GLOBE Estonia Learning Expedition 2025

Relationships Between Benthos, Water Chemistry and Human Activity in Jõulumäe Trench

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Abstract

GLOBE Estonia Learning Expedition 2025 in Pärnumaa, Jõulumäe, focused on investigating a drainage trench located next to Jõulumäe Recreational Sports Centre. The aim was to provide an overview of the ecological status of the waterbody and to explore the relationships between benthic community composition, water chemistry, and the intensity of human activity. We formulated three research questions: How does the composition of benthic organisms change along the trench? How are water properties influenced by human activity? How is the benthic community composition related to water chemistry?

This study is important because, at present, the Estonian state is able to monitor the status of only 14% of flowing waters and 3% of lakes. Monitoring a greater number of waterbodies would contribute to the protection of Estonian aquatic ecosystems, since detecting problems at an early stage makes it possible to reverse the deterioration of freshwater ecosystems and drinking water quality.

On August 17, 2025, we collected data from nine monitoring sites distributed along a 3-km section of the trench, measuring several water quality parameters: pH, temperature, electrical conductivity, hardness, nitrate, and phosphate content. In addition, at each monitoring site we used a kick-net to take two samples and observed the benthic invertebrate communities present. For data collection, we employed a multimeter and water analysis tools.

As a result of the study, we obtained an overview of the condition of the Jõulumäe trench: overall water quality was poor, the trench showed signs of eutrophication, and in one monitoring site the phosphorus concentration exceeded the threshold for the "very bad" status class. Signs of human activity were recorded at six out of nine sites, and in general, phosphorus concentrations were higher in sites affected by human activity, whereas nitrate was not detected in any site. The benthic community composition showed clear variation along the trench, although no direct relationship with water chemistry could be identified from our results.

Keywords: Pärnumaa, hydrosphere, benthos, water chemistry, monitoring

1. Introduction and Review of Literature

We conducted fieldwork to investigate the condition of the Jõulumäe trench. To assess its ecological status, we examined the benthic invertebrate community. In addition, we measured water temperature, pH, and electrical conductivity, and later analyzed water samples for nitrate and phosphate concentrations as well as hardness, in order to obtain a comprehensive picture of the trench's water chemistry.

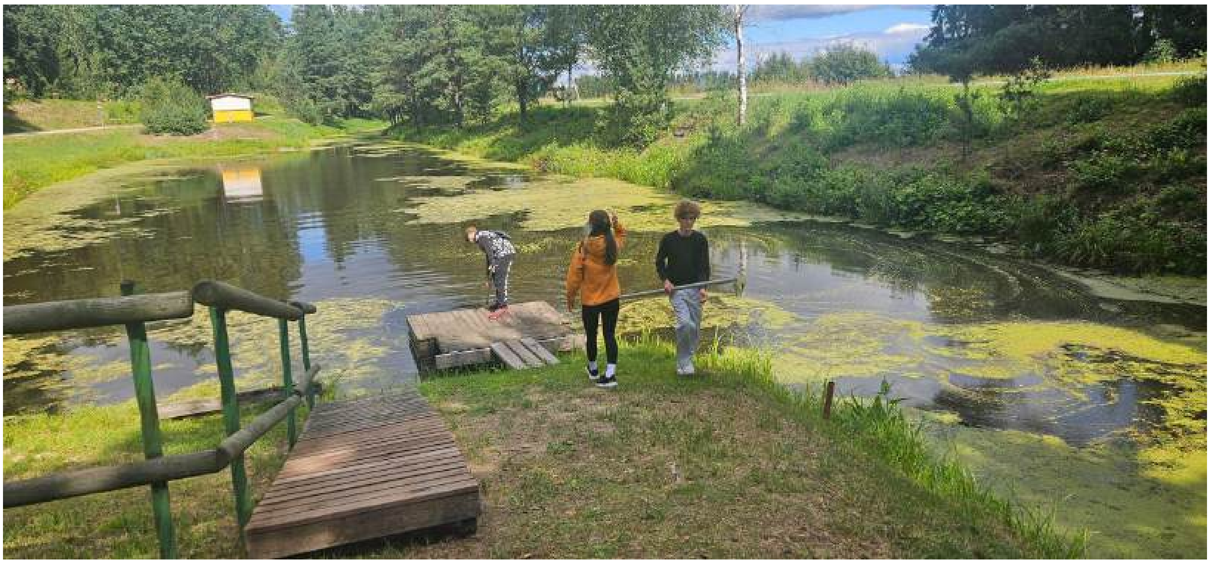

Figure 1. Jõulumäe trench and students (A. Vaarik)

The aim of the expedition was to identify relationships between the benthic community composition, water chemistry, and the intensity of human activity in the Jõulumäe trench, and to evaluate the overall status of the waterbody. We formulated three research questions and corresponding hypotheses:

1. What is the composition of the benthic community at different sampling sites along the trench?
   Our hypothesis was that the benthic community composition varies along the trench.

2. How is water chemistry related to the intensity of human activity?
   Our hypothesis was that sampling sites closer to human activity would show higher nutrient concentrations in the water, for example due to wastewater entering the trench.

3. How is benthic community composition related to water properties?
   Our hypothesis was that higher nutrient concentrations in the water would be associated with greater diversity in the benthic community.

These research questions are of scientific interest because they provide insights into the ecological status of the waterbody. The Estonian state currently monitors only 3% of lakes and 14% of flowing waters, which is a very limited proportion. Expanded monitoring would support the protection of aquatic ecosystems and help to prevent the deterioration of freshwater ecosystems and drinking water quality (Veestik.info, n.d.).

The ecological status of the trench was interpreted based on nutrient concentrations, drawing on whole-lake experiments that have demonstrated that phosphorus availability primarily determines the extent of eutrophication and that reducing phosphorus inputs can rapidly improve water quality (Schindler, 1974).

Phosphate and nitrate ion concentrations were used to classify the waterbody's status according to the criteria provided in Appendix 4 of Regulation No. 19 of the Estonian Minister of the Environment (Keskkonnaminister, 2020).

2. Research Methods

During the expedition, we collected data from nine different monitoring sites along a 3 km stretch of the Jõulumäe trench (Figure 2) in order to assess the ecological status of the waterbody and the potential impact of human activity on water quality. This survey represented the first monitoring effort conducted on the trench. To visualize the monitoring sites on a map, we used the Estonian Land Board’s online mapping application. Jõulumäe trench is located adjacent to a road and in close proximity to areas of intensive agriculture, while on the opposite side it is bordered by pine forest.

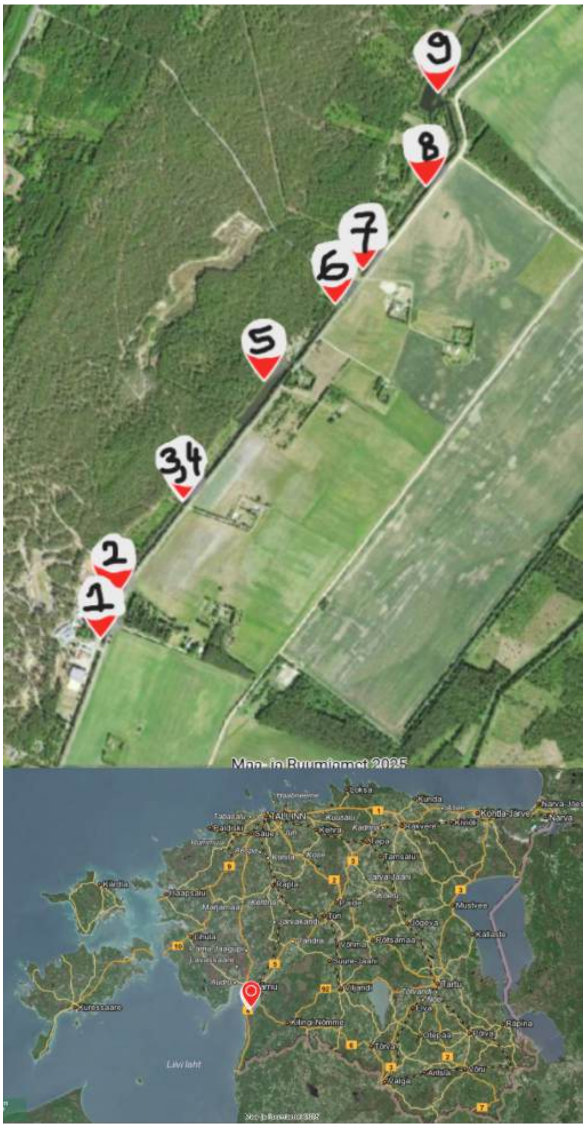

Figure 2. Jõulumäe trench on the map of Estonia (below) and locations of the 9 monitoring sites above) (X-GIS, 2025)

