J. Elem. s. 989–1000

DOI: 10.5601/jelem.2014.19.3.581

EFFECT OF SOIL POLLUTION WITH POLYCYCLIC AROMATIC HYDROCARBONS ON MAIZE BIOMASS YIELD AND ACCUMULATION OF SELECTED TRACE ELEMENTS*

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Abstract

The research was conducted to assess the effect of artificial soil pollution with polycyclic aromatic hydrocarbons on the amount of produced maize biomass and the accumulation of selected trace elements. Benzo(a)pyrene (BaP), chrysene (Ch) and fluorene (Fl) were added to soil in the liquid form (dissolved in dichloromethane – DCM) in doses of 0.1 mg kg^{-1} d.m. and 10 mg kg^{-1} d.m. The experiment comprised: the control (C) – soil with the natural content of the studied PAHs and without a mineral salt supplement; object 0 – soil with the natural content of PAHs and a mineral salt (NPK) supplement, object I – soil with a DCM and mineral salt supplement, object II – soil with a supplement of 0.3 mg PAHs per kg of soil d.m. (0.1 mg BaP + 0.1 mg Ch + 0.1 mg Fl) + mineral salts, the amount of introduced PAHs was equivalent to an elevated content; object III – soil with an addition of 30 mg PAHs per kg of soil d.m. (10 mg BaP + 10 mg Ch + 10 mg Fl) + mineral salts, the quantity of PAHs was equivalent to very strong pollution. The test plant was cv. San maize. The dried biomass was crushed in a laboratory mill and mineralized in a chamber furnace (450°C, 5 h). The residue was dissolved in diluted nitric acid 1:2 (v/v). The content of the trace elements (Zn, Cu) in the solutions was assessed with the ICP-AES method on a JY 238 Ultrace apparatus. The quantity of absorbed trace elements was derived from the biomass amount and the content of these elements in the biomass. On the basis of the total maize biomass (shoots and roots), the tolerance coefficient was computed as a ratio of the yield of the plant dry mass in objects C, I, II and III to the yield in the object where NPK medium was introduced to the unpolluted soil (object 0). The pollution coefficient was calculated from on concentrations of the elements in the plant shoots and as a ratio of the elemental content in plants from objects C, I, II and III to the content in object 0. The translocation coefficient was calculated as a ratio of the element content in plant shoots to the content in

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* The research carried out under subject No. 3101 was financed with a grant from the Ministry of Science and Higher Education.

roots. Soil pollution with the analyzed aromatic hydrocarbons did not inhibit either the growth or the development of maize roots or shoots. The biggest amount of biomass was obtained in the object where the soil was characterized by an elevated content of the analyzed aromatic hydrocarbons. The value of the tolerance index in the objects where the stressor had been introduced was above one, which indicates no effect of soil pollution with PAHs on the plant biomass quantity. The value of the tolerance index below one was achieved only in the control biomass. A significantly higher content of Cu and more of this element absorbed by maize shoots were determined in the objects where dichloromethane and polycyclic aromatic hydrocarbons had been introduced to the soil in comparison with the unpolluted objects. The values of maize shoot biomass contamination with Zn and Cu were visibly higher in the objects where the soil was polluted with aromatic hydrocarbons in comparison to the values obtained in the object where only the mineral medium was supplied to the soil. A similar dependency pertained to the translocation coefficient of zinc and copper.

Key words: soil pollution, PAHs, zinc, copper, maize.

WPŁYW ZANIECZYSZCZENIA GLEBY WIELOPIERŚCIENIOWYMI WĘGLOWODORAMI AROMATYCZNYMI NA ILOŚĆ BIOMASY KUKURYDZY ORAZ AKUMULACJĘ WYBRANYCH PIERWIASTKÓW ŚLADOWYCH

