GLOBE Estonia Learning Expedition

Ecological status of macrophytes in Lake Viljandi (Sammuli)

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Abstract

Negative human impact can affect lakes very differently. We can see litter near the shoreline, erosion and lost habitats, but organisms that are living at these places must react as well. One way is to assess the ecological status of macrophytes (aquatic plants). This method allows us to evaluate how much different the plant community is compared to the natural state of the aquatic plants.
The purpose of our project was to find out the ecological status of the plants near Lake Viljandi. The research site was near Sammuli Holiday Village, the research transect was an artificial shoreline (bay for small boats and leisure purposes). We explored the shoreline and identified the macrophytes growing there. After the expedition, we used our collected data to examine the ecological status of the macrophytes using the quality indicator species. The methods are following the guidelines of the European Union Water Framework Directive (WFD) and Estonian National lake monitoring methodology. We identified 70 different plant species at the research site, but the ecological quality of the plant community was moderate.

Research Question and Hypothesis

Our main objective was to evaluate the ecological status of the macrophytes (aquatic plants) and the water quality at our research site in Lake Viljandi (Estonia) near Sammuli Holiday Village by identifying the plant community growing on the shoreline.

On the natural shoreline, there are usually more different microhabitats, lower water levels, and rocks. This affects the plant community, therefore there should be more different plant species, and indicator species are more “good” (characteristics of good ecological status). Negative human impact (e. g. litter, pollution, modifications of the shoreline, deepening the lakebed) is a negative effect for the plant and animal species living in that environment. Because of it there usually live fewer plant species and more negative indicator species are present. Lake Viljandi is near a rather big town (population approx. 17 000) and the Sammuli Holiday Village (situated on the opposite bank) has an artificial shoreline, therefore the quality of macrophytes should be rather low.

Research question:
What is the ecological quality of the macrophytes near Sammuli Holiday Village?

Hypothesis:
The water quality (according to macrophytes) is rather poor because the shoreline is artificial.

Figure 1. The shoreline near Sammuli Holiday Village.

Introduction and Review of Literature

Overview of Lake Viljandi

Lake Viljandi is located in the Sakala Upland, 42.5 m above sea level. The lake is quite deep, 11 m, average depth 5.6 m. The area of the lake is 160.6 ha. The shoreline of the lake is 12.6 km and it is highly complex. The shore is usually sandy or muddy, and it is deepening fast. Water is with high alkalinity (272 mg/l) and water changes twice a year.

The color of water is usually yellow or greenish-yellow and quite often transparent (> 2 m). The nutrient levels are quite high, average phosphorus concentration in the water column is 53 mg/m^3 and nitrogen concentration 1270 mg/m^3 (Laarmaa et al., 2019). These parameters create good conditions for high species richness.

The concentration of phytoplankton species in a sample can be very high (73 species in the sample), but usually there are 30-35 species in one sample. There could be around 20 zooplankton species in the samples. Additionally, there are many macroinvertebrates and fish species, many of them endangered (Laarmaa *et al*., 2019).

Lake Viljandi is a very beautiful and important lake for the locals. In the northern shores, there is the town of Viljandi with around 17 000 inhabitants. Lake Viljandi is located in a primeval valley and is a part of the Viljandi nature park. The town of Viljandi is also situated on the shore of the lake (Laarmaa *et al*., 2019).

The pond, which we investigated, is artificial and it is impacted by humans. The bay is situated on the south shore next to Sammuli Holiday Village. There is a bay with average boat traffic and the grass is mowed regularly on its shore. Also, the holiday visitors are affecting the lake (e.g. swimming, paddling-boats, boat traffic, litter).

Macrophytes (plants) in Lake Viljandi

In conclusion from earlier studies, 57 different aquatic plant species have been found in Lake Viljandi. The most common plants are narrowleaf cattail (*Typha angustifolia*) and yellow waterlily (*Nuphar lutea*). The most common underwater plant species is common water moss (*Fontinalis antipyretica*) (Laarmaa et al., 2019).

