GLOBE Estonia Learning Expedition 2025

INVESTIGATION OF WATERBODY PARAMETERS AT JÕULUMÄE USING GLOBE METHODS

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ABSTRACT

The hydrosphere plays a vital role in shaping environmental conditions. Monitoring changes in water characteristics over time provides valuable insight into ecological health and pollution levels. This study examined the physical and chemical properties of three artificial water bodies in the Jõulumäe area. Our aim was to compare current conditions (August 17, 2025) with previous data (August 14, 2018). We followed GLOBE protocols and utilized instruments such as a Secchi tube, dissolved oxygen probe, potentiometric pH meter, nitrate test kit, conductivity probe, and LabQuest 2. With these, we measured water transparency, pH, nitrate concentrations, and electrical conductivity.

We hypothesized a decline in transparency and pH, an increase in nitrate levels and electrical conductivity, and an overall deterioration in water quality. The results, however, showed mixed outcomes across the sites. Transparency decreased in the quarry and pond but unexpectedly increased in the ditch; this improvement may reflect surface conditions rather than actual water depth. Conductivity rose consistently across all three sites, supporting the hypothesis of increasing dissolved salts and pollutants. pH levels dropped significantly at all locations, likely due to both improved measurement accuracy and the unusually rainy summer of 2025, which introduced more acidic precipitation. Contrary to expectations, nitrate concentrations fell to undetectable levels in the pond and ditch (possibly due to biological uptake) while remaining unchanged in the quarry.

These findings illustrate the complex dynamics of water quality in artificial ecosystems. While some results aligned with initial hypotheses, others diverged, highlighting the roles of environmental variability and biological processes. Comparing the 2018 and 2025 dataset, this study contributes to global environmental monitoring efforts and underscores the importance of long-term, standardized measurements in understanding freshwater systems.

INTRODUCTION

This group project examines the hydrosphere by analysing changes in water characteristics over time and studying the hydrosphere helps to understand the rest of the environment (Appendix 4). Analysing in what way, and how much the water characteristics change over time gives an overview of the hospitality to aquatic life and also the pollution in the area. Water transparency shows the living conditions of aquatic plants which need sunlight to photosynthesis. Nitrates are also needed for plant growth. The pH level of water shows the acid content of water. It affects most of the chemical processes of water. The electrical conductivity of water is based on the salinity of it.

In this study, we gathered water characteristic data in the Jõulumäe area in South West Estonia. Our goal was to compare research results from August 14, 2018, with the information we collected during our research on August 17, 2025. Both studies were conducted in the same three separate bodies of water. Different human impact is noticeable around all of the three waterbodies. According to the hypotheses the water transparency, pH (hydrogen ion concentration) levels, nitrate content, electrical conductivity, and water quality have changed. Our data collection tools included a bucket with a rope, a thermometer, a dissolved oxygen probe, a potentiometric pH meter, a Labquest 2 device, a Secchi tube, nitrate test kit, a conductivity probe, and distilled water.

By applying GLOBE protocols, this research contributes to a broader understanding of changes in water characteristics. The study also provides data that can be compared with other observations globally. The outcome can help to illustrate how the conditions of artificial water bodies vary across different locations, and the information we collected can support ongoing environmental education and citizen science efforts. Our study focused primarily on water transparency, pH (hydrogen ion concentration) levels, and nitrate content. Based on initial observations, we formulated the following hypotheses: The water transparency of water bodies has lowered. The pH levels have changed significantly but the most change will be seen in Metsaääre farm's pond. The nitrate level has increased in the ditch more than in the quarry. The electrical conductivity has increased in all the bodies of water over time. The overall quality of the water bodies has decreased.

1. CHEMICAL AND PHYSICAL PARAMETERS OF WATERBODIES AND MONITORING SYSTEM

1.1. Chemical and Physical Parameters of Waterbodies

Water transparency is a physical parameter of water that refers to the depth to which light penetrates a water body. It is influenced by the presence of suspended particles, which may be inorganic (e.g., sediments from erosion) or organic (e.g., algae, phytoplankton). **(**CITCLOPS, 2025**)** Reduced transparency limits sunlight reaching aquatic plants, decreasing photosynthesis and oxygen production. Increased turbidity, often caused by algal blooms or sediment inputs, disrupts ecosystems, stresses fish populations, and signals nutrient pollution. Transparency is strongly influenced by nutrient enrichment (nitrate and phosphate), which drives algal blooms. Land use, erosion, and sediment inflow further reduce water clarity.

pH is a quantitative parameter of the acidity or basicity of water, expressed on a logarithmic scale of 0–14, with 7 representing neutrality. It reflects the concentration of hydrogen ions in a solution. **(**The Editors of Encyclopaedia Britannica,n.d. 2025**)** The pH of water affects nutrient and metal solubility, as well as the health of aquatic organisms. Extreme acidity or alkalinity stresses ecosystems: acidic conditions mobilize toxic metals, while alkaline conditions can increase ammonia toxicity. Both natural processes (e.g., photosynthesis, respiration, rock weathering) and human activities (e.g., acid rain, wastewater inputs) influence pH. Algal blooms often raise pH during the day due to carbon dioxide consumption in photosynthesis.

Nitrate is a highly soluble nitrogen compound that forms when nitrogen combines with oxygen. It is commonly present in fertilizers, manure, wastewater, and industrial discharges**.** Nitrate fuels algal growth in surface waters, contributing to eutrophication. Algal blooms block light, reduce oxygen levels through decomposition, and sometimes release harmful toxins. **(**Fernández-López et al., 2023**)** In groundwater, nitrate poses health risks, exceeding the World Health Organization (WHO) guideline of 50 mg/L can cause methemoglobinemia ("blue baby syndrome") in infants and is linked to cancer risks. (Ward et al., 2005) Factors Affecting Nitrate Levels: Fertilizer leaching from soils, agricultural runoff and livestock manure, sewage leakage and urban stormwater, industrial discharges, natural processes such as atmospheric deposition and soil mineralisation.

Phosphates are phosphorus-containing compounds essential for growth in plants and animals. Sources include natural weathering, fertilizers, detergents, and sewage. **(**Claridge, 2017) Elevated phosphate concentrations promote eutrophication. Excess algal growth lowers oxygen availability, reduces biodiversity, and degrades water quality. Phosphate pollution arises primarily from fertilizer use, sewage effluents, detergents, and erosion of phosphorus-rich soils and rocks.

Nitrate and phosphate are the key nutrients regulating algal productivity. Elevated concentrations stimulate algal blooms, which in turn reduce water transparency, alter pH (via photosynthesis), and increase oxygen demand upon decomposition. Electrical conductivity also rises due to dissolved nutrient inputs. This cascade of effects destabilizes aquatic ecosystems, making nutrient control critical for water quality.

Both nitrate and phosphate are limiting nutrients for algal growth. Excessive inputs, often from agriculture and wastewater, fuel rapid algal proliferation. Blooms increase water turbidity, decrease transparency, and cause severe oxygen depletion when algae die and decompose. In extreme cases, harmful algal blooms release toxins that are harmful to both aquatic organisms and humans. The combined presence of high nitrate and phosphate amplifies eutrophication, making their management essential for healthy aquatic ecosystems.

Electrical conductivity measures how well water conducts electricity. Pure water has very low conductivity, while dissolved ions such as salts, nutrients, or pollutants increase it. (LAWA, 2023) High electrical conductivity can indicate elevated salinity or dissolved pollutants. Many freshwater organisms are sensitive to changes in ionic balance, so excessive conductivity can threaten biodiversity. Electrical conductivity rises with dissolved salts and nutrients (e.g., nitrate, phosphate). Seasonal variations, evaporation, and land-use practices also influence conductivity.

