

**AN ESTIMATION OF THE URBAN SYSTEM'S MUTAGENIC
BACKGROUND USING *POPULUS BEROLINENSIS* DIPP.**

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As informative biomarkers of a level of pollution of urban surroundings the sensitive test-parameters of *Populus berolinensis* Dipp. was used. The concentration of the majority of heavy metals in vegetative tissues increased with augmentation of an industrial-transport load. In some areas, an increase in the degree of chromosomal apparatus damage and a pronounced mitotic inhibition were observed. Basing on the carried out research, an estimation of the studied areas state according to its mutagenic background was made.

Key words: bioindication, urban surroundings, environmental mutagens, *Populus berolinensis* Dipp.

Urban terrains are characterized by the availability of a great deal of contamination sources, their irregular distribution, and composite distributional pattern of pollutants [12]. Many of them are mutagens. Toxic and nontoxic mixtures are capable to interact among themselves and to be transformed into new products, both in environment, and in alive organisms. Practically, it is impossible to make a real prognosis of such chemical transformations.

Heavy metals are one of the priority pollutants of urban surroundings. A broad spectrum of toxicity, including the cytogenetic one characterize their mixtures. Literature sources tell us about high gas-absorbing and metal-accumulating capacity of leaves of some species of the *Populus* type [8, 11]. Research as for the accumulation of toxicant ingredients in the buds, except for some authors, is practically not available [1]. There are few reports in the literature, accessible to us, presenting cytogenetic effects, caused by contaminants of urban surroundings, in woody plants [2, 5]. At the same time, the *Populus* species are characterized by stability to the factors of urban surroundings, they are widespread in urban flora and, as perennial plants, are suitable objects for biological screening and monitoring.

The researches were conducted in the city of Ivano-Frankivsk. The zone of its compact urban building has the area 92,8 km², 25% of which is an industrial territory, 60% – housing and 15% – municipal area. While determining zones of research we were guided by the general architectural plan of urban building and the data of the state department of ecological security in Ivano-Frankivsk region. The territory of the city was divided into five districts: North, Northeast, Central, South, Southeast and Northeast industrial suburb – village Yamnytsa. The relatively non-polluted terrain, approximating in soil-climatic condition, settlement Rozhniativ, served as control.

In each respective area not less than 10 meters from highways, we picked out five trees of poplar: of the same age (60–80 years), sex and satisfactory sanitary state. For the prospective research, we took 3–5 vegetative buds from the inferior layer of the top of each selected tree on the northwest side on one-year shoots. This procedure was performed in the period of vernal sap moving of plastic materials.

That part of buds, which was planned to be used for cytogenetic analyses, was fixed in Carnoy's mixture at $t=0-4^{\circ}\text{C}$ for 24 hours; 4% acetoirhamatoxylin was used for coloring. Subsequent

clarification, preservation and making preparation were performed in Goyer's mixture [13]. Not less than 300 anaphases (test for chromosome aberrations) and not less than 1000 dividable cells (for quantitative and qualitative estimation of their mitotic activity) of each tree were analyzed.

Vegetative buds, planned for energy-dispersion X -ray microanalysis, were washed in a mixture of detergents (EDTK), then in deionized water and incinerated [4]. The ash was formed into a tablet. One was mounted on a copper stage with the help of electrically conductive glue and evaporated by a layer of carbon in vacuum. Then the preparation was subjected to bombardment with an electronic beam in a scanning electron microscope. Microanalysis was made using an installation for energy-dispersion X -ray microanalysis on a micron level and the method of registration of energy and intensity of a characteristic X -radiation in a definite range. A concentration of the respective chemical elements (mg/kg of ash) was determined in each version. Using the results of quantitative determination the individual (the ratio of the quantitative contents of a contaminant in experiment to monitoring value) and summarized (sum total of individual) coefficients of heavy metals accumulation were calculated. All the findings obtained were statistically evaluated and correlation analysis was carried out.

As a result of the conducted researches we have determined that absolute values of the contents of the majority of the studied heavy metals in buds of plants growing in urban system conditions are much higher than in the control (fig. 1). Trees from Central, Northeast and North districts of the city accumulated the maximum quantity. Nickel contents increase, most of all – 5,6–6,0 times, Zinc – 4,2–6,0 times, Cadmium – 4,7–5,0 times and Lead – 3,7–4,3 times. Copper ones were somewhat less – 2,0–3,0 times. The amounts of other metals did not differ from monitoring parameters. Thus, it is possible to present the change of accumulation coefficients, and, accordingly, the ratio of each trace elements under the effect of the urban system in such series: Ni > Zn > Cd > Pb > Cu > Cr > Al > Fe = Mn.

