Soil erosion on the slope of the primeval valley of Lake Viljandi

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Abstract

The purpose of our research expedition was to investigate different soils in the primeval valley of Lake Viljandi. The research focus was supported by the aspect that the eroded soil was Estonian soil of the year in 2020. We conducted fieldwork during one day. Based on previous knowledge we set a hypothesis that the slope's lower area has a thinner layer of soil than the upper side.

We did two soil excavations and took samples from six auger holes on the 100m transect. The results show that slope's upper sides (research stations 3-5) have less soil horizons than the bottom of the valley. The hypothesis that "Slope's upper side has less horizons than the bottom of the valley," is partially true and vegetation does not reduce erosion.

Introduction and Review of Literature

Viljandi is located in the central part of Estonia. Our research was conducted on the southern bank of Lake Viljandi primeval valley. Lake Viljandi was formed after the last ice age as a result of continental ice erosion 12000 years ago. Its length is 4km and width is 450m in the widest spot, maximum depth is 11m (Laarmaa et al., 2019).

Figure 1. View over the investigation area from the upper area on the slope of the valley.

Our group studied erosion in the Viljandi primeval valley (Figure 1). We chose this topic because Estonian soil of the year 2020 was eroded soil (Novaator, 2019). Soil examination is important as it gives a lot of information about soil history. We used the MUC Field guide book to describe our measurement locations (GLOBE MUC Field Guide). We identified the soil by measuring the pH of the soil, studying its texture, we determined soil color, and examined the presence of carbonates in the soil.

Research Question and Hypothesis

Our research question was: "How does the location on the slope of the primeval valley affect soil erosion?" and hypotheses were:

1. Slope has a thinner layer of soil than the upper side of the valley.
2. Slope's upper side has less horizons than the bottom of the valley.
3. Vegetation reduces erosion.

Research Methods and Materials

We conducted our fieldwork by using GLOBE protocols and instruments recommended by GLOBE.
Data was collected from eight research stations on a 100m transect of which 2 were soil excavations and 6 auger holes (Figure 2 and 3).

The transect was chosen due to natural conditions in the area, and it was bounded by the lake from the beginning and a road from the end. The first site for excavation was made on flat ground and the second on the slope. Auger hole locations were chosen to have as equal distance between each other as possible, and where it was possible to drill (no rocks or big roots).

We used shovels, measure tape, soil drill, cups for soil, pH-meter, thermometers, soil color book, MUC Field Guide, smartphone microscope, clinometer, worksheets, camera, compass, sprayer, water and distilled water, vinegar and Vernier LabQuest2 for data collection.

