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BIOINDICATION RESEARCH OF SULFUR COMPOUNDS AEROTECHNOGENIC DISSEMINATION INTO THE ATMOSPHERE OF CHERKASY WITH THE USE OF ACER PLATANOIDES L.

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Purpose. To conduct research bioindication aerotechnogenic distribution of sulfur compounds and there scattering in urban ecosystem using *Acer platanoides* L. leaf lesions and fungus species of ascomycete *Rhytisma acerinum* (Pers.) Fries. **Methodology.** Modern methods of phytoindication and biochemical methods for detection of sulfur compounds have been used. **Results.** The issues of SO₂ industrial emissions impact on processes of *Acer platanoides* L. leaves lesion by chlorosis and maple *Rhytisma* have been highlighted. Correlation connection between their accumulation in the atmospheric environment and plants leaves has been established. The increase of the *Acer platanoides* leaves lesions percentage by ascomycete *Rhytisma acerinum* indicates the relative safety of park areas and recreational areas of the city. **Findings.** Scattering of sulfur compounds concentrations is in the north-east of the industrial zone. The lesion of maple leaves by fungus *Rhytisma acerinum* can be used as bioindicative sign of low concentration of pollutants in the air of the area. This is especially important when placing recreational areas and the development of residential districts of the city. **Originality.** Scientific novelty of research is in the fact that theoretical and practical foundations of the concept of bioindicative estimation of aerotechnogenic influence factors have been intensified in the context of environmental monitoring system in Cherkassy; the availability of bioindication research methods have been proved concerning determination of optimal conditions and environmental safety in urban areas. **Practical value.** The study results can be used for environmental activities planning in a modern metropolis, as well as for more effective biomonitoring system organization regarding aerotechnogenic distribution of sulfur compounds and creation of safe living conditions.

Key words: bioindication, aerotechnogenic pollution, industrial SO₂ emissions, *Acer platanoides*, *Rhytisma acerinum*, urban ecosystem, environmental safety areas.

БІОІНДИКАЦІЙНІ ДОСЛІДЖЕННЯ АЕРОТЕХНОГЕННОГО ПОШИРЕННЯ СІРЧИСТИХ СПОЛУК У АТМОСФЕРІ МІСТА ЧЕРКАСИ З ВИКОРИСТАННЯМ ВИДУ ACER PLATANOIDES L.

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Місто Черкаси відноситься до найбільш забруднених міст Черкаської області. Концентрація сірчистих сполук у атмосфері міста з переходом Черкаської ТЕЦ на тверде паливо постійно зростає. Наявність сірчастого ангідриду в атмосферному середовищі може призвести до сумачії забруднень, що збільшує ефект впливу поллютантів на живі організми. Стаття присвячена біоіндикаційним дослідженням аеротехногенного поширення сірчистих сполук і їх розсіюванню в урбоекосистемі з використанням *Acer platanoides* L., а також ураженням листків виду сумчастим грибом *Rhytisma acerinum* (Pers.) Fries. Матеріали статті висвітлюють питання впливу техногенних емісій сірчистих сполук у атмосфері на процеси ураження листків виду клену гостролистого хлорозом і кленовою ретизмою. Встановлено, що концентрація сірчистих сполук у атмосфері міста Черкаси корелює з їх накопиченням у листках рослинного матеріалу, а збільшення відсотку уражень листків клену сумчастим грибом *Rhytisma acerinum* вказує на відносну безпеку територій паркових і рекреаційних зон міста.

Ключові слова: біоіндикація, аеротехногенне забруднення, емісії SO₂, *Acer platanoides*, *Rhytisma acerinum*, урбоекосистема, екологічна безпека територій.

PROBLEM STATEMENT. Intensive development of industry and transport has led to increased pollution of air, water and soil both on the territory of Ukraine, and in the Cherkasy region. In modern cities, on the background of air pollution emissions from industrial enterprises, the share of emissions from transport sources, depending on the category and level of industrial capacity varies within 20-80% [1]. The city of Cherkasy is among the most polluted cities in the Cherkasy region. Along with the growing emissions of Cherkasy heat electropower station, working mainly on solid fuel, motor vehicle emissions are added, the number of which is increasing [2]. Air pollution compared to the contamination of other objects of the environment plays a key role in the ecological load on urban ecosystem. Stationary and mobile sources of emissions contain hazardous compounds including phenol, formaldehyde, ammonia, nitrogen and sulfur

