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ANALYSIS OF LICHEN BIODIVERSITY IN DIFFERENT AREAS OF HUNGARY

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In the present study, a comparison between air polluted and non-polluted areas was observed depending on the frequency and distribution of lichens. Comparing our test results, based on OKIR data, it was found that in the area of Tatabánya, and the most serious emission of harmful substances were sulfur oxides (SO₂) and nitrogen oxides (NO_x). It was found few or damaged samples, and even in the area of the new industrial park we did not find any samples at all. On the other hand, we found few, but healthy and abundant lichens in the vicinity of shopping centres and one of the industrial areas (sampling site "A"). Based on the retrieved data, we found that the emissions of SO₂ and NO_x have decreased somewhat over the past 6 years, but are still significant in the given area. In Budapest (e.g., the XXII district) the emission of harmful substances is almost a third of the values in Tatabánya in terms of SO₂, which is surprising given the presence of a significant amount of chemical industry. The emission of NO_x also remains well below the values in Tatabánya. On the other hand, based on the queried data, it was found that over the past 6 years, the emission of SO₂ has increased, while that of NO_x has decreased in the monitored area. We did not find an evaluable lichen sample within the investigated area. In the XIII district harmful substance emissions remain significantly lower compared to the previous test areas, in contrast to this, it was demonstrated that the second highest result in the emission of NO_x. The lichen samples are varied, in one location (sampling location "A") we found damaged and sparse colonies, but in the others we could find particularly rich and large colonies, mainly in the parks and areas along the Danube. In the XX district, the emission of SO₂ in the residential area of the district is extremely low, and that of NO_x is also significantly lower than the previously investigated ones. We observed healthy lichen colonies in the district. SO₂ emissions are not typical in the Várgesztes area, and the amount of NO_x is negligible. At the sampling locations, it was found that the lichen colonies are extensive, healthy and grow abundantly. The most dominant lichen species of the investigated areas were: in Tatabánya area: Xanthoria parietina, Physcia ascendens, Hypogymnia physodes, Flavoparmelia caperata, where in Várgesztes area, it was found the following strains: Xanthoria parietina, Physcia ascendens. But in Budapest areas such as XIII district, Flavoparmelia caperata, Flavoparmelia caperata, Physcia ascendens, and only Flavoparmelia caperata was found in XX district and no lichens were detected in XXII district. Finally, it was concluded that in the industrial areas, Tatabánya and XXII district has a high level of pollution, which is not healthy for humans and other living beings. In addition, it can also have a negative impact on the ecosystem in terms of development and can also cause the buildings to corrode. The XIII district and XX district is characterized by significantly less air pollution data, and in addition, their environmental conditions can also have a positive effect on them. Thanks to the location next to the Danube, pollutants are cleared from the air in this area more quickly due to the wind. In addition, green zones are also common, where there is a chance for dirt to accumulate. On the other hand, the test sites "C", "D", and "E" are located near park areas and the Danube, where several factors ensure adequate air exchange and purification.

Keywords: lichen biodiversity, air pollution, distribution of lichens

INTRODUCTION

More than 20,000 types of lichens are known worldwide, hundreds of which can also be found in Hungary. It is mainly a terrestrial species, but a few aquatic species are also known. Pioneering organisms, they can be found in extreme habitats (rocks, deserts, tundras), both on natural and man-made surfaces. Lichens are long-lived, resistant to drying out, but light-demanding plants. Lichen acid can also erode the substrate. Lichens are perennial, colonizing, tube-spored, cellular organisms. They are not simple organisms, but organisms formed from the coexistence (symbiosis) of fungi, fungi and algae, or cyanobacteria (blue-green algae).

All lichens contain at least one photobiont and one mycobiont partner, but there may be more than one photobiont partner. The non-fungal partner is called photobiont and contains chlorophyll; the fungal partner can also be called mycobiont. Scientists define them as biological indicators, or bioindicators since most of lichens are sensitive to the amount of pollutants mainly sulphur dioxide (SO₂) in the air, so they are also suitable for determining air quality.

The shape and protection of the lichens are given by the fungal filaments. These fungal threads are intertwined as a dense, intricate and resistant structure in the lower and upper bark layers. Seaweeds and algae can be observed in the photosynthesizing layer. The most common algae species found in domestic lichens are the following:

- Trebouxia
- Myrmecia
- Pleurococcus
- Coccomyxa
- Pseudochlorella
- Trentepohlia
- Phycopeltis
- Gloeocapsa
- Nostoc
- Scytonema.

Among the photobionts there are filamentous structures, but they consist of chains or clusters of more or less spherical cells. Thanks to the chlorophyll content, color hydrates are produced during photosynthesis with the help of light. Unlike photobionts, fungi cannot produce carbohydrates for themselves. Carbohydrates produced by photobionts in lichens are primarily used by photobionts, but also by mycobionts. The algal cells supply ready-made organic material to the fungal filaments, and they supply the host cells with salts dissolved in water and carbon dioxide, which the lichens absorb from their environment through their entire body surface.

The shape of rhizina shows great diversity. It can be simple, forked, and shaggy or have a slipper-like adhesive surface. The lichen-forming fungus is not viable to survive on its own, but the photobiont partner is. It is possible for them to survive on their own under laboratory conditions, but it is almost impossible to resynthesize them. It succeeded under the influence of stress (reduction of water and nutrient levels), which may indicate that the lichen communities were created to overcome different extremes.

The appearance of lichens shows great diversity. Their color is determined by the species of algae / seaweed that are also responsible for photosynthesis. Some lichens have special pigments. An example is usnic acid, which gives the characteristic yellow color and leads to many shades, from orange to red to brown. Lichens that do not have such special pigments are gray or gray-green when dry. These species then glow green or olive-green when wet (the photosynbiont layer emerges due to the cortex layer becoming more transparent). The color (usually the color considered in the dry state) plays a significant role in the definition of the variety.

LICHENS: CLASSIFICATION AND GROUPING

Lichens are usually classified according to fungi. The fungi are mainly hose fungi, but they can be basidium and algal fungi.

They can be divided into four classes according to Hortobágyi(1979):

- Class 1: Phycolichenes
- Class 2: Tuberous lichens:
 - Ascolichenes o Subclass:
 - a. Pyrenocarpeae o Subdivision
 - b. Discocarpeae (Gymnocarpeae)
- Class 3: Basidial lichens - Basidiolichenes
- Class 4: Semilichens - Deuterolichenes

Grouping lichens is not an easy task, so we can approach this problem from several perspectives.

Based on their living space, we distinguish:

- epiphytic species
 - bark dwellers – corticol
 - Lichen
 - Map lichen
 - branch dwellers - ramikol
 - leaf inhabitants – epiphyll
- terrestrial species
 - rock dwellers – saxicol
 - soil dwellers – terricol)

Another grouping method is grouping based on morphology.

1. Lichens with bark colonies:
 - They adhere firmly to the substrate with their entire lower surface.
 - Substrate can be: rock, tree bark, anthropogenic
 - Colonies can be: contiguous, fissured, granular, bordered, warty
2. Leafy lichens:
 - It is between the bark and beard lichen.
 - Sheet-like, flat, with rounded edges.
 - It is not completely fixed to the ground.
 - Substrate can be: rock, tree bark, soil.
3. Bushy lichens:
 - Small, bush-like colony.
 - Not always fixed to the ground.
 - Fluffy, ribbon-shaped, or thread-like colony
 - Branching, simple, erect, drooping

Lichens can be divided into three groups based on the closeness of the symbiosis of fungi and algae:

- [1] Algal cells and fungal filaments live freely side by side o For example: Pedunculate lichen species
- [2] Algal cells and fungal filaments are loosely involved o For example: Some of the bark lichens
- [3] The hyphal threads that hold the algae together penetrate deep into the cells

LICHENS: THEIR IDENTIFICATION:

Lichen identification is possible in most cases in the field.

Certain species, on the other hand, require examination of their macroscopic and microscopic structure (reproductive structures, spores, cellular characteristics) and chemical properties.

Chemical reagents can be used on the lichen tissues, as a result of which it can be concluded about a color change, or its absence, but the chromatographic method is more accurate.

LICHENS: THEIR REPRODUCTION

Lichens are long-lived organisms. They grow extremely slowly, their diameter increases by one or two millimeters per year. Their reproduction (Figures 1 and 2) takes place in the way of algae, fungi and lichens.

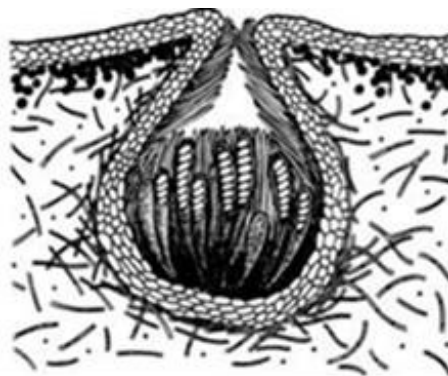


Figure 1. Perithecium longitudinal section



Figure 2. Longitudinal section of apothecary

- In the kelp mode: asexually with zoospores or division into two
- In a fungal way: Fungi can develop a fruiting body (for example, perithecium or apothecium, but the spore only sprouts when gonidia meet.
- With lichen reproduction: There are several types of vegetative reproduction.

It can be realized vegetatively in several ways:

- With colony parts: Thanks to the genetic identity, it can continue to reproduce from fragments broken off from the lichen body. Foliage and bark lichens can easily become brittle when dry.
- With soredia: Dust-like grains, soredia, which consist of photobiont cells surrounded by fungal filaments, appear on the colony body.
- With isidia: The colony body creates simple or branched outgrowths, isidia, which are a mixture of fungal and photobiont cells. The isidium contains everything necessary for the production of the new colony body, so it can reproduce by breaking off and dispersing.
- With pycnidia: With tiny spherical or pear-shaped pycnosporos.

LICHENS: THEIR ECOLOGICAL IMPORTANCE

Their living space:

Lichens have successfully multiplied in many different habitats, especially in extreme places such as deserts, tundras, and stone surfaces. This can be attributed to several things. The first such factor, which helps their spread, is poikilohydricity, so they are resistant to drought, primarily they require light. It can be said that lichens are tolerant of various environmental factors. They are also pioneer organisms.

We call pioneers the organisms that appear first when the cause of destruction has ceased, or settle in areas where life has died out for some reason, be it natural or artificial. Their occurrence and

distribution are primarily determined by the substrate and climatic factors, and whether there is an organism that would compete with the number of lichens.