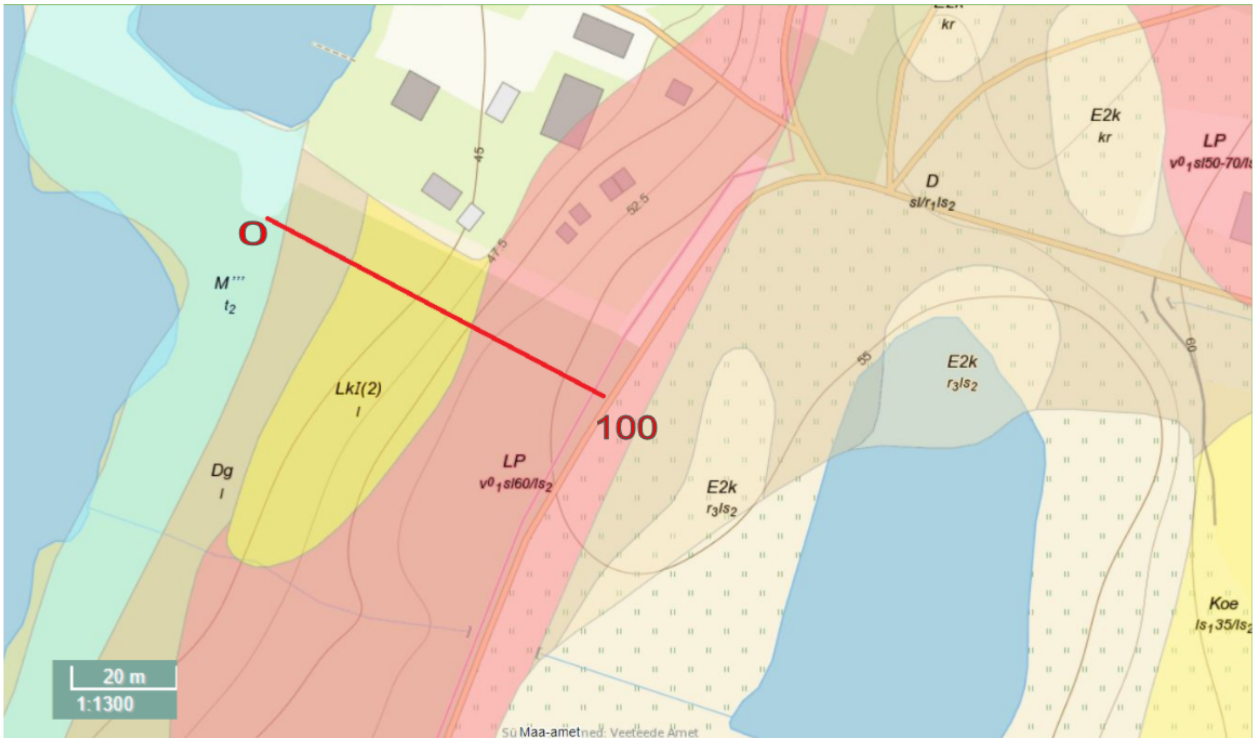

Figure 2. Investigation transect (red) (Estonian Land Board, 2021)

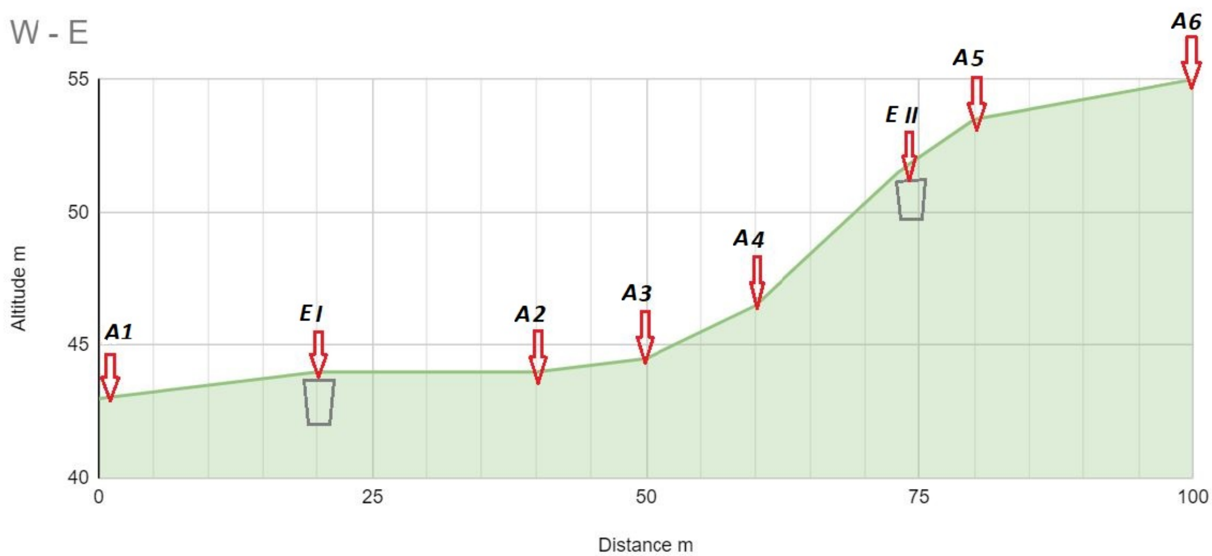

Figure 3. Profile of investigation transect including soil excavation and auger hole sites

Our research methods were soil excavations, which we did to identify the soil horizons. We described the soil profile, which was important information for our research. We made auger holes to find out the thickness of the humus horizon. We measured soil temperature (Figure 4) to draw conclusions from it later. We analyzed the soil in several different ways.