For the investigation of trench water, we used the following equipment (Figure 3): a telescopic rod for collecting water samples, sampling bottles, a bucket, the Estonian Land Board's online mapping application, and a kick-net for capturing invertebrates. Water pH, electrical conductivity, and temperature were measured with a multimeter.

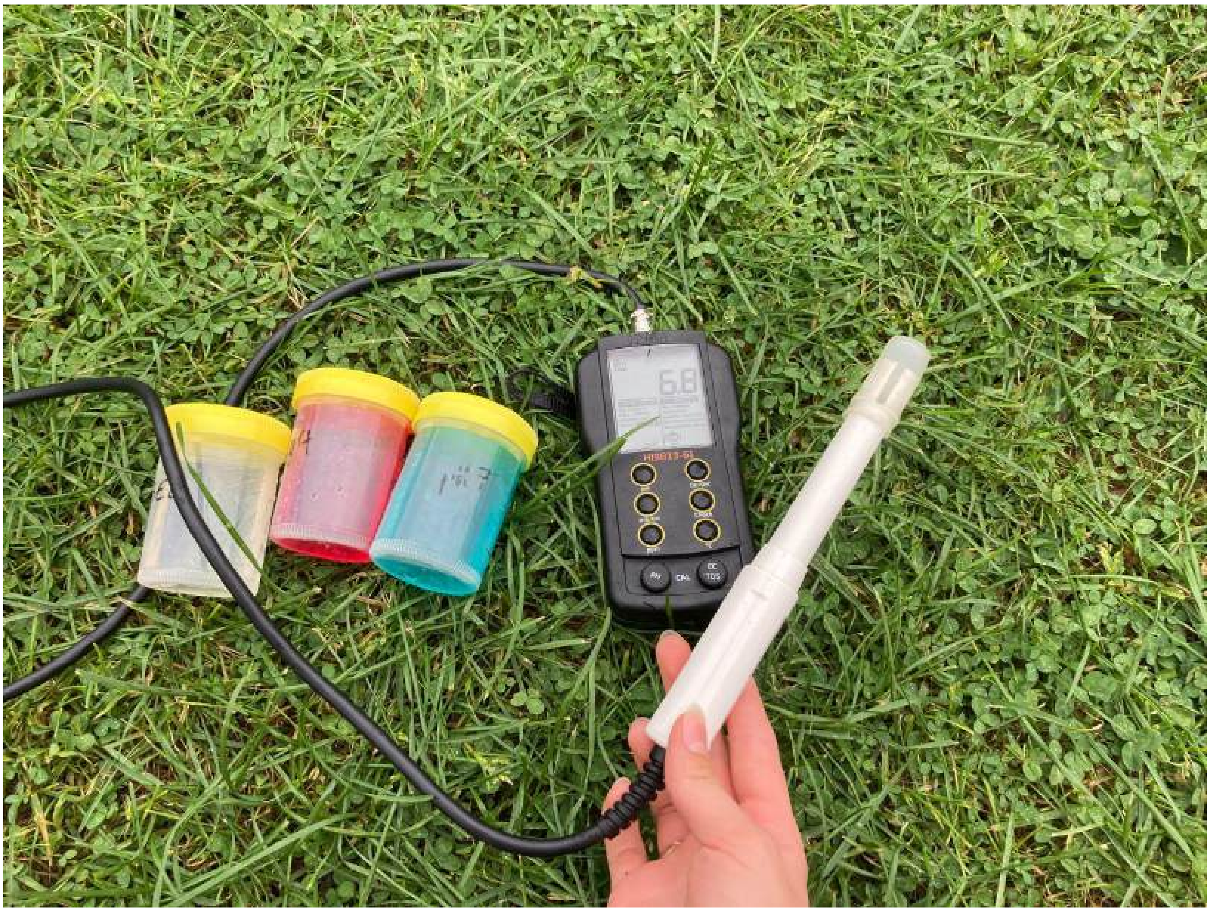

Figure 3. Multimeter and the solutions used to calibrate it (M. Loit)

All water samples were collected using a telescopic rod with sampling cups, with one cup assigned to each monitoring site. To avoid contamination from residual water, each container was rinsed three times prior to sampling. The sampling cups were labeled with the code *JK* (referring to the Jõulumäe trench) and the respective monitoring site number (Figure 6).

At each monitoring site, two kick-net samples were taken. After each sampling, the contents of the net were examined for two minutes to identify organisms (Figure 4). Photographs were taken of the macroinvertebrates, which were then counted and released. At each site, water pH, temperature, and electrical conductivity were measured using a multimeter.

Figure 4. Looking for macroinvertebrates in a kick-net sample (A. Vaarik)

Subsequently, phosphate and nitrate ion concentrations in the water samples were analyzed with a Handheld Colorimeter Phosphate LR and a Handheld Colorimeter Marine Nitrate HR sensor, respectively (Figure 5). Total hardness was measured using Visocolor School drop titration test kits, series 933100.

The results of the chemical analyses and the benthic community observations were compiled into Excel spreadsheets for comparison. Graphs were used to explore potential correlations between parameters. Benthic invertebrate abundance was assessed on a scale of 0–3, where a score of 3 indicated that the taxon was markedly more abundant at that monitoring site compared to others, while a score of 0 indicated that no individuals of that taxonomic group were captured in two net samples from the site.

