Hydrology of Lake Viljandi

Report

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Abstract

Lakes are a crucial part of the Earth's ecosystems - they provide habitats for many different animal and plant species, provide fresh water for continental areas, and also shape local climates. Lakes are invaluable for humans, providing fresh water, food, hydropower, and numerous services from tourism to fishing.

Hydrology has an important role in understanding the effects of waters and water ecosystems to the Earth's biosphere. The chemical compositions of waters give us information about the concentration of nutrients, acidity and purity of the waters. This information can be used to evaluate the overall state of the waters, which, in turn, can be a baseline for improving the quality of water and ensure sustainability for ecosystems and human activity that depend on those waters. The aforementioned is the reason why an expedition and research by Lake Viljandi in Estonia was carried out. The purpose of the expedition was to evaluate and to compare different water ecosystems around and by Lake Viljandi. It was accomplished by measuring hydrological parameters at five different sites around Lake Viljandi. The four hypotheses stated in the paper aimed to find out the impact of vegetation to waters around Lake Viljandi, impact of the City of Viljandi to the quality of lake water and the differences of water characteristics between stream and lake waters. It was discovered that vegetation has a clear effect on the water characteristics, the environmental policies around Viljandi lake were found to be effective enough to avoid contamination of waters by nitrates. Soil was discovered to have a high oxygen-removing effect on the waters.

Research Question and Hypotheses

Based on the knowledge about Lake Viljandi, the following research question was proposed: how do the water conditions differ in different parts of the lake's ecosystems?

To investigate this question, four hypotheses were proposed:

1) The oxygen concentration is higher in the streams than in the lake.
2) The higher the water temperature, the lower the oxygen concentration in the water.
3) The more vegetated the sites are, the higher the concentration of oxygen is.
4) The closer the sites are to the town of Viljandi, the higher the concentration of nitrates and nitrides is.

The research question and hypotheses were inspired by the acknowledgment that Lake Viljandi has a great impact on the areas around the lake's shores and town of Viljandi. Understanding the connections between different attributes of local waters and ecosystems could help in planning better and more effective ways for humans to live consciously in nature.

Introduction

Lake Viljandi is located in the Sakala upland with a surface elevation of 41.9 m. It is 4.6 km long, and up to 400 m wide, average depth is 5,6 and deepest point is 11 m, watershed size is 66,8 m^2. Shores are high, elevated up to 30 m, swampy and overgrown with *scirous* and *phragmites australis*. The lake emerged after the last ice age into Lake Viljandi urstromtal.
The lake has a well-balanced out- and inflow of water. Uueveski and Valuoja streams with many smaller springs flow into the lake, and Lake Viljandi is the source for Raudna river. Lake Viljandi is rich in nutrients and has a diverse ecosystem. (Keskkonnaagentuur, 2010b) Lake Viljandi has a great impact on the areas around the lake's shores and town of Viljandi. Understanding the connections between different attributes of local waters and ecosystems could help in planning better and more effective ways for humans to live consciously in nature.

As a part of the research The GLOBE Program's "MUC Field Guide A Key to Land Cover Classification" was used to get MUC codes of the sites.

Hypotheses

1) The oxygen concentration is higher in the streams than in the lake.

As it can be seen in Figure 1, the hypotheses turned out to be opposite to reality. The streams had lower oxygen concentration than the lake.

This result might have been caused by the oxygen-removing effect that soil around the streams has on rainwater, which is one of the sources of the water in streams.

