

GLOBE Regional Learning Expedition 2025

Researching fieldside water bodies near Jõulumäe using GLOBE methods

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ABSTRACT

Using GLOBE hydrosphere protocols, we assessed how cultivated farmlands around Jõulumäe influence nearby trench water quality at four sites spanning forest-adjacent trenches, a field-adjacent roadside trench, and a confluence with Leina stream. We measured the following parameters: pH, dissolved oxygen, conductivity, and water temperature, using Vernier sensors; transparency using a Secchi tube; and nitrate and alkalinity concentrations using Macherey-Nagel kits.

Nitrate concentration increased the more agricultural effect the trench had (growing from ≈ 0.2 mg/L at Jõulumäe trenches to ≈ 0.45 mg/L within fields and ≈ 0.7 mg/L at the downstream confluence), while conductivity and alkalinity were also rising in the same order (from ≈ 163 to 385 to 782 $\mu\text{S}/\text{cm}$, and from ≈ 155 – 210 to 310 to 450 mg/L CaCO_3). In contrast, dissolved oxygen tended to be lower at field-adjacent sites (≈ 1.7 – 2.6 mg/L) compared to Jõulumäe trench segments (≈ 3.1 – 4.3 mg/L). pH varied modestly (≈ 6.2 – 6.7), offering little evidence of alkaline fertilizers influence during the sampling window.

Overall, results indicate subtle agricultural signals (nitrate and ionic increases; lower dissolved oxygen) without visible nitrate pollution at the time of sampling. We recommend adding phosphate and ammonium measurements, reporting replicate statistics, quantifying trench geometry and flow for future monitoring.

Keywords: GLOBE methods, agriculture, trench/ditch, water quality

1. Introduction

Water plays a vital role in our everyday life – everyone depends on water, we use it to water our plants and fields, give it to animals that we raise, use it to generate electricity and make building materials. To do all that, we need a proper source of clean water and must avoid negatively impacting the environment.

By researching and ensuring our water bodies stay clean without disturbing the ecological system, we can achieve a sustainable life. During our research, we used GLOBE (Global Learning and Observations to Benefit the Environment) methods to measure different water parameters such as pH levels, nitrate and dissolved oxygen concentrations, to see what effect cultivated farmlands had on the surrounding areas.

In this study, we conducted our research in the surrounding areas of Jõulumäe (Figure 1) during the 2025 GLOBE Estonia learning expedition. We tested areas next to the Jõulumäe sports centre itself and in the middle of cultivated farmlands near the centre. Our goal was to see if the cultivated farmlands had any negative effect on water quality, and to compare the pH of areas near forests to areas in the middle of fields.

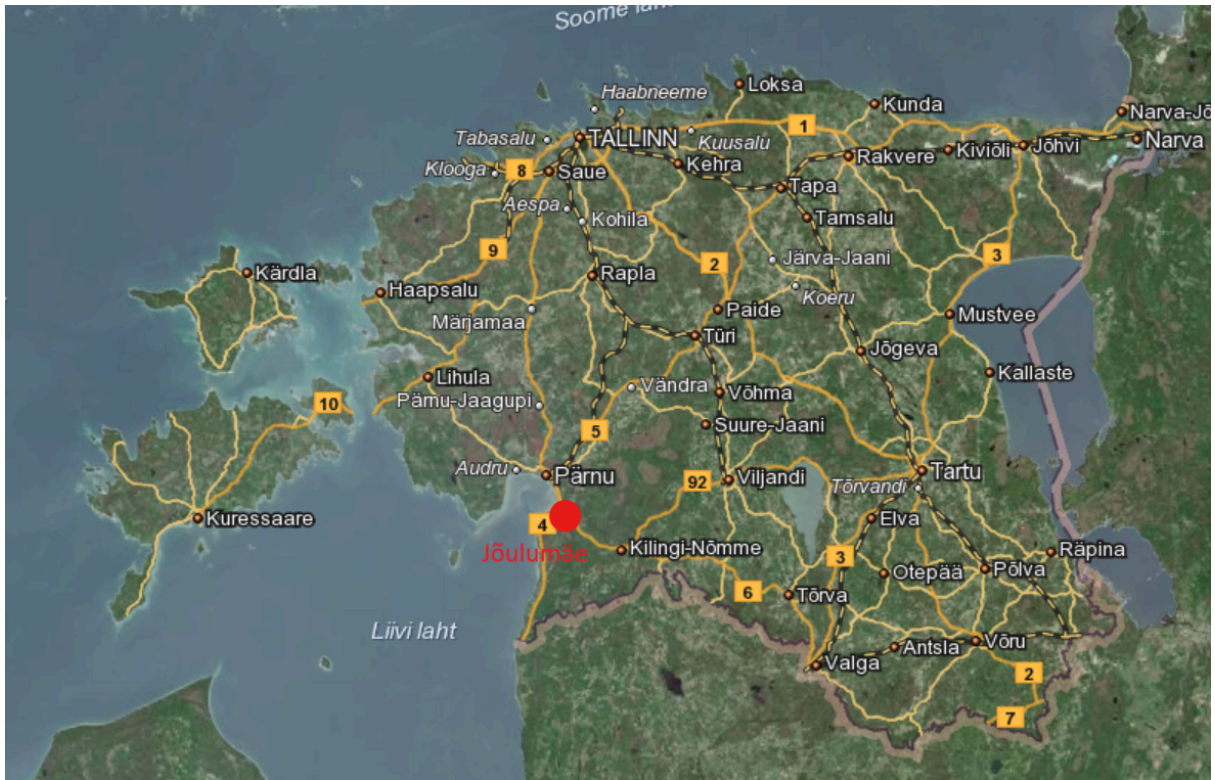


Figure 1. Location of Our Research Area (Jõulumäe). Basemap sourced from Maa-amet (Estonian Land Board)

