MICROBIOLOGICAL PROPERTIES OF ALUMINO-SILICEOUS SOIL UNDER NATURAL GRASSLANDS

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Considering that the numbers of certain groups of microorganisms can serve to determine the soil production properties, the aim of this paper was to establish the biological character of the humus-siliceous soils under the Mt. Zlatibor natural grasslands based upon monitoring of the total of microorganisms and the numbers of actinomycetes, oligonitrophils and ammonifiers.

Microbiological and agrochemical soil properties were investigated in four Zlatibor localities, using standard laboratory methods.

The study results indicate that the total number of microorganisms significantly correlated to the humus and total nitrogen contents ($r=0.65$) in the soil of the localities investigated. The negative correlation between the content of the readily available nickel and the numbers of ammonifiers ($r=-0.77$) and oligonitrophilic bacteria ($r=-0.72$) points to significant sensibility of these groups of microorganisms towards increased concentrations of the heavy metal in the soil. The variability of the chemical soil properties exerted the smallest effect on the soil actinomycetes numbers.

Key words: soil, microorganisms, heavy metals, humus

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INTRODUCTION

Soil is a habitat for diverse and numerous microorganisms that, with their enzymes, play a central role in creating and maintaining its biological productivity. Microorganisms, as the most important biological soil component, serve as an important indicator of soil fertility or soil degradation (the biodiversity and the redox status decrease, food chain disturbance, pollutant accumulation etc), their presence in the overall soil activity being 60-90% (LEE, 1994). Domination of certain groups of microorganisms directs the synthesis or decomposition processes and determines the soil quality for the safe food production (HIGA and PARR, 1994; MILOŠEVIĆ et al., 2004).

Climatic conditions, agromeliorative measures, plant species, the content of pesticides and heavy metals, as well as interrelations between microbial populations, are of great significance for regulating the occurrence and biodivergence of microorganisms (CERVELLI et al., 1978; MILOŠEVIĆ et al., 1999; DJUKIĆ et al., 1999).

The humus-siliceous soils of the investigated area are created on serpentine rocks, the mineralogic composition of which much affects the production properties of these soils. According to the data obtained by Jakovljevic and Stevanovic (2004), low productivity of these soils has not been precisely determined yet although it is supposedly a result of a deficiency of basic biogenic elements (NO_3, P, K, S), as well as of the high content of Cr and Ni.

The aim of the investigation was to examine the biogenity of the humus-siliceous soils under natural pastures of Mt. Zlatibor.

MATERIAL AND METHODS

Towards the end of June 2002, samples of soils under natural grasslands owned by the Agricultural-Industrial Complex "Zlatibor" on Mt. Zlatibor were taken for microbiological and agrochemical properties examination. The soil investigated is a shallow humus-siliceous soil type formed on serpentine rocks. The localities (Kriva Breza, Farm, Zelenkada, Pustovo Brdo) examined are characterized by moderately acid soil reaction, high humus and total nitrogen contents, low phosphorus and potassium contents and a narrow Ca/Mg ratio (tab. 1).

Tab. 1. - Chemical properties of the localities investigated

		Kriva breza	Farma	Zelenkada	Pustovo brdo
pH	H_2O	6.25	6.28	6.35	6.35
	KCl	5.65	5.60	5.62	5.62
Humus %		14.5	13.2	11.4	14.8
Ukupni N %		0.67	0.68	0.53	0.69
P_2O_5	mg/100g	0.6	0.7	0.8	0.3
K_2O		10.0	11.1	14.5	15.3
Ca	mg/100g	218	170	125	218
Mg		300	175	173	255

With the exception of Ni and Cr, the concentration of which was several times higher than the MPC, the concentration of other heavy metals was within the values permitted for the production of good quality animal feed (tab. 2).