One of the rarest macroalgae in Estonia, green-macroalgae “lakeball” or “marimo” (*Aegagropila linnaei*), could also be found there, but due to negative human impact from the nearby town, its population has been rapidly declining (Laarmaa et al., 2019).

Research Methods and Materials

We conducted our research on 12 August 2020, and collected data by identifying plants along the transect and doing different weather measurements.

The transect we investigated was near Sammuli Holiday Village (Figure 2). The length of our transect was 150 meters. The pond was artificial and it was connected to Lake Viljandi with a channel.

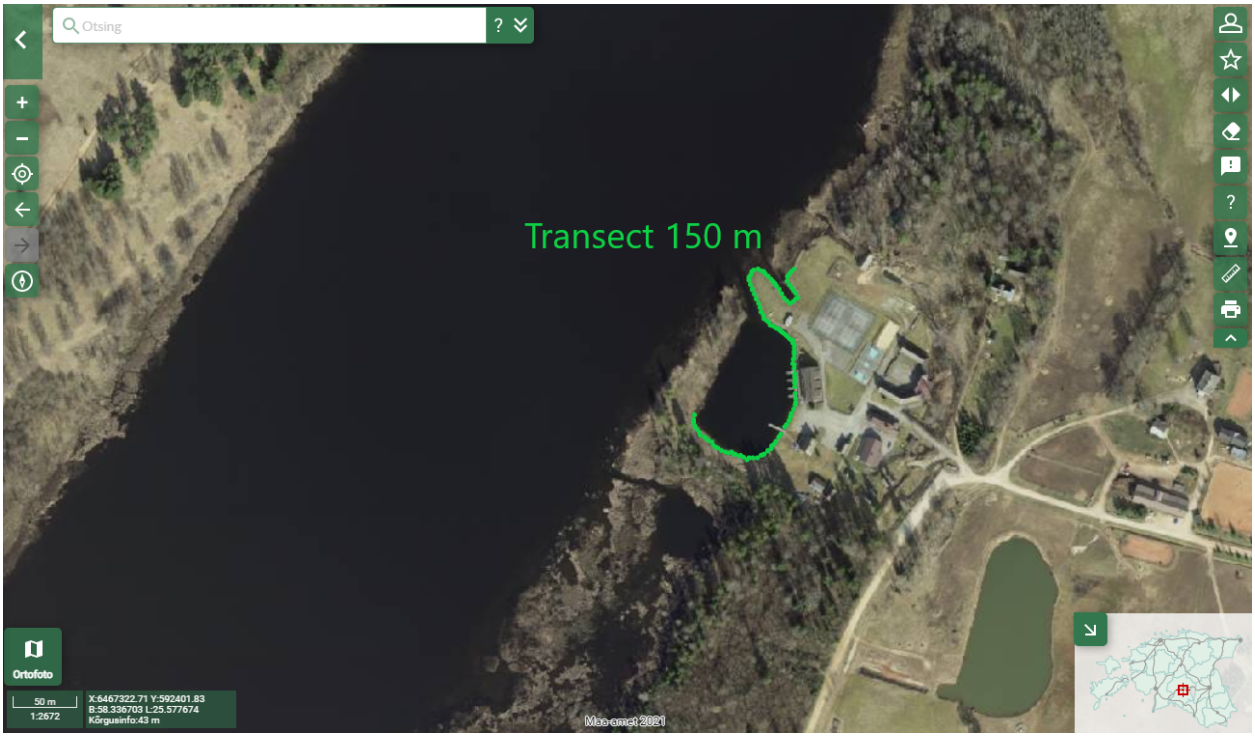

Figure 2. Sample site near Sammuli Holiday Village (Estonian Land Board, 2020)

We walked through the shoreline and identified the plants growing there. We used two different plant identification guides for that: *Eesti taimede kukeaabits* (Kukk, 2015) and *Eesti taimede määraja* (Krall *et al.*, 2010).

