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INFLUENCE OF THE CONTENTS OF TOTAL FORMS OF LEAD ON THE NUMBER OF SELECTED GROUPS OF MICROORGANISMS IN THE FOREST SOILS OF THE PROTECTED ZONE IN THE ROZTOCZE NATIONAL PARK

WPŁYW ZAWARTOŚCI OŁOWIU OGÓLNEGO NA LICZEBNOŚĆ WYBRANYCH GRUP DROBNOUSTROJÓW W GLEBACH LEŚNYCH OTULINY ROZTOCZAŃSKIEGO PARKU NARODOWEGO

Abstract: The aim of the study was to determine the influence of the contents of total forms of lead on the number of selected microorganisms in the light soils situated in the protected zone in the Roztocze National Park. The experiment was carried out in spring in pine forest that belongs to Senderki Forest Sub-District. The total number of ten soil outcrops was done in the area. The samples were taken from humus levels and mother rock levels. The study reveals that the norms for protected zones concerning the contents of total forms of lead were not exceeded in the forest soils. Nevertheless, a significant enrichment in total lead was observed in surface levels, as compared with mother rock levels. The amount of total lead in humus levels influenced the number of marked colonies of bacteria, *Actinomycete* and fungi, which was also proved by the statistical analysis that was carried out. The amount of total lead in the humus level was significantly negatively correlated with the number of marked colonies of microorganisms. It should be noted, that this study should be treated as preliminary investigation. Further detailed investigation of the content of total lead in the protected soils of south-eastern Poland will allow to determine the influence of this element on the number of soil microflora.

Keywords: total lead, forest soils, soil microorganisms, protected areas

Pollution of soil environment with heavy metals has been studied by many researchers for decades. In spite of decreasing emission of industrial pollution with dust and gas in the whole area of Poland, studies on the contents of heavy metals in soils are still being undertaken. These studies are often treated as monitoring. It is necessary to conduct such studies because heavy metals have enormous abilities to bioaccumulate –

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they systematically accumulate in the environment, especially live environment, which increases the intensity of their negative effects [1].

The protected zone in the Roztocze National Park is one of the areas that are under special supervision as far as the condition of soil and contents of heavy metals are concerned in Lublin Province. The protected zone consists mainly of light soils, which are prone to accumulation of heavy metals. Excessive amounts of heavy metals in soil causes changes in both quantity and quality of organisms living there, which often leads to changes of biological activity of pedosphere [2]. It is often emphasized that biological activity of soils should be used to determine soil quality and estimate changes taking place in soil, that are caused by the use of potentially dangerous factors [3, 4].

The aim of the study was to determine the influence of the contents of total forms of lead on the number of colonies of bacteria, *Actinomycete* and fungi in the light forest soils situated in the protected zone in the Roztocze National Park.

Material and methods

The soils under pine forests in Senderki Forest Sub-District, situated in the protected zone in the Roztocze National Park (which is located in south-eastern part of Poland), were investigated in this study. These soils had granulometrical composition of loose sands and slightly loamy sands.

The samples for the analysis were taken in May from the humus level and the mother rock level from ten soil profiles without preserving their natural structure.

In the fresh soil material that was taken from the humus levels, the following were marked: the number of colonies of bacteria and *Actinomycete* on nutrient agar with soil extract, and the number of fungi on Martina's nutrient agar [5].

In air-dry soil material from the humus levels and the mother rock levels the following were marked: contents of C organic with Tiurin's method in Simakow's modification, pH in H_2O and in 1 mol $\cdot$ dm^{-3} KCl potentiometrically, total absorptive capacity of the soil (T), total contents of Pb in extract of $HClO_4$ and HNO_3 with atomic absorption spectrometry (AAS).

Results and discussion

The investigated genetic levels of forest soils in the protective zone in the Roztocze National Park revealed acidic pH or strongly acidic pH (Table 1). The values of pH_{KCl} in the humus levels ranged from 4.5 to 5.0, and in the mother rock levels – from 3.8 to 4.2. The contents of C organic in the surface levels was 1.6–2.2 % (Table 1). The value of absorptive capacity decreased with the depth of the soil profile. In the humus levels it was within the range 4.7–5.6 cmol(+) $\cdot$ kg^{-1}, and 2.8–3.6 cmol(+) $\cdot$ kg^{-1} in the mother rock levels.