Abstrakt

Celem badań była ocena wpływu sztucznego zanieczyszczenia gleby wielopierścieniowymi węglowodorami aromatycznymi na ilość wytworzonej biomasy kukurydzy oraz akumulację wybranych pierwiastków śladowych. Benzo(a)piren (BaP), chryzen (Ch) i fluoren (Fl) dodawano do gleby w postaci roztworu w ilościach 0,1 mg kg^{-1} i 10 mg kg^{-1}. Odpowiednią ilość WWA rozpuszczono w dichlorometanie. Badania obejmowały: obiekt kontrolny (K) – gleba o naturalnej zawartości badanych WWA i bez dodatku soli mineralnych, obiekt (0) – gleba o naturalnej zawartości badanych WWA z dodatkiem soli mineralnych, obiekt (I) – gleba z dodatkiem dichlorometanu oraz soli mineralnych, obiekt (II) – gleba z dodatkiem 0,3 mg WWA kg^{-1} s.m. gleby (0,1 mg BaP + 0,1 mg Ch + 0,1 mg Fl) + sole mineralne – ilość WWA wprowadzona do gleby w tym obiekcie odpowiadała podwyższonej zawartości, obiekt (III) – gleba z dodatkiem 30 mg WWA kg^{-1} s.m. gleby (10 mg BaP + 10 mg Ch + 10 mg Fl) + sole mineralne – ilość WWA wprowadzona do gleby w tym obiekcie odpowiadała bardzo silnemu zanieczyszczeniu.

Rośliną testową była kukurydza odmiany San. Następnie wysuszoną biomasę rozdrobniono w młynku laboratoryjnym i mineralizowano w piecu komorowym (temp. 450°C, 5 h). Pozostałość rozpuszczono w rozcieńczonym kwasie azotowym 1:2 (v/v). W tak przygotowanych roztworach zawartość badanych pierwiastków śladowych oznaczono metodą ICP-AES w aparacie JY 238 Ultrace. Ilość pobranych pierwiastków śladowych obliczono na podstawie ilości biomasy i zawartości składnika w biomasie. Na podstawie sumarycznej ilości biomasy kukurydzy (części nadziemne i korzenie) wyliczono wskaźnik tolerancji jako iloraz suchej masy plonu roślin w obiektach I, II i III oraz obiekcie, w którym do gleby niezanieczyszczonej wprowadzono pożywkę mineralną (obiekt 0). Wskaźnik stopnia zanieczyszczenia wyliczono na podstawie zawartości pierwiastka w częściach nadziemnych roślin jako iloraz zawartości pierwiastka w roślinie z obiektów K, I, II i III i z obiektu, w którym do gleby niezanieczyszczonej wprowadzono pożywkę mineralną (obiekt 0). Wskaźnik translokacji obliczono jako iloczyn zawartości pierwiastka w częściach nadziemnych i w korzeniach roślin. Zanieczyszczenie gleby badanymi węglowodorami aromatycznymi nie hamowało wzrostu i rozwoju części nadziemnych i korzeni kukurydzy. Największą ilość biomasy uzyskano w obiekcie, w którym gleba zawierała zwiększoną ilość badanych węglowodorów aromatycznych. Wartość wskaźnika tolerancji w obiektach, w których wprowadzono czynnik stresowy, kształtowała się powyżej jedności, co wskazuje na brak wpływu zanieczyszczenia gleby WWA na ilość biomasy roślin. Wartość wskaźnika tolerancji poniżej jedności dotyczyła jedynie biomasy z obiektu kontrolnego. Istotnie większą zawartość Cu oraz większą ilość tego pierwiastka pobraną przez części nadziemne kukurydzy stwierdzono w obiektach, w których do gleby wprowadzono dichlorometan i wielopierścieniowe węglowodory aromatyczne, w porównaniu z obiektami niezanieczyszczonymi. Wartości wskaźnika zanieczyszczenia biomasy części nadziemnych kukurydzy Zn i Cu były wyraźnie większe w obiektach, w których glebę zanieczyszczono węglowodorami aromatycznymi, w porównaniu z wartościami uzyskanymi w obiekcie, w którym do gleby wprowadzono tylko pożywkę mineralną. Podobna zależność dotyczyła wskaźnika translokacji cynku i miedzi.

Słowa kluczowe: zanieczyszczenie gleby, wielopierścieniowe węglowodory aromatyczne, cynk, miedź, kukurydza.

INTRODUCTION

Excessive levels of polycyclic aromatic hydrocarbons (PAHs) in soil constitutes a hazard to both the human health and all biotic elements of a soil ecosystem (Cousins et al. 1997, Maliszewska-Kordybach, Smreczak 1999). PAHs form a numerous group of cyclic compounds whose various structural forms are characterized by different reciprocal positions of benzene rings, which makes these compounds particularly dangerous. Moreover, their transformation may lead to the formation of intermediate products, characterized by considerably higher toxicity than the primary forms (Marr et al. 2006).