1. We studied the texture and structure of the soil (Figure 5).

2. We measured the pH of the soil.
3. We studied the soil color (Figure 6).
4. We checked for carbonates in the soil.
5. We also measured altitudes (Figure 7) and checked our measurement sites’ MUC-Codes.

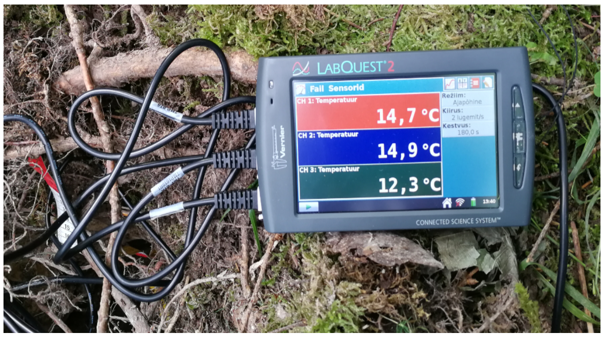

Figure 4. Measuring soil temperature

Figure 5. Determining soil texture

Figure 6. Determining soil color

Figure 7. Measuring an angle of a slope

Results

We collected data from eight sites (six auger holes and two excavations) on a 100m transect. On each site we identified soil layers, thickness of humus, the MUC code for land cover, and added other interesting aspects (Table 1).

Table 1. Results of measurements

Auger holes/Excavations	**A 1**	**E I**	**A 2**	**A 3**	**A 4**	**E II**	**A 5**	**A 6**
MUC	1221	1221	1221	1221	1221	1222	1222	1222
Soil layers	T+	O-A-B-T+	A-B+	A-B+	B+	A-B-C+	A-B+	A-B+
Thickness of humus layer cm	0	19	40	10	0	7	10	35
Other features	Lowland peat 70+ cm	B-lacustrine lime, many roots	Many rocks, roots	Many rocks, roots	Many rocks, roots, red color	Many rocks, roots, red color	No redness in A horizon	No redness in A horizon
Altitude (m)	43	44	44	44.5	46.5	51.5	53.5	55

First auger hole (A1)

First Auger hole (Auger hole 1 - A1 on Figure 3) was made 0m from the starting point of the transect (Figure 3 and 8). A1 is close to the lake and the land cover type was forest. We identified 70cm peat (Figure 16).

Figure 8. First auger hole (A1)

First soil excavation (EI)

The first soil excavation was made at 20m (Excavation I - E I) (Figure 9). MUC code 1221 was identified for land cover. The excavation was made on a flat surface and it consisted of four horizons: Decay-3cm, humus-19cm, lacustrine lime -43cm and peat -28+cm (Figure 16). We did not identify rocks, but there were many roots. The texture of the humus was sandy clay, the structure of the humus is gritty (Table 1). We used vinegar to determine carbonates in the lacustrine lime layer/horizon. We also measured temperature at the depth of 5cm (14.7C), 10cm (14.9C), 100cm (12.3C) (Figure 2) in soil excavation sites.

Figure 9. First soil excavation (E I)

Second auger hole (A2)

The second auger hole (A2) was drilled at 40 m on the transect (Figure 10).
We identified 40cm of humus (Figure 16) and we could not drill deeper because there were stones. The site was on a flat surface and the forest was denser than 20m prior.

Figure 10. Second auger hole (A2)

Third auger hole (A3)

The third auger hole (A3) was drilled at 50m on the transect (Figure 11). We identified 10 cm of humus (Figure 16). The soil color was slightly lighter compared to A2. The site was at the foot of the slope (Figure 7), the density of the forest canopy was the same as at the previous site.

Figure 11. Third auger hole (A3)

Fourth auger hole (A4)

The fourth auger hole (A4) was drilled at 60m on the transect (Figure 12). We identified no humus, the upper horizon/layer was reddish (Table 1). The site was located on a steep slope, and land cover was forest (Figure 12), canopy cover was the highest.

