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INTEGRATED EXPRESS-ASSESSMENT OF AIR QUALITY UNDER CONDITION OF CHANGING INDUSTRY INFRASTRUCTURE OF THE REGION

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Purpose. To make integrated express assessment of the quality of habitat for living organisms, in particular assessment of plant fluctuating asymmetry in terms of change of industrial infrastructure in the region using the upper tier vascular plants. ***Methodology.*** We have applied the morphological characters for leaf tree crops according to method "Biotest". We have identified the most appropriate indicator plants of urban atmospheric pollution. We have taken the bark of trees that concerning their properties to the types of poor bark (pine, birch) for definition pH bark in order to review the distribution of toxic substances on the territory of Sumy. ***Results***. We have calculated the integral index of asymmetry of the plant leaf blade for urban areas with different levels of anthropogenic impact. We have correlated the experimental results of level of fluctuation asymmetry foliage of the most common tree species in Sumy and data of the ecological state of the urban environment. We have built the bioindication range of tree crops' sensitivity for Sumy. ***Originality.*** We have carried out the integrated research of complex assessment of air quality under changing industrial infrastructures of Sumy with using bioindication methods. The impact of pollutants in pH of tree bark caused depletion of lichen flora of the city. Accordingly, we have substantiated that the implementation of biological indication with using the tree species is the most rational and effective for integrated assessment of air pollution in urban environments. ***Practical value***. Prognostic bioindication estimation have confirmed possible risks in the changing industrial infrastructure of urban areas which allows designing a series of administrative decisions and measures to reduce environmental risk index values under increasing anthropogenic load. *References 10, figures 2.*

Key words: express-assessment, atmospheric pollution, bioindication, industrial infrastructures

ІНТЕГРАЛЬНА ЕКСПРЕС-ОЦІНКА ЯКОСТІ ПОВІТРЯНОГО СЕРЕДОВИЩА В УМОВАХ ЗМІННОЇ ПРОМИСЛОВОЇ ІНФРАСТРУКТУРИ РЕГІОНУ

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У статті здійснено визначення комплексу полютантів та фактичні джерела забруднення атмосферного повітря урбанізованої території на прикладі м. Суми. Визначено найбільш оптимальні рослини-індикатори забруднення атмосфери міста відповідно до біоіндикаційного ряду чутливості деревних культур. Встановлено залежність між екологічним станом урбанізованого середовища та флуктуаційними змінами асиметрії листяного покрову найбільш поширених в досліджуваній місцевості видів дерев. Розраховано інтегральний показник асиметрії листової пластинки для ділянок з різним рівнем техногенного навантаження в умовах зміни промислової інфраструктури міста. Для ознайомлення з розподілом токсичних речовин на території міста було здійснено дослідження значень показника pH кори дерев, що відносяться за своїми властивостям до видів з бідною корою. Підвищення pH кори дерев пов'язано з лужним забрудненням атмосфери, яке обумовлюють катіони металів, що осаджуються на рослини з атмосферного пилу.

Ключові слова: експрес-оцінка, атмосферне забруднення, біоіндикація, промислова інфраструктура

PROBLEM STATEMENT. Integrated assessment modeling can be considered as an approach used to decide how to reduce emissions to improve air quality, reduce exposure and protect human health. This issue is also linked to the need of defining a set of indexes and a methodology to measure the sensitivity of the decision problem solutions. Taking into account current practices of member states of European Union different components of an Integrated Assessment (IA) system were identified, namely[1]: (i) source apportionment; (ii) emission reduction measures at different scales; (iii) air quality modeling approaches; (iv) health effects of air pollution; and (v) uncertainty.

In the scenario analysis approach, source-apportionment can be used to identify the main emission sources that contribute to air pollution concentrations. Emission reduction measures are selected and/or established taking into consideration synergies at different scales.