We then assessed the cover of the plants using the Braun-Blanquet scale (Table 1; Braun-Blanquet, 1927). It is used for assessing the plant coverage by determining how many plants approximately were present from each individual plant group. The numbers from 1 to 5 show both the numbers of species and the proportion of the area covered by these plant species, ranging from + (covering a small area) to 5 (covering more than 75% of the area).

Table 1. Braun-Blanquet scale (Braun-Blanquet, 1964) for assessing macrophyte coverage.

+	< 5 %; few individuals
1	< 5 %; numerous individuals
2	5 - 25%
3	25 - 50%
4	50 - 75%
5	75 - 100%

After assessing the abundance of the plant groups, we compared this data with quality indicators (Table 2). These methods are following the guidelines of the European Union Water Framework Directive (WFD, 2000) and Estonian National lake monitoring methodology (Assessment …, 2020).

After determining the plant coverage, we assessed different parameters of plants according to the EU Water Framework Directive and Estonian Standards (Assessment …, 2020; see also Figure 3). These standards are used to determine the water quality using color coding. For example, yellow is moderate and red is poor.

We assessed six quality indicators:

- Maximum depth of the plants
- Plant community
- The abundance of *Potamogeton* (pondweed)
- The abundance of *Chara spp*.
- The abundance of *Ceratophyllum* (coontails)
- The abundance of *Cladophora* (green macroalgae)

The ecological status classes for these indicators are in Table 2.

Table 2. Quality indicators and assessment scale for assessing the ecological status of macrophyte communities (Assessment …, 2020).

Quality indicator	**High**	**Good**	**Moderate**	**Poor**	**Bad**
Maximum depth of macrophytes	>4 m	4-3 m	3-1,6 m	1,6-1 m	<1 m
Plant community	Bryophyta= Charophyta, Potamogeton	Charophyta= Potamogeton, Bryophyta, Myriophyllum= Elodea	Ranunculus, Ceratophyllum, Potamogeton, Charophyta	Ceratophyllum , Ranunculus, floating-leaved plants	not determine d
Abundance of Potamogeton	3	4-5	1-2	0	0

Abundance of Charophyta	3	4-5	1-2	0	0
Abundance of Ceratophyllum or abundance of floating-leaved plants	0	1-2	3	4-5	not determined
Abundance of green macroalgae and epiphyton	0	1	1-2	3-4	5

These quality indicators are trying to compare the conditions of the sites where the natural state has not been impacted by humans (the high and good ecological status). For example, when the light conditions are good in the lake, the plant species can populate deeper habitats. When negative indicator species (e.g. green macroalgae and Ceratophyllum) are abundant, then the ecological status is poorer.
The ecological status of the plants was developed from the arithmetic mean. The high and good ecological statuses are acceptable and meet WFD goals, but moderate, bad and poor status classes need urgent attention (Figure 3).

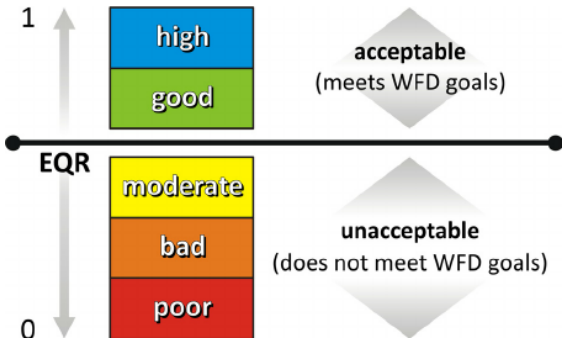

Figure 3. Ecological status classes and their colour code according to the EU Water Framework Directive and Estonian Standards.