Nitrogen use:

The Earth's atmosphere contains 80% nitrogen, which most organisms cannot use directly. Cyanobacteria are capable of this and know how to fix atmospheric nitrogen. As a result, after the nitrogen has been fixed, the nitrogen fixed by it will be available to other plants as well, with the death of the lichen colony or the excrement of herbivorous animals. In addition, some of the nitrogen can be leached from the lichen, where it can reach other epiphytic species or seep into the soil. Many studies have shown that nitrogen is essential for plants. Non-nitrogen-fixing lichens also contribute significantly to the nutrient cycle. Lichens can also absorb minerals through their plant bodies. In forests overgrown with dense lichens, epiphytic species can bind nutrients in fog and precipitation (e.g. ammonium nitrate).

Food for living things:

Some vertebrates also feed on lichens, especially deer and caribou in North America and Eurasia. In winter, these animals feed mainly on beard lichens, thanks to which they can survive the nutrient-poor period. It can also be used for animal feed (for example, reindeer husbandry). It is interesting that former species are also food for humanity served, for example manna moss. Some lichen colonies may serve as habitat for some invertebrates, which may serve as food for larger invertebrates or vertebrates. Lichen is also important from the point of view of the food chain.

Their positive effect on the soil:

Thanks to being a pioneer, it plays an important role in soil formation, referring here to rock compaction, soil binding and humus formation. Certain lichens are effective sand and soil binders that can help stabilize dunes and help prevent erosion. In dry, subarid areas, lichens and bryophytes can create biological soil crusts that maintain the soil's basic structure. Lichens can also settle on barren surfaces, such as road cuts, rock outcroppings, or volcanic ash and prepare the area for other plants. It captures moisture, wind-blown organic debris and contributes to organic deposits.

Their role in scientific life:

Lichens also "take on a role" in scientific life, since the drained juice of certain lichen species (*Rocella*, *Lecanora* and *Variolaria* species) is used to make litmus paper. Lichen acid has an antibacterial effect, i.e. it is effective against some bacteria, which is why it is the basis of several medicinal products. The best-known species used in medicine, Iceland lichen, is an excellent anti-inflammatory and cough suppressant. Their use has important ecological significance; they are also used as food, medicine, and clothing dye (e.g. Harris tweed).

EFFECT OF POLLUTION ON LICHENS

Lichens are excellent at concentrating nutrients from dilute sources and indiscriminately absorbing essential substances from the atmosphere, such as sulfur dioxide, fluoride or heavy metals. Pollutant sources that can have a harmful effect on lichens:

- Smelters: heavy metals, pollutants
- Car exhaust gases: nitrogen oxide
- Intensive animal husbandry: ammonia
- Agricultural chemicals: fertilizer, herbicide
- Oil contamination Pollutants can be microscopic particles, gases, or liquids. Microgranules of microscopic particles are absorbed by the colony body, which can embed in the thallus tissue and release harmful substances over a long period of time.

Sulfur dioxide:

The most intensively studied pollutant is the sulfur dioxide compound, which is a gas that dissolves easily in water and creates highly reactive acid ions. They are absorbed through the plant body and

interfere with photosynthesis. It inhibits the growth of lichens, the germination of spores and the activity of nitrogenase. Many lichen species are sensitive to air pollution, especially sulfur dioxide. In areas polluted with sulfur dioxide, the majority of lichens show an increased concentration of sulfur in the soil. Sulfur damages chlorophyll, which causes the photobionts to die and the fungal component as well, as it cannot survive on its own. By the way, lichens can also detect the hydrogen fluoride content of the air. In general, beard lichens are the least and bark lichens the most resistant to harmful effects. Thanks to this, the pollutant level can be monitored by noting the species and their condition in the given area. Sulfur dioxide has been a significant industrial pollutant for years. It can enter the atmosphere as a by-product of high-sulfur fuels, although their emissions have decreased thanks to various sulfur removal technologies, they are still significant. *Lecanora conizaeoides* is extremely tolerant to sulfur dioxide; it became widespread around industrial cities during the industrial revolution. Thanks to environmental protection measures, their number has decreased, already close to the times before the industrial revolution.

Oxidation:

There are few studies on the effects of oxidizing compounds on lichens, but several experimental studies have shown that ozone has adverse effects on lichens, which may vary among species. For example, in Southern California, sulfur dioxide emissions are low, but oxidizers are present in high concentrations in this area, as a result of which the number of lichen species found at the beginning of the 20th century has significantly decreased or disappeared

Metals:

Certain metals can have different effects on lichens. It is mainly observed around the plaques placed on the rocks. Metals containing copper, bronze or zinc are often used for plaques, which, if dissolved by precipitation, damage or destroy the lichen colonies living around it.

Determination of air quality based on SO_x and NO_x and their physiological effects

The Hungarian air quality index presents the composition and proportions of air pollution in various areas of Hungary with regard to the most important environmental pollutants. Different limit values apply to different pollutants depending on their health-damaging effects, the sources of which enter our environment mainly from the industrial and transport spheres.

The index takes into account the concentration values of the following pollutants and is given in µg/m³:

- Benzene (C₆H₆);
- Carbon monoxide (CO)
- Nitrogen dioxide (NO₂);
- Ozone (O₃);
- Aerosol particles, fraction below 10 microns (PM₁₀);
- Aerosol particles, fraction below 2.5 microns (PM_{2.5});
- Sulfur dioxide (SO₂)

During our tests, we primarily dealt with nitrogen and sulfur oxides, which are the most determining points of air quality, along with carbon oxides. 2. Presentation of the most common NO_x and SO_x

Nitrogen dioxide:

Nitrogen dioxide (NO₂) is a reddish-brown gas with a pungent smell and an acidic chemical reaction.

Highly reactive, highly oxidizing and corrosive.

It is heavier than air and poorly soluble in water.

Molecular weight: 46.01

Its sources: NO₂ is usually not released directly into the air, but is formed during atmospheric reactions of nitrogen oxide (NO) and other nitrogen oxides (NO_x) with other substances or is produced during the combustion of N-containing compounds. Volcanic activity from nature, lightning and significant amount is released into the atmosphere through its nitrifying bacteria. NO₂ comes mainly from the burning of fossil fuels (coal, natural gas, crude oil), especially diesel fuel used in vehicles. Cars account for a very high percentage of NO₂ emitted in cities. Burning

natural gas, especially in the winter, also produces NO and NO₂. Industrial sources: nitric acid production, welding, petroleum refining, metal manufacturing processes, use of explosives, and the food industry.

Physiological effects: Nitrogen oxides are toxic to both animals and humans. The mechanism of action of NO₂ is twofold. On the one hand, in connection with the wet respiratory mucosa, saltpeter- or it turns into nitric acid and locally damages the tissue. On the other hand, it is absorbed into the bloodstream, where it oxidizes the hemoglobin molecule into methemoglobin, so it is unable to transport oxygen to the organs. Symptoms of acute poisoning: conjunctival and mucous membrane irritation, coughing, vomiting stimulus, headache, and dizziness.

The symptoms resolve within 1-2 hours, and after several hours of symptom-free period, emphysema and pneumonia develop. Acute poisoning does not occur in free atmospheric conditions.

Symptoms of a prolonged effect: NO₂ reduces the lung's resistance to infections, aggravates asthmatic diseases, can lead to frequent respiratory diseases and, over time, to the weakening of lung function and changes in the blood count.

Groups at particular risk: Young children and the elderly, asthmatics (especially children), people with diseases of the circulatory system and respiratory organs. Health limit value: 100 µg/m³ 1-hour, 85 µg/m³ 24-hour and 40 µg/m³ annual average

Danger level: II. Extremely dangerous Effect on the ecosystem: NO₂ has a toxic effect on plants; over a concentration around 120 µg/m³ and it reduces their development even in a short time. If NO₂ and O₃ (ozone) are present at the same time, the effect is enhanced. Together with sulfur dioxide, it is involved in causing acid rain. Lichens show the presence of NO₂ as a bio-indicator, because they cannot develop in its presence or only with difficulty. Effect on buildings: NO₂ has an acidic chemical effect in the presence of moisture, which is why it strongly corrodes metals and building materials. Effect on visibility: NO₂ forms secondary particles, nitrates, which can form a dark yellowish haze, impairing visibility.[2]

Sulfur dioxide

Sulfur dioxide (SO₂): SO₂ is a colourless, water-soluble gas with a typically pungent smell. It combines with water to form sulfuric acid or sulfurous acid.

Molecular weight: 64.07

Sources: SO₂ mostly comes from the burning of sulfur-containing fuels, a significant part of which is the energy industry, and it also comes from the oxidation of coal and oil-containing compounds. SO₂ can also escape from other industrial technologies, such as fertilizer production, aluminum industry and steel production. It can also be released into the air from natural sources during geothermal processes (volcanism).

Physiological effects: Adsorbed to the moist respiratory mucosa, it has an irritating effect due to its acidic chemistry. Once in the bloodstream, it converts hemoglobin into sulphemoglobin, thus inhibiting oxygen uptake. In clean air, the blood count is restored. During its acute effect, it irritates the mucous membranes of the nose, throat and lungs, and can cause coughing, phlegm formation and asthma attacks. These do not occur at free atmospheric concentrations. In chronic cases, SO₂ respiratory diseases e.g. can cause bronchitis. Most vulnerable groups: Children and the elderly, people with respiratory diseases, especially asthma. Health limit value: 250 µg/m³ in a 1-hour period, 24-hour average 125 µg/m³, annual average: 50 µg/m³ Danger level: III. Dangerous Its effects on the ecosystem: SO₂ forms sulfuric acid and sulfurous acid with the humidity of the air, which harms the living world. It is the main component of acid rain, which destroys trees and can destroy entire forests.

Lichens show the presence of SO₂ as a bioindicator, because they cannot develop in its presence, or only with difficulty. Effect on visibility: SO₂ turns into sulfate in secondary form, which can cause fog, worsening visibility. It is the main component of reducing type smog (mainly occurring in winter). EU trends and regulations:

Nitrogen oxides (NO_x):

One of the main reasons for exceeding the nitrogen dioxide (NO₂) limit value is nitrogen oxide (NO_x) emissions from diesel cars and light trucks, energy and the metallurgical industry. The new

EU-wide testing procedure adopted in 2017, which reflects the emissions of these vehicles under real driving conditions, and the 2016 Commission proposal for a revised type-approval system (10) will go a long way towards making progress in this area. . 9 Amended Commission Regulations 2017/1151/EU. OJ L 175, 7.7.2017, p. 1. 10 COM(2016) 31 final.[3]

Sulphur oxides (Sox):

1979: The Geneva Convention on long-range transboundary air pollution aimed to reduce the emission of acidic substances. Since the signing of the convention, sulfur emissions have decreased significantly in Europe, but due to the increase in road traffic, the level of nitrogen oxide emissions has not changed or increased as a result of modernization.

1985: Most of the member states of the European Union accepted the protocol related to the Geneva Convention on the reduction of sulfur emissions. The protocol aimed to reduce sulfur dioxide emissions by 30% by 1993 compared to the 1980 level. The group of countries that signed the document became known as the 30% club. The objective was met by all of the signatory countries, as well as many states that did not join the agreement.