In the optimization approach, the emission reduction measures are selected by an optimization algorithm assessing their impact on air quality, health exposure, implementation costs. Such optimization algorithms requires thousands of air quality assessments; in these cases, Air Quality (AQ) of systems cannot directly be used because of the computing time demand, so they provide tens to hundreds simulations processed to identify 'simple' emissions-AQ links (source-receptor relationships)[1].

Today bioindication methodology is the widely developing for complex assessment of environment pollution. Bioindicators include biological processes, species, or communities and are used to assess the quality of the environment and how it changes over time [2]. Changes

in the environment are often attributed to anthropogenic disturbances (e.g., pollution, land use changes) or natural stressors (e.g., drought, late spring freeze), although anthropogenic stressors form the primary focus of bioindicator research [3,4].

Thus the main task of bioindication is to create methods and criterion that can show the level of anthropogenic impact and diagnose early damages in the most sensible components of biocoenosis.

In the bioindication lichens [5] and different vessel plants (pine, birch, poplar, etc.) [6,7] are used as indicator plants to assess the ambient air or integrated express assessment of air quality habitat of living organisms. The lichen indication is a very common as a result of such lichens characteristics [8]: rapid accumulation of toxic substances is distinct anatomical and morphological changes thalli that are easily defined; wide spread, each species is confined to a particular growth; very high sensitivity to pollution. But lichens used as indicator plants have some disadvantages for bioindication of pollution from stationary sources.

Because such pollution emission occur at high altitude 5-20 m, as a result pollutant are transferred of air flow and deposited on the foliage and top of trees trunks belonging to the upper tier of vegetation. After the toxicants accumulation in vascular plants (trees) only some part of it partial sucked on the lower tier and accumulation in different types of lichens. In addition, plant indicators should be not too sensitive and inert to contamination. It is essential that bioindicator have quite a long life cycle and low capacity for autoregulation. The lichen indicator is used only to assess air pollution from road transport that was substantiated in most investigation [5,8].

But for complex and systematic assessment of air in the region in joint actions of different sources of human impact, primarily production capacity, is needed the indicator with the upper tier of vegetation. This kind of trees must be the most common in the studied areas with sufficiently high sensitivity to contamination. Besides drawing up maps of cities with using lichen indication cannot explain the inhibition of plant flora. In a complex air pollution assessment include the joint impact of vehicle exhaust, chemical plant pollutants, dust, ash dumps. Thus it is difficult to conclude that the dominance of a particular type of pollutants based on lichenoindication, as confirmed in [9].

The aim of this study is make integrated express assessment of the quality of habitat for living organisms. Thus, tasks of this work next:

- determining the bioindication ability of different plant species in Sumy region;

- assessment of fluctuating asymmetry in terms of change of industrial infrastructure in the region using the upper tier vascular plants (stands).

EXPERIMENTAL PART AND RESULTS OBTAINED.

Materials and methods. The system of the morphological characters for leaf tree crops according to method “Biotest” was used .The study of plant communities was carried out in the appropriate test points and build rows corresponding sensitivity bioindication of tree crops. Requirements for bioindicators [10]:

- to be typical for the conditions;
- to have wide area of distribution;
- to have a broad ecological amplitude;
- to have high numbers in the studying ecotope;
- to dwell in this place for a number of years, which makes it possible to trace pollution dynamic;
- to growth in conditions that are suitable for sampling;
- to be characterized by positive correlation between pollutant concentration in the plant and object (factor) of investigation;
- to have a low spontaneous frequency of display features that take into account.

The study was conducted in the city Sumy. The technogenic impact is increased by pollutant emissions from stationary and mobile sources. The first phase of study was carried out for definition priority pollutants. Accommodation observation points was performed according to the location of the main sources of pollution due to the territorial division of the city (PJSC “Sumykhimprom”, PJSC “Sumy Frunze Machine-Building Science and Production Association”, LLC “Sumyteploenerho”).