1.1. Research Question and Hypotheses

Research question: How do cultivated farmlands around Jõulumäe affect the trench water quality – nitrate concentration, pH level, and dissolved oxygen concentration – in the surrounding areas?

Hypothesis:

1. Trenches closer to cultivated farmland have a higher nitrate compound concentration than trenches further away.
2. Trenches closer to cultivated farmland have higher pH values.
3. Larger and wider trenches contain more dissolved oxygen due to greater reaeration and mixing.

2. Theoretical Background

Agricultural activities influence water quality through multiple interconnected ways. Fields and other agricultural landscapes often contribute to increased nitrate levels in adjacent water bodies via fertilizer and manure runoff or leaching. Research in Spain's Ebro River Basin showed that agricultural cover explained 82% of nitrate variability over 25 years¹. A meta-analysis of 18 studies confirmed significantly higher nitrate concentrations associated with nitrogen fertilizer application (average concentration of 34.28 mg/L of NO₃⁻)². In Poland, nitrogen concentrations in groundwater and streams were strongly correlated with intensive agriculture and a severe deficiency of phosphorus and potassium in applied fertilizers³.

Furthermore, conductivity and alkalinity tend to rise in waters draining from cultivated soils because of increased leaching and runoff of dissolved salts and soil minerals. Studies in settings such as the Nile Delta confirm transport of dissolved organic carbon and nutrients in agricultural drainage, contributing to altered chemistry and reduced water quality.⁴

Water pH responses to agricultural land use are often subtle and highly variable. The effect depends heavily on fertilizer type, soil buffering capacity, hydrology, and vegetation cover. As such, shifts in pH tend to be modest and inconsistent across sites. Under agricultural influence, subtle shifts in pH may be caused when fertilizers or irrigation water contain alkaline or acidic substances. Acidic soils generally show greater pH fluctuations because they have lower buffering capacity, whereas alkaline calcareous soils tend to resist such

¹ García-Gómez, H., & Gimeno, B.S., Lassaletta, L., & Rovira J.V. (2009). *Agriculture-induced increase in nitrate concentrations in stream waters of a large Mediterranean catchment over 25 years (1981-2005)*. *Sci Total Environ*, 407(23):6034-43. <https://doi.org/10.1016/j.scitotenv.2009.08.002>

² Adebajo-Aina, O., & Oludoye, O. (2025). *Impact of Nitrogen Fertiliser Usage in Agriculture on Water Quality*. *Pollutants*, 5(3), 21. <https://doi.org/10.3390/pollutants5030021>

³ Lawniczak, A.E., & Nowak, B., & Zbierska, J., *et al.* (2016). *Impact of agriculture and land use on nitrate contamination in groundwater and running waters in central-west Poland*. *Environ Monit Assess*, 188, 172. <https://doi.org/10.1007/s10661-016-5167-9>

⁴ Bakr, N., & Essa, E.F., & Shahin, S.A., *et al.* (2024). *Water Quality and Dissolved Organic Carbon Content in Agricultural Streams: Northern Nile Delta Region, Egypt*. *Water Air Soil Pollut* 235, 147. <https://doi.org/10.1007/s11270-024-06959-z>

changes⁵. In practice, farmers sometimes use lime⁶ or acidifying fertilizers to intentionally adjust soil pH toward the optimal range for plant growth.

Dissolved oxygen is often depleted in agricultural catchments because nutrient and organic loading increase microbial biochemical oxygen demand, while channel modifications and low flow rates reduce reaeration, compounding dissolved oxygen loss⁷. Nutrient-driven algal blooms worsen the problem: algal growth fueled by excess nitrogen and phosphorus ends in decomposition that consumes oxygen^{8,9}, sometimes creating hypoxic or anoxic “dead zones”¹⁰.