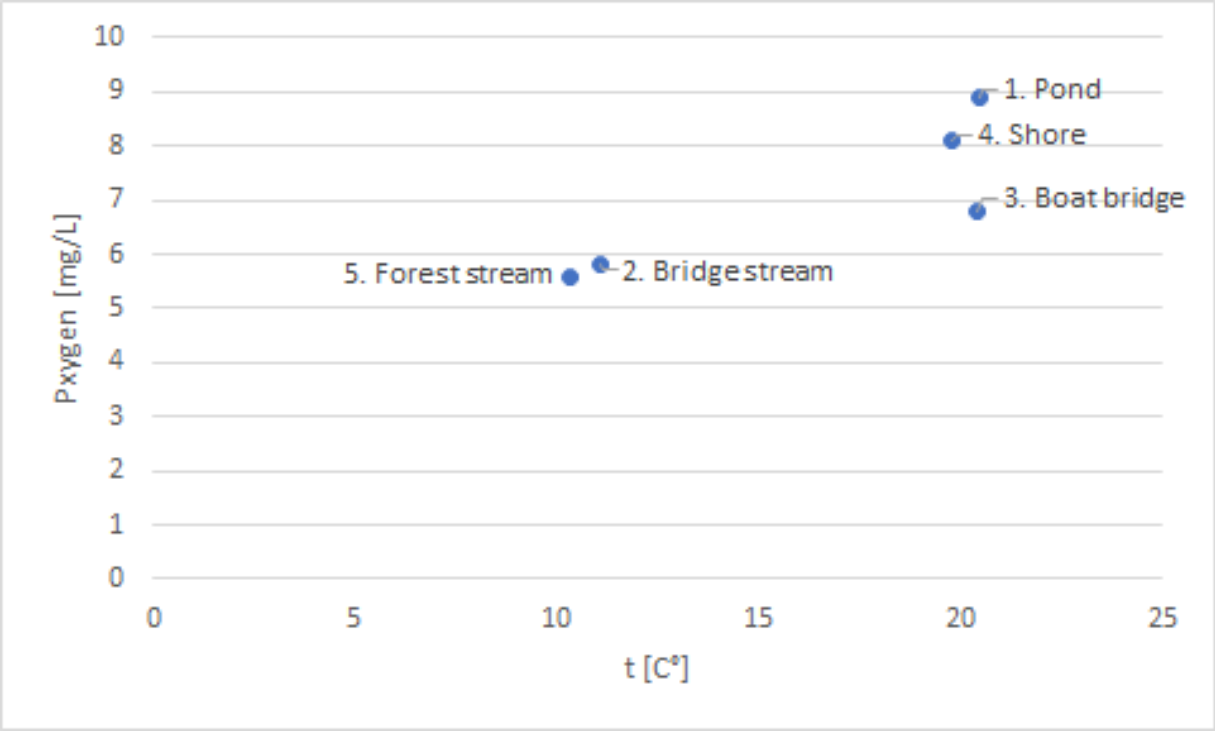


Figure 1. Oxygen concentrations in the lake (high temperature) and streams (low temperature)

2) The higher the water temperature, the lower the oxygen concentration in the water.

   Hypothesis turned out to be incorrect as can be seen in Figure 1. The opposite seems to have been true the lower the temperature, the lower the concentration of oxygen, which was surprising because the solubility of gases is higher in cooler liquids.

   Streams get part of their water from the rainwater that, before reaching streams, goes through soil. It is possible that the oxygen-removing effect that soil organisms have on rainwater is the reason why stream waters had lower oxygen concentration than lake water despite oxygen having higher solubility in cooler stream waters.

3) The more vegetated sites are, the higher the concentration of oxygen.

By evaluating the vegetation in measurement sites by MUC codes the following was found:

1. The forest stream had less vegetation than the bridge stream.
2. The boat bridge had less vegetation than the shore site.
3. The shore site had lower vegetation rates than the pond site.

Stream and lake waters were analyzed separately, because lakes and streams are by principle different bodies of water.

Comparing the vegetation rates with the oxygen concentration, it was concluded that the vegetation rates around the sites directly influences the oxygen concentration in the waters. The higher the vegetation rates were, the higher the oxygen concentrations were, which means that the stated hypothesis was correct.

This result could be caused by byproducts of photosynthesis (mainly oxygen) which dominates over the oxygen-removing decomposing processes of organic material.

4) The closer the sites are to the City of Viljandi the higher the concentration of nitrates and nitrides is.

As can be seen from figure 2 and figure 3, the nitrate concentrations were not influenced by distance from the city, as measurements from sites did not differ although the sites were at different distances from the city.