Tab.2 - Content of harmful microelements in the soil (mg/kg)

Lokaliteti	Cr	Pb		Ni		Cd		As	Hg
	A	A	B	A	B	A	B	A	A
Kriva Breza	530	43	3,1	1450	224	0,5	0,1	1,9	0,03
Farma	535	41	3,1	1200	136	1,0	0,1	2,3	0,04
Zelenkada	955	38	2,3	1190	150	0,5	0,1	1,3	0,03
Pusovo Brdo	210	54	2,3	1915	234	0,5	0,1	1,8	0,04

A=total content, B=available forms,

Chemical soil analyses were made at the Faculty of Agriculture in Belgrade. pH value, concentrations of humus, N, P, K, Ca and Mg were established using standard agrochemical methods (Guidebook of the Yugoslav Soil Science Society: Chemical Soil Investigation Methods, 1996). The total contents of the microelements studied were determined following the sample destruction by concentrated HNO_3, with the addition of H_2O_2, whereas the content of the readily available forms was established in the 0.005m DTPA extraction solution, by atomic spectrometry.

Microbiological properties of the soils investigated were determined at the Faculty of Agronomy in Cacak, based upon registering of the total number of microorganisms (POCHON and TARDIEUX, 1962), the numbers of ammonifiers (MPA), oligonitrophils (Fyodorov's agar) and actinomycetes (Krasilnikov's agar).

The statistical analysis included determination of the correlation dependence between the numbers of microorganisms and the soil chemical parameters studied.

RESULTS AND DISCUSSION

The analysis of the obtained data indicates that the localities examined differ both in their chemical properties (tabs. 1., 2) and in the numbers of the microorganisms studied (tab. 3).

The highest number of microorganisms was recorded in the Kriva Briza and Pustovo Brdo localities, which is in close correlation with the increased humus and total nitrogen contents in the soil of these localities (graph 1). This is in conformity with the results obtained by other authors (VAN GASTEL *et al.*, 1996; KEREK *et al.*, 2002), who point out that the change in the microbial biomass is highly correlated to the organic matter and humus contents in the soil under cultivated grasslands.

Tab. 3. The number of certain groups of microorganisms in the localities investigated

	Kriva Breza	Farm	Zelenkada	Pustovo Brdo
Total number of microorganisms (10^5/g soil)	280	175.3	139.3	177
Numbers of ammonifiers (105/g soil)	109	159	114.3	103
Numbers of oligonitrophils (104/g soil)	365	425	346.6	227
Numbers of actinomycetes (104/g soil)	16.6	16.0	18.5	20.8

$$y = 10.250 + .01672 * x$$
Correlation: $r = .65469$
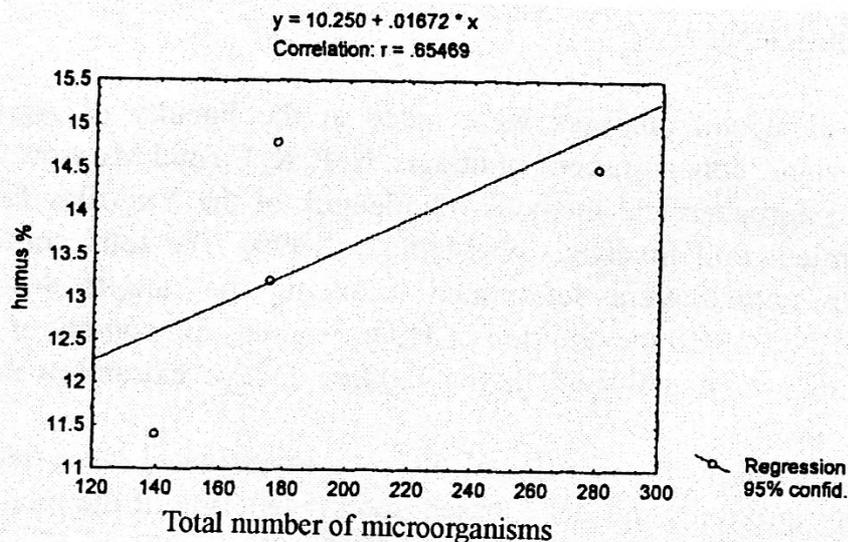
Graph 1. Correlation dependence between the humus concentration and the total number of microorganisms