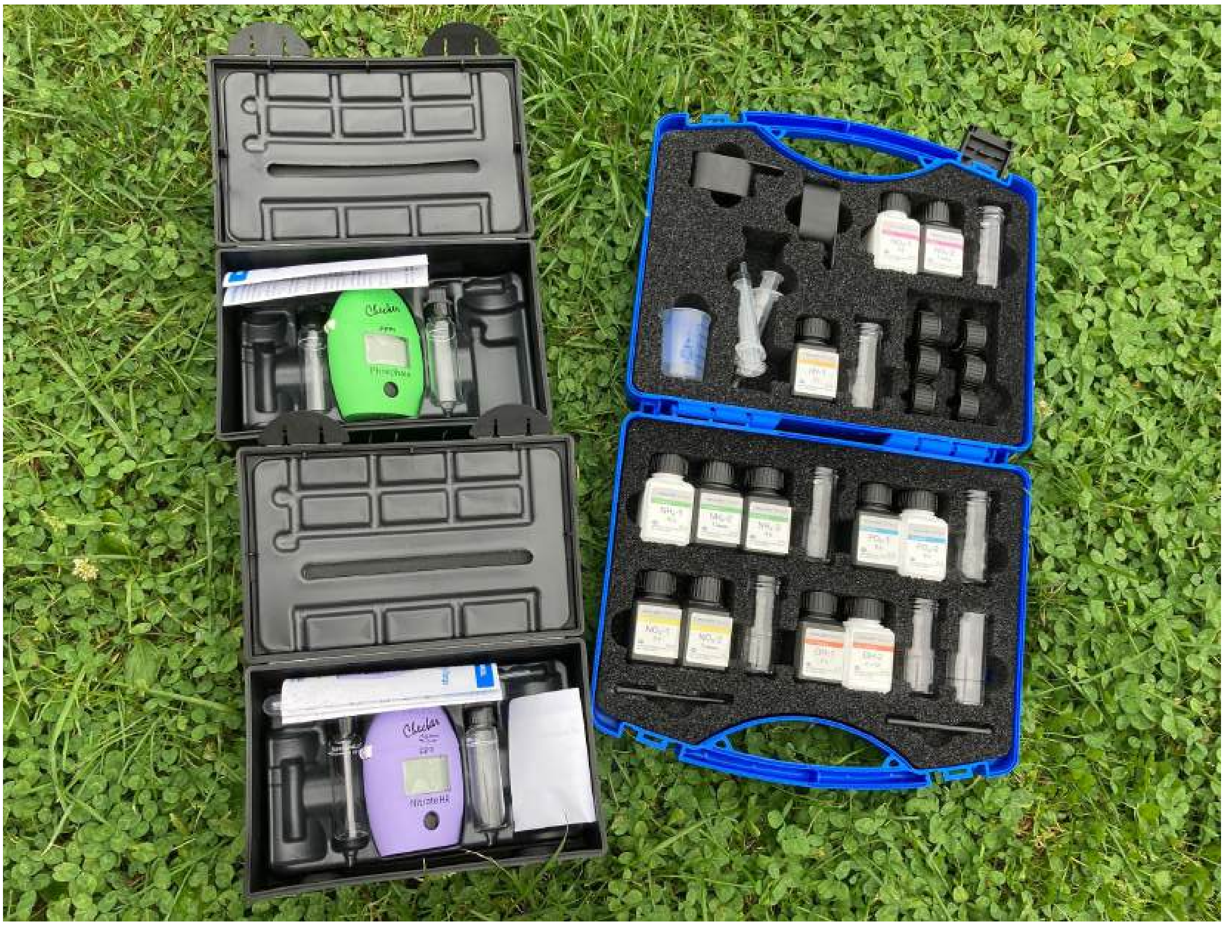

Figure 5. Testing kits used to analyze the water chemistry of the samples (M. Loit)

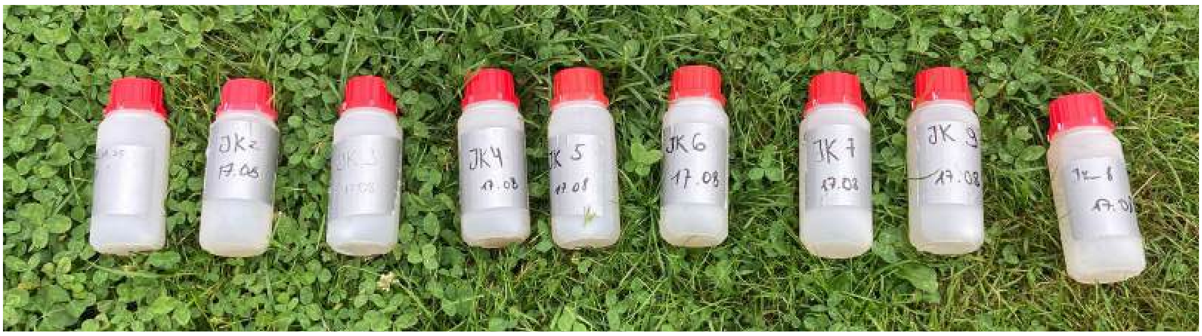

Figure 6. Sample bottles with water taken from each monitoring site (M. Loit)

3. Results and Discussion

Table 1. Overview of our monitoring sites.

Site	Coordinates	Description / key notes
JK1	58.223°N 24.517°E	Near Jõulumäe Recreational Sports Centre
JK2	58.224°N 24.518°E	Near Jõulumäe Recreational Sports Centre, old swimming spot
JK3	58.227°N 24.522°E	Strange water tank and pump in the trench; whole water surface covered by common duckweed
JK4	58.227°N 24.522°E	Very close to JK3, separated by a road dam - water flows through a pipe; much less common duckweed
JK5	58.231°N 24.527°E	The trench is much wider here
JK6	58.233°N 24.530°E	The trench is much more shallow here
JK7	58.234°N 24. 533°E	Openly next to an intersection
JK8	58.237°N 24.536°E	-
JK9	58.240°N 24.537°E	Artificial pond that is connected to Jõulumäe trench

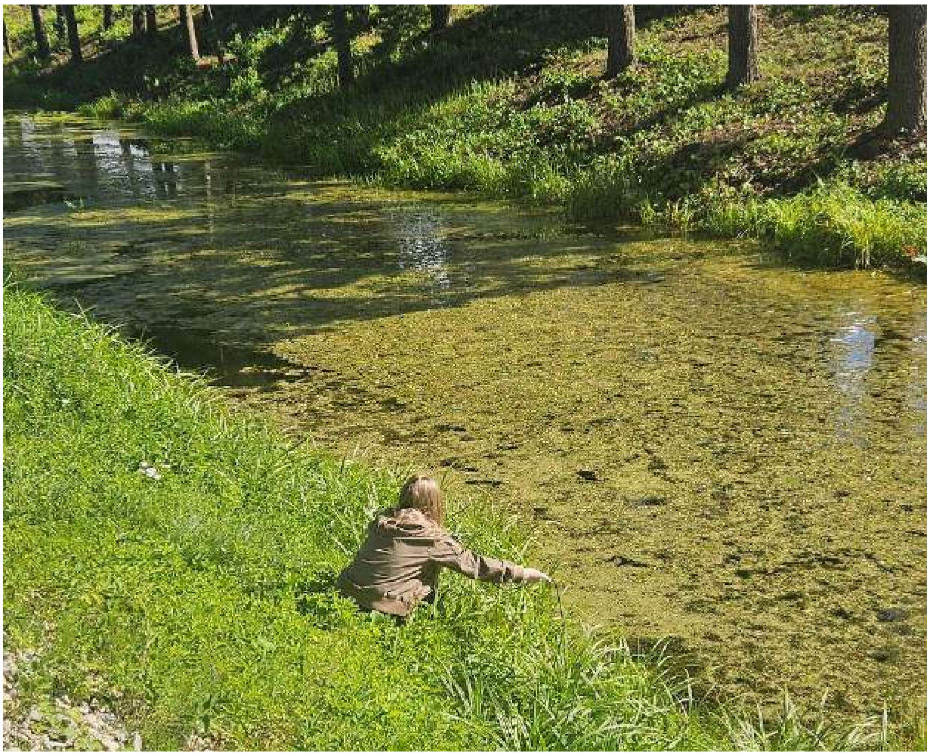

Figure 6. Measuring temperature at site JK1 (A. Vaarik)

