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ECOLOGICAL ASSESSMENT OF ANTHROPOGENIC IMPACT ON THE STATE OF PHYTOCENOSES OF HOLOSIIV PARK NAMED AFTER MAKSYM RYLSKYI OF THE CITY OF KYIV

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Abstract. *Anthropogenic load on natural phytocenoses is manifested by disturbance of plant cover, synanthropization of the floristic composition of groups, destruction of plant distribution areas, reduction of biodiversity, and changes in plant growth and development conditions. The degree of anthropogenic load on natural phytocenoses is a global problem that requires detailed study and monitoring studies, especially in the conditions of urban ecosystems.*

The natural conditions affecting the state of the phytocenoses of Holosiiv Park named after Maxim Rylskyi city of Kyiv according to physical and geographical, climatic, edaphic, and orographic features.

The influence of anthropogenic activity in the experimental plots was determined and the level of anthropogenic pressure on the state of the phytocenoses of Holosiiv Park named after Maxim Rylskyi city of Kyiv was carried out by analyzing available sources of industrial production, transport, etc. It has been established that Holosiiv Park named after Maksym Rylskyi is subjected to constant anthropogenic load, in particular, intensive recreational use, atmospheric air pollution has been established, which leads to the impoverishment of biodiversity in certain areas of the park.

The level of atmospheric air pollution in the territory adjacent to the experimental sites was assessed using computational and instrumental methods. It was established that the estimated CO level exceeds the standards by 8 times on Holosiivskyi Avenue and by more than 30 times at the intersection of Maksym Rylskyi Street and Holosiivskyi

Avenue. The analysis of the state of the atmospheric air using instrumental research methods did not show an excess of the content of the main pollutants, however, according to the Air Quality Index, it is moderately polluted by the content of dust with a diameter of 2.5 microns.

The study of the state of the phytocenoses of Holosiiv Park named after Maksym Rylsky of the city of Kyiv within the experimental plots was carried out by studying their floristic composition and evaluating the ecological groups of plants. Because it is the analysis of ecological groups of plants that makes it possible to assess the ecological conditions of plant groups, the place of growth, and phytocenotypes of plant species that are part of the phytocenosis, that is their role in the formation of the phytocenosis.

The ecological assessment of the state of phytocenoses of Holosiiv Park named after Maksym Rylskyi of the city of Kyiv was carried out using the method of bioindication and lichen indication (lichen research). These methods make it possible to determine the level of anthropogenic load acting quickly and relatively easily on phytocenoses within the experimental plots. To determine the state of the trees in the experimental plots, the method of assessing the asymmetry of morphological structures was used (using the example of the hanging hornbeam Carpinus betulus L.).

A comparison of the floristic composition and the state of the phytocenoses showed that plot No. 1 has a depressed state, plants do not grow evenly, and drying of trees was observed. Plot No. 2 has the best condition, the plants of the plot are characterized by the best indicators of growth and development, the largest number of species, and the frequency of occurrence of species. Site No. 3 did not record significant degradation of the phytocenosis, but there is a certain mosaic of the phytocenosis, which may be due to atmospheric air pollution and significant recreational pressure, in particular, trampling.

Plot No. 2 and Plot No. 3 have the highest coefficient of species composition commonality. Common plant species in the respective areas are: Carpinus betulus L., Anemonoides ranunculoides L., Ficaria verna, Trifolium repens and Corydalis solida.

Key words. *Phytocenosis, assessment of anthropogenic load, species composition, urboecosystem, environmental pollution.*

Introduction.

Phytocoenoses are groups of plant organisms that play an important role in providing many ecosystem services of natural areas (Tokareva T.G., 2019, Shishchenko P.G. and other, 2019). The state of plant communities affects the preservation of biodiversity, as they have genetic potential and adaptive capabilities during changes in the environment. Contribute to the preservation of ecological balance, as they ensure the performance of a number of important biosphere functions.

The state of forest ecosystems depends on the state of the environment, in particular, the content of pollutants, which leads to significant transformational changes in plant communities. To ensure the preservation of biodiversity and resistance of forests to adverse environmental impacts, its control is required. That is why it is necessary to monitor the state of plant communities in areas subject to constant anthropogenic stress (Warning R.H. and other 2010).