No such interdependence was determined with the ammonificating microorganisms and oligonitrophils, being likely the result of a more dominant effect of the readily available forms of the heavy metals, nickel in particular, the concentration of which considerably exceeded the MPC values (136-234 mg/kg). Since these groups of microorganisms are extremely sensible to different xenobiotic effects (DJUKIĆ and MANDIĆ, 2000), their low number recorded in the localities with a high nickel content (Kriva Breza and Pustovo Brdo) was completely expected. A negative correlation between the numbers of these groups of microorganisms and the concentration of readily available nickel (graphs 2, 3) confirmed the data by other authors (AMIR and PINEU, 2003), who in their analyses of the 40 samples of the New Caledonia soils, stressed a significant contribution of this element to the reduction in the number of many specific groups of oligotrophic bacteria. Conversely, the low coefficient of correlation (r=0.13) between the numbers of ammonificating microorganisms and the Cr content in the soil indicated that the Cr effect in such soils (rich with humus) was considerably smaller, as confirmed by the results obtained by other authors (BERSOVA, 1976).

$$y = 369.54 - 1.514 * x$$
$$\text{Correlation: } r = -.7717$$
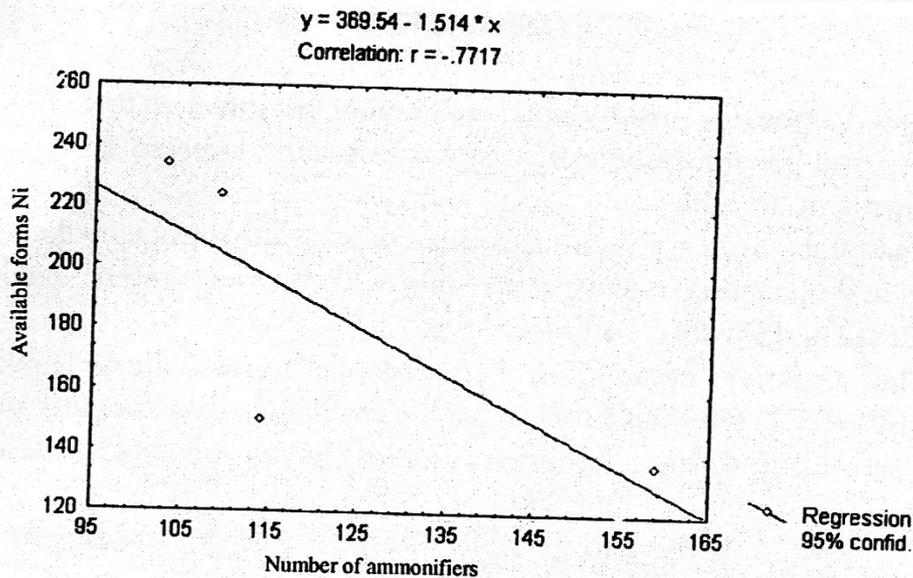
Graph 2. - Correlation dependence between the readily available Ni concentration (mg/kg) and the number of ammonifiers

