Estimates of the air condition in the city of Maykop

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Abstract. Anthropogenic sources of pollution include industry, transport, agriculture, waste disposal, and so on. The methods of passive lichen indication according to A.S. Bogolyubov were used. The main stage is the observation of taprophytes and determination of their number. The research was carried out in the city of Maykop. The lichen flora of the city of Maykop along highways with different surfaces consists of scale, foliate and bushy lichens. 20 species of lichens have been identified, such as candelaria monochromatic Candelaria concolor (Dicks.) Stein, Goat parmelia (Parmelialecterata L.). There has been dubious parmeliopsis Parmeliopsis ambigua, fissia powdered Physciapulverulenta, xanthorium on the wall of air Xanthoria and others. The research task was to increase the number of plant species resistant to atmospheric gas pollution to stabilize the situation.

1. Introduction

Air pollution is one of the global environmental problems. Air pollution occurs when harmful substances, gases, particles and biological molecules enter the atmosphere.

This problem affects the question of morbidity and mortality of the population, and adversely affects the ecological state of the Earth.

Every year millions of people die from diseases caused by air pollution. Based on the data from the World Health Organization of 2014, air pollution can lead to premature deaths, and this figure reaches about 7 million people worldwide. A 2019 study showed an increase in the number of deaths to 8-9 million per year. Then all age groups were compared and we noted that children are the most vulnerable. The reason is not only technogenic impact, but also natural disasters.

Anthropogenic sources of pollution include industry, transport, agriculture, waste disposal, and so on. Each of them causes an irreparable damage to human health.

There are also sources of a non-anthropogenic nature. These are volcanic eruptions or dust storms. This facilitates the movement of fine particles over thousands of kilometers. Indoor air pollution and poor urban air quality are among the most serious toxic pollution problems in the world. The absence of visible smog does not mean clean air. All over the world today, any settlement is exposed to the toxic effects of pollutants, the levels of which exceed the average annual values recommended in GOSTs and SanPiNs for air quality. The intensive development of energy and transport leads to an increase in the consumption of hydrocarbon fuels, which supplies combustion products to the atmosphere. Coal-fired power plants contribute significantly to air pollution. The use of diesel generators in areas not connected to the grid is of growing
concern. Therefore, the effects of air pollution have been observed for a long time. Scientists hypothesize that all this is leading to climate change across the planet. There is no exact opinion on this matter, so the issue is being discussed; there are many disputes and discussions.

The most global consequences are:
- destruction of the ozone layer and the harmful effects of ultraviolet rays on all living things;
- climate change, when everyone noted that the action of greenhouse gases led to warming of winters in the northern hemisphere, where less snow falls;
- the effect on animals and humans is manifested in an increase in the number of heart diseases and diseases of the respiratory system in the form of lung problems (lung cancer, asthma), etc.;
- acid rain, which destroys forests, destroys buildings, architectural monuments, causes corrosion, as well as diseases in humans and animals;

At the moment, environmentalists and the government are working out measures to solve this problem. These measures include:
- reduction of industrial emissions, introduction of filter installations;
- improvement of waste disposal and recycling methods (instead of waste incineration or burial, use granulators, crushers, dryers, and recycling is also necessary);
- use of alternative energy sources;
- planting green spaces that will emit oxygen;
- construction of eco-farms, where animal feeding will be environmentally friendly without growth stimulants.

Measures are also being developed at the legislative level. Restrictions are introduced on the emission of harmful substances into the atmosphere, fines for excess emissions.

2. Methods of Research
We used the methods of passive lichen indication according to A.S. Bogolyubov. We identified the features of lichen flora (lichen flora), determined the degree of tree coverage with lichens, and the index of relative air purity. As a result, a comparative analysis of the state of the air environment in the experimental areas was carried out. The main stage is the observation of talplophytes and determination of their number. We studied lichens throughout the year in spring, summer and autumn. We carried out measurements of the projective cover on the test plots and, as a result, calculated the average values of the projective cover for the city of Maykop. By the amount of the total projective cover, and the projective cover of individual species, using lichen sensitivity scales and indices, the degree of pollution in space was judged. Before the start of the research, the center of the site was determined. For this, a pole was driven into the ground, and then 10 trees of the same species and approximately the same height were selected around the center of the site. It was on these model trees that the number of lichens was counted.

