NATURAL ENERGY AROUND US
A study of movement of energy in natural ecosystems surrounding Sammuli Holiday Village

Sofia Bernadska[a], Ilona Fjodorova[a], Markus Lambing[a], Kerttu Vipper[b], Teele Piirimäe[b], Maret Mesi[b]

Mentors: Ülle Kikas
Riina Hopp
Tatjana Sedova

Narva Kesklinna High School[a], Rakvere Secondary School of Science[b]

Estonia
2021

Table of Contents

Abstract

Energy surrounds us. It is able to persist inside animate and inanimate objects. This report resumes an expedition of GLOBE students, related to the study of energy accumulated and moving in nature. This topic is important as it allows us to learn more about possible renewable energy sources. Mankind faced this problem when it realized that the energy sources that we now use are exhaustive. At the moment, humanity requires a huge amount of energy consumed for daily and extremely important needs.

The study was performed during the GLOBE Estonia Learning Expedition in August 2021. Members of our team were GLOBE students of two Estonian schools. Our team decided to study in detail the amount of energy around us during expedition day. We have collected data about biomass and thermal energy in natural ecosystems, performed data analysis and summarised the obtained measurement results.

We've discovered that the energy stored in trees per a square meter of forest is about 30-50 times higher than the energy stored in grass biomass growing in a square meter. A tree can store more energy in itself than a grass, since trees live longer than herbs.
We've also discovered that different spheres of the Earth have different temperatures. Distribution of higher and lower temperatures depended on site characteristics, time of day and atmospheric conditions. Therefore, heat can move between soil, ground cover and air in various directions.

1. Introduction

Earth spheres are connected with energy and water cycles. Energy enters ecosystems during photosynthesis and is dissipated mainly in the form of heat when organisms use it for their livelihoods. Due to the continuous loss of energy, it is necessary that it also continuously enters the ecosystem in the form of energy from sunlight. The concept of “energy” combines all the phenomena of nature into one whole, and is a general characteristic of the state of physical bodies and physical fields. Due to the existence of the law of conservation of energy, the concept of “energy” combines all natural phenomena. **[1]**

This study was performed in August 2020 during Estonian GLOBE Learning Expedition.
The expedition took place near the City of Viljandi at the Sammuli Holiday Village and lasted 4 days. The first day was devoted to getting to know the group members, other students, teachers and camp organizers. On the second day, the training sessions for GLOBE measurements and preparations for the expedition took place. The entire third day was devoted to the expedition. We took an expedition journey, where we determined types of clouds and landscapes, collected fresh green and dry cut grass, measured water flow in the river, wind speed, circumferences of trees, and temperatures of air, surface and soil.
In the afternoon, our team created a presentation about expedition results and prepared a speech for the next day.

This work is divided into two parts: theoretical and practical. The theoretical part covers topics related to energy in various natural sources. The practical part includes the analysis of the expedition results, and conclusions about energy reservoirs and flows in the natural environment near the City of Viljandi, Estonia.
.

2. Research Questions and Hypotheses

Before starting our research in expedition, we discussed with the whole group how our research work will go, what interests us, how we can conduct our expedition and what we will study. Also, together with the leaders, we drew up a plan for studying the environment around Sammuli. We set ourselves certain questions, based on which we carried out the points of our plan. We decided to collect data to answer the following research questions and their sub-questions:

How much biomass energy is stored in forest and herbaceous ecosystems?

● What is the biomass of trees in a forest area of 30x30 meters?
● What is the biomass of trees in a boggy forest area of 15x15 meters?
● What is the biomass of fresh grass in an area of 50x50 centimeters?
● What is the biomass of straws on the harvested oat field in an area of 50x50 centimeters?

How thermal energy moves between spheres?

● Which of the Earth spheres has the highest temperature currently: soil, surface cover, air, sky or water?
●What are the current weather conditions - cloud types, cloud cover and air humidity - that we observe during the expedition?

Also, we formed hypotheses, which we would like to confirm or refute.
● The trees' biomass has higher biomass energy per m^2 than the grass biomass.
● The soil temperatures are lower than temperatures of other spheres.
● There is little water flow energy in Raudna river´s waterflow.

Following these questions, we used GPS, map, and satellite image, and moved from one point to another for collecting data.

3. Introduction and Review of Literature

Energy is in everything. Humanity uses the processed under the standards required energy to the numerous devices for the food processing, to perform certain functions, with which a person himself cannot cope with, to heat the world's population, in need thereof. The nutrients we get from food also contain energy. We spend it during games, exercise or some work.Energy provides us with the ability to work. **[1]**

Nature has huge reserves of energy. It is exposed to sunlight, winds and river water. Energy is stored in wood, gas, oil and coal deposits, and is released during the combustion of these substances. The electricity we use at home in Estonia is produced by burning oil shale or in hydroelectric power plants.

All energy sources can be divided into renewable and non-renewable. Renewable energy sources are characterized by natural replenishment in relatively short periods of time. Due to this, they have a constant power. Non-renewable energy sources are characterized by the impossibility of their replenishment after use. **[4]**

Non-renewable energy sources include natural sources that are formed or recovered much more slowly than consumed: coal, oil, natural gas, peat, nuclear fuel. **[5]**

Renewable energy sources are not limited. They regenerate naturally in a short period of time. **[6]**

Nevertheless, it became interesting how exactly the process of energy transfer from one sphere to another takes place, how it is stored and accumulated, how much they differ, how they affect the spheres where they are. **[1]**

Our aim was to measure and study energy in different spheres, namely in water, in the air, in the atmosphere, in the soil and on the surface, and to understand its effect on these spheres. In addition, we were interested in what energy can be recognized and measured in the environment, how does heat energy flow between the soil, soil cover, air and the upper atmosphere, and how much biomass energy is stored in trees and grass.

The expediency in this study lies in the understanding that the use of these energy resources is not an innovation, and some of them are not relevant and problematic. Humanity every minute needs to be processed into a possible form for consumption and use of energy for its own needs.

Better understanding of natural energy flows and accumulation areas would help people to build up new technologies for management and sustainable use of natural energy resources.

4. Background information

4.1. Solar energy

The main source of energy on Earth is the Sun. Without solar heat and light, life on Earth would be impossible. Coal, oil and gas are formed from the remains of ancient organisms, so the energy stored in them is also the energy of the Sun. It is released during the combustion of non-renewable fuel material. Solar energy is converted into electricity, so-called solar electricity. It can be used everywhere: in calculators and cars, water heaters, fountains, buildings, power plants and satellites. All energy sources (e.g. wind, water, coal, oil, natural gas) depend on the Sun. That is why many countries around the world are building solar power plants.

Solar energy does not pollute the environment, does not emit harmful gases, it can not be spilled like oil. **[2]** Every person who has access to open, well-lit by the sun countryside is able, without paying any taxes, to take the opportunity to collect and recycle solar energy using specific devices.

The method of direct conversion of solar radiation into electricity is, firstly, the most convenient for the consumer, because it produces the most used type of energy, and secondly, this method is considered environmentally friendly means of obtaining electricity unlike others that use fossil fuels, nuclear raw materials or hydro resources. The basis of a semiconductor solar cell is a semiconductor wafer with a p-n junction. His work is based on the phenomenon of the photo effect, discovered in the last century by G. Hertz and studied by OG Stoletov. The theory of the photo effect was created by A. Einstein in 1905, for which he was awarded the Nobel Prize. The essence of the effect is that quanta of sunlight with energy greater than the band gap of the semiconductor are absorbed by the semiconductor and create pairs of current carriers: electrons in the conduction band and holes in the valence band **[7].**

4.2.Wind energy

Due to the ability of a person, on the basis of observations, to adopt the abilities of animate and inanimate objects, inventions were created that could make human life easier. In ancient Egypt, wind turbines were used to lift water and grind grain. Windmills with wings and sails made of fabric were the first to be built by ancient Persians.

