cyclotella operculata (Ag.) Kützing	.	.	.	.	.	.	.	.
Cyclotella radiosa (Grun.) Lemm.	0,004	0,012	0,03	0,03	0,05	0,057333	0,02	0,046
Cymatopleura solea (Breb.) W. Smith	0,159	.	.	.	.	.	.	.
Cymbella affinis Kützing	.	.	.	.	.	.	.	.
Cymbella lanceolata (Ehr.) Kirchner	.	.	.	.	.	.	.	.
Cymbella microcephala Grun.	.	.	.	.	.	.	.	.
Cymbella minuta Hilse ex Rabenhorst	0,001	.	.	.	.	0,005	.	.
Diatoma vulgare Bory	.	.	.	.	.	.	.	.
Fragilaria capucina (Desm.) Rabenhorst	.	.	.	.	.	.	.	.
Fragilaria crotonensis Kitton	0,016	0,003	0,005	0,017	0,0125	0,009	0,0475	0,009
Fragilaria pinnata Ehr.	.	.	0,001	.	.	.	0,01	.
Fragilaria ulna (Nitzsch) Lange-Bertalot	0,014	.	0,017	0,017	0,023667	0,034333	0,034333	0,023
Fragilaria ulna var. *angustissima* Sippen	0,009	.	0,015	0,015	.	0,007	0,013	0,026
Gomphonema acuminatum Ehr.	0,002	.	.	.	.	.	.	.
Gomphonema olivaceum (Horn.) Breb.	0,002	.	.	.	.	.	0,004	.

Gomphonema parvulum (Kütz.) Kütz.	.	.	.	.	.	.	.	.
Hippodonta capitata (Ehr.) L-B, Metz. Et Witk.	.	.	.	.	.	.	.	.
Melosira varians Ag.	.	.	.	.	.	.	.	.
Navicula cincta (Ehr.) Ralfs	0,002	.	.	.	0,004	.	.	0,003
Navicula mensiculus Schumann	.	.	.	.	.	.	.	.
Navicula radiosa Kützing	0,003	.	.	0,008	0,004	.	0,008	.
Naviula tripunctata (O.F. Muller) Bory de Sain. Van	.	.	.	.	.	.	.	.
Nitzschia palea (Kütz.) W. Smith	0,007	.	.	.	.	.	0,004	.
Nitzschia recta Hantzsch ex Rabenh.	.	.	.	.	.	.	.	.
Nitzschia sigmoidea (Ehr.) W. Smith	.	.	.	.	0,017	.	.	.
Nitzschia sinuata (W. Sm.) Grunow	.	.	.	.	.	.	.	.
Pinnularia viridis (Nitzsch) Ehr.	0,027	.	.	.	.	.	.	.
Rhopalodia gibba (Ehr.) Muller	.	.	.	.	.	.	.	.
Total:	**0,246**	**0,018**	**0,073**	**0,131**	**0,146667**	**0,1255**	**0,1565**	**0,121**
Chlorophyta - green algae								
Botryococcu braunii Kütz.	0,007	0,026	0,027	0,008	.	0,021	.	0,075
Characium aqngustatum A. Braun	.	.	.	.	0,001	.	.	.
Chlamydomonas passiva Skuja	.	0,004	.	.	0,003	.	.	0,002
Coelastrum astroideum De Notaris	.	.	0,01	.	0,025	0,01	.	0,005
Coelastrum reticulatum (Dang.) Senn	.	0,015	0,0425	0,02	.	0,055	0,006	0,006
Cosmarium abbreviatum Raciborski	.	.	.	0,005	.	0,005	0,002	.
Cosmarium phaseolus Brebisson in Ralfs	0,009	.	.	.	0,016	.	.	.
Cosmarium regnellii Wille	0,002	.	.	.	.	.	.	.
Desmodesmus communis (Hegew.) Hegew.	0,002	0,006	0,007	0,002	0,007	.	.	.