To measure the number of lichens on trees, in particular, their projective cover, we used a technique called the “palette” method. It gives a more visual result. The “palette method” is a method for directly measuring the projective cover of lichens on tree trunks, i.e. measuring the percentage of the lichen-covered area to the lichen-free area. The palette is a frame on a transparent film, divided into 1 x 1 cm squares. The measurement procedure is very simple. The palette was placed on the tree trunk and fixed. Lichens were counted at each section of the trunk as follows. First, we counted the number of squares in which lichens occupy by eye more than half the area of a square and, conventionally, attribute a coverage of 100% to them. Then, the number of squares in which lichens occupied less than half of the area of the square (b) was counted, conventionally assigning coverage of 50% to them.

The total projective cover in percent (R) is calculated by the formula: \( R = \frac{(100 \cdot a + 50 \cdot b)}{C} \), where C is the total number of squares of the palette.
3. Research results

Each person is faced with the question of how to prevent air pollution. But not everyone takes any action. We have organized the air condition monitoring system.

An effective way to determine the level of air pollution is lichen indication. Even an insignificant presence of sulfur dioxide in the air is well diagnosed by lichens. It was noted that bushy forms first disappear, then foliated, and finally scale forms. Lichens can be considered a natural indicator of the habitat.

When identifying the degree of environmental pollution, we saw the reaction of biological objects to pollutants. Not all lichens are capable of living in modern conditions. There are places in the city where there are no lichens at all or their number is minimal, but they adapt to living in a polluted environment.

The sensitivity of lichens to air composition is determined by the characteristics of their growth. Leaves, roots and stems of lichens are practically absent. They are fixed by outgrowths of the lower crust (rubber) and absorb moisture and air, as well as minerals (dissolving the surface of the stones).

By absorbing moisture, these plants are able to absorb contaminants. As the air is polluted, the bushy forms gradually begin to disappear, then the leafy and the last - the crusty (crustal) – form lichens.

The research was carried out in the city of Maykop, where the temperate continental climate prevails; the winds of the southern directions prevail. The average annual air temperature in Adygeya is noted as positive and ranges from +8.5 to +9.8 °C. The coldest month is January; the average temperature varies from +7 to +2 °C. The duration of the frost-free period on the plain is 190 days; the annual precipitation is 500 - 700 mm.

Test sites (0.5 × 0.5 km) were located in four districts of the city. The following sites were selected for observation: along highways, in a residential area, in a park and in an industrial area. After calculating the sectors, choosing experimental trees, we determined the species composition of lichens.

We described the experimental plots and selected ten lichens for the analysis, and the projective cover - three trees. The first research site was identified in the western residential area of the city (Cheryomushki microdistrict) in Dimitrov Street. The second site is the eastern area (the area of the Confectionery Factory behind the railway) in Pervomaiskaya str. and Sovietskaya str. The third research site is located in the city center at the intersection of two roads – Pervomaiskaya and Pobedy, which captures the territory of MBOU "Lyceum No. 34". The fourth research site - the southeastern district of the city - covers Shosseynaya and 2nd Lane streets (Figure 1).

![Figure 1. Investigated sites in the city of Maykop](image-url)
lichens were packed on site in stored packages, each containing one lichen from a specific experimental site. The packages were marked with the exact place of selection and the name of the person in charge. Then the lichens were air-dried. After that, the species of lichen was determined according to the key.

The air purity index IAQ was calculated using the formula (1):

\[ IAQ = \frac{\sum_{i=1}^{n} QiFi}{10} \]  

where \( Qi \) – index of toxophobia; 
\( Fi \) is a combined indicator of coverage and occurrence; 
\( n \) is the number of species.