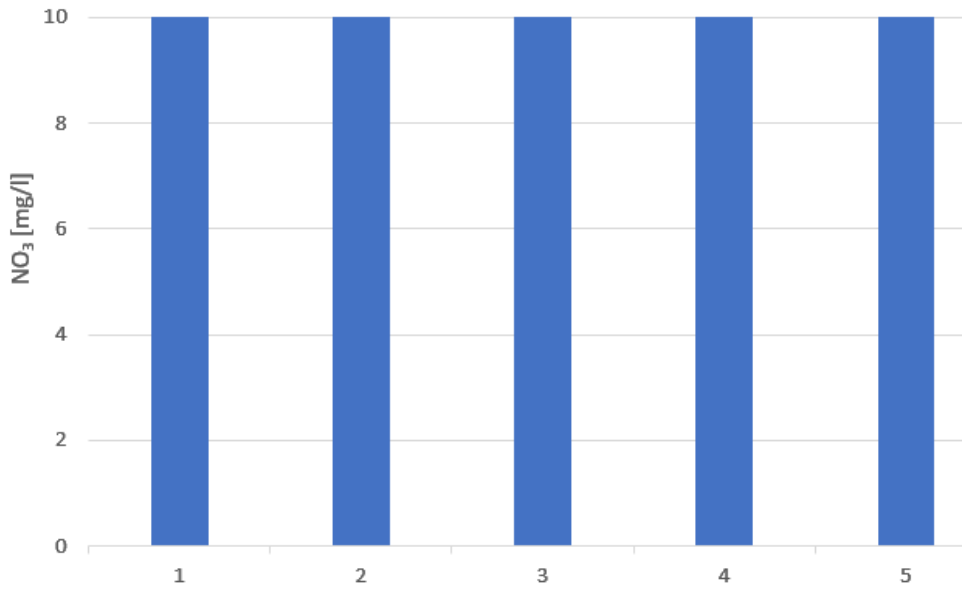


Figure 2. The concentration of nitrate ions in different site

The result could be influenced by successful environmental policies, especially by Viljandi nature reserve, which aims to preserve diverse landscapes and habitats of rare species (Keskonnaagentuur, 2010a), around Lake Viljandi that have kept the concentrations of nitrates and nitrides low in waters around the lake.

Research Methods and Materials

To find answers to aforementioned hypotheses data was collected from five different locations around the lake. The sites were chosen while taking into account their accessibility, biodiversity and relevance for research. Three of the locations were at the shore (Appendix 1, 4 and 5) and two of them were at the streams (Appendix 2, 3, 6 and 7) close to the lake to collect more diverse data. Site locations can be seen in Figure 3 and coordinates in Table 1.

