GLOBE Learning Expedition

Hydrological measurements in Varemurru August 2021

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Abstract

Hydrological measurements are important, because they help us understand the climate and analyze everything around water bodies (Mander et al., 2014; Ott et al., 2020).

We were interested in how water bodies' hydrological parameters differ from each other and wanted to explore and analyze the hydrochemistry of water bodies. We studied 3 different research locations near Varemurru Holiday Village, Pärnumaa, Estonia. Two of the research locations were bio-ponds (one natural bio-pond and one artificial bio-pond), the third research location was the Baltic Sea.

Our hypotheses were:

1. High amounts of nitrates are in the actively used bio-pond.
2. The amount of dissolved oxygen decreases with the increase of temperature.
3. Seawater has a higher electrical conductivity than the water in the bio-ponds.
4. Water alkalinity decreases with the decrease of the water pH level.
5. Water transparency is better in the sea than in the artificial bio-ponds.

We used different tools to analyze the water bodies' parameters. The parameters we analyzed were water temperature, amount of dissolved oxygen, conductivity, pH value, alkalinity, the amount of nitrates, and transparency.
The results showed that one of our hypotheses were supported and four were partially supported. The bio-ponds and the Baltic Sea have quite different hydrochemistry. The biggest surprises were in the dissolved oxygen amount and in the electrical conductivity of the water bodies.

In the future it would be interesting to analyze the same water bodies in different seasons to see if and how much the bio-ponds' and the sea's hydrochemistry changes over the year. How do they change compared to themselves and each other, do the differences between water bodies' hydrochemistry become bigger or smaller?

Key-words: hydrology, hydrochemistry, bio-ponds, sea

1. Introduction

Hydrosphere forms a huge volume of our planet, approximately 1 386 000 000 km^3. The scope of the hydrosphere layer is around 20 kilometers - from the Mariana Trench to the glaciers on the mountain tops. The water on our planet plays a big role in supporting everyday life, dissolving different chemical compounds and shaping our climate on a local and global scale (Mander et al., 2014; Ott et al., 2020). Investigating connections in the hydrosphere are crucial for understanding the processes in this planet.

The purpose of our research was to explore and analyze the hydrochemistry of different water bodies near the Varemurru Holiday Village in South-West Estonia. Hydrological measurements are needed because this is how you can determine the quality of the water. As the water is important for different species to exist, it is great to know how various water's hydrological indicators affect the functioning of the water body. Hydrological measurements are also important to see how the water hydrochemistry changes throughout the years (Ott et al., 2020).

There is no data about the bio-ponds, but there has been numerous investigations of the ecological problems and water quality in the Baltic Sea (e.g. Lainela et al., 2020; Reckermann et al., 2021; Dietz et al., 2021). Regular measurements of water parameters have been carried out along the coast of Estonia since 1968 (Lainela, et al., 2020). The main problem is eutrophication which directly affects hydrochemical parameters and living organisms (Randmaa et al., 2020).

We suggested that there are differences between sample sites (sea water and water of bio-ponds).
Our hypotheses were:

1. High amounts of nitrates are in actively used bio-pond.
2. The amount of dissolved oxygen decreases with the increase of temperature.
3. Seawater has a higher electrical conductivity than the water in the bio-ponds.
4. Water alkalinity decreases with the decrease of the water pH level.
5. Water transparency is better in the sea than in the artificial bio-ponds.

2. Research locations

We studied three different research locations near Varemurru Holiday Village (Fig. 1, 2). The first research location was a probably abandoned, now almost natural bio-pond. The second research location was an artificial bio-pond, which was actively in use, and the third was the coastal area of the Baltic Sea.

Figure 1. Location of Varemurru Holiday Village in Estonia. Source: Google Maps.

