

INTERNATIONAL SUMMER SCHOOL - DUROWSKIE LAKE

Wągrowiec & Poznan

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HYDROLOGY AND LAKE MANAGEMENT REPORT

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All photo were taken during the field work by the team members of lake management group

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1. Introduction

1.1 Lake Ecosystem Services – Durowskie Lake

The Millennium Ecosystem Assessment services regards all benefits which people obtain from ecosystems as the Ecosystem Services. These include provisioning services such as food, water and timber; regulating services which affect climate, floods, control of disease, waste treatment, and water quality; cultural services that provide recreational, aesthetic, and spiritual benefits; and supporting services such as soil formation, photosynthesis and nutrient cycling. (De Groot 2010).

The ecosystem services associated with the freshwater ecosystems such as lakes and rivers contribute directly towards the human well-being. One such important ecosystem service is the maintenance of water quantity and quality for its various uses. Furthermore they act as a buffer against floods and erosion, which are amongst the regulatory services associated with these ecosystems. The aquatic organisms in such ecosystems are associated with the provision of food and medicines. In addition to this there are many cultural services that are not only important for the recreational aspects but at the same time they are also associated with countless socio-economic benefits. These include tourism, especially kayaking, fishing etc.

Very similarly to what occurs in other freshwater ecosystems, in **Lake Durowskie**, located in the beautiful and peaceful town of Wągrowiec, the anthropogenic pressures such as agriculture, expansion of human settlements, sewage disposal and irresponsible tourism, are main factors which has been contributing towards the deterioration of its water quality. Among the **causes of deterioration**, the ones that are well known to produce most of the impact (around 80%) come from the influence of upstream waters, and are;

- Sewage water from Wągrowiec and all up-flow towns and urban areas that had been disposed-off straight to up-stream river sections and lakes until 1999. This sewage was carrying loads of detergents, which contain phosphates, chlorides.
- Drainage from agricultural areas, input of nutrients from fertilizers, as well as other chemicals such as pesticides and herbicides (mainly upstream agricultural lands, because Durowskie lake is mostly surrounded by forest).

This pollution led to the appearance of **Cyanobacterial blooms** in Durowskie Lake during past summers, which had devastating consequences in the lake ecosystem: The blooms raised the water pH over 9, which was not good for some fish and other organisms. Many cyanobacteria

produce toxins that caused killing of fish and other organisms, bioaccumulation and biomagnification, and non-suitable water quality levels for bathing. The blooms also diminished water transparency.

This whole situation led towards the initiation of a **restoration project** in which different institutions and companies took part and is coordinated by Wagrowiec local government. The main measures included in its program and carried so far are:

- Aeration of hypolimnion: installed by AERATOR firm (University of Life Sciences, Poznan), contracted by Wagrowiec authorities.
- Addition of Iron sulphate: (PIX) in order to sediment phosphorous. Implemented by AERATOR firm (University of Life Sciences, Poznan).
- Bio-manipulation: Introduction of pikes and pike-perch. Carried out by the private fishing firm MAY, which has a contract with the regional water management authorities to manage fish and fishermen permits in Durowskie lake.

The Department of Water Protection, Faculty of Biology, Adam Mickiewicz University in Poznan is conducting a monitoring project of the lake restoration by analysing chemical parameters, phytoplankton and zooplankton once per month.

Lake Durowskie enhances the beauty of Wagrowiec and is associated with the lives of the inhabitants of this town in many aspects. The keen interest of the local government to modernize infrastructure, promotion of tourism and recreation spots shows its willingness to develop the town and also brings new income generation options. Since the tourism here is primarily associated with the Lake Durowskie, its degradation would have negative impacts not only on this important cultural service but also on all other ecosystem services including provision of fish, habitat, nutrient cycling, freshwater etc.

1.2. Aim of the study

The main objective of the group working on the lake management was to find out some possible and practical solutions to the problems associated with the management of the lake, having an emphasis on enhancing the participation of the inhabitants in such activities to find out a long-term solution. Furthermore, an assessment of the present water quality of the lake was also carried out to check whether its situation has improved during the past years.

2. Hydrological Condition of Lake Durowskie

2.1. Sampling locations

We collected the water samples and made discharge measurement from three different locations including inflow and outflow of Durowskie Lake and inflow of Lake Kobyleckie from 30th June till 5th July 2014. Inflow of Kobyleckie Lake (Inflow_K) is situated in the northern part of this lake with stones in the middle and muddy areas close to its shores. Inflow of Durowskie Lake (Inflow_D) is located towards northwards of this lake. We measured the discharge and collected water samples under the bridge situated at Road 190. This was the only place where could manage to go in the water to take samples and measure flow velocity. Outflow of Durowskie Lake (Outflow_D) is situated in the southern part of the lake. In addition to this some additional sampling and measurement of other water quality parameters was also made in the three upstream lakes including Lake Laskownickie, Lake Grylewskie, and Lake Bukowieckie were taken 5th July 2014.

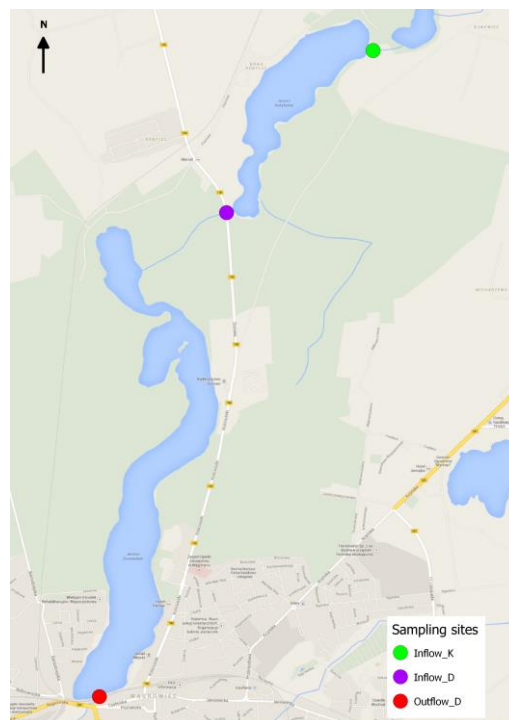


Figure 1: Map showing the sampling locations for water quality assessment tests

2.2 Materials and Methods: water quality assessment

Temperature, conductivity and oxygen content were measured by a handheld multiparameter device. Whereas pH was measured using a pocket pH meter. We however did not measure pH on the 30th June, 2014 due the damaged device.