Urban ecosystems are the most vulnerable to the action of anthropogenic

factors, because in these natural-anthropogenic systems these factors are constantly active. Plant communities located within urban ecosystems are affected by such effects as:

Environmental pollution. In urban environments, there is pollution of the atmosphere, water resources, and soils, which can lead to a decrease in the diversity of plant and animal species, a decrease in the number of useful bacteria and microorganisms.

Changing the landscape. Due to the construction and development of infrastructure in cities, natural biotopes decrease, which leads to a decrease in the number of natural ecosystems and an increase in the number of artificial ones (Mihely S.V., 2013).

Excessive construction. Excessive development of the territory, including the development of green areas such as parks and squares, can lead to a decrease in the number of plants and animals (Svets V.V. and other, 2013).

Climate change. As a result of anthropogenic influence on the climate, changes in the temperature regime, wind regime and amount of precipitation can occur, which can lead to changes in the vegetation cover and the distribution of species (Shevtsov A., 2021).

Introduction and invasive species. As a result of the introduction of new species of plants and animals into urban ecosystems, there may be a decrease in biodiversity and an increase in the number of invasive species that can compete with local species (Bozhko E., Ozhynska Yu., 2022).

Ecological assessment of the state of phytocenoses is carried out by various methods of determining the species composition of plant communities (Havrylenko, 2021, Myroshnyk N.V. and other, 2021, bioindications (Miroshnyk N.V. and other, 2022, Onyshchenko V.A. and other, 2020). It is also important to determine the state of the natural environment of the area where the studied plants grow.

To protect phytocenoses, it is necessary to take urgent measures, which include the preservation of species, control of the introduction of invasive species, rational use of resources and reduction of pollution.

Research materials and methods.

Holosiivskyi National Nature Park is a unique natural complex of historical, cultural, educational, scientific, recreational, and aesthetic significance, located in the southwest of Kyiv. On the territory of the Holosiivsky district there are three objects of the nature reserve fund: Holosiivskyi Park, Holosiivskyi Park named after Maksym Rylsky, and the Botanical Park of the National University of Bioresources and Nature Management of Ukraine (Vasylyuk O.V., 2020).

The park is in the southern part of the city of Kyiv, in the Holosiivskyi district, within a section of the forest massif, separated from the main massif by transport roads and residential buildings. The area of the park is 140.9 hectares.

A comprehensive method of assessing the ecological state of phytocenoses was chosen for conducting research, which involved the use of such methods as: the observation method, the lichen indication method, the method of fluctuating leaf asymmetry, and the calculation method of assessing the impact of motor vehicles.

The observation method is based on the floristic description and phenological observations of the phytocenoses of

Figure 1. – Layout of experimental plots in Holosiiv Park named after Maksym Rylskyi

the studied areas. Experimental plots of 500 m^2 (25×25 m) with different influence of anthropogenic factors were selected for the research (Fig. 1). Experimental site 1 is located near the entrance to the Holosiiv Park named after Maksym Rylskyi, the terrain is flat with a very gentle slope (less than 3˚), there is an influence of recreation and traffic pollution. Experimental site 2 is in the depths of Holosiivsky Park and is characterized by minimal human influence, the topography of the site is slightly undulating. Experimental site 3 - near the Holosiivska metro station, the surface is terraced.

In the study of the projective coverage of areas, the method using the L.G. grid was used. Ramensky grid is a frame with a wire stretched over it, calculated in such a way that the area of one cell is 1 cm2. The commonality coefficient of the species composition is calculated according to Jaccard's formula.

Areas with different density of trees measuring 10x10m were selected for lichenindication. The number of trees is counted, and each tree is examined in the studied areas at a height of 30 to 150 cm. The H. Truss scale was used to determine air pollution by species composition of lichens.

Determining the estimated level of atmospheric pollution with carbon monoxide was monitored by the traffic load of Holosiivskyi Avenue at 8:00 a.m., 1:00 p.m. and 6:00 p.m. Determination of air quality in Kyiv was carried out using portable dust and gas analyzers SEM DT 9881M and K-600 Gas detector according to generally accepted methods and approaches at 1.5 m from the road at a height of up to 1 m.

The impact of pollution on woody species was determined using the method of fluctuating leaf asymmetry to assess the stability of the development of plant organs (on the example of leaves of common hornbeam (*Carpinus betulus* L.) under conditions of anthropogenic influence.

Research results and their discussion.