According to Kabata-Pendias and Pendias [6], the natural amount of lead in soil should not exceed 50 mg $\cdot$ kg^{-1}, and the permitted amount of lead in soil should not exceed 100 mg $\cdot$ kg^{-1}. Special norms for permitted amounts of metals in protected areas [7] say that permitted amount of lead in such areas should not exceed 50 mg $\cdot$ kg^{-1}.

Table 1

Basic chemical properties of forest soils

Horizon	pH_{H_2O}	pH_{KCl}	$C_{org.}$ [%]	Absorption capacity of soils (T) [cmol(+) · kg^{-1}]
Ap	5.0	4.6	1.8	4.9
C	4.4	4.0	not investigated	3.2
Ap	5.1	4.9	1.7	5.2
C	4.6	4.2	not investigated	2.9
Ap	4.9	4.5	2.1	4.7
C	4.2	4.0	not investigated	3.3
Ap	4.8	4.5	1.6	5.0
C	4.1	3.9	not investigated	2.9
Ap	5.0	4.8	2.2	5.6
C	4.2	4.0	not investigated	3.6
Ap	5.2	4.8	1.9	4.8
C	4.4	4.1	not investigated	3.1
Ap	5.0	4.7	2.0	4.9
C	4.2	4.0	not investigated	3.3
Ap	5.3	5.0	1.9	5.1
C	4.5	4.0	not investigated	3.1
Ap	5.1	4.8	1.7	4.9
C	4.4	4.0	not investigated	2.8
Ap	5.0	4.7	1.9	5.3
C	4.2	3.8	not investigated	3.1

Table 2 reveals that the permitted amount of lead was not exceeded in the investigated soils. The content of lead in the humus levels ranged from 19.0 to 39.0 mg · kg^{-1} and was noticeably higher than in the mother rock levels (6.8–9.4 mg · kg^{-1}).

Despite the lack of a direct threat that the content of lead (lower than permitted) could have caused in the investigated soils, attention should be paid to the amounts of lead in the humus levels and the mother rock levels. This study revealed enrichment of the humus levels in lead, as compared with mother rock levels that were geo-chemical background. This enrichment was very high and ranged from 228.9 % to 443.2 %. Ciesla and others [8] emphasize the fact that chemical properties of forest soils like acidic pH and high contents of C organic enhance accumulation of lead in these soils.

Heavy metals, including lead, can be present in soil for hundreds or even thousands of years [9]. They can have a toxic effect on soil microorganisms. This effect depends on the concentration of a metal, correlation with other elements and ecological condition [10].

Many authors investigated the influence of heavy metals on the susceptibility of soil microorganisms in pot experiments [11, 12]. Such investigation allows to analyse in detail the influence of increasing doses of selected heavy metals on soil microflora. In the soils that occur naturally in the area, relations between the concentration of heavy

metals and the number of soil microflora are more complicated and more difficult to estimate [2]. In spite of that, the literature presents field experiments that try to estimate the influence of heavy metals on the number of selected groups of microorganisms in soils located in the vicinity of the emitters of these elements [2].

Table 2

Content of heavy metals in forest soils and number of colonies of investigated microorganism

Horizon	Pb [mg · kg^{-1}]	Enrichment of Ap level as compared with C [%]	Bacteria and *Actinomycete* [10^9 cfu kg^{-1} d.m. soil]	Fungi [10^6 · cfu kg^{-1} d.m. soil]
Ap	21.3	300	21.0	105
C	7.1	100	not investigated	
Ap	21.8	320.6	12.5	90
C	6.8	100	not investigated	
Ap	29.5	364.2	5.2	92
C	8.1	100	not investigated	
Ap	27.1	343.0	12.1	80
C	7.9	100	not investigated	
Ap	21.7	319.1	14.8	100
C	6.8	100	not investigated	
Ap	38.0	427.0	7.6	85
C	8.9	100	not investigated	
Ap	31.1	330.9	11.0	104
C	9.4	100	not investigated	
Ap	39.0	443.2	7.2	80
C	8.8	100	not investigated	
Ap	19	228.9	14.3	100
C	8.3	100	not investigated	
Ap	25.0	316.5	13.0	90
C	7.9	100	not investigated	