Apart from fuel burning, industrial processes or transport, application of organic waste materials in agriculture and processes connected with transformation of organic matter contained in soil may be the source of PAHs (Marr et al. 2006, Stahl et al. 2004).

Soil pollution with PAHs leads to changes in soil chemical properties and modifies the composition of microorganism populations (Gondek et al. 2008). Quantitative and qualitative changes of soil microflora directly affect most of biochemical processes occurring in soil – apart from degradation of pollutant substances, also the processes involved in trace element mobility (Lin et al. 2008). A change in the trace element availability may have a serious influence on plants, particularly in the early stages of development (Maliszewska-Kordybach, Smreczak 2003). Bioavailability of trace elements is of key importance for stimulation or inhibition of plant growth and development in later stages, and consequently leads to changes in the biological value of biomass, thereby restricting its use.

The research was conducted to assess the effect of artificial soil pollution with PAHs on the amount of maize biomass produced and the accumulation of trace elements (Zn, Cu) in the biomass.

MATERIAL AND METHODS

The investigations were conducted as a pot experiment on soil material collected from the Ap (0-20 cm) layer of an arable field. The soil contained 26% of the < 0.02 mm fraction and had the particle-size distribution and texture of sandy loams (IUSS Working Group WRB, 2007). The soil revealed a slightly acid reaction (pH H_2O = 6.27). Hydrolytic acidity assessed after extraction with 1 mol dm^{-3} CH_3COONa was 23.9 mmol(+) kg^{-1} d.m. the organic carbon content was 15.99 g kg^{-1} d.m. and total nitrogen was 1.54 g kg^{-1} d.m. The total zinc content was 104 mg kg^{-1} d.m. and total copper was 8.01 mg kg^{-1} d.m.

The soil was polluted with three hydrocarbons from the PAHs group: benzo(a)pyrene (BaP), chrysene (Ch) and fluorene (Fl), which differ in physicochemical properties. Because a soil environment is never polluted with a single PAH, mixtures of these compounds were used in the experiment (Cousins et al. 1997, Maliszewska-Kordybach, Smreczak 1998). BaP, Ch and Fl were added to the soil in the liquid form (dissolved in dichloromethane – DCM) in doses of 0.1 mg kg^{-1} d.m. and 10 mg kg^{-1} d.m. The experiment comprised the control (C) – soil with the natural content of the three PAHs and without a mineral salt supplement; object 0 – soil with the natural content of the PAHs and a mineral salt (NPK) supplement, object I – soil with a DCM and a mineral salt supplement, object II – soil with a supplement of 0.3 mg PAHs per kg of soil d.m. (0.1 mg BaP + 0.1 mg Ch + 0.1 mg Fl) + mineral salts, the amount of introduced PAHs was equivalent to an elevated content; object III – soil with an addition of 30 mg PAHs per kg of soil d.m. (10 mg BaP + 10 mg Ch + 10 mg Fl) + mineral salts, the quantity of PAHs equivalent to a very strong pollution (Kabata-Pendias et al. 1995).

The pot experiment was conducted in PVC containers, each filleed with 8.6 kg of air-dry soil. In order to meet the plant's nutritional requirements, the soil in all objects except the control (C) received nitrogen, phosphorus and potassium in the form of chemically pure salts. The quantities of nutrients introduced per 1 kg of soil were: 0.12 g N (NH_4NO_3); 0.06 g P ($Ca(H_2PO_4)_2\,H_2O$); 0.19 g K (KCl). The research was conducted in 4 replications; the soil moisture during the plant growing period was maintained at the level of 60% soil water capacity. The test plant was cv. San maize, and 5 plants per pot kept until harvest, which was conducted at the stage of 7-9 leaves. Following the harvest of maize shoots, the roots were taken from the soil and washed.

The plant material was dried until constant weight in an airflow dryer (70°C) so as to determine the dry weight. The dried biomass was crushed in a laboratory mill and mineralized in a chamber furnace (450°C, 5 h). The residue was dissolved in diluted nitric acid 1:2 (v/v) (Ostrowska et al. 1991). The content of the trace elements (Zn, Cu) in the solutions was assessed with the ICP-AES method on a JY 238 Ultrace apparatus. The quantity of absorbed trace elements was computed from the volume of biomass and the the content of elements in it. On the basis of the total maize biomass yield (shoots and roots), a tolerance coefficient was computed as a ratio of the plant dry mass yield in objects C, I, II and III to the analogous yield in the object where the NPK medium was introduced to unpolluted soil (object 0). The pollution coefficient was calculated from concentrations of the elements in the plant shoots and as a ratio of the content of the elements in plants from objects C, I, II and III to the content in object 0. The translocation coefficient was calculated as a ratio of the elemental content in plant shoots to the content in roots (Kopcewicz, Lewak 1998).