oxides, ozone, benzpyrene, heavy metals and others. The presence of sulfur dioxide in the ambient environment can lead to a summation of pollution, which increases the effect of pollutants on living organisms, including man. [3] The presence of the large number of sulfur compounds and formaldehyde (CH₂O), which recently are recorded by monitoring observations in the atmosphere of the city, may weaken urban floras resistance to pathogenic fungi and insects. It becomes more vulnerable and falls much easier under the influence of biotic origin factors - pathogens and pests. And sometimes their presence increases plant resistance to several fungal diseases [4]. For example, it is known that SO₂ is a fungicide against the fungus *Rhytisma acerinum* (Pers.) Fries - embossed shiny spots on the leaves of *Acer* maples, resembling tar stains [5].

Recent publications indicate that preservation of natural vegetation and landscaping of settlements by

decorative and resistant plant species, nowadays, is one of the means of optimizing the environment in industrial regions. Authors of articles point out the issue of increasing the stability of trees in an industrial city and, in particular, emphasise that recently plants of the genus *Acer* L. Are significantly affected by the defeat fungal pathogens. This leads to loss of decorative effect, reducing the period of life, often to the death of plant organisms. *Acer* maples at planting settlements deserves special attention because of valuable tree species, its rich diversity of species and forms makes it possible to meet a large number of requests green construction [6 - 9], so it has been successfully used in Cherkasy. At the same time the number of publications on the use of species *Acer platanoides* L. as bioindicator of sulfur compounds emissions are not enough. In our opinion ascomycete *Rhytisma acerinum* (Pers.) Fr., causing the appearance on the forofit leaves of unsightly irregular black spots, also deserves a special attention among many phytopathogenic flora. The problem of aerotechnogenic impact of pollution both on the course of processes in the atmosphere and on the functioning of urban phytocenosis, the questions of pollutants depositing in the environment requires a quick solution. Therefore, establishing relationships between the presence of sulfur compounds in atmosphere environment depositing in the leaves of trees and *Acer* maples *Rhytisma* lesions may point to the direction of propagation of pollutants and in areas of high concentration of SO₂ in the air, which is important in creating conditions for ecological safety areas.

The purpose was to conduct bioindication research aerotechnogenic distribution of sulfur compounds and

their scattering in urban ecosystem using *Acer platanoides* L. leaf lesions and fungus species of ascomycete *Rhytisma acerinum* (Pers.) Fries., and the development of measures to improve the ecological conditions of urban flora existence.

WORK GOAL. The task of research also included objectives determining the degree of damage of forofits trunks and crowns lesions and the percentage of leaves using phytoindication, content research of sulfur compounds in plant material by biochemical methods and establishment of correlation dependence between the accumulation of sulfur compounds in the leaves of *Acer platanoides* L. and in the city atmosphere.

MATERIAL AND RESULTS. For carrying out the research in the city of Cherkasy 10 model plots have been allocated located in different areas at different distances from industrial facilities such as joint venture "Azot" and SE "Cherkasy heat electropower station." Particular attention was paid to park areas and recreation areas. At each of the sites 20 *Acer platanoides* L. trees up to 25 years old were chosen and the degree of tree trunks and plants leaves damage was visually determined. Great attention was paid to representatives of the species *Acer platanoides* the leaves of which were affected by fungus *Rhytisma acerinum*, the settlement percentage of which was determined by a special template. 100 leaves were selected from each tree. Mass of sulfur in the leaves of plants were determined by titration [10,11].

On the photographs of Figure 1 the defeat leaves of trees in some areas of the city has been shown.



Figure 1 – The photos of *Acer platanoides* leaves with different degree lesion by chlorosis, necrosis and *Rhytisma acerinum*:

a) «Victory 30 anniversary» park; b) «Sosnivka» park; c) «Chemists» park; d) «First city hospital» park

As it can be seen in Figure 1 the greatest lesion of trees leaves by tar spots is observed in the park of the First City Hospital and the area «Dakhnivka» that are located far from industrial plants (lesions have more spot disease). Spot necrosis are more visible in areas

close to the industrial area, including the «Chemists» park. Some authors testify that the maples *Acer platanoides* L. have a relatively low capacity to absorb pollutants and this is due to the specific structure of leaf plate. But 10kg maple leaves consume about 20 liters of

SO₂. And the appearance of necrotic areas on leaf plate - is the result of this process [12].

