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BIOINDICATION OF AEROTECHNOGENOUS SOILS POLLUTION IN THE INDUSTRIAL CITIES OF DNIPROPETROVSK REGION

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Зроблено біотестування аеротехногенно забруднених ґрунтів міст Дніпропетровська та Дніпродзержинська. Мінливість забруднення навколишнього середовища важкими металами знайшла своє відображення у відповідній варіабельності різних обмінних процесів досліджуваної тестової рослини, які включають зниження інтенсивності загального білкового синтезу, формування різного за складом і інтенсивністю пулу легкорозчинних цитоплазматичних білків, зміну активності системи антиоксидантного захисту.

The amount of the atmospheric emissions made by the enterprises of mining-metallurgy industry makes 54,3 % of harmful substances from the total amount of emissions in the Dnipropetrovsk region. The range of pollutants depends on the number and types of the industrial enterprises located within the urban area [1]. The most crucial factors which determine the quality of the atmosphere in the megalopolice of Dnepropetrovsk are the amounts and compositions of industrial emissions [2]. Proteins, being the primary products of gene expression, represent information about genetic systems in the most explicit way [3]. Therefore, an analysis of a protein phenotype provides a direct way for an analysis of a genotype. In this regard, the application of the method of protein markers in investigations of the impacts of pollutants on vegetation organisms seems to be the most appropriate approach in terms of its efficiency. It provides a reliable assessment of quality of the urbanized areas. With the above in view, the goal of the present research was to apply genetic-environmental approach as a tool for investigating the impacts of industrial emissions on test plant condition in Dnepropetrovsk and Dniprodzerzhinsk cities.

Materials and Methods. The multipollution exposure assessment was made for the several sites in Dnipropetrovsk and Dneprodzerzhinsk cities. Soil samples were taken near several enterprises in DP city: site 1 – Gagarina av.(botanic garden); site 2 – Shevchenko park; site 3 – Philosopsky st.; site 4 – Petrovsky av.; site 5 – Heroes av;

Dniprodzerzhinsk city: site 6 – Tsarichansky district (arable land), site 7 – Pelina av.; site 8 – Liberators av. site 9 – Dnipropetrovska st., $77^{б}$; site 10 – Lenina av. $28^{а}$.

Different distances from metallurgical, chemical plants or roads with motorcar emission were taken in account. The coefficient of heavy metals accumulation in soil of industri-

al sites has been calculated as following [4]:

$$K_{c_i} = C_i / C_b, \quad (1)$$

where C_i – element content in soil, mg/kg;

C_b – background content, mg/kg.

Index of soil total airborn polution (TAP) with heavy metals Z_c was calculated with formula [4]:

$$Z_c = \sum_{i=1}^{n} (K_{c_i} - (n-1)), \quad (2)$$

where n – elements number.

The threat caused with technogenic pollution is fixed when $K_{c_i} \geq 1$, and $Z_{c_i} \geq 1$, or more detailed as bellow:

- $Z_c < 16$ – permissible level of soil pollution;
- $16 < Z_c < 32$ – moderate threatening;
- $32 < Z_c < 128$ – threatening;
- $Z_c \geq 128$ – extraordinary threatening.

Soil samples were prepared for chemical analyses by heavy metal extraction with 1NHCl. The content of heavy metals in the samples was determined by flame atomic-absorption spectrophotometer.

The multifactorial soil pollution influence on functional state of test radish seedlings was studied. 4-days radish seedlings were treated in the water-soluble soil extracts in the Petri dishes. The contents of readily soluble proteins of coleoptiles in 4-days red radish plantlets withdrawn by the buffer 0,05 M tris-HCl and pH 7,4 were defined according to the method of Bradford [5] the activity of peroxidase was determined right after the secretion [6]. Protein spectra in the 4-days radish roots (variety "Frenchpop") were determined with SDS-electrophoresis. While analyzing an individual sample set comprising 50–100 seeds,

1. Contents of heavy metals in soils withdrawn from different industrial sites of Dnepropetrovsk and Dniprodzerzhinsk, mg/kg

Element	Site 1	Site 2	Site 3	Site 4	Site 5
Dnipropetrovsk					
Lead	27,4	25,0	22,4	122,0	24,0
Cadmium	1,2	0,01	0,45	5,0	0,55
Nickel	20,3	22,0	11,0	49,0	9,63
Zinc	219,5	137,0	232,1	389,0	267,4
Copper	16,4	35,0	26,3	143,0	38,3
Iron	1001,6	1670,8	1508,3	1563,6	1308,3
Manganese	87,0	454,0	519,6	3135,0	449,6
Dniprodzerzhinsk					
Lead	15,0	36,5	42,9	36,09	4,61
Cadmium	0,50	1,15	0,7	0,4	2,70
Nickel	8,6	6,2	6,7	8,0	6,89
Zinc	67,1	258,5	230,9	59,9	120,2
Copper	10,3	27,69	14,4	7,4	21,92
Iron	584,2	4553,4	2145,9	1177,8	1393,0
Manganese	563,13	1598,55	1338,53	494,56	706,64

Dnipropetrovsk: site 1 – Gagarina av.(botanic garden); site 2 – Shevchenko park; site 3 – Philosopsky st.; site 4 – Petrovsky av.; site 5 – Heroes av;

Dniprodzerzhinsk: site 1 – Tsarichansky district (arable land), site 2 – Pelina av.; site 3 – Lenina av. 28[а] ; site 4 – Liberators av.; site 5 – Dnipropetrovska st., 77[б].

the following parameters were defined: the total number of spectrum types as an inherent characteristic of each level of polymorphism in the seed proteins, a quantitative ratio of spectrum types, and frequencies of occurrence of the most common spectrum types being studied.

