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# Analysis of air pollution from industrial plants by lichen indication on example of small town

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**Abstract.** According to the research the species of lichens such as *Parmelia sulcata*, *Parmeliopsis ambigua*, *Phiscia stellaris*, *Xanthoria parietina* are founded on example of small town. Values of clear air index correlated with the average content of sulphur dioxide in the air. These measurement points correspond to residential areas and regions of the objects of food industry. Two zones zero projective coverage are selected. These most polluted zones corresponded to the location of the metallurgical industry and heat electropower station. The roof production and abrasive industry do not show a significant increase in the concentration of sulfur dioxide in the contiguous territory. By method lichen indication on example of small city two zones lichen deserts (sulfur dioxide concentration greater than 0.3 mg/m<sup>3</sup>) and one area of critical pollution (sulfur dioxide concentration of 0.1 -0.3 mg/m<sup>3</sup>) were founded. The largest area of air pollution allegedly linked to the activities of plants. Thus metallurgical industry and heat electropower station can be called major air pollutants in small towns.

## 1. Introduction

Anthropogenic sources that cause air pollution, as well as serious violations of the ecological balance in the biosphere are too many [1-5]. However, the most significant of them are two: the industry and transport [6, 7]. Strongest anthropogenic impacts on plant communities exert pollutants in ambient air, such as sulfur dioxide, nitrogen oxides, hydrocarbons, etc. Among them, the most typical is the sulfur dioxide formed by the combustion of sulfur-containing fuel [8] (thermal power plant, boilers, heating stoves populations, as well as transport especially diesel [9-10]).

One of the main objects of global biological monitoring selected lichens.

**The goal of the research is an investigation of the state of the atmosphere of the city by method lichen indication.**

**Objectives:**

- 1. Identify the species composition of lichens found in the city;**
- 2. Qualitative and quantitative analysis of air pollution by projective cover;**
- 3. Make a conclusion about the extent of air pollution in the city.**

Lichens are highly peculiar group of spore-bearing plants, consisting of two components - a fungus and single-celled rarely filamentous algae that live together as an integrated organism. When the main breeding and feeding function is due substrate belongs to the fungus, and the function of

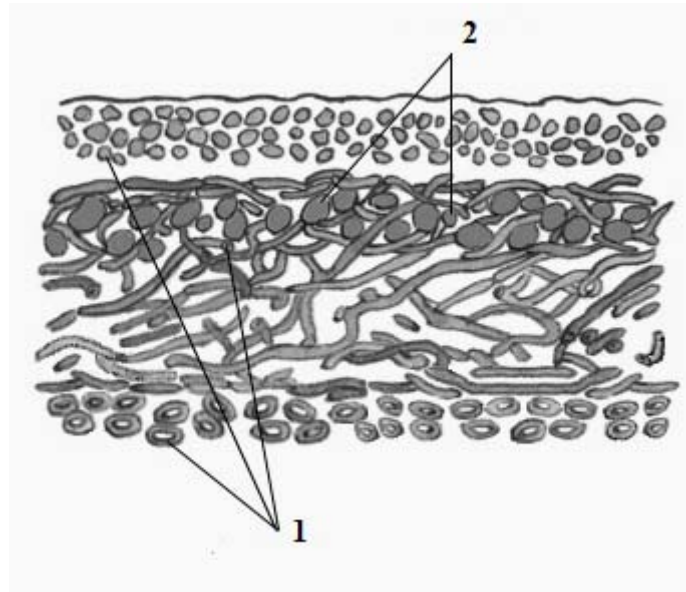


photosynthesis belongs to the algae. Most Lichen consists of a dense crust are formed by hyphae, which contain the necessary breathing pores (Fig. 1). Cora allows absorbing moisture from the air and protects the lichen from hypothermia or overheating. The hyphae are more porous under the bark. Between them algae cells are located [11]. Normally, photobiont cells are concentrated on the periphery closer to the light forming photosynthetic layer.

According to the anatomy of lichens are distinguished:

- In which algae are more or less uniformly distributed throughout the body;
- In which algae are located just beneath the bark.

