The dissertation work was carried out at the Department of Botany of Ganja State University.

Scientific supervisor: Corresponding member of ANAS,
Honored Scientist, doctor of biological sciences, professor
Vagif Seyfaddin oglu Novruzov

Official opponents: Doctor of biological sciences,
Aydın Musa oglu Asgarov

Doctor of biological sciences, professsor
Elman Osman oglu Isgandar

Doctor of Philosophy in Biology, associate professor,
Teyyub Yunis oglu Pashayev

Dissertation council of ED1.26 of Supreme Attestation Commission under the President of the Republic of Azerbaijan operating at the Institute of Botany of Azerbaijan National Academy of Sciences

Chairman of the Dissertation Council:
Active member of ANAS, doctor of biology sciences, professor
_____ **Valida Movsum gizi Ali-zade**

Scientific Secretary of the Dissertation Council:
Doctor of Philosophy in Biology, associate professor,
_____ **Arzu Yusif gizi Huseynova**

Chairman of the scientific seminar:
Doctor of biology sciences, professor
_____ **Eldar Novruz oglu Novruzov**

INTRODUCTION

The actuality of the subject. The lichenoindication method has been used for several decades to assess the level of environmental pollution[1]. Numerous field and laboratory studies have shown that air pollution in industrial centers is a major factor in the destruction of lichens in cities[2,3]. There is no doubt that microclimate conditions (increased drought in the air, temperature changes, dew reduction and increase, weakening of solar radiation) have a negative impact on the distribution of lichens.

One of the most important problems of environmental is the selection of bioindicators and assessment of their tolerance. Among the most important pollutants carbon oxide, nitrogen oxide, sulphur dioxide, ozone, carbohydrates, aldehydes, heavy metals (Pb, Cu, Zn, Cd, Cr), ammonia, atmospheric dusts, radioactive isotopes, and other sulphur dioxide (SO_2) are main pollutants in the atmosphere[4].

The range of impacts of modern industrial centers to the nature is very wide. As a result of human economic activity, a special type of ecosystem - urboecosystems - emerges instead of natural plant groups[5]. This process has now become a catastrophic natural factor. As a result, it has led to qualitative changes in the relationship between nature and society.

“CITY EFFECT” is one of the most promising problems of

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[1] Байбаков, Э.И. Оценка экологического состояния урбанизированных территорий с помощью методов лихеноиндикации (на примере Казани): автореф. дис. канд. биол. наук. /-Ижевск, 2003. -19 с.

[2]. Алексеев Д.К., Гольцова В.В., Дмитриев В. В. Экологический мониторинг: современное состояние, подходы и методы: учеб. пособие. СПб., 2011

[3] Байбаков, Э.И. Лихенофлора г. Казани: влияние атвтотранспортного загрязнения атмосферы на эпифитную лихенофлору / Э.И.Байбаков, А.П.Ситников, И.И.Костюкевич //Вестн. Татарстанского отд-ния Рос. Экологической Акад., - 2001. - № 1-2, -С. 44-47.

[4] Сонин, Н.А. Экология и охрана окружающей среды: методическое пособие по выполнению лабораторных работ / Н.А.Сонин, Е.Л.Терехова, – Хабаровск: Изд-во ДВГУПС, -2006 .- 44 с.

[5] Григорьевская А.Я. Антропогенная трансформация растительного покрова Среднерусской лесостепи: Автореф.докторс.дисс./-Воронеж, -2003. - 38 с.

modern biology and ecology. The history of this problem has been more than 100 years. Bioindication features of many cities such as Moscow (Sluka, Abramova, 1984; Byazrov 2002), St. Petersburg (Malisheva, 2003), Yekaterinburg (Paukov, 1997), Grozny (Zakutnova, 1988), Lviv (Kucheryaviy, 1990), Yoshkar-Ola (Suetina, 1997), Volga (Liyv, 1984), Madrid (Qrespo, Bueno, 1982), Berlin (Leuckert, 1982), London (Havksworth, Mc Manus, 1982), Munich (Macher, 1987), Paris (Derulle, Qarsia Schaeffer, 1983), Prague (Liska, Vezda, 1990), Hamburg (Germany, John, 1989) were investigated. In recent years, research in this area has accelerated significantly. These researches are very important for urban planning. Different species of lichens are valuable bioindicators for determining the degree of air pollution because they have different poleotolerant properties.

The results of many researches on the study of the theory and practice of the problem of lichenoindication through lichens have been published in England, America, the Baltics[6,7]. Despite the fact that the taxonomic structure of the lichens in Azerbaijan has been sufficiently studied by Sh.O.Barkhalov, V.S.Novruzov, S.M.Alverdiyeva, A.A.Bayramova, D.Sh.Ganbarov and others, there is little information about the possibility of using it as biomonitoring. The efficient use of natural resources and the problem can be solved only on the basis of the study of natural processes. In this regard, it is important to study the species composition of lichens in natural and anthropogenic ecosystems. Although lichens are widespread in nature, they are not inexhaustible, and a number of species have become extinct as a result of human intervention[8]. A number of species have already been included in the International

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[6] Skye, E. Lichens and air pollution. A study of cryptogamic epiphytes and environment in the Stockholm region // Acta Phytogeogr. Suecica. -1968. -Vol. 52, -p. 1-123.

[7] Hawksword, D.L. A first checklist of parmelioid and similar lichens in Europe and some adjacent territories: additions and corrections / D.L.Hawksword, P.K.Divakar, A.Crespo et al. // The Lichenologist, -2011. -vol. 43 (6), -p.639-645.

[8] Новрузов, В.С. Флорогенетический Анализ лишайников Болъшого Кавказа и Вопросы их Охраны / В.С.Новрузов – Баку: -1990. - 322 с.

Red Books, including the 2nd edition of the Red Book of Azerbaijan[9].

The role of lichens as a bioindicator of environmental pollution is great. The bioindication method has some advantages over physical-chemical methods, as it does not require expensive equipment and devices. The results are obtained by continuous observation, without interfering with the vital processes of the organism. At the same time it is possible to characterize a large area[10].

Different species of lichens react differently to atmospheric air pollution. The factor of differentiation of species composition in urban conditions is environmental pollution. Pollution in suburbs is not the main factor of differentiation (limiting factor). In this regard, the disturbance of the ecological balance is also reflected in the social and economic development of society. This process is typical for the developed cities of Azerbaijan - Ganja, Mingachevir, Yevlakh, Dashkasan, Gazakh, Shirvan.