Preliminary studies carried out in this work aim at negative changes in the monitoring potential that take place in the closest vicinity of the Roztocze National Park. The area of the investigation was purposefully located in the forest soils in the protected zone of the park, because in protected areas contents of heavy metals should not exceed the norms – even the contents slightly below the norms are not satisfactory.

The humus levels of forest soils had different numbers of colonies of bacteria, *Actinomycete* and fungi. The number of colonies of bacteria and *Actinomycete* ranged from 5.2 to 21.0 · 10^9 cfu · kg^{-1} d.m. of soil, and in the case of fungi it ranged from 80 to 105 · 10^9 cfu · kg^{-1} d.m. of soil (Table 2).

The statistical analysis that was carried out revealed that the contents of total lead in the humus levels influenced the amount of colonies of bacteria, *Actinomycete* and fungi. Significant negative correlations were obtained between the contents of total lead and the number of colonies of bacteria, *Actinomycete* ($r = -0.754$), and fungi ($r = -0.580$).

Moreover, it was observed that the content of total lead was significantly, positively correlated with pH, content of C organic and absorption capacity (Table 3).

Table 3

Correlation coefficients between Pb and basic chemical properties of forest soils at p = 0.01

	pH_{H_2O}	pH_{KCl}	C_{org}	T	Bacteria and *Actinomycete*	Fungi
Pb	0.897	0.887	0.913	0.859	–0.754	–0.580

The preliminary results of the study suggest that it is necessary to continue further studies in this matter, which will allow to monitor in detail the changes in soil environment in protected areas.

Conclusions

1. Total contents of lead in the investigated soils did not exceed the permitted norms for protected areas. However, significant enrichment of the surface levels in lead was observed, as compared with the mother rock levels (geo-chemical background).

2. The statistical analysis that was carried out revealed that the amount of Pb in the humus level significantly, negatively correlated with the number of colonies of bacteria, *Actinomycete* and fungi that were present in the investigated soil environment.

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Abstrakt: Celem badań była próba określenia wpływu zawartości ogólnej ołowiu na liczebność wybranych grup drobnoustrojów w glebach lekkich położonych w otulinie Roztoczańskiego Parku Narodowego. Badania przeprowadzono w okresie wiosennym na terenie lasu sosnowego Leśnictwa Senderki. Ogółem w terenie wykonano 10 odkrywek glebowych, z których pobierano próbki z poziomów próchnicznych i skały macierzystej. Z przeprowadzonych badań wynika, iż w glebach leśnych nie zostały przekroczone dopuszczalne normy zawartości ogólnych form ołowiu opracowane dla trenów chronionych. Stwierdzono jednak znaczne wzbogacenie w ołów całkowity poziomów wierzchnich w stosunku do skał macierzystych. Ilość ołowiu ogólnego w poziomach próchnicznych miała wpływ na ilość oznaczonych kolonii bakterii i promieniowców oraz grzybów. Prawidłowość tą potwierdza przeprowadzona analiza statystyczna. Ilość ołowiu ogólnego w poziomie próchnicznym istotnie ujemnie korelowała z liczebnością kolonii oznaczonych drobnoustrojów. Należy podkreślić, iż badania przeprowadzone w niniejszej pracy mają charakter badań wstępnych. Ich kontynuowanie pozwoli nie tylko na szczegółowe śledzenie zawartości ołowiu ogólnego w glebach chronionych południowo-wschodniej Polski, ale także na ocenę wpływu tego pierwiastka na liczebność mikroflory glebowej.

Słowa kluczowe: ołów ogólny, gleby leśne, drobnoustroje glebowe, tereny chronione