GLOBE Regional Learning Expedition

Soil samples from the bank of Emajõgi and the park of Ülejõe

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Abstract

The GLOBE Estonia Learning Expedition 2023 has, among other subjects, embarked on a profound exploration of the intricate world beneath our feet—the soil. This report offers an extensive overview of the expedition's objectives, research inquiries, methods, discoveries, and their profound repercussions. Spearheaded by our dedicated team of students, led by the seasoned instructor Eelika Kiil (University of Tartu), and supported by Regina Univer, this journey of discovery was placed in various locations, from the Emajõgi river bank to the park of Ülejõe. This research investigates the influence of environmental factors on soil properties in specific geographical areas. Through meticulous data collection and analysis, our study supports three hypotheses. The results reveal variations in soil temperature, moisture levels, and pH across different sites, providing valuable insights into the complex interplay between ecological elements and soil characteristics.

"How can I stand on the ground every day and not feel its power? How can I live my life stepping on this stuff and not wonder at it?" (Logan, 2007).

Keywords: Estonia, soil conditions, environmental impact, urban soils, ecological interplay

Research Question and Hypothesis

Soil is a complex ecosystem that plays a vital role in our environment. There are a few key characteristics of soil that significantly influence its properties.

1. The soil beneath trees exhibits a lower temperature than the surrounding areas.

The first hypothesis posits that the soil beneath trees exhibits a lower temperature compared to the surrounding areas. This conjecture is grounded in understanding how trees influence their immediate environment. Trees provide shade through their canopy, blocking a significant portion of the incoming solar radiation. As a result, the area under the trees receives reduced direct sunlight, which in turn leads to lower soil temperatures. Additionally, the presence of tree roots can further contribute to soil cooling by absorbing moisture and nutrients, a process known as evapotranspiration. This hypothesis is rooted in the observation that shaded areas tend to feel cooler, and we suspect this phenomenon extends to the soil beneath trees.

2. Moisture levels near the river are higher than in the areas adjacent to the road.

The second hypothesis suggests that moisture levels in the vicinity of the river are higher in comparison to the areas adjacent to the road. This supposition is based on our understanding of hydrological systems and landscape features. Rivers are natural sources of moisture and provide a continuous supply of water to the surrounding soil through processes such as groundwater recharge and capillary rise. In contrast, roads are typically constructed with asphalt or concrete, which are impermeable and do not support water retention. Furthermore, road construction often involves drainage systems that efficiently remove excess water. Consequently, we anticipate that moisture levels will be elevated near the river due to its proximity to a consistent water source. At the same time the road area is expected to have lower soil moisture levels.

3. The soil adjacent to the road will contain traces of human activity or anthropogenic contaminants.

The third hypothesis posits that the soil adjacent to the road will contain traces of human activity or anthropogenic contaminants. This hypothesis stems from our understanding of the role of roads as transportation routes and their interactions with human activities. Roads are commonly used for vehicular traffic, which can release pollutants such as oil, fuel, and debris onto the road surface. Over time, these contaminants can accumulate in the soil adjacent to the road due to runoff and deposition. Additionally, road maintenance activities, such as salting during winter, may introduce chemicals into the soil. Therefore, we suspect that the soil near the road may exhibit discernible signs of human activity or pollution, in contrast to more remote areas where such activity is less pronounced. Human activity may mix up the soils, so the type of the soil could be hard to define.

These hypotheses are based on our observations and knowledge of ecological and environmental processes. Testing and validating these hypotheses through empirical data collection and analysis will help us better understand the specific conditions and interactions in the study area.

Introduction and literature review

Soil research plays a vital role in addressing many global challenges, making it an indispensable field of scientific inquiry. The study of soils in urban environments is quite a new research topic. In 1963, Zemlyanitskiy was the first scientist to use the term “urban soil”. Since then, the topic has been studied more, but the problem is that there is still not enough research done to understand urban soils. It has mostly been found that soils in the urban environment contain traces of human activity and are more polluted than the soils in rural areas. “Each soil has had its own history. Like a river, a mountain, a forest, or any natural thing, its present condition is due to the influences of many things and events of the past.” (Kellogg, 1956).