Wind proved to be an excellent source of energy. Wind energy is very powerful. It can be obtained without polluting the environment: the production of energy from wind does not lead to emissions of harmful substances into the atmosphere or the formation of waste. But in the wind there are significant disadvantages. The wind is unpredictable because it often changes direction. Sometimes it subsides even in the windiest parts of the globe, and sometimes reaches such a strength, breaking wind turbines. The rotating turbine blades pose a potential hazard to some species of living organisms. According to statistics, the blades of each installed turbine are a prerequisite for the death of at least 4 birds per year. Also, the noise produced by "wind turbines" can cause disturbance to both animals and people living nearby. **[8]**

Wind energy is a branch of renewable energy that specializes in the transformation of kinetic energy into electricity. This type of energy source is an indirect form of solar energy, and therefore belongs to renewable energy sources. The source of wind energy is the sun, as it is responsible for the formation of wind. The wind is caused by the uneven distribution of air pressure on the Earth's surface, which is caused by the uneven distribution of temperature. **[9]**

All life processes on Earth are caused by thermal energy. The main source from which the Earth and the atmosphere receive thermal energy is the Sun. **[10]** Thus, the main factors that form the circulation of the atmosphere on a global scale are the difference in air heating between the equatorial and polar regions (which causes a difference in temperature and, accordingly, the density of air flows, and therefore a difference in pressure) and the Coriolis force **[11]** (one of the inertial forces used when considering the motion of a material point relative to a rotating frame of reference **[12]** (planet Earth around its axis; planet Earth around the Sun). Of the total amount of solar energy, around 1-2% is converted into wind energy.

The advantage of wind energy is that it is an environmentally friendly way of generating electricity. It does not pollute the atmosphere, does not consume fuel, and does not cause thermal pollution. **[2]**

4.3.Hydropower

Solar radiation is the driving force of the water cycle. Water is also a powerful source of energy. It became one of the first types of energy that mankind has learned to use for economic purposes. Initially, these were river mills in which the flow of water through several gears activated the millstone. Subsequently, the design of the water drive became more complicated, it began to be actively used in industry, for example, driving multi-ton hammers for forging metal. **[2]**

4.4. Geothermal energy

Geothermal energy is the thermal energy generated and stored in the Earth. Thermal energy is the energy that determines the temperature of matter. The geothermal energy of the Earth's crust originates from the original formation of the planet and from radioactive decay of materials. The Earth's heat reserves are practically inexhaustible - when the core cools down by 1 ° C, 2 * 1020 kWh of energy will be released, which is 10,000 times more than all explored fossil fuels contain, and millions of times more than the annual energy consumption of mankind. At the same time, the core temperature exceeds 6000 ° C, and the cooling rate is estimated at 300-500 ° C per billion years. The layer of soil between the depth of heating and the isothermal surface can be considered as a natural seasonal accumulator of thermal energy, and the energy that was used in the winter will be restored in the warm period of the year. This also applies to groundwater contained in the top layers of soil and sedimentary rocks. Thermal energy of soil and groundwater can be used for heating and ventilation. Selection of thermal energy from the soil can be carried out using ground heat exchangers of different types. The temperature of the heat carrier in the ground heat exchanger makes from 3-5 ° C to 10-12 ° C and is suitable for application of the heat pumps which provide increase of temperature of the heat carrier to 40-70 ° C. The experience of leading countries shows that ground energy is most often used in heat pump installations with a capacity of 10-20 kW, which serve individual small houses. Geothermal energy in a number of countries is widely used for heat supply and electricity generation. **[2]**

Geothermal power plants have many advantages:

- Relatively environmentally friendly. Unlike coal-fired power plants, geothermal power plants use a renewable heat source that has a constant supply. Research has shown that the industry employs only 6.5% of the world's total potential, which means that there will be enough energy for many years to come. In addition, the amount of greenhouse gas from GeoTPP is only 5% of that emitted by coal-fired power plants;
- More energy. GeoTPs have a large capacity - they can significantly help meet the demand for energy, which is growing every year in both developed and developing countries;
- Stable prices. Conventional power plants depend on fuel, so the cost of electricity they generate varies based on the market price of fuel. Because GeoTPs do not use fuel, they do not need to consider its cost, and they can offer their customers a stable cost of electricity;
- Low operating costs. Geothermal installations require minimal maintenance compared to traditional power plants. As a result, they are reliable and cheap to operate;
- Renewable and sustainable source. Geothermal energy will never run out, unlike non-renewable energy sources. As long as the earth sustains life, geothermal energy will exist, GeOTPPs will operate;
- Constant power supply. Unlike other renewable energy sources, geothermal can provide a constant energy supply - 24 hours a day, 7 days a week, 365 days a year, regardless of external factors. For example, solar panels can generate electricity only during the day, and wind turbines produce energy only when there is enough wind;
- Insignificant area. Occupy less space than their coal, oil and gas equivalents. Although they will reach far below the earth's surface, their area will be small;
- Low-noise work. There was little noise in the production of geothermal energy. The main source of noise is the fans that are in the cooling systems. To reduce its level, engineers can install in generator shops materials with high damping properties. This helps reduce noise pollution;
- Energy security. Using local geothermal resources reduces the need to supply sources from other countries, which, in turn, reduces dependence on external influences and helps increase our energy security.

As often happens, some pros can smoothly turn into cons, it all depends on the angle at which to consider a particular issue. No wonder they say that the coin has two sides. Thus, the disadvantages of geothermal power plants.

- Environmental problem. Damage to the environment can be high consumption of fresh water, which will eventually lead to its shortage. Liquids extracted from the ground during drilling contain large amounts of toxic chemicals (including arsenic and mercury), as well as greenhouse gases (such as hydrogen sulfide, carbon dioxide, methane, ammonia and radon). If they are not properly disposed of or handled, they can enter the atmosphere or seep into groundwater and harm the environment and human health;
- Geographical restrictions. Geothermal activity is highest along tectonic fault lines in the earth's crust. It is in these places that geothermal energy has the greatest potential. The disadvantage is that only some countries can use geothermal resources;
- Seismic instability. There is reason to believe that geothermal structures have caused earthquakes in different parts of the world. Although seismic activity is often insignificant, it can lead to building damage, injury, and death. In 2006, scientists accused a geothermal exploration project in Basel, Switzerland, of causing a series of earthquakes. Some of these earthquakes were rated at 3.4 on the Richter scale. Further research in 2011 found a strong correlation between geothermal exploration and seismic activity;
- Expensive construction. GeoTPs require significant investment. Although they have low operating costs, their construction costs can be much higher than those of coal, oil and gas power plants. A significant part of these costs relates to exploration and drilling of geothermal energy resources. Traditional power plants do not require exploration and / or drilling. GeoTPs also require specially designed heating and cooling systems, as well as other equipment capable of withstanding high temperatures;
- Exhaustion is possible. Studies show that without careful management, geothermal reservoirs can be depleted. In such cases, GeoTPPs will become unnecessary until the reservoir is restored. The only inexhaustible option is to obtain geothermal energy directly from magma, but this technology is still under development. This option is worth the investment at least because the magma will exist for billions of years.