Figure 12. Fourth auger hole (A4)

Second soil excavation (E II)

A second excavation (E II) was made at 73 meters (Figure 13). We identified three layers: Humus-7cm, subsoil-38cm and C-Horisont-37 + cm (Figure 16). The color of the soil was red. We found plenty of rocks and roots (Table 1). Compared to the previous excavation (EI) we identified some differences: the soil temperature was warmer (5cm-14.5C, 10cm-14.8C, 60cm-13.9C), the site was located on a steep slope, the MUC code was 1222 and the soil texture was clayey sand.

Figure 13. Second soil excavation (E II)

Fifth auger hole (A5)

The fifth auger (A5) was drilled at 80 m on the transect (Figure 14). We identified 10cm of humus. It could be seen that the dark humus gradually became brighter. Surface of the site was a flat slope and the canopy cover was sparser compared to previous sites (Figure 7).

Figure 14. Fifth auger hole (A5)

Sixth auger hole (A6)

The sixth auger hole (A6) (Figure 15) was made at 100 m on the transect (Figure 1). We identified 35 cm of dark humus. The site was located on a flat surface, the forest was sparse.

Figure 15. Sixth auger hole (A6)

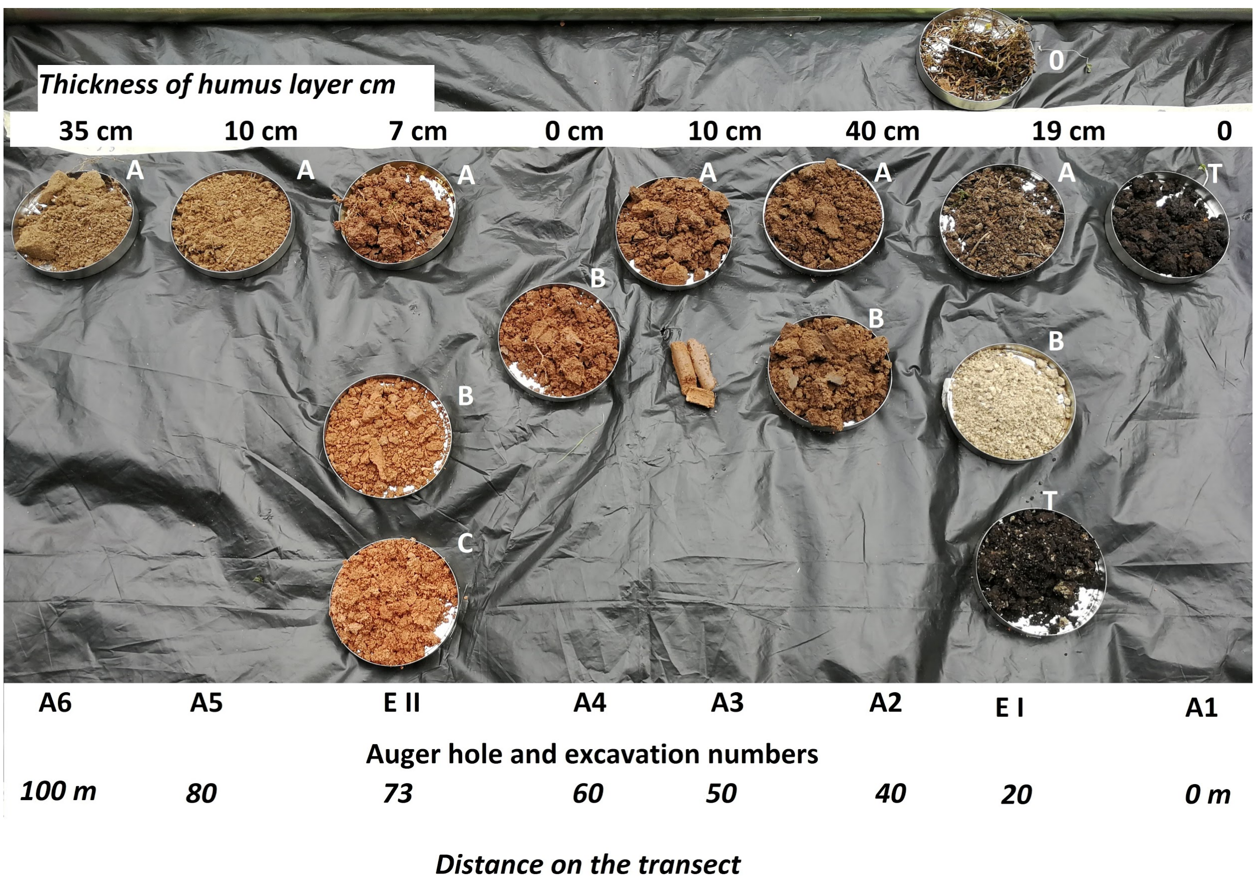

Figure 16. Soil samples in the order of excavations/auger holes and horizons and their humus horizon thickness (cm).

Discussion

The first auger hole (A1) was close to the lake, which explains why we only identified lowland peat. The excavation (EI) which was made 20m after gave some surprising results: we identified a decay and humus horizon, but beneath these was a layer of lacustrine lime with considerable thickness and we found peat under it. We assume it had once been the bottom of the lake. We used vinegar to identify the presence of carbonates in lacustrine lime and we confirmed the presence of carbonates.

In the 40m auger hole(A2) all the peat and lacustrine lime had disappeared, which is also logical, as the location is farther from the lake. In this auger hole we identified a 40cm thick layer of humus, which had eroded from the slope, because the place was directly below the slope. The dark humus layer found there was replaced by a much lighter one 10m later. The sparse forest at the beginning of the research transect had also been replaced by a rather dense forest. In the 50 m auger hole(A3) the humus horizon was only 10 cm thick. We thought the next auger hole would have more eroded soil.