1.2. Water monitoring in Estonia

Water monitoring is the systematic measurement and analysis of physical, chemical, and biological parameters in lakes, rivers, groundwater, and coastal waters. It tracks ecosystem health, identifies pollution sources, and informs water management. (Veeseire, n.d.)

Water monitoring is the systematic measurement and analysis of physical, chemical, and biological parameters in lakes, rivers, groundwater, and coastal waters. It tracks ecosystem health, identifies pollution sources, and informs water management. Estonia carries out monitoring of inland and coastal waters, including measurements of pH, oxygen content, nutrients, transparency, and hazardous substances. Monitoring is important for protecting the Baltic Sea from eutrophication and chemical pollution. (Roots & Lukki, 2016)

Estonia has participated in EU-supported projects such as BaltActHaz and COHIBA, which analyse hazardous substances in the Baltic Sea region. These initiatives examined surface water, treated effluent, bottom sediment, and sewage sludge to build a comprehensive overview of chemical pollution. In total, 130 hazardous substances from 12 chemical groups were analysed in Estonian studies (*Baltic actions for reduction of pollution of the Baltic Sea from priority hazardous substances,* n.d.).

Analyses in Estonia's large screening study were carried out in German-accredited laboratories operating under ISO/IEC 17025 standards, ensuring accurate and reliable results. The findings show that most Estonian surface-water bodies contained hazardous-substance concentrations below analytical detection limits, indicating generally good water quality. (Roots & Roose, 2013)

However, some local exceedances were identified. Higher levels of phthalates (such as di-isobutyl phthalate and DEHP) and heavy metals were found in the oil-shale mining region of north-east Estonia. In coastal and port areas, organotin compounds, including tributyltin, exceeded environmental quality standards. These results demonstrate the need for continued and targeted monitoring, particularly in industrial and coastal regions, to support environmental protection efforts in line with Baltic Sea objectives.

2. METHODS

To determine the actual parameters of water quality in the man-made waterbodies, we gathered data in three different bodies of water that were all nearby each other. We chose the locations based on the 2018 study so we could compare our results (Appendix 2)(Appendix 3). The research took place at Jõulumäe Recreational Sports Centre on August 17th 2025. Jõulumäe Recreational Sports Centre is located in the South-West of Estonia (Figure 1).

Figure 1.Research Area (Jõulumäe Recereational Sports Centre). Basemap: Estonian Land Board

Our equipment consisted of bucket with rope (used to collect water), distilled water (used for cleaning and calibrating), Vernier devices for measuring water's temperature,oxygen concentration, and pH, Labquest 2 for displaying the information gathered by Vernier devices, Secchi tube (used to measure the transparency of the water) , Nitrate test kit, Conductivity probe (Figure 2).

A bucket with a rope was used to collect water samples from the surface and, when possible, from slightly deeper layers of the water body. This allowed for a more representative sampling of the pond or quarry water. Distilled water was used to clean and calibrate all measuring instruments before and after each use to ensure the accuracy of the results. Vernier sensors were connected to the LabQuest 2 device, which displayed and recorded the measured values. The Vernier temperature sensor measured water temperature, the dissolved oxygen probe measured oxygen concentration in milligrams per liter (mg/L), and the pH sensor measured the acidity or alkalinity of the water on a scale from 0 to 14. Water transparency was determined using a Secchi tube, which has a black-and-white pattern on the bottom and a graduated scale along its side. The transparency was read in centimeters (m) as the depth at which the pattern was no longer visible. Nitrate concentration was assessed using a nitrate test kit, which provided an estimate of nitrate levels in milligrams per liter (mg/L) through a color comparison on a scale: 0,1,3,5,10,20,30,50,70,90,120 (Appendix 5). Conductivity was measured with a conductivity probe, which expressed the water's ability to conduct electrical current in microsiemens per centimeter (µS/cm). This parameter is often linked to the concentration of dissolved salts and ions in the water.

In general, the method involved collecting water samples from each study site, calibrating the sensors, and directly recording physical and chemical parameters in the field using the LabQuest 2 device. Each measurement was repeated several times to ensure reliability, and the instruments were rinsed with distilled water between uses to prevent contamination.

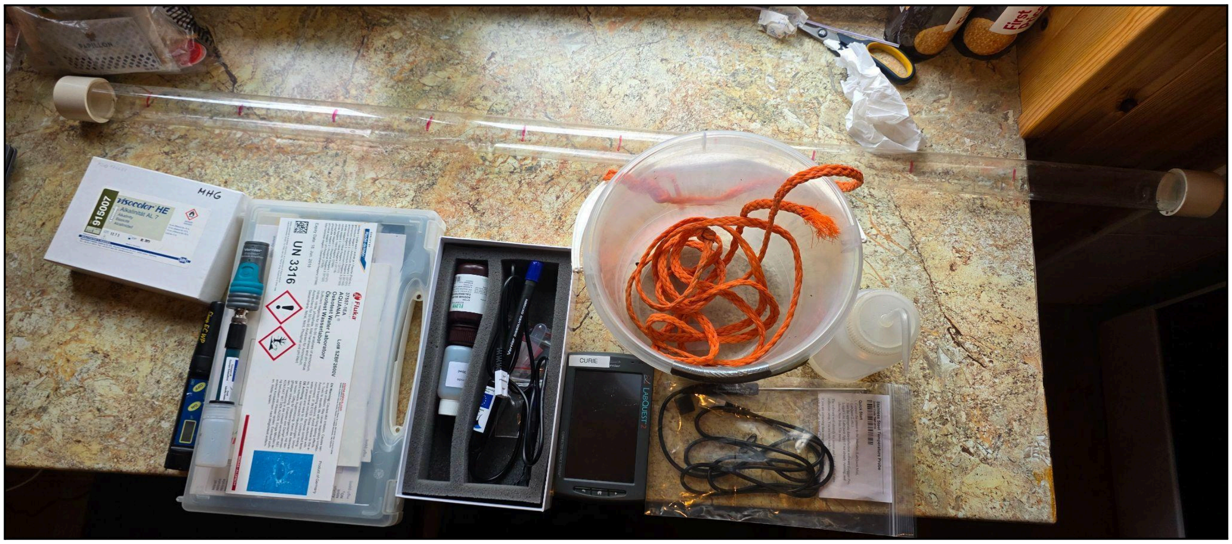

Figure 2.Tools and equipment. Photo: authors.

2.1. Research area 1

The first body of water is the Jõulumäe Recreational Sports Centre swimming spot. It is a freshwater pond which forms part of a ditch next to the Jõulumäe Recreational Sports Centre (Figure 3). The measurements were gathered from a small pier. Different types of human impact are evident around this water body. A parking area next to it. A road runs along its side. These features may contribute to pollution through surface runoff, which can carry oil residues, heavy metals, or other contaminants from vehicles into the water. Across the road, there is a cultivated field that could increase the nutrient load of the water body through the leaching of fertilizers or pesticides, particularly during rainfall. The immediate surroundings of the water body include aquatic vegetation, and the bottom is composed of muddy sediments. The presence of aquatic plants and soft sediment suggests a relatively high nutrient level that supports plant growth. Overall, the proximity of the parking area, road, and agricultural land indicates that human activities are likely influencing the trophic state of this water body.