1987: The Montreal Protocol set targets and deadlines for the reduction of emissions of gases dangerous to the ozone layer.

198:- In a directive, the European Union obliged power plants, as well as the energy, iron, chemical and wood industries, as well as the waste processing sector, to reduce their sulfur dioxide and nitrogen oxide emissions. Restrictions were also introduced in the areas of waste incineration, transport, and heat and energy production.

1992: At the Earth Summit held in Rio de Janeiro, Brazil, the European Union also signed the UN Framework Convention on Climate Change. This is where the principle of "sustainable development" was formulated. This means improving the quality of life in a way that does not harm the environment, future generations, or residents of rich or developing countries.

1994: The second protocol on sulfur emissions was signed by many European countries. Since signing, all EU member states have achieved the goal of reducing emissions by 35% compared to 1990 levels. During the next decade, sulfur dioxide emissions are expected to decrease further.

1996: The Car/Oil program began, proposing stricter emission standards for passenger cars.

1997: In the agreement signed in Kyoto, Japan, the European Union promised to reduce sulfur dioxide emissions by 50% and ammonia emissions by 30% by 2010 compared to the 1990 level.

According to the experts, the targets for sulfur dioxide are achievable, on the other hand, the level of nitrogen oxide emissions is extremely worrying, and little has been done so far to solve the problem of ammonia emissions.

2001: Clean air for Europe started! (CAFE) program, which aims to eliminate air pollution harmful to human health and the environment.

2005: The European Commission announced an air cleanliness strategy in order to reduce air pollution. Among its goals, the Commission wants to reduce the number of premature deaths caused by diseases related to air pollution by almost 40% in the twenty years until 2020.

Another goal of the strategy is to reduce the area of forests and other ecological systems damaged by atmospheric pollutants. The strategy pays special attention to fine particles and ground-level ozone pollution, as they represent the most serious threat to human health.

Macro and micro habitats

Large habitats, such as rainforests, can be divided into smaller, so-called micro-habitats. For example, in rainforests, other types of lichens can settle on the leaves of flowers or on the bark of trees. According to this, other lichen species need different growth conditions. Lichens can live not only in exotic, but also in urban environments, but their numbers decrease more and more as pollution increases.

The decrease in the diversity of lichens when approaching cities is influenced by factors other than distance. In protected places, various lichens can survive even in hostile environments. Such protected places can be created by trees, shrubs, and walls. The highly polar sulfur dioxide molecules are deposited on all kinds of surfaces, so the shrubs can absorb them and provide cleaner air for the lichens, thus creating micro-habitats. Valleys can provide protection against wind-blown

pollutants, and an alkaline substrate can protect the lichen against acidic pollutants (in combat zones, desert zone).

LICHENS: THEIR ROLE AS BIOINDICATORS:

Although lichens are tolerant of most environmental factors, air pollution is a critical factor for them. They are particularly sensitive to the content of sulfur dioxide in the air, on the other hand, they have a narrow tolerance. For this reason, the quality of the air is characterized very precisely. The idea of using lichens in biomonitoring first arose in 1859 and was developed in 1866 by the Finnish lichenologist W. Nylander to study lichens near Paris. Based on the lichens, the air pollution of an area can be assessed using lichen maps. (Figure 3)

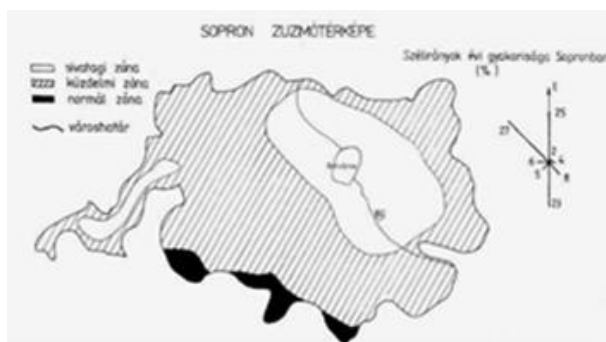


Figure 3. Air pollution in Sopron based on lichen map

Based on this, we can distinguish three zones.

- Desert zone: no lichens can be found within this zone due to the level of air pollution
- Struggle zone: the amount of lichens is sparse and scattered
- Normal zone: the air quality is suitable for lichens Based on the different levels of air pollution. Different species appear that can tolerate different levels of SO₂ concentration.

MATERIALS AND METHODS

In our research, we documented the lichen species found in the different observation areas with photographs, identified and characterized them in a table using the Képes lichen guide. In choosing our research area, we tried to choose areas with as diverse an environmental impact as possible, such as: industrial areas, residential areas in the center and outskirts of the capital, or in the countryside. (XXII. district of Budapest, Tatabánya, XX. district of Budapest, XIII. district of Budapest, Várgesztes) For each study area, we determined which type of lichen is dominant in the given area, which we compare at the end of the study. From the website of the National Environmental Protection Information System (OKIR), we queried the air pollution data for specific areas for sulfur oxides and nitrogen oxides, which can affect the lichen population. Since lichens have a very slow growth time and pH-lowering factors also affect their development, we reviewed the data from 2016 to 2020 inclusive.

RESULTS

Examination of lichens in the XXII. in the vicinity of district industrial areas

In the southwestern part of Budapest, the XXII. In the district's industrial areas (Figure 4), there are many companies involved in the chemical industry and other economic activities, such as SONEAS chemical and pharmaceutical raw material manufacturer, Agro Chemie Kft., Brenntag Hungaria

Kft., Green-Ex Trans, Reyclan, ESD Work Hungary, Geo Build Kft. Hatarai Érd, the Danube. The lichen survey monitored the lichen population up to the M6 motorway, but probably due to its similar conditions, the other part of the M6 motorway also has similar air quality data.

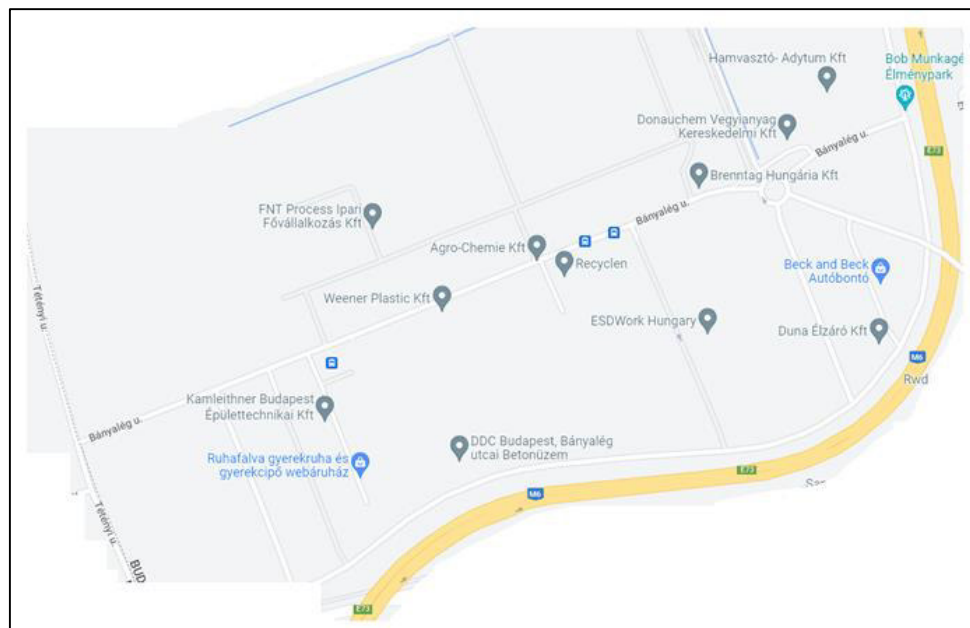


Figure 4. Map of XXII. district

In the area of the map (Figure 5), we did not encounter lichens at a height of 30-250 cm in negligible quantities, or only in open (open areas more active in air movement) located above 5 m (typically on acacia, oak and birch), which could not be found due to access obstacles were documented and were not identified. However, based on my experience with lichens, they typically looked like *xanthoria parietina* and *pertusaria albescens* from a distance. The following figure is XXII. district shows the emissions of various sulfur oxides and nitrogen oxides based on OKIR data between 2016-2020 (Figures 6 and 7):