4.5.The law of conservation of energy in thermal processes

Based on precision experiments conducted in the mid-nineteenth century, the English physicist Joel and the German Mayer, and most fully Helmholtz, established a pattern according to which the amount of energy in nature is constant, it only passes from one body to another or transforms from one type to another. This statement is called the law of conservation and conversion of energy. This law is universal and applicable to all natural phenomena.
The law of conservation of energy, extended to thermal phenomena, is called the first law of thermodynamics.
In thermodynamics, bodies whose position of the center of mass is almost unchanged are considered. The mechanical energy of such bodies remains unchanged. Only the internal energy U can change. The change U of the body can occur due to the performance of work A or heat transfer. Generally, in the case of transition of the system from one state to another, U changes simultaneously due to the performance of work and due to heat transfer. It is for the following general cases that the first law of thermodynamics is applied - the change ΔU of the internal energy of the system during its transition from one state to another is equal to the sum of the work of external forces A' and the amount of heat transferred to the system Q:

$$\Delta U = A' + Q.$$

If the system is isolated, work on it is not performed (A = 0) and it does not exchange heat with the surrounding bodies (Q = 0), therefore, ΔU = 0.
If we take into account that A'= - A, then the expression of the first law of thermodynamics will take the form

$$Q = \Delta U + A$$

Therefore, the amount of heat Q transferred to the system is spent on changing its internal energy U and on the system's performance of work on external bodies.Internal energy changes as a result of work and heat transfer. In each state, the system has a certain internal energy U. The work and the amount of heat are not contained in the body, but characterize the changes in its U.

We apply the first law of thermodynamics to various processes, in particular to those during which one of the physical quantities remains unchanged (iso-processes). If the thermodynamic system is an ideal gas and its volume does not change (isochoric process), then A'= 0, and the change in internal energy will be equal to the amount of heat:

$$Q = \Delta U + A$$

$$Q = c_v m\Delta T = \frac{3}{2}\frac{m}{\mu}R\Delta T + 0$$

$$c_v = \frac{3R\Delta T}{2\mu}$$

From where it is easy to obtain the value of the molar heat capacity of the gas in the isochoric process:

$$C_{v\mu} = \frac{3}{2}R$$

We can conclude that the amount of heat it takes to heat 1 mole of a monatomic ideal gas by 1 K in the isochoric process is the value of the constant.

Isothermal process. If T = const., the internal energy of the system does not change. All the amount of heat transferred to the gas is spent on work on external bodies. Thus, the system receives (or gives off) heat and the internal irregularity (and temperature) remains unchanged. This means only one thing – in the isothermal process, the heat capacity of the gas (specific, molar) is equal to either + ∞ or −∞

$$A = p\,\Delta V$$

$$A = \frac{m}{\mu}R\,\Delta T$$

Q = A

Isobaric process. The amount of heat Q transferred to the gas at constant pressure is spent on changing its internal energy and on its performance of work on external bodies.

$$Q = c_p m\Delta T$$

$$\Delta U = \frac{3}{2}\frac{m}{\mu}R\Delta T$$

$$A = \frac{m}{\mu}R\Delta T$$

$$c_p m\Delta T = \frac{3}{2}\frac{m}{\mu}R\Delta T + \frac{m}{\mu}R\Delta T = \frac{5}{2}\frac{m}{\mu}R\Delta T$$

$$c_p = \frac{5}{2}\frac{R\Delta T}{\mu}$$

$$c_{p\mu} = \frac{5}{2}R\Delta T$$

$$Q = \Delta U + A$$

We can conclude that the amount of heat needed to heat 1 mole of monatomic ideal gas by 1 K in the isobaric process is of constant value.

Now it is easy to get another expression, which has reason to be considered the law of conservation and conversion of energy - the Mayer equation:

$$\mathbf{C_{p\mu} - C_{v\mu} = R}$$

From this equation it can be seen that the molar constant R is equal to the work performed by 1 mole of monatomic ideal gas when it goes through isobaric heating by 1 K.

The **adiabatic process** is a process that takes place in a heat-insulated system (there is no exchange of energy with external bodies). In this case, Q = 0 and change the internal energy of the system can only be done by working on it:

$$\Delta U = A$$

Of course, it is impossible to surround the system with a shell that is completely impermeable to heat, but sometimes you can consider real processes very close to adiabatic. To do this, they must be carried out so quickly that during the process there is no heat exchange (for example, the propagation of sound in the air), or if the processes occur with huge masses of gas (for example, in the Earth's atmosphere).

As you can see, in this process the system temperature changes without heat exchange, i.e. heat capacity (specific or molar) is equal to 0.

The first law of thermodynamics follows the impossibility of building a "perpetual" engine of the first kind, because any system cannot do work indefinitely without transferring heat to it. Indeed, when Q = 0, the work must be performed due to the internal energy of the system, which is limited.

The law of conservation and conversion of energy states that the amount of energy in any of its transformations is unchanged, but nothing in it indicates what energy transformations are possible. However, many processes that are perfectly acceptable from the point of view of the law of conservation of energy, never take place in reality. For example, a heated body, gradually cooling, transfers its energy to the colder bodies that surround it. The reverse process of heat transfer from a cold body to a hot one cannot occur spontaneously. The number of such examples is many. All of them indicate that the processes in nature have a certain direction. In the opposite direction, they can not happen arbitrarily.

All processes in nature are irreversible. The direction of possible energy transformations is indicated by the second law of thermodynamics. It confirms the irreversibility of processes in nature and was formulated on the basis of research facts by Clausius: it is impossible to transfer heat from a colder system to a hotter one, unless there are other simultaneous changes in both systems or bodies that surround them. **[13]**

5. Research Methods and Materials

Our investigation was related to various natural spheres. We measured:

- Temperatures of soil,water, surface, air and sky, in order to learn how thermal energy moves throughout spheres; (study material)
- Biomass of trees to estimate energy accumulated in trees per square meter;
- Biomass of grass to estimate energy, accumulated in graminoids per square meter;
- Flow rate of water in Raudna river and wind speed at the same site to estimate kinetic energy in water and air;
- illumination and cloud cover to understand the background of measurements.

We drew up an observation plan, and divided it into three parts. The first part shows how to measure the biomass of trees. The second part of the plan shows how to measure the biomass of dry and fresh herbaceous plants. The third part of a plan shows how to measure the temperatures of various natural spheres: water, soil, air, surface of the earth, and atmosphere. Therefore, we had a detailed plan for the study of various natural areas.

The following equipment for measurements and observations was used:

- Soil thermometer
- Liquid filled thermometer
- Infrared thermometer
- Psychrometer
- Vernier sensors: air, flow rate, wind speed, light
- Globe data entry app and cloud charts
- Mobile phones
- Compass
- Scale
- Measurement tapes (50 m and 1 m)
- Flags
- GLOBE protocols, route map, GPS, table with MUC codes, paper bags, grass scissors.

For each part of our plan we used the following methods:

1.Method for tree biomass estimation (based on GLOBE biometry, herbaceous and carbon cycle protocols, **[3]).**

1) Measure the investigation area 30 m x 30 m (15 m x 15 m)

2) Measure three circumferences at 1.35 m
3) Find tree species
4) Find tree biomass from graph (a model showing dependence of above-ground biomass of trees on stem diameter for different tree species, Jenkins et all 2003 from GLOBE Website))
5) Find sum of biomasses of all trees with circumference over 20 cm
6) Calculate energy of tree biomass per m^2 (use energy content 18 MJ/kg for tree biomass)

2. Method for grass biomass estimation (based on GLOBE herbaceous biomass protocols, **[3]**)
1) Measure the investigation area 50 cm x 50 cm
2) Cut all biomass from the area
3) Weigh the biomass
4) Calculate energy of grass biomass per m^2
(use energy content 5 MJ/kg for humid grass)

3. Method for measuring the temperature of different spheres (based on GLOBE temperature protocols (current air, water, soil, surface temperature), **[3]**)
1) measure the temperature in each of the spheres
2) compare the results

4. Method for measurement site description (based on GLOBE land cover protocol, MUC Field Quide and GPS protocols), **[3]**)

Having distributed the general plan in this way, it became much more convenient for us to explore the environment, and share the roles between the group members - we knew exactly where and what we would study.