Coordinates: 58° 13′ 27″ N, 24° 31′ 5″ E

Time: 06:22 UT, 17.08.2025

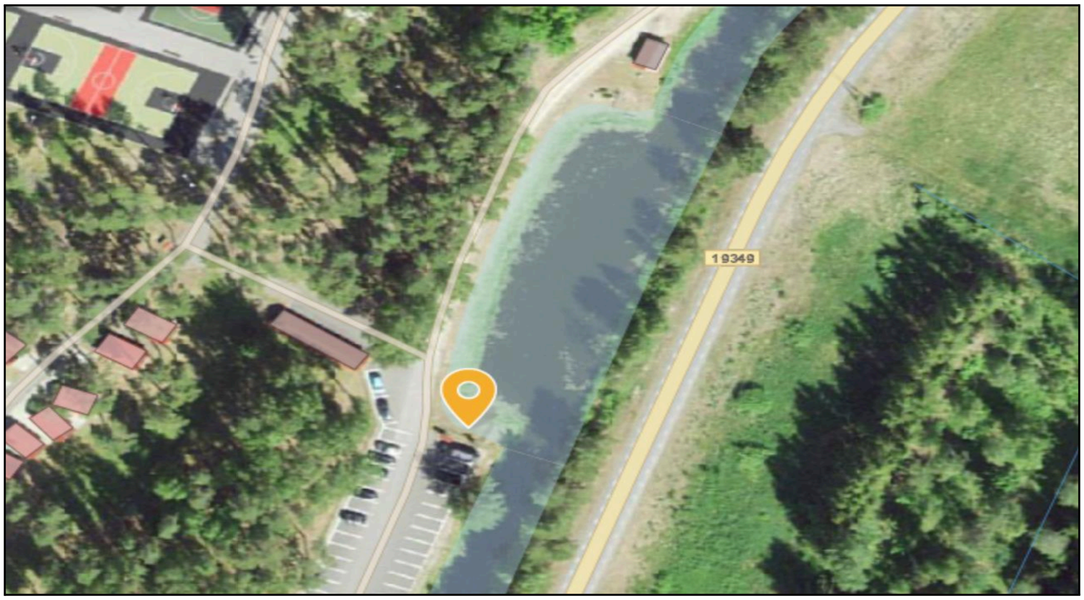

Figure 3. Body of water 1, ditch. Basemap: Estonian Land Board

2.2. Research area 2

The second body of water is Metsaääre farm's freshwater pond inside a yard less than a kilometer away from the first location (Figure 4). The measurements were taken from a small pier and the bank had vegetation. Various human impacts were evident around this water body. A trail runs alongside it, and a pine forest surrounds the area, creating both natural and modified features. The pond sits on private property and is likely maintained or used by the residents. Green algae on the water surface suggest high nutrient levels and possible eutrophication. Despite algal growth, the presence of fish indicates the pond supports aquatic life. Pool floats in the pond indicate recreational use, such as swimming. This activity can stir sediments and circulate nutrients, potentially affecting water quality. Overall, both natural surroundings and human activity, especially recreation, influence this pond's ecological condition.

Coordinates: 58∘13'11" N   24∘30'42" E

Time: 11:34 UT, 17.08.2025

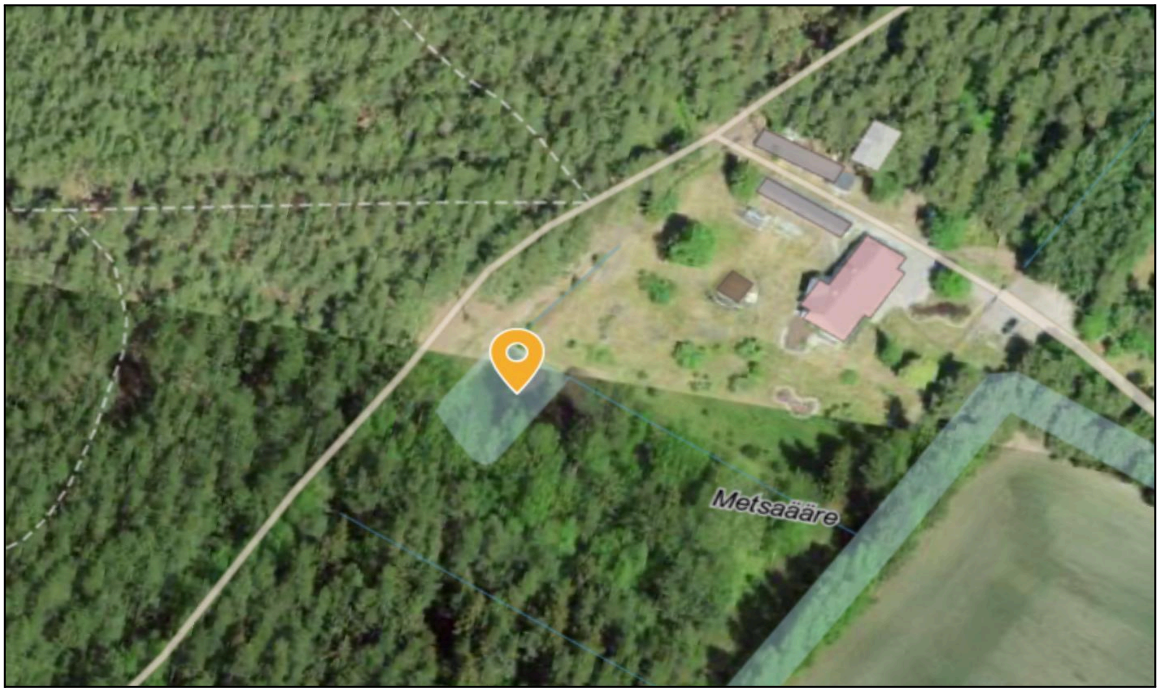

Figure 4. Body of water 2, pond. Basemap: Estonian Land Board

2.3. Research area 3

The third location is a freshwater sand quarry with multiple swimming spots within it. It is located 1.4 km from the first location (Figure 5). We gathered our info from the shore in one of the swimming spots. This quarry is used for recreation and sports, including swimming and competitions. It was reportedly cleaned in 2024, though it is unclear if this refers to the water or the surroundings. The bottom and the bank are sandy. A road runs beside the quarry along a hill; a forest lies on the other side. These surroundings indicate a mix of natural and human influences. The nearby road and recreational use suggest ongoing human impact, while the forest and reeds contribute to the natural character of the environment. Overall, the quarry represents a partly modified ecosystem shaped by both human activity and natural vegetation.