In the urban conditions, we observed an increase in the damage level of *P. berolinensis* buds rudimentary leaves meristem cells chromosome apparatus (table). Especially, a large percent of aberrant anaphases was observed in plants of the Central region and village Yamnytsa, it was, respectively, 2,8 and 3,7 times more than in the control. Somewhat smaller amount of cells with rearrangements were observed in the Northeast and North regions. There, this parameter exceeded the control values by 89 and 56%. In the above regions, the authentic augmentation of aberrations quantity, per one investigated cell was observed too. In other regions (Southeast and South) statistically authentic differences as to the used cytogenetic characteristics were not revealed.

In ecologically unfavorable areas, the change of a chromosome rearrangement spectrum was observed. It was shift in the direction of chromatid aberrations. Such specific chromosomal apparatus damage was observed especially in the Central area and industrial suburb. The amount of retarded chromosomes in all investigated areas authentically does not differ from the control parameter.

The analysis of mitotic activity has shown that in all the city's districts it isn't significantly different from the control. Only in the industrial suburb, we observed an authentic decrease of the mitotic index approximately by 1,6 times. While analyzing the distribution of cells in mitosis phases, we found out, that in the Southeast and South areas of the city it was practically the same, as in the control. In all the remaining areas, we watched definite changes (fig. 2). First of all, it is necessary to point out, that though in the Northeast and North areas we observe an authentic decrease in the quantity of prophase cells and an increase in telophase queues, but general dynamics of the mitotic cycle remain. In the Central area of the city, and especially in its industrial suburb, there are not only a reduction in number of cells in prophase,

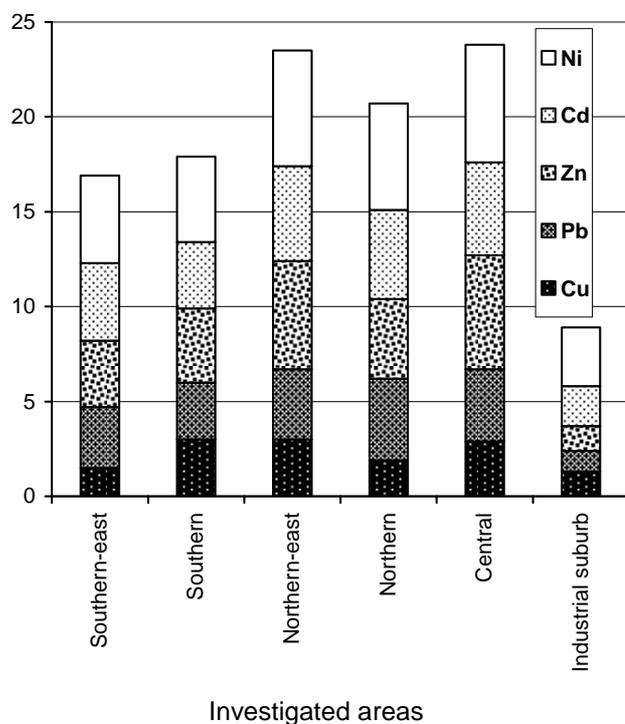


Fig. 1. Summarized index of total buds pollution of *P. berolinensis* by heavy metals.

received by other scientists [5]. The significant amounts of aberrant anaphases in the industrial suburb are connected with the emission of major industrial firms located there.

The authentic augmentation, observed by us, of the anaphases ratio with rearrangements in the North and Northeast districts was surprising to some extent. These terrains as to the results of a lichenoidication were referred to as rather non-polluted [7]. At the same time, previously Kurinny *et al.*, indicated a possibility of absence of direct dependency between the contamination rate and mutagenic strain in definite terrains [9]. This is in line with the correlation

Level of a chromosome aberrations ($\bar{x} \pm S\bar{x}$) in leaves meristem cells of *P. berolinensis* in different districts of Ivano-Frankivsk

District of research	Quantity of anaphases		Percent of anaphases with aberrations
	common	with rearrangements	
District of research	1534	17	$1,11 \pm 0,09$
South	1520	17	$1,12 \pm 0,08$
Northeast	1530	19	$1,24 \pm 0,07$
North	1554	27	$1,73 \pm 0,24^*$
Central	1525	32	$2,10 \pm 0,16^*$
Industrial suburb	1547	48	$3,16 \pm 0,19^*$
	1548	64	$4,13 \pm 0,40^*$

* Authentic differences in comparison with the control

but the very process of a mitotic division (the prophase index becomes less than the metaphase one) was observed.