Agricultural pressure on Estonian waterbodies is quite significant. The problem is not only the rivers and trenches that get polluted, but the pollution reaches the Baltic sea. Estonia has agreed with other countries surrounding the sea that nitrate and phosphorus strain on the Baltic sea must be decreased.¹¹

⁵ Barnhill, J., & Cardon, G., & Gale, J., & Koenig, R., & Yost, M., & Zesiger, C. (2023, December). *Managing Soil pH for Crop Production in Calcareous- Alkaline Soil*. Utah State University. extension.usu.edu/crops/research/managing-soil-ph-for-crop-production

⁶ Lentz, E., & Mullen, R., Watson, M. (November 2, 2016). *Soil Acidity and Liming for Agronomic Production*. The Ohio State University. ohioline.osu.edu/factsheet/AGF-505-07

⁷ Cormier, S., & Marcy, S.M., & Suter II, G. (October 3, 2025). *Dissolved Oxygen*. Read on October 22, 2025 at <https://www.epa.gov/caddis/dissolved-oxygen>

⁸ Walters, A. (2016). *Nutrient pollution from agricultural production: Overview, management and a study of Chesapeake Bay*. Hauppauge, NY: Nova Science Publishers.

⁹ U.S. Geological Survey. (2019, March 2). *Nutrients and eutrophication*. USGS. Read on February 22, 2024. <https://www.usgs.gov/mission-areas/water-resources/science/nutrients-and-eutrophication>

¹⁰ Diaz, R. J., & Rosenberg, R. (2008). Spreading dead zones and consequences for marine ecosystems. *Science*, 321(5891), 926–929. <https://doi.org/10.1126/science.1156401>

¹¹ Elias, K. (June 3, 2020). *TTÜ teadlane: põllumajanduse mõju Eesti vee kvaliteedile on üsna suur*. Novaator. <https://novaator.err.ee/1096135/ttu-teadlane-pollumajanduse-moju-est-vee-kvaliteedile-on-usna-suur>

3. Materials and Methods

We used GLOBE hydrosphere protocols to gather and systemise our data. We mainly used Vernier and its different sensors, and alkaline and nitrate testing kits by Macherey-Nagel. Specifically, we used the following materials and tools seen in Table 1 and Figure 2.

Table 1. Field equipment used for sampling and measurement

	Equipment	Usage
1	Bucket with rope	Gathering water from the trenches
2	Vernier sensors	Measuring water temperature, dissolved oxygen, pH and conductivity
3	Vernier labquest 2	Viewing the data from the Vernier sensors
4	Phone GPS	Pinpointing our exact locations
5	Secchi tube	Measuring water transparency
6	Paper and pen – GLOBE hydrosphere protocols	Writing down the gathered data
7	Nitrate kit	Measuring the amount of nitrates in the water
8	Alkalinity kit	Measuring the alkalinity of the water



Figure 2. Field equipment used for sampling and measurement.

3.1. Study area and sites

Tests were conducted at four sites (Figure 3): (1) Jõulumäe trench near the sports centre; (2) Jõulumäe roadside trench segment of the same trench; (3) roadside trench within cultivated crop fields; and (4) a confluence of Leina stream with a trench draining a swampy area¹². Site coordinates and basic descriptions are provided below and in the Results paragraph.

¹² Republic of Estonia Land Board. (2025). *Geoportaal*. Read on October 22, 2025 at <https://xgis.maaamet.ee/xgis2/page/app/mullakaart>



Figure 3. Location of all of the sites. Basemap sourced from Maa-amet (Estonian Land Board)

3.2. Notes on testing

Measurements are reported as site averages from the field session – at a minimum of two separate samples were tested at each site, while differing results were confirmed by a third test.

All tools were provided by the GLOBE program during the learning expedition, giving us a limited timeframe for testing and data recording.

4. Results and Discussion

4.1. Site one – Jõulumäe trench

The first site is located right next to the Jõulumäe sports centre at 58.223322°N 24.517298°E (Figure 4). It is a freshwater trench that is partly overgrown, the water was not visibly moving. The bottom of the trench was not visible, but we could tell it was covered with plants. The Secchi tube depth was 85 cm. The water was on average 16.5°C and it had an average dissolved oxygen of 3.1 mg/L. It did not have many minerals as the conductivity of the water was relatively low – 163 $\mu\text{S}/\text{cm}$. There were also only 0.2 mg/L of nitrates. It had an average pH of 6.2, and it had some alkalinity at 210 mg/L CaCO_3 . The trench was around 6.5 m across.