Coordinates: 58∘12’48” N 24∘30’60” E

Time: 12:16 UT, 17.08.2025

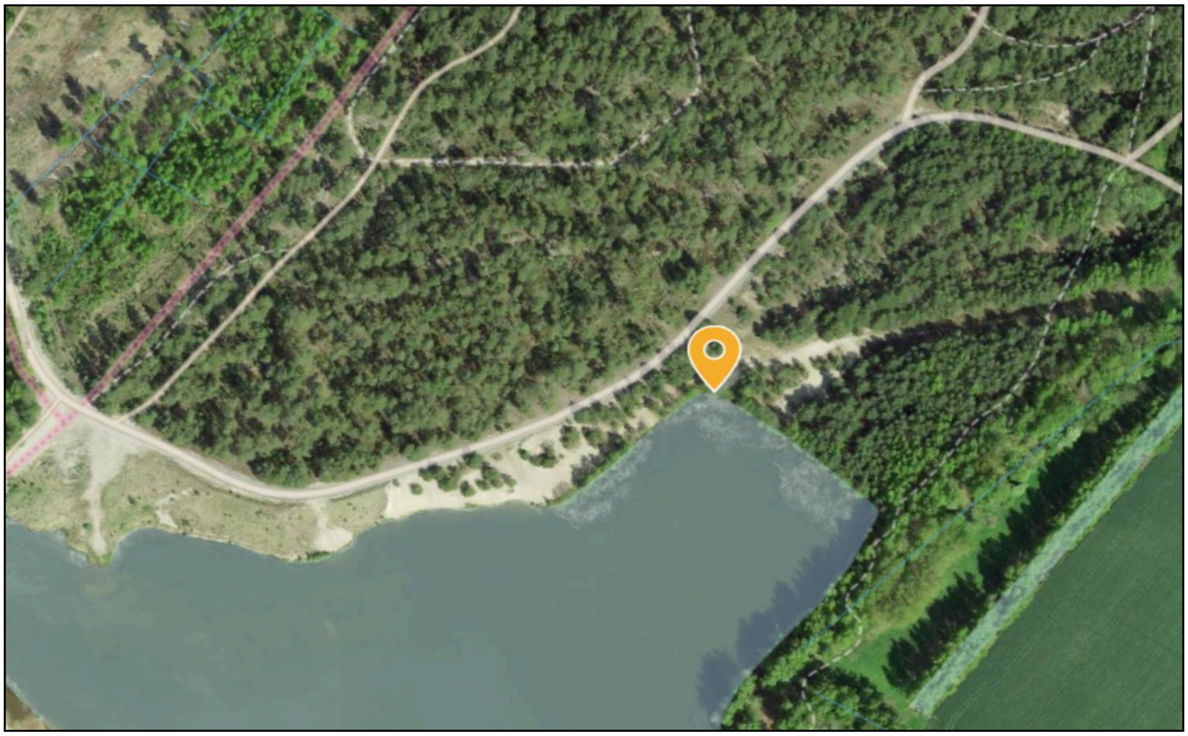

Figure 5. Body of water 3, quarry. Basemap: Estonian Land Board

3. RESULTS

This chapter presents water quality results from 2018 and 2025 at three sites: the quarry, pond, and ditch. Results are analyzed against hypotheses: (1) water transparency decreased, (2) pH dropped, especially in the pond at Metsaääre Farm, (3) nitrate rose more in the ditch than in the quarry, (4) electrical conductivity rose in all sites, and (5) overall water quality decreased between 2018 to 2025. And there is a table containing the results in the appendices (Appendix 1).

3.1. Quarry (near Jõulumäe Recreational Sports Centre)

Hypothesis 1 predicted that water transparency would decrease over time. The transparency of the quarry water decreased from 0.60 m in 2018 to 0.44 m in 2025 (Figure 6). This supports the prediction that clarity would decline with time. The reduction in visibility appears not to be primarily algae-driven, as in the pond, but rather related to sand particles stirred up by strong winds commonly reported in Western Estonia.

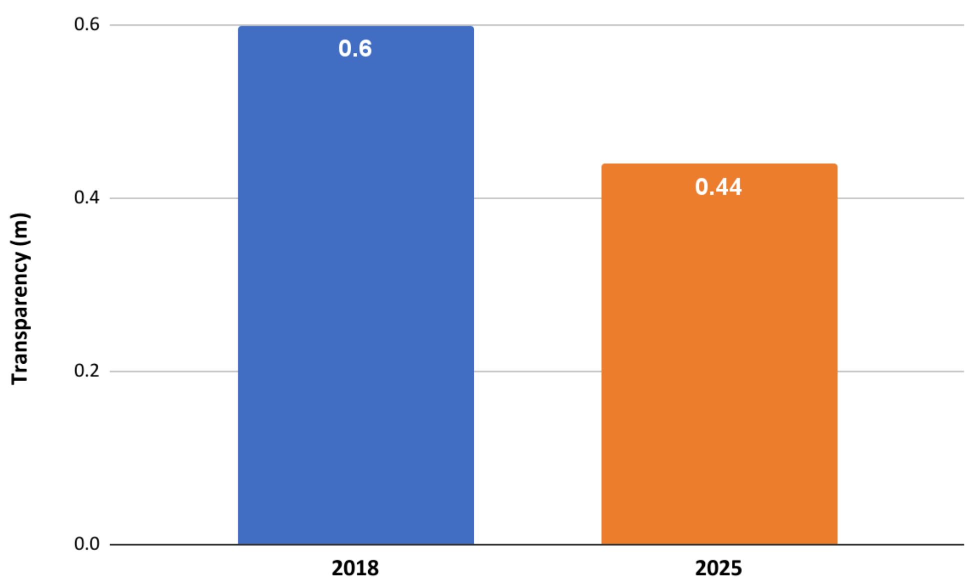

Figure 6. Transparency of the water of the quarry, in 2018 and 2025.

Hypothesis 4 suggested that electrical conductivity would rise as dissolved salts accumulated over time. Conductivity increased from 252.0 µS/cm in 2018 to 272.0 µS/cm in 2025 (Figure 7), confirming the hypothesis. This gradual increase indicates a buildup of minerals and salts as the quarry remained active.

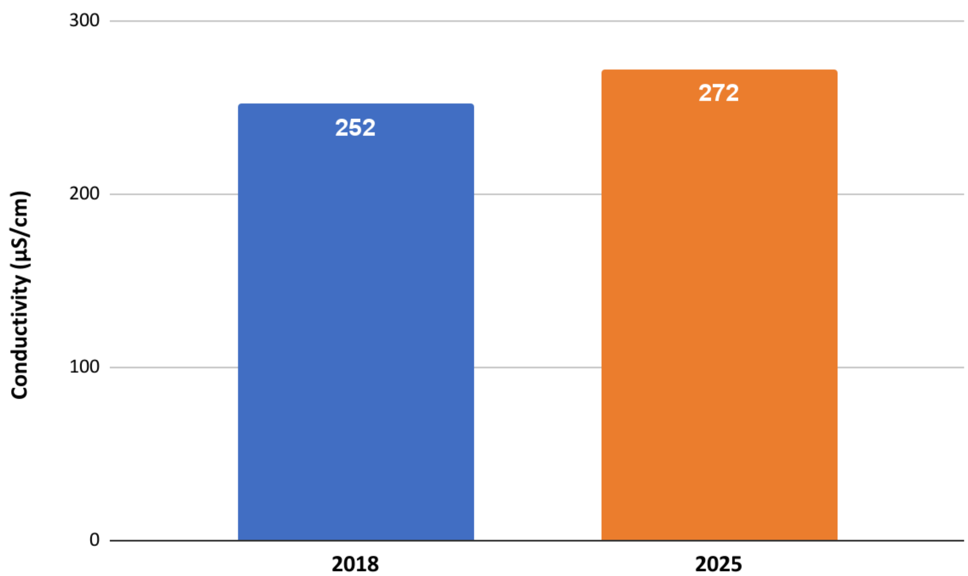

Figure 7. Conductivity of the water in the quarry, in 2018 and 2025.

Hypothesis 2 proposed that pH levels would decrease significantly. The pH of the quarry water fell from 8.0 in 2018 to 6.1 in 2025 (Figure 8). This notable shift of nearly two units is consistent with the hypothesis. The decrease may be explained by both differences in measurement tools (a pH pen in 2018 versus a Vernier probe in 2025) and by environmental conditions such as the unusually rainy summer of 2025. The heavy storms before sampling may have affected the results.