As the foundation of terrestrial ecosystems, soils are essential for supporting life and fostering biodiversity. “We must come to understand our past, our history, in terms of the soil and water and forests and grasses that have made it what it is.” (Vogt, 1948). We study the chemical composition, chemical properties, and chemical reactions that occur in soils or are related to environmental issues and soil quality. Understanding soil composition, structure, and function is crucial for sustainable planting, as it directly influences growth and it also influences construction work, as it is the foundation of all buildings. And Ed Begley Jr has said “I saw all the people hustling early in the morning to go into the factories and the stores and the office buildings, to do their job, to get their check. But ultimately it’s not office buildings or jobs that give us our checks. It’s the soil. The soil is what gives us the real income that supports us all.”

Materials and methods

In this meticulously detailed section, we unveil the inner workings of our research methods:

- comprehensive explanations of each protocol employed for data collection, including soil temperature measurements, characterization, moisture analysis, and pH assessment,
- an exhaustive catalog of the equipment that accompanied us on our soil odyssey — comprising soil drills, thermometers, pH indicator strips, and a host of other indispensable tools,
- detailed descriptions of the study sites, replete with precise coordinates, mapping out our journey from the River Emajõgi and the road to the serene fields and the protective canopy of trees.

To do our measurements and research correctly, we used GLOBE pedosphere protocols: soil temperature, soil characterization, soil moisture and soil pH. We followed them very precisely with very few minor exceptions.

We used soil drills for drilling holes and getting the soil out to examine it. For temperature we used soil thermometers, and to measure pH we used indicator strips. To identify what soil we discovered, we used the GLOBE soil color book, to measure the weight and later to calculate the moisture. We investigated the soil because we wanted to know the moisture of the soil. We used airtight metal cups to collect the soil and scale for weighing the soil and transported our soil samples to the dryer, where the soil was overnight, after they came out of the dryer we weighted them again, that's how we found out the soil moisture content, to measure our drilled hole and the depth of the horizons.. We used vinegar to detect the presence of carbonate particles and by the intensity of the reaction we roughly estimated the amount of free carbonates in our soil samples. Paper and plastic cups were used to observe the soils. We used plastic film to observe the collected soil samples on top of it and to see the differences in color and texture.

Study sites

We had 4 study sites. The location of the sites is shown in Figure 1. We named the sites after the locations from which we took the samples - river Emajõgi, field, road, and trees.

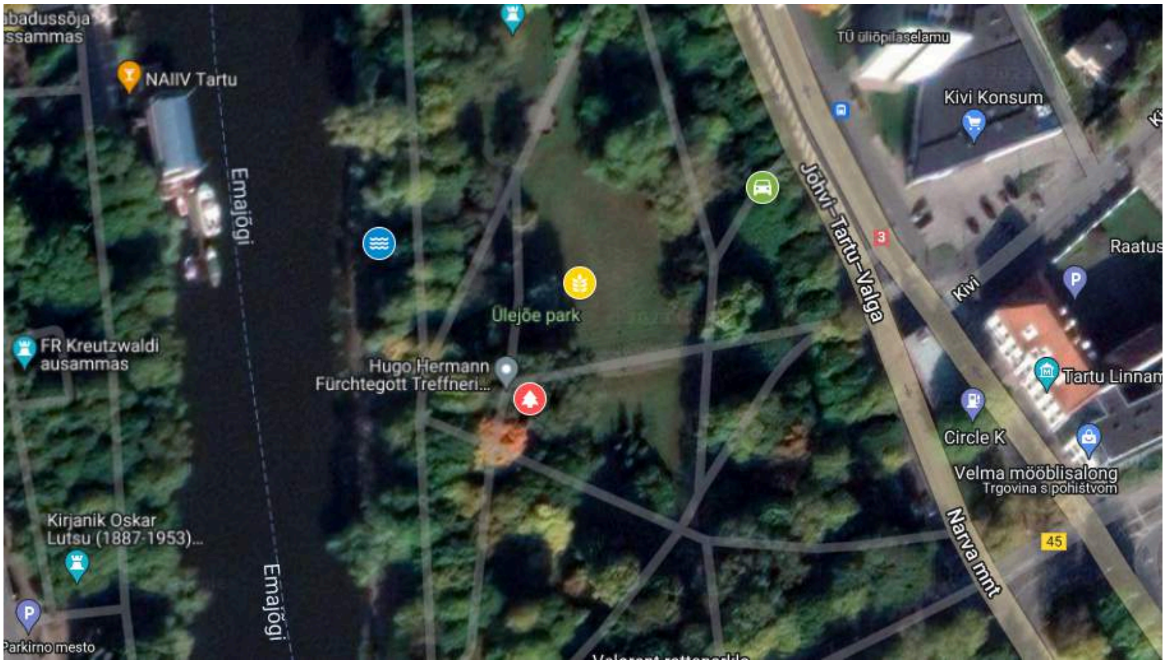

Figure 1. Map showing our 4 study sites. Green is our study site road, blue is our study site river Emajõgi, red is our study site trees, yellow is our study site field.