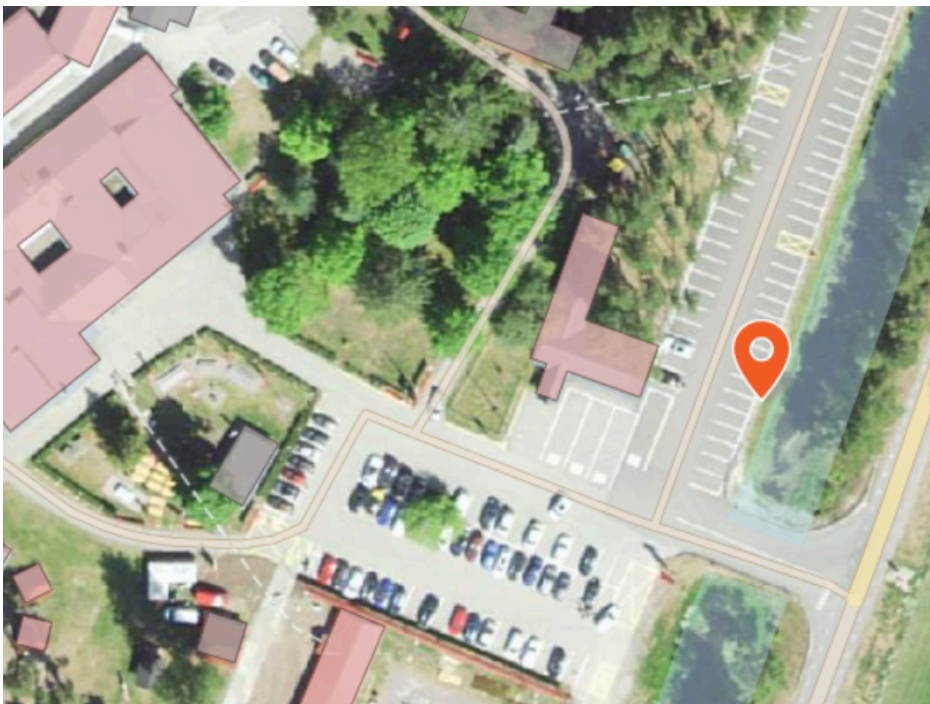


Figure 4. Site one. Basemap sourced from Maa-amet (Estonian Land Board)

4.2. Site two – Jõulumäe roadside trench

The second site is the same trench as the first site, but located a bit south in a more tree-covered area at the coordinates 58.220031°N 24.515136°E (Figure 5). The trench was

slightly less overgrown and it was possible to see moving water. It was not possible to see the bottom of the trench, but the measured Secchi tube depth was less – 73 cm. The water was on average 17.6°C, this might be because the second site measurements were done 6 hours later than the first site, and it had an average of 4.3 mg/L of dissolved oxygen. The conductivity of the water was the same in both the first and second site – average of 163 $\mu\text{S}/\text{cm}$. The nitrates also stayed the same at 0.2 mg/L. The average pH was 6.72 and the alkalinity was at 155 mg/L CaCO_3 .

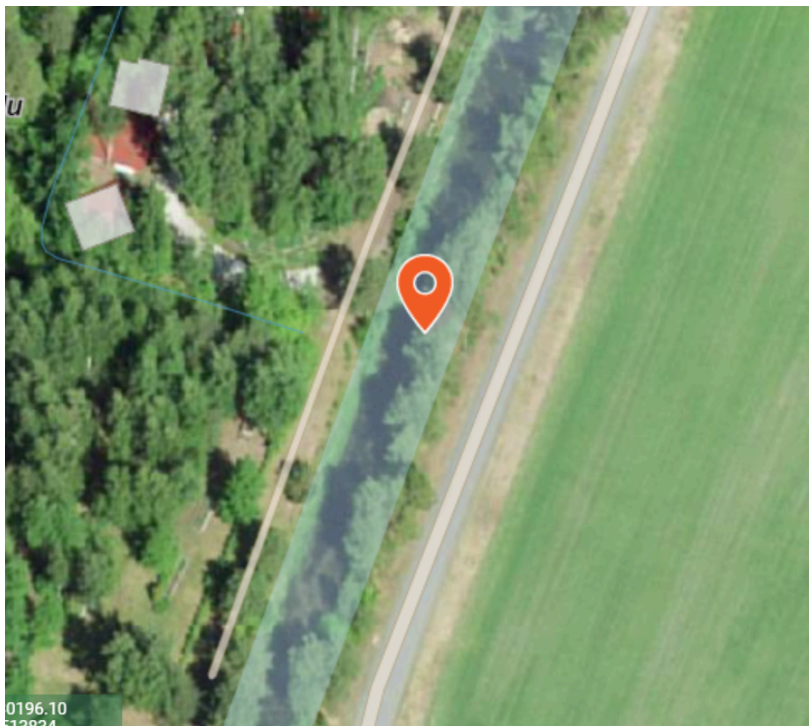


Figure 5. Site two. Basemap sourced from Maa-amet (Estonian Land Board)

4.3. Site three – Roadside trench beside crop fields

The third site is located in the middle of crop fields at least 300 metres from most trees and forested areas. Its coordinates are 58.217495°N 24.52299°E (Figure 6). It is also a freshwater trench with the bottom covered with plants. At this location the bottom was visible because of the low water levels, although we could only see through on average 35 cm. The average temperature was 15.8°C and the average dissolved oxygen was 2.6 mg/L. It had an intermediate conductivity of around 385 $\mu\text{S}/\text{cm}$ and nitrates of 0.45 mg/L. The pH was a slightly acidic 6.72 and some level of alkalinity at around 310 mg/L CaCO_3 .