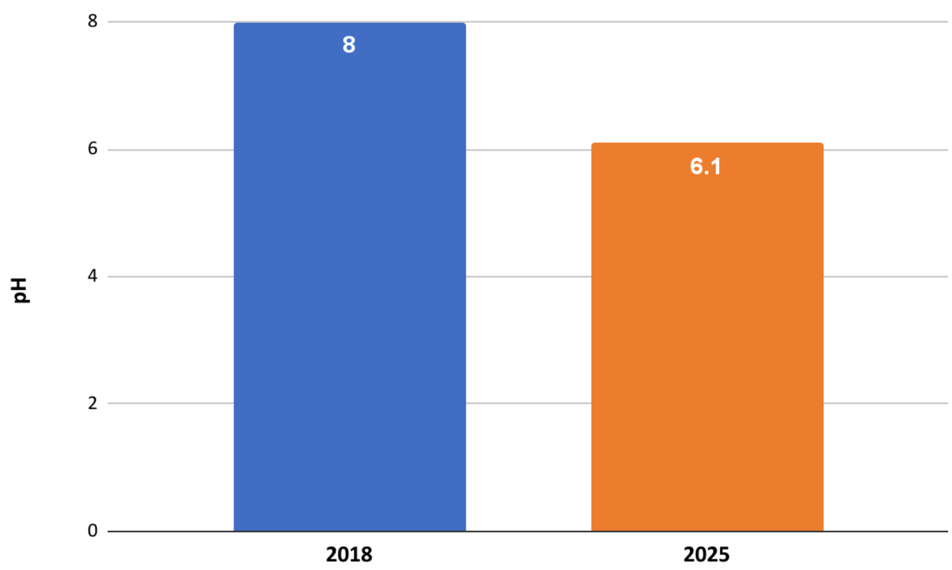

Figure 8. pH in the quarry, in 2018 and 2025.

Hypothesis 3 predicted that nitrate levels would increase more in the ditch than in the quarry. In the quarry, nitrate levels remained unchanged at less than 1 mg/l in both years, contradicting the expectation of an increase. This suggests that the quarry, unlike the ditch, was not influenced by agricultural runoff from nearby fields.

3.1.1 Summary for the Quarry

The quarry results confirm hypotheses 1, 2, and 4, but contradict Hypothesis 3. The findings show reduced transparency, increased conductivity, and lower pH values, while nitrate levels remained stable.

3.2. Pond (Metsaääre Farm)

Hypothesis 1 suggested that water transparency would decline. The pond's transparency decreased slightly from 0.19 m in 2018 to 0.16 m in 2025 (Figure 10), supporting the hypothesis. The pond water exhibited a visible green coloration, indicating heavy algal presence, which likely caused the reduced clarity.

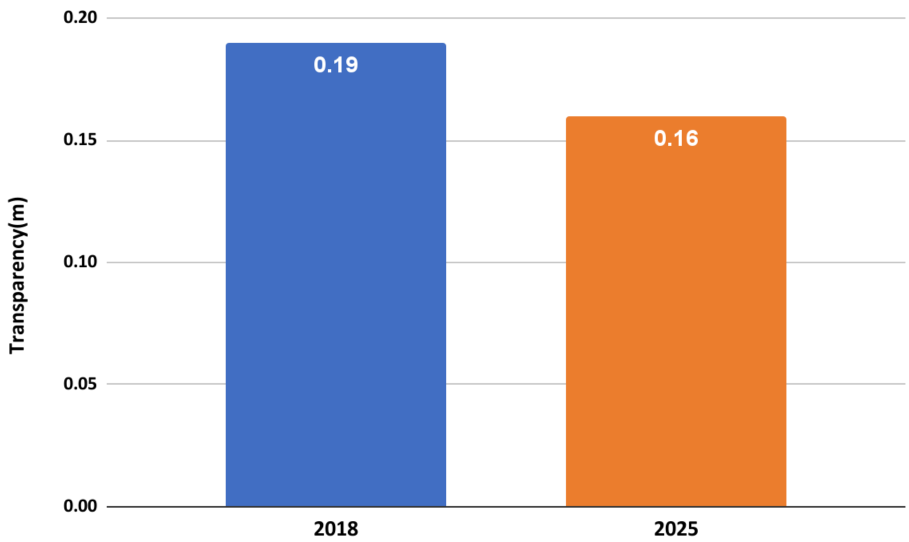

Figure 10.Transparency in the pond, in 2018 and 2025.

Hypothesis 4 expected that conductivity would increase over time. The pond's conductivity rose from 76.3 µS/cm in 2018 to 81.5 µS/cm in 2025 (Figure 11), confirming this hypothesis. The increase suggests ongoing accumulation of dissolved salts due to environmental and possibly human influences.

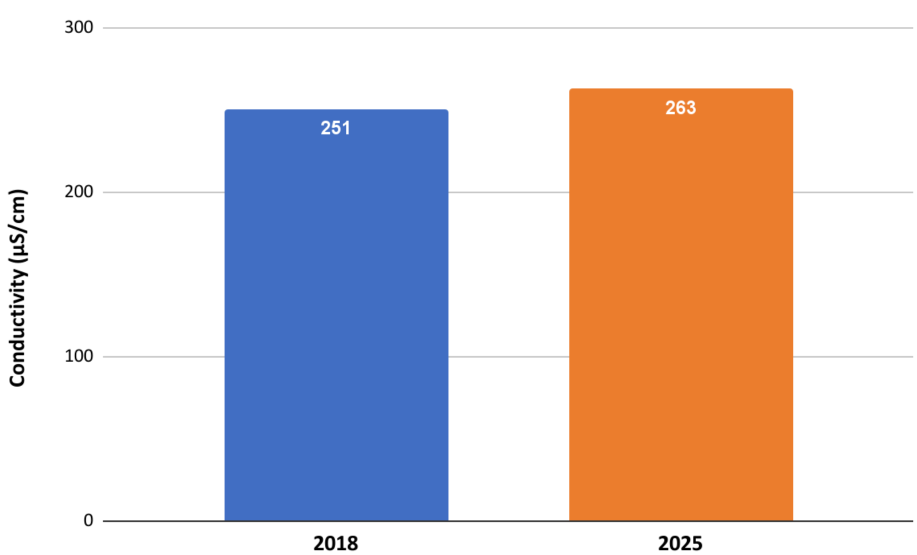

Figure 11. Conductivity in the pond, in 2018 and 2025.

Hypothesis 2 proposed a significant drop in pH, especially in the pond. The pH decreased from 9.5 in 2018 to 7.0 in 2025 (Figure 12), confirming the strongest decrease among all three sites. The decline of 2.5 units supports the hypothesis and can be attributed both to improved measurement accuracy in 2025 (Vernier probe) and to acidic rainfall during an unusually rainy summer. Heavy storms just before sampling likely intensified this acidification.