5.1. Expedition route and working process

To measure certain quantities, we had to visit various points on our expedition journey. According to the map (Fig.1), we first followed a forest path, along which we reached our first investigation site in a nice old forest of various tree species (mainly birches, aspens, spruces). After the measurements were taken, we went further along the path and came out to the turn that led to the track. At this turn we made our second stop in a boggy birch grove. We made the third stop on the bridge, where we measured the speed of the water flow in the river. Then we returned back to the forest path. Turning in the other direction, we got to the fourth site. This place interested us, because of rich ground cover, and because only a small amount of sunlight passed through the foliage of trees. The moisture in the soil was different than in other parts of the forest we were before. Later we got to the fifth stop where we collected green fresh grass from a quadrant of 50x50 centimeters. Nearby was a harvested cornfield, where we collected dry remains of plants (again from a quadrant of 50 x 50 cm). Having collected all the planned data, it remained for us to analyze it and draw conclusions.

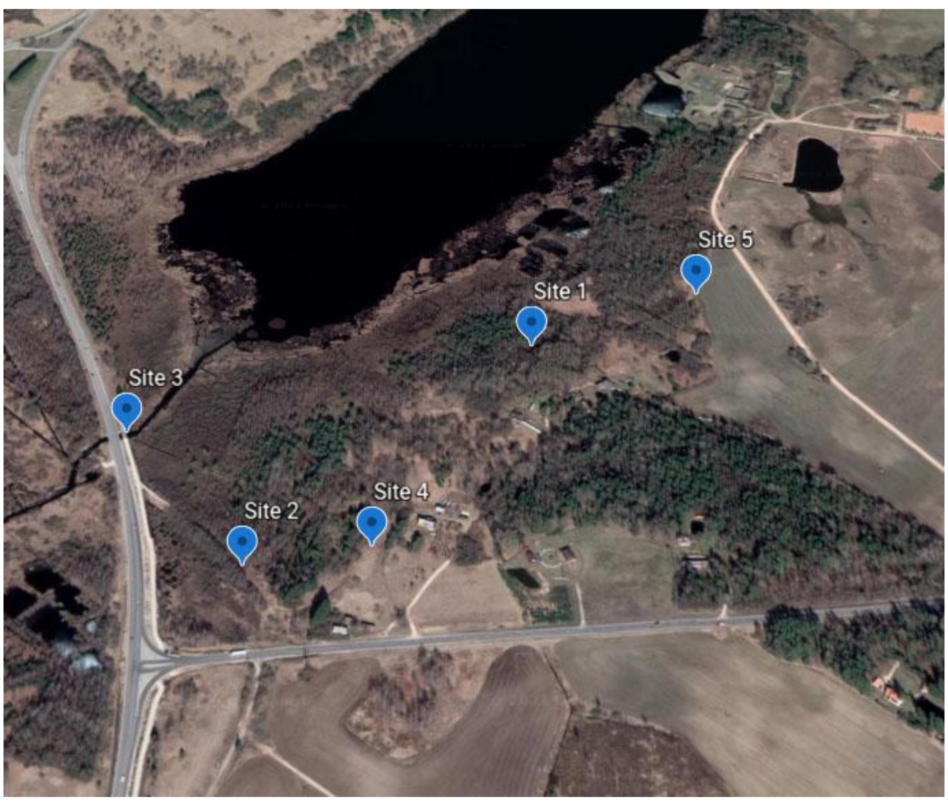


Figure 1. Map of measurement sites close to Sammuli recreation complex (58°20'17" N 25°35'19" E).

Site	Name	Coordinates	MUC code	Characteristics
1	Dense vegetation under forest	58.333196, 25.583568	022	An old mixed forest with big trees (aspen, birch, bruce, pine), also smaller trees and bushes
2	Dense birch grove	58.329978, 25.577900	023	A boggy forest with dense small birch trees, very few bushes
3	The Raudna river, the Pammi meadow	58.331835, 25.575120	4233	A bridge over river, a meadow near the river
4	Dense grass vegetation	58.330076, 25.580006	423	A forest rail in the forestal area, an open road with lush herbs
5	Cut straw field	58.334056, 25.587002	811	An open meadow next to harvested cornfield

Table 1. Characteristics of observation sites

At the first site, we entered the forest, which was located near the camp. We had to mark the measurement area of 30m x 30m, then measure and record the circumference of a tree stem, estimate species of the tree, and estimate biomass of the tree from a graph. Finally, we summarised biomasses of all measured trees, and calculated carbon storage, biomass and energy storage per square meter.

At the second point, we reached a wet forest near the river. We measured the trees' circumferences, and assessed the biomass and energy storage in the area of 15m x 15 m, using the same method described above.

Figure 2. Measuring the circumference of a tree in the second site.

The third point was located on the bridge over Raudna River. At this site, we measured the speed of the water in the river, and the temperature of water and of the water surface (with IR thermometer).

Figure 3. Measuring the speed of the water in the Raudna River (site 3)

At the fourth site, we collected fresh green grass to measure biomass and measured the soil temperature.

Figure 4. The fourth site.

At the fifth site, we collected dry cut grass for biomass measurement.
In all route points, we observed clouds and measured air and surface temperatures.

Figure 5. Measuring air temperature and wind speed in the third point.

6. Results

The obtained results were divided according to the observation plan.

6.1. Energy stored in biomass

6.1.1. Biomass of trees

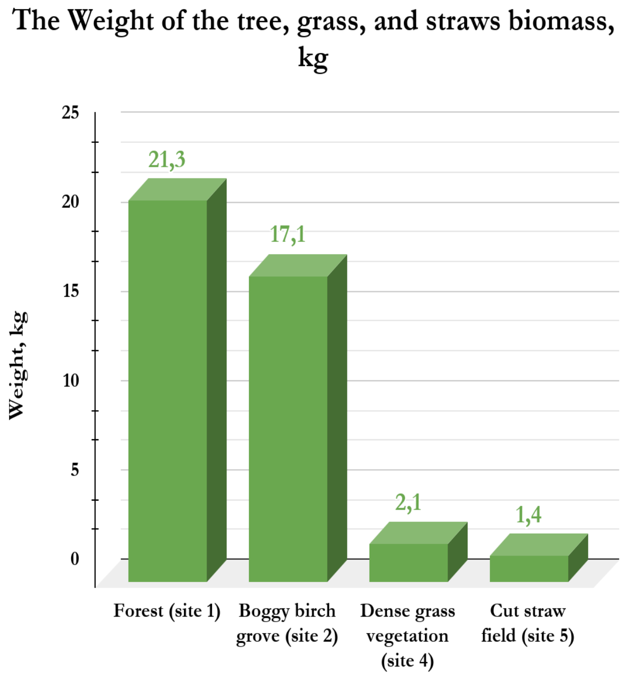
In total we measured 34 trees at the first observation site of the area of 900 m^2, including birch,spruce and aspen trees. The total biomass of those trees was 19170 kg and energy density in the old forest was 383 MJ/m^2.
In the second observation site we measured 50 trees in the area of 225 m^2, which were all birch trees The total biomass of those trees was 3840 kg and energy density in this boggy forest was of 307 MJ/m^2.