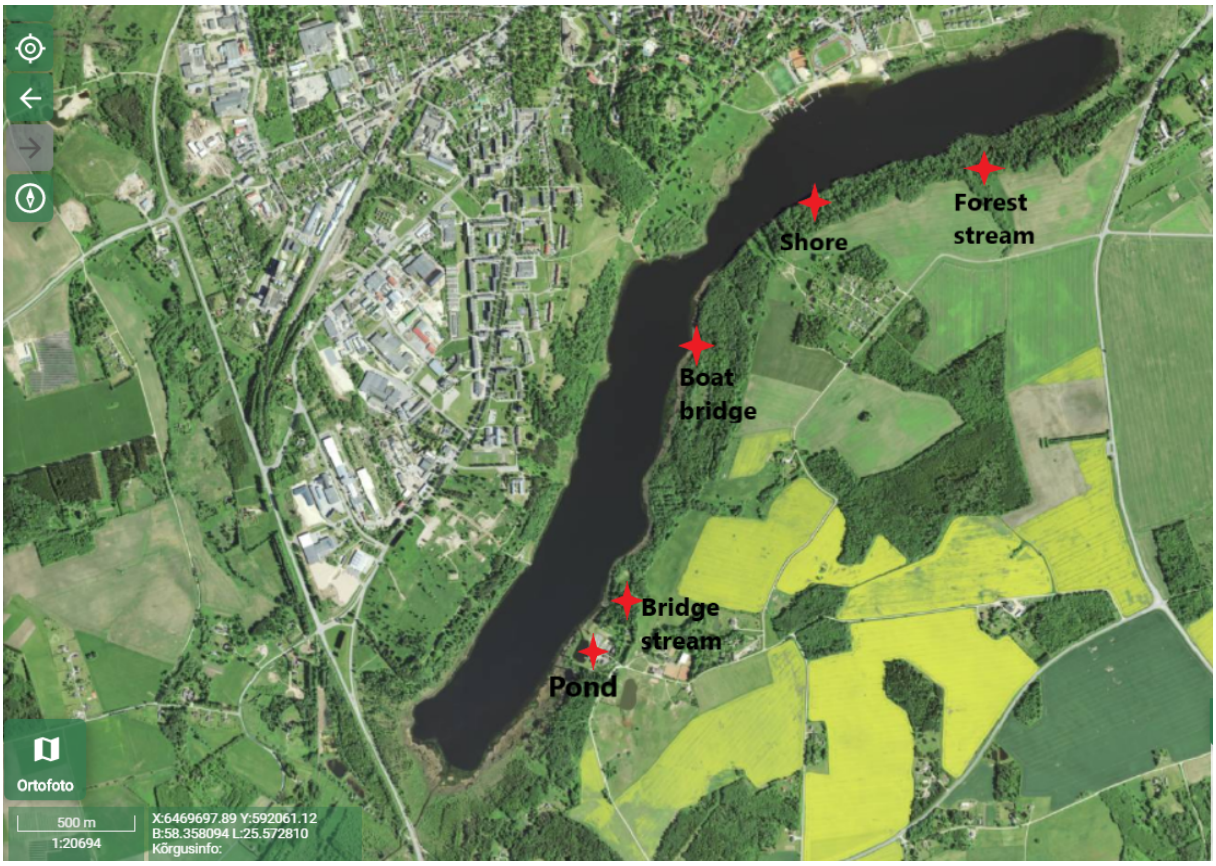


Figure 3. Sites of measurement

Data was collected with Vernier kits and AQUANAL Oekotest Water Laboratory Kit about the air and water temperature, colour, transparency, conductivity, pH, alkalinity of the water, concentrations of nitrates and nitrides and dissolved oxygen present in the water at each site. Photos of every observation site were also taken to later determine MUC codes of the sites using the Globe Program's "MUC Field Guide A Key to Land Cover Classification". At every site data about weather and atmosphere were collected which were sent to GLOBE via GLOBE's Science Data Entry app.

Table 1. Data used to answer by hypothesis

Indicators measured	Hypothesis	Equipment used
The oxygen concentration	There is higher oxygen concentration in the streams	Sauerstoff SA 10 Visocolor HE, Vernier Dissolved Oxygen Probe
The water temperature and the oxygen concentration and water temperature	The higher the water temperature, the lower the oxygen concentration in the water	Sauerstoff SA 10 Visocolor HE, Thermometer, Vernier Dissolved Oxygen Probe
MUC codes and oxygen concentration	The more vegetated sites are the higher the concentration of oxygen is	Sauerstoff SA 10 Visocolor HE, Vernier Dissolved Oxygen Probe
The nitrate and nitride ion concentrations	The closer the sites are to the Viljandi city the higher the concentration of nitrates and nitrides is	AQUANAL Oekotest Water Laboratory Kit

Air temperature, colour of water, transparency and alkalinity were measured to send a more thorough report to GLOBE through their science data entry app (Figure 11 and 12).

Results

As a result of the research only one of the four hypotheses were found to be correct.

Table 2. Initial Data

Name of site	Pond	Bridge stream	Boat bridge	Shore	Forest stream
Coordinates	58.338 N; 25.558 E	58.334 N; 25.583 E	58.359 N; 25.603 E	58.357 N; 25.613 E	58.364 N; 25.608 E
MUC codes	91	023	43	52	022
Water temperature (°C)	20.5	11.1	20.4	19.8	10.3
Colour	Yellowish	Transparent	Yellowish	Yellowish	Transparent
Transparency (m)	1.4	-	-	0.97	-
Dissolved O_2 (mg/l)	8.9	5.8	6.8	8.1	5.6
Conductivity (µS)	480	697	536	472	814
pH	8.21	7.34	8.24	8.52	8.2
Alkalinity (mg/l)	230	340	150	270	310
NO_3 (mg/l)	10	10	10	10	10
NO_2 (mg/l)	0.02	0.02	0.02	0.02	0.02
Air temperature (°C)	19.7	20.1	19.6	19.6	18.7

Discussion

The Republic of Estonia Environment Agency's claim that Viljandi lake has a diverse ecosystem (Keskkonnaagentuur, 2010) found confirmation as the MUC codes of the sites differed significantly.
The research expedition was able to show clear dependencies of the attributes of the waters around the lake, which makes it easier to apply effective environmental policies to protect these diverse ecosystems. This could be one of the reasons why the environmental policies to preserve the lake's ecosystems were found to be so effective.
The research could be repeated with more accurate equipment and with new sites for more detailed and diverse results.

Conclusion

Only one of four hypotheses (hypothesis 3) was found to be correct, which clearly shows the impact that vegetation has on the waters around it. This implies that researchers that study water conditions around vegetated sites, need to take into account the flora of their measurement sites when analyzing the results.

The other three hypotheses turned out to be incorrect due to the high oxygen removing effect of soil close to the streams (Hypotheses 1 and 2) and due to effective environmental policies around the lake the levels of nitrates and nitrides were equal in all the sites (Hypothesis 4).

The research was accurate enough to show the dependencies that different water ecosystems around Lake Viljandi have. The government's environmental policy was found to be effective on the waters in Lake Viljandi. Hopefully the research can be used for further improvements in human activities in the area.