Results and discussion. The carried out investigation of the different industrial sites in Dnepropetrovsk and Dniprodzerzhinsk cities have shown nonuniformity of soil pollutions with heavy metals (table 1).

Highest level of the heavy metals soil pollution of Dnipropetrovsk sites (in comparison with Botanic Garden as the conditional control) was fixed for neighboring with metallurgical plant of Petrovsky (MPP) area. Index of soil total airborn polution (TAP) with heavy metals for MPP site was obtained after calculations on formula (1) and (2). Final result of calculation is following:

$$Z_c = (1{,}56 + 36 + 8{,}7 + 1{,}77 + 2{,}41 + 4{,}45 + 4{,}27 - (7-1)) = 53{,}16.$$

Taking in account that index of TAP is more then 32 current environment load near MZP can be estimated as threatening situation.

Highest level of the heavy metals soil pollution of Dniprodzerzhinsk sites (in comparison with arable land of Tsarichansky district as the conditional control) was fixed also for neighboring with metallurgical plant of Dzerzhinsky (MPD) site. Zc for neighboring with MPD area (square near "Prometey" monument, Pelina av.) is 16. This site Zc calculation (in comparison with Botanic Garden as the control) was 20. Thus current environment load near MPD regarding comments to formula (2) was estimated as moderate threatening.

The multipollution exposure influence on functional state of 4-days test radish seedlings was studied for the several Dnipropetrovsk city sites (table 2).

There was not fixed any limitation for sprouts growth in Dnipropetrovsk soil samples on lenghth and mass indexes. It can be explained with high level of buffer capacity of chernozem soil to heavy metals [3]. Toxic ingredients of the polluted soil have affected an essential influence on the metabolism of red radish plantlets, which was shown in the reduction of protein level accumulation. The

2. Morpho-physioloogical indexes changing in 4-days radish sprouts grown on water extracts of soil from different sites of Dnipropetrovsk city

Plant organ	Soil sampling site				
	Petrovsky av.	Philosopsky st.	Shevchenko park	Heroes av	Botan. garden
Length, mm					
Roots	55,2	54,2	55,4	49,8	51,5
Sprout	39,3	35,9	38,0	45,7	35,2
Ratio.r/s	1,40	1,51	1,46	1,09	1,46
Sprout mass, mg					
Sprout	145,0	147,0	134,0	135,0	135,0
Ratio.r/s	0,47	0,36	0,44	0,48	0,53
Protein concentration, mg /ml					
Roots	2,20	3,76	2,32	2,20	2,52
Sprout	59,4	53,8	51,1	63,5	64,1
Peroxidase activity, cond.unit. opt.sq./ g · sec					
Roots	8,28	17,46	11,.52	20,76	9,18
Sprout	8,25	9,90	21,45	21,78	28,05

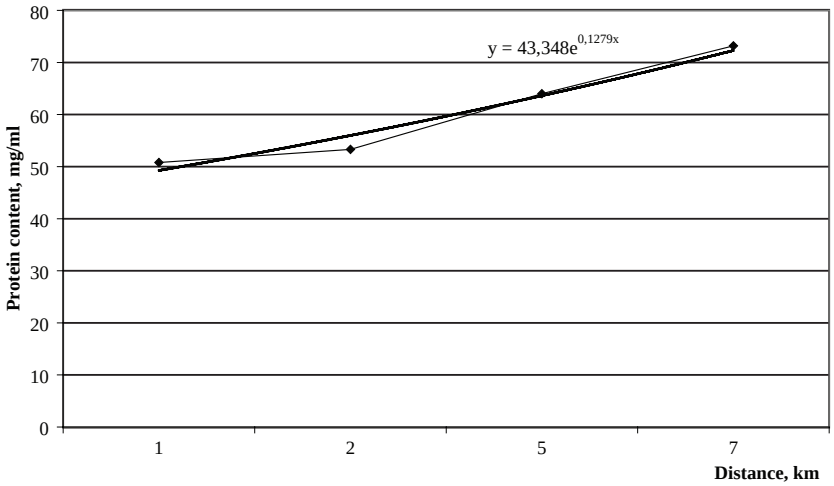
3. Morpho-physioloogical indexes changing in 4-days radish sprouts grown on water extracts of soil from different sites of Dniprodzerzhinsk city