The toxophobility index characterizes the number of species accompanying a given species at all description sites according to the degree of air pollution in the city. We used a combined coverage and occurrence score from Table 1.

| Frequency of occurrence | Coverage         | Score |
|------------------------|------------------|-------|
| Very rare (less than 5%) | Very low (less than 3%) | 1     |
| Rarely (4 – 22 %)       | Low (4 – 22 %)   | 2     |
| Average frequency (22 – 45 %) | Average (22 – 45 %) | 3     |
| Often (45 – 65 %)       | High (45 – 65 %) | 4     |

To measure the projective cover of epiphytic lichens, a “palette” \((10 \times 10 \text{ cm})\) was used, which was placed at a height of 1.5 m on the tree trunk from four sides and the area occupied by lichens was examined. Lichens on the southern side were sporadic. The palette was made by us independently in the form of a film. Zones are drawn on it in the form of squares with sizes \(1 \times 1 \text{ cm}\). We have counted the number of squares in which lichens grew in areas of more than 50% of the square's area, conditionally attributing to them coverage equal to 100%.

After that, we calculated the squares in which lichens occupied less than 50% of the square area, conventionally considering the coverage equal to 50%. The data is recorded in a field diary. The total projective cover \((R)\) as a percentage is calculated by the formula:

\[ R = \frac{(100a + 50b)}{C} \]

where \( C \) – total number of squares of the palette.

Then the data were averaged over all test sites.

On the first site in the western residential area of the city (microdistrict Cheremushok) in Dimitrova str., gardening is represented only by tree species. Around the multi-storey buildings, holly-leaved, western sycamore, small-leaved linden, pedunculate oak, prickly spruce, eastern spruce, Crimean pine, Nordman fir grow. The first tier includes a ripe and ripening stand (consists of trees over 7 m in height) with a barrel diameter of 30 - 60 cm. The trunk and branches were inhabited by lichens, bark crevices; the bulk is concentrated at heights from 1 to 2.5 m. The impact of human activity is average. Recorded in Dimitrova str., the movement of cars, trolleybuses, fixed-route taxis, passage of any freight transport are prohibited.

The most common lichens from the first site are Parmelia goat Parmeliacaperata (L.) Ach., Xanthoriaaprietina (L.) Belt. Physciapulverulenta (Schreb. Candelariaconcolor (Dicks.). Stein. On lindens, there was a star-shaped office and a round theosophia. Xantoria mural thallus (X. parietina) found on all trees in small numbers without apothecia. P. caperata (L.) Ach. It has a leafy thallus, often rosette-shaped, irregular in shape (up to 22 cm in diameter). In the center, it is tightly fixed to the substrate. The upper surface is yellowish-greenish (when located in bright places) or grayish-greenish (being in the shade). The
underside is brown with darkish ribs. X. parietina (L.) Belt has a thallus over 2 cm in diameter in the form of regular orange-yellow rosettes, consisting of large, wide, rounded lobes at the edge. The blades are notched-cut at the ends. In the center, there are numerous apothecia, the disc of which is usually brighter. Pulverulenta (Schreb.) has a thallus in the form of large regular rosettes, from above the color varies from olive to dark brown, often with a strong bluish bloom, which makes it ash-gray, dark below, with thick dark gray or black rhizoids. In total, we met 11 species of lichens; nine of them are leafy and have two types of scale (candelaria and lepraria). No bushy lichens were noted.

The main plants are fruit tree plantations located in the eastern part of the city, on the second site near private residential buildings, away from busy streets and railways. They are white and black mulberry, walnut, apple, quince, pear, plum, cherry and ornamental shrubs with a high planting density; common lilac, white-flowered spiraea, hanging forsythia, linden and birch are very rare. Trees of the III high-rise group (up to 4 m high) - undergrowth, consisting of shrubs and tree species are not included in the main tree canopy. The diameter of the trunks is from 20 to 40 cm. The parts are inhabited by lichens, the trunk and branches, crevices are in the bark. The bulk is concentrated at a height of 1 to 2.5 m. The anthropogenic load is insignificant, cars move along dirt roads. On the trunks of fruit trees X. parietina apothecia, this lichen sometimes rises to a height of more than 2 m. Especially a lot was noted on cherries and plums. Further, a light yellow scattering can sometimes be seen in Caloplaca chrysodeta and Candelaria concolor. And plums can be found in several types: Parmeliaceae: P. sulcata, P. ernstiae, P. caperata, P. ambiguca; Physciaceae: Ph. caesia, Ph. distorta, Ph. tenella, Ph. adscendens, Ph. stellaris, Ph. Grisea.