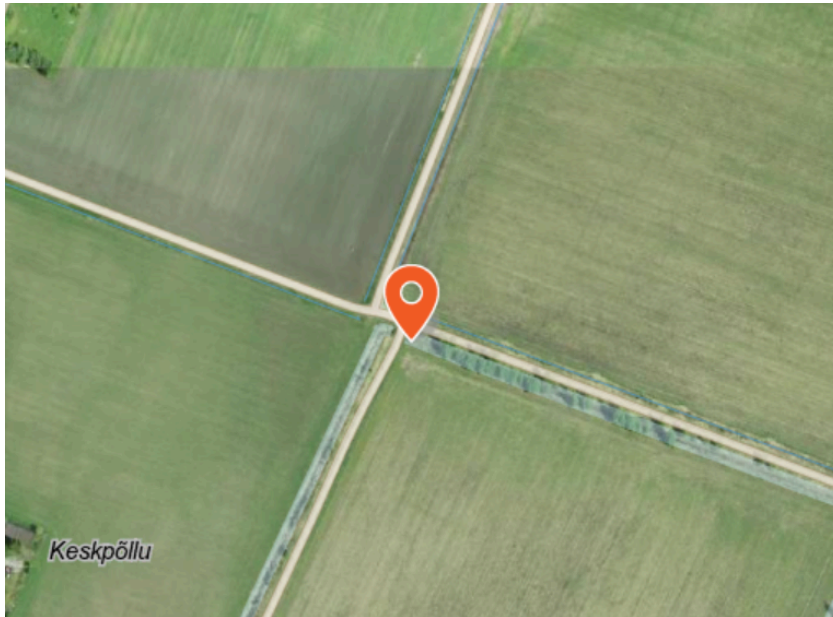


Figure 6. Site three. Basemap sourced from Maa-amet (Estonian Land Board)

4.4. Site four – Leina stream

The fourth site is located at a meeting point of Leina stream and a trench which has water flowing out from a swampy area (Figure 7). The exact point is at 58.21518°N 24.534541°E. The water temperature was around 17.2°C and dissolved oxygen was on average 1.7 mg/L. It had a higher conductivity than the other sites – 782 $\mu\text{S}/\text{cm}$, and the highest of our measured nitrate levels of 0.7 mg/L. It also had a pH of 6.5 and alkalinity of 450 mg/L CaCO_3 .



Figure 7. Site four. Basemap sourced from Maa-amet (Estonian Land Board)

4.5. Comparison of all sites

As we predicted, the nitrate compound concentration was higher in the middle of the cultivated crop field at site three – it was 0.5 mg per litre opposed to 0.2 mg/L at sites one and two. Site four had a higher nitrate concentration of 0.7 mg/L – this can be explained by the fact that site four is downstream of the same trench as site three and as a result more nitrates could have collected there from the fertilizers used in the fields. See Figure 8 for the full breakdown of nitrate concentration. There is a clear difference between the nitrate levels at our testing sites, but the relatively low concentration of nitrates overall, compared to dangerous levels of 50 mg/L¹³, shows us that there is not a risk of nitrate pollution at the current time of testing. Therefore, we cannot confirm the negative effects of nitrate fertilizers to nearby trenches.

¹³ World Health Organization. (2016). *Nitrate and Nitrite in Drinking-water*. www.who.int/docs/default-source/wash-documents/wash-chemicals/nitrate-nitrite-background-document.pdf