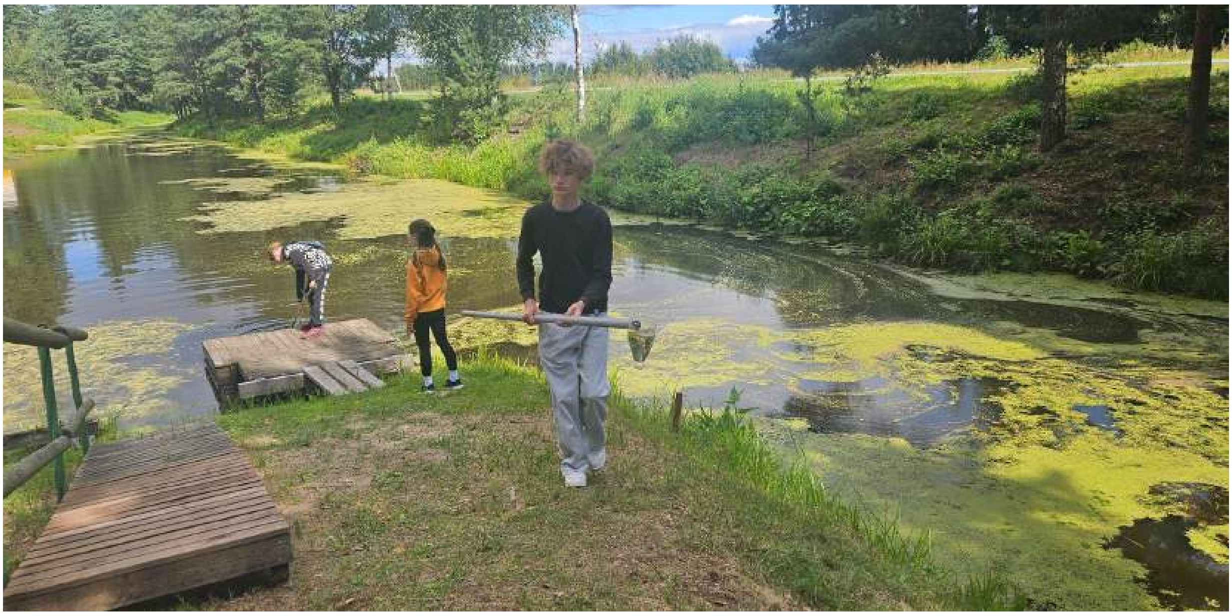

Figure 7. Sampling at JK2 (A. Vaarik)

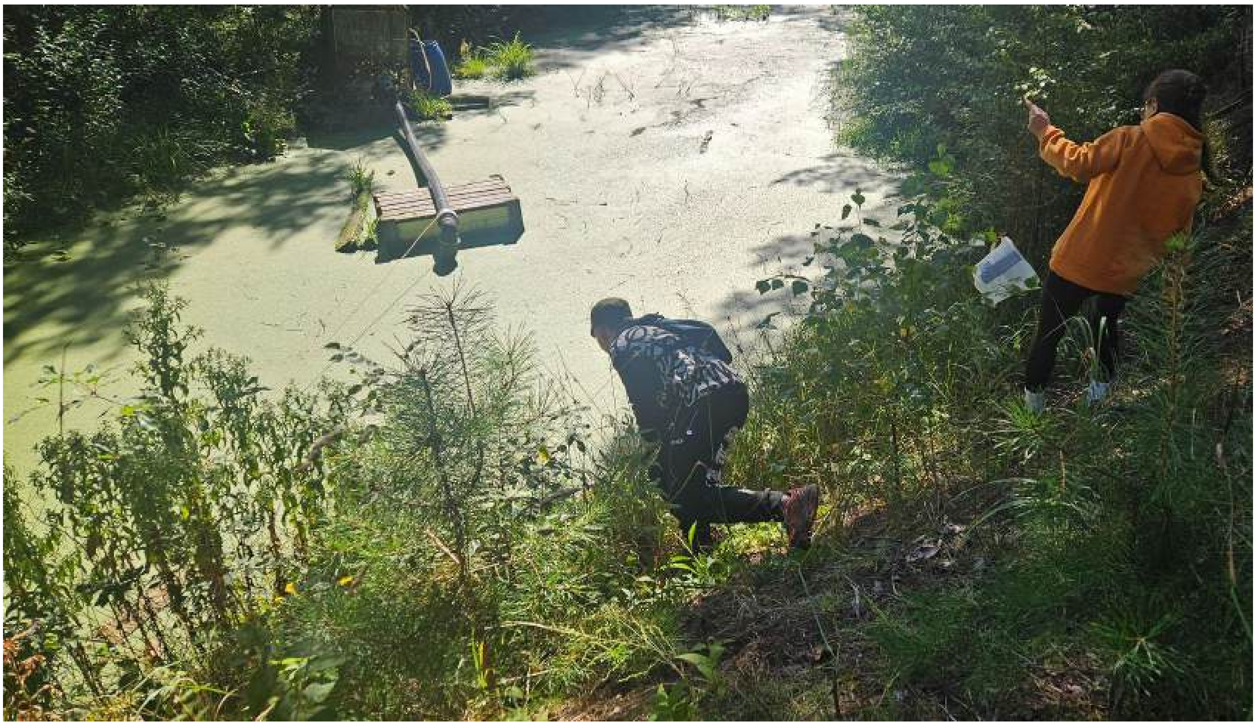

Figure 8. Sampling at JK3 (A. Vaarik)

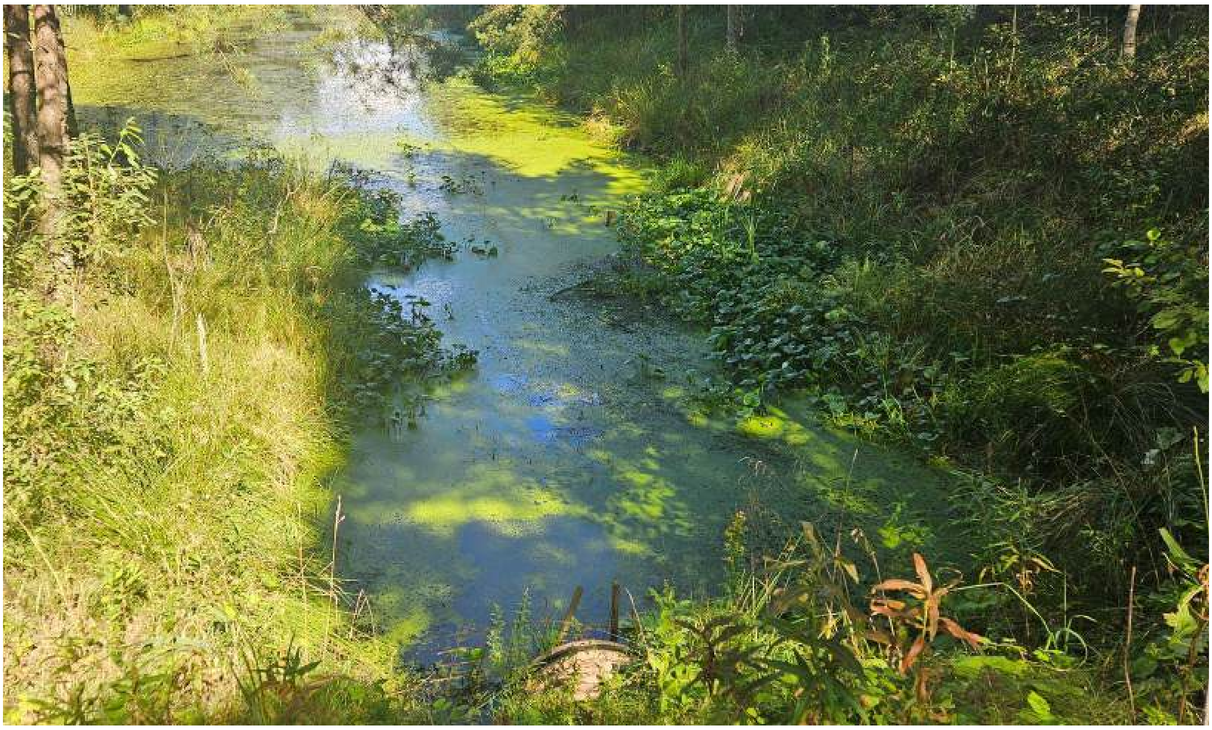

Figure 9. Monitoring site JK4 (A. Vaarik)