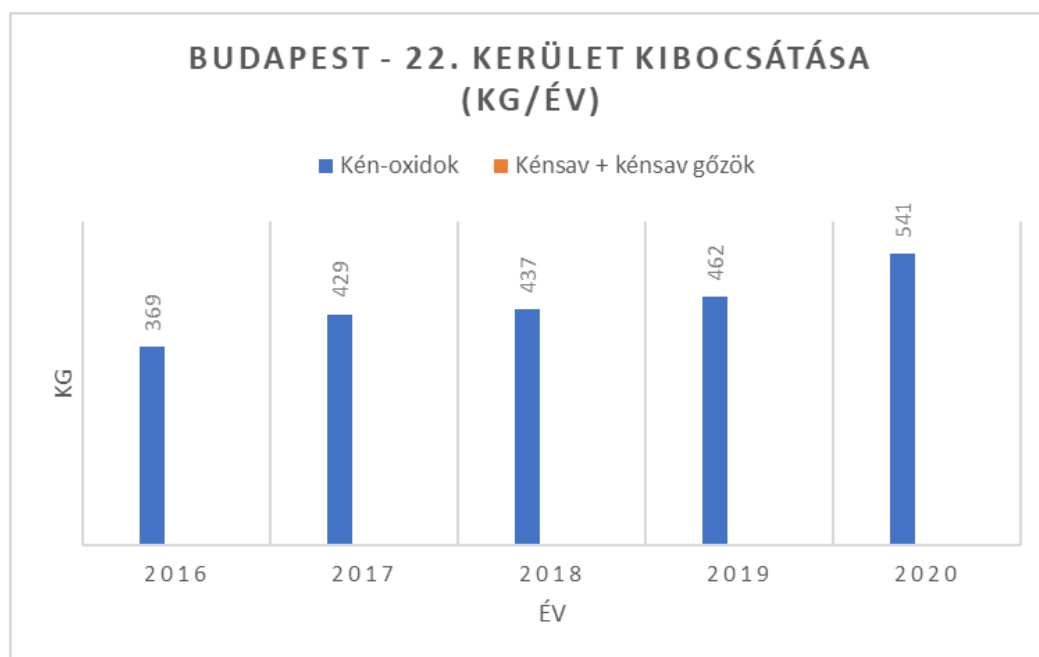


Figure 6. The XXII. district average annual (2016-2020) sulfur oxide emissions

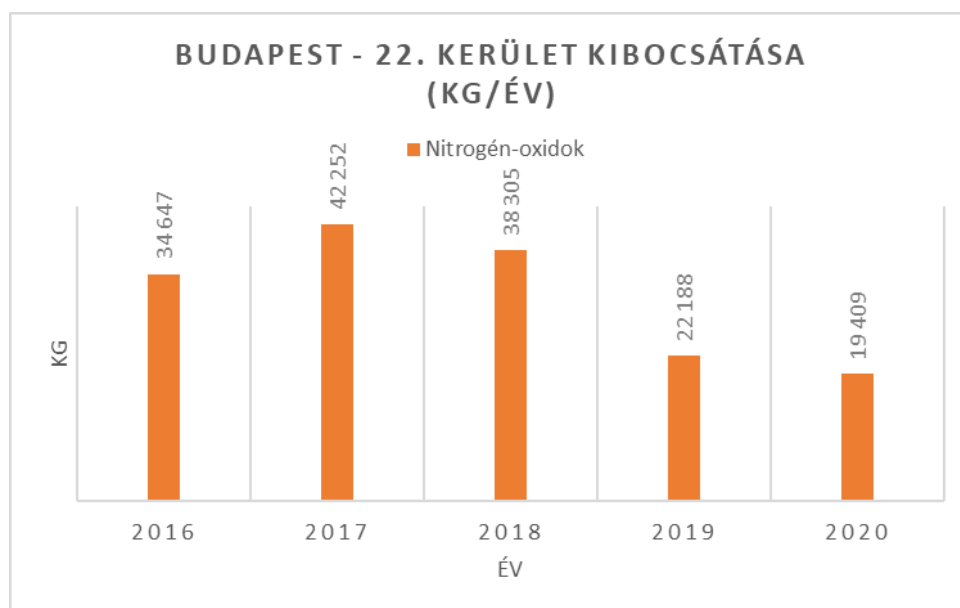


Figure 7 The XXII. district average annual (2016-2020) nitrogen oxide emissions

Examination of lichens around the industrial areas of Tatabánya

One of the important stops of our investigation was Tatabánya (Figure 9) and its industrial area. Tatabánya is located in the southern part of Komárom-Esztergom county in the Tatai ditch, which stretches between Vértess and Gerecses. It is bordered by the Vértess and Gerecses rivers to the north, east and south, and the Kisalföld to the west. The largest water catchment in the region flows through the settlement, which is the Ártal River and the Galla stream. It is located 55 kilometers from Budapest, and its average height above sea level is 199 meters. It is considered a traffic hub at the county, regional and national level and is located almost halfway between Budapest and Győr. In terms of vehicular traffic, the M1 highway connecting Budapest and Vienna, the main road No. 1, and the Budapest-Hegyeshalom-Rajka railway pass through here. In addition to these, Tatabánya is of course connected to the surrounding settlements by high-traffic roads and, in terms of public transport, by other railway lines and bus routes.

The life of the city was determined by coal mining from 1894 until the regime change in 1989, which brought economic changes. The former coal, bauxite, stone mining, cement and aluminum production, as well as the state-owned construction industry activity gradually ceased or receded into the background. Their place was gradually taken over by the Industrial Park established in Tatabánya, which now operates in the following areas with 27 large companies:

- Machine industry
- Automotive industry
- Electronics
- Logistics, shipping
- Packaging technology and plastics industry
- Healthcare industry

In Tatabánya, the factories of the multinational companies are basically located in the area of the Industrial Park, which was established on the border of Tatabánya from the Környe side, but one or two larger companies have also settled on the site of the old mine buildings. Thus, we can say that two pollution zones with industrial activities have formed in Tatabánya. The companies located here are active in the following areas on the site of the buildings connected to the older mining industry:

- Machine industry
- Chemical industry
- Logistics
- Quarrying

- Sawmill

I completed my examination in the area of Tatabánya on 18.03.2022. The weather was cool, with temperatures around 5-10 °C. Location "A" (Figure 8) is located in the older industrial part of Tatabánya, near the production hall of a chemical multinational company, on Fatelepi út. Here, the huge traffic contributes to the pollution of the factory, as both a lot of trucks arrive at the factory and the neighboring logistics company handles a lot of traffic on an average day. Also, there is a sawmill and a quarry nearby, so the concentration of airborne dust is very high in the area. There are very few trees in the area due to industrial activities.



Figure 8. Sampling site "A" in front of Fatelepi 15

There are very few trees in the area due to industrial activities. I managed to find a total of 3 examinable trees in the area. (Figure 9)

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red	<i>Physcia adscendens</i> • The colony has a warty, vesicular, uneven surface, and the back is whitish • Colony: Lobos

• Socket: Tree bark • Size: Large, 10-12 cm	• Body color: ash gray • Size: Small, 2-5 cm
	
<i>Xanthoria parietina</i> (Sárga falizuzmó) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large, 5-10 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 2-3 cm
	
<i>Xanthoria parietina</i> • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large, 12-17 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 1-2 cm

Figure 9. Collection and identification of lichen samples taken at Tatabánya (Fatelepi 15)

Based on the sampling, it can be said that *Xanthoria parietina* (Yellow wall moss) and *Physcia adscendens* are the dominant species at sampling location "A". Our next sampling site (Figure 10) was the Ifjúság grove, located not far from the "A" site, which is close to the Tatabánya thermal power plant and a busy road passes by it. The Park does not occupy a large area; there was no lichen to be found on most of the trees. (Figure 11)

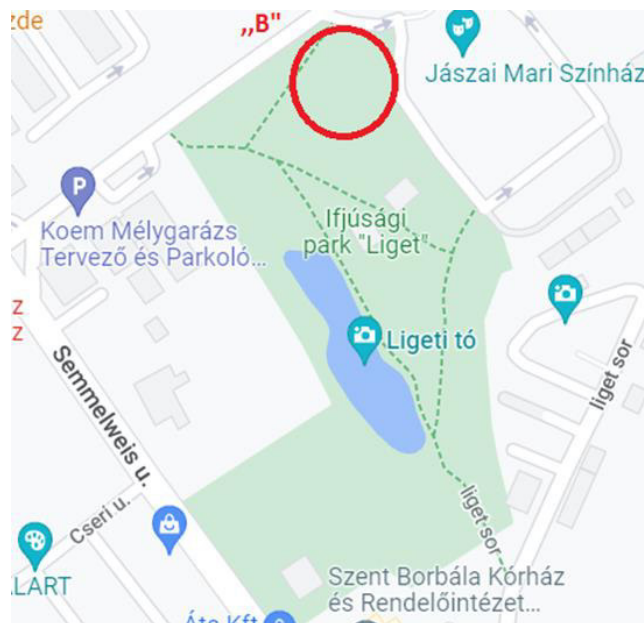


Figure 10. "B" sampling location, the Youth Park, "Liget"

					
<i>Physcia adscendens</i> • Colony: Lobos, Body color: ash gray, Size: Small, 3-4 cm					
					

Flavoparmelia caperata

- Colony: Lobos;
- Colony color: Grey-green, possibly yellowish;
 - Size: Small, 0.5-1cm;
- Base: Tree bark Other: its back is black

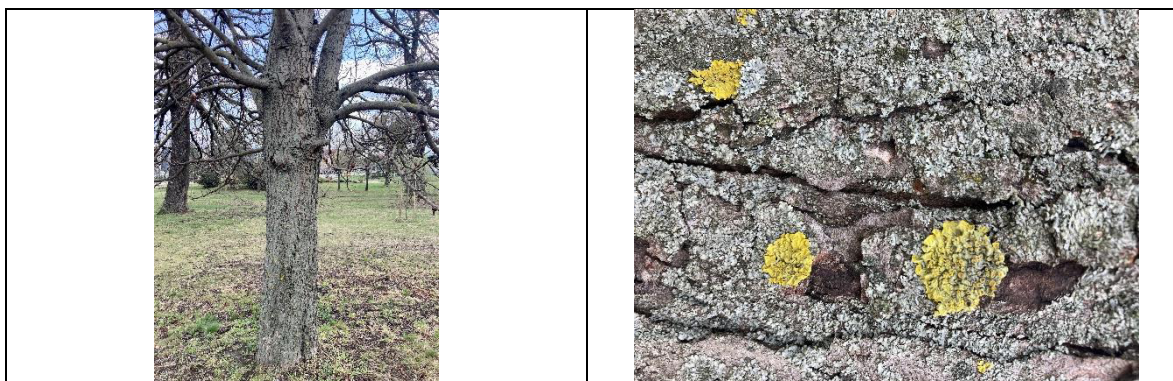
	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Small, about 0.5 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.5 cm • Sporadic in several places on the trunk

Figure 11. The collection and identification of my lichen samples taken at Tatabánya (Youth Park (Liget))

Based on the sampling, it can be said that *Xanthoria parietina* (Yellow wall moss) and *Physcia adscendens* are the dominant species at the "B" sampling site, similarly to the "A" test site. Our next location (Figure 12) is about two kilometers from here, at a traffic junction. There is a 4-lane main road here with a lot of traffic, as well as a bus interchange and a gas station.



Figure 12. "C" sampling location, Károlyi Mihály utca



<i>Xanthoria parietina</i> • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Small, about 2-3 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.5 cm • Sporadic in several places on the trunk
	
<i>Xanthoria parietina</i> • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large, approx. 12 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: very small, about 0.3 cm • Sporadic in several places on the trunk
	
<i>Xanthoria parietina</i> • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Small, about 0.5 cm • Socket: Tree bark	<i>Physcia adscendens</i> • Colony: Lobos • Colony color: ash gray, dark gray • Size: continuous layer • Trunk in several places

• Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	
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Figure 13. Collection and identification of my lichen samples taken at Tatabánya (Károlyi Mihály utca)

As in the previous two study sites, the same two species were dominant here. Our next test location was Bánhida in Tatabánya (Figure 14). It is a residential area, but there is a 2-lane road with heavy traffic next to my sampling location. (Figure 15)



Figure 14. "D" sampling site, Bánhida sculpture park

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large, about 4 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	

	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Leafy lichen. • Color: grey. • Size: small, 0.5 cm and smaller • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.	<i>Flavoparmelia caperata</i> • Colony: Lobos • Colony color: Grey-green, possibly yellowish • Size: Small, 0.5-1cm • Socket: Tree bark • Other: His back is black
	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Leafy lichen • Color: grey • Size: small, 0.5-1 cm • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.	<i>Flavoparmelia caperata</i> • Colony: Lobos • Colony color: Grey-green, possibly yellowish • Size: Large, 4 cm • Socket: Tree bark • Other: His back is black

Figure 15. Collection and identification of lichen samples taken at Tatabánya (Bánhida)

Based on the sampling, it can be said that *Hypogymnia physodes* and *Flavoparmelia caperata* are the dominant species at sampling site "D". The location "E" is also a busy hub, there are grocery stores here, and a construction site is currently underway. The M1 ramp is also not far from it.