An inventory of the availability of this type and their general status revealed indicators of tree trunks damage (tumours, bark detachment) 20% -75% of selected patterns and minor lesions of the crown from 5% to 10%. Most of the city forofit vegetation and buffer zones is in unsatisfactory condition. This is due to the overall effect of atmosphere pollutants, the use of saline solution in winter and specificity of vehicles emission

accumulated in the surface layer of the atmosphere. The general condition of the trees used in bioindication studies can be considered as satisfactory one.

Biochemical studies have found little content of sulfur compounds in the leaves of plants, but the pollutant concentration changes dynamics can still be traced. Indicators of lesions in percentage of research data and the content of sulfur compounds in leaf plates of surveyed trees are shown in Table 1.

Table 1 – Results of studies using *Acer platanoides*

№ p/p	The name of the model plot	The number of trees with damaged bark, pieces	% trees with damaged leaves			The concentration of sulfur compounds, %
			Common the percentage	Chlorosis and necrosis	Rhytisma acerinum	
1	Goint venture «Azot»	16	40	40	-	0,0011
2	SE «Cherkasy heat electropower station»	18	55	55	-	0,0020
3	The «Chemists» park	16	45	45	-	0,0017
4	«The 30th Anniversary of Victory» park	15	55	45	10	0,0014
5	The Central District «B. Khmelniysky Square»	13	27	20	7	0,0007
6	The «Cathedral» park	12	33	30	3	0,0009
7	The «Sosnivka» park	10	42	5	37	0,0004
8	«The First City Hospital» park	12	97	5	92	0,0002
9	The «Mytynysya» district	14	40	30	10	0,0006
10	The «Dahnivka» district	10	80	10	70	0,0004

Implemented research of the species of the maples *Acer platanoides* L. existence in of Cherkasy city phytocenosis indicates that the vast majority of forofits are under the dual pressure from both stationary and mobile sources of the vehicle. This is indicated by the appearance of trees, fixed rates lesions of the trunk, branches and leaves. This is especially noticeable in trees at industrial sites close to industrial and central areas of the city. Lesion of trunks by ulcers, tumors can be observed as well as the presence of phyto- and entomological pests that is informative feature of the current state of tree plantations, which are exposed to man-made press. Such signs are also evidence of possible forofits immunity failure which further reduces due to various influences of abiotic stress factors (high temperatures and humidity).

The largest number of chlorosis are recorded in areas close to Cherkasy heat electropower station – «Chemists» park. This area is subjected to the pollution summation of joint venture «Azot», «Cherkasy heat electropower station», mobile vehicles sources, which are focused on the Chemists Avenue bypass highway.

The amount of chlorosis in remote areas is minimal. The table also shows various contents of sulfur compounds in the plant material. The highest content of this index in leaves of selected areas on joint venture «Azot», «Cherkasy heat electropower station», slightly

lower content is in areas of the «Chemists» park, «The 30th Anniversary of Victory» park and the «Cathedral» park. The lowest content of sulfur compounds is in areas of the «Sosnivka» park, the «First City Hospital» park and «Dakhnivka», indicating the dispersion of pollutants in the atmosphere. At the same time, the number of chlorosis and necrosis increases with the content of sulfur compounds in the leaves of plants, and the growth of lesions by Maple *Rhytisma* occurs with a decrease of their content in plant material. This confirms the view about fungicidal properties of sulfur and gives reason to believe that the level of anthropogenic impact on industrial and recreational areas varies. Instead, the presence of maple leaves lesions by fungus *Rhytisma acerinum* is bioindication sign of tree species on pollutant concentration ratio SO₂ in the atmosphere of explored Cherkasy regions.

Most aerotechnogenic burden by these signs suffer the plants of the Southern industrial area - joint venture «Azot», «Cherkasy heat electropower station», «Chemists» park somewhat less, but high enough impact on the territory of «The 30th Anniversary of Victory» park, «Cathedral» park and the Central District – «B. Khmelniysky Square» and the «Mytynysya» district which is also under the influence of breeze inversions of the Dnipro River. Foliage of trees in all these areas suffer mainly from regional and spot

necrosis. The least impact is in the areas of «The First City Hospital» park, «Sosnivka» park and «Dahnivka» district belonging to recreation areas.