Results

Ecological status of macrophytes

The shoreline is artificially modified and therefore there are not many good indicator species. We identified 70 species of plants during 4 hours of fieldwork (for more information, see Appendix 1). The most frequently found plants were: yellow water-lily *(Nuphar lutea*), *Carex* spp., and bulrush (*Schoenoplectus lacustris*) which form a continuous zone at the investigated transect. Water hemlock (*Cicuta virosa*), bugleweed (*Lycopus europaeus*), nightshade (*Solanum dulcamara*), frogbit (*Hydrocharis morsus-ranae*), sweet flag (*Acrus calamus*) and bur-reed (*Sparganiun microcarpum*) were also common.

The results for quality indicators and assessment scale (Table 2) with values in the research site can be found in Table 3. The color indicators are the following: green=good; yellow= moderate; orange= poor. By an arithmetic mean we can tell that the average water quality is moderate.

Table 3. Quality indicators and their values.

Quality indicator	**Unit**	**Value**
Max depth of the plants	m	2,1 (moderate)
Plant community		*Nuphar lutea* = *Carex* spp. = *Schoenoplectus lacustris* (moderate)
Abundance of *Potamogeton*	Braun-Blanquet scale 0-5	1 (moderate)
Abundance of *Chara* spp.	Braun-Blanquet scale 0-5	0 (poor)
Abundance of *Ceratophyllum* (coontails)	Braun-Blanquet scale 0-5	1 (good)
Abundance of *Cladophora* (green macroalgae)	Braun-Blanquet scale 0-5	3 (poor)

Ecological status of plants (Average of quality indicators)	Scale 1-5	**3 (moderate)**

Potamogeton species were low in abundance and Charophytes were not present at all, but usually in these types of lakes they are very common. This could be affected by artificial shore and negative human impact.

Negative indicator species, especially green macroalgae (*Cladophora*), were very abundant. These species are directly associated with phosphorus and nitrogen rich waters. Coontail (*Ceratophyllum*) species abundance was low, which is a good result.

Although we found 70 different plant species in the transect, the ecological status of different indicators indicates moderate status.

Figure 4. Yellow water lily (*Nuphar lutea*)

Weather conditions during the fieldwork

Making weather observations is very important for understanding the world around us better, and scientists can use the data collected from GLOBE students for research.

On our fieldwork day (12 August 2020), we made different atmospheric observations using the GLOBE protocols. We observed the clouds, measured the precipitation, temperature, air pressure and humidity.

The minimum temperature during our observations was 12.8 ℃ and the maximum temperature was 20.6 ℃. The air pressure was 1020 hPa and the humidity was 39%. The cloud coverage was 50-90% and the cloud types that we observed were altocumulus and stratocumulus. There was no rainfall during our observations.