The bushy lichen Evernia plum Everniaprunastri (L.) Ach. is of interest. In total, 14 species of lichens have been identified, consisting of ten foliose – one scale and one bushy.

At the third research site, which is located in the city center, the road is characterized by heavy traffic in the morning and in the evening.

At busy intersections, oppression of woody vegetation is observed, the crown is most often sparse, premature leaf fall is noted, there are even areas where bark damage is observed. At such crossroads, trees lag significantly behind in growth and development, and shrubs are prone to partial drying out. Trunk circles are small. The main species in the landscaping of such intersections are decorative crops such as Norway maple, small-leaved linden, black walnut, catalpa, birch, bird cherry. Trees of the I and II height groups (undergrowth) make up the tree canopy from young forest-forming species with a height of 3 to 7 m. The diameter of the trunks is from 15 to 45 cm. The trunk is overgrown with lichens, crevices in the bark, the bulk is concentrated at heights from 1 to 2.5 m. We have found 6 species of lichens, of which 4 are leafy: Scoliciosporumchlorococcum, Xanthoriaparietina, C. chrysodeta C. concolor, Ph.stellaris.

The fourth test site is located at the corner of Shosseinaya and Batareynaya streets. Nearby there is a railway, along which trains move. The road is an exit from the city. Nearby, about 500 meters, there is the Kartontara plant, which is a local environmental pollutant. We identified three species of lichens, two foliose Sc. chlorococcum, X. parietina, Ph.stellaris. Using the combined point indicator, characterizing the coated sites, we determined the lichen species that we found – Sc. chlorococcum, X. parietina, Ph. stellaris, that is, it is very rare and with very low coverage.

4. Conclusion
The field tolerance index (IP) of the species composition of lichens for the first site was 8.14. The IP values are correlated with the average annual SO2 content in the air. The gas content is 0.08 - 0.10, this area is considered to be heavily polluted. For the second site, the field tolerance index of the species composition of lichens was 7.0. The gas content ranges from 0.03 to 0.08. It turns out that this is an area of medium pollution. The field tolerance index of the species composition of lichens for the third site was 7.8. IP is correlated with the average annual SO2 content in the air and the gas content is 0.08 - 0.10, this zone refers
to areas with severe pollution. For the fourth site, the Field Tolerance Index of the species composition of lichens is 9.25. The gas content is 0.10 - 0.30, so this is a highly polluted area.

Thus, the lichen flora of the city of Maikop along highways with different surfaces consists of scale, foliate and bushy lichens. We identified 20 species of lichens, such as candelaria monochromatic Candelaria concolor (Dicks.), Stein. Parmeliacaperata, L Parmeliopsisambigua, Physciapulverulenta Xanthoriapijariaetina. Using the field tolerance index, we determined the degree of atmospheric pollution at the sites under study. Sites 1, 3, 4 refer to areas with severe pollution, site 2 - to an area with medium pollution. For a general characterization of the degree of pollution of the fourth site, the atmospheric purity index was used, which is widely used in bioindication studies of cities and industrial areas:

$$IAQ = \sum_{i=1}^{n} \frac{QiFi}{10}$$

where Qi – ecological index of toxicity or index of association; Fi is a combined indicator of coverage and occurrence; n – number of species.

The air purity index for the fourth site was 17.9, which confirms the calculations based on the field tolerance index. The considered lichen species characterize urban landscapes as moderately and strongly anthropogenically modified habitats. The air purity index for the fourth site was 17.9, which confirms the calculations based on the field tolerance index. The considered lichen species characterize urban landscapes as moderately and strongly anthropogenically modified habitats.

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