The next phase was selection test objects on experimental plots and then statistically estimated value fluctuating asymmetry leaf blade. The average value of the relative differences a sign was used as a integral index of the ratio of the sum of the difference measurements letter to the left and right side referred to the number of signs, which is calculated by the formula

$$I_A = I_0 \cdot \frac{(A-B)}{(A+B)}, \qquad (1)$$

where I_A – integral index of fluctuating asymmetry; I_0 – absolute value; A, B – characteristic value of the left and right sides of the leaf blade respectively.

pH was analyzed by pX-meter pX-150 (ionometer) (Belarus).

This integral indicator enables comparison and averaging the values of attributes at different absolute value as well as comparison of signs expressed by linear and angular units.

The study of the dynamics of trees fluctuating asymmetry. Figure 1 shows the bioindication range of tree crops’ sensitivity, which are the most common local variety of tree plantations. Studies have been conducted bioindication properties of such tree crops: birch - *Betula pendula Roth*, white willow - *Salix alba L.*, maple - *Acer platanoides L.*, pyramidal poplar - *Populus pyramidalis Borkh*. Investigation of bioindication properties of tree crops can provide a birch warty as an effective bioindicator. The pyramidal poplar is the most resistant to changes in environmental quality. Average integral index fluctuating asymmetry for warty birch is 0.054 ± 0.003, indicating that the approach to the ecological state before a critical level.

Figure 1 provides results of fluctuating asymmetry changes of birch leaves (from 0.048 ± 0.003 to 0.059 ± 0.003). The value of the integral index of control point was 0.045.

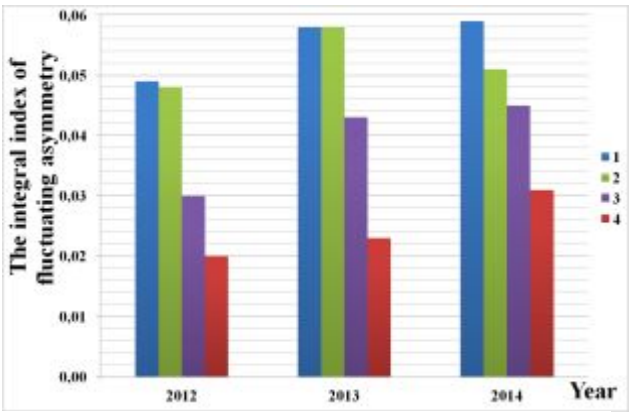

Figure 1 – Bioindication range of tree crops' sensitivity in Sumy: 1 – birch; 2 – willow; 3 – maple; 4 – poplar.

Compared to the benchmark high rate of instability seen in trees growing in central and in northern, northeastern, eastern and southeastern parts of the city. It is generally coincides with zones dispersion of emissions from industrial facilities infrastructure and high transportation load. The maximum rate asymmetry birch warty observed in the northeastern experimental section. Because emissions from the chemical industry facility was observed in this section. That allows you to trace the trend of transition as the state of the environment "before critical" in a state of "critical." The high stability of the indicator for warty birch and willow white, compared to other crops studied in areas of the city with the largest anthropogenic load allows mark them as more sensitive bioindicators.

During the study the integral index increased for three years, in 2012 was 0.048, in 2013 was 0.058, in 2014 it amounted to 0.059, due to changes in output for the objects of industrial infrastructure. The relatively favorable conditions of magnitude of the asymmetry were observed in western and north-western areas (0.045–0.049). In general, comparing the asymmetry of the leaf blade birch warty with data of pollutants dispersion was conducted for stationary sources in the surface atmosphere. The average and high levels of integral index of instability was observed in areas of the city with a high concentration of nitrogen oxides and sulfur dioxide, which suggests the formation of areas of environmental risk due to air pollution.

The bark of trees that concerning their properties to the types of poor bark (pine, birch) was taken for definition pH bark in order to review the distribution of toxic substances on the territory of Sumy (fig. 2).