$$y = 333.88 - .4338 * x$$
$$\text{Correlation: } r = -.7178$$
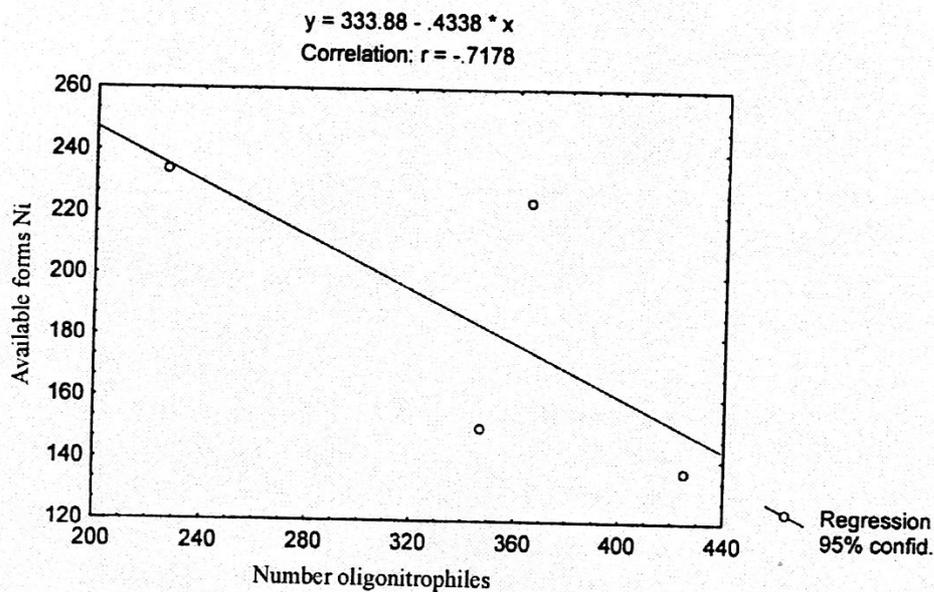
Graph 3. - Correlation dependence between the readily available Ni concentration (mg/kg) and the number of oligonitrophils

The number of actinomycetes was rather uniform, meaning that the effect of variable soil chemical properties, particularly that of the high heavy metal content, was considerably smaller compared to the other groups of microorganisms studied (tab. 3). This is also confirmed by the results obtained by ABOU-SANAB *et al.* (2003), who underline a significant resistance of this group of microorganisms towards the increased nickel concentrations in the soil. An explanation for this feature of actinomycetes, as found by PAUL and CLARK (1989), lies in a more complex structure of their cell wall as well as in their possibility to create conservation forms enabling them to survive even in the conditions of increased heavy metal concentrations.

CONCLUSION

Based upon the results obtained it may be inferred that the chemical properties of the localities investigated considerably affected the numbers of microorganisms in the soil.

The total number of microorganisms was significantly correlated with the humus and total nitrogen contents in the soil (r=0.65), which refers specifically to the Kriva Breza and Pustovo Brdo localities.

The negative correlation between the ammonifiers (r=0.77) and oligonitrophils (0.72) numbers and the readily available nickel content points to a significant sensibility of the microorganisms mentioned towards the heavy metal in question.

The lowest reaction to variable chemical soil properties was recorded with the soil actinomycetes.

MIKROBIOLOŠKE KARAKTERISTIKE ALUMO-SILIKATNOG ZEMLJIŠTA POD PRIRODNIM TRAVNJACIMA

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I z v o d

Kako brojnost pojedinih grupa mikroorganizama može poslužiti kao determinator proizvodnih karakteristika zemljišta, to je cilj ovog rada utvrđivanje biološke karakterizacije humusno-silikatnog zemljišta prirodnih travnjaka Zlatibora, na osnovu praćenja ukupne brojnosti mikroorganizama, brojnosti aktinomiceta, oligonitrofila i amonifikatora.

Mikrobiološka i agrohemijska svojstva zemljišta ispitivana su na četiri lokaliteta Zlatibora, korišćenjem standardnih laboratorijskih metoda.

Rezultati istraživanja ukazuju da je ukupna brojnost mikroorganizama u značajnoj korelativnoj vezi sa sadržajem humusa i ukupnog azota (r= 0.65) u zemljištu proučavanih lokaliteta. Negativna korelacija između sadržaja lakopristupačnog nikla i brojnosti amonifikatora (r=-0.77) i oligonitrofilnih bakterija (r=-0.72) ukazuje na značajnu senzibilnost ove grupe mikroorganizama prema povećanim koncentracijama ovog teškog metala u zemljištu. Varijabilnos u pogledu hemijskih karakteristika zemljišta najmanje se odrazila na brojnost aktinomiceta.