The susceptibility of lichens to air pollution is due to the fact that their water enters not only from the substrate, but also through chemicals in the atmosphere. Some lichens are intolerant to small amounts of pollutants in the air. Others, on the contrary, live in settlements in anthropogenic conditions. It is possible to determine the degree of contamination through licnehs[11,12,13].

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[9] Azərbaycan Respublikasının "Qırmızı kitabı". Nadir və nasli kaəsilməkdə olan bitkilər və göbələklər [2 cilddə] /-Baku: -cild 2. -2013. - 676 s.

[10] Трасс, Х.Х. Проблемы охраны низших растений /Х.Х.Трасс //В кн. Охрана генофонда природной флоры, - Новосибирск: Наука, -1983, -с. 92

[11] Гайдыш, И.С. Биоиндикация природной среды малого северотаежного промышленного города: на примере г. Костомукша: Автореф.дисс. …канд. биол.наук. /– Петрозаводск:- 2012. – 23 с.

[12] Мартин, Ю. Л. Лихеноиндикация состояния окружающей среды //–Таллин: Взаимодействие лесных экосистем и атмосферных загрязнителей, -1982. - 6. Ч. 1. -С.27-47.

[13] Трасс, Х.Х. Классы полеотолерантности лишайников и экологический мониторинг // - Л.: -Проблемы экологического мониторинга и моделирования экосистем, -1985. - Т.7, - С. 122-137.

Taking into account the urgency of the problem, the dissertation work on "Assessment of lichenobiota and bioindication features of some industrial cities of Azerbaijan" was completed.

Object and subject of the research. Lichens distributed on different substrates were taken as an object of research.

Purpose and objectives of research. It consists of determining the species composition and distribution patterns of lichenobiota in some industrial cities of Azerbaijan, assessing the bioindication features in urboecosystems. The following tasks have been set to achieve the purpose:

- Identification and environmental assessment of major pollution sources in some industrial cities;
- Provision of characteristics of lichenobiota of the studied cities (Ganja, Mingachevir, Yevlakh, Gazakh, Dashkesen, Shirvan);
- Compilation of lichenoindication maps of Ganja, Yevlakh, Mingachevir, Gazakh, Dashkasan, Shirvan cities and their ecological substantiation;
- Identification of road transport pollutants and explanation of the mechanism of impact on the lichens;
- Identification of sensitive epiphytic lichens by analysis of existing approaches and identification of optimal methods that can be applied to lichenobiota of the urboecosystem;
- Spatial distribution of some species of lichens and determination of their distribution in Ganja, Mingachevir, Yevlakh, Dashkasan, Gazakh, Shirvan cities as a whole;

Research methods. The researches were performed by route and stationary methods. At the same time, floristic, floristic-systematic, areological, botanical-geographical, phytocenological, statistical methods were taken into account. Poleotolerance index (PI) was calculated, sensitivity scale of the species was compiled. Vital forms and ecological groups of lichens, occurrence frequency of species, general distribution patterns and dominant synusia depending on the type of substrate were determined, the structure of sample sites was compared and analyzed.

The main provisions of the defense.

1. The lichen flora of Ganja, Gazakh, Mingachevir, Yevlakh,

Dashkasan, Shirvan was formed under the influence of complex ecological factors. The decisive role among them is the anthropogenic transformations of the urban environment. The nature of the development of epiphytic lichens determines the characteristics of the functional use of the area;

2. Urbanization of the natural environment of Ganja, Gazakh, Mingachevir, Dashkasan, Yevlakh, Shirvan affects the composition of lichenobiota;

3. It is correlated with the level of condition of the epiphytic lichens of the city highway. Maps compiled using the lichenoindication method can be applied in the design of urban and suburban areas.

4. Lichenological maps are complex indicators of environmental pollution of industrial cities;

5. The structure and composition of the lichen synusia of the studied cities provide an assessment of atmospheric pollution.

Scientific novelty of the research. As a result of lichenoindication researches conducted for the first time in the region, model areas were selected in Ganja, Mingachevir, Yevlakh, Dashkasan, Shirvan, Gazakh cities, the species composition of urban lichenobiota was studied, tolerant species resistant to atmospheric pollutants and widespread species were selected, areas exposed to anthropogenic influences were selected, the causes of air pollution were clarified by applying the cartography method and scientific explanation of the anthropogenic transformation of lichenobiota was provided. As a result, tendency towards an increase in the anthropogenic load and decrease in the species diversity and abundance of lichens were observed.

It was found out that 29 species in Ganja, 32 in Gazakh, 22 in Yevlakh, 18 in Mingachevir, 20 in Shirvan, 34 in Dashkesan have been toxitolerant and recommended as biological monitors.

For the first time, 29 families, 41 genera and 68 species have been identified for industrial cities. Of these:

1. Ganja city -16 family, 16 genera, 29 species
2. Dashkesan city - 21 family, 25 genera, 34 species

3. Yevlakh city -11 family, 11 genera, 22 species
4. Mingachevir city - 11 family,13 genera, 18 species
5. Shirvan city -14 family, 14 genera, 19 species
6. Gazakh city - 20 family, 23 genera, 31 species

Theoretical and practical significance of the research. It is necessary to select indicator species for different sources of pollution, use lichens as biomonitoring of the environment, provide biomorphological characteristics, determine the ecological sustainability of species, their role in the phytocenosis, identify resource sources and create forecast maps, as well as efficient use of natural resources.

The obtained data allow to analyze the air condition of the studied cities and on this basis to develop measures to improve air quality.

The results of the study of lichens in the territory of Ganja city can be used in compiling the regional lichenoflora, specifying the ecology, geography and habitats of different species, as well as in developing a system of measures for rare lichen species.

The results obtained are considered the basis for predicting technogenic impacts harmful to the environment and human health.

Research materials can be used in the teaching of biology, biology-teaching, chemistry-biology, ecology and environmental protection faculty specialities, and information on species composition can be used in the teaching of relevant sections of botany.

Approbation and application. Based on the results of the research, seven scientific articles, three conference materials and five theses were published in accordance with the dissertation topic. Of them two articles and three theses were published abroad. The main provisions of the dissertation were presented and discussed in International scientific conference on "Actual problems of Biology and Chemistry" (Ganja, 2015; 2016; 2019); Symposium on euroasian biodiversity (Baku, 2015; Minsk, 2017); at the XXI Republican Scientific Conference of Doctoral Students and Young Researchers (Baku, 2017), at the Conference "New Challenges in Botanical Research" dedicated to the 90th anniversary of academician Vahid Jalal oglu Hajiyev organized by the Institute of Botany of ANAS and the

Society of Azerbaijan Botanists (Baku, 2018), at the conference dedicated to the 120th anniversary of V.I.Ulyanishev (Baku, 2018), Scientific Conferences of Ganja State University (2015; 2016; 2017; 2018), Scientific seminar and Scientific Council of the Institute of Botany of ANAS.