Flow velocity data were collected from 30th June to 3th July in order to evaluate the total discharge (Q) of water which comes in and goes out from the lake. The width and the depth of the river were measured for calculation of the cross section of the stream and then flow velocity was assessed by an Electromagnetic velocity meter (FlowSens) at different depths and different points of width.

From each sampling location, two samples of water were taken. Chloroform was added to samples for physico-chemical analysis to avoid the initiation of any organic reactions. Samples for chlorophyll *a* were filtered immediately after returning from field. The remaining steps of analysis were taken in laboratory in Poznań (AMU Faculty of Biology). Concentration of following parameters were determined: ammonium, nitrite, nitrate, total phosphorus, soluble reactive phosphate and chlorophyll *a*.

2.3 Results and Discussion

2.3.1 Temperature

Temperature is an important parameter of water which has a major influence on the biological activity of aquatic organisms. It has also an impact on other physical and chemical parameters in this kind of environment. Since the graph shows an increasing tendency of temperature with every passing day which is due to summer season.

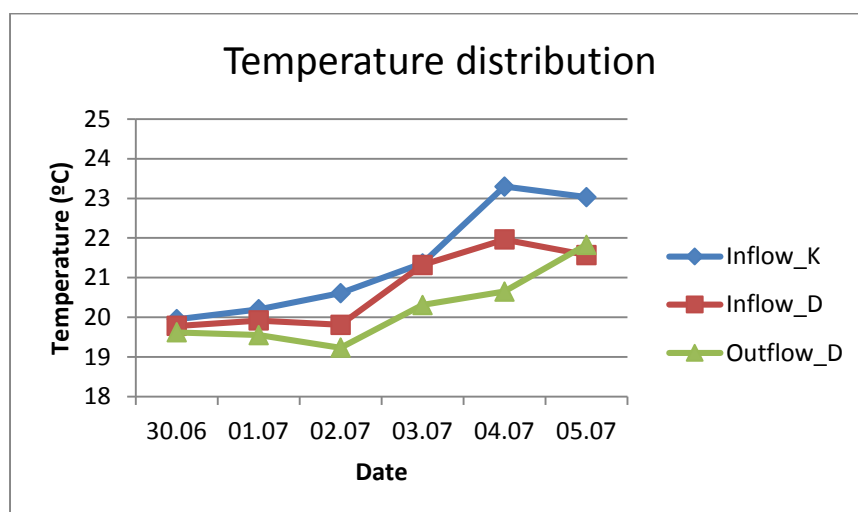


Figure 2: Measurement of temperature from the three sampling locations

2.3.2 pH

pH is a measure of acidity and basicity. The pH value varies between 0 (acidic) and 14 (basic) and is neutral at pH 7. It gives an idea about the amount of free hydrogen ions in the solution. The pH of water is also an important factor to determine bio-availability of chemical compounds including nutrients (phosphorus, nitrogen, and carbon) and heavy metals (lead, copper,

cadmium). For natural waters, pH varies from 4 to 9. Pollution, sewage, or rain can change the pH , which has an impact on water plants animals. A pH change in a stream can be an indicator of increasing pollution or some other environmental factors.

The overall pH value was fluctuating during different days of sampling. The lower pH level was noticed for Inflow_K and the highest for Inflow_D. This could also be an indication that in Kobyleckie Lake primary production is high and has a negative impact on Durowskie Lake.

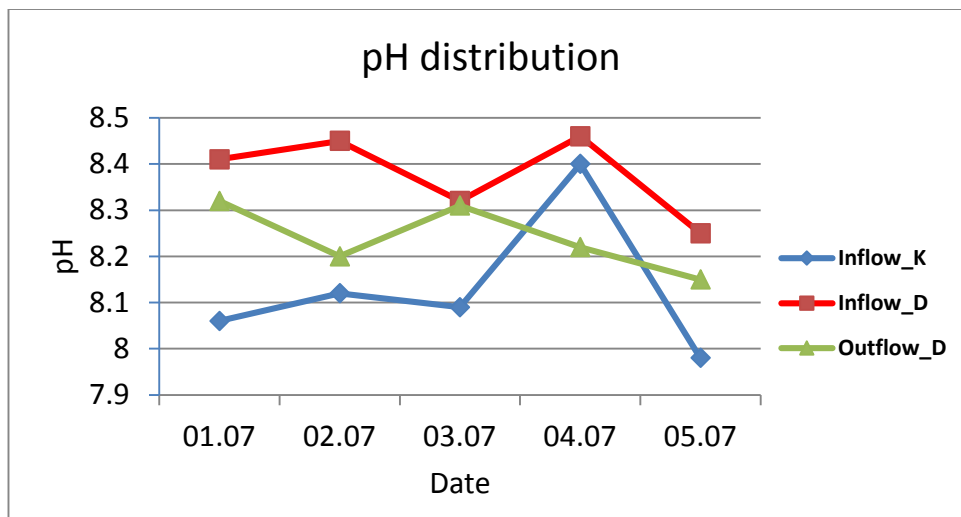


Figure 3: pH range from the three sampling locations

2.3.3 Conductivity

Conductivity indirectly measures presence of inorganic solid including Phosphate and nitrates. The higher the amount of such solids in the water the higher would be the conductivity. The results have shown the samples taken inflow of the Lake Kobyleckie during all six days have the highest conductivity. This higher level of conductivity indicate presence of higher loads of Phosphorus into this part. Whereas the conductivity of the sample collected from Inflow and outflow of Lake Durowskie were almost similar and had much more lower conductivity than the Inflow of Kobyleckie