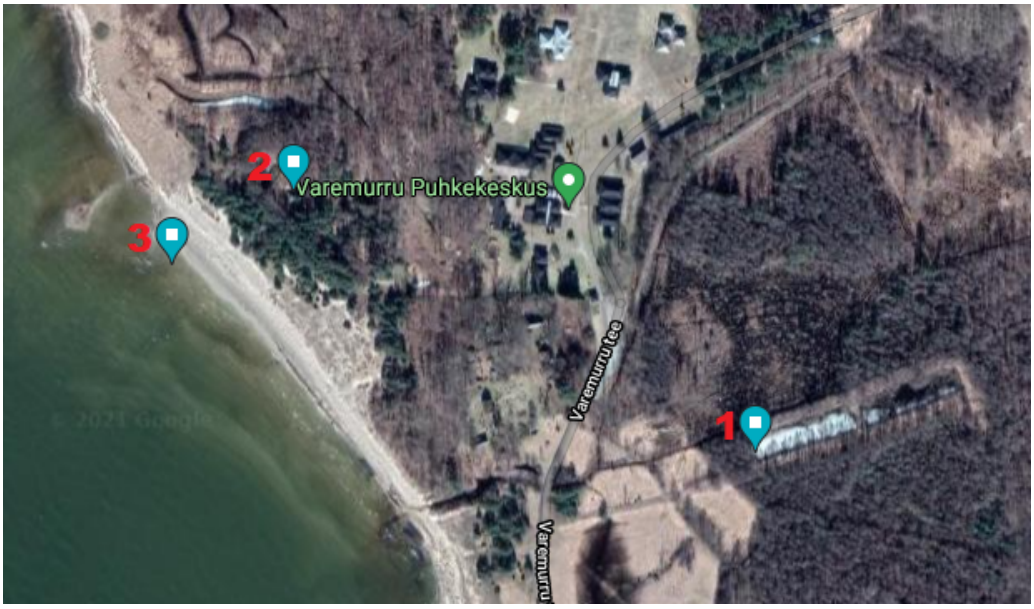

Figure 2. Map of research and sampling locations. Numbers refer to sampling sites: 1 - natural bio-pond; 2 - artificial bio-pond; 3 - the Baltic Sea. Source: Google Maps, with author additions.

The natural bio-pond (Fig. 3) was very shallow and surrounded by trees and the measurements were taken earliest during the expedition (9.30 AM). The second sampling site, the artificial bio-pond, was completely surrounded by trees, was deep and surrounded with metal sheets. It seems that this was actively in use. The *in-situ* measurements were carried out around 10 AM. The Baltic Sea coast was without shading, totally under the sun and was very windy. The *in-situ* measurements were carried out at 10.25 AM.

Figure 3. Research sites of expedition. 1 - Natural bio-pond (Photo: T. Piirimäe); 2 - Artificial bio-pond (Photo: T. Piirimäe); 3 - Coast of the Baltic Sea (Photo: I.-K. Nursi).

3. Materials and methods

We did fieldwork at the research locations and analyzed the water samples on 10 August 2021 from 9:30 AM to 12:30 PM.

We analyzed the dissolved oxygen and the water temperature at the sampling site. We had tools and chemicals with us, thanks to which we could analyze the data right away (especially the rapidly changing parameters). For other analyses, we collected water samples from each sampling site. Other parameters were analyzed at the campsite. We used both chemical test kits and electronic probes (Vernier) to analyze the water samples. We used GLOBE hydrology protocols to collect data. After analyzing the data, we entered the collected data to the database at the globe.gov website (Fig. 4).

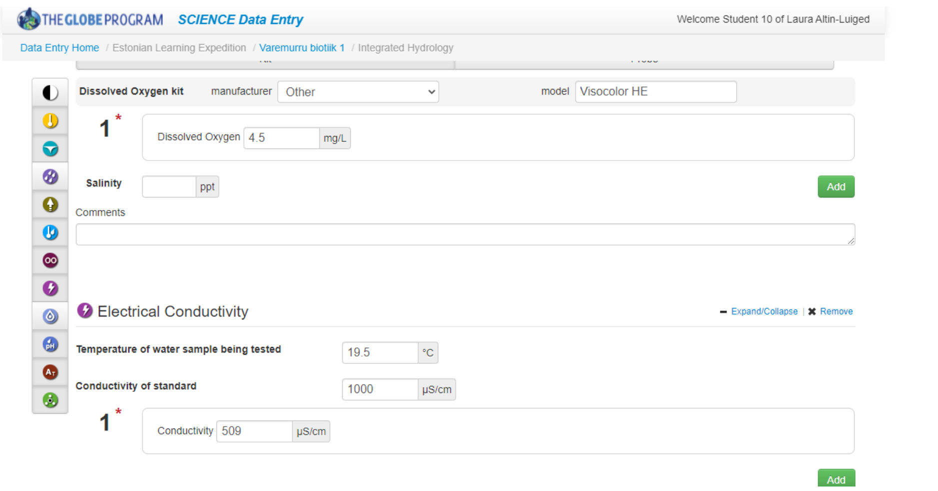

Figure 4. Screenshot of inserting the data to the database. Source: globe.gov.