The dominant plant grouping of the experimental site is a maple-ash association with three distinct tiers. The first tier is mossy, the second tier is grassy, and the third is wooden. Edifying plants

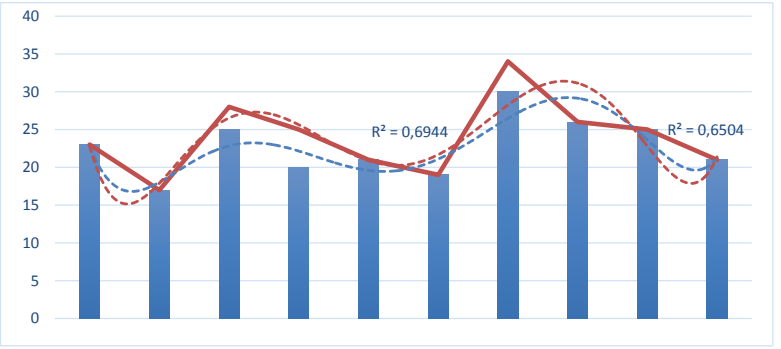


Figure 2. – The results of lichen-indication at site No. 1 (near the entrance to the park named after Maksym Rylskyi)

are forget-me-not (*Myosotis arvensis*) and common dandelion (*Taraxacum officinale*).

On the territory of plot No. 2, hornbeam-oak forest prevails. The layering is represented by three layers: lichen, grass, and wood. You can also find here such edifying plants as: dense gorse (*Corydalis solida*) and European hooves (*Asarum europaeum* L.), which indicate a low content of nutrients in the soil, and there is also sweet-scented fennel (*Galium odoratum*), it is indicator of excessive humidity of the territory.

Experimental plot No. 3 – near st. Holosiivska, terraced surface. A plant association dominated by white willow (*Salix alba* L.), the phytocenosis has three layers: lichen, grass, and tree. Edifying plants: plantain (*Plantago major* L.) and rough sedge (*Glechoma hirsuta*), they indicate moist environmental conditions.

It was established that the highest coefficient of commonality of the species composition has Plot No. 2 and Plot No. 3 according to Jacquard's formula. Common plant species in the respective areas are: *Carpinus betulus* L., *Anemonoides ranunculoides* L., *Ficaria verna, Trifolium* repens and *Corydalis solida*.

Licheo-indication, which was carried out on experimental sites, showed that in experimental site No. 1 the percentage of leafy lichens is very small, and scaly lichens - 18 to 30%, the average value of the degree of lichen coverage of tree trunks is 24.9% (Fig. 2), this can testify to the significant anthropogenic load of the territory. According to the Brown-Blanquet scale, the area corresponds to 2 points, the degree of coverage is 5-20%.

At experimental site No. 2, scaly lichens covering tree trunks range from 37 to 55%, the degree of coverage by leafy lichens is approximately 12%, and scaly lichens - 10%. The average value of lichen coverage of tree trunks is 53.8% (Fig. 3). According to the Brown-Blanquet scale, the area corresponds to 4 points, the degree of coverage is 50-75%.

On plot No. 3, which is located near the Holosiivska metro station, calcareous and leafy lichens prevail, there are no bushy lichens. Point on the Brown-Blanquet scale 3 – degree of lichen coverage from 25 to 50%.

The percentage of calcified lichen coverage of breakthrough area No. 3 ranges from 14 to 42%, the degree of

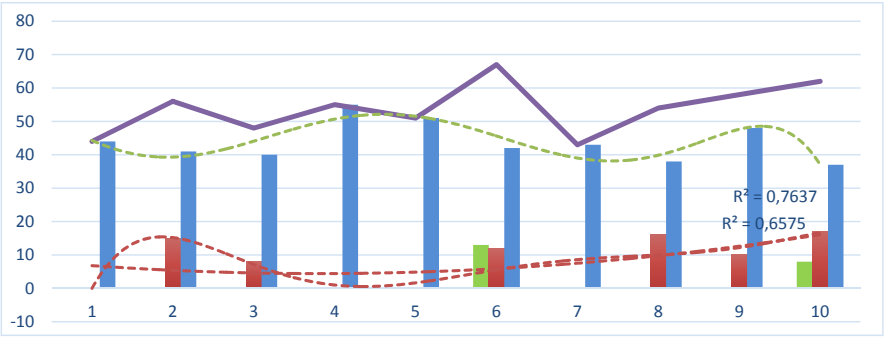


Figure 3. – The percentage ratio of the number of lichens in plot No. 2, Holosiivsky forest