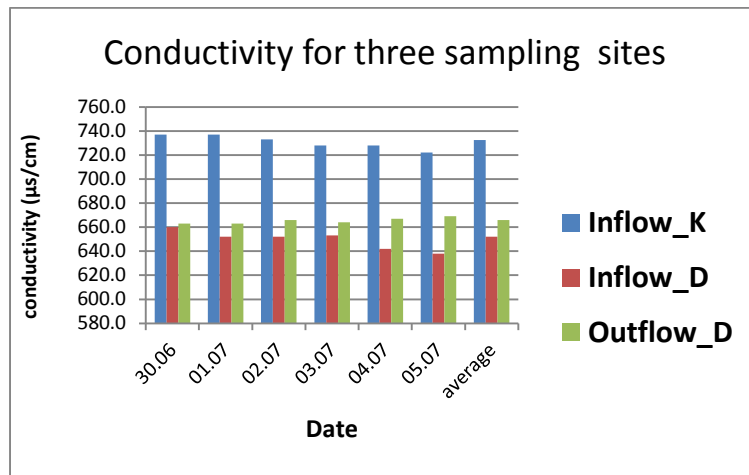


Figure 4: Measurement of conductivity at the three sampling sites

2.3.4 Oxygen content

The outflow of Lake Durowskie in average has the lowest oxygen saturation which is probably due to the highest rate of decomposition. The inflow of Lake Durowskie interestingly showed highest amount of oxygen saturation during the first two days and the later days it was recorded between 7 and 8. The higher level of oxygen saturation during the first two days of sampling in our opinion were attributed to the heavy rains during the sampling.

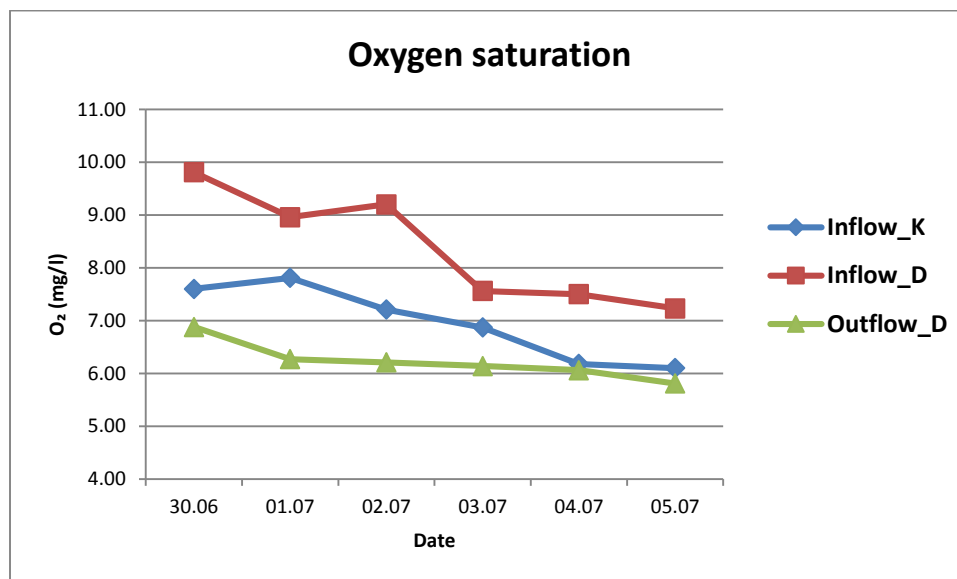


Figure 5: Oxygen saturation in three lakes

2.3.5 Chlorophyll *a* and Total Phosphorus content (TP)

The results of Chlorophyll *a* and TP contents were also not very different from the earlier, inflow Durowskie was the one carrying the highest amount of Chlorophyll *a* and TP contents for all six days of sampling. The inflow of Lake Kobyleckie was carrying the second highest amount of the Chlorophyll *a* contents. This can be an indication of high amount of algal biomass production due to excessive loads of nutrients.