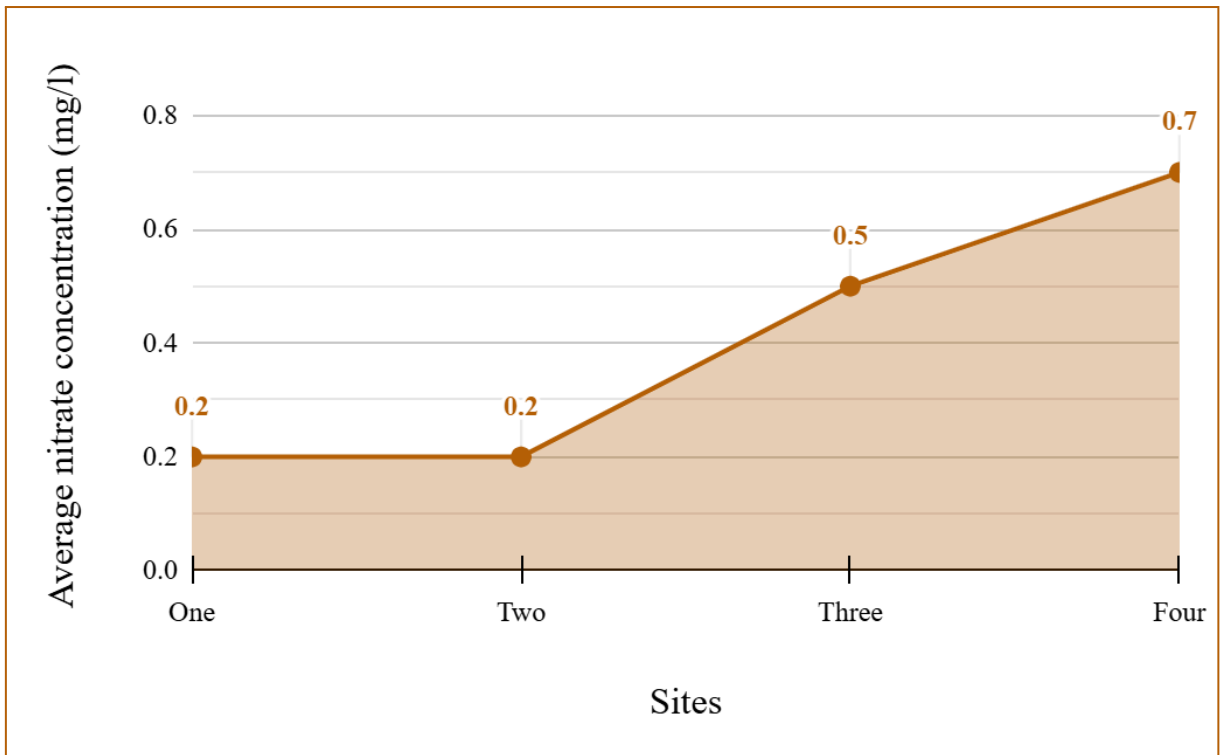


Figure 8. Nitrate concentrations of all the research sites

We found out that the pH only differed a maximum of 0.5 levels, as seen on Figure 9, indicating that the fields had no direct impact on the pH levels. This indicates that alkaline fertilizers most likely have not been used lately on the fields or they have had very little effect on the water pH levels. Furthermore, at site four the connecting trench, where the water came from a swampland, also did not have an effect on the water pH levels. Usually water from swamplands is slightly acidic due to the constant decomposition of plant life, the lack of oxygen, and accumulation of organic acids¹⁴, but the difference at site three and four was negligible.

¹⁴ Crafter, S.A., & Njuguna, S.G., & Howard, G.W. (July 3-5, 1992). *Wetlands of Kenya*. IUCN, 162-163 portals.iucn.org/library/sites/library/files/documents/WTL-003.pdf

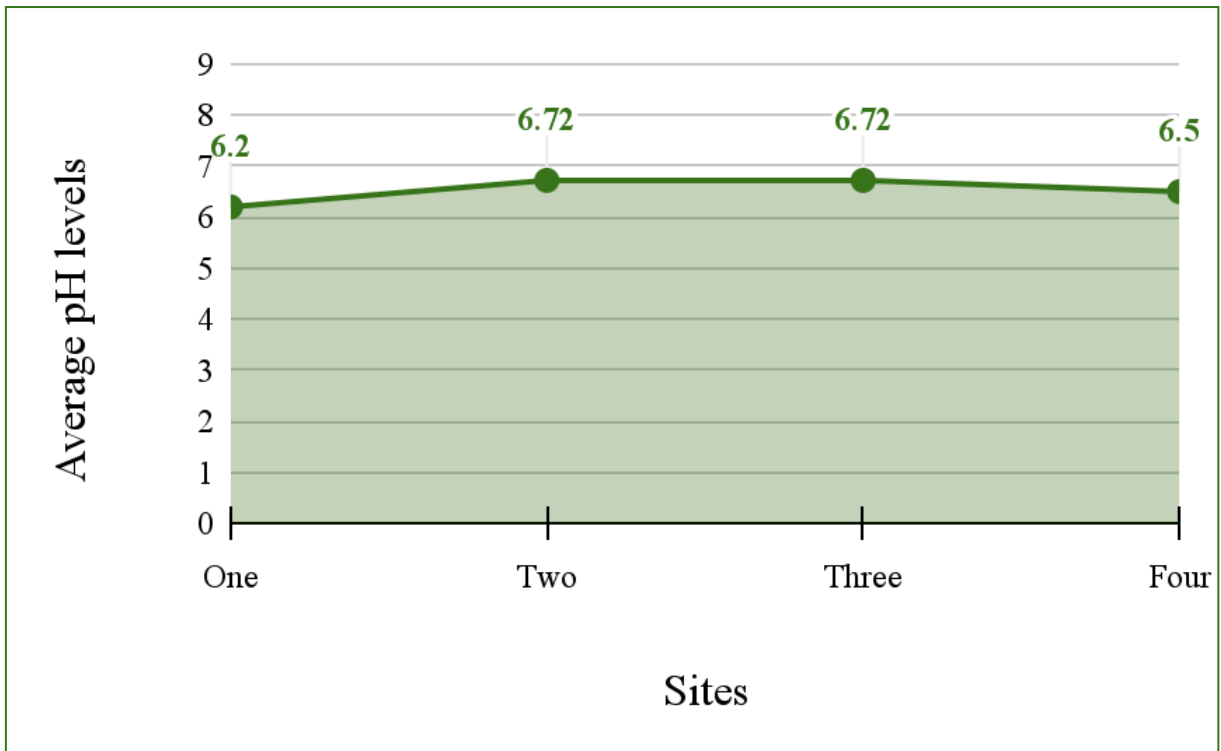


Figure 9. pH levels of all the research sites

There was a visible difference of the oxygen levels at sites one and two compared to sites three and four (Figure 10). This indicates some level of pollution or stress on the water as all of our results were below the average threshold, but the results at sites three and four were especially low. The temperatures most likely did not play a vital role in the difference in dissolved oxygen concentration, because the results were in the same size range. The oxygen deficiency might be caused by the excessive plant growth in the trench, which leads to more decomposition at the bottom of the trenches, resulting in all the oxygen in the water being used up. Yet the higher dissolved O₂ levels at sites one and two can be attributed to the surface area of the trench, as the Jõulumäe trench had a visibly larger surface area than the trench in the fields.¹⁵