Detailed descriptions of each site

1. RIVER EMAJÕGI - The first site was at the Emajõgi river at the coordinates X: 58.382242° Y: 26.726133°, about 30 meters above sea level and about 2 meters from the river (Figure 2). The soil was clayey and flooded. The soil color was 7,5YR 2,5/1, and the structure was loose (Figure 3).

Figure 2. The location of the river Emajõgi site.

Figure 3. The river Emajõgi site's soil horizons.

2. ROAD - The second site was by the road at the coordinates X: 58.382366°Y: 26.727741°, approximately 35 meters above sea level and 5 meters from the road (Figure 4). There were trees around the road. We could also see some stones on the ground. The color of the first soil layer was 10YR 2/2, and for the second layer 10YR 3/3, the soil structure was loose (Figure 5). We couldn't define the colors by the color book because the soil was too mixed up with a very loose structure (Figure 5).

Figure 4. The location of the road site.

Figure 5. The road site’s soil horizons.

3. FIELD - The third site was in the field with coordinates X: 58.382156° Y: 26.726975° and an altitude of about 55 meters (Figure 6). The field was overgrown with tall grass (approx. 0.5-1 m). We could also see a few trees on the edge of the field. We couldn’t define the colors by the color book because the soil was too mixed up with a very loose structure (Figure 7).

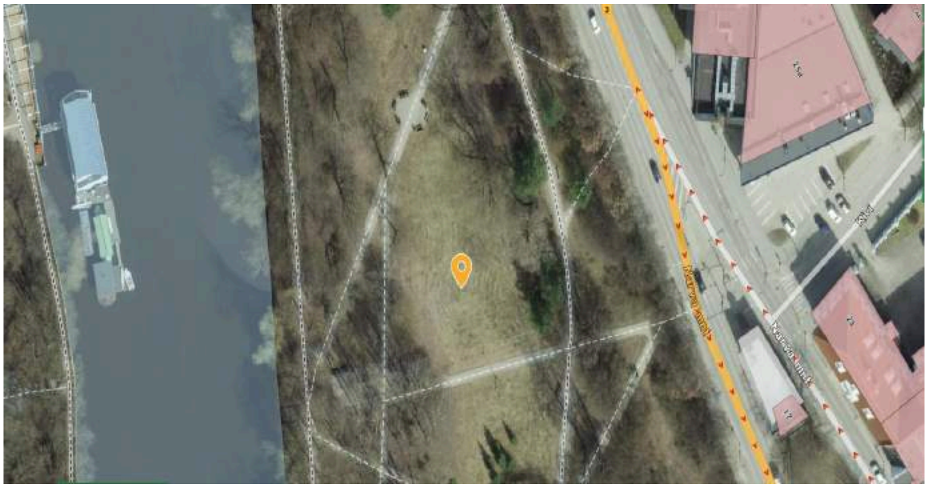

Figure 6. The location of the field site.

Figure 7. The field site soil horizons.

4. TREES - The fourth location was at *Fagus sylvatica* trees with coordinates X: 58.381898° Y: 26.726764° and an altitude of about 55 meters (Figure 8). The color of soil layers in descending order was 10YR 5/4; 10YR 4/3; 10YR 2/1; 7,5YR 2,5M; 7,5YR 2,5/1, and the structure accordingly was loose, then friable and lastly firm. We concluded that there has not been practically any human activity, because the layers were not mixed at all and we could dig very deep.