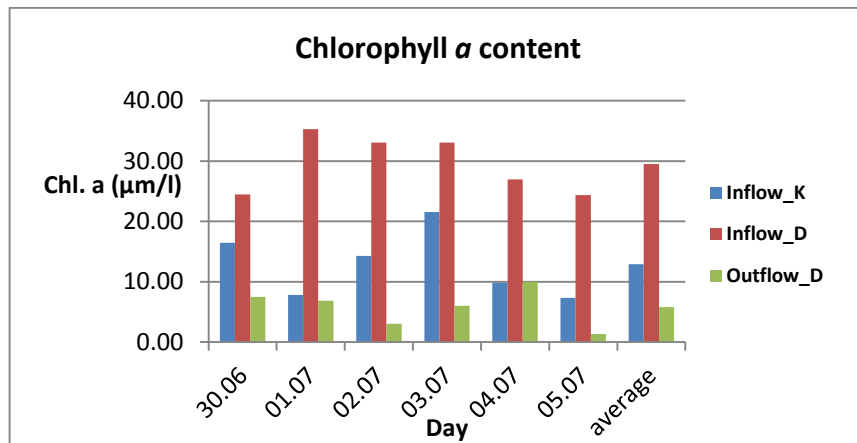


Figure 6: comparison of Chlorophyll *a* content with previous years

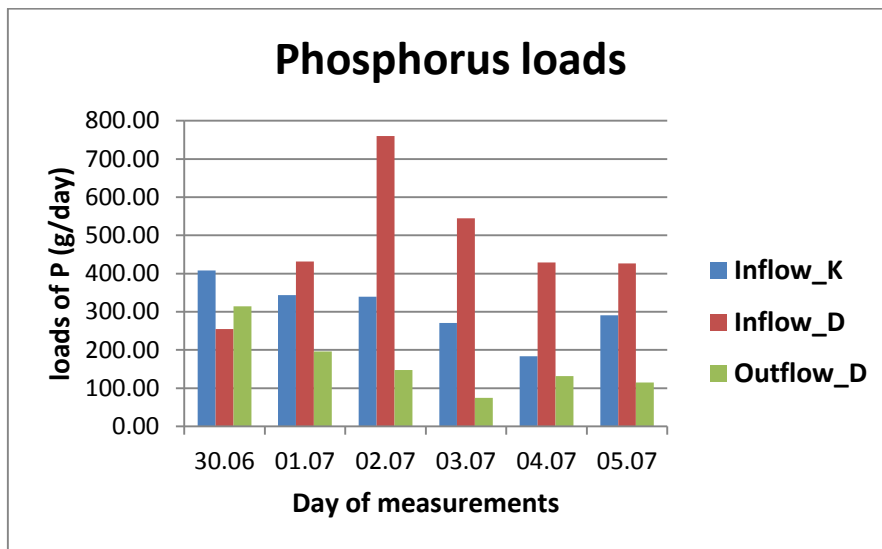


Figure 7: comparison of TP with previous years

Furthermore we also compared the results with the past years to see if the amount of Chlorophyll *a* and TP contents have been changed within this duration at the inflow and outflow of Lake Durowskie. It was noticed that the amount of Chlorophyll *a* have been decreased in comparison to year 2013 in case of outflow of the lake. Whereas in comparison to 2012 the Chlorophyll *a* for both inflow and outflow has been decreased.

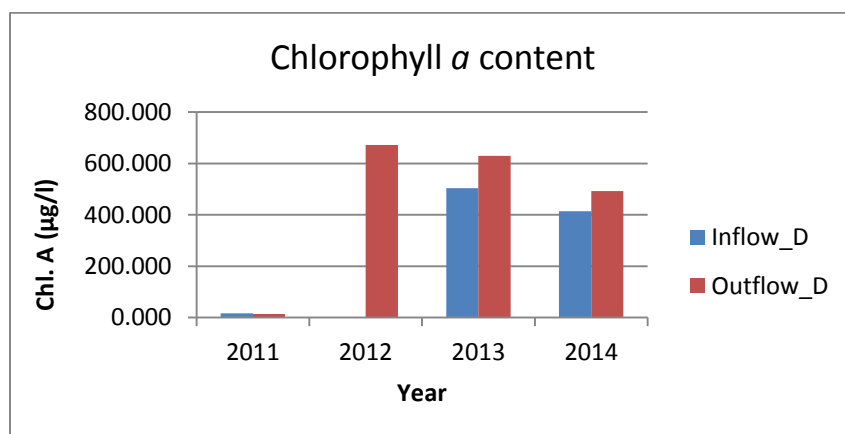


Figure 8: comparison of Chlorophyll *a* with previous years

Whereas the TP have almost at the same level as in 2012. These results however are not comparable with the 2013 as the heavy rains last year caused heavy loads of erosion into the lake and hence the elevated the amount of Phosphorus beyond the expected levels.

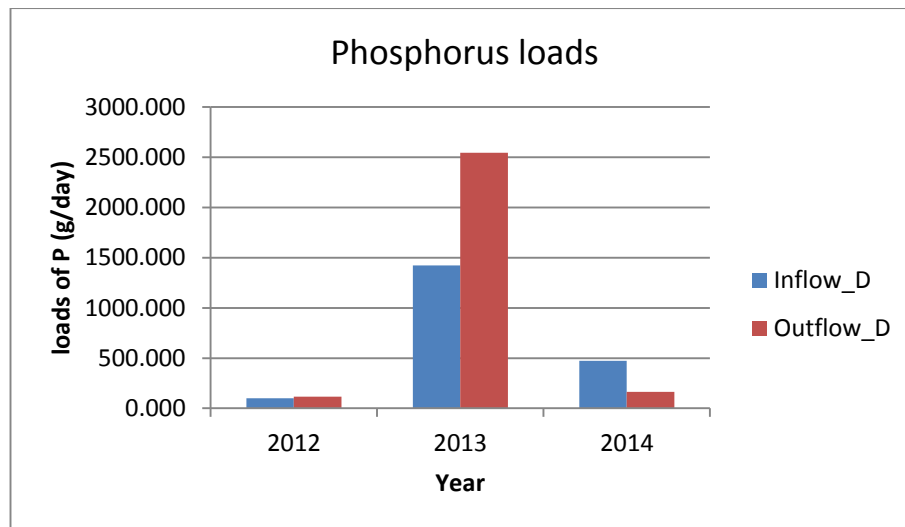


Figure 9: comparison of Chlorophyll *a* with previous years

2.3.6 Nitrogen loads

The loads of NH_4 were higher in both outflow of Durowskie and at the inflow of Kobyleckie. This was a little deviated from the previous result where the outflow of Lake Durowskie was showing less percentage of different measured parameters.