6.1.2. Biomass of grass (graminoids)

In the fourth observation site we took grass from an area of 0,25 m^2. The total biomass of the fresh grass was 523,6 grams and energy density was 10MJ/m^2. In the fifth observation site we took grass from an area of 0,25 m^2. The total biomass of the hay was 343,6 grams and energy density was 6,8MJ/ m^2.

	Forest (site 1)	Boggy birch grove (site 2)	Dense grass vegetation (site 4)	Cut straw field (site 5)
Biomass, kg/ m^2	21.3	17.1	2.1	1.4
Biomass energy MJ/ m^2	383	307	10	6.8

Table 2. Biomass of trees and herbs; energy stored in biomass per square meter in different observation sites.



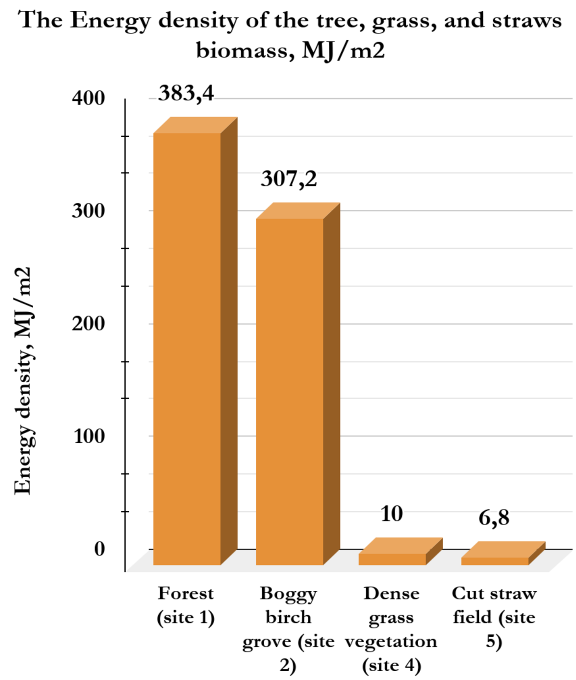


Figure 6 and Figure 7. Biomass and energy stored in trees and grass in different observation sites.

It was decided that 900 m^2 and 225 m^2 areas would be selected for assessment of the biomass and energy of trees per square meter. To assess the biomass and energy of plants and straw, two distant territories with area of 0.25 m^2 each were selected.

The diagrams (Fig 6 and 7) show that trees have higher energy density than graminoids. The highest energy density was in the forest (383.4 MJ / m^2), where big trees accumulate huge amounts of biomass during several years. Grass can accumulate about 40 times less energy per quadrat meter than forest trees (Tab 2). However, grass biomass is growing again every year, whereas trees store their biomass for a long time.

6.2.Temperatures in different spheres

In order to have a better understanding of thermal energy we measured temperatures in five sites and in four different spheres.

The diagram (Fig 8) shows that the arithmetic average of soil temperatures at 10 cm depth was 16 °C. As can be seen, the soil temperature was 15 °C in forest as well as under rich grass cover (sites 1, 2, 4), but remarkably higher (18 °C) in the cornfield exposed to sunshine. Water temperature in Raudna river was higher than 10-cm-depth soil temperatures in surroundings. It may come from the higher thermal capacity of water compared to soils.
The measured air temperatures varied during the expedition time from 17 - 18 °C .

The average surface temperatures of vegetation-covered ground (sites 1,2,4) were less than the air and the soil temperatures. Temperatures slightly increased with time of day (going from site 1 to 5). In contrast, the temperatures of the water surface and cornfield surface were higher than the according soil and air temperatures. The highest surface temperature of 23,1°C was measured in the harvested cornfield where the ground cover was mostly dry soil with few dry plants which was exposed to the sun during morning-time.

We also estimated the efficient radiation temperature of sky background using the IR-thermometer. It depended on cloud cover and cloud types. This information was necessary for us, as it makes it possible to analyze and understand the influence of weather on the movement of energy in different areas. Clouds reflect long and unscattered rays of sunlight, which is one of the most important environmental indicators for plant life. It is absorbed by chlorophyll and is used in the construction of primary organic matter. Like all living organisms, plants have the ability to adapt to changing conditions. This ability is different for different species. There are plants that quite easily adapt to sufficient or excessive light, but there are also those that develop well only under strictly defined illumination parameters. As a result of the adaptation of the plant to low illumination, its appearance changes somewhat. The leaves become dark green and slightly increase in size (linear leaves lengthen and become narrower), the stem internodes begin to stretch, which at the same time loses its strength. Then their growth gradually decreases, because the production of products of photosynthesis, which goes to the rear of the plant's body, is sharply reduced. With a lack of light, many plants stop blooming. In strong light, plant growth slows down, they turn out to be more squat with short internodes and wide short leaves. The appearance of a bronze-yellow color of the leaves indicates a significant excess of light, which is harmful to plants. Therefore, we can understand that the grass that grew in the field (site 5) was much drier and lighter than the grass that grew closer to the forest (site 4). It was positive (+1,8°C) under a stratocumulus cloud in the cornfield, but was deeply negative (under -26 °C) for all other cases. Since the sky is cold, the heat energy moves up from the Earth surface.