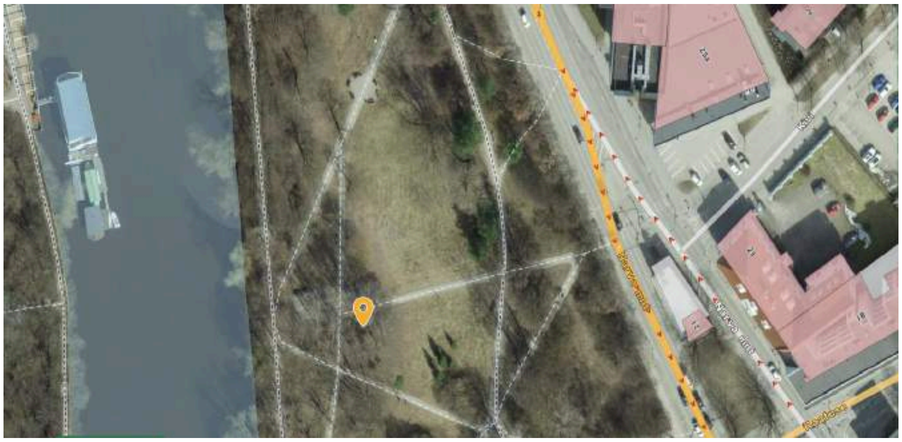

Figure 8. The tree site.

Figure 9. Trees site's soil horizons.

Results

Our results, curated in tabular and graphical forms, shed light on soil characteristics, temperature dynamics, and moisture variations. These comprehensive findings, complemented by statistical tables, graphs and keen observations, offer a multifaceted view of the world beneath our feet.

Table 1. Detailed comparison of soil properties in four study sites.

	Horizon number	*Date*	*Top depth (cm)*	*Bottom depth (cm)*	*Moisture*	*Structure*	*Main color*	*Consistence*	*Texture*	*Roots*	*Rock*	*Carbonates*	*pH*
ROAD	1	8.08.23	-	-	dry	granular	10YR 2/2	loose	clay sand	few	few	slight	5
	2	8.08.23	-	-	dry	granular	10YR 3/3	loose	Sand	few	few	very slight	5.5
FIELD	1	8.08.23	0	30	moist	granular	-	loose	sand clay	few	some	very strong	6
	2	8.08.23	30	37	moist	granular	-	loose	sand clay	none	few	very strong	6
RIVER	1	8.08.23	10	31	wet	granular	7.5YR 2.5/1	loose	clay sand	few	many	strong	7
TREES	1	8.08.23	0	8	moist	granular	7.5YR 2.5/2	loose	sand clay	many	few	slight	5
	2	8.08.23	8	19	moist	granular	7.5YR 2.5/1	loose	clay sand	few	none	none	5
	3	8.08.23	19	47	moist	granular	10YR 2/1	loose	clay sand	none	none	none	5
	4	8.08.23	47	65	less moist	granular	10YR 5/4	firable	sand clay	none	few	very few	4.5
	5	8.08.23	65	116	less moist	granular	10YR 4/3	firm	sand clay	none	none	none	5

Here is a brief description of each characteristic in Table 1:

1) Horizon number: This refers to the different layers of soil. Each layer has distinct properties that can tell us a lot about the soil's formation, qualities and composition.
2) Top and bottom depth: These values indicate the depth of the soil at the top and bottom of each horizon. This can give us an idea of the soil's structure and how nutrients and water move through it.
3) Moisture: This is the amount of water present in the soil. Soil moisture is crucial for plant growth as it affects the availability of nutrients.
4) Color: The color of the soil can provide clues about its mineral content and organic matter. For example, dark soils tend to be rich in organic matter.

5) Consistency: This refers to how the soil feels and how well it holds together. It can affect how easily roots can penetrate the soil and how well the soil can retain water.
6) Texture: This is determined by the size of the soil particles. Soil texture affects water retention, nutrient availability, and other physical properties.
7) Roots: The presence of plant roots in the soil can indicate the soil's fertility and structure.
8) Rocks: This presents how many rocks we found in the soil.
9) Free carbonates: The presence of calcium carbonate in the soil can affect its pH and nutrient availability.
10) pH: This measures the acidity or alkalinity of the soil. Soil pH can influence the availability of nutrients to plants.

Comparing these properties across different locations can help us understand how soil characteristics vary and how these variations can impact plant growth and other ecological processes. For example, soils with high moisture and nutrient content are generally more conducive to plant growth. Similarly, soils with a neutral pH are typically more fertile because most nutrients are readily available in this pH range. However, the optimal soil properties can vary depending on the specific needs of the plants or crops being grown.