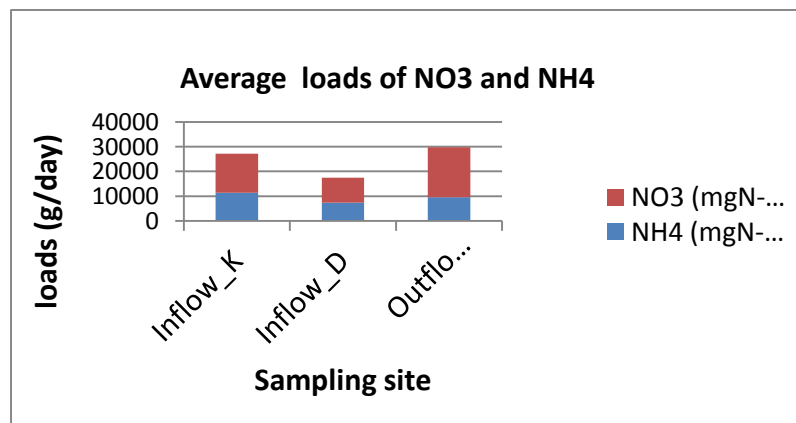


Figure 10: Average load of NO_3 and NH_4 in three sites

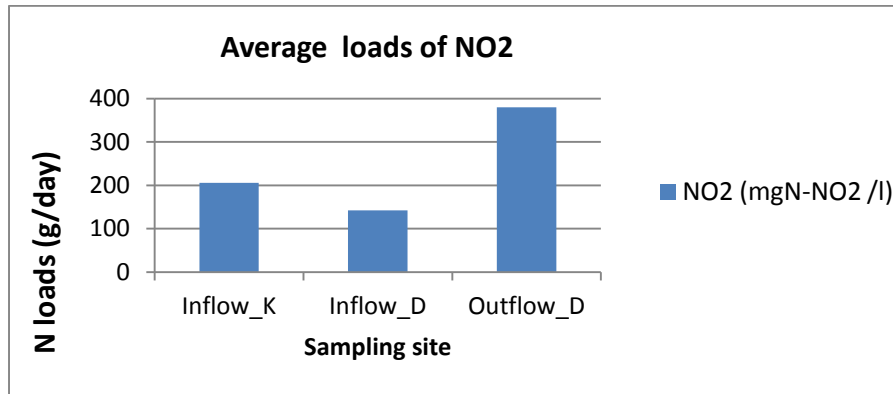


Figure 11: Average load of NO₂ in three sites

2.4 Water quality assessment of the upstream lakes

When considering the state of Durowskie Lake it is necessary to evaluate the situation in the upstream lakes. It is due to the fact that any change in the quality of upstream lake would have the significant impacts of the balances of downstream lake.

Since Durowskie Lake is situated at the end of all the lake therefore all the contaminants would eventually find their way to this lake. Therefore we decided to collect samples from all three upstream lakes. These samples were used to analyse chlorophyll *a* content, NO₂, NO₃, NH₄ and PO₄ and rest of the physic-chemical parameters of water quality assessment.

2.4.1 Chlorophyll *a*

The analysis of chlorophyll *a* content helped us to provide the sufficient prove to support our idea that the upper lakes are also contaminated. The figure below highlights that chlorophyll *a* content are increasing from upstream towards downstream lakes starting from Laskownickie and ends at Lake Kobyleckie. Since Lake Durowskie is an outflow of Lake Kobyleckie hence all the contaminants from these sources are ended-up accumulating in the Lake Durowskie.

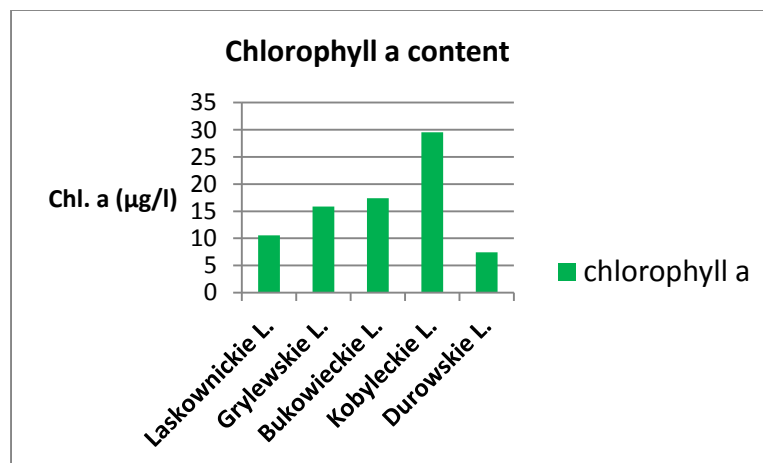


Figure 12: estimation of Chlorophyll *a* contents from the Upper lakes

2.4.2 Total Phosphorus contents

The same trend in terms of Total Phosphorus (TP) contents was observed in the upstream lake i.e TP was increasing from upstream to downstream with one exception of Lake Laskownickie. The elevated level of TP in this lake is due to extensive agricultural activities in the catchment areas of which are contributing higher loads of the phosphorus into the lake. This lake can be one of the areas where the extraction of water from hypolimnion can be a possible solution to improve the water quality.