All plant material analyses were conducted in 4 replications. Precision of the assessments was determined using reference material NCS DC733448 (China National Analysis Center for Iron & Steel). The data concerning precision and accuracy of the assessments (Fuentes et al. 2004) are presented in Table 1.

Table 1

Amounts of metals released from material NCS DC733448 (mean±SD) and data for analytical precision and accuracy

Metal	Experimental value (mg kg^{-1} d.m.)	Recommended value (mg kg^{-1} d.m.)	Precision	Accuracy
Zn	21.4±1.0	20.6±2.2	4.71	3.88
Cu	5.3±0.1	5.2±0.5	1.88	1.92

The results were elaborated statistically according to a constant model, in which the PAH pollution level was a factor. The statistical computations included a one-way Anova and the significance of differences between arithmetic means was estimated by means of the t-Tukey test at the significance level $\alpha<0.05$ (Stanisz 1998). StatSoft, Inc. (2011) Statistica version 10 was the software used.

RESULTS AND DISCUSSION

The effect of soil pollution with PAHs on the plant growth and development depends not only on the species but also – as observed by Maliszewska-Kordybach and Smreczak (1999) – on soil properties, especially the organic matter content. In the present experiment, the amount of maize biomass in the objects where the soil was polluted with PAHs was bigger than in the control (object C – unpolluted soil without the NPK medium) – Table 2. Therefore, it may be stated that the soil pollution did not inhibit the maize growth or development. The analysis of the total maize biomass (shoots and roots) revealed the highest amount in object II, where the soil was characterized by a lower level of pollution. Maliszewska-Kordybach and Smreczak

Table 2

Amounts of maize dry biomass (g d.m. pot^{-1} ± SD) and values of tolerance coefficient

Object	Shoots	Roots	Total biomass	Tolerance coefficient
C	72.2^{a}±4.0	12.6^{a}±2.4	84.8^{a}±6.3	0.58^{a}±0.04
0	127.9^{b}±4.1	17.6^{ab}±1.1	145.5^{b}±4.3	1.00*
I	135.3^{b}±5.5	19.1^{ab}±3.7	154.4^{b}±9.1	1.06^{b}±0.07
II	140.0^{b}±7.0	20.4^{b}±3.5	160.4^{b}±10.0	1.10^{b}±0.07
III	133.3^{b}±1.9	17.8^{ab}±0.9	151.2^{b}±2.5	1.04^{b}±0.03

* Object 0 = 1.00;
Means followed by the same letters in columns did not differ significantly at $\alpha<0.05$ according to the *t*-Tukey test.

(1999) also described a stimulating effect of PAHs on plant yield at the level of these substances in soil below or slightly exceeding 1 mg kg^{-1} d.m. Similar results were presented by KRZEBIETKE and SIENKIEWICZ (2010*b*) while studying the effect of foliar application of anthracene and pyrene (PAHs) on yields and chemical composition of butterhead lettuce (*Lactuca sativa* L.) grown under varied abundance of substrate in nutrients. KUMMEROVA et al. (1995) demonstrated that a PAHs concentration no more than 10 mg dm^{-3} in a solution might intensify the plant biomass increment.

Apart from the assessment of plant biomass volume in the presence of an increased content of stressor in soil, various other indices demonstrating more specifically the impact of a stress agent were tested as well. The value of the tolerance coefficient in the objects where the stressor was introduced (objects II and III) exceeded one (Table 2), which indicates the absence of any effect of soil pollution with PAHs on the biomass amount. The value of that coefficient lower than one was found only in the biomass from the control (object C – the soil with the natural PAHs content and no NPK medium), which may be associated with a deficiency of available nitrogen, phosphorus and potassium forms.

The zinc content in the maize shoots did not exceed 30 mg kg^{-1} d.m. (Table 3) and was within the normal content range (GORLACH, GAMBUŚ 2000). The shoot biomass contained significantly the lowest Zn quantity in the control (object C – soil with natural PAHs content and without NPK medium). The level of soil load with PAHs did not cause any significant changes in the Zn content in the shoots. In the roots, this element was more abundant than in the shoots. A larger difference was noticed between the Zn content in the roots from the control (object C) and from the other objects than in the case of the shoots, which was due to Zn accumulating in a relatively smaller biomass amount.