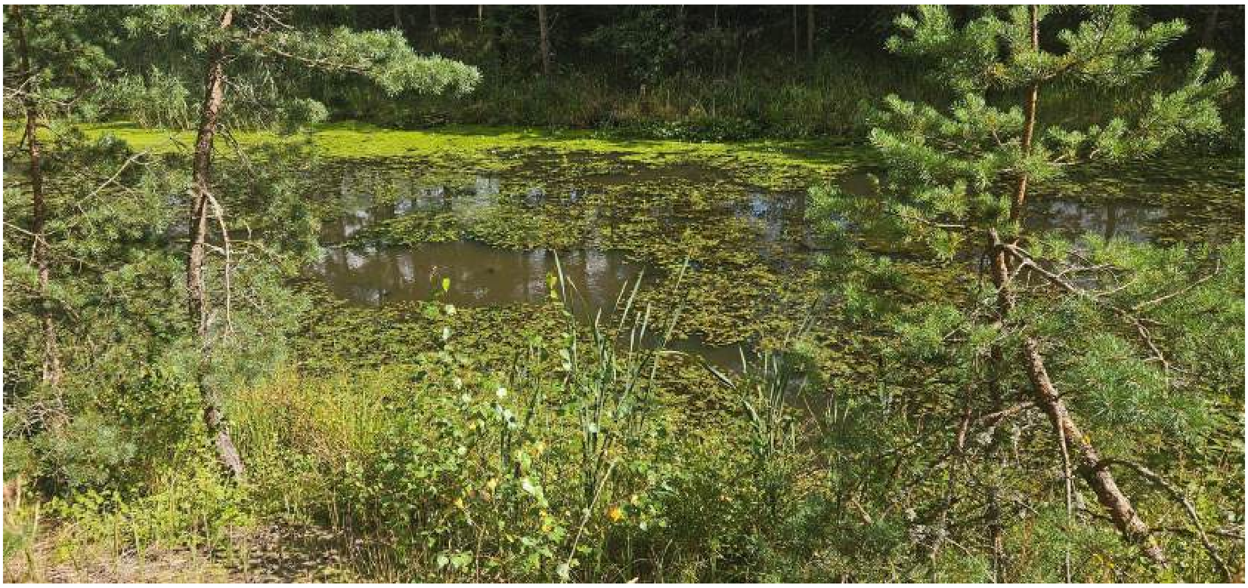

Figure 10. Monitoring site JK5 (A. Vaarik)

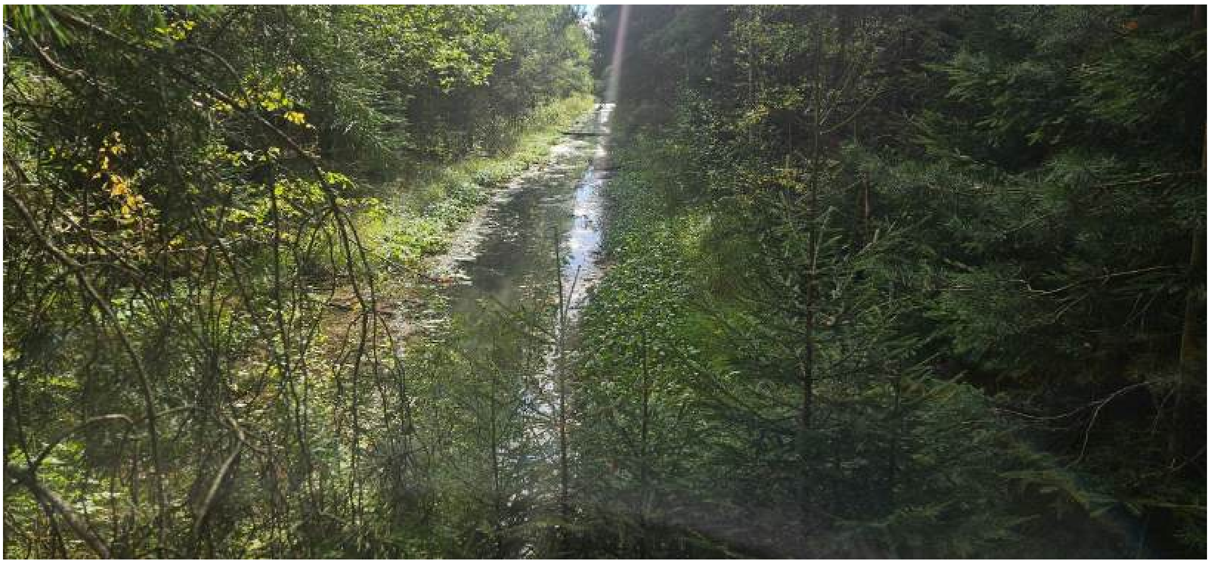

Figure 11. Monitoring site JK6 (A. Vaarik)

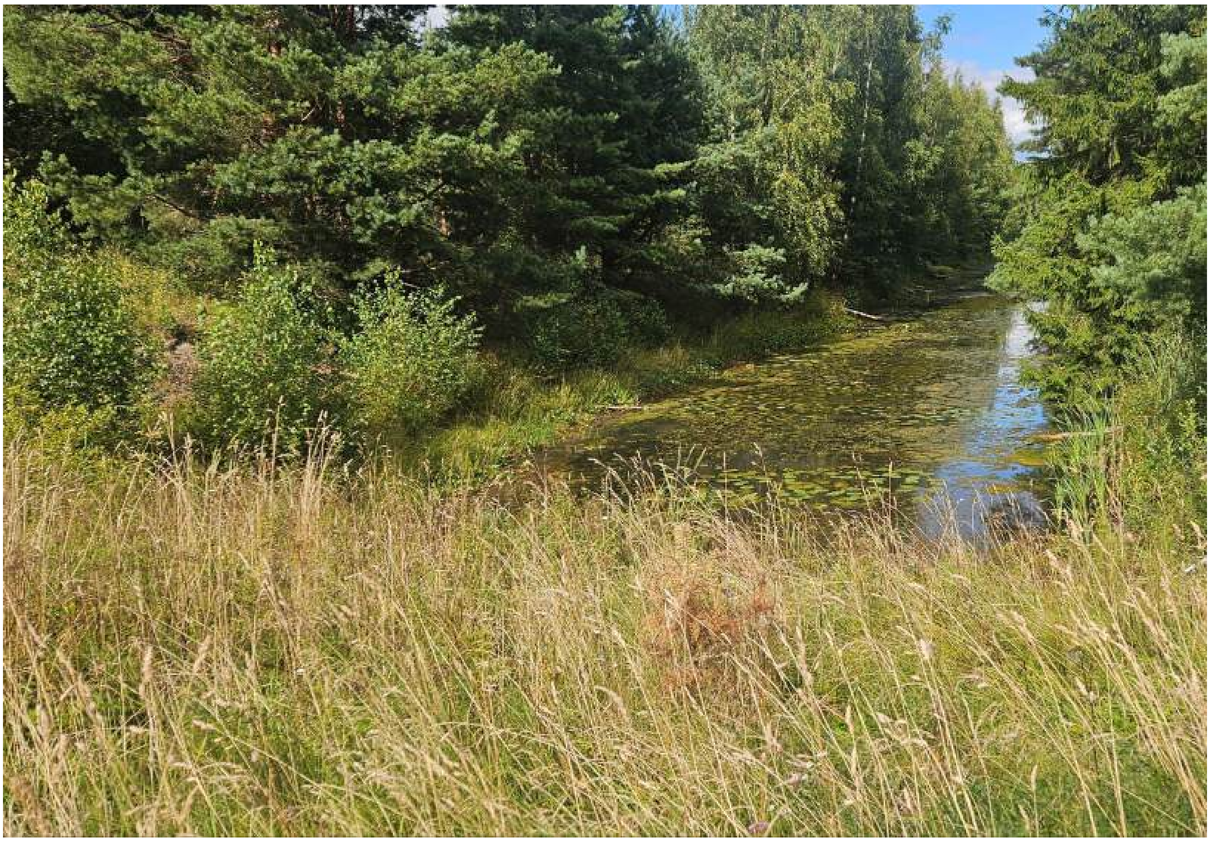

Figure 12. Monitoring site JK7 (A. Vaarik)