Figure 16. "E" sampling site on Győri út

<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large, 15-20 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscende</i> • Colony: Lobos • Body color: ash gray • Size: Small, 1-2 cm

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large, 15-20 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Phycia adscende</i> • Colony: Lobos • Body color: ash gray • Size: Small, about 1 cm scattered
	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large, 5-10 centimeter colonies form vertically running strips that almost touch each other • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Phycia adscende</i> • Colony: Lobos • Body color: ash gray • Size: Small, 2-5 cm

Figure 17. The collection and identification of my lichen samples taken at Tatabánya (Győri út)

Yellow wall lichen was the most dominant species at this sampling site. Our last sampling location in Tatabánya took place in the area of the new industrial park, where there are very few trees. No lichens were found in the examined area (Figure 18).

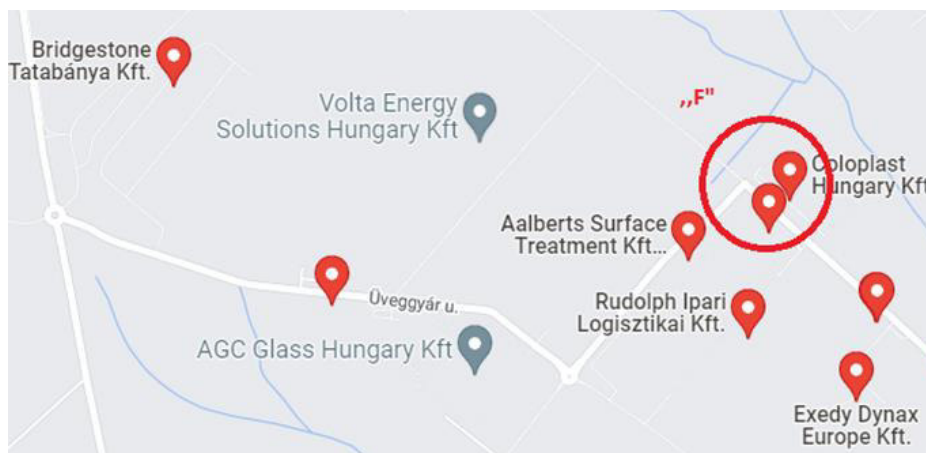


Figure 18. Sampling location "F" in the area of the industrial park

Table 2 summarizes how the number of trees with and without lichen developed on the trees examined in the area I chose: The Table shows how many testable samples we found among the trees in the selected area:

Table 2. Number of trees examined in Tatabánya, with and without lichens

Location	Area	Number of trees with lichens	Number of trees without lichens	Diameter	Type and number
Tatabánya	A	3	1	2-17 cm	Yellow and grey
	B	3	5	0,5-4 cm	Grey and yellow
	C	3	2	0-12cm	Grey and yellowish green
	D	3	4	0,5-4cm	Yellowish grey and grey
	E	3	0	1-20cm	Yellow and grey
	F	0	2	-	-

The following Figures show Tatabánya's emissions of various sulfur oxides and nitrogen oxides based on OKIR data between 2016-2020 (Figure 19, Figure 20), respectively.

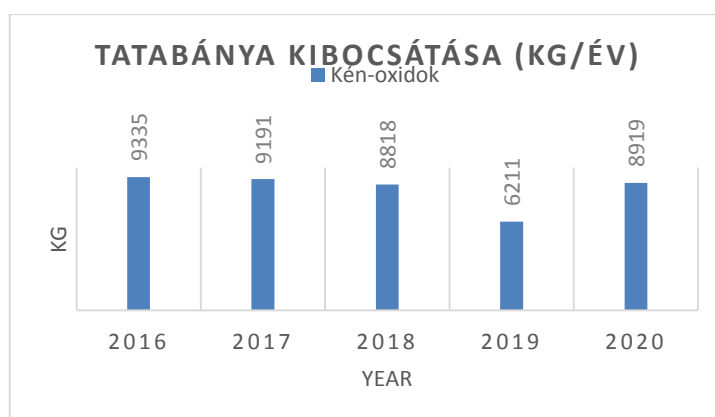


Figure 19. Average annual (2016-2020) sulfur dioxide emissions in Tatabánya

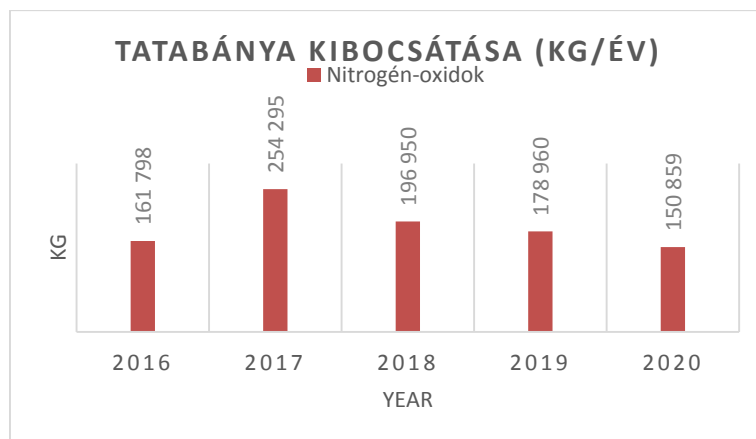


Figure 20. Average annual (2016-2020) sulfur dioxide emissions in Tatabánya

Examination of lichens in Budapest, XIII. district kindergartens Our examination in the XIII. We completed it in the area of district kindergartens on 11.03.2022 and 16.03.2022 (Figure 21) which shows the locations of the collections in the afternoon hours between 13.00 and 17.00. The weather was cool, with temperatures around 10-15 °C.



Figure 21. Map of the Budapest, XIII. district. Samples collection

The XIII. district is located on the Pest side of Budapest, next to the Danube. In the 20th century, it was considered one of Hungary's most important machinery industry centers, but after the change of regime, industrial activity took a backseat, and trade took over the leading role. The busiest roads in the district are: Váci út, Béke utca, Lehel utca, Újpest-rakpart, Róbert Károly körút, Dózsa György út and Szent István körút. The heavy traffic in this area results in significant noise and air pollution. It is one of the fastest developing districts of the capital. Construction is currently underway in several parts of the district, which creates a lot of airborne dust in the area. In the district, more and more emphasis is being placed on the development of groves and green areas and the construction of parks. The first test sites are located in the vicinity of location "A", Angyalföldi út and Lőportár utca (Figure 22).



Flavoparmelia caperata

• Colony: Leafy lichen. • Colony color: yellowish, greyish, greenish. • Size: larger, about 8-10 cm. • Fruiting body: Apothecium (yellowish, greyish) • Socket: Tree bark • Other: The lichen colony is damaged. Its surface is matte, its apothecia are slightly protruding and yellowish in color.



Flavoparmelia caperata (Yellow plate lichen)

• Colony: Leafy lichen. • Colony color is yellowish, greyish, greenish. • Size: smaller, about 1-2 cm. • Fruiting body: Apothecium (grey) • Socket: Tree bark • Other: The surface is matte, the apothecia are slightly protruding, wrinkled and yellowish in color. Damaged lichen colonies.



Flavoparmelia caperata (Yellow plate lichen)

• Colony: Leafy lichen. • Colony color: Yellowish, greyish. • Size: The colony is approximately 5-6 cm in diameter. • Fruiting body: Apothecium (orange) • Socket: Tree bark • Other: The surface is matte, the lobes are wrinkled and fragmented.



Physcia caesia

• Leafy lichen. • Its color is whitish, grey. • Size: small, 0.5 cm • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.

Figure 22. The XIII. district: ollection and identification of collected lichen samples from the XIII. district (Angyalföldi út and Lőportár út)

Based on the samples, the most dominant species around area "A" is *Flavoparmelia caperata* (Yellow plate lichen). The location of the next investigation location is "B", this area around Jász utca and Rokolya utca.



Hypogymnia physodes (Swollen plate lichen)

• Leafy lichen. • Color: grey. • Size: small, 0.5 cm (many small ones scattered over a large area) • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.

	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Leafy lichen. • Color: grey. • Size: small, 0.5 cm (many small sizes scattered over a large area) • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.	
	
<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Leafy lichen. • Its color is yellowish, grey. • The diameter of the colony is approximately 3-4 cm. • Its surface is matte, its lobes are ruffled. • Found on tree bark	<i>Hypogymnia physodes</i> (Swollen plate lichen) • Leafy lichen. • Color: grey. • Size: difficult to determine, covers a large area of the tree trunk • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.
	
<i>Hypogymnia physodes</i> (Swollen plate lichen)	

• Leafy lichen. • Color: grey. • Size: small, 0.5 cm (many small sizes scattered over a large area) • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.	
	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Leafy lichen. • Color: grey. • Size: Undeterminable, dense, scattered over a large surface • Its surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled. • Found on tree bark.	

Figure 23. The XIII. collection and identification of lichen samples from the district (around Jász utca and Rokolya utca)

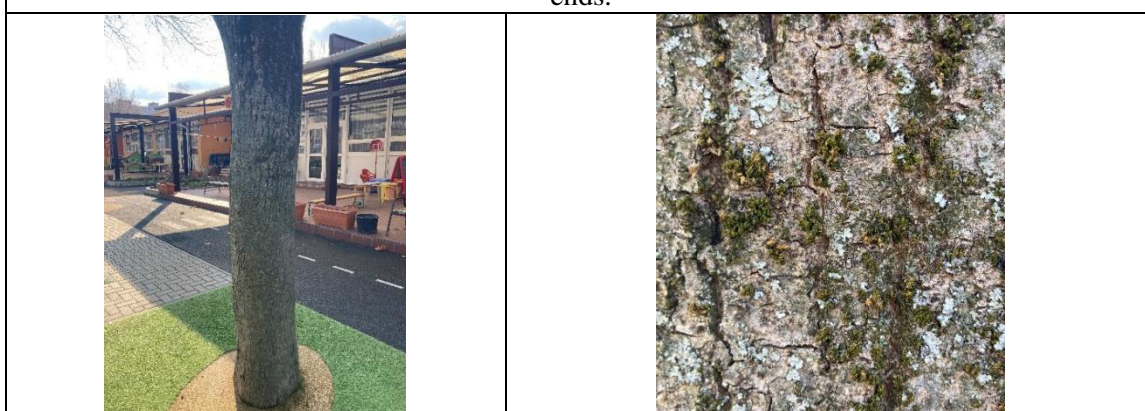
Based on the pictures, it can be observed that the most dominant species around area "B" is *Hypogymnia physodes* (Swollen plate lichen). The location of next investigation and location is "C", located at the Gyöngyösi promenade and its surroundings

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Colon color: golden yellow • Fruiting body: apothecium • Size: small, 2-3 cm • Base: tree bark • Other: Colony uneven with warts and blisters	<i>Phaeophyscia orbicularis</i> • Colony: Lobos • Battery color: Dark gray • Fruiting body: Apothecium • Size: Small, 0.5 cm • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.