Soil temperature

Figure 10 shows the temperature variation throughout different sites and depths. The highest temperatures that were measured were located at the river Emajõgi study site: air temperature 22.5℃, soil temperature at 5 cm 20.8℃ and soil temperature at 10 cm 21.8℃. The lowest air temperature was measured at the trees study site, and it was 20℃. The lowest soil temperature was measured at the road study site at 5 cm was 18℃, and at 10 cm, it was 13℃.

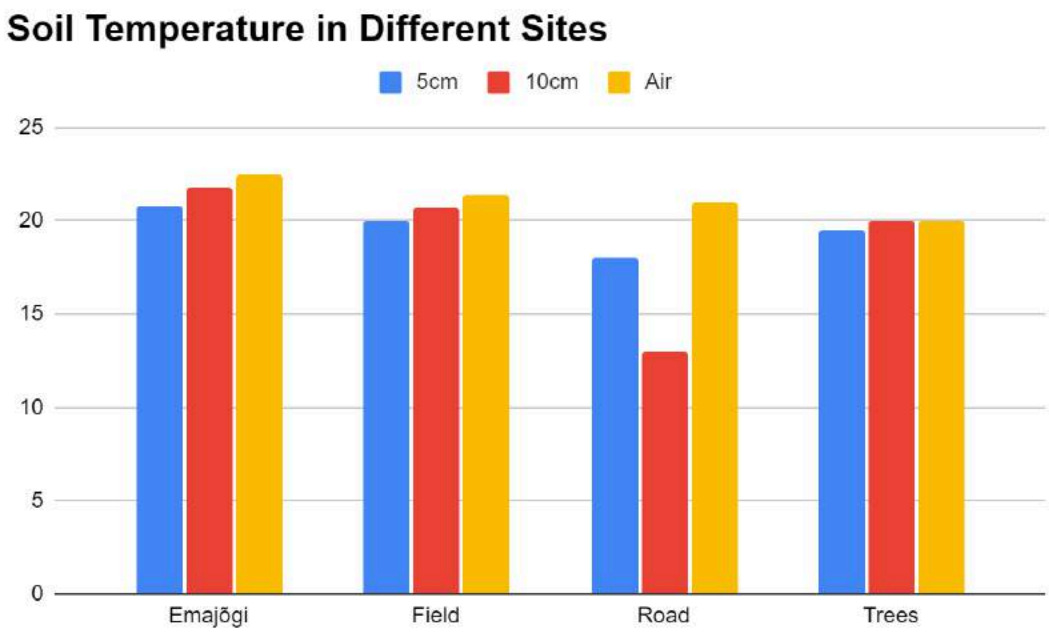

Figure 10. The temperature changes at different sites.

<u>Soil moisture</u>

Figure 11 shows the soil moisture content in different sites and how it varies. The minimum soil moisture was 3% at 30 cm depth at the field study site. The maximum soil moisture was 23% at 30 cm depth at the Emajõgi study site. When the depth increases, the soil moisture typically decreases, except at the river site, where the groundwater level was measured at a depth of 12 cm and because of that, the soil had more moisture. We can also see that the soil at the field study site was drier than at other sites, and we think it is because the plants there had absorbed most of the moisture, and the site was also directly in the sun.