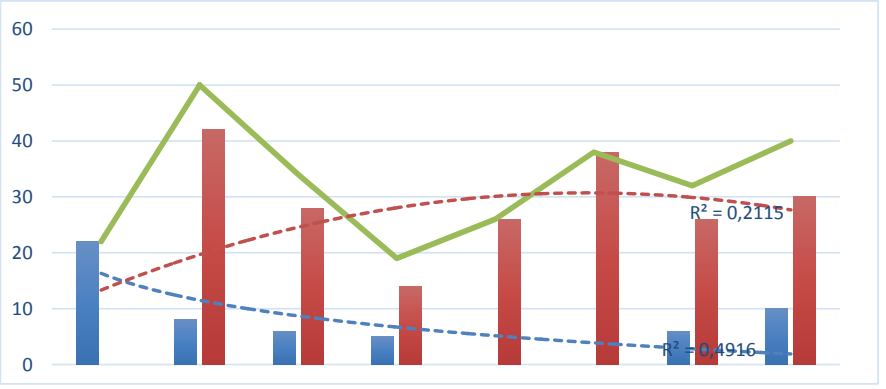


Figure 3. – The percentage ratio of the number of lichens in plot No. 2, Holosiivsky forest

leafy coverage is 14%. The average value of the degree of lichen coverage of tree trunks is 33% (Fig. 4).

Determining the condition of tree species will allow us to draw a conclusion about the level of anthropogenic load on the experimental areas; for this, the method of determining the fluctuating asymmetry of leaves was used with the use of Hornbeam Carpinus betulus L., since this species was common to all experimental areas.

Studies have shown that plot No. 1 and No. 3 are determined by increased values of fluctuation according to characteristic 2, 3 and 5, which may be caused by a greater anthropogenic load, which negatively affects the morphological characteristics of plants. However, according to the integral indicator (Table 1), the population is in a state of conditional norm – plot No. 1 and normal – plots No. 2 and 3.

To carry out an ecological assessment of the phytocenosis, it is also necessary to assess the state of the atmospheric air in the studied area and the territories adjacent to them. For this purpose, instrumental (using gas analyzers) and calculation methods for assessing the level of atmospheric air pollution were carried out.

1. Integral index of fluctuating asymmetry of the population of Carpinus betulus L. in the territory of Holosiiv Park named after M. Rylskyi

No	Name of the research area	Average value of fluctuating asymmetry for each feature					Average value of asymmetry	Rating	Characteristics of the state of the environment
		1	2	3	4	5			
1.	Plot No 1	0,026	0,071	0,065	0,038	0,033	0,050	1	conditional norm
2.	Plot No 2	0,019	0,042	0,039	0,028	0,017	0,028	0	norm
3.	Plot No 3	0,022	0,067	0,056	0,035	0,028	0,042	0	norm

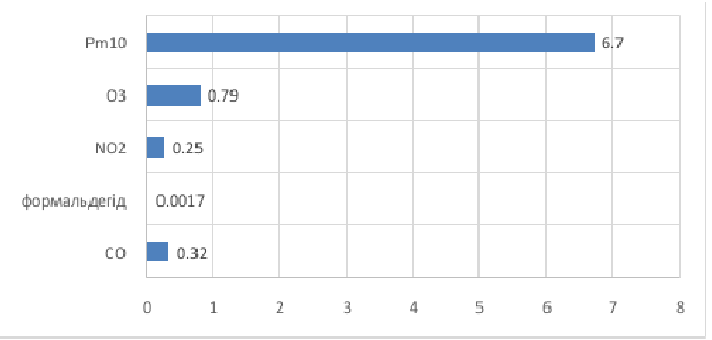
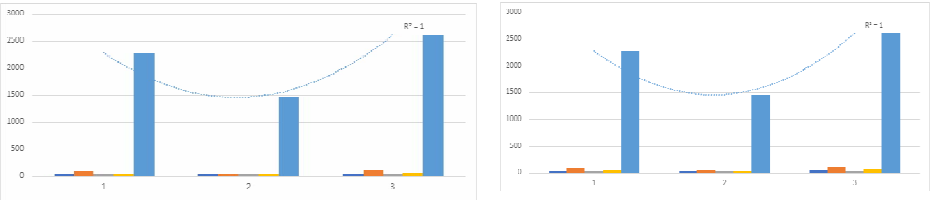