Desmodesmus grahneisii (Heynig) Fott	.	.	.	.	0,003	.	.	.
Desmodesmus subspicatus (Chod.) Hegew. et Schmidt	0,001	.	.	0,008	.	.	.	.
Elkatothrix gelatinosa Wille	.	0,003	0,002	0,005	.	0,002	.	.
Franceia ovalis (Franc) Lemm.	.	.	.	0,0006	.	.	.	.
Golenkinia radiata Chodat	0,011	0,0022	0,007	0	0,001	.	.	.
Kirchneriella contorta var. *elegans* (Schmidle) Bohlin	.	0,00055	.	.	0,0001	0,0003	.	.
Lagerheimia ciliata (Lag.) Chodat	.	.	0,001	.	.	.	.	.
Monoraphidium contortum (Thur.) Kom.-Legn.	.	.	0,001	.	0,0003	.	.	.
Monoraphidium griffithii (Berk.) Kom.-Legn.	0,019	.	.	.	.	.	.	.
Monoraphidium komarkovae Nygaard	.	0,004	.	.	.	.	.	.
Monoraphidium komarkovae Nygaard	0,007	.	.	.	.	.	.	.
Oocystis lacustris Chodat	.	.	0,008	0,006667	0,007	0,016	.	.
Pediastrum boryanum (Turpin) Meneg.	.	0,236	0,219333	0,094	0,094	0,094	.	0,047
Pediastrum duplex Meyen	0,047	.	0,141	0,0455	.	.	.	.
Pediastrum tetras (Ehr.) Ralfs	.	0,003	.	.	.	.	.	.
*Phacotus lenticularis (*Ehr.) Stein	.	0,003667	0,033	0,003333	0,007333	0,015	0,008	0,003
Provasiorella sp.	.	0,0009	.	.	.	.	.	.
Scenedesmus acuminatus (Lager.) Chodat	.	.	0,002	.	.	.	.	.
Scenedesmus ecornis (Ehr.) Chod.	.	.	.	0,002	.	.	.	.
Sphaerocystis planctonica (Korsikov) Bourrelly	.	0,037333	0,076333	0,031333	0,053333	0,036	0,029	0,044
Staurastrum gracile Ralfs	0,005	0,013333	0,033	0,008	0,012	0,012	.	.
Staurastrum paradoxum Meyen	0,009	.	.	.	.	.	.	.
Tetraedron minimum (A. Br.) Hansgirg	.	0,001	0,001	.	0,00002	0,0001	.	.
Tetrastrum glabrum (Roll) Ahlstr. et Tiff	.	0,002	.	.	.	.	.	.

Tetrastrum staurogeanieforme (Schroed.) Lemm.	.	.	.	0,0005	0,0004	0,0004	.	.
Treubaria schmidlei (Schroeder) Fott et Kovacik	0,026	.	.	.	.	.	.	.
Total:	**0,145**	**0,357983**	**0,611167**	**0,239933**	**0,230487**	**0,2668**	**0,045**	**0,182**
Cryptophyta - cryptophytes								
Chroomonas acuta Uterm.	0,004	.	.	.	.	.	.	.
Cryptomonas erosa Ehrenberg	0,006	0,036	0,0455	0,013	0,029333	0,013	0,005	.
Cryptomonas marssonii Skuja	.	0,003333	0,0455	0,002	0,095	0,002	.	0,11
Cryptomonas ovata Ehrenberg	0,021	.	.	.	0,003	.	.	.
Cryptomonas rostrata Troitzskaja emend I. Kiselev	0,009	0,0045	0,017	0,0115	0,185	0,01	0,074	0,01
Rhodomonas minuta Skuja	0,002	0,003667	0,011	0,001	0,001005	0,003	0,001	0,009
Total:	**0,042**	**0,0475**	**0,119**	**0,0275**	**0,313338**	**0,028**	**0,08**	**0,129**
Dinophyta - dinoflagellates								
Ceratium cornutum Ehrenberg	.	.	0,135	.	.	.	.	.
Ceratium hirundinella (F. B. Müller) Bergh	0,316	0,155	0,3095	0,155	.	0,155	.	.
Peridinopsis berolinense (Lemm.) Bourrelly	.	0,074	.	.	.	.	.	.
Peridiniopsis cuningtonii Lemm.	0,068	0,1105	0,117	0,0375	0,1205	0,093	0,018	.
Peridinium cinctum (O.F. Müller) Ehrenberg	.	0,212	0,318	0,084667	0,2335	0,85	0,042	0,042
Peridinopsis elpatiewskyi (Ostenf.) Bourrelly	0,026	0,029667	0,013	0,06	.	0,026	.	.
Total:	**0,41**	**0,581167**	**0,8925**	**0,337167**	**0,354**	**1,124**	**0,06**	**0,042**
Euglenophyta - euglenoids								
Trachelomonas hispida (Perty) Stein	.	0,005	0,0025	0,002	0,0185	0,002	.	.
Trachelomonas volocina Ehrenberg	.	0,001	.	.	.	.	.	.
Total:	0	0,006	0,0025	0,002	0,0185	0,002	0	0
Chrysophyceae - chrysophyces								

Dinobryon bavaricum Imhoff	.	0,005	0,00565	0,00065	0,009	0,01	.	0,002
Dinobryon divergens Imhof	0,003	0,048967	0,464667	0,176	0,355333	0,837	0,159	0,19
Erkenia subaequiciliata Skuja	0,008	0,001667	0,003	0,0008	0,001567	0,002	0,001	0,001
Total:	**0,011**	**0,067633**	**0,478317**	**0,18145**	**0,4029**	**0,853**	**0,16**	**0,193**