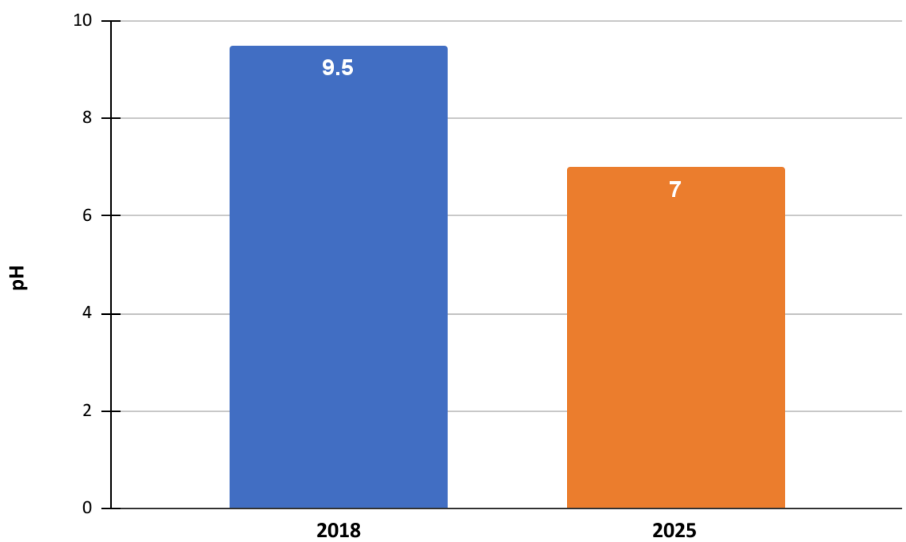

Figure 12. pH in the pond, in 2018 and 2025.

Hypothesis 3 predicted that nitrate levels would increase in the ditch more than in the quarry, implying possible rises elsewhere as well. However, in the pond, nitrate levels fell sharply from 10 mg/L in 2018 to less than 1 mg/l in 2025 (Figure 13), contradicting the expected trend. The reduction may indicate that algae or microorganisms consumed available nitrates, linking the pond's green coloration to nutrient depletion.

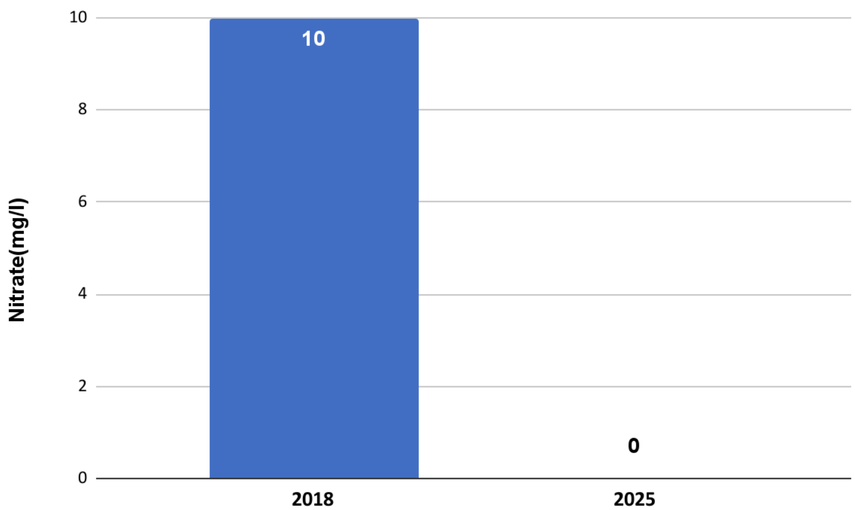

Figure 13. Nitrate level in the pond, in 2018 and 2025.

3.2.1. Summary for the Pond

The pond data support Hypotheses 1, 2, and 4, but contradict Hypothesis 3. The strongest overall pH decline occurred here, confirming the prediction that the pond would exhibit the most pronounced chemical change.

3.3. Ditch (Jõulumäe Recreational Sports Centre parking area)

Hypothesis 1 predicted decreasing transparency over time. Contrary to expectations, the ditch's transparency increased from 0.50 m in 2018 to 1.0 m in 2025 (Figure 14), contradicting the hypothesis. Although transparency improved, the bottom remained obscured by black mud, suggesting the measurement may reflect surface clarity rather than actual depth visibility.

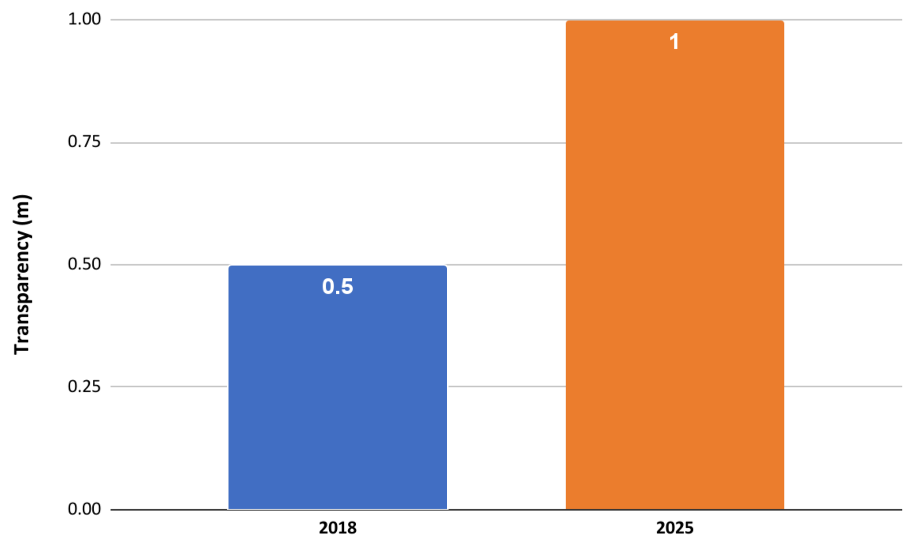

Figure 14. Transparency in the ditch, in 2018 and 2025.

Hypothesis 4 anticipated rising conductivity. The ditch's conductivity increased from 251.0 µS/cm to 263.0 µS/cm (Figure 15), consistent with the hypothesis. This increase is likely caused by road and parking-lot runoff, including salts and de-icing agents, which gradually raise dissolved substance concentrations.

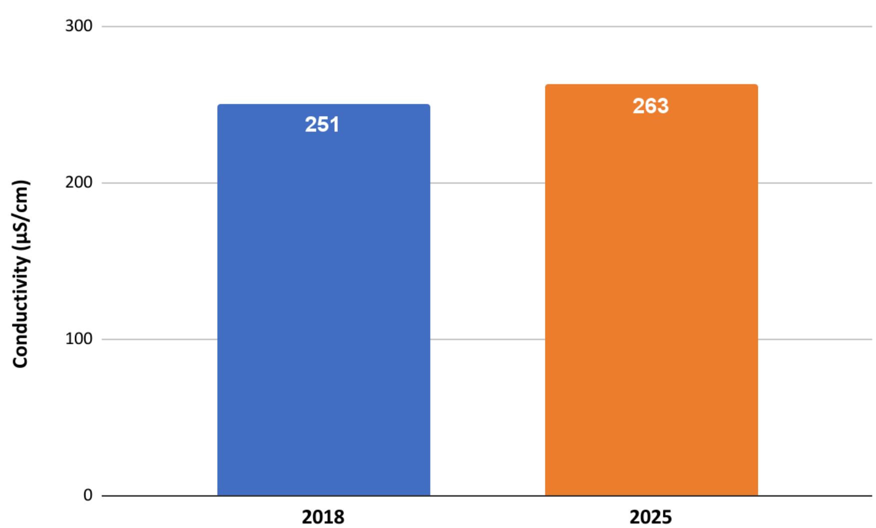

Figure 15. Conductivity in the ditch, in 2018 and 2025.