An increase of the contents of heavy metals in shoots of urban plantations is determined, mainly, by their aerosol entering through the leaves surface [12] or dilated lenticells in winter [14]. To a definite degree, it can be connected with their excessive absorption by the root [6]. The absence of accumulation effect of iron and manganese may be accounted for by their mutual antagonism as well as that with zinc, cuprum and nickel [6].

A high level of karyokinesis pathology, typical of the Central and Northeast areas of the city, must be accounted for by discharges of a number of industrial enterprises located there as well as intensive movement of motor vehicles. Similar results from trees of the urban environment were received

analysis made by us. Close, in value, the parameters of chromosome apparatus damage in the control and in the Southeast and South districts of the city, possibly, indicate the fact that the contamination of the indicated terrains does not exceed "buffer" capabilities of the ecosystems formed there.

In ecologically unfavorable areas of the city and industrial suburb, we observed a shift of chromosome rearrangements spectrum in the direction of chromatide aberrations. This fact indicates, basically, to a chemical etiology of mutagenesis [10]. The latter is also confirmed by the fact that in the city terrain the radiation background does not exceed the marginal level.

The accumulation of metaphase cells in *P. berolinensis* in the Central district and industrial suburb can indicate to the fact that the environmental pollutants inhibit processes of formation and/or of normal operation of a division's spindle. The increase in quantity of cells in telophase in the Northeast and North regions of the city, to all appearances, is a consequence of disturbance in the phragmoplast formation.

On the basis of the mutagenic background evaluation [3], it is possible to say that the state of the investigated terrains can be described as: satisfactory – in the Southeast and South regions, alarming – in the Northeast and North regions, critical – in the Central region and dangerous – in the industrial suburb.

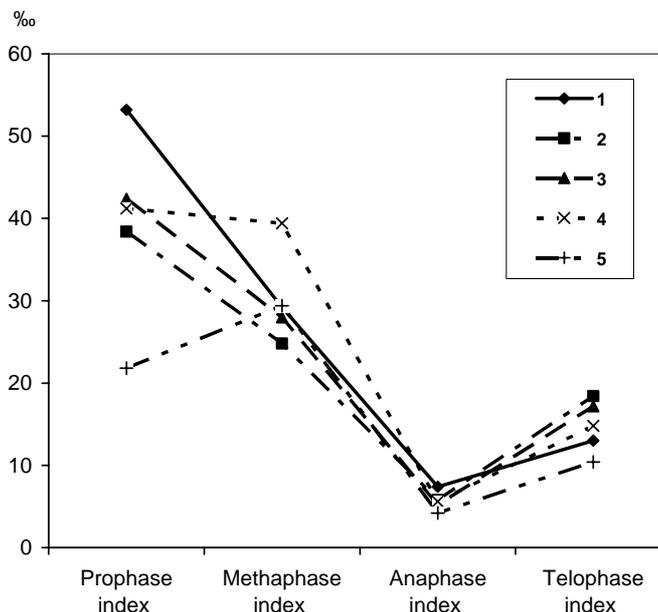


Fig.2. Mitotic activity of rudimentary leaves meristem of *P. berolinensis* in different urban system areas: 1 – control; 2 – northern; 3 – northeast; 4 – central; 5 – industrial suburb.

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ВИКОРИСТАННЯ *POPULUS BEROLINENSIS* DIPP. ДЛЯ ОЦІНКИ МУТАГЕННОГО ФОНУ УРБОСИСТЕМИ

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Як інформативні біомаркери рівня забруднення окремих районів урбосистеми Івано-Франківська використано чутливі тест-параметри *Populus berolinensis* Dipp. Концентрація більшості важких металів у рослинних тканинах збільшувалась із зростанням техногенного навантаження. В окремих районах зафіксовано достовірне збільшення кількості хромосомних аберацій і мітотичну інгібіцію. За результатами досліджень оцінено стан районів міста за мутагенним фоном.

Ключові слова: біоіндикація, урбанізоване середовище, мутагени доквілля, *Populus berolinensis* Dipp.

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