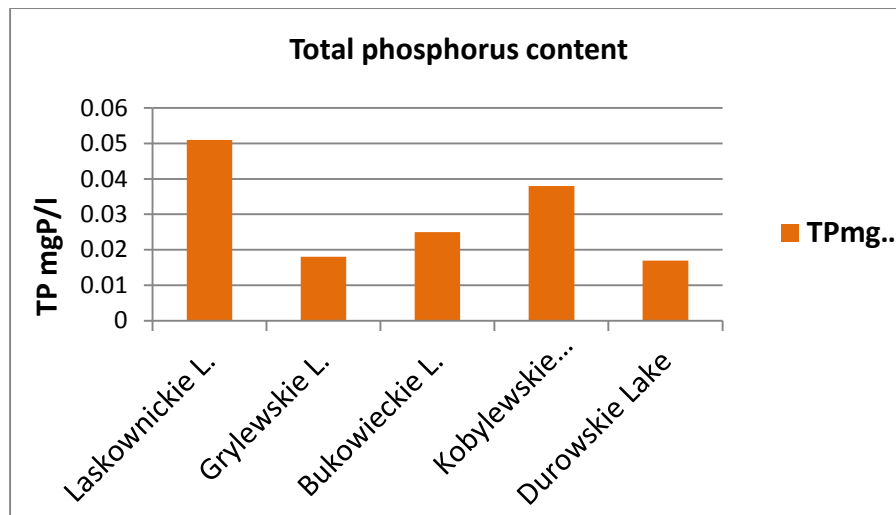


Figure 13: estimation of Total Phosphorus contents from the Upper lakes

3. Lake Durowskie: Management Aspects

3.1 Materials and Methods

We decided to consult the team of professors from Adam Mickiewicz University in Poznan (Poland) and University of Kiel (Germany) who are working on the Lake Durowskie restoration project since 2009. We organized individual interviews with all of them, focusing on main questions concerning the situation of the lake prior to the restoration work, measures taken so far, main stakeholders involved in this initiatives and suggestions for future improvements.

In addition to this, we visited different lake locations by kayak with Prof. Wilhelm Windhorst (Kiel University) to see how anthropogenic pressures, especially tourism activities such as fishing and use of speed motorboats for recreational activities, are affecting the water quality. We also tracked the forest paths surrounding the lake to explore the areas which are being used as hiking trails by people and also for mountain biking. Pictures and measurements were taken to assess the erosion potential and calculate its contribution to additional loads of phosphorus in the lake. Further steps involved review of the reports from the previous years' summer school to see what had been already proposed, and brainstorm of ideas to come up with some recommendations that would complement previous suggestions.

3.2. Contribution of erosion to lake deterioration

We have observed that up to this summer 2014 soil erosion is still going on a high rate. The question raised in our minds about the contribution of this eroded soil into putting more organic matter into the lake. To get an idea of it we calculated the erosion potential of some activities which are going on in this areas:

Fishing activities led towards the shoreline erosion and also affecting the littoral vegetation. The construction of fishing docks implies the cutting of shoreline macrophytes and in general their structure do not allow emergent vegetation to grow underneath. In some cases macrophytes are even impeded from growing in the areas next to docks, as swimmers also use such openings. Furthermore, many fishermen destroys the shoreline during the construction of fishing platforms and fishing spots which are more common in the southernmost part of the lake. This creates many littoral vegetation gaps that, according to calculations done by the previous summer school students which makes upto 1 km in total length and 920 m² in total surface area in the past years.



Figure 14: a fishermen harvesting macrophytes along the shoreline

Tourism activities are the other major originators of soil erosion. We could identify a wide range of actions that contribute to it:

In our observations an increased runoff was attributed to the un-planned infrastructure of access ways to the Lake. We saw several stairs sections and boat access ways that lead directly to Lake Front without any sediment retention walls or structures that could slow down the rain water flow. Consequently, these accesses ways strongly channel rain waters to a single point, multiplying their velocity and erosion capacity, especially during summer storms, which destroys the littoral vegetation and potential the wave erosion on the beach. We observed that people have also put some retention structures such as plastics and wood in front of access ways to control shore-line erosion.



Figure 15: shoreline erosion around along the shoreline

We observed around 20 new path ways made by locals and visitors that, intensified by the steep morphology of the lake basin, have slowly created big cuts without any vegetation coverage and huge erosion potential. According to our measurements we estimate that one such cut means a loss of 30 m^3 of soil, summing-up 640 m^3 in total, which equals to the carrying capacity of 36 Lorries. Considering the input levels of P into the lake through the water inflow, and

knowing that 1 m³ of sandy soil contains 700 gr of P, we got to the interesting comparison that the P input with 1 m³ of soil equals the P input through the inflow in one day.

Furthermore, we could spot a number of sport and recreational activities with great erosive effects. Motorboats, apart from its annoying acoustic disturbance, they also produce evident wave erosion on the shore. Besides, mountain bikers have totally transformed some places in the forest by excavating the ground for soil and building big hills suitable for their leisure sport, making huge paths for further erosion and sand run-off that finally reaches the water, which is situated only few metres ahead. And in last place, in some cases hiking and biking trails have fomented extensive erosion to surrounding areas. Such is the case of a beach situated in the southern-west shore of the lake, on the right of the main hotel of that lake's side. This open littoral gap suffers from wave erosion from the inside of the lake and also from run-off along the steep introduced-conifer forest (conifer forest soils have a poorer ground vegetation that enhances erosion process in steep slopes). Through that beach pass a hiking-biking signalled route. This incites people to make a stop right there to rest and bath, what supposes further pressure in the site. We had a look of this place from the upper side too, to have a full idea of the dynamics of its degradation. Surprisingly, we found that the erosion was much greater of what we expected from the shoreline view. Not only runoff of surface ground is occurring but the whole soil structure is collapsing downhill, creating a big canyon of significant size. We esteemed its soil loss in 360 m³, which is comparative the carrying capacity of 20 Lorries.



Figure 16: Eroded channel resembles to Grand Canyon

3.3 Recommendations for further management of the lake

a) Erosion control measures

Considering that erosion is contributing additional load of nutrients into Durowskie Lake, it is important that the control of those factors which are causing erosion should be taken into consideration in order to make the management of the lake more effective. We propose the following few ideas which may be considered to overcome the issue of erosion.

Fishing platform management:

The contribution of the fishing platform in the shoreline erosion is also significant as fishermen clear macrophytes for building these platform. There are several ways through which the erosion associated to these fishing docks can be minimized without disturbing the privilege for the people to enjoying fishing in lake Durowskie. We during the field visit around the lake observed a number of abandoned fishing platforms which are no more use by anyone. One suggestion to the authority which issue licenses to the people for building fishing docks would be that rather than allotting new undisturbed areas for fishing platform building they should try to repair the abandoned ones. Reuse of these platforms would reduce number of new platform and hence would help control macrophytes harvesting.