Figure 5. Results of air quality measurement in the Holosiivsky District (Holosiivskyi Prospekt St.) of Kyiv, mg/kg



A B

Figure 6. Traffic congestion of highways at 8:00 a.m. (1), 1:00 p.m. (2) and 6:00 p.m. (3) a – the intersection of Maksym Rylskyi Street and Holosiivskyi Avenue b - st. Holosiivsky prospect

The results of measuring air quality with portable gas analyzers (Fig. 5) showed that the maximum permissible concentrations (maximum one-time) were exceeded for ozone by 4.9 times, nitrogen dioxide by 3.8 times. The content of formaldehyde and carbon monoxide is within the MPC. The content of dust particles in the air of the studied area is slightly increased, which is caused by weather and climate conditions.

Monitoring the traffic at the intersection of Maksym Rylskyi Street and

Holosiivskyi Avenue and St. Holosiivskyi Avenue by motor vehicle (Fig. 6) showed that the largest share is passenger cars.

The calculated total emission of carbon monoxide from 5 categories of transport on Holosiivskyi Avenue is 43.8 mg/m^3, while the intersection of Maksym Rylskyi Street and Holosiivskyi Avenue is 150.7 mg/m^3.

Conclusions and perspectives.

Holosiiv Park named after Maksym Rylskyi is exposed to constant anthropogenic load, in particular, intensive use for recreational purposes, atmospheric air, and water pollution, which leads to the impoverishment of biodiversity, which requires measures to protect and preserve the ecosystem of the park.

Experimental site 1 is located near the entrance to the Holosiiv Park named after Maxim Rylsky is characterized by a flat topography with a very gentle slope (less than 3˚), erosion processes are not observed. Experimental site 2, located in the Holosiiv forest (in the center), is characterized by minimal anthropogenic influence, the relief is slightly undulating, the hornbeam-oak forest prevails. Experimental site 3 Horikhuvatiy pond (near the city of Holosiivska), terraced surface. Plant association with the predominance of white willow (*Salix alba* L.).

Plot No. 2 and Plot No. 3 have the highest coefficient of species composition commonality. Common plant species in the respective areas are: *Carpinus betulus* L., *Anemonoides ranunculoides* L., *Ficaria verna*, *Trifolium repens* and *Corydalis solida*. A particularly large share is made up of spring plants.

An assessment of the ecological state of the phytocenoses of the Maksym Rylsky Holosiiv park was carried out using a comprehensive methodology. A comparison of the composition and state of phytocenoses showed that site No. 1 has a depressed state, plants do not grow evenly, and drying of trees is also observed. Plot No. 2 is in the best condition, plant groups have existed for several years and are capable of self-sustaining. Plot No. 3 does not have serious problems, unlike experimental plot 1, but plant groups grow in certain groups, which is the effect of trampling.

Determination of the quality of the environment by lichen indications showed that the tree trunks of plots 1 and 3 are dominated by calcareous and leafy lichens. Bushy lichens appear only in plot No. 2, which is an indicator of very clean air. The analysis of the degree of lichen coverage of tree trunks according to the Brown-Blanquet point scale and the H. Truss scale showed that the studied sites #2 and #3 are clean, and only site #1, which is located near the entrance to the park named after Maksym Rylskyi, has an average level of pollution. This is explained by the close location of the site near the highway.

Assessment of the stability of the development of tree trees, which is calculated as an integral indicator according to Zakharov, showed that plots No. 1 and No. 3 are under greater anthropogenic load, which negatively affects the morphological characteristics of plants.

The calculated method of assessing atmospheric air pollution with carbon monoxide from vehicles showed that emissions exceed 8 times on Holosiivskyi Avenue and more than 30 times at the intersection of Maksym Rylskyi Street and Holosiivskyi Avenue. Holosiivskyi Avenue is located close to the researched plot 1, and the street intersection is close to the researched plot

#3. Instrumental research showed that the most polluted streets of the Holosiivsky District of Kyiv were Holosiivskyi Prospekt. The high content was recorded of such substances as: carbon monoxide (CO), nitrogen oxide (NO_2) and formaldehyde.