¹⁵Cormier, S., & Marcy, S.M., & Suter II, G. (October 3, 2025). *Dissolved Oxygen*. Read on October 22, 2025 at <https://www.epa.gov/caddis/dissolved-oxygen>

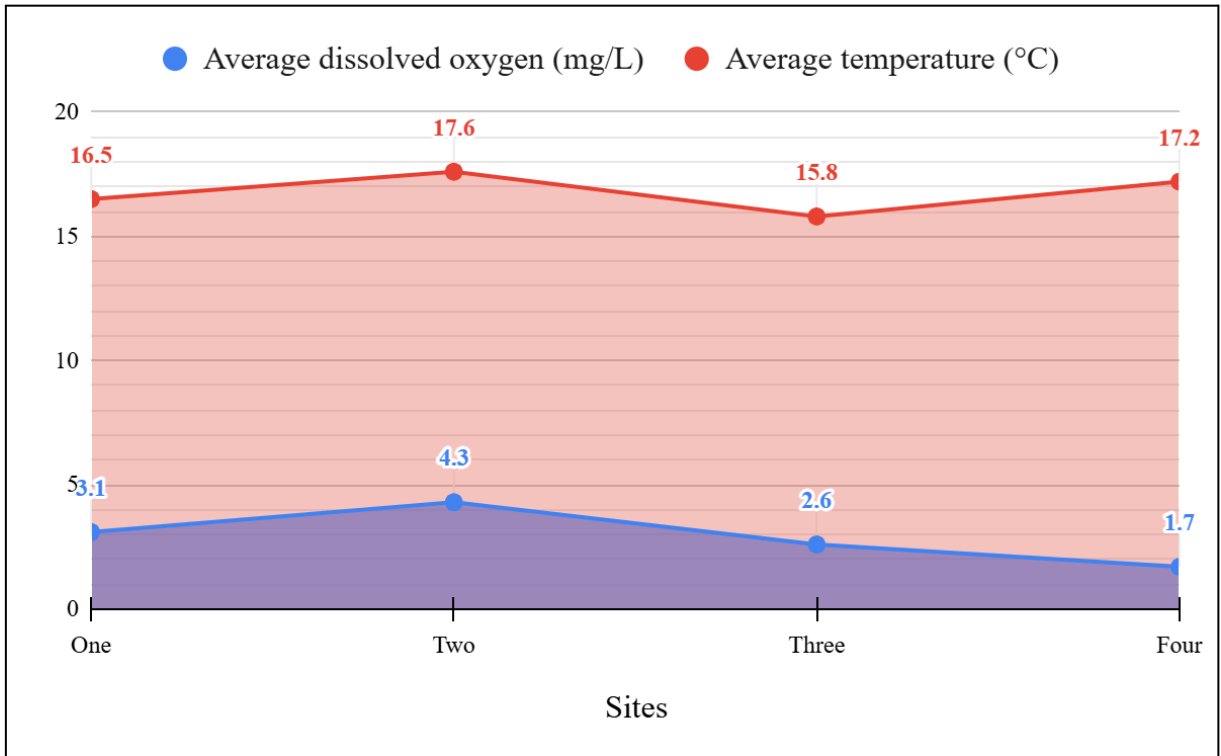


Figure 10. Dissolved oxygen concentration and temperature of all the research sites

4.6. Further discussion

While looking over our collected data, we found out that the trenches had relatively different alkalinity. Sites one and two had on average 210 and 155 mg/L of CaCO_3 , yet sites three and four had 310 and 450 mg/L CaCO_3 respectively as seen on Figure 11. High alkalinity levels at the last two sites also point towards the trenches being more polluted than at the first sites.

This is also confirmed by the conductivity tests where the results were in order 163, 163, 385, and 782 (mg/L) as seen on Figure 11. Higher conductivity shows the existence of more minerals, which may have collected in the water because of human activity.