References

The GLOBE Program (2000), *MUC Field Guide A Key to Land Cover Classification,* The GLOBE Program

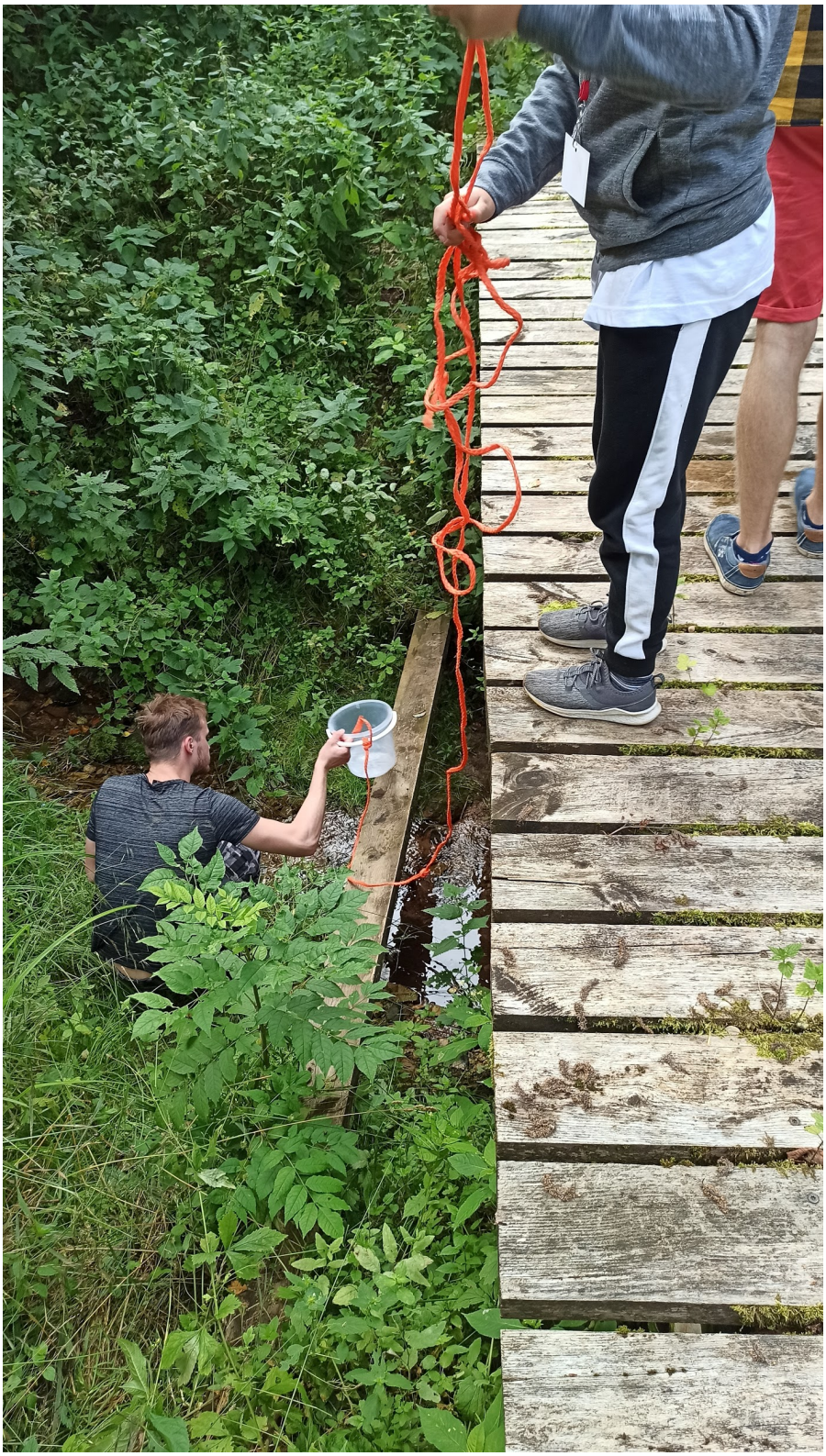
Keskkonnaagentuur, *Viljandi maastikukaitseala,* 2010a, https://eelis.ee/default.aspx?state=2%3B-1158249072%3Best%3Beelisand%3B%3B&comp=objresult%3Dala&obj_id=1161. Accessed: 14.08.2020

Keskkonnaagentuur, *Viljandi järv,* 2010b, https://infoleht.keskkonnainfo.ee/default.aspx?state=6;572247461;est;eelisand;;&comp=objresult=yrg&obj_id=1036670416. Accessed: 04.10.2020

