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Microbiological and basic agrochemical properties of *Fluvisols* along the Western Morava basin

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Abstract

The most common type of soil in the valleys of large lowland rivers is *Fluvisol* or Alluvial soil. In order to determine the biogenity of this type of soil along the Western Morava basin, the representation of the total microflora, fungi, actinomycetes, ammonifiers, *Azotobacter* sp. and oligonitrophiles was examined. The samples were taken from soils used in the most common two different ways (plough fields and meadows). For that were used standard microbiological methods of inoculation a certain decimal dilution on appropriate nutrient media. No correlation was established between the number of examined groups of microorganisms and the way of land use, nor was there a correlation with chemical properties, primarily with pH and organic matter content. A good representation of *Azotobacter* sp., as an indicator of soil fertility, was found. Agrochemical analyses showed an acidic to neutral reaction, a low to medium percentage of organic matter, a very low to very high content of easily available phosphorus and easily available potassium.

Keywords: biogenity, *Fluvisol*, microflora

Introduction

Microorganisms are the most important biological component of the soil because with their enzyme systems they actively participate in the processes of decomposition of organic matter, the synthesis and decomposition of humus and the creation of easily available plant assimilatives (Milošević et al., 2003). The tolerance of microorganisms to pesticides and heavy metals allows certain genera and species to be used in soil bioremediation (Ajmal et al., 2021). Some microorganisms can be indicators of soil pollution with pesticides (Đurić at al., 2006; Verma et al., 2016). In addition, bacteria live in the rhizosphere that colonize the roots of plants and promote plant growth (PGPR) by synthesizing certain substances useful for plants such as phytohormones, facilitating the uptake of certain nutrients from the soil and protecting plants from diseases (Zahir et al. 2004; Cakmakci et al., 2006; Yazdani et al., 2009). By inoculating seeds with these bacteria

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before sowing, an increase in the yield of plant crops and an improvement in the microbiological properties of the soil are achived (Hajnal Jafari et al., 2012.). The abundance of individual groups of microorganisms is used as one of the indicators of general microbiological activity and potential soil fertility. A small number of certain groups of microorganisms (e.g. nitrogen fixers) indicates reduced biogenity, i.e. soil fertility (Milošević, 2008). Each type of soil has its own characteristic microbiocenosis and the method of land use can have a positive or negative effect on microbiological activity, which directly affects soil fertility (Marinković et al., 2018). The abundance and enzymatic activity of microorganisms are highest in the surface layer of the soil, in the phase of intensive plant grow, while at the end of the vegetation period, the abundance and enzymatic activity of microorganisms decrease. The abundance of microorganisms in the soil also depends on the presence and nature of organic matter, methods of processing, fertilization and plant cover (Bolton er al., 1984; Stamenov et al, 2016.). The number of microorganisms also depends on a number of abiotic factors such as pH, temperature, soil moisture, the presence of heavy metals, pesticides and other harmful substances (Jemcev and Đukić, 2000). It was established that the physical and chemical characteristics of the soil are the most important property that affects the number and activity of microorganisms (Marinković et al., 2008). Bacteria, actinomycetes and fungi are the most quantitatively represented in the soil, followed by representatives of algae and protozoa.

Fluvisol (alluvial soil) is a loose and porous soil of fluvial origin (Antić et al., 1990.). *Fluvisols* are formed by the deposition of river sediments and are formed along the courses of large lowland rivers. The process of their creation begins with erosion, and ends with deposition, that is, the creation of alluvial sediments. *Fluvisols* usually consist of different materials such as fine particles of silt and clay, or larger particles such as sand and gravel. The morphology of *Fluvisol* is characterized by very pronounced layering. The proportion of humus is mostly small, from 1-2%, and in sandy forms it is below 1%. According to their mechanical composition, they can be gravelly, sandy, loamy and clayey (Ćirić M.,1991.). The reaction of the environment is neutral to weakly alkaline in carbonate subtypes, and weakly acidic, rarely neutral in carbonate-free subtypes. These are fertile soils because periodic floods enrich them with organic matter and naturally fertilize them (Pekeč et al., 2012.). They are suitable for growing cereals, vegetables, fodder plants etc. In Serbia, they are most often used as plough fields for corn production or as meadows. *Fluvisols* occupy considerable areas in Serbia, it is estimated that there are about

500.000 ha. They extend in the valleys of lowland rivers such as the Danube, Sava, Morava, Tisa and others. Although *Fluvisols* are one of the most widespread soils in Serbia, little research has been done on them (Gajić et al., 2020).

Based on the above, basic agrochemical and microbiological analyses of 24 composite *Fluvisol* samples taken along the Western Morava basin, which separates Šumadija from the southern parts of the country, were performed at the Institute of Soil Science in Belgrade. The tested *Fluvisols* were used in plough field and meadow. The basic chemical characteristics were determined and the abundance of the basic physiological groups of microorganisms (total microflora, fungi, actinomycetes, ammonifiers, *Azotobacter* sp. and free nitrogen fixers) was examined in order to observe the general soil biogenity and thus fertility of the soil.

The aim of this research was to determine the correlation between the number of microorganisms and soil exploitation type, as well as the correlation between the number of microorganisms and the basic agrochemical properties of the examined soil type. The 24 localities along the Western Morava basin were selected. The presence of different groups of microorganisms in collected soil samples were analysed.

Materials and Methods

Along the Western Morava basin, 24 localities were chosen: 16 plough fields and 8 meadows. As the number and enzymatic activity of microorganisms is the highest in the surface soil layer (Marinković et al., 2008). Soil samples were taken aseptically from a depth of 0-30cm for microbiological and agrochemical analysis.

The basic parameters for assessing soil biogenity were: total microflora, total number of fungi, actinomycetes, ammonifiers, *Azotobacter* sp. and oligonitrophils. The number of examined microbial groups was assessed using the indirect method followed by plating of soil suspension on different selective media using decimal dilutions (10^{-1}-10^{-8}) (Pochon and Tardieux**,** 1962). The number of total microflora was determined on agar soil extract (Sarić, 1989). Fungi was determined on Chapek media (Sarić, 1989); actinomycetes on synthetic agar with sucrose according to Krasiljnikov (Govedarica and Jarak, 1996); ammonifiers in a liquid media with asparagine as a nitrogen source (Vojinović et al, 1966); *Azotobacter* sp