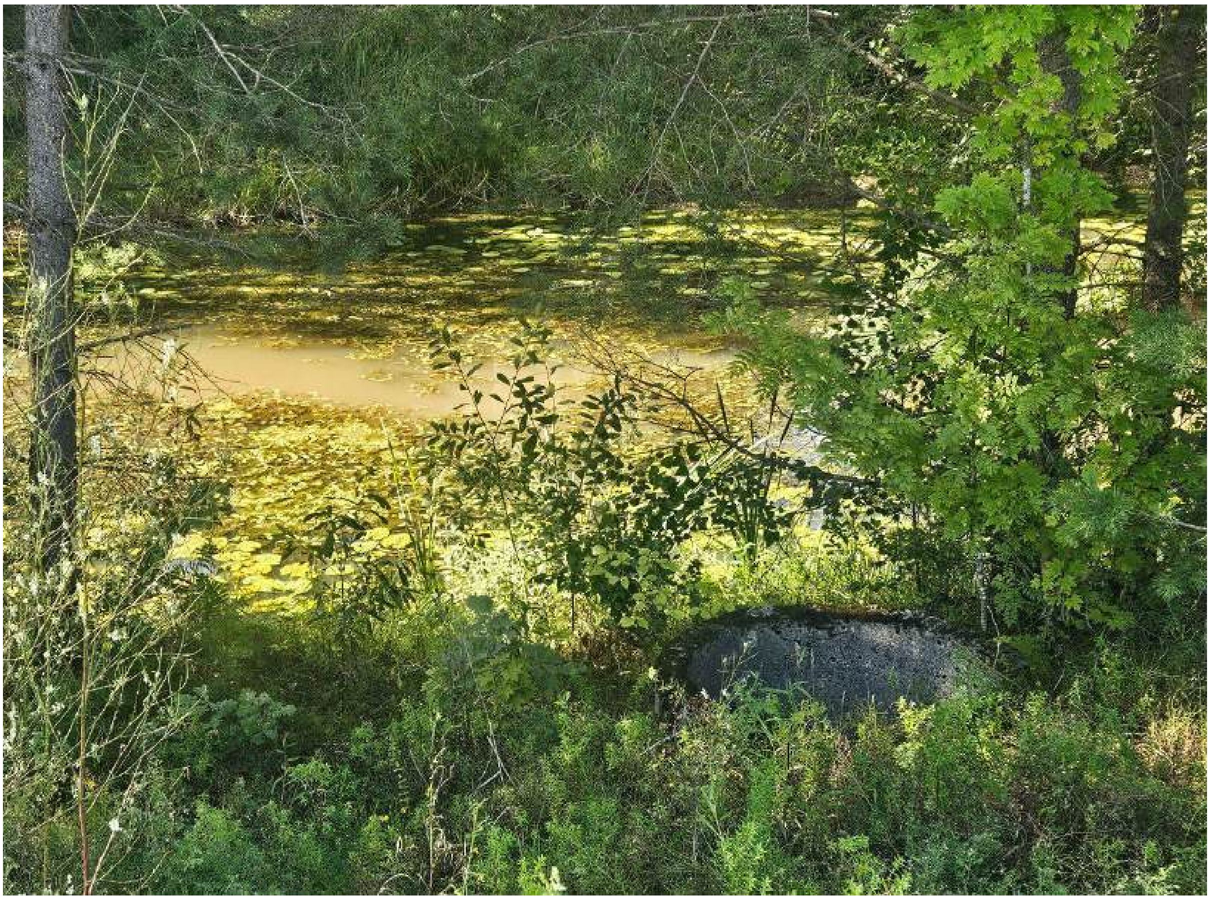

Figure 13. Monitoring site JK8 (A. Vaarik)

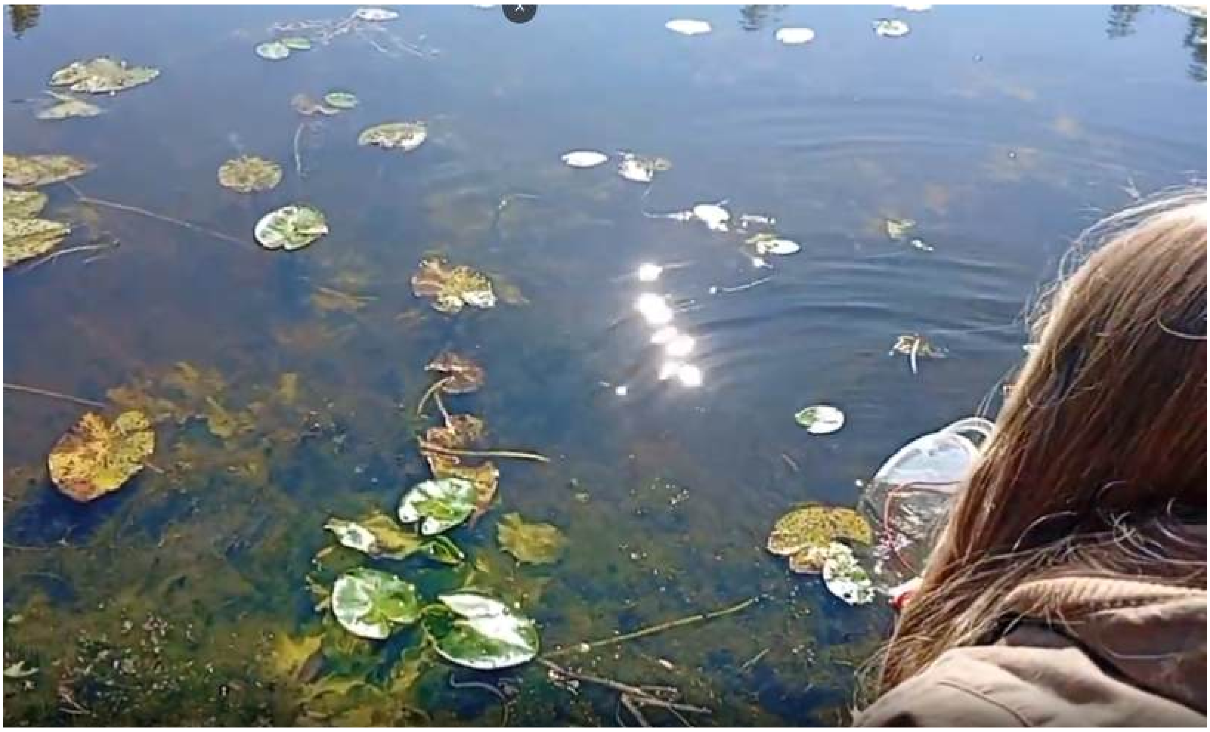

Figure 14. Sampling at JK9 (J. Metsaalt)

Table 2. Water data from our nine monitoring sites.

Point	pH	Conductivity (µS/cm)	Temperature (°C)	Nitrates (mg/l)	Hardness (mg/l)	Phosphates (mg/l)	Human activity
JK1	6.7	220	18.2	0	89	0.27	Yes
JK2	7.1	230	18.5	0	106.8	0.29	Yes
JK3	7.2	250	16.5	0	106.8	0.26	Yes
JK4	7.5	230	16	0	89	0.89	No
JK5	7.9	350	20	0	106.8	0	No
JK6	6.8	240	13.7	0	89	0.1	Yes
JK7	6.8	340	17.3	0	106.8	0.45	Yes
JK8	7.4	330	19.5	0	124.6	0	No
JK9	7.8	160	22.6	0	71.2	0.05	Yes

The pH values of the water samples ranged from 6.7 to 7.9. The highest pH was recorded at monitoring site JK5, while the lowest occurred at site JK1. Overall, the results indicate a neutral to slightly alkaline aquatic environment.