The organization where the dissertation work is performed. The dissertation work was carried out at the Department of Botany of Ganja State University.

The structure and total volume of the dissertation. The dissertation consists of 139 pages - introduction, 7 chapters, conclusion, 28062 characters, including practical recommendations, a list of literature with 222 titles.

CHAPTER I. PHYSICAL GEOGRAPHICAL CHARACTERISTICS OF THE RESEARCH AREA

A brief description of the natural-geographical features of the study area was given, the relief, climatic conditions, hydrology, soil and vegetation cover of the area were analyzed.

CHAPTER II. RESEARCH MATERIALS AND METHODS

The research was conducted in Ganja, Mingachevir, Dashkasan, Yevlakh, Gazakh, Shirvan and its environs in 2014-2019.

Routing and stationary methods, as well as floristic, floristic-systematic, areological, botanical-geographical, phytocenological, statistical methods used in botany were used in the research (Grossheim, 1948). Poleotolerance index was studied in Estonia (Liv, 1988), Kazan (Golubkova, 1978), the Baltics (Trass, 1988), Grozny (Zakutnova, 1988) and Astrakhan (Pilipenko, 2008). It is known that lichens are an indicator of air pollution and can be used in the environmental monitoring system of the region.

A comprehensive study of lichens should include information not only on the lichenoflora of the study area, but also on the local and biological characteristics of nearby urboecosystems. On the other hand, a comparative analysis should be conducted on regional backgrounds. In many cases, the choice of such areas is problematic. The shown approaches should be adequate to the environmental variabi-

lity of the urboecosystem we are studying. We have taken Goy-Gol National Park and Korchay State Nature Reserve as a clean regional background. These objects were used as a source of information to assess anthropogenic transformations of remote areas. This allowed to achieve successful results in the context of cluster approaches.

As a result of anthropogenic load analysis of the distribution of epiphytic lichens in urban parks and gardens, a sensitivity scale of the species has been compiled. Species are divided into sensitive (heterophobia), moderately sensitive (mild) and resistant (hemerophil) groups.*Evernia prunastri, Ramalina fastigiata, Ramalina dilacerata, Ramalina fraxinea, Parmelia saxatilis* belong to the first category. Moderate-sensitive species *Melanella laura, Lecanora sambuci* and etc. are found in parks and floors of the central parts. Resistant (tolerant) species *Xhantoria parietina, Physcia orbicularis, Physcia stellaris, Physconia grisea, Physconia distorta* and etc. are spread in all parts of the park.

Materials were implemented in linden (*Tilia cordata* L.), maple (*Acer platanopolics* L.), common pine (*Pinus sylvestris* L.), plane (*Platanus orientalis* L.), ash-tree (*Fraxinus excelsior* L.), pear (*Pyrus communis* L.) and other trees. The city's plan system is divided into square meters (1km) and geobotanical description of the lichen groups within it was given:

1.With the help of a system of sample sites, the species composition of lichenobiota of Ganja, Mingachevir, Dashkasan, Yevlakh, Gazakh, Shirvan and its environs was studied, and the vital forms and ecological groups of lichens spread in these areas were determined;

2.Lichen species were identified in and around cities and the occurence frequency of species was studied;

3.General distribution patterns of different lichen species and vital forms depending on the substrate type were identified;

4.Types of lichenosynusia were determined, the presence of lichens in different phytocenoses and different substrates was assessed, dominant synusia was determined;

5.Comparative characteristics of different industrial centers and

built sample areas were given. According to the methodology of lichenoindication studies[14], the map of cities is divided into square points.

A plan map was used in the research cities to clarify the distribution characteristics of the lichens. A frame was used to calculate the coverage of the epiphytic lichens[15]. The dimensions of the frames can be different: 5x10 cm; 10x10 cm; 20x20 cm.

The nomenclature of taxa was given according to modern catalogs (Hauck, Dulamsuren 2016)[16]. In the studied cities, a 20x20 cm experiment was performed on each tree and the poleotolerance index (PI) was calculated using the following formula. The average value PI was conducted for each tree trunk studied, and then for each sample area[13]. In the studied urban areas, the IO value was correlated with the average concentration of sulphur oxide in the air and calculated by the poleotolerance index:

$$\text{IP} = \sum_{1}^{n} axc/C^1$$

Here, *a* – degree of tolerance of lichen species in urban environment;

c- the degree of cover of species (by point);

n- quantity of species;

C- average total coverage of all species.

The occurrence of each species was determined on a five-point scale: 1 point -0-20%; 2 points-21-40%; 3 points-41-60%; 4 points-61-80%; 5 points-81-100%.

Cover was assessed on the following 5-point scale [100]: 1 point-1-5%; 2 points-6-20%; 3 points-21-40%; 4 points-41-65%; 5 points-66-100%.

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[14] Закутнова, В.И. Лихенофлора Астрахани //-Астрахань: Естественные науки. Жур. фундаментальных и прикладных исследований, - 1999. - №1, -С. 133-139.

[15] Инсарова, И.Д. Влияние тяжелых металлов на лишайники // -JL:Проблемы экологического мониторинга и моделирования экосистем, - 1983. - Т. 6, - с. 101-113.

[16] Randlane, T., Saag, A. & Suija, A. Lichenized, lichenicolous and allied fungi of Estonia //Ver. December 31, 2013 (jurnaldı ? səh….)

Poleotolerance index was studied in Estonia (Liv, 1988; Martin, 1982), Kazan (Golubkova, 1978), Southern Baltic (Trass, 1988), Grozny (Zakutnova, 1988) and Astrakhan (Pilipenko, 2008).

CHAPTER III. PROBLEM OF USING LICHENS AS AN INDICATOR

There is a need to create special information systems - monitoring system to assess anthropogenic changes of the condition of the environment. To determine the degree of impact of environmental pollutants on industrial facilities, it is important to know the response of biological facilities to pollutants. For this purpose, lichens were selected as the main object for biological monitoring[17, 18].

The chapter provides a critical analysis of the literature on the use problem of lichens as an indicator, the analysis of results of research on the study of the theory and practice of the lichenoindication problem.