Hypothesis 2 stated that pH levels would decline. The pH of the ditch dropped from 7.8 in 2018 to 6.3 in 2025 (Figure 16), confirming the hypothesis. This mirrors the general trend seen in all water bodies. The shift may be partly due to the use of more precise equipment in 2025, as the earlier measurements relied on a pH pen, whereas the newer ones utilized a Vernier pH probe. Environmental factors also played a role: the summer of 2025 was notably rainier, and since rainwater has a pH of around 5.5, the heavy storms just before sampling could have contributed to lowering the ditch's pH.

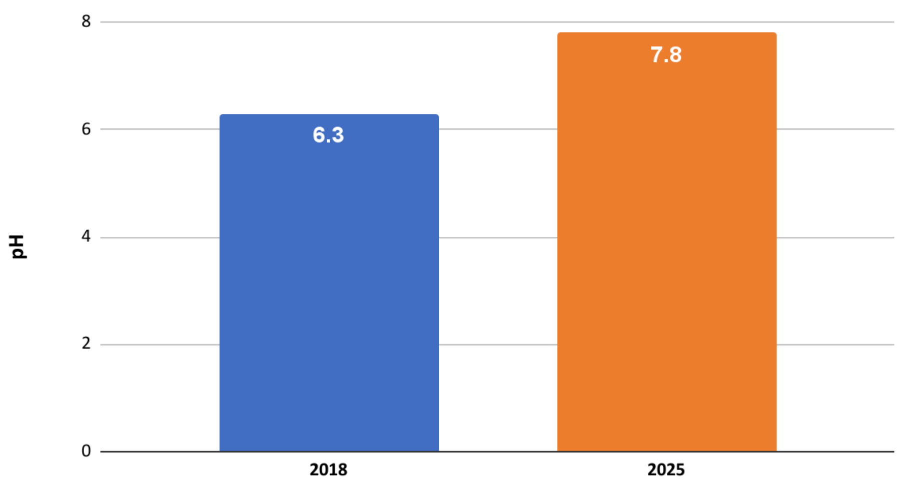

Figure 16. pH in the ditch, in 2018 and 2025.

Hypothesis 3 expected nitrate levels to rise more in the ditch than in the quarry. Instead, nitrate concentrations fell from 6.7 mg/L to less than 1 mg/l (Figure 17), contradicting the expectation that nitrates would rise due to agricultural runoff from the nearby fields. Although the hypothesis mentioned a possible increase of 3.3 in the ditch, the actual measurements in 2025 show no detectable nitrates. This may be due to the limited sensitivity of the sampling kit, or it could suggest that biological processes within the ditch removed available nitrates before testing was conducted.

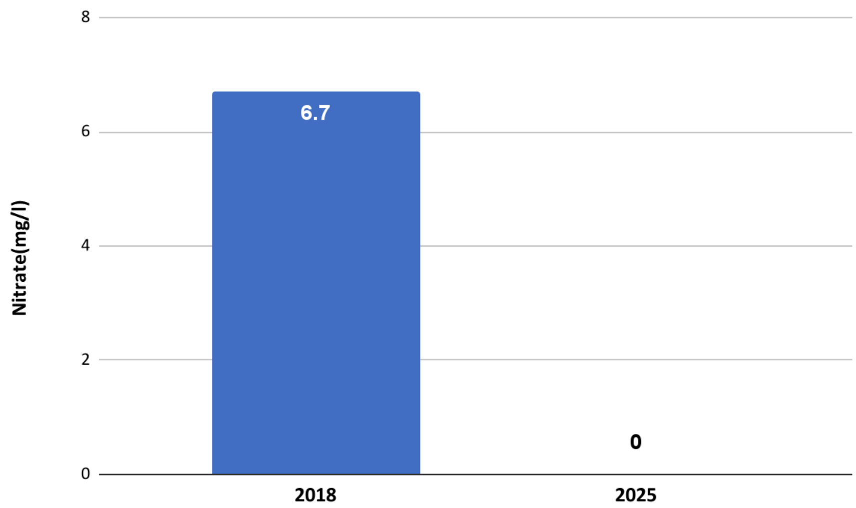

Figure 17. Nitrate level in the ditch, in 2018 and 2025.

3.3.1. Summary for the Ditch

The ditch results confirm Hypotheses 2 and 4 but contradict Hypotheses 1 and 3. Transparency increased unexpectedly, while conductivity and pH trends followed the predicted direction.

3.4. Overall Interpretation

When comparing all study sites, clear patterns emerge in how the hypotheses were supported or contradicted. Water transparency decreased in both the quarry and the pond, but unexpectedly increased in the ditch, confirming the first hypothesis for two out of three locations. The second hypothesis, which predicted a decline in pH levels—with the most significant change occurring in the pond—was fully supported, as all water bodies showed lower pH values in 2025, with the greatest drop observed in the pond at Metsaääre Farm. The third hypothesis, suggesting that nitrate concentrations would increase in the ditch more than in the quarry, was not supported; in fact, nitrate levels fell to zero in all sites, likely due to biological uptake or limited sensitivity of the measurement method. The fourth hypothesis, which predicted increased conductivity across all locations, was confirmed consistently. To sum up, these findings indicate that the overall water quality of the studied sites has declined between 2018 and 2025, supporting the final hypothesis.

4. CONCLUSION

This study found that between 2018 and 2025, pH decreased in all three sites, conductivity increased in all three sites, transparency decreased in two sites, and nitrate decreased to undetectable levels in two sites while remaining unchanged in one site. These results answer the research question: measurable water quality changes have occurred in the three artificial water bodies in Jõulumäe during the 7-year period, but not all parameters changed in the same direction across sites.

Hypothesis 1 (transparency decrease) was partly supported: transparency declined in the quarry and pond, but unexpectedly increased in the ditch. This deviation likely reflects temporary surface conditions rather than actual long-term clarity improvement. Hypothesis 2 (pH decrease, strongest in pond) was fully supported: all three sites became more acidic, with the largest decline in Metsaääre pond. This aligns with the literature on the influence of acid rain and the effects of measurement precision. Hypothesis 3 (nitrate increase in the ditch is bigger than in the quarry) was rejected: instead, nitrate fell to zero in the pond and ditch and stayed at 0 mg/L in the quarry. This may reflect biological uptake or denitrification rather than nutrient accumulation. Hypothesis 4 (conductivity increase) was fully supported: conductivity rose in all sites, implying increasing dissolved ions and long-term pollution accumulation. The overall hypothesis (general water quality decline) was supported because two major indicators of deterioration (conductivity rise and pH drop) were consistent across all three sites.

Taken together, these results show that the strongest long-term signals in these small artificial systems are acidification and increased dissolved ions, while nutrient behaviour and transparency are more site-dependent. The conclusions should therefore be generalized mainly to similar small human-influenced standing water bodies in South-West Estonia under similar climatic conditions.

The results can be used in local water management, school environmental education, and citizen science interpretation – especially for early warning in conductivity and pH-based water quality decline. Future research should include year-round monitoring, direct phosphate measurements, and biological data to quantify nutrient cycling and improve the interpretation of nitrate dynamics.

SUMMARY

This study examined changes in the physical and chemical properties of three artificial freshwater bodies in the Jõulumäe area. The goal was to assess long-term developments in water quality. The research compared measurements collected on August 14, 2018, with data obtained on August 17, 2025. It focused on water transparency, pH, nitrate concentration and electrical conductivity. To collect data we used the GLOBE monitoring methods and protocols. The aim was to determine whether measurable changes occurred over the seven years and to evaluate the changes in water quality.