Since the southern parts of the lake are facing heavy loads of the contaminants already and in our opinion further construction of fishing platforms would be additional factor to promote the bank erosion further. Therefore in the selected areas where the construction of the fishing platform have eroded bank substantially, controlled fishing should be carried out. This could be done by specifying certain points where access of the fishing is allowed and construction of fishing platform would not be allowed until the restoration of the that part of the lake.

Change the designing of the fishing platform could also be an effective strategy to control the clearing of macrophytes from the shore. We noticed that the use of such fishing platform is already in practice. The relevant authority can specify the designs of the fishing platform which should be built. Trainings for the fishermen regarding building and maintenance of such preferred platforms can be organized in order to make people enable to build them by themselves and also to make it cost effective.

Management of the eroded areas along the shore line:

Sealing/closing the areas for public access around the lake where the human disturbance led to the erosion upto the hazardous level would be an important step towards the restoration of such areas. The management can declare such areas as protected for a certain period of time and after restoration they can be open for the public access through the specified trails or pathways. Plantation on such highly eroded can be a possible solution to stabilize the eroded areas

especially along the hiking trails. Additionally this plantation can also act as a fence to manage the hiking trail and make sure that people use the specified trail to access the lake.



Figure 17: one of the highly eroded beaches close to the hotels at Lake Durowskie

Furthermore the usage of specified trails to access the lake would be very important to stop development of gullies. We during the field visit observed a number of shortcut pathways to access the lake which are also responsible to destabilize the slope further. This is also an indication about changing the human behaviour as most such access points were lying very close the stairs or actual access point. Therefore awareness raising and putting sign boards indicating the trails directions could be helpful to make people use the right path.

Use of structure such as sedimentation retention walls can be a solution to control flow of sediments into the lake. We observed the usage of such structures at the end of each trail.



Figure 18: Access point of the lake where sedimentation retention wall has been built

A rough calculation of the erosion potential has been carried out to get an idea about the amount of nutrient loads which are arriving in Lake as a resultant of soil erosion. In the coming year, further details study on calculating the erosion potential should be included in the lake monitoring activities. This would be helpful to identify these additional sources of nutrient going into the Lake and also exploring the eroded areas for management.

B) Lake water quality improvement: Withdrawal of water from hypolimnion

The findings of this year's lake monitoring highlighted that the southern part of Lake Durowskie are still facing high loads of nutrients. One of the possible cause of this higher level of contaminants could be the inflow from the upper lakes and most significant of which is Lake Kobyleckie which is bringing heavy loads of nutrient which are settling in Lake Durowskie.

One strategy of deal with these elevated level of contaminants is the removal of water from the hypolimnion from Lake Kobyleckie. The method Water withdrawal from the hypolimnion is extraction of nutrient rich and oxygen deficient water from the bottom of the lakes through pumping. This is considered a low cost process and has been applied successfully in the past to restoration of eutrophicated lakes such as Lake Varese in Italy. (Zaccara 2007). Furthermore, this would not be a new initiative in this area as in the Lake Durowskie, the sports centre is already withdrawing water through pumping from the epilimnion.



Figure 19: Water withdrawal from the epilimnion in Lake Durowskie

This would also bring twofold benefits one in the form of improved quality of the water in the lake and the other one this nutrient rich water would act as natural fertilizer for the crops which would save substantial amount of money.

C) Education and awareness raise

Education and awareness are critical to achieve the goal of the lake restoration and to ensure its good state in the long-term.

Education of Fishermen community:

Fishing activities also contribute to the load of nutrients into the lake. As the fish stock decreases, most fishermen tend to use excessive extra amount of bait to attract them (sometimes up to 1 Kg of bait), being anyway able to catch few fish. Although such amount of organic matter added with bait may seem quite small, it reaches a great multiplier impact when dozens of fishermen practice it daily.

The previously mentioned regulation specifying the bait usage limits per catch would be a good solution but not successful in the absence of an effective control. Furthermore, it is more important to make fishermen realize how this activity makes the lake quality worse, and would ultimately lead towards the disappearance of fish from the lake.

In order to raise awareness, meetings of the local government with fishermen groups might be organized to convey them about the lake restoration and to highlight the role which fishermen can play in this process by limiting the amount of bait they use. Another possible idea would to be share with them the pamphlets or small booklets with information about the environmental friendly fishing methods.

Participation of local community:

Lake Durowskie builds up the identity for Wagrowiec and its people, and so its degradation would mean the destruction of such reputation and cultural wealth. The inhabitants of this area therefore have the responsibility to preserve the natural beauty of this lake so that this precious resource would be available for the future generations. To achieve it, the most important step is to raise awareness amongst locals and to involve them in the lake restoration. This could be done by the following ways:

Awareness raising events, such plantation campaigns (grass, shrubs and trees where possible) in those areas around the lake where erosion is a high due to vegetation removal. Inviting people to participate in this small-scale activity would allow to approach them to the importance of a

better lake water quality. At a later stage, people could be requested to visit the planted area to see how its improvement.

Similarly, works with children could be of special benefit. Many groups of children attend summer schools in Wagrowiec and have most of their activities around the lake, including swimming, motor boat rides... Since these children will be the custodians of this area in the future, it would be a good idea to engage them with conservation activities. This can make up their minds to become nature loving citizens as they grow. For instance, summer schools could carry out additional nature study activities such as nature camps, bird watching, solid waste collection etc. in which children can observe the lake biodiversity and participate in its cleaning and improvement. This could be applied to both local and visitor children from different towns and cities.