The quantity of Zn absorbed by the shoots was the biggest in object I, where the NPK medium and DCM were introduced. Comparable amounts of Zn taken up by the shoots were registered in the objects where PAHs were

Table 3

Content of trace elements in maize biomass (mg kg^{-1} d.m. ± SD), and uptake of trace elements by maize (mg pot^{-1} ± SD)

Object	Content of trace elements			
	shoots	roots	shoots	roots
	Zn		Cu	
C	$19.0^{a}\pm2.2$	$82.2^{b}\pm5.7$	$1.71^{a}\pm0.24$	$7.24^{b}\pm1.01$
0	$25.7^{b}\pm1.6$	$56.6^{a}\pm1.4$	$1.93^{a}\pm0.05$	$4.33^{a}\pm0.68$
I	$29.1^{b}\pm0.9$	$54.3^{a}\pm3.3$	$2.42^{b}\pm0.11$	$3.83^{a}\pm0.37$
II	$25.7^{b}\pm2.3$	$54.3^{a}\pm9.6$	$2.24^{b}\pm0.22$	$3.83^{a}\pm0.45$
III	$28.7^{b}\pm0.6$	$47.9^{a}\pm5.5$	$2.38^{b}\pm0.28$	$3.23^{a}\pm0.42$
Object	Uptake of trace elements			
	shoots	roots	shoots	roots
	Zn		Cu	
C	$1.36^{a}\pm0.10$	$1.03^{a}\pm0.20$	$0.12^{a}\pm0.01$	$0.091^{a}\pm0.02$
0	$3.29^{b}\pm0.27$	$1.00^{a}\pm0.05$	$0.25^{b}\pm0.01$	$0.077^{a}\pm0.02$
I	$3.93^{c}\pm0.21$	$1.05^{a}\pm0.25$	$0.33^{c}\pm0.01$	$0.074^{a}\pm0.02$
II	$3.59^{bc}\pm0.32$	$1.10^{a}\pm0.26$	$0.31^{c}\pm0.02$	$0.078^{a}\pm0.02$
III	$3.82^{bc}\pm0.11$	$0.85^{a}\pm0.07$	$0.32^{c}\pm0.04$	$0.057^{a}\pm0.01$

Means followed by the same letters in columns did not differ significantly at $\alpha<0.05$ according to the *t*-Tukey test.

added to the soil, irrespective of the amount (Table 3). The quantities of Zn absorbed by the roots, regardless of the object, were lower and non-significantly diversified among the objects.

The coefficient of shoot biomass pollution with Zn, except the control (object C), was higher than one, which evidences a bigger Zn content in the biomass from the objects in which PAHs were introduced to the soil (objects II and III) and from the object where DCM was introduced to the soil (object I), in relation to the biomass from the object in which NPK medium was used (object 0) – Table 4. Zinc translocation from roots to shoots, described by the translocation coefficient, was significantly bigger in the objects where the DCM (object I) and PAHs (objects II and III) were added to the soil than the object where mineral salts were used (object 0) or in the control (object C).

More copper was found in the maize root system than in the shoots (Table 3). The shoot biomass from the objects where the DCM and PAHs were introduced (objects I, II and III) contained significantly more Cu. Cu concentrations in the roots were on average over twice as high as in the shoots. The highest levels of this element were determined in the root system of the control plants (object C).

The quantities of Cu taken up by the shoots were the highest in the objects where the DCM and PAHs were introduced to the soil (objects I, II

Table 4

Values of pollution and translocation coefficients (mean ± SD)

Object	Pollution coefficient		Translocation coefficient	
	Zn	Cu	Zn	Cu
C	$0.42^{a}\pm0.06$	$0.50^{a}\pm0.07$	$0.23^{a}\pm0.02$	$0.24^{a}\pm0.04$
0	1.00*	1.00*	$0.46^{b}\pm0.03$	$0.46^{b}\pm0.06$
I	$1.21^{b}\pm0.15$	$1.33^{b}\pm0.08$	$0.53^{c}\pm0.04$	$0.64^{c}\pm0.08$
II	$1.10^{b}\pm0.15$	$1.27^{b}\pm0.14$	$0.48^{c}\pm0.06$	$0.59^{c}\pm0.09$
III	$1.17^{b}\pm0.11$	$2.51^{c}\pm0.34$	$0.61^{c}\pm0.06$	$0.74^{c}\pm0.06$

* Object 0 = 1.00

Means followed by the same letters in columns did not differ significantly at $\alpha<0.05$ according to the *t*-Tukey test.

and III), which resulted from a higher content of this element in the biomass (Table 3). The amount of Cu absorbed by the root system was much smaller, which correlates with the volume of biomass amassed in this part of the plant. No significant diversification was noted in the quantity of Cu absorbed by the roots.