Taking into consideration the method of Merkov A.M. we calculated the correlation figures between the content of sulfur compounds in plant material and the city atmosphere, which are presented in Figure 2 clearly demonstrate the impact of industrial emissions of sulfur compounds in the atmosphere on the processes of the maples *Acer platanoides* L. leaves lesion by chlorosis and maple *Rhytisma*.

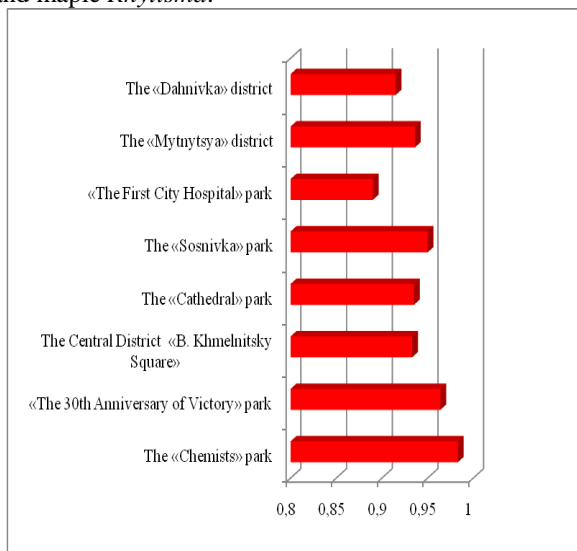


Figure 2 – Indicators of correlation

High values of correlation indicators reaffirm once again that the pollutant concentration in plant material depends on the placement area the source of emissions and depositing conditions in the respective areas. At the same time, increase of the percentage of maple leaves ascomycete *Rhytisma acerinum* lesions indicates the relative safety of park areas and recreational areas of the city.

We have also proposed measures to reduce the risk of emissions of pollutants from stationary and mobile sources of vehicles, including:

- Improving the environmental situation in the city due to the execution of environmental legislation requirements and decrease of the harmful effects of toxic substances on the environment in the process of equipment operation, due to the introduction of new systems of harmful emissions neutralization;
- Carrying out of effective land-improvement measures concerning improvement of operating conditions for vegetation of the city, including: feeding, watering and mulching of the soil and dead branches pruning etc.

CONCLUSIONS. Scattering of sulfur compounds concentrations is in the north-east from the industrial zone. Technogenesis causes the greatest damage to the plants, because vegetation in the urban system is a weak link. The lesion of maple leaves by fungus *Rhytisma acerinum* can be used as bioindicative sign of low concentration or absence of sulfur compounds in the air of the area. This is especially important when placing recreational areas and the development of residential districts of the city.

The study results can be used for environmental activities planning in a modern metropolis, as well as for more effective biomonitoring system in terms of state of the air, aerotechnogenic distribution of sulfur compounds and for creation of safe living conditions for the population.

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**БИОИНДИКАЦИОННЫЕ ИССЛЕДОВАНИЯ АЕРОТЕХНОГЕННОГО РАСПРОСТРАНЕНИЯ
СЕРНИСТЫХ СОЕДИНЕНИЙ В АТМОСФЕРЕ ГОРОДА ЧЕРКАССЫ С ИСПОЛЬЗОВАНИЕМ ВИДА
ACER PLATANOIDES L.**

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Город Черкассы относится к наиболее загрязненным городам Черкасской области. Концентрация сернистых соединений в атмосфере города с переходом Черкасской ТЭЦ на твердое топливо постоянно растет. Наличие сернистого ангидрида в атмосферной среде может привести к суммации загрязнений, что увеличивает эффект воздействия поллютантов на живые организмы. В работе освещаются вопросы биоиндикационных исследований аеротехногенного распространения сернистых соединений и их рассеивания в урбоэкосистеме с использованием *Acer platanoides* L., а также поражением листьев вида сумчатым грибом *Rhytisma acerinum* (Pers.) Fries. Материалы статьи освещают вопросы влияния техногенных эмиссий соединений серы в атмосфере на процессы поражения листьев вида клена остролистного хлорозом и кленовой ретизмой. Установлено, что концентрация сернистых соединений в атмосфере города Черкассы коррелирует с их накоплением в листьях растительного материала, а увеличение процента поражений листьев клена сумчатым грибом *Rhytisma acerinum* указывает на относительную безопасность территорий парковых и рекреационных зон города.

Ключевые слова: биоиндикация, аеротехногенне загрязнення, эмиссии SO₂, *Acer platanoides*, *Rhytisma acerinum*, урбоэкосистемы, экологическая безопасность территорий.

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