In the next auger hole(A4), which was 10m higher above sea level, it turned out that all the humus had been removed due to erosion. The reddish color of the lower horizons was revealed. The fact that we were on a much steeper slope than at previous sites probably had an impact on soil compositions. We planned to make a soil excavation at 75m, but due to the abundance of stones, we did it at 73 meters (EII). The eroded soil at the site was not very surprising as we were still on the slope and identified 7cm of humus.

The biggest surprise of the whole research process was the auger hole drilled at 80m (A5), where we identified that the upper layers had eroded and had been completely replaced by brown agricultural soil, the humus horizon was 10 cm thick.

The reason behind it was probably the fact that the 80m auger hole was already on the flat surface at the top of the slope. The last auger hole(A6) we made 20m after did not offer any surprises, the color of soil was a bit lighter and the humus horizon was thicker (35 cm) compared to the previous site.

Conclusion

Our research question was "How does the location on the slope of the primeval valley affect soil erosion?". In order to find the answer to the question, we made 6 auger holes and 2 soil excavations on the 100m transect, took soil samples and later analyzed the results. The obtained results confirm that the humus layer in the valley bank is thinner than on the flat land due to erosion. The soil changed a lot throughout the 100m transect.

We set up three hypotheses:
1. "Slope has a thinner layer of soil than the upper side of the valley." Changes in the thickness of the soil humus horizon indicated that the hypothesis was correct. The thickest layer of humus was in auger hole 2, which was at the bottom part of the slope, but on the steep slope, in auger hole 4, there was no humus at all.

2. "Slope's upper side has less horizons than the bottom of the valley." The hypothesis was partially correct. Auger hole 1 consisted of 70cm of well-decomposed peat only. Excavation 2 had the most horizons (4), there was a layer of lacustrine lime that was not found at other sites.

3. "Vegetation reduces erosion." To check this hypothesis, we compared soil samples with MUC codes determined at auger holes and excavation sites (Table 1). It turned out that the hypothesis is not true. Roots have not been able to completely prevent erosion. This was shown in the steepest part of the slope by the absence of a humus horizon (A4) and the thick layer of humus accumulated at the foot of the slope (A2), which had been washed from the top to the bottom.

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