First we addressed changes in water transparency. Results showed that transparency decreased in both the quarry and the pond. This indicates a decline in water clarity over time. In contrast, transparency in the ditch increased, which contradicted the hypothesis. However, this increase is likely caused by temporary surface conditions and is not a genuine improvement in water quality. Deeper visibility remained limited by the presence of dark sediments. Therefore, the hypothesis predicting a general decrease in transparency was only partially supported.

The next objective we focused on were the changes in pH levels. A clear and consistent decrease in pH was observed in all three water bodies between 2018 and 2025. The most pronounced decline occurred in the pond at Metsaääre Farm, confirming the hypothesis that this site would experience the strongest pH change. The overall acidification trend may be linked to improved measurements accuracy in 2025 as well as environmental factors, particularly the unusually rainy summer, which could have had an impact on the increased influence of acidic precipitation.

Thirdly we examined nitrate concentrations, with the hypothesis that nitrate levels would increase more in the ditch than in the quarry. This hypothesis was not supported by the results. Instead, nitrate concentrations decreased to below detectable levels in both the pond and the ditch, while remaining unchanged in the quarry. These findings suggest that biological uptake or other natural processes played a more significant role than nutrient accumulation from external sources during the study period.

Electrical conductivity increased in all three water bodies, fully supporting the corresponding hypothesis and indicating a gradual accumulation of dissolved ions over time.

Overall, the results show that water quality has declined since 2018, although changes were not uniform across all sites. The most consistent indicators of deterioration were the decrease in ph and the increase in electrical conductivity, while transparency and nitrate concentrations varied depending on local conditions.

The study demonstrates that small, human-influenced artificial water bodies in south-western Estonia show clear long-term trends of acidification and increased dissolved substances, whereas nutrient dynamics are more variable. The research fulfilled the objectives set in the introduction and partially confirmed the initial hypothesis.

These findings support the value of long-term, standardized monitoring for detecting gradual changes in freshwater systems and are relevant for environmental education, local water management, and citizen science. Future studies should incorporate consistent monitoring, phosphate measurements, and biological indicators to enhance the understanding of nutrient and ecosystem dynamics.

KOKKUVÕTE

Käesolev uurimistöö „Veekogude parameetrite uurimine kasutades GLOBE meetodeid“ käsitleb hüdrosfääri seisundi muutusi ja nende mõju veekvaliteedile. Töö eesmärk oli võrrelda kolme Jõulumäe piirkonnas asuva tehisliku veekogu (kraav, tiik ja liivakarjäär) füüsikaliste ja keemiliste näitajate muutusi võrreldes 2018. aastal kogutud andmetega.

Uurimistöö olulisus seisneb korduvate ja standardiseeritud mõõtmiste teostamises samades veekogudes, mis võimaldab hinnata veekvaliteedi muutusi ajas ning panustab globaalsesse keskkonnaseiresse. Andmete kogumiseks kasutati GLOBE seireprogramme ja mõõtmisprotokolle. Mõõdeti vee läbipaistvust, pH-d, nitraatide sisaldust ja elektrijuhtivust Secchi toru, Vernieri andurite, LabQuest 2 seadme, nitraaditesti ja elektrijuhtivuse sondi abil. Mõõtmised viidi läbi 17. augustil 2025 samades veekogudes nagu 2018. aastal.

Tulemused näitasid, et vee läbipaistvus vähenes karjääris ja tiigis, viidates vee hägususe suurenemisele. Kraavis suurenes läbipaistvus, kuid musta muda tõttu jäi põhi nähtamatuks, mistõttu kajastab tulemus tõenäoliselt vaid pinnakihi selgust. Seega leidis hüpotees läbipaistvuse üldise vähenemise kohta kinnitust osaliselt.

pH väärtused langesid kõigis veekogudes, kusjuures suurim langus toimus Metsaääre talu tiigis, kinnitades hüpoteesi tugevamatest keemilistest muutustest seal. Nitraatide sisalduse osas hüpotees ei kinnitunud: tiigis ja kraavis langes nitraatide tase skaalal 0–1 vahele ning karjääris jäi see muutumatuks, mis viitab bioloogilisele toitainete omastamisele. Elektrijuhtivus suurenes kõigis veekogudes, osutades lahustunud ioonide ja saasteainete järkjärgulisele kuhjumisele.

Kokkuvõtteks näitab uurimistöö, et Jõulumäe piirkonna tehislikes veekogudes on toimunud märgatavad muutused, millest kõige ühtlasemad on pH langus ja elektrijuhtivuse tõus, samas kui läbipaistvuse ja toitainete muutused on asukoha spetsiifilised. Tulemused rõhutavad pikaajalise veeseire olulisust ning on rakendatavad keskkonnahariduses ja veemajanduse planeerimisel.

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APPENDICES

Appendix 1. Table 1. Comparison of data from 2018 and 2025

Table 1. Comparison of data from 2018 and 2025.

Body of water	Type	Condition	Transparency (m)		Conductivity (µS/cm)		pH		Nitrate	
			2018	**2025**	**2018**	**2025**	**2018**	**2025**	**2018**	**2025**
1	fresh water ditch	normal	0.50	1.00	251.0	263.0	7.8	6.3	6.7	0
2	fresh water pond	normal	0.19	0.16	76.3	81.5	9.5	7.0	10	0
3	fresh water quarry	normal	0.60	0.44	252.0	272.0	8.0	6.1	0	0

Appendix 2. Photos of the man-made waterbodies in 2018

Figure 18. The quarry in 2018. Author: Aiki Jõgeva

Figure 19. The pond in 2018. Author: Aiki Jõgeva

Figure 20. The ditch in 2018. Author: Aiki Jõgeva

Appendix 3. Photos of the man-made waterbodies in 2025

Figure 21. The quarry in 2025. Photo: authors

Figure 22.. The ditch in 2025. Photo: authors

Figure 23. The pond in 2025. Photo: authors

Appendix 4. Our research team

Figure 24. Our research team. Photo: authors

Appendix 5. Photo of the nitrate concentration scale

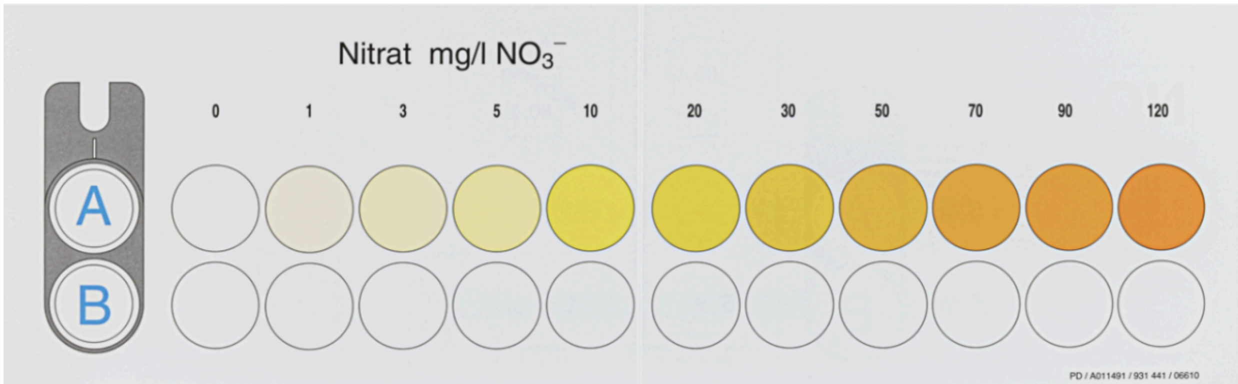

Figure 25. Nitrate scale from Nyos nitrate test kit.