According to the conducted research, it is possible to explain the depressed state of Site No. 1, as it is located almost on the highway, trampling is also increased compared to other experimental sites.

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ЕКОЛОГІЧНА ОЦІНКА АНТРОПОГЕННОГО ВПЛИВУ НА СТАН ФІТОЦЕНОЗІВ ГОЛОСІЇВСЬКОГО ПАРКУ ІМЕНІ МАКСИМА РИЛЬСЬКОГО МІСТА КИЄВА
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Анотація. *Антропогенне навантаження на природні фітоценози проявляється порушенням рослинного покриву, синантропізацією флористичного складу угрупувань, знищенням ареалів поширення рослин, скороченням біорізноманіття та зміною умов росту та розвитку рослин. Ступінь антропогенного навантаження на природні фітоценози є глобальною проблемою, яка потребує детального вивчення та проведення моніторингових досліджень, особливо в умовах урбоекосистем.*

Проаналізовано природні умови, які впливають на стан фітоценозів Голосіївського парку ім. Максима Рильського міста Києва за фізико-географічними, кліматичними, едафічними та орографічними особливостями.

Проведено визначення впливу антропогенної діяльності у зоні розташування дослідних ділянок та встановлено рівень антропогенного тиску на стан фітоценозів Голосіївського парку ім. Максима Рильського міста Києва здійснювалось шляхом аналізу наявних джерел промислового виробництва, транспорту, тощо. Встановлено, що Голосіївський парк імені Максима Рильського піддається постійному антропогенному навантаженню, зокрема, інтенсивному рекреаційному використанню, встановлено забруднення атмосферного повітря, що призводить до збіднення біорізноманіття на окремих ділянках парку.

Оцінено рівень забруднення атмосферного повітря прилеглої до дослідних ділянок території із використанням розрахункових та інструментальних методів. Встановлено, що розрахунковий рівень CO перевищують нормативи у 8 разів на проспекті Голосіївський та більш ніж у 30 разів на перехресті вулиці Максима Рильського та проспекту Голосіївський. Аналіз стану атмосферного повітря із використанням інструментальних методів дослідження не показало перевищення рівня вмісту основних забруднюючих речовин, проте за Індексом якості повітря є помірно забрудненим за показником вмісту пилу діаметром 2,5 мкм.

Дослідження стану фітоценозів Голосіївського парку імені Максима Рильського міста Києва у межах дослідних ділянок проводилось шляхом вивчення їх флористичного складу та оцінки екологічних груп рослин. Оскільки саме аналіз екологічних груп рослин дає змогу оцінити екологічні умови рослинних угрупувань місце зростання та фітоценотипи видів рослин, що входять до складу фітоценозу, тобто їх роль у формуванні фітоценозу.

Екологічна оцінка стану фітоценозів Голосіївського парку імені Максима Рильського міста Києва проводилась із застосуванням методу біоіндикації та ліхеноіндикації (дослідження лишайників). Ці методи дозволяють швидко та відносно легко визначити рівень антропогенного навантаження, яке діє на фітоценози у межах дослідних ділянок. Для визначення стану дерев на дослідних ділянок було використано метод оцінки асиметрії морфологічних структур (на прикладі граба повислого Carpinus betulus L.).

Порівняння флористичного складу та стану фітоценозів, показало, що ділянка №1 має пригнічений стан, рослини зростають не рівномірно спостерігалось засихання дерев. Ділянка №2 має найкращий стан, рослини ділянки характеризуються найкращими показниками росту і розвитку, найбільша чисельність видів та частотою зустрічання видів. Ділянка №3 не зафіксовано значної деградації фітоценозу, проте присутня певна мозаїчність фітоценозу, що може бути зумовлене забрудненням атмосферного повітря та значним рекреаційним тиском, зокрема, витоптуванням.

Найбільший коефіцієнт спільності видового складу має Ділянка №2 та Ділянка №3. Спільними видами рослин на відповідних ділянках є: Граб звичайний (Carpinus betulus L.), Анемона жовтецева (Anemonoides ranunculoides L.), Пшінка весняна (Ficaria verna), Конюшина повзуча (Trifolium repens) та Ряст щільний (Corydalis solida).

***Ключові слова**. Фітоценоз, оцінка антропогенного навантаження, видовий склад, урбоекосистема, забруднення довкілля.*