Appendixes

Appendix 1. Collecting data from the pond site

Appendix 2. Collecting data from the bridge stream site (1)



Appendix 3. Collecting data from the bridge stream site (2)

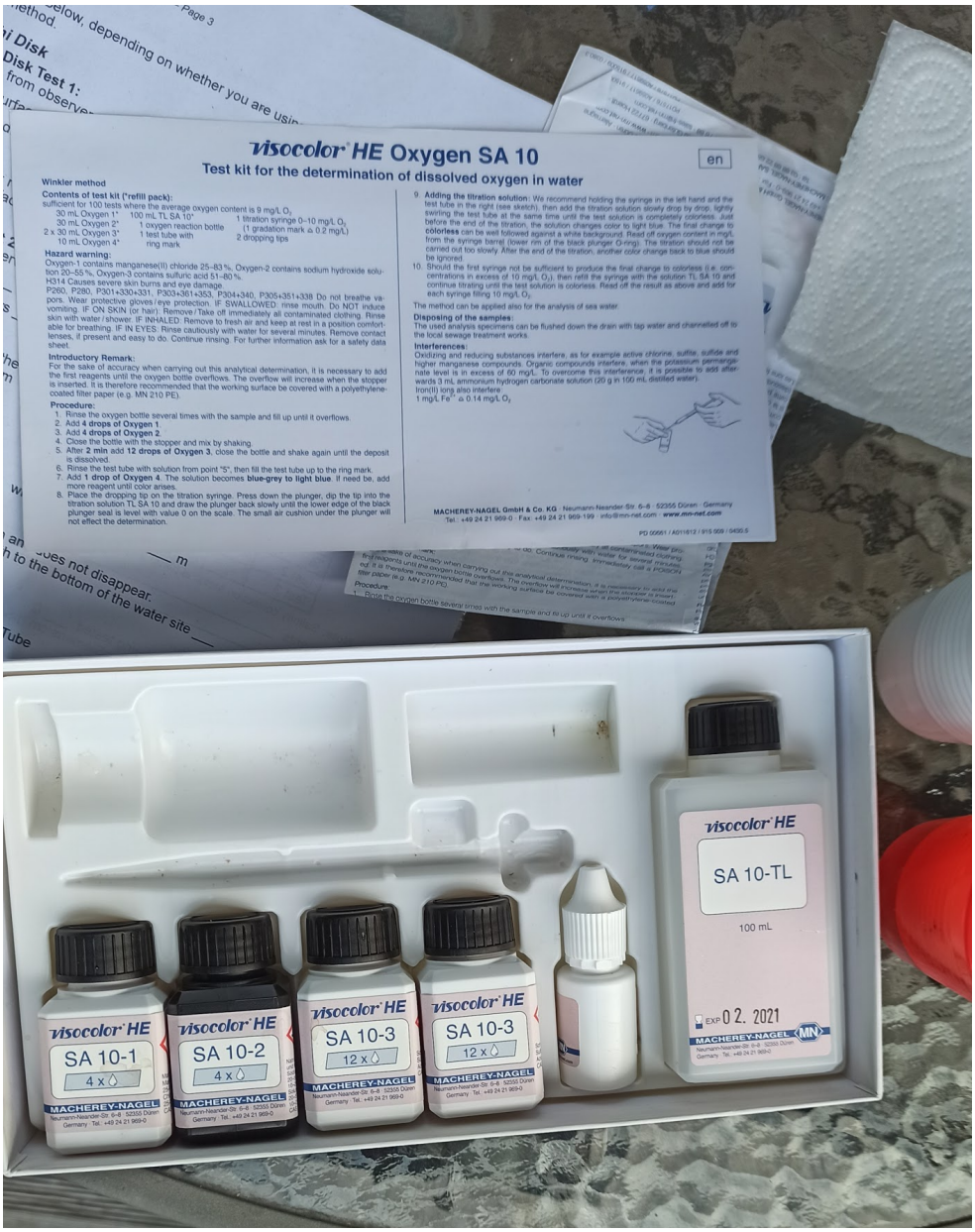
Appendix 4. Collecting data from the boat bridge site

Appendix 5. The shore site

Appendix 6. Collecting data from the forest stream site (1)

Appendix 7. Collecting data from the forest stream site (2)

Appendix 8. Oxygen concentration measuring equipment



Appendix 9. Vernier LabQuest Data Logger