We also did atmospheric measurements at noon. We observed clouds, measured air temperature, humidity, precipitation and air pressure.

The tools we used were Vernier sensors:

- for pH, sensor PH-PTA,
- for conductivity, probe CON-BTA,
- for temperature, the stainless steel temperature probe TMP-BTA,

For chemical analyses we used different test kits:

- for dissolved oxygen, Visocolor HE Oxygen SA 10,
- for alkalinity, Visocolor HE Alkalinity AL 7,
- for amount of nitrates, Visocolor ECO Nitrate,
- transparency tube.

4. Results

We gathered the collected data into tables for a better overview. In this section, the results of the fieldwork will be presented for each research location, followed by a comparison of the results. The atmospheric measurements at noon showed us that the air temperature was 24.1℃, humidity 60%, air pressure 1019.5 hPa. The most common cloud types were cirrus and cirrostratus, and there was no precipitation. Table 1 shows hydrological measurements made at each sampling site.

Table 1. Results of analyzed samples from the sampling sites. For comparison, the summer average of different parameters of the Baltic Sea coast are presented in the final column.

		Sampling site 1	**Sampling site 2**	**Sampling site 3**	**Coast of Baltic Sea**
Analyzed parameter	Unit	Natural bio-pond	Artificial bio-pond	The coast of Baltic Sea	Summer average (from Lainela et al., 2020)
Temperature	°C	19.5	16.7	19.1	17.1
Dissolved oxygen	mg/l	4.5	6.25	9.3	6.2
Conductivity	µS/cm	509	409	12862*	*n.d.*
pH		7.27	6.71	8.36	8.21
Alkalinity	mmol/l	2.8	2.6	2.1	*n.d.*
Nitrates	mg/l	0	0.2	0	0
Phosphates	mg/l	*n.d.*	*n.d.*	*n.d.*	0
Transparency	m	1.13	>1.2	>1.2	1.9

* - An anomaly, which we could not explain.

We compared the relationship between the pH and alkalinity of the water (Fig. 5). The highest alkalinity was measured at the sampling site 1 (natural bio-pond). Highest pH value was measured on the coast of the Baltic Sea.

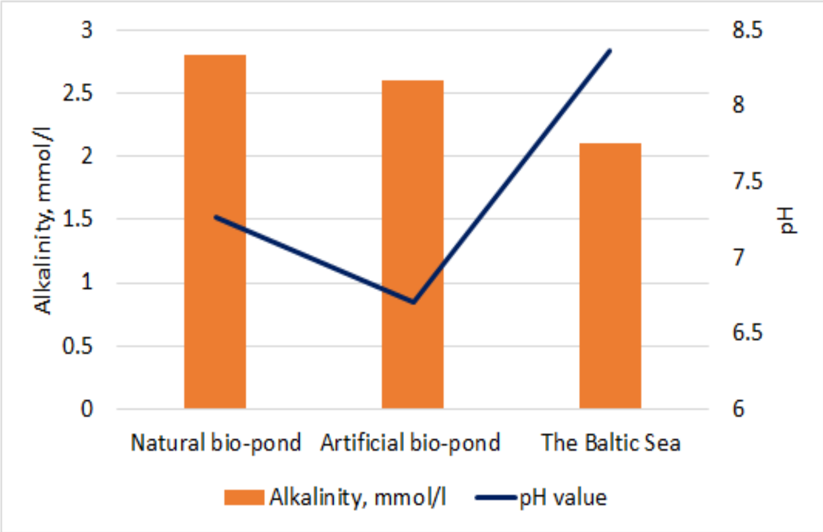

Figure 5. Relations between pH and alkalinity in different sampling sites.

The water's pH was also compared to the dissolved oxygen amount (Fig. 6). The highest amount of dissolved oxygen was measured in the Baltic Sea. Smallest amount of dissolved oxygen was measured in the natural bio-pond.