The values of the coefficient of maize shoot pollution with Cu were significantly higher in the objects where the DCM and PAHs were introduced to the soil (objects I, II and III) than the same coefficient computed for the control (object C) – Table 4. The values of the translocation coefficient calculated for Cu turned out to be less than one, although in objects I, II and III, where the DCM and PAHs were introduced to the soil, these parameter values were significantly higher than the ones computed for the control (object C) and object 0, in which mineral salts were added to the soil.

Discussion of the research results of heavy metal content in maize in conditions of soil pollution with PAHs is difficult due to the shortage of references addressing the presented issue. The problem of heavy metal bioavailability is widely discussed in the aspect of the effect of these elements on biochemical processes occurring in plants, in the context of remediation of chemically polluted lands, but also of environmental application of waste materials (Gondek et al. 2010, Khan et al. 2000). Plants growing ina polluted environment may accumulate considerable amounts of toxic trace elements or change the proportions of macronutrients, which poses a serious threat to animals and people (Okoronkowo et al. 2005, Krzebietke, Sienkiewicz 2010*a*).

Heavy metal detoxification mechanisms developed by plants, which are activated after absorbing metals from the soil solution, enable these organisms to function in a polluted environment without any visible symptoms of phytotoxicity (Lin et al. 2008). Investigations conducted by other authors demonstrated considerable differences in trace element uptake depending on soil particle-size distribution and texture, pH, organic matter content or sorption capacity, although a plant species is not without importance either (Basta et al. 2005). Increasing the soil pH value and organic matter content results in diminishing trace element availability (Rosselli et al. 2003). However, the trace element content in plants may be also significantly influenced by soil pollution, caused for example by PAHs (Khan et al. 2011). The investigations presented above justify the statement that the trace elements were accumulated mainly in the maize roots. Investigations conducted by MacNicol and Beckett (1985) confirm that roots constitute the first barrier restricting trace element translocation to shoots, irrespectively of the stressor, although – as stated by Batty and Anslow (2008) – there are plants which accumulate more trace elements in shoots. Barriers against the transport of trace elements from roots to shoots generally act effectively towards copper in all plants. On the other hand, considering zinc transport, it obviously depends on a cultivated plant species. According to Chu and Wong (1987) and Galler (1992), such barriers inhibit also the transport of metals within shoots.

In the conducted experiment, the Cu content in the maize shoots was higher in the objects where the DCM and PAHs were introduced to the soil. According to Lin et al. (2008), a high content of pyrene in soil may inhibit the Cu uptake by plants. No such dependence was observed in the present experiment, in which the soil material was polluted with benzo(a)pyrene, chrysene and fluorene. Batty and Anslow (2008) revealed that soil contamination with pyrene did not reduce the Zn uptake, nevertheless Zn and pyrene application to the soil significantly decreased the growth of *Brassica juncea*. In the authors' own research, the introduction of hydrocarbons did not reduce significantly the Zn uptake by the maize shoots, nor did it affect negatively the amount of maize biomass.

CONCLUSIONS

1. Soil pollution with the analyzed PAHs did not inhibit the growth and development of the maize roots or shoots. The greatest amount of the biomass was obtained in the object where the soil was characterized by an elevated content of PAHs. The value of the tolerance coefficient in the objects where the stressor was introduced was above one, which indicates the lack of any effect of soil pollution on plant biomassyield.

2. In comparison with the unpolluted objects, significantly higher Cu content of Cu and the amounts of this element up taken up by the shoots were determined in the objects in where DCM and PAHs were introduced to the soil. The values of the coefficient of maize shoot biomass pollution with Zn and Cu were distinctly higher in the objects where the the soil was polluted with PAHs in comparison with the values obtained in the object where only NPK medium was introduced to the soil. A similar dependency pertained to the translocation coefficient.

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