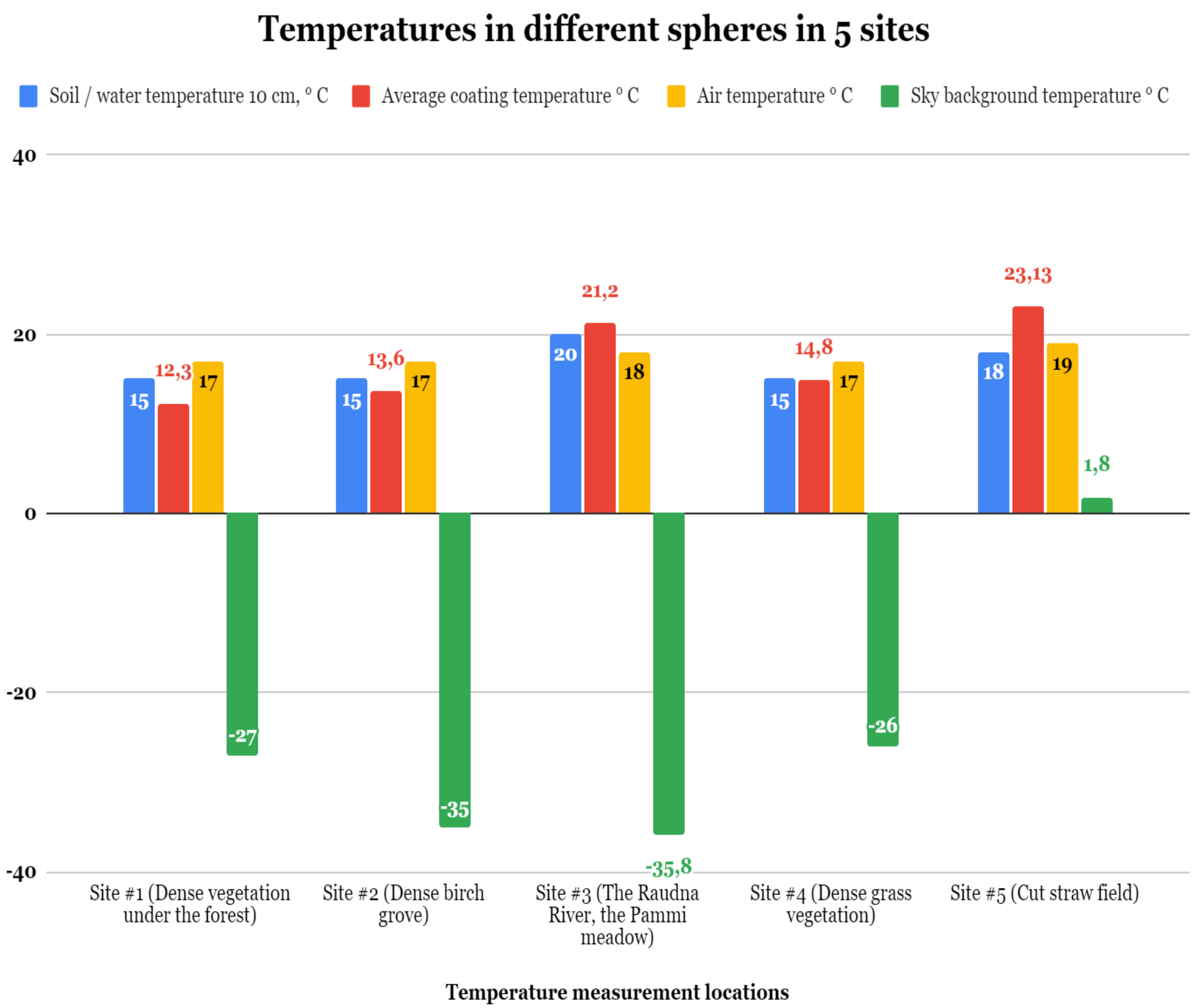


Figure 8. Temperatures of the spheres at five measurement sites.

6.3. Other measurements in expedition route

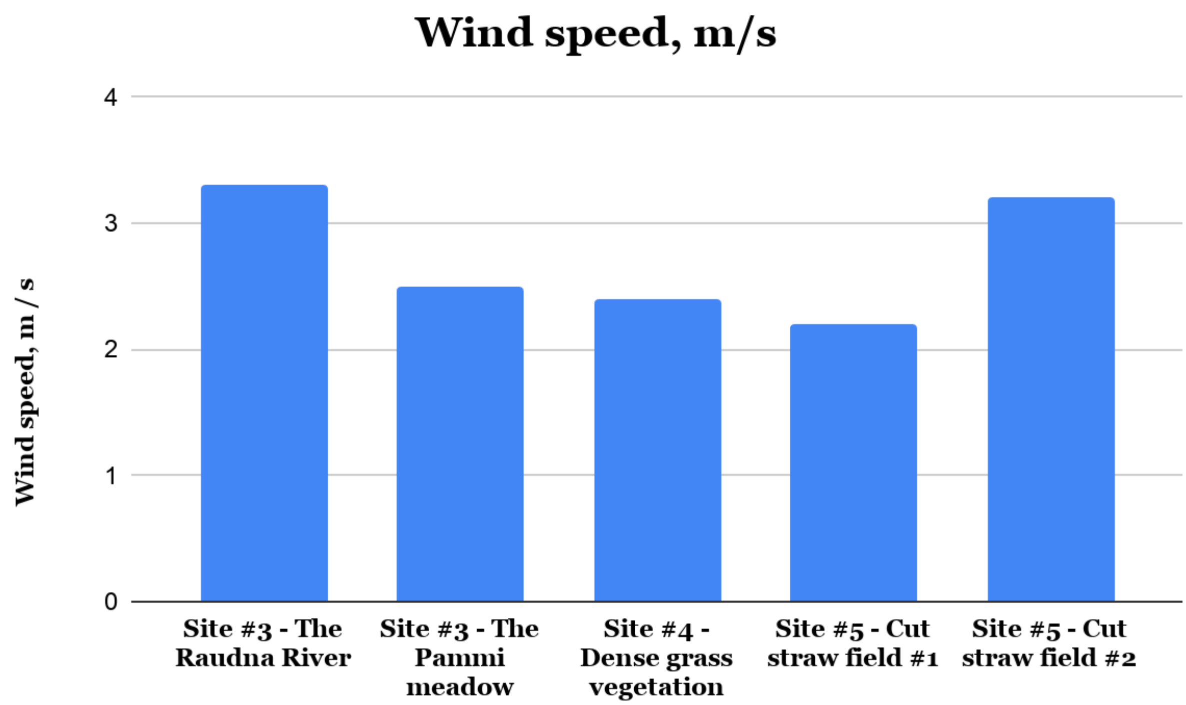


Figure 9. Wind speed at five different locations.

Wind speed was measured in five different sites.The highest speed was measured in the second cut straw field, namely 3.3 m / s. The lowest speed, 2.2 m / s, was measured in the first cut straw field.

The average speed of water flow in Raudna river resulted in 0,01 m/s. As the water flow and wind speeds were low, it can be concluded that there was little kinetic energy in air and river.