Plant organ	Soil sampling site			
	Pelina av.	Lenina av.	Liberators av.	Dnipropetrovska st.
Length, mm				
Roots	53,8	64,2	49,1	62,0
Sprout	36,4	38,2	35,0	42,0
Ratio.r/s	1,48	1,68	1,40	1,48
Sprout mass, mg				
Sprout	100,0	110,0	109,0	113,0
Ratio r/s	0,69	0,75	0,66	0,69
Protein concentration, mg /ml				
Roots	2,76	1,80	2,84	2,48
Sprout	50,8	53,3	64,0	73,2
Peroxidase activity, cond.unit. opt.sq./ g . sec				
Roots	23,82	7,98	18,87	14,82
Sprout	5,28	14,52	12,21	28,71

roots/sprouts ratio of red radish biomass was between 0,36–0,48 or low in 10–30 % in comparison with the conditional control (Botanic Garden). Peroxidase activity in leaves of the sprouts grown on water extracts of soil taken from Botanic Garden and Shevchenko Park were 2–3 time more then in other samples.

The multipollution exposure influence on functional state of 4-days test radish seedlings was studied for the several Dniprodzerzhinsk city sites (table 3).

There was not fixed any limitation for sprouts growth in Dniprodzerzhinsk soil samples on length and mass indexes. The protein concentration in sprout samples rised up to 1,5 times while moving away from DPP (square



Protein content in radish sprouts depending on distance from source of emission, mg/ml

4. The components composition and peroxidase activity of the easily soluble proteins of the 4-days radish sprouts radish growed in the water soil solutions of the samples taken in the different cities sites

pI	Cities sites								
	1	2	3	4	5	6	7	8	9
roots									
4,50	-	-	-	trace	-	+	+	-	+
4,53	+	+	+	+	++	+++	++	++	+
4,55	-	-	-	-	trace	-	trace	trace	trace
4,60	-	-	-	-	-	+	trace	trace	trace
4,70	-	trace	trace	trace	+++	-	++	+	++
4,80	+	+	++	++	+++	+++	++++	++++	+++
4,95	-	-	-	-	+	trace	+	+	+
5,15	-	+	+	+	+	+	+	+	+
5,30	+	+	+	+	+	++	+	+	+
sprouts									
4,49	++	+	trace	+	+	-	trace	++	+
4,54	++++	+++	++	++++	++++	+	+	++	+++
4,56	+	-	+	+	+	+	-	-	-
4,60	+	+	-	+	+	+	-	+	+
4,65	+	trace	+	+	+	+	-	+	+
4,80	+++	+++		+++	+++	+++	+++	+++	+++
4,85	-	trace	trace	+	+	-	-	-	-
5,00	-	-	++	trace	+	+	-	-	-
5,05	-	trace	trace	+	+	+	-	-	-

Note. DP city: site 1 – Gagarina av.(botanic garden), site 2 – Shevchenko park, site 3 – Philosopsky st., site 4 – Petrovsky av., site 5 – Heroes av., in DZ city: site 6 – Pelina av., site 7 – Liberators av., site 8 – Dnipropetrovska st., site 9 – Lenina av. Peroxidase activity: "-" – is absent; "+" – very weak; "++" – weak; "+++" – strong; "++++" – very strong.

near "Prometey" monument, Pelina av.) to Dnipropetrovska street in distance 5–7 km (fig.). Similar dependence was observed also for peroxidase activity in radish sprouts. The decreasing in the peroxidase activity from 3,5 to 5,5 times in the radish sprouts grown on water extracts of soil taken near MPP and MPD sites was established.

The lowering of intensity of protein synthesis in radish sprouts near source of pollution has its own physiological meaning. It can promote to keep the device synthesizing protein at the translation stage. It also reduces the energy loading on the cell, because protein synthesis is one of the most power-intensive physiological processes, and this process reduces a probability of the metabolic self-damage of cells.

One of the most important features of the change in metal-induced metabolism of cells is the change of activities of enzymes antioxidant protection.

The myltipollution exposure influence on functional state of 4-days test radish seed-

lings was studied for nine cities sites (table 4). EF-spectra comparative assessment shows that variability of soil pollution from different sites lead to active reorganization in cell protein system. In our study the activity of peroxidase determined in roots and leaves of radish sprouts varies considerably. That is caused by the nonuniformity of the composition in the investigated sites.

It was found both an increase, and a decrease in the specific activity of peroxidase. Thus, it is possible to suppose that an increase in the enzyme activity can be considered as a demonstration of the protective reaction of plants under the conditions of the polluted environment. Oppression of the peroxidase activity testifies to a significant toxic influence of xenobiotics on the root of sprouts.

Concluding remarks

1. The soil airborn pollution influence on functional state of radish seedlings was studied. It has been shown, that the variability of chemical composition of soils from different polluted sites lead to active reorganization in cell protein system.

2. The bluing of environment pollution with heavy metals has found its reflection in the corresponding variability of different exchange processes of the cell, which includes a decrease of intensity of general protein synthesis, the formation of different in the composition and intensity of pool readily soluble cytoplasm inclusion proteins, the change in activity of the antioxidant protection system.

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