Electrical conductivity varied between 160 and 350 µS/cm. The highest value (350 µS/cm) was measured at site JK5, whereas the lowest (160 µS/cm) was observed at site JK9. Elevated conductivity may indicate higher concentrations of dissolved substances, but all values remained within naturally occurring ranges.

Nitrate concentrations were below the detection limit in all water samples. Phosphate concentrations, however, fluctuated across sites. In most monitoring sites, phosphate levels ranged from 0.05 to 0.29 mg/L, but site JK4 exhibited a markedly elevated concentration of 0.89 mg/L. This may suggest local diffuse pollution, potentially from organic matter or fertilizer residues.

Water hardness values ranged from 71.2 to 124.6 mg/L. The highest hardness was measured at site JK8 (124.6 mg/L), while the lowest occurred at JK9 (71.2 mg/L). All results fell within natural ranges and did not indicate problematic contamination.

One of our research questions concerned the relationship between water properties and human activity. Signs of human activity were observed at six out of nine sites. In general, phosphate concentrations tended to be higher at sites located near human activity, while nitrate concentrations remained undetectable across all sites. Our hypothesis—that nutrient concentrations (phosphates and nitrates) would be elevated in water near areas of human activity—was therefore only partially supported. Interestingly, the site with the highest phosphate level (JK4) showed no visible human activity, whereas other sites with documented human activity, such as JK9, had phosphate concentrations near baseline levels. This suggests that local human activity is not necessarily a direct source of nutrient pollution.

Overall, the chemical parameters indicate that the trench is at risk of eutrophication, primarily due to phosphorus enrichment.

Table 3. Benthos composition observations in each measuring point.

Point	Phosphates (mg/l)	Leeches	*Dytiscus*	Odonata larvae	Water scorpion	Gastropods	Mayfly larvae	Bivalvia
JK1	0.27	2	2	0	0	2	0	0
JK2	0.29	2	3	0	1	1	1	0
JK3	0.26	1	0	0	0	0	0	3
JK4	0.89	3	1	2	0	0	0	3
JK5	0	1	3	0	0	0	0	0
JK6	0.1	3	2	0	0	0	0	0
JK7	0.45	0	0	0	0	3	1	0
JK8	0	0	0	0	0	3	0	0
JK9	0.05	0	0	1	1	0	0	3

Our second research question concerned the composition of the benthic community along the sampling points of the trench. We hypothesized that the composition of benthic organisms would vary along the trench, and this was indeed confirmed. Near the sports facility, in the first sampling points, we observed a greater abundance of medicinal leeches (*Hirudo medicinalis*) and backswimmers (*Notonectidae*). In the last three sampling points, these taxa were entirely absent; instead, we found numerous mud snails (*Lymnaea stagnalis*) and wandering snails (*Radix balthica*).

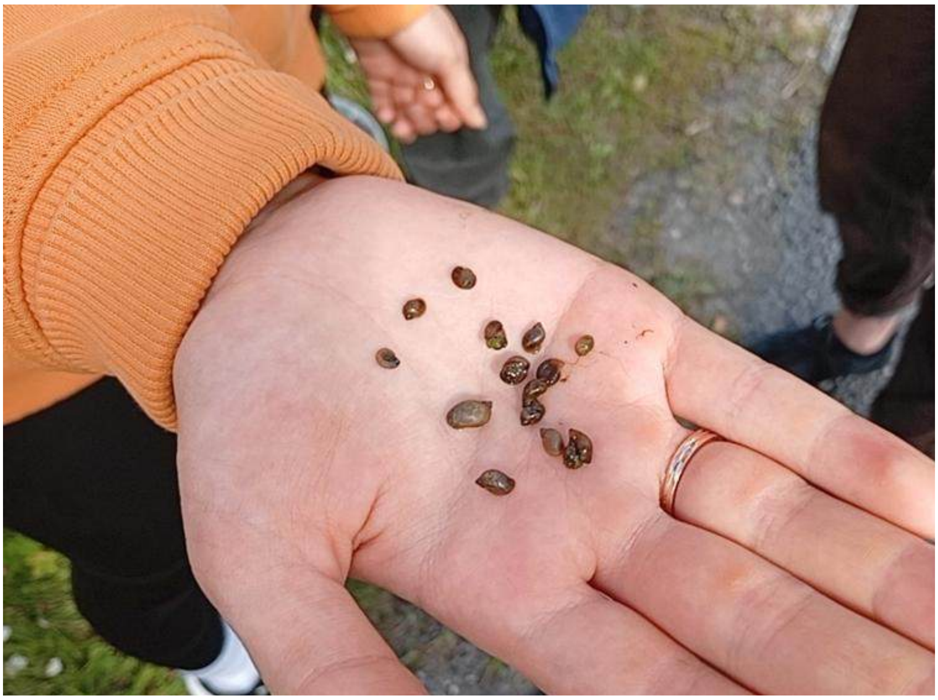

Figure 15. An abundance of mud snails found from site JK7 (A. Vaarik)

In the final point, located in an artificial pond, the biota was already markedly different: near the shore we observed many small fish and common pond mussels (*Anodonta anatina*).

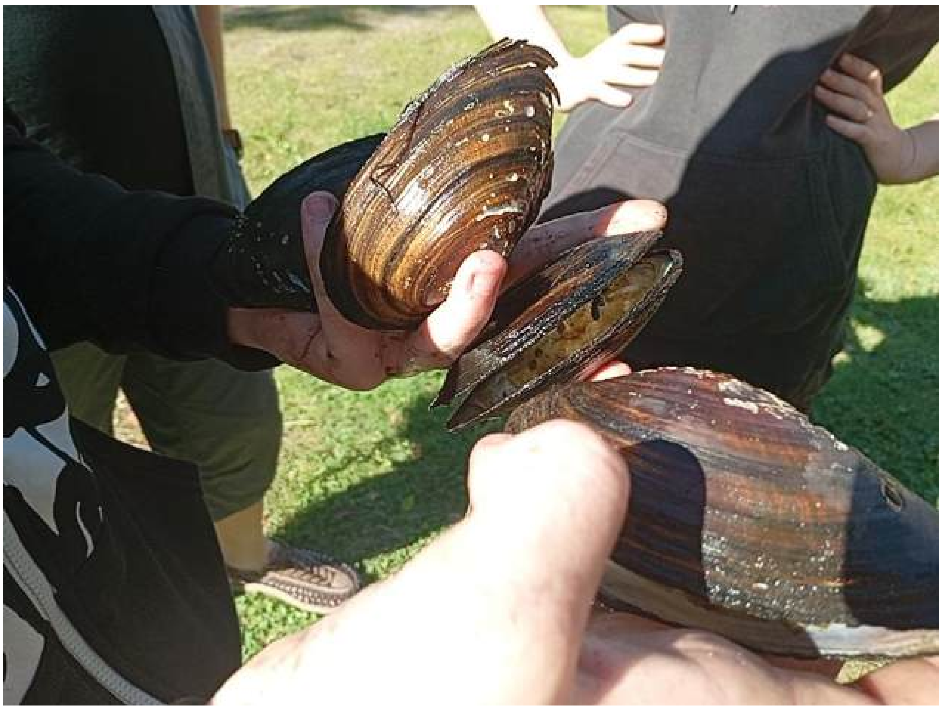

Figure 16. *Anodonta anatina* found from site JK9 (J. Metsaalt)

Starting from the sixth point, aquatic vegetation also changed: the dominant common duckweed (*Lemna minor*) was replaced by Canadian waterweed (*Elodea canadensis*).