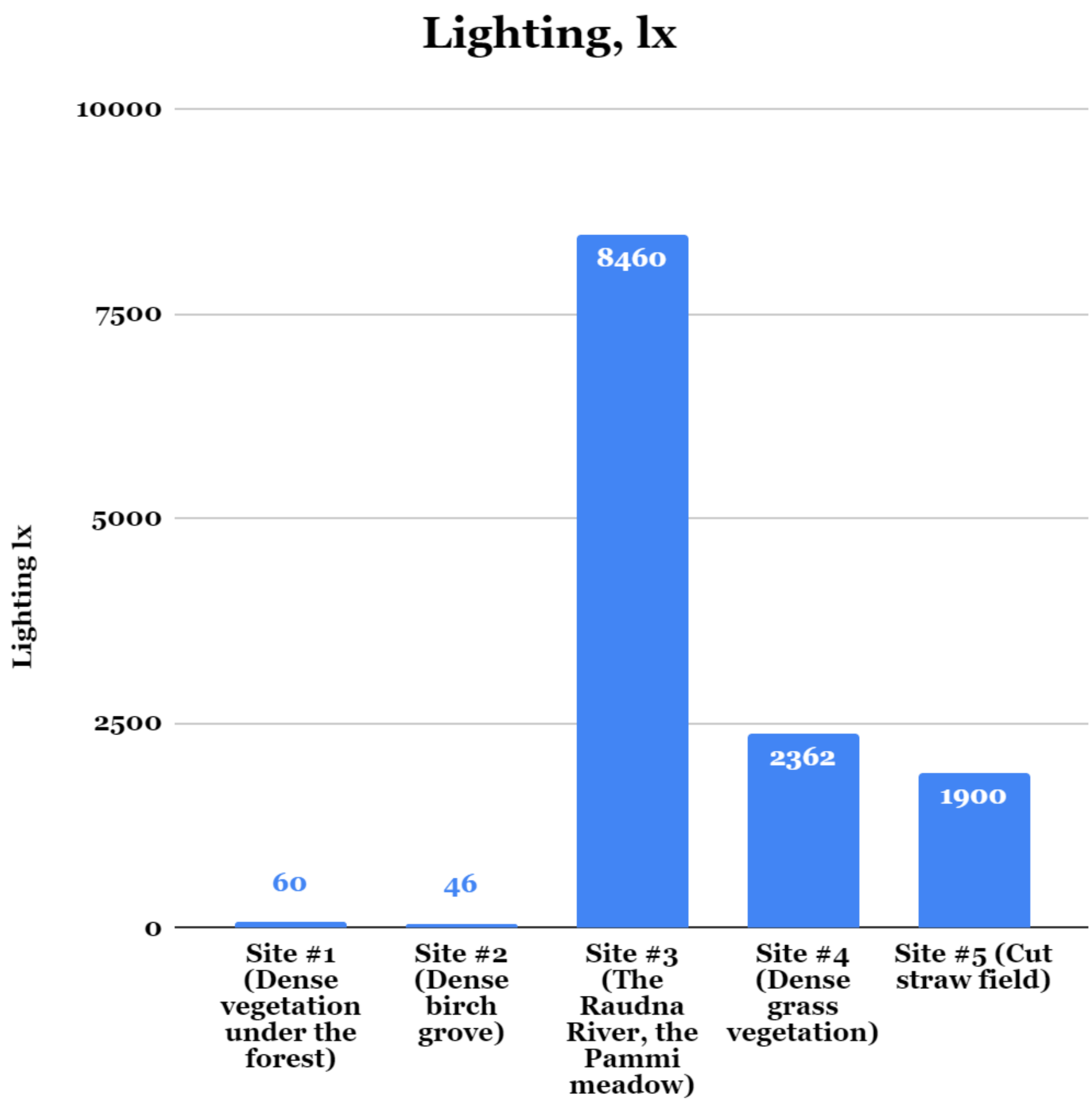


Figure 10. Sunlight illumination at five observation sites

The sunlight exposure was measured at five different sites. This helped us to find out how much sunlight affects the temperature in various areas. The Raudna River site had the greatest illumination, namely 8460 lux. The lowest illumination levels were measured under dense birch grove (46 lux) and under forest (60 lux).

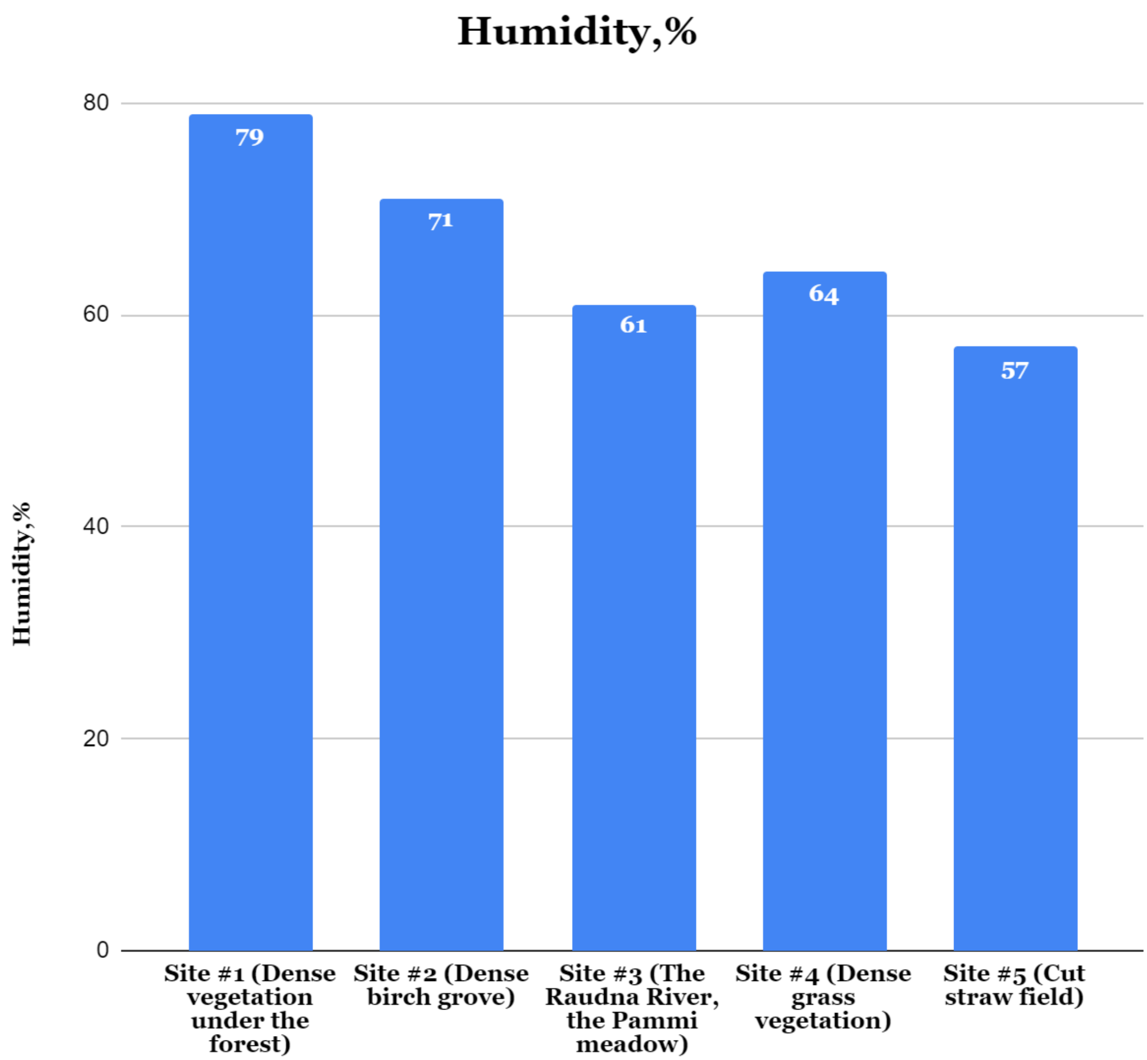


Figure 11. Air humidity at five sites.

Measurements of air humidity were made to assess the effect of humidity on temperatures in the selected areas. The highest humidity, 79%, was measured in the first site - dense vegetation under the forest. The lowest humidity, 57%, has the fifth site - cut straw field. The arithmetic average of all air humidity measurements resulted was 65,5%. Decreasing of humidity from site 1 towards site 5 was likely to have been caused by the changing time of the day and increasing flow of sun energy. However, the humidity was also influenced by illumination of a certain place.

7. Discussion

After we completed our plans for the expedition, the results of our research were obtained. Some surprised us, others we expected to see.

The investigation of biomass showed that the energy stored per 1 square meter is much higher for the areas with trees than for the areas with herbaceous plants. This is partly related to their lifespan and life cycle. Trees store more energy for growth and development because they live longer, from 40 to hundreds of years. As a result of photosynthesis they bind solar energy and CO_2 to create biomass which accumulates during a long time. Herbaceous plants die off every year and new ones grow in place of the old ones. Accordingly, an herbaceous plant does not store as much energy during its life cycle as a pine tree stores.
The investigation confirmed our initial hypothesis that the trees' biomass would have higher biomass energy per m^2 than the grass biomass.

It was impossible not to pay attention to the difference and similarities of the temperatures in different spheres. We assume that this is mostly due variation of the humidity and illumination of the area where the temperature measurements were taken. It is remarkable that the temperature of water in the river was higher than that of soil. This is likely to have been caused by the higher heat capacity of water which can store more sunlight energy than soil does.
In the open field, the air, soil and surface temperatures were higher than in other land sites. Also, the surface temperature was higher than the soil temperature. This site had no obstacles, such as trees and bushes, preventing sunlight, and the site was exposed to sunlight long before the measurement time.
The efficient temperature of the sky background was in most cases negative, and remarkably lower than the temperatures near the ground. Therefore, as the heat moves up, the Earth's surface is cooled. Clouds can reflect back the heat flux from the surface generated by sunlight. When heat flux hits the cloud and is reflected back, it remains in the lower atmosphere.

Different temperatures in different spheres cause local movements of heat energy between spheres. According to the laws of thermodynamics thermal energy always moves from the warmer objects towards the cooler ones. As an illustration a figure about thermal fluxes in expedition site 2 is presented (Fig 12).
The temperature measurements did not confirm our initial hypothesis that the soil temperatures would always be lower than temperatures of other spheres.