CHAPTER IV. LICHENOBIOTA OF URBOECOSYSTEMS OF SOME INDUSTRIAL CITIES

As a result of the development of literature and field research materials, the taxonomic composition of the lichenobiota of urboecosystems of Ganja, Mingachevir, Yevlakh, Dashkasan, Gazakh, Shirvan was discovered. It was determined that the lichenobiota of the studied urboecosystems consists of 68 species belonging to 41 genera on 29 families.

Physceaceae (11 species), *Lecanoraceae* (10 species), *Caloplacaceae* (5 species), *Arthoniaceae* (3 species) predominate in lichenobiota of urboecosystems. Each of *Lecideaceae, Pyrenulaceae, Megasporaceae* families was represented with two species. 12 families are monotype and represented with one species. Analysis at the ge-

[17] Боголюбов, А.С. Оценка загрязнения воздуха методом лихеноиндикации /А.С.Боголюбов, М.В. Кравченко //«Экосистема», -2001. - с.1 – 6, 11.

[18] Пчелкин А.Б., Боголюбов А.С. Методы лихеноиндикации загрязнения окружающей среды / А.Б.Пчелкин, А.С.Боголюбов //Методическое пособие, -М.: Экосистема, -2007. – 25с.

nus level shows that *Lecanora* (9 species), *Teloschistes* (4 species), *Physcia* (3 species), *Caloplaca* (5 species) predominate.

It was found that lichenobiota of urboecosystems of Ganja city consists of 29 species belonging to 16 families, 16 genera, lichenobiota of urboecosystems of Mingachevir city – 18 species belonging to 11 families, 13 genera, lichenobiota of urboecosystems of Yevlakh city – 22 species belonging to 11 families, 11 genera, lichenobiota of urboecosystems of Gazakh city – 31 species belonging to 20 families, 23 genera, lichenobiota of urboecosystems of Dashkasan city – 34 species belonging to 21 families, 25 genera and lichenobiota of urboecosystems of Shirvan city – 19 species belonging to 13 families, 13 genera.

CHAPTER V. SOCIO-ECONOMIC CHARACTERISTICS OF SOME INDUSTRIAL CITIES AND EVALUATION OF BIOINDICATION FEATURES OF URBOECOSYSTEMS

The chapter consists of 5 sections. The sections identifies socio-economic characteristics of Ganja, Mingachevir, Yevlakh, Gazakh, Dashkasan and Shirvan cities, main atmospheric pollutants and their sources and assess bioindication features of urboecosystems.

5.1. Assessment of bioindication features of Ganja city urboecosystems. The main limiting factor in the city of Ganja is the Ganja DET.AL aluminum complex, motor transport and industrial centers. The main atmospheric air pollutants are Ganja Metal Casting and uninterrupted combustion plant, Electrolysis, Neon Flour Mill, Automobile factories, Royal LLC concrete, glass, brick plants. The role of road transport in urban air pollution is high.

Sulfur gas, nitrogen oxides, fluorides, ozone and heavy metals have the greatest impact on the life of lichens in Ganja. SO_2 is the dominant factor. SO_2 provides the spread of epiphytic lichens. It was found that 0,08 – 0,1 mml3 of sulfur dioxide disrupts the process of photosynthesis. Brown spots are observed in the chloroplast of lichens. At low pH, chlorophyll acidifies when the humidity is 3,4. When the pH is 2-3, it turns into a pheophytin. The increase in humidity enhances the dissolution of SO_2 and the acidic environment. For

this reason, lichens are not resistant to high humidity. However, they are resistant to high concentrations of SO_2 in dry air. At the same time, it is known that young thallomes are more sensitive than older thallome.

The relative purity index of the atmosphere in the study area is given in Table 1. Then the points system was calculated using a special scale. When the relative purity coefficient is high, the air is clean.

Table 1

Relative purity index of the atmosphere in the study area

Area	Point score of bark-like lichens	Point score of leaflike lichens	Point score of shrublike lichens	Relative atmospheric pollution
Railway H.Aliyev avenue, connection of hospital No.3	3	1	0	0,20
Asphalt plant with observed industrial pollution.	3	1	0	0,20
Aluminum factory	6	1	0	0,40
Machine building factory	7	1	0	0,30
Concrete plant	7	1	0	0,43
Central park	15	1	0	0,60
Gulustan park	10	1	0	0,57
Damiryolchular park	10	1	0	0,30
Equipment building factory	9	1	0	0,40
New Ganja park	12	1	0	0.63

The regularities of the spread of lichens in the territory of Ganja city are given in Table 2.

As a result of the increase in anthropogenic load, the species diversity of lichens, the projective cover of different species and lichenosynusia decrease. Analysis of trees covered with lichen thallo-

mes shows that the number of lichens in artificial groupings decreases sharply. It makes up 37 species in parks and sidewalks, the average projective coverage of lichen synusia is low in natural groupings in the city. The number of trees in the city park that are not covered with lichen is lower than in the natural vegetation groups of the city. In the city park, the average number of lichen-covered trees is 55% and no more than 15% as opposed to plant groups.

Table 2

Species diversity of lichens in different areas of Ganja city

Plant groups	Number of species	Average projective coverage of lichenosynusia%	Percentage of trees not covered with lichens
Pine alleys	22	19.4	23
Plane alleys (city)	15	14,5	150
Riverside greenery	40	9.5	52
Parks and sidewalks	37	3	65
Greenery inside settlement	35	2,4	69
Side of highways	24	2.1	70

The city of Ganja is one of the cities of the republic with a high level of man-made pollution, where large industrial enterprises are located. Unused wastes of industrial enterprises, as well as housing and communal services are discharged into the urban environment in solid, liquid and gaseous form and cause pollution of the atmosphere, soil surface and groundwater. According to the Azerbaijan State Hydrometeorology Center, pollution with dust and smoke in Ganja is 9,2 times higher than normal, pollution with sulfur dioxide is 2,2 times higher, and pollution with hydrogen sulfide is 8 times higher than normal. The pollution index in the city is 13,5. The average annual dust concentration in the atmosphere is 4,62 mg/m3, and 5,8 mg/m3 in the central and eastern part of the city. Road transport was-

te alone pollutes the city's atmosphere by 42,9%, including 90,9% of transport waste is carbon dioxide, 57,6% - nitrogen oxides and 97.6% - carbohydrogens. According to the Azerbaijan Gas Cleaning Territorial Inspectorate, only 17 enterprises in the city have 734 sources of hazardous waste. Of these, 425 do not have treatment facilities. Therefore, the atmosphere of Ganja city is included in the list of cities richer in chemical elements. In general, the city's air basin contains sulfur, nitrogen, hydrogen sulfide, aluminum compounds, fluorine, lead, zinc, copper and various dust compounds. Industrial enterprises alone release 7,749 thousands tons of solids, 27999 tons of gas and liquid waste into the atmosphere per year.