Some lichens are involved in symbiosis also with bacteria thereby obtaining nitrogen directly from the air, or are parasitic on mosses and lichens.



**Figure 1.** The composition of lichen: 1 - fungal hyphae, 2 - algae cells

The research was conducted on only one type of trees: Poplar (lat. *Pópulus*). The analysis of scientific evidence revealed the dependence of growth of epiphytic lichens on the different tree species [12]. For example lichens can actively spread on poplars and conifers and less on the birches. Thus, to eliminate the error associated with the tree species composition poplar was selected for investigation.

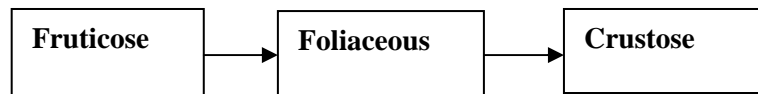
There are three groups of epiphytic lichens:

- **Crustose**. If thallus fit snugly to the substrate in the granular or like dust form plaque or in the form of scales and crusts of different shapes, such lichens are called crustose. These lichens are similar to the planar crust. It tightly fused with bark, stones, soil. It is difficult to separate the touch, velutinous and moist [5,14].

- **Foliaceous** (leaf like). If lichen thalli have the form of a more or less dissected plates (leaf blades), lichens are called foliaceous. These lichens have the shape of small plates, flakes, adhere to the surface by the thin filament fungus. And these lichens are rather easily separated from it.

- **Fruticose**. Lichens, which are bushy thallus consisting of in varying degrees of vertical branched columns are called fruticose. These lichens are either grow up as small bushes or hang from the tree down like a beard. Not having roots, lichens quite firmly attached to the substrate by special appendages located on the underside of the thallus[3,15].

Study all the lichen species in major cities around the world revealed a number of general laws: the more industrialized cities, more polluted than the air, the less common within its boundaries lichen species, the smaller area covered lichens on tree trunks, the lower the "vitality" of lichens. Found that an increase in air pollution lichens disappear as follows in descending order:



**Figure 2.** The disappearance of lichens with increasing air pollution [16]

## 2. Results and discussion

Before the measurements were allocated on a map of the point at which it is necessary to carry out measurements (Fig. 3). Test points were chosen on the location of basic industries and residential areas of the small city (Table 1).



**Figure 3.** Map of small town with marked measurement points

**Table 1** Location of basic industries and residential areas of the small city

Place of measurement (number of points on the -map)	Availability of industrial facilities
1,6	Food processing Industry
4	Heat electro power Station
8	Engineering production
7	Roof production
9	Metallurgical Plant
10	Abrasive production
5,2,3	Residential area

In the city found the following species of lichens:

- *Parmelia sulcata*

- *Phiscia stellaris*
- *Parmeliopsis ambigua*
- *Xanthoria parietina*.

Groups of epiphytic lichens are recorded in the Table 2.

For measuring the actual number of lichens on trees used mainly two methods - method of estimating projective cover, and methods of linear intersections. We used the method of measurement of projective cover. One of the most common ways to assess the relative abundance of lichens on tree trunks is to define the parameters of the projective cover, ie percentage of area covered with lichens, and areas free of lichens.

**Table 2** The species composition of lichens on the example of small towns

Number of measurement points	Species composition
1	Crustose , Foliaceous
2	Crustose , Foliaceous
3	Crustose , Foliaceous
4	No
5	Crustose
6	Crustose
7	Crustose
8	Crustose
9	No
10	Crustose , Foliaceous

Calculation of lichens follows:

First, the number of squares pallets in which lichens occupy more than half an eye on the area of the square (a) is counted, attributing to them conditionally cover of 100%. Then the number of squares in which lichens occupy less than half the area of the square (b) is counted, conventionally ascribing coating of 50% [17]. Data are recorded in the worksheet.

The total projective coverage in the percent (R) is calculated by the formula:

$$R = \frac{(100 \times a + 50 \times b)}{C} \quad (1)$$

a – number of squares pallets in which lichens occupy more than half on the area of the square

b - number of squares in which lichens occupy less than half the area of a square

C - total number of squares in the grid (for example, by using the grid of 10 x 10 cm. The cells with 1 x 1 cm., C = 100).