Measurements of wind speed and water flow have confirmed our hypothesis that the kinetic energy in air and in the river are low in the expedition day.

Data collection during the expedition and later analysis enabled recognise the observable and measurable energy forms in the natural environment. We were able to assess the amount of biomass energy stored in trees and herbaceous plants. We also learned a lot about distribution and movement of thermal energy between spheres.

The results obtained can lead us to the conclusion that not all energy sources are chaste for human use for their own purposes. It is not profitable for energy producers such as heat from a power plant to use it as fuel.

Thermal energy at TPPs is used to heat water and generate steam - at steam turbine power plants or to obtain hot gases at gas turbine power plants. To obtain heat, organic fuel is burned in boiler units of TPPs. Coal, peat, natural gas, fuel oil, oil shale are used as fuel. For this, raw materials such as straw, wood and grass, which we studied in this study, are not a suitable source of energy, since a large volume of these raw materials will be needed to meet the needs of humanity, which can lead to catastrophic consequences. For example, a large intake of vegetation can lead to the fact that certain types of insects will be smaller and more of them will become extinct. They pollinate plants, are an important link in the process of soil formation, serve as food for birds, mammals, reptiles, reptiles and fish, and also perform many other useful functions and their disappearance can lead to so many losses, which in turn lead to more serious problems that already concern climate change.

Global climate change is one of the most acute environmental problems facing humanity. According to forecasts of leading international research centers for climate research, over the next century the temperature will rise by 2-5 degrees Celsius. Such global warming will cause severe climate change and endanger various ecosystems. Life affects the climate through participation in the carbon cycle, the water cycle, and natural mechanisms such as albedo, total evaporation, cloud formation, and weathering. An example of how life has previously influenced climate formation is: glaciation caused by the development of oxygen photosynthesis 2.3 billion years ago, or glaciation known for long-standing deposits of decomposing detrital vascular terrestrial plants (coal formation), which occurred 300 millions of years ago, or the end of the Late Paleocene thermal peak 55 million years ago, due to the rapid growth of marine phytoplankton, or the reversal of global warming 49 million years ago caused by Arctic azole blooms and global cooling that occurred more than 40 million years ago.

If problems occur in the life and energy cycles, it can lead to serious climate change. The most noticeable consequence of climate change will not be gradual warming, but "emergencies" such as severe droughts, floods, storms, hurricanes, extremely hot days that will occur more often. The level of the world's oceans will rise and ocean currents may change significantly. Mankind will face water supply problems and the degradation of agricultural land and forests.

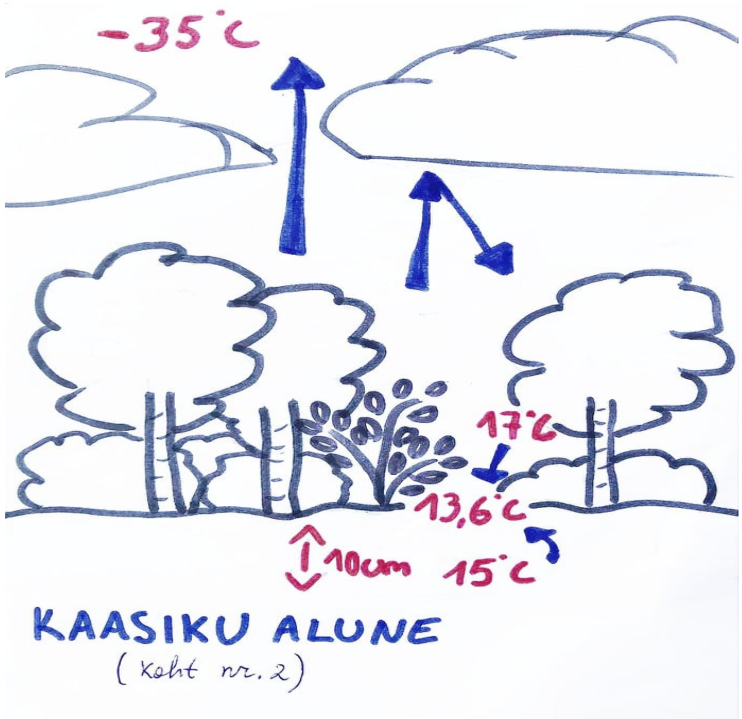


Figure 12. Heat flows in birchwoods in observation site 2 (author Markus Lambing).

8. Conclusion

In this research work, the theoretical part of the issue was studied, observations and measurements in the natural environment were carried out, and the results were analyzed. The goals have been achieved. The hypotheses were controlled and approved, except one. Questions were answered.

According to the results of the study, it was revealed that:
- temperature of various spheres is influenced by many factors, including sunlight, clouds, illumination, humidity, ecosystem characteristics, and movement of thermal energy between spheres;
- the life cycle affects the energy stored in the biomass of herbs and trees;
- biomass and energy stored per square meter differ between forested and herbaceous areas.
- energy is permanently moving between spheres and parts of an ecosystem.

No system works without energy, movement is impossible without it. It is difficult to imagine life without energy. It turns out that something independent in nature does not exist. It is the result of an inhomogeneous, nonequilibrium state of matter. In this case, a driving force spontaneously arises aimed at leveling out these inhomogeneities (nonequilibrium) and establishing equilibrium, which is the fundamental principle of nature. This gives rise to the phenomenon of energy (and force).
The concepts of potential and kinetic energy, which we have been using for a long time, also "originate" here. Potential energy is the presence and degree of nonequilibrium (asymmetry), and kinetic energy is a spontaneous movement towards equilibrium. At this point, it is said that potential energy turns into kinetic energy. Therefore, the non-equilibrium state of matter combined with striving for balance is the source of energy and motion. As long as there is asymmetry (disequilibrium), there will be movement. If there would be no asymmetry, there would be no energy, no movement.

References

1) Anaxagoras, K. Is there energy in nature, October 30, 2001 Ufa (educational material) https://scorcher.ru/art/theory/anaksagor/energ.htm , used August 2020 - January 2021
2) Gilberg, T. , Suk, T. , Genesis Publishing House , Natural science, 2014 (study material) https://cutt.ly/jjk24V2 , used August 2020 - January 2021
3) The GLOBE Program homepage, https://www.globe.gov/, used August 2020 -January 2021
4) Feshchuk, Y., Kulik, V., Influence of renewable energy sources on the functioning of the power system (Research work) https://cutt.ly/yjBKM0N , used August 2020 -January 2021
5) Senova O., Fedorov A., Non-renewable energy sources, (study material) https://cutt.ly/sjBLCwT , used August 2020 -January 2021
6) Shell Global Solutions International B.V., Energy, 2018 (educational material) https://cutt.ly/MjNuXYR , used August 2020 -January 2021
7) What is solar energy and does Ukraine need it? February 2015 (educational material) https://cutt.ly/FjNkiAF , used August 2020 -January 2021
8) Advantages and Disadvantages of Wind Energy, January 24, 2021 (educational material) https://cutt.ly/MjNSDsc , used August 2020 -January 2021
9) Winds and their origin , (study material) https://cutt.ly/zjN8ynG , used August 2020 -January 2021
10) Heating the atmosphere , (study material) https://cutt.ly/rjN8bvq , used August 2020 -January 2021
11) Wind, January 12, 2021 (educational material) https://cutt.ly/ijN4bbQ , used August 2020 - January 2021
12) Coriolis force, January 23, 2021 (educational material) https://cutt.ly/tjN4wpI , used August 2020 -January 2021
13) © Physicon, The first law of thermodynamics, 1999-2021 (study material) https://cutt.ly/MktVviF , used August 2020 -January 2021