According to the data of 2017, pollutants of 20871,40 tons (CO2, CH, NO, etc.) were released into the atmosphere of Ganja city by motor transport. The number of enterprises polluting the atmosphere in Ganja city is 31, the number of sources of pollution is 56. Hazardous substances of 3834,174 tons were released into the atmosphere. Species of lichens adapted to such a polluted environment are divided into 3 groups according to the degree of tolerance: cosmopolitan species, species that are selective against certain pollutants, intolerants. The range of anthropogenic anomalies was determined by implementing observations at a distance of 43 km in the direction of Ganja-Goy-Gol by the linear-transect method. The impact of anthropogenic anomalies on vegetation continues 30 km east, 20 km west, 12 km north and south, 10 km south-east. Depending on the condition of the test species, the range of impact of anthropogenic anomalies can be considered to be 25-30 km[19]. As a result of the analysis of the collected materials, the indication of atmospheric pollution of Ganja city was calculated on the basis of the tolerance index (TI) using the methods developed by Estonian lichenologists[20]. According to the level of occurrence of tolerant species, a lichenoindication map of Ganja city was compiled (Map-scheme 1).

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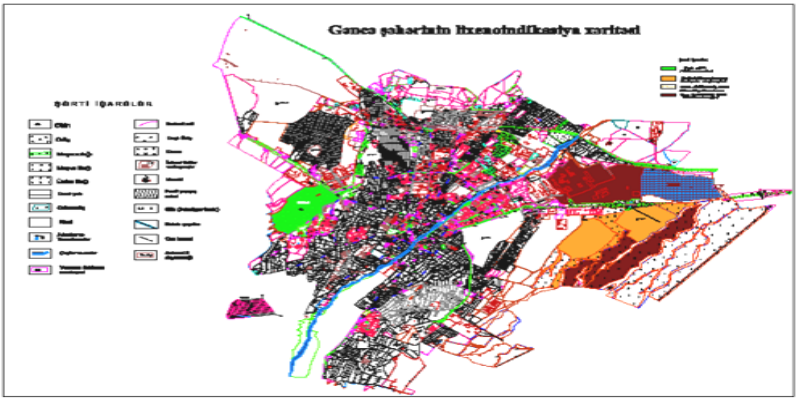
[19] Bayramova, A.A. Kiçik Qafqazın Şimal-Şərq hissəsinin şibyə florası və genofondun mühafizəsi: Avtoreferat diss..biol.üzrə fəls. dokt., -Bakı: - 2007. -21 s.

[20] Новрузов, В.С., Исаева, Ф.М. Лишайники- Биоиндикаторы Атмосферного загрязнения г. Гянджа (Азербайджан) //Аграрная Наука Москва, -2017. -с.2-4.

The city of Ganja is divided into four pollution zones:

The first zone – T.I. = 9.0-10.0 - zone exposed to strong impact of nitrogen anhydride, nitric oxide, sulfur dioxide gas and other atmospheric pollutants. This includes Azeraluminium, an oil and fat plant, an equipment-making plant and the central part of the city, where a major highway passes. No lichen is found in the central part of this zone. *Caloplaca cerina, Phaeophysia orbicularis* were registered at a distance of 2500m, *Xanthoria parietina, Physconia grisea* at a distance of 1500m to the west, *Clodonia furcata* on the ground, *Candelariella aurella* on the rock. No lichen species was registered up to 3000 m on the roofs of the houses towards Azeraluminum.



Map-scheme 1. Lichenoindication map of Ganja city

The second zone - TI = 6,0- 9,0 the central part of the city under the influence of industrial enterprises and the area within a radius of 2-4 km, as well as the lower part of the Ganja railway station, a radius of 1 km is considered a pollution zone. No lichens are encountered in the central streets and sidewalks. However forms specific lichen synusia consisting of the *Candelaria concolor-Caloplaca lactea, Candelariella aurella– Caloplaca elegans* on the roofs of houses located in the opposite direction to industrial enterprises. The thallome of the whitish-gray *Physconia caesia* are observed between two synusia forming a yellowish-pink cover.

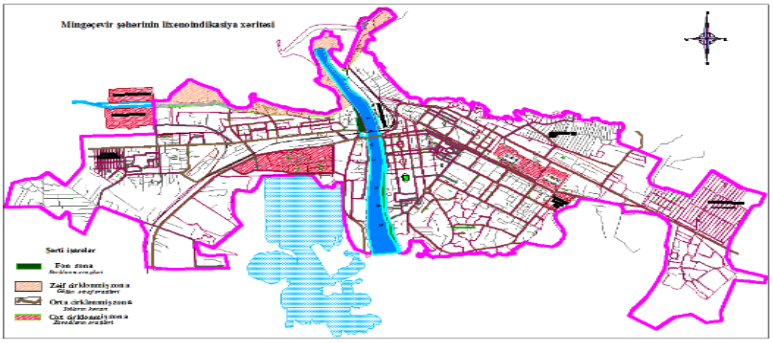
Third zone - TI = 3,0- 6,0 *Xhanthoria paretina, Lecania dime-*

ra, Lecanora atra, Physconia grisea, Caloplaca citrina, Parmelia saxatilis species are found in orchards at a distance of 4 km along Bagbanlar settlement and the banks of the Ganja River.

The fourth zone - TI = 1,0- 3,0 covers an area of 5-6 km around the city. *Cladonia furcata, C.foliaceae, Tonini candida, Collema crispum, Diploschistes scruposus* and etc. species are encountered among the steppe vegetation in the soil.

5.2. Evaluation of bioindication features of urboecosystems of Mingachevir and Yevlakh cities. The city of Mingachevir was built in connection with the construction of a hydroelectric power plant on the Kura River. It received the status of a city on November 11, 1948. It is located 323 km from Baku. It is 17 km from the Baku-Tbilisi railway. The national airport is located 30 km from the Yevlakh region, and the international airport is located 80 km from the city of Ganja.

The lichenobiota of Mingachevir is almost unstudied. Taking into account the bioindication features of lichens, there is a need to study the biological diversity of lichens of Mingachevir city. According to the level of occurrence of tolerant species, a lichenoindication map of Mingachevir city was compiled (Map-scheme 2).