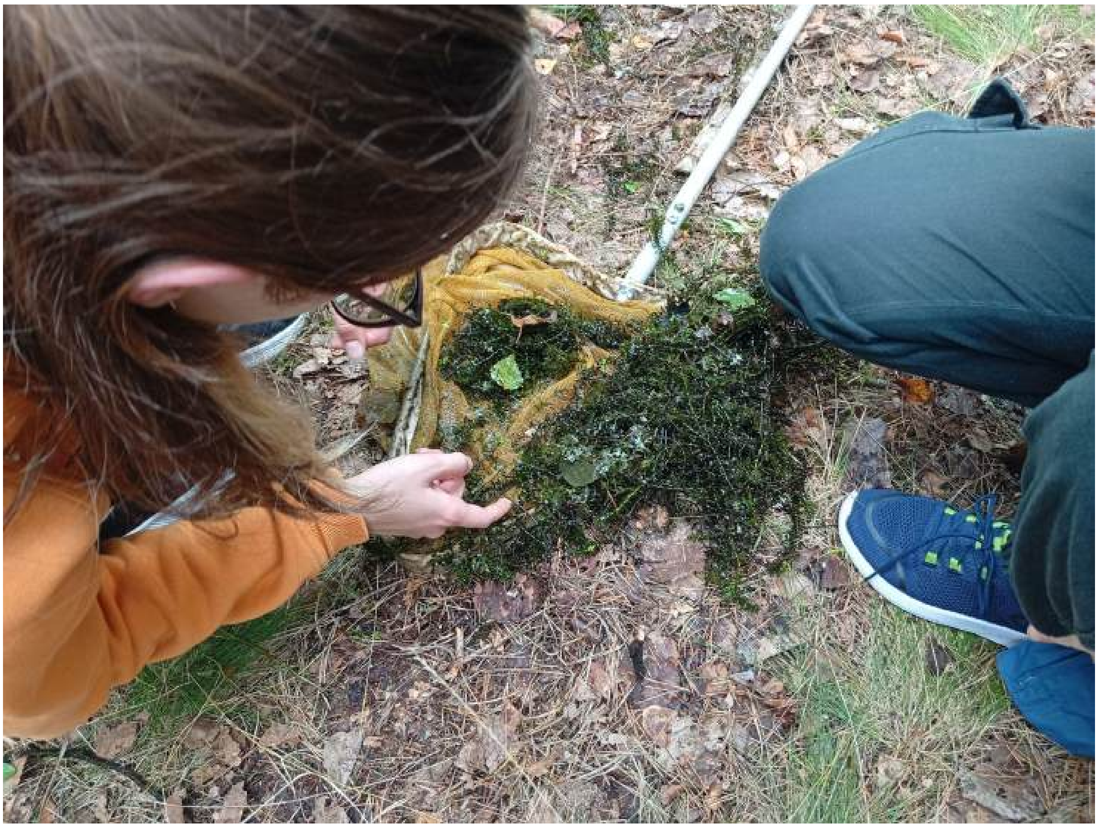

Figure 17. A kick-net filled with *Elodea canadensis* from site JK6 (A. Vaarik)

Water scorpions (*Nepa cinerea*) were recorded in points JK2 and JK9.

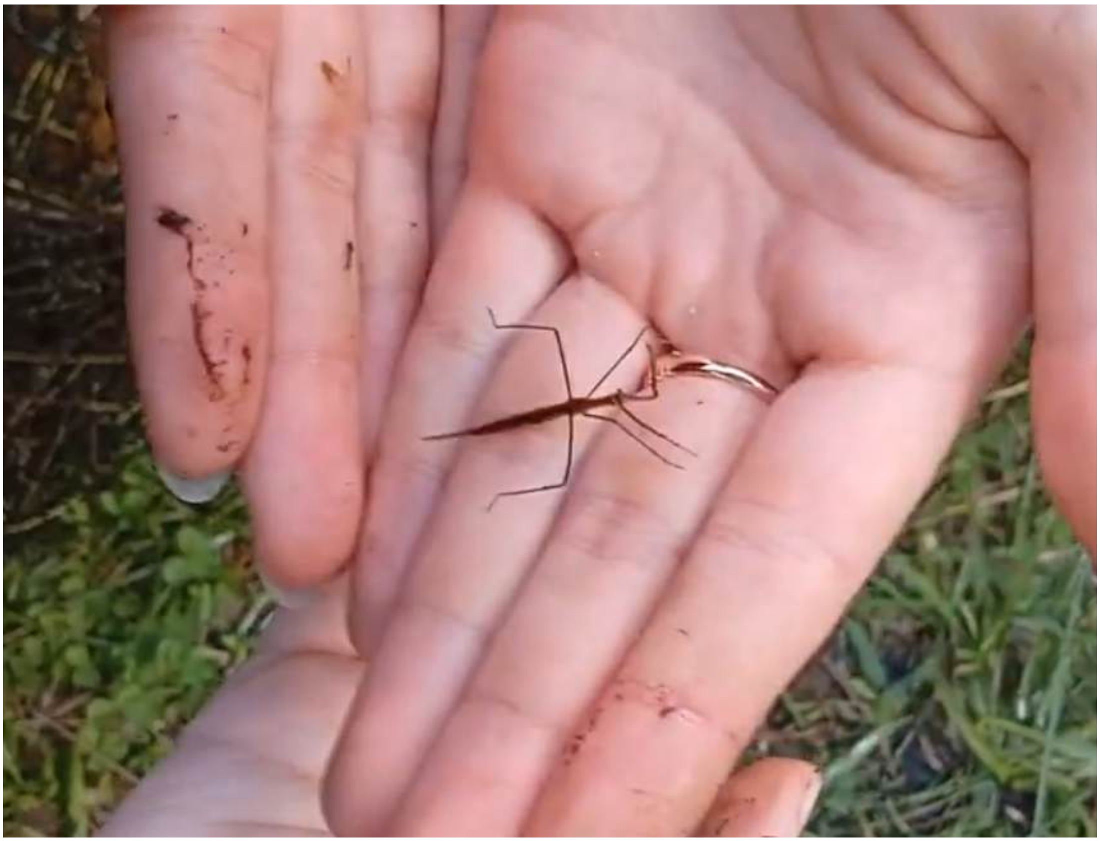

Figure 18. Water scorpion (*Nepa cinerea*) at JK2 (J. Metsaalt)

Our third research question asked how benthic community composition is related to water properties. We hypothesized that higher nutrient concentrations would support a more diverse benthic community. However, our data did not confirm this: no clear relationship was observed between the benthic community composition and phosphorus concentrations measured in the water. It is likely that identifying such a relationship would require more detailed investigation of benthic organisms, inclusion of aquatic vegetation, and measurement of additional water parameters. It is also possible that data from a single water body are too limited in scope to reveal such a pattern.

In addition to addressing the three hypotheses, a few further remarks can be made for future research. The elevated electrical conductivity and pH values at points JK5 and JK7 may indicate the presence of a groundwater spring, which should be investigated further. Nutrient concentrations should also be measured repeatedly throughout the year, as phosphate and nitrate levels may be lower during summer due to plant uptake.

Conclusions

Out of the three hypotheses formulated for the study of the Jõulumäe trench, only two were confirmed. Regarding the research question on how benthic community composition changes along the trench, our hypothesis that the community would vary between sampling points was supported by the results. We also asked how water properties are related to human activity, and hypothesized that nutrient concentrations would be higher near areas of human influence. This hypothesis was likewise confirmed, as water samples from points marked with human activity generally contained more phosphorus.

The third research question concerned the relationship between benthic community composition and water properties. Our hypothesis—that higher nutrient levels would result in a more diverse benthic community—was not supported by the data. To establish such a relationship, benthic fauna should likely be studied in greater detail, aquatic vegetation included, additional water parameters measured, and surveys conducted across multiple water bodies.

Overall, the ecological status of the Jõulumäe trench is not good but rather poor, and in one sampling point even very poor. Viewed as a whole along the 3 km section, the trench shows clear signs of eutrophication.

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