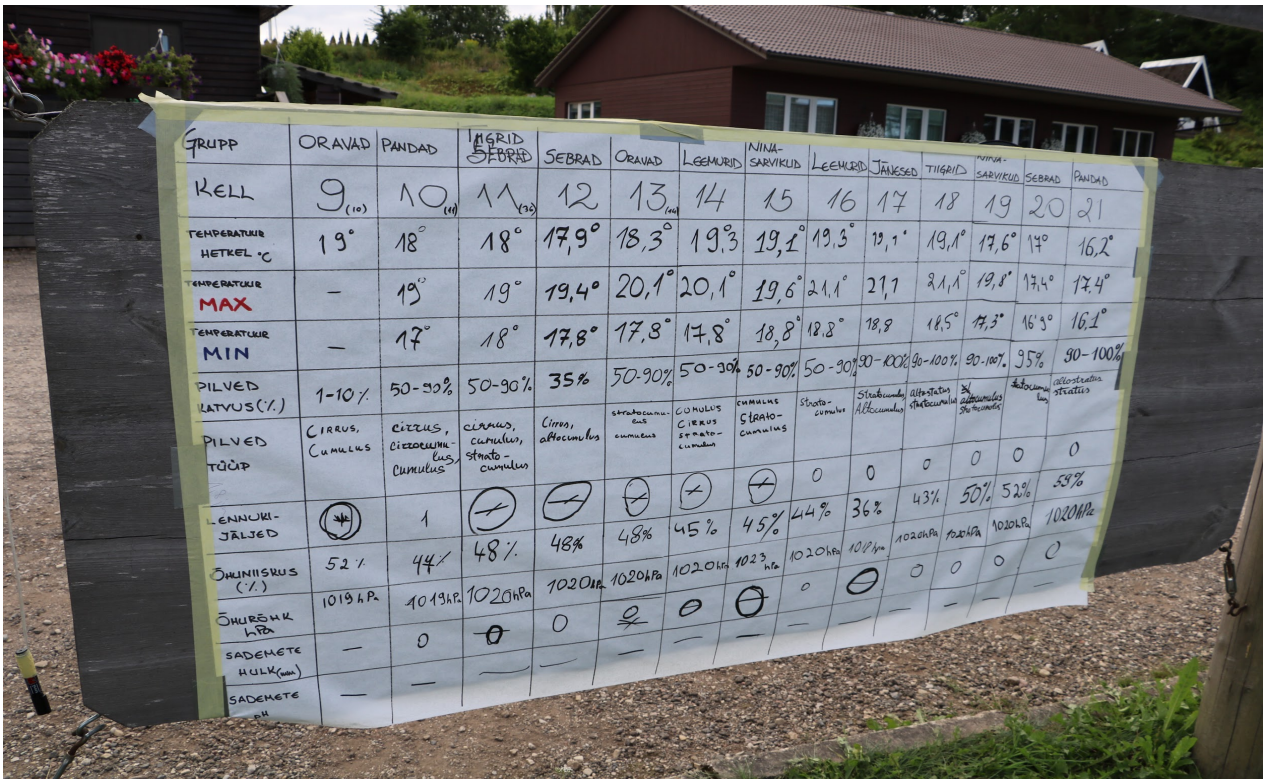

Figure 5. The weather observations in our field site.

Discussion

Lakes with different microhabitats, with a smoothly deepening shore, and with alkaline water have good preconditions for rich flora and fauna. Many Estonian aquatic plants need alkaline waters, therefore these types of lakes are usually with high species richness, and are mostly quite stable against negative human impact (e.g. pollution). Therefore, there can be rich communities of species, but many of them indicate eutrophic (nutrient rich) conditions.

The plants growing in our transect are mostly there because of the high human impact. The pond has been artificially modified and many plants cannot grow there,especially Bryophytes and Charophytes, who need clear water for photosynthesis.

The results show that the ecological status in our site was moderate. It is because there were very few indicator species that usually grow in areas with good quality and high alkalinity. The high species number comes from different artificial conditions, and there were many species that normally inhabit dry land, but for some reason were in water. One possible explanation is high water level.

The abundance of the negative indicator species Ceratophyllum was low. This was the only indicator that was assessed to have a “good status”. All the other quality indicators were assessed as “moderate” or even “poor”. This shows that the reality is very deviated from the natural shore macrophyte flora of this type of lake.

Conclusion

We found out that the number of plant species is higher in waters with higher alkalinity. Our transect was mostly artificial, and from that we can conclude that the number of good indicator species are declining in the areas of strong human impact.
The Cladophora (green macroalgae) species were very abundant, the plant community was moderate, and Chara species were totally missing. This is due to artificial shore and modifications of natural shoreline.
From the quality indicators table, *Chara* spp were missing, and *Bryophyta* abundance was very low. We should investigate the deeper areas in the Holiday Village bay to try to find Chara and Bryophyta species. They could be there, but we did not have suitable equipment to investigate deeper areas.
To investigate further in the future, we could choose other transects on the shore of Lake Viljandi and compare the data of these transects. We could also analyze the water chemistry data (mainly nutrients levels).
In conclusion, the ecological status of the plants at this transect was moderate because of negative human impact at the shore.

Figure 6. Fieldwork in Sammuli Holiday Village shoreline on 12 August 2020.