Map-scheme 2. Lichenoindication map of Mingachevir city

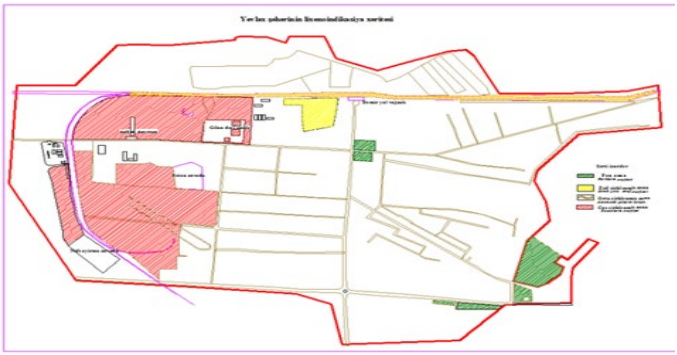
Yevlakh - The city of Yevlakh is located on the right bank of the Kura River, 293 km from Baku, in a plain area. (The south-eastern of the Ganja-Gazakh plain, the north-western edge of the

Karabakh and Shirvan plains, the city of Yevlakh is on the Ancient Silk Road). The climate is characterized by temperate-hot semi-desert and dry steppe with dry winters.

Since March 2004, a number of industrial facilities in the city have been reconstructed or built. “Tamir” ATSC has been reconstructed, where tractors of different brands are assembled and repaired. “Lala-Tekstil” sewing, “Arfa” furniture factories, “Gilan” leather processing, “Dan” brick factories, “Gida” LLC cannery and other new production enterprises also operate. Yevlakh is also a transport hub. The nationally important Baku-Tbilisi railway, Baku-Gazakh highway, Baku-Supsa, Baku-Tbilisi-Ceyhan oil, Gazakh-Agstafa, Baku-Erzurum gas pipelines also pass through Yevlakh. Yevlakh Airport, which serves domestic flights also located in Yevlakh. The passing of the Baku-Tbilisi-Kars railway, which has been under construction in recent years, also promises significant prospects for Yevlakh.

The level of occurrence of species in anthropogenic and natural ecosystems of Mingachevir and Yevlakh is not the same. Chemical analysis of the species found in those cities revealed a correlation between poletolerance and SO_2. As a result of ecobiomorphological analysis, five groups of vital forms of lichens were identified. Poletolerant species for Mingachevir and Yevlakh have been identified on the basis of route researches.

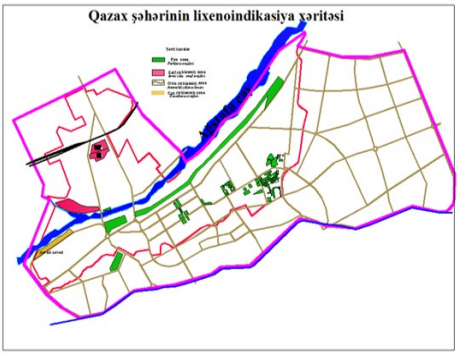
According to the level of occurrence of tolerant species, a lichenoindication map of Yevlakh was compiled (Map-scheme 3).

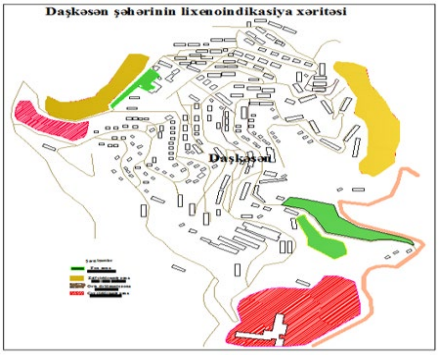


Map-scheme 3. Lichenoindication map of Yevlakh city

5.3. Evaluation of bioindication features of urboecosystems of Gazakh and Dashkasan cities. One of the main pollutants for the city of Gazakh is the highway connecting Azerbaijan with Georgia, Russia and Turkey.

In total, 27 species of lichens were found for Gazakh city. Most of them are found in tree bark, substrate, roof cover. From the special group of lichens, five species are observed in artificial substrates, concrete, cement, brick, roof cover and 5 nitrophilic lichens were recorded on these substrates. It was determined that there is a correlation between the lichenoflora and degree of air pollution according to the amount of nitrogen oxide and the nature of the lichens. The occurence of each species was calculated based on the ratio of area where the species was found in the sample area to the total area. In addition, the percentage of trees that do not have a lichen thallome was calculated in each plant group. It was determined that 28 species are found in Gazakh city and 31 species in Dashkasan. Species of *Anaptychya, Acarospora, Arthopyrenia, Melanea, Lecidella Everina, Ramalina* genera found in the natural flora are not present in urboecosystems. Lichenoindication map of Gazakh and Dashkesan cities according to the level of occurrence of tolerant species was compiled (Map-scheme 4-5).





Map-scheme 4. Lichenoindication map of Gazakh city

Map-scheme 5. Lichenoindication map of Dashkesan city

As a result of studying the lichenobiota of Gazakh and Dashkasan cities, the following were identified:

- The biodiversity of lichens in cities is declining;
- Species diversity is declining from the outskirts of the city to the center. Formation abundance of *Soredia* genus exposed to atmospheric pollution is increasing in urban areas. In areas 2.5 km away from the city, there are no areas that have not been exposed to one or another anthropogenic impact in the urban landscape.
- Species *Xanthoria parietina* is a permanent resident of urban greenery.

Based on the above, the poletolerance index was calculated. Poletolerance index of Gazakh and Dashkasan cities is equal to IP = 3.

5.4. Evaluation of bioindication features of Shirvan city urboecosystems. Sulfur gas, nitrogen oxides, fluorides, ozone, heavy metals have the greatest impact on the life activity of lichens of Shirvan city. SO_2 is considered the dominant factor. SO_2 determines the prevalence of epiphytic lichens. It was found that 0.08 - 0.1 mml3 disrupts the process of photosynthesis (Methodology of measurement, 2008). Brown spots are observed in the chloroplast of lichens. When the pH is low, chlorophyll is acidified when the humidity is 3,4. When the pH is 2-3, it turns into a pheophytin [Trass, 1968]. Increased humidity enhances the dissolution of SO_2 in acidic environments. For this reason, lichens are not resistant to high humidity. However, they are resistant to high concentrations of SO_2 in dry air.

As a result of studying the lichenobiota of Shirvan city, the following was determined.