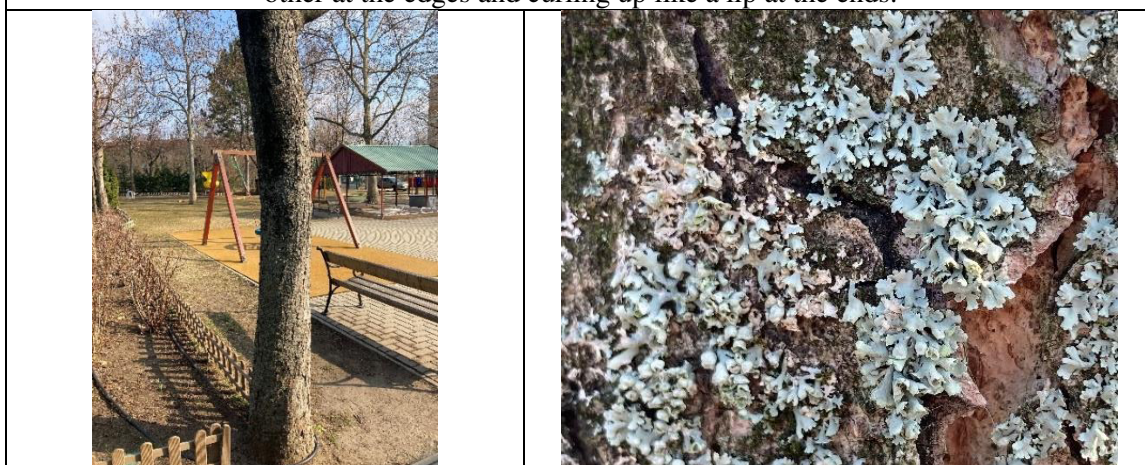
Hypogymnia physodes (Swollen plate lichen)

- Colony: Lobos • Body color: Ash gray • Size: Small, 2-3 cm • Socket: Tree bark • Other: The colony consists of frills overlapping each other at the edges and curling up like a lip at the ends.



Hypogymnia physodes (Swollen plate lichen)

- Colony: Lobos • Body color: Ash gray • Size: Small, 0.5 cm (Dense, covers a large surface on the bark of the tree) • Socket: Tree bark • Other: The colony consists of frills overlapping each other at the edges and curling up like a lip at the ends.



Physcia adscendens

- Colony: Lobos • Body color: ash gray • Size: Large, 10-15 cm • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large 5-6 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.5-1 cm • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.
	
<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.5-1 cm (They are located densely on the bark of the tree, covering a large surface) • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.	

	
<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Large, 10-15 cm • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.	<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 1 cm • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.
	
<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 2-3 cm • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.	<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 2-3 cm • Fruiting body: Apothecium, yellow • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.
	
<i>Xanthoria parietina</i> (Yellow wall lichen)	

• Colony: Lobos • Battery color: Golden yellow • Size: 4-5 cm • Fruiting body: Apothecium, orange • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.	
	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Colony: Lobos • Body color: Ash gray • Size: Can't be determined (Dense, covers a large area on the bark of the tree) • Socket: Tree bark • Other: The colony consists of frills that overlap each other at the edges and bend up like a lip at the ends	

Figure 24. The collection and identification of the lichen samples from the XIII. district (Gyöngyösi sétány).

Based on the pictures, it can be observed that the most dominant species around area "C" is *Physcia adscendens*. The location of the next investigation is the location "D", Vizafogó promenade and its surroundings.

	
<i>Hypogymnia physodes</i> (Duzzadt tányérzuzmó) • Hypogymnia physodes (Swollen plate lichen) • Colony: Lobos • Body color: Ash gray • Size: Small, 0.5 cm (Rarely, scattered on the bark of the tree) • Socket: Tree bark • Other: The colony consists of frills overlapping each other at the edges and curling up like a lip at the ends.	

	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Colony: Lobos • Body color: Ash gray • Size: Small, 0.5 cm (Rarely, scattered on the bark of the tree) • Socket: Tree bark • Other: The colony consists of frills overlapping each other at the edges and curling up like a lip at the ends.	
	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Colony: Lobos • Body color: Ash gray • Size: Small, 0.5 cm (Rarely, scattered on the bark of the tree) • Socket: Tree bark • Other: The colony consists of frills that overlap each other at the edges and bend up like a lip at the ends	
	
<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 4-5 cm • Fruiting body: Apothecium, yellow • Socket: Tree	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: It is difficult to determine, it is densely located on a large surface on the trunk of the tree. • Other: Light-colored eyelashes can be seen on

bark Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.	the edges of slender frills. The end of the frills bulges out in the shape of a helmet.
	
<i>Hypogymnia physodes</i> (Swollen plate lichen) • Colony: Lobos • Body color: Ash gray • Size: Small, 1 cm (Rarely, scattered on the bark of the tree) • Socket: Tree bark • Other: The colony consists of frills overlapping each other at the edges and curling up like a lip at the ends.	
	
<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 4-5 cm • Fruiting body: Apothecium, yellow • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: It is difficult to determine, it is densely located on a large surface on the trunk of the tree. • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.

Figure 25. The collection and identification of lichen samples from the XIII. district (Vizafogó sétány).

The most dominant lichen species around area "D" is *Physcia adscendens*. The location of my next investigation is the location "E", it is located at the Karpát and the vicinity of Vág utca (Figure 26).



Flavoparmelia caperata (Yellow plate lichen)

- Colony: Lobos • Colony color: Yellowish, greenish • Size: Small, 0.5-1 cm (Scattered on a small surface) • Fruiting body: Apothecium, yellow • Socket: Tree bark Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.



Hypogymnia physodes (Swollen plate lichen)

- Colony: Lobos • Body color: Ash gray • Size: Small, 0.5 cm (Rarely, scattered on the bark of the tree) • Socket: Tree bark • Other: The colony consists of frills overlapping each other at the edges and curling up like a lip at the ends.



Hypogymnia physodes (Swollen plate lichen)

Flavoparmelia caperata (Yellow plate lichen)

• Colony: Lobos • Body color: Ash gray • Size: Small, 0.5 cm • Base: Fabric material on tree bark • Other: The colony consists of frills overlapping each other at the edges and curling up like a lip at the ends.	• Colony: Lobos • Colony color: Yellowish, greenish • Size: Small, 0.5 cm (Scattered on a small surface, damaged) • Socket: Tree bark Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.
	
<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 4-5 cm • Fruiting body: Apothecium, yellow • Socket: Tree bark Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.	<i>Phaeophyscia orbicularis</i> • Colony: Lobos • Battery color: Dark gray • Fruiting body: Apothecium • Size: Small, 4-5 cm Base: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.
	
<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 4-5 cm • Fruiting body: Apothecium, yellow • Socket: Tree bark Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.	Swollen • Colony: Lobos • Battery color: Dark gray • Fruiting body: Apothecium • Size: Difficult to determine, covers a large surface, approx. 100 cm • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.

	
<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 2-3 cm • Socket: Tree bark Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.	<i>Phaeophyscia orbicularis</i> • Colony: Lobos • Battery color: Dark gray • Fruiting body: Apothecium • Size: Small, 2-3 cm (Several smaller ones are scattered on the tree trunk) • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled
	
<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: It is difficult to determine, it is densely located on a large surface on the trunk of the tree, about 1 m in size. • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.	<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony: Lobos • Colony color: Yellowish, greyish • Size: Small, 2-3 cm • Fruiting body: Apothecium, yellow • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.

	
<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: It is difficult to determine, it is densely located on a large surface on the trunk of the tree, about 1.5 m in size. • Other: Light-colored eyelashes can be seen on the edges of slender frills. The end of the frills bulges out in the shape of a helmet.	<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Yellow • Size: Small, 2-3 cm • Fruiting body: Apothecium, yellow • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.
	
<i>Phaeophyscia orbicularis</i> • Colony: Lobos • Battery color: Dark gray • Fruiting body: Apothecium • Size: Large, covers most of the tree trunk, about 1.5 in height. • Socket: Tree bark • Other: The surface is matte, it has wrinkled lobes, the edges of the colonies are wrinkled.	

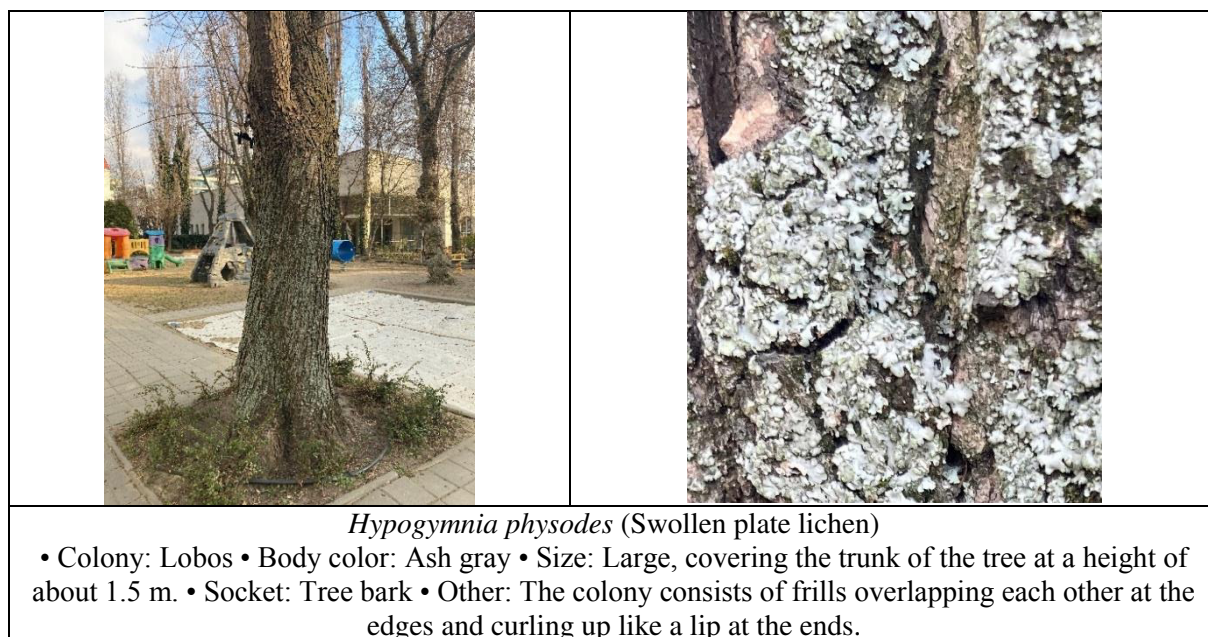


Figure 26. The collection and identification of lichen samples from the XIII. district (Kárpát utca and Vág utca)

The most dominant species from the investigated area "E" is *Physcia adscendens*, which can be found on the largest surface.