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Appendix 1. Plant species and their abundance on 12 August 2020 in research transect near Sammuli Holiday Village

Name in Estonian	Name in Latin	Name in English	Abundance
Kollane vesikupp	Nuphar lutea	Yellow water lilly	5
Järvekaisel	Schoenoplectus lacutris	Bulrush	5
Perekond tarn	Carex	Carex	5
Mürkputk	Cicuta virosa	Water hemlocks	4
Parkhein	Lycopus europaeus	lycopus/bugleweed	4
Maavits	Solanum dulcamara	Nightshade	4
Konnakilbukas	Hydrocharis morsus-ranae	Common frogbit	4
Kalmus	Acrus calamus	Calamus/sweet flag	4
Väikeseviljaline jõgitakjas	Sparganiun microcarpum	branched bur-reed	4
Liht-jõgitakjas	Sparganiun emersum	unbranched bur-reed	4
Vesioblikas	Rumex aquaticus	Western Doc	3
Vesi-kirburohi	Persicaria amphibia	longroot smartweed	3
Niitrohevetikas	Chlorophyta	green macroalgae	3
Vesikanep	Eupatorium cannabium	boneset	3
Jõgi-kõõlusleht	Sagittaria sagittifolia	arrowhead	3
Konnarohi	Alisma plantago-aquatica	Common water-plantain	3
Luigelill	Butomus umbellatus	Flowering rush	3
Ahtalehine hundinui	Typha angustifolia	Narrowleaf cattail	3

Valge vesiroos	Nymphaea alba	White Water-Lily	2
Räni-kardhein	Ceratophyllum demersum	Coontail	2
Angervaks	Filipendula ulmaria	Meadowsweet	2
Kuuskhein	Hippuris vulgaris	mare's-tail	2
Metsvits	Lysimachia vulgaris	Garden loosestrife	2
Kolmisruse	Bidens tripartita	three-lobe beggartick	2
Seaohakas	Cirsium oleraceum	cabbage thistle	2
Pilliroog	Phragmites australis	common reed	2
Metskõrkjas	Scirpus sylvaticus	Wood club-rush	2
Tihashein	Scutellaria sp.	Skullcaps	2
Hunditubakas	Hieracium sp.	Hawkweed	2
Lodumadar	Galium uliginosum	fen bedstraw	2
Käbihein	Prunella sp.	Heal-all	2
Kõrvenõges	Urtica dioica	Common Nettle	2
Suur teeleht	Plantago major	Broadleaf plantain	2
Hanijalg	Argentina anserina	Silverweed	2
Valge mesikas	Melilotus albus	White sweetclover	2
Paiseleht	Tussilago farfara	Coltsfoot	2
Aasosi	Equisetum pratense	meadow horsetail	1
Konnaosi	Equisetum fluviatile	water horsetail	1
Soopihl	Potentilla palustris	purple marshlocks	1
Heinputk	Angelica sylvestris	Wild Angelica	1
Soo-lõosilm	Myosotis scorpioides	water forget-me-not	1
Vesihernes	Utricularia vulgaris	common bladderwort	1
Loalised	Juncus spp.	Soft rush	1
Parthein	Glyceria fluitans	floating sweet-	1

		grass	
Soovõhk	Calla palustris	Water-arum	1
Väike lemmel	Lemna minor	Common Duckweed	1
Vesitähthein	Myosoton aquaticum	Giant Chickweed	1
Karvane pajulill	Epilobium hirsutum	Hairy willowherb	1
Väikeseõieline lemmalts	Impatiens parviflora	Small Balsam	1
Soo seahernes	Lathyrus palustris	marsh pea	1
Hiirehernes	Vicia cracca	Bird vetch	1
Naistepuna	Hypericum sp.	St. John's wort	1
Arujumikas	Centaurea jacea	Brown knapweed	1
Kukesaba	Lythrum salicaria	Purple loosestrife	1
Põdrakanep	Chamaenerion	Fireweed	1
Puju	Artemisia vulgaris	Mugwort	1