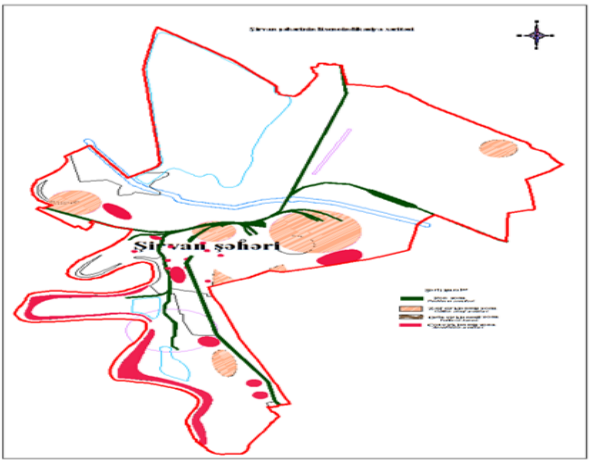
- Biodiversity of lichens is decreasing in cities;
- Species diversity is declining from the outskirts of the city to the center. Formation abundance of Soredia, which is exposed to atmospheric pollution, is increasing in urban areas. (There are no areas that have not been exposed to anthropogenic influences to one degree or another in the urban landscape 2.5 km away from the city).

Xhantorina parentina is a permanent resident in urban greenery. Sensitive species are not resistant to atmospheric pollution.

Xhantoria parientina, Parmerliopsis ambigua, Physcia pulverulenta, Ph.ciliata, Ph.stellaris, Physconia grisea, Phaeophycia ciliata, Candelariella vitellina are the most common urban lichen nitrophytes: Ecological activity of *Caloplaca cerina, C. holocarpa, Lecanora hagenii, P(4) Phaeophyscia orbicularis* and etc. species and wide range of their occurence areas are close to the species of Mingachevir and Yevlakh cities.

Bioindication features of lichens, purity index of Shirvan city atmosphere and poleotolerance indices were calculated according to H.H.Trassa (1968). The city of Shirvan and suburban areas are divided into 3-zone, 4-zone and 7-zone areas according to the species diversity of lichens[21].

According to the level of occurrence of tolerant species, a lichenoindication map of Gazakh city was compiled (Map-scheme 6).



Map-scheme 6. Lichenoindication map of Shirvan city

[21] Novruzov, V.S. Şirvan şəhərinin şibyə florası və onların bioindikasiya xüsusiyyətləri /V.S.Novruzov, F.M.İsayeva //Gəncə Regional Elm Mərkəzi, Xəbərlər Məcmuəsi, -Gəncə: - 2016. -səh 3-7.

There are similarities in the species composition, depending on the nature of the adaptation of the lichen flora of the studied cities to pollutants. The urban flora of the western region of Azerbaijan is compiled based on the analysis of materials on the example of 6 cities.

A comparative analysis of the lichenobiota of these cities revealed that the fresh air indicators substantiate the occurrence of shrublike forms in the city. Shrublike forms are not found in Mingachevir, Yevlakh and Shirvan. Four shrublike forms in Dashkasan, two in Gazakh are found. In Dashkasan and Gazakh cities, leaflike forms predominate. These indicators show that the atmosphere of these cities has a moderate level of toxic and gaseous emissions.

In general, Shirvan, Mingachevir, Ganja and Yevlakh are the main cities in terms of pollution. The percentage of forms in the surveyed cities is given in diagram 1.

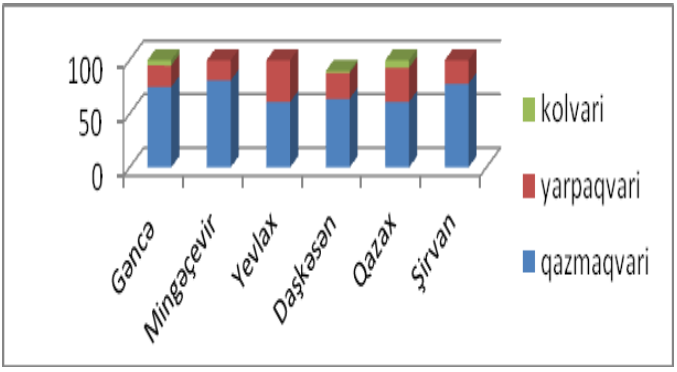


Diagram 1. Percentage of the studied cities according to the vital forms

According to the diagram No. 1, barklike vital forms in Ganja city make up 75%, leaflike 20%, shrub-like only 5%. Barklike and leaflike forms are 81%, 19% in Mingachevir city, 61%, 39% in Yevlakh, 78%, 22% in Shirvan, respectively. No shrublike lichens are found in all 3 cities. It is 64%, 24%, 12% in the city of Dashkasan, respectively, and 61%, 32%, 7% in the city of Gazakh.

The analysis of the areas exposed to the level of pollution re-

vealed certain regularities. As the anthropogenic load increases, the amount of lichens decreases. At the same time, different morphological deformations are observed at the level of occurrence of different species, as well as in the lichen thallomes.

No "normal" zone was found in any model area. However, the number of "Lichen deserts" has increased. *Arthonia radiata, Candelariella aurella, Candelariella vitellina, Caloplqaca cerina, Cuphelium tigilare, Physconia grisea* can be considered model species for all areas with similar source of contamination (sulphur anhydrate and other sulphur compounds, nitrogen oxides and other heavy metal compounds). There are taxonomic and biomorphological differences between the contaminated areas and the lichenobiota of the relatively "clean" areas. It is important to carry out planning work in the industrial cities of Azerbaijan, to take special measures to improve the environmental situation.

CHAPTER VI. ECOLOGICAL-SENOTICAL FEATURES AND GEOGRAPHICAL STRUCTURE OF LICHENS OF STUDIED CITIES

Lichenobiota of Ganja, Gazakh, Mingachevir, Yevlakh, Dashkasan, Shirvan cities includes 8 geographical elements. The main place consists of multiregional species, boreal, nemoral geographical elements.

An integral part of the analysis of lichenobiota is the combination of species with similar distributions in geographical elements. Analysis of geoelements allows to reveal information about the area, origin of species and migration routes. There is no common approach among lichenologists on the classification and determination of geoelements. Geographical elements of lichenobiota are determined on the basis of modern habitats. Although many methods have been known for the geoelements of higher plants, the classification of these elements for lichens has not been resolved.

As a result of the analysis of geoelements in some industrial cities (Ganja, Mingachevir, Yevlakh, Dashkasan, Gazakh, Shirvan) the classification system of 68 species was compiled according to

M.P. Tomin[22]. Of these, holarctic (6), polyarctic (8), boreal (6), panboreal (8), nemoral (14), Mediterranean (14), multiregional (8) and species with unknown habitats (7) are divided into geoelements.