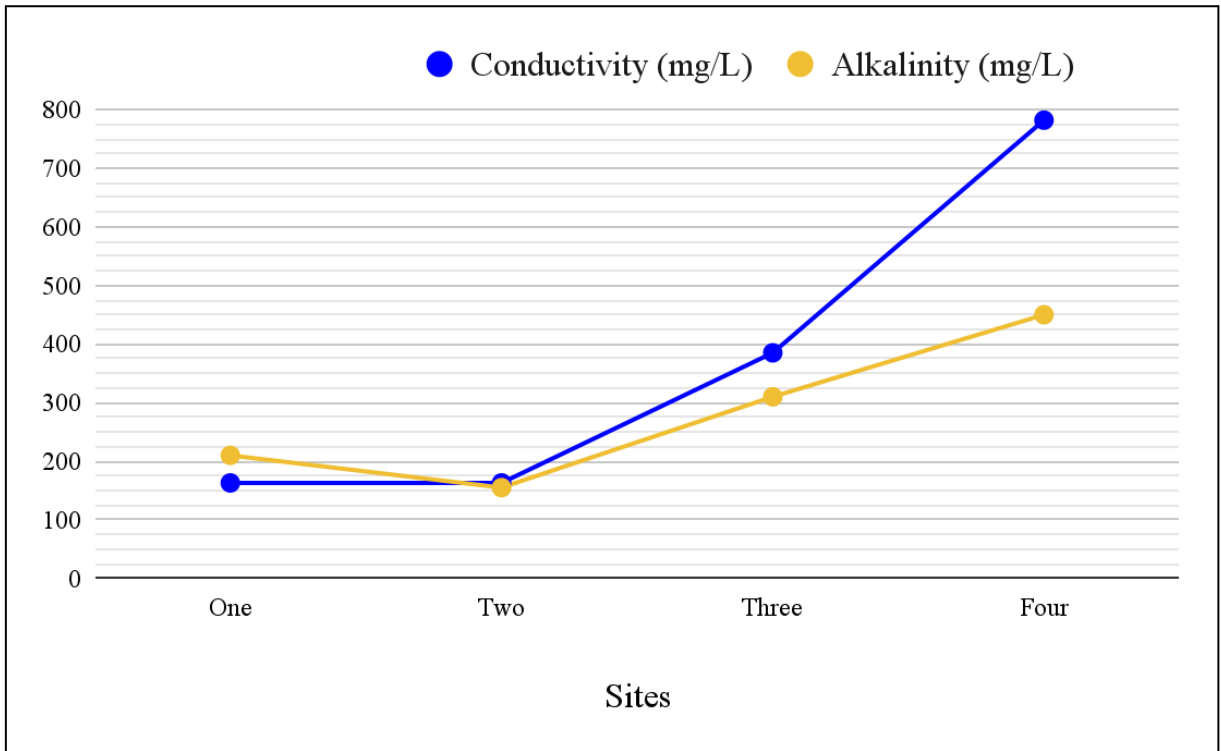


Figure 11. The conductivity and alkalinity of all the research sites

Lastly, at our locations we visually observed the amount of plant life growing in and around the water. Sites one and two had a visible layer of algae growing on the water, yet the trenches at sites three and four had an even higher concentration of plant life growing in them. More plant life refers to an excess of nutrients, which again indicates that fertilizers have seeped into the trenches by the fields.

We could also observe the process of fertilizing the field, because we arrived while the field was being fertilized with manure (Figure 12). This more organic way of taking care of your field might have positively impacted the nitrates concentration at sites three and four, and as a result the overall nitrate concentration was not very high.



Figure 12. Trucks refilling manure to continue fertilizing the field. Source: Authors

4.7. Possible improvements to our fieldwork

We did our best to find out the possible ways fields could affect nearby trench waters, but there are some points to improve on. Firstly, nitrate fertilizers are not the only ones commonly in use on farms – there is also a considerable amount of potassium, phosphorus, and other NPK fertilizers in use, as shown by statistics from the Food and Agriculture Organization of the United Nations¹⁶. Our research could be improved by also including potassium and phosphorus test kits in our equipment. This could help us more accurately determine the pollution level at the trenches and their connection to farming and fertilizers. We could benefit from further measuring the geometry of all the trenches to better compare the effects of surface area to dissolved oxygen.

¹⁶ Food and Agriculture Organization of the United Nations. (July 11, 2025). *Inorganic fertilizers. 2002-2023*. www.fao.org/statistics/highlights-archive/highlights-detail/inorganic-fertilizers-2002-2023/en

CONCLUSIONS

Agricultural effects on waterbodies have been noted all over the world, for example in Spain, as described in our theoretical background chapter. These studies showed that the fertilizers used in cultivating the farmland have a negative effect on surrounding waterbodies.

In Estonia the pressure agriculture has on water quality is very high and that is concerning. Monitoring the effects that agriculture has on water quality because too many nutrients in the streams will start affecting the quality of the groundwater which we use for drinking.

We managed to get an overview of the effect farmlands have on the surrounding areas at Jõulumäe, yet all of our hypotheses did not get verified. We recorded a small increase of nitrates concentration at the sites amidst the cultivated farmlands, but it did not reach a noticeably high concentration, and the risk of nitrate pollution seems unlikely. Therefore, the negative effect of nitrate fertilizers cannot be fully confirmed in our study.

The levels of pH did not differ to a high degree between all the sites, which shows that alkaline fertilizers most likely have not been used lately, or they have had very little effect on the water pH levels.

We did note a difference in oxygen levels between the trenches, with the two trenches closer to the fields having less oxygen. This may be connected to the trenches' surface area or the amount of plant growth and decomposition. Trenches further from the fields had a larger surface area and less plant growth within them, resulting in less decomposition and oxygen consumption.

More plant life in the fieldside trenches indicates the presence of excess nutrients that show some effect from the fields, but overall, our research showed that fieldside trenches can be healthy and not overly pressured by the fields, fertilizers, and extra nutrients.

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ChatGPT was used to help with wording, translating and to support with “Theoretical Background”

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APPENDIX



Figure 13. Our research team and instructors. Source: Riin Värton