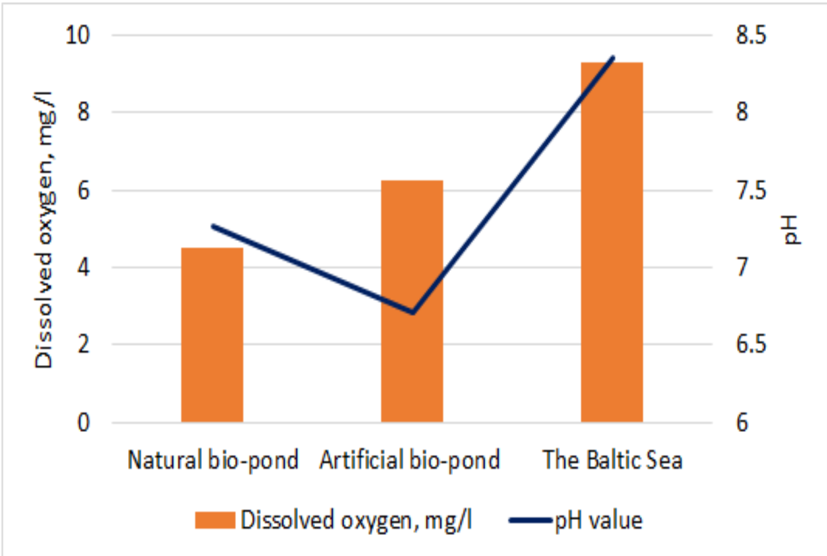

Figure 6. Relations between pH and dissolved oxygen in different sampling sites.

The relationship between the water's dissolved oxygen amount and temperature was compared as well (Fig. 7). Temperature of the natural bio-pond and the coast of Baltic Sea were quite similar. The lowest temperature was measured in the artificial bio-pond.

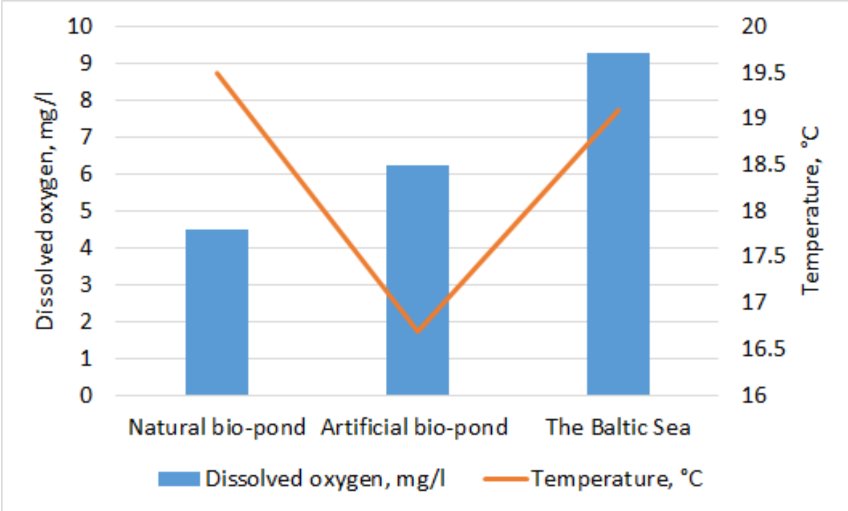

Figure 7. Relation between dissolved oxygen and temperature in different sampling sites.

We also made a graph to compare the electrical conductivity in different water bodies (Fig. 8). The highest value was measured in the Baltic Sea. This is an anomaly which we could not explain, considering that the Baltic Sea is a brackish water body.

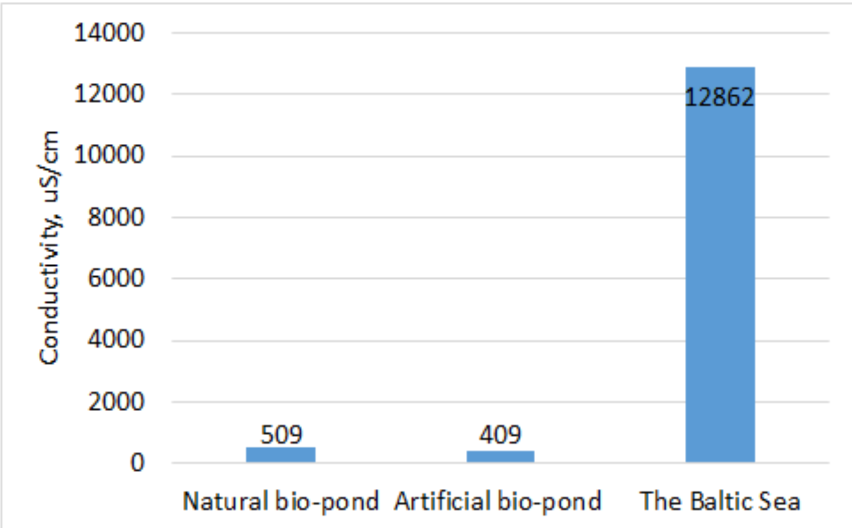

Figure 8. Conductivity in the different water bodies.