The local government should also share and provide an easy access for people to the information about the efforts which it is making to preserve the natural beauty of the lake and the results of the restoration initiatives. This is an important step to rise people awareness and involvement. This objective could be easily achieved by adding a new section on the town council website regarding the lake restoration initiatives. Pictures of important events related to the restoration work could be uploaded on this page. Use of social media, such as Facebook, to develop a page about the restoration of the lake could be another practical option. This could also be used as a tool to highlight the good work of Wagrowiec town and to set an example to follow for other towns which are contributing loads of pollution into the lake such as agricultural run-off from the outflow of Kobyleckie.

Tourist education:

Although the tourists do not have an important contribution in increasing the lake pollution, their environmental education is still very important to turn tourism into eco-tourism in real means. During our visits to lake and forest we found several spots with trash left by people. This indicates lack of awareness and shows a need to promote responsible tourism. Signboards and displays with information about the water quality state, threats and restoration measures, and with messages persuading not to throw waste in open spaces in and around the lake would be a good option to minimize such actions.

D) Management of macrophytes *Typha* reeds

During our visit to Lake Durowskie with Prof. Richard, we figured out that there are few points where *Typhatum* is growing in excess, these plants contribute to the additional loads of organic

matter in the lake during the winter season. The excessive *Typha* can be harvested from the selected areas without disturbing the breeding sites of birds which can be used to develop local community products such as small mats, decoration items and souvenirs. This would not only be good way to engage community and to promote the cultural aspect of the ecosystem services.

E) Regulate the use of motorboats

Tourism activities within the lake such as use of motorboats and water scooters causes strong turbulence in the water which leads towards the wave erosion and also mixing of the water from epilimnion to hypolimnion. Although the motorboats are not allowed to go beyond the aerators but we witnessed the breach of this regulation. Furthermore these motor boats in addition to water-scooters create immense noise which destroys all the peace in the surroundings and is a nuisance those which are visiting the lake for relaxing and fishing. The control of this factor however depends on the management objectives and preferences of the local government. If the restoration of the lake is the key priority than regulation of the usage of motor-boats should be a priority.

F) Restoration of water ecosystems at a regional scale

It is essential to plan a better communication and a joint restoration encouragement at regional scale with the towns and villages in charge of the management of upstream lakes (lakes Kobyleckie, Bukowieckie, Grylewskie and Golancz reservoir), which also have severe algal blooms due to eutrophication. And agree a benefit sharing among the communities involved.

Until now, the water pollution prevention and restoration activities have been only implemented by Wagrowiec authorities. Other towns of the region have not significantly cooperated as they do not probably recognize important reasons to take part in the process. The absence of any joint effort to improve the general situation could neutralize the measures taken so far by the city of Wagrowiec or even lead to a further aggravation of the situation. Moreover, from a political point of view, it will be always more difficult to go on with projects of lake restoration, using public money, without any remarkable improvement. A good way to involve the other cities in the restoration project could be making a general plan of development of regional tourism having the lakes chain and the surrounding areas as a focal point. The touristic activities should have a low impact on the ecosystem and consider the general good condition of the water, to give an incentive to the proper management of the lake. The benefit of the new economic activities have to be shared among the different communities to allow a real collaboration which would increase the revenues for all the parts involved. The spread of

activities and infrastructure in the region would not only be a way to start a profitable collaboration, but also important to avoid an excessive concentration in a small area like the city of Wagrowiec, which could cause a high impact on an ecosystem which is already suffering.

Among suggested proposals of active tourism activities that would involve different communities from the region are the following:

- Promote companies that would advertise “big adventure kayak routes” along the chain of lakes in the area, providing kayak rental (or other kind of vessels) and the possibility of its transport by van in the parts where river sections are too shallow for rowing.
- In the same way, create longer common hiking and biking trails and routes that would surround the whole lake’s region. And foment a cooperation between bike rental companies so that people could indifferently pick and give bikes back in different points along the region.
- Distribute the camping areas and resting places along such routes in an equidistant and sensible way.
- Develop other kind of interesting attractions, like canopy walkways parks and paint-ball enclosures, in up-stream town areas that are not as touristic as Wagrowiec and have a worst lake state to benefit from water recreation.
- Also some cultural events could be planned. For example, music festivals with stages in various towns throughout different days. A good bus connection between towns would be crucial for the success and crowd attendance to such events.

4. Conclusions

To conclude, the restoration of Lake Durowskie is an admirable step of the local government of Wagrowiec which is certainly improving the quality of the Lake water and it is hoped that lake would be returned to its original state one day. However, it is important to consider that the upper lakes are continuously contributing the loads of nutrients into this lake which is one of the reason of elevated level of contaminants in the southern part of the lake according to this year’s monitoring results. Therefore increase of cooperation between the governments of the other towns would be a very positive steps to find out the ways to maintain the water quality in other lakes. This can also be achieved through finding out the joint ventures to promote tourism for the whole region and by projecting the tourism potential of this region.

Furthermore, erosion along the shoreline and from the other parts of the forests is responsible to bring additional loads of Phosphorus into the lake. This source of contamination is localized and needs immediate attention. Tourism activities within the lake such as use of motorboats and water scooters causes strong turbulence in the water which leads towards the wave erosion and also mixing of the water from epilimnion to hypolimnion. Remedial measures such as building of small sediment retaining walls and control of macrophytes removal for the construction of fishing platform could be adopted. Community education focusing of specific groups such as fishermen, tourists, community members and children would be one of the way to raise the awareness about the importance of this lake and also to control the activities.

Furthermore the success of the restoration initiative is also associated with priorities defined by the local government. Since both restoration and tourism are accompanying each other, therefore in this case awareness raising and continuous restoration would be the possible way to achieve the target of a healthy and clean Lake Durowskie.

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