There is increasing pH bark in most of the study urbanized area in comparison with the same species in the park area, which taken as a control. Therefore, increasing the pH of bark associated with alkaline pollution that cause metal cations, which are deposited on plants with atmospheric dust with precipitation and the exhaust gases of vehicles that contain significant amounts of lead.

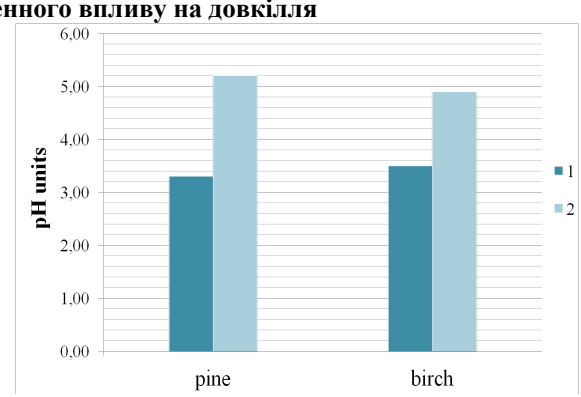

Figure 2 – Change values of pH bark: 1 – control zone; 2 – urbanized territory.

The impact of these pollutants in pH of tree bark caused depletion of lichen flora of the city. Accordingly, the implementation of biological indication with using the tree species is the most rational and effective integrated assessment of air pollution in urban environments.

CONCLUSIONS. In the research was carried out integrated express assessment of quality of atmospheric environment that include analysis of fluctuating asymmetry of vascular plants of the upper tier in the changing industrial infrastructure of the region. The optimal plant-indicators of air pollution in Sumy were identified according to the bioindication range of sensitivity of tree crops.

The dependence between the ecological state of urbanized environment changes and fluctuating asymmetry deciduous was determined for the most common species of trees in the study area. Analysis of the results suggests that anthropogenic pressure was strengthened in the period of time 2012–2014. The response of tree crops is almost identical such as enhanced value fluctuating asymmetry leaves all selected tree crops. Study of bioindication properties of tree crops allow to note that warty birch was the most appropriate to use as a sensitive bioindicator. The pyramidal poplar was most resistant to changes in environmental quality.

Detailed analysis of bioindication properties of tree crops, allowing them to build the next bioindication row: birch warty> maple> salix alba> pyramidal poplar.

Prognostic bioindication estimation of possible risks in the changing industrial infrastructure of urban areas can be using for developed a series of administrative decisions and measures to reduce environmental risk index values under increasing anthropogenic load.

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ИНТЕГРАЛЬНАЯ ЭКСПРЕС-ОЦЕНКА КАЧЕСТВА ВОЗДУШНОЙ СРЕДЫ В УСЛОВИЯХ ИЗМЕНЕНИЯ ПРОМЫШЛЕННОЙ ИНФРАСТРУКТУРЫ РЕГИОНА

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В статье проведено определение комплекса загрязнителей и фактических источников загрязнения атмосферного воздуха урбанизированной территории на примере г. Сумы. Определены наиболее оптимальные растения-индикаторы загрязнения атмосферы города в соответствии с биоиндикационным рядом чувствительности древесных культур. Установлена зависимость между экологическим состоянием урбанизированной среды и флуктуационными изменениями асимметрии лиственного покрова наиболее распространенных в исследуемой местности видов деревьев. Рассчитано интегральный показатель асимметрии листовой пластинки для участков с разным уровнем техногенной нагрузки в условиях изменения промышленной инфраструктуры города. Для ознакомления с распределением токсичных веществ на территории города было проведено исследование значений показателя pH коры деревьев, относящихся по своим свойствам к видам с бедной корой. Повышение pH коры деревьев связано с щелочным загрязнением атмосферы, которое обусловливают катионы металлов, что осаждаются на растениях с атмосферной пылью.

Ключевые слова: экспресс-оценка, атмосферное загрязнение, биоиндикация, промышленная инфраструктура

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