CHAPTER VII. ABSTRACT OF LICHENOBIOTA OF INDUSTRIAL CITIES OF AZERBAIJAN

Flora's abstract is based on many years of research and literature. The lichen flora of some industrial cities of Azerbaijan (Ganja, Mingachevir, Yevlakh, Dashkasan, Gazakh, Shirvan) consists of 29 families, 41 genera and 68 species[23]. The nomenclature of taxa was given according to modern literatures such as Hawksworth, David (Blinkova, 2005; Hale, 1967); Santesson (Randlane, 2013), Esslinger (Blanco, 2004; Ertz, 2011; Esslinger, 2004). Volume of genus is given according to Santesson (Skye, 1968), Esslinger (Esslinger, 2009), Canon (Bungartz, 2007; Cannon, 2007), Checklist (Chobanoglu, 2011; Coppins, 2005; Crespo, 2011).

Within a genus, species are listed in alphabetical order. For each species, information on the growth area, ecology, brief botanical characteristics, geographical distribution in the research areas are provided.

RESULTS

1. It was determined that 68 species of lichens belonging to 29 families and 41 genera were distributed in the studied industrial cities. Of them 29 species belonging to 16 families, 16 genera are found in the urboecosystems of Ganja city, 22 species belonging to 11 families, 11 genera in Yevlakh, 18 species belonging to 11 families, 13 genera in Mingachevir city, 31 species belonging to 20 families, 23 genera in Gazakh, 34 species belonging to 21 families, 24 genera in Dashkasan city, 19 species belonging to 13 families, 13 genera in Shirvan city.

[22] Томин, М.П. Определитель лишайников БССР. Часть 1. Кустистые и листоватые формы / М.П.Томин. -Минск: Изд-во АН БССР, -1936. -96 с.

[23] İsayeva, F.M. Azərbaycanın bəzi sənaye şəhərləri şibyələrinin monitorinqi //– Gəncə: Gəncə Dövlət Universitetinin Elmi Xəbərlər jurnalı, –2017. –s. 103-107.

2. It was clear that the lichenobiota of urboecosystems is dominated by *Physceaceae (11 species), Lecanoraceae (10 species), Teloschistaceae (5 species), Arthoniaceae (3 species)*. Each of *Lecideaceae, Pyrenulaceae, Megasporaceae* families was represented with two species. 12 families are monotype and represented with one species. Analysis at the genus level shows that *Lecanora (9 species), Teloschistes (4 species), Physcia (3 species), Caloplaca (5 species)* are represented.
3. Bark-like forms predominate in the studied areas (54 species, 79,5%). Ten species (14,7%) account for leaflike forms, four species (5,8 %) for shrublike forms. Hemerophob (45%) species, medium resistant (35%), hemerophils (20%). As the level of industrial use of cities increases, the number of hemerophobs of medium-resistant species increases, hemerophil species decreases. Based on the I.P index, high levels of air pollution were found in the study areas.
4. It was found that the occurrence of shrub-like forms of lichens in the studied cities is an indicator of the degree of air purity. No shrub-like forms were found in Ganja, Mingachevir, Yevlakh and Shirvan, 4 shrub-like forms are registered in Dashkasan and 2 in Gazakh. In Ganja city, bark-like forms make up 75%, leaflike - 20%, shrublike only - 5%. Respectively, 81%, 19% in Mingachevir city, 61%, 39% in Yevlakh city, 78%, 22% in Shirvan and shrublike lichens are not found in all 3 cities. In the city of Dashkasan it is 64%, 24%, 12%, respectively, and in the city of Gazakh - 61%, 32%, 7%.
5. It was discovered that an increase of 4% of large amounts of organic and inorganic wastes to the atmosphere in Ganja, Yevlakh, Mingachevir railway stations: dust-50%, carbon oxide-21%, sulfur oxide-21%, nitrogen oxide-5% and others (alkaline and acid vapors, fluoride compounds, hydrocarbons, hydrogen sulfide, acetone, gasoline vapors, ammonia) has formed “Lichen deserts” in the territory of these cities.
6. It has been found that the biodiversity of urban lichens is declining from the outskirts of the city to the center. Industrial cities

and suburban areas are divided into 3-zone, 4-zone and 7-zone areas according to the species diversity of lichens. *Xhantoria parientina, Parmerliopsis ambigua, Physcia pulverulenta, Ph ciliata, Ph stellaris, Physconia grisea, Phaeophycia ciliata, Candelariella vitellina* are the most common urban lichens.

7. Based on oligorithm modification four regional scales of epiphytic lichenobiota (CT) have been developed in common pine, small-leaved linden, oriental plane, Caspian honeylocust. Medium projective cover of species and toxiphobia index (TI) on cluster toxiphobia (CT) were determined, atmospheric air quality of the studied cities was divided into 4 zones according to the results of lichenoindication monitoring: relatively satisfactory (ACH + 22), intensive (15-21), critical (ACH = 10-15) and crisis (ACH = 10-6).
8. The similarity of the species composition of lichens in the studied cities is determined by 2 factors based on the nature of clustering: natural-climatic conditions and anthropogenic factors. Anthropogenic factors have been found to play a decisive role in reducing species composition in a cluster site that differs according to natural and climatic conditions.

PRODUCTION PROPOSALS

It is considered advisable to implement controls on some harmful emissions from cars, including lead, sulfur, solid particles, benzapyrene, polycyclic aromatic hydrocarbon aldehydes.

- Taking measures to reduce emissions of special harmful compounds in enterprises.

- *Xanthoria parietina, Parmelia sulcata, Parmeliopsis ambigua, Physcia pulverulenta, Physcia ciliata, Physcia tenella, Physcia stellaris, Physconia distorta, Phaeophyscia ciliata, Candelariella vitellina* are recommended for bioindication, nitrophyte species such as *Caloplaca cerina, C.holocarpa, Lecanora hagenii, Xanthoria parieti*na for anthropogenic changes in environmental conditions in phytocenoses.

- Comparison of lichenobiota of contaminated areas with the biomorphological structure of natural areas reveals taxonomic and

biomorphological differences. It is important to carry out planning work in the industrial cities of Azerbaijan, to take special measures to improve the environmental situation.

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4. Novruzov, V.S. Şirvan şəhərinin şibyə florası və onların bioindikasiya xüsusiyyətləri /V.S.Novruzov, F.M.İsayeva //Gəncə Regional Elm Mərkəzi, Xəbərlər Məcmuəsi, –Gəncə: – 2016. –səh 3-7.
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