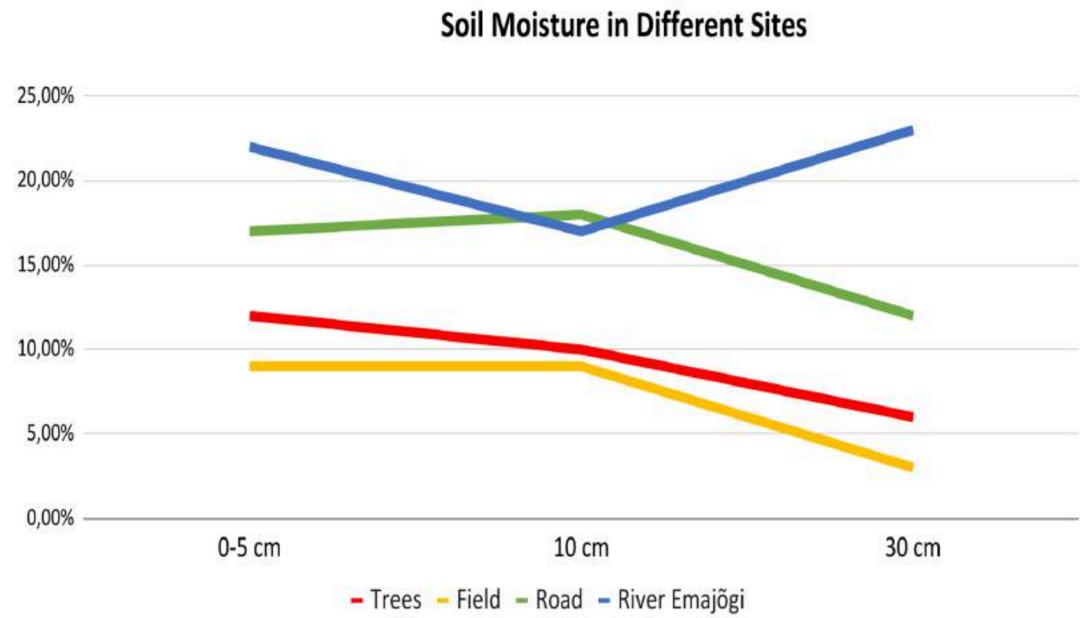

Figure 11. The soil moisture in different sites.

Discussion and Conclusion

Our soil research endeavors were conducted with meticulous attention to detail and adherence to established protocols, particularly the GLOBE protocols for soil temperature, characterization, moisture, and pH measurements. Despite minor exceptions, our adherence to protocols and the rigorous application of various methodologies strengthened the reliability and validity of our research outcomes.

The hypotheses presented here delve into the multifaceted nature of soil, exploring its temperature variations, moisture levels, and susceptibility to anthropogenic influences. The first hypothesis highlights the potential cooling effect of tree canopies, attributing lower soil temperatures beneath trees to reduced direct sunlight and the moisture-absorbing properties of tree roots. The second hypothesis underscores the significance of hydrological systems, positing higher moisture levels near rivers compared to impermeable road areas. Lastly, the third hypothesis anticipates discernible signs of human activity and contaminants in soil adjacent to roads, driven by vehicular traffic and maintenance practices.

These hypotheses are not merely speculative; they draw on a foundation of ecological and environmental knowledge, observations, and logical reasoning. However, to validate these conjectures and enhance our understanding of the study area, empirical data collection and analysis are imperative.

Precise measurements were achieved through the use of specialized tools and detailed observation which all contributed to the reliability of our findings.

We also found out during our expedition, if our hypotheses were true or not. Our first hypothesis was that the soil beneath trees exhibits a lower temperature than the surrounding areas. This hypothesis was partially true. The soil beneath the trees was colder than the soil beside the river Emajõgi and the field, but the lowest soil temperature was actually next to the road. The second hypothesis was that the moisture levels near the river are higher than in the areas adjacent to the road. This hypothesis was partially true. The soil moisture was higher by the road only at the depth of 10 cm. Other moisture results were indeed higher near the river. Our third hypothesis was that the soil adjacent to the road will contain traces of human activity or anthropogenic contaminants. This hypothesis was true and during our research we found that the field site also had traces of human activity. Because of human activity on these sites, the soil horizons were mixed and it was really hard or even impossible to define the colors by the color book.

In summary, our research has the potential to contribute both globally and locally by informing sustainable practices, supporting environmental conservation, and addressing challenges related to agriculture and land management.

In a global context, our research on soil characteristics holds significant implications for broader scientific endeavors and global initiatives. The findings contribute to understanding biodiversity and ecosystem health worldwide, aiding the integration of knowledge into global models.

On a local scale, our research directly influences the regions studied, offering valuable insights for land use planning and plant selection, for example tulips can not survive beneath trees because there is not enough sunlight. Local authorities and land managers can utilize our findings to inform decisions that optimize land use for agriculture, forestry, or conservation.

The information on soil health and biodiversity in our research can guide local conservation efforts, prioritizing the protection and restoration of areas with unique or sensitive soil characteristics, like there was on our road and field study sites. Sharing these findings with relevant lawmakers, and the scientific community will amplify the impact of our research on a broader scale.

We hope that next time, we will explore more sites and collect more data, dig a wider hole with a shovel so we could see the horizons more clearly and mark the layers better. Overall, we are very satisfied with our research and results, we hope that our work will help the environment in the future.

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