The following Table 3 shows how many testable samples we found among the trees in the selected area.

Table 3. The number of trees examined in the XIII. district, with and without lichen

Location	Area	Number of trees with lichens	Number of trees without lichens	Diameter	Type and number
Budapest XIII. kerület	A	4	3	0.5-10 cm	Yellowish-grey, grey
	B	5	2	0.5 -4 cm	Yellowish-grey, grey
	C	10	3	0.5-150 cm	Yellowish-grey, grey, yellow
	D	8	2	0.5- 20/30 cm	Yellowish-grey, grey
	E	10	4	0.5-160 cm	Yellowish-grey, grey, yellow

The following Figures 27 and 28 are showing the emissions of various sulfur oxides and nitrogen oxides from XIII. district based on OKIR data between 2016-2020.

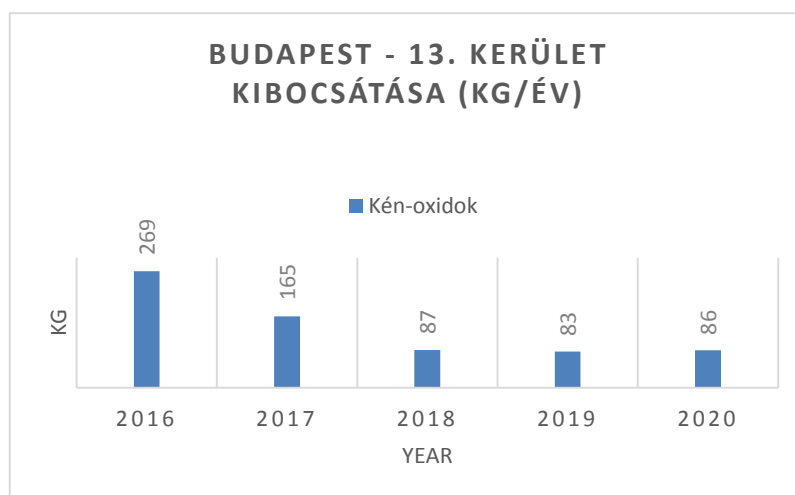


Figure 27. The XIII. district average annual (2016-2020) sulfur oxide emissions

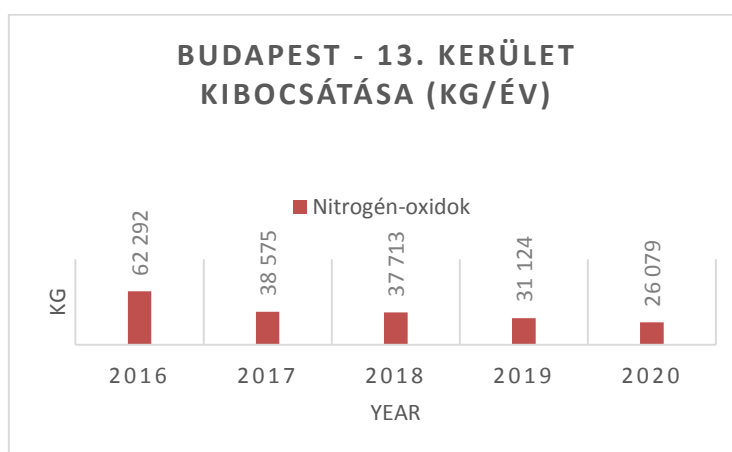


Figure 28. Average annual (2016-2020) nitrogen oxide emissions in XIII. District

EXAMINATION OF LICHENS IN THE XX. DISTRICT RESIDENTIAL AREA

Pesterzsébet, Budapest XX. district (Figure 29), touching the banks of the Soroksári-Danube, it is located in South Pest. Its area is 2.3% of the total area of the capital, which makes it the seventeenth place among Budapest's 23 districts. The district consists predominantly of residential properties, its industry is negligible. An important institution of the district is the Jahn Ferenc Dél-Pest Hospital, which was handed over in 1980. In the northwest, along the Határ road, the IX. bordering the district, in the northeast, it is separated from the XIX. from the district, Soroksár separated from the district from the south, the XXIII. district, while on the western edge is the Ráckevei (or Soroksári)-Danube, on the other side of which is Csepel, the XXI. district is located. The Gubacsi Bridge (or Csepel Passage) spanning the river connects the town with Csepel Island.

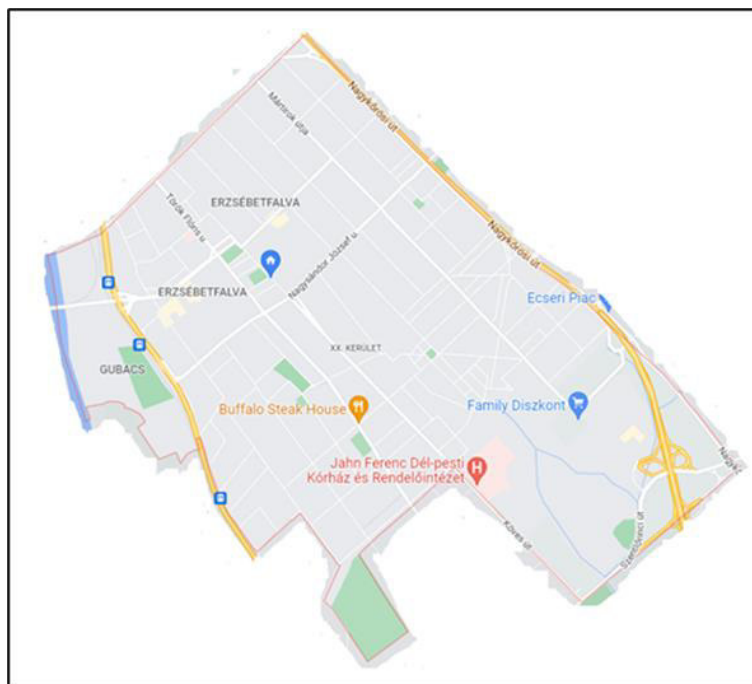


Figure 29. Map of collection sites in Budapest XX. district

Traffic in the district is relatively quiet, because a significant part of the roads with heavy traffic run along the edge of the district (Soroksári út on the west side, the entrance section of the M5 highway on the east, Határ út on the north). From the south, the fastest approach by rail is HÉV H6 and the Budapest–Kunszentmiklós–Tass–Kelebia railway line. Both railways have stops near the city centre. The study of lichens is the whole of the 20th century. District-wide. The main environmental impacts are caused by traffic.

	
<i>Pertusaria albescens</i> A family of bark beetles • Colony color: greenish white. grayish white. • Fruiting body: apothecium, rare. • Base: tree bark. • Habitat: wooded, light-rich forest. • Frequency: common. Other: its colony is surrounded by a white precolony, on which characteristic small, white spot corals can be seen.	

	<i>Flavoparmelia caperata</i> A Family of Deciduous Plants • Colony color: yellowish green, greyish green. • Fruiting body: apothecium, rare. • Substrate: tree bark, rock. • Habitat: wooded, light-rich forest, rare orchard. • Frequency: common. • Other: declining due to increasing air pollution.
	<i>Flavoparmelia caperata</i> (Yellow plate lichen) • Colony color: greenish gray. • Fruiting body: apothecium, yellowish-brown, red-brown. • Base: tree bark. • Habitat: also in human environment. • Frequency: moderately common. • Other: a species of lichen resistant to air contamination (toxitolerant).
	<i>Xanthoria parietina</i> Deciduous • Colony color: golden yellow, orange. • Fruiting body: apothecium, orange-red. • Substrate: tree bark, rock. • Habitat: open, rich in light, also in a human environment. • Frequency: common. • Other: colony with warty, vesicular, uneven surface, thread whitish.

Figure 30. The collection and identification of lichen samples from in the XX. district

The most dominant lichen species around District XX is *Flavoparmelia caperata* (Yellow plate lichen), which can be found on the largest surface. The following Figures 31 and 32 show the emissions of various sulfur oxides and nitrogen oxides based on OKIR data between 2016 and 2020.

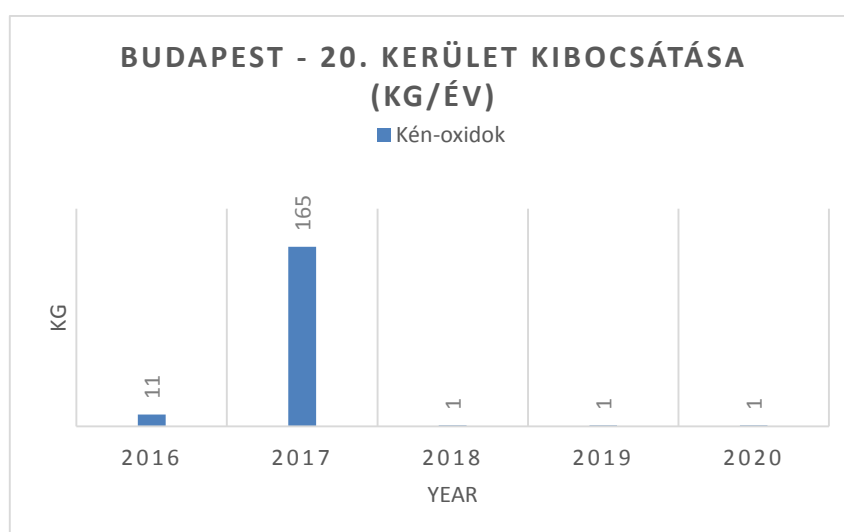


Figure 31. The XX. district average annual (2016-2020) sulfur oxide emissions

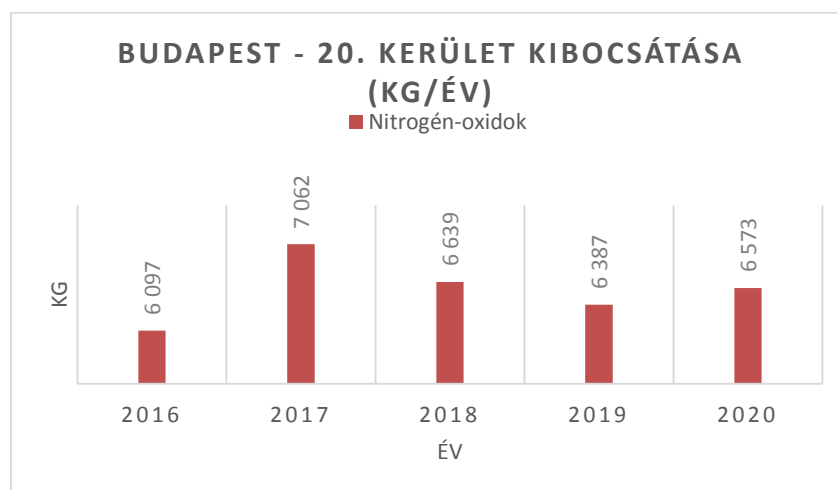


Figure 32 The XX. district average annual (2016-2020) nitrogen oxide emissions

EXAMINATION OF LICHENS IN VÁRGESZTES

Characterization of Várgesztes

Territorially, the settlement of Várgesztes belongs to the geographical large landscape of the Transdanubia Mountains, within it the Vértes-Velencei Mountains to the central landscape, the Vértes Mountains to the small landscape group and the Vértes Peripheral Region to the small landscape. It is located on the edge of Komárom-Esztergom County, in the northwestern part of the Vértes Mountains, in a valley, 17 kms from Tatabánya. It can be approached by a single road, a sack village. There is very little vehicular traffic, and there are no industrial areas in the vicinity (Figure 33).