5. Discussion

Our research showed that the water parameters of the bio-ponds and the Baltic Sea are quite different.

The pH was the highest in the Baltic Sea (8.36) and the lowest in the artificial bio-pond (6.71). The high value of pH in the sea may be the result of decomposing microscopic and macroscopic algae and/or plants. This natural phenomenon is usual after a very hot summer.

The warmest water body was natural bio-pond (19.5℃), the coldest water body was the artificial bio-pond (16.7℃) and the Baltic Sea had a temperature of 19.1℃.

All investigated water bodies were quite transparent, although the artificial bio-pond and the Baltic Sea had better transparency than the natural bio-pond. The transparency of the artificial bio-pond and the Baltic Sea was bigger than the length of the transparency tube.

The natural bio-pond and the Baltic Sea did not have any nitrates and the artificial bio-pond had 0.2 mg/l of nitrates. Usually, the water bodies with photosynthetic plants (algae, macrophytes) use all the nitrates and phosphates that are dissolved in the water. This is the only free form of nitrogen that plants can use for forming biomass. We did not measure the total nitrogen, which could be much more informative for assessing the chemical status of the water body.

Alkalinity was the highest in the natural bio-pond (2.8 mmol/l) and the lowest in the Baltic Sea (2.1 mmol/l). In the big picture, these results are quite the same.

Conductivity in the artificial bio-pond was the lowest (409 µS/cm). The conductivity of natural bio-pond was 509 µS/cm and in the Baltic Sea the electrical conductivity was 12862 µS/cm, which was surprisingly high. After calibrating the sensor, the result was the same. The Baltic Sea is a water body with brackish water, and therefore the result can not be that high. This anomaly we can not explain.

Another surprise was the high oxygen amount in the Baltic Sea (9.3 mg/l). We suggested that the highest oxygen amount would be in the coldest water body, in the artificial bio-pond. The oxygen amount of artificial bio-pond was lower (6.25 mg/l) than in the sea. The lowest oxygen amount was in the natural bio-pond (4.5 mg/l). The high oxygen values in the Baltic Sea could be the result of aeration by the wind.

6. Conclusion

The purpose of our research, which was to explore and analyze the hydrochemistry of water bodies, was met.

Hypothesis 1 was supported. An actively used artificial bio-pond has more nitrates than a natural bio-pond and the sea. **Hypothesis 2** was partially supported. The content of dissolved oxygen decreases with the increase in temperature in bio-ponds but not in the sea. High oxygen values may be the result of aeration by the wind. **Hypothesis 3** was partially supported. Seawater has very high conductivity when compared to the water from the bio-ponds. This must be viewed critically, because of the anomalous result of conductivity of the Baltic Sea water. **Hypothesis 4** was partially supported. Alkalinity decreases with the decrease of the pH level in the bio-ponds but not in the sea. That is due to the carbonate/hydrocarbonate buffer system of the sea water pH level. Water with pH 7-10 has higher concentration of hydrogen carbonate ions. Water bodies with acidic pH have never high alkalinity. **Hypothesis 5** was partially supported. The sea has better transparency than the natural bio-pond but we do not know if it has better transparency than the artificial bio-pond.

If we were to do this research again, we would plan our activities more ahead so we could be more organized in our work. It was a little difficult to analyze all the different parameters of the water bodies, when we did not know exactly how to do everything. Now that we have some experience, we could do this better.

In the future, it would be interesting to see how the investigated parameters change throughout the year. Bio-ponds and the sea should be analyzed in different seasons to see how it affects the investigated parameters. It would be informative to do even more analyzes (e.g. total nitrogen and total phosphorus). This would give us a more precise picture of the status of the water body.

Figure 9. Group photo of team Swans. (Photo: T.-M. Ämarik)

7. References

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