After determining the projective cover clear air index (CAI) is calculated.

$$CAI = \sum_{i=1}^n \frac{a_{i1} \times C_i}{C_i} \quad (2)$$

where

n - the number of species described in the test area,

$a_i$  –class type of clear air (1 to 10),

$C_i$  - projective cover of this species in points,  $C_n$  - the sum of all coating species.

Clear air index is correlated with the average content of SO<sub>2</sub> in the air (Table 3 and Table 4). Biological principle of quantitative composition of lichen with the amount of sulfur dioxide correlation based on the action of sulfur dioxide on lichens.

Lichens need to be very good at absorbing water and nutrients to grow there. Rainwater contains just enough nutrients to keep them alive. Air pollutants dissolved in rainwater, especially sulfur dioxide, can damage lichens and prevent them from growing.

Many fuels contain small amounts of sulfur compounds. When these fuels are burned sulfur dioxide is released into the air. Sulfur dioxide causes acid rain that can kill plants and aquatic animals [4,13].

**Table 3** The species composition of lichens on the example of small towns

Mark	1	2	3	4	5	6	7	8	9	10
Projective coverage, [%]	1-3	3-5	5-10	10-20	20-30	30-40	40-50	50-60	60-80	80-100

For example if there are no lichens present, the air quality is very poor (lichen desert, critical area of contamination), whilst generally only crusty lichens can tolerate poor air quality (zone of strong pollution). In moderate to good air, leafy lichens such as *Parmelia caperata* can survive and in areas where the air is very clean, rare species lichen may grow.

**Table 4** Correlation clear air index containing sulfur dioxide in air [14]

CAI	Concentration SO <sub>2</sub> [mg/m <sup>3</sup> ]	Conditional zone
1 – 2	Less than 0.01	normal
2 – 5	0.01 - 0.03	small pollution
5 – 7	0.03 - 0.08	medium pollution
7 – 10	0.08 - 0,10	severe contamination
10	0.10 – 0.30	critical pollution
0	More then 0.3	lichen desert

According to the research several zones with high values of projective coverage (over 50%) are identified. And two zones zero projective coverage are selected. That is, on the selected method of study for trees two observation measurement points lichen almost were not observed (Table 5).

It is important to note that the sulphur dioxide levels are increasing. If sulphur dioxide conditions are falling, lichens rarely colonise in exactly the same sequence; lichens are slow growing and may take a year or two to recolonise bark or other substrates following a reduction in air pollution levels, and tiny recolonising specimens can be difficult to spot and identify.

**Table 5** Results of quantitative research in the state air pollution on example of small town.

Number point	Projective cover, [%]	CAI
1	52	4
2	56	4
3	67	2
4	0	0
5	19	7
6	22	8
7	15	10
8	16	9
9	0	0
10	23	8

It is need for further studies of air pollution by lichenoidication in the city with the use of combination other techniques and with additional methods to produce lichenoidication maps of the city.

### 3. Conclusions

According to the research the species of lichens such as *Parmelia sulcata*, *Parmeliopsis ambigua*, *Phiscia stellaris*, *Xanthoria parietina* are founded on example of small town. The projective cover and clear air index are calculated. Values of clear air index correlated with the average content of sulphur dioxide in the air. According to the research several zones with high values of projective coverage (over 50%) identified. These measurement points correspond to residential areas and regions of the objects of food industry. Two zones zero projective coverage are selected (zone of lichen desert). These most polluted zones corresponded to the location of the metallurgical industry and heat electro power station. The roof production and abrasive industry do not show a significant increase in the concentration of sulfur dioxide in the contiguous territory. Although these factories used chemicals which containing in their composition the sulfur compounds.

As a result, biomonitoring by method lichen indication on example of small city two zones lichen deserts (sulfur dioxide concentration greater than 0.3 mg/m<sup>3</sup>) and one area of critical pollution (sulfur dioxide concentration of 0.1 -0.3 mg/m<sup>3</sup>) were founded. The largest area of air pollution allegedly linked to the activities of plants. Thus metallurgical industry and heat electro power station can be called major air pollutants in small towns.

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