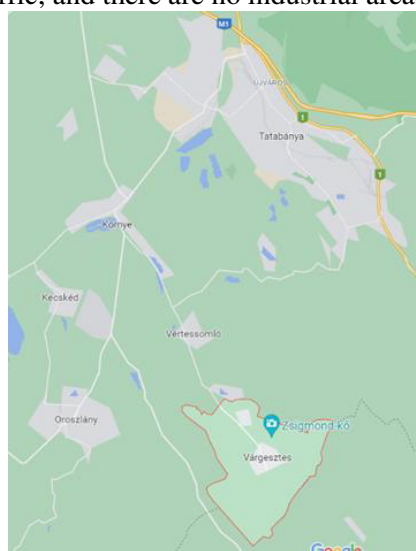


Figure 33. Location of Várgestes compared to the surrounding settlements

Topography: The structure of the Vértes is sásslar and slightly more segmented than that of neighboring Gerecs to the north and Bakony to the south. On average, there are valleys with a length of 4 km projected onto an area of 1 km². The trench basins in Várgesztes and Vértessomló are tectonic trench basins covered with Tertiary sediments between tuffaceous cherts, which follow fault lines in a southwest-northeast direction. From a landscape ecological point of view, vertical separation can be said about forest communities. The Atlantic influence is in effect, thanks to which it is a rainier

area, the average annual rainfall exceeds 700 mm. In the northern part, approximately a few hundred millimeters more precipitation falls than in the southern parts.

Climate: The climate of Várgestes can be said to be very specific. The surrounding elevations, which exceed 400 m, are characterized by a moderate cool, wet, mild winter climate. However, in the pool where the village is located, the average annual temperature is 9°C, 16°C in the summer semester, with an average July temperature of 19.5-20°C. The low temperature is partly due to the fact that the North Vértes can be classified as one of the more gloomy landscapes of our country. The annual average of cloud cover is nearly 60%, and can reach up to 45% in summer. The Gestes basin is particularly characterized by damp weather with fog formation. The number of foggy days can be up to 30-40 days per year. For example, in December, the pool is shrouded in fog for an average of 6-8 days. Due to the average cloud cover, the number of sunny hours can only be 1900-2000 hours. The summer is moderately hot; there are 5-20 so-called hot days out of 60 summer days. This can be considered low in national terms.

There is no strong summer warming in the pool. The frosty period covers a large part of the year, since the first autumn frost sets in already in mid-October and frosty days are frequent until the end of April. These days make roughly 100 days. Thanks to the effect of the pool, the winter is not extreme, but moderately cold, with an average temperature of 2°C. The number of winter days is more than 35. On average, we can talk about 35-45 days with snow, when the thickness of the snow is 7-9 cm, in rare cases a maximum of 80 centimeters.

Blows of snow are common. It is interesting that, leaving the Gesztes basin, it can be 1-2°C cooler than the Somlói bridge, despite this, the snow melts in the basin up to 2-3 weeks later than on the plain in front of it.

The prevailing wind direction in the area is north-west, which is reinforced by the Móri and Tatai moats. The wind speed is around 3-3.5 m/s.

The distribution of the annual 700 mm of precipitation is as follows:

- Maximum: June is the wettest, with an average of 65-85 mm of rain
- Second maximum: November, 60-80 mm is typical
- Minimum: March is the poorest in terms of precipitation, characterized by 30-40 mm Although in terms of the number of rainy days, the area is above the national average with its 140-170 rainy days, and the landscape is subject to high precipitation uncertainty. A single rain can be followed by a longer dry period or even a year.

Hydrogeography There are few watercourses in Vértes, the reason for which is that the dolomite has an extremely good water storage capacity, and the water permeability of the loose soil and crumbly, gravelly rocks found here is also very high. The consequence of this is that precipitation can seep deeply in a fairly short time. So it is not surprising that the Gesztesi stream also appears in a wet area, but its water yield is very small.

The water quality of the water in the Gesztes basin has improved significantly since the canal system was established in 1993. Flora-Fauna Due to the segmentation of Vértes, we can observe a rich fauna and flora in this area. We can meet many protected animal species, such as the bald eagle or the peregrine falcon, the alpine and the mourning hawk. Among the plants, we can see sand female petals or even black and maidenhair primrose, bear's ear primrose.

Although Várgesztes is marked on the vegetation maps at the boundary of the cherry-oak and chert-oak areas, there are also pines, beeches and acacias here. Unfortunately, the size of the forest has shrunk significantly in recent times due to human activity and forestry reasons, thus having a significant impact on the lichens that live here. Várgestes can therefore be said to be a very favorable habitat for various lichens.

There is a difference in level between the different locations and the water supply of the areas also varies. We took the samples on the afternoon of March 26. Sampling site "A" is located in a dead-end street at 6 Erdősor utca. Vehicle traffic can only be experienced in the morning and evening hours. (Figures 34 and 35).



Figure 34. Sampling sites "A" and "B" in Várgesztes

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Large 5-6 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.5-1 cm
	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: approx. 5 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.5-2 cm scattered in several places on the trunk

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: 4-5 cm • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: approx. 0.5 cm
	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: 5-7 cm, several large colonies on the trunk and branches • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.3-0.5 cm
	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: 7-10 cm, mainly on the branches • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Physcia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: 3-4 cm

Figure 35. Collection and identification of lichen samples taken in Várgesztes (Erdősor utca)

Based on the samples, *Xanthoria parietina* (Yellow wall moss) and *Phycia adscendens* are the most dominant in area "A". The other sampling location "B" is the sports field in the village center. In addition, there is the village hall, kindergarten and a cemetery, so there is little traffic here. I was able to document the following lichens on the sports field:

	
<i>Xanthoria parietina</i> (Yellow wall lichen) • Colony: Lobos • Battery color: Golden yellow • Fruiting body: apothecium, orange-red • Size: Stripes running vertically on the trunk • Socket: Tree bark • Other: The colony has a warty, vesicular, uneven surface, and the back is whitish	<i>Phycia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Small, 0.5-1 cm
	
<i>Flavoparmelia caperata</i> • Colony: Lobos • Colony color: Grey-green, possibly yellowish • Size: 3-4 cm • Socket: Tree bark • Other: His back is black	<i>Phycia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: Scattered on the trunk
	
<i>Flavoparmelia caperata</i> • Colony: Lobos • Colony color: Grey-green, possibly yellowish • Size: 2-5 cm • Socket: Tree bark • Other: His back is black	<i>Phycia adscendens</i> • Colony: Lobos • Body color: ash gray • Size: 0.5 – 2 cm colonies touching each other on the trunk

Figure 36. The collection and identification of my lichen samples taken at Várgeszttes (Sports Field)

Based on the samples collection, *Physcia adscendens* is the most dominant in area "B". The following Table shows how many samples were found on the trees in the selected area (Table 4).

Table 4. Number of trees examined in Várgesztte, with and without lichen

Location	Area	Number of trees with lichens	Number of trees without lichens	Diameter	Type and number
Várgeszttes	A	5	0	0,3-7 cm	Yellow-grey Grey Yellow-green
	B	3	0	0,5-5 cm	Yellowish-grey Grey Yellow-green

At the sampling locations, we found that the lichen colonies are extensive, healthy and grow abundantly. In the following table, we have summarized the typically dominant lichen species of the investigated areas (Table 5):

Table 5. Summary of dominant lichen species in the investigated areas

Area	Location	dominant Lichen
Tatabánya	A	<i>Xanthoria parietina</i> <i>Physcia ascendens</i>
	B	<i>Xanthoria parietina</i> <i>Physcia ascendens</i>
	C	<i>Xanthoria parietina</i> <i>Physcia ascendens</i>
	D	<i>Hypogymnia physodes</i> <i>Flavoparmelia caperata</i>
	E	<i>Xanthoria parietina</i>
	F	-
XXII. kerület		-
XIII. kerület	A	<i>Flavoparmelia caperata</i>
	B	<i>Hypogymnia physodes</i>
	C	<i>Physcia ascendens</i>
	D	<i>Physcia ascendens</i>
	E	<i>Physcia ascendens</i>
XX. kerület		<i>Flavoparmelia caperata</i>
Várgeszttes	A	<i>Xanthoria parietina</i> <i>Physcia ascendens</i>
	B	<i>Physcia ascendens</i>

CONCLUSION AND SUGGESTION

Based on our investigation, we conclude that in the industrial areas of Tatabánya and XXII. district in Budapest have a high level of pollution, which is not healthy for humans and other living beings. As we explained in the literature section, the high content of nitrogen dioxide and sulfur dioxide in the air can damage the mucous membrane, cause respiratory diseases and even lead to an asthma attack, and when it gets into the bloodstream, it can inhibit oxygen delivery. In addition, it can also have a negative impact on the ecosystem in terms of development and can also cause the buildings to

corrode. The XIII. district and XX. district is characterized by significantly less air pollution data, and in addition, their environmental conditions can also have a positive effect on them. Thanks to the location next to the Danube, pollutants are cleared from the air in this area more quickly due to the wind. In addition, green areas are also common, where there is a chance for dirt to accumulate. For example, XIII. In the sampling area of district "A", we can see damaged lichens in several places, which can be caused by the fact that, in addition to being located near busy roads, there is little wooded area around it, so there is nothing to catch dirt coming from the direction of traffic. On the other hand, the test sites "C", "D", and "E" are located near park areas and the Danube, where several factors ensure adequate air exchange and purification. Várgesztes, like small rural settlements, has the most ideal properties in all respects compared to the other areas we examined, which can also be seen in the lichen samples. Nitrogen dioxide is produced by the burning of fossil fuels and natural gas, or by the use of vehicles, mainly diesel fuel. We can even contribute to reducing them by replacing the heating with more environmentally friendly solutions, such as heat pumps, ground probe heat pumps, or electric heaters. And during transport, we can give preference to public transport or electric vehicles. In the literature review, we also touched on the positive effects of the green environment, trees, shrubs and bushes, with the help of which microclimates are recommended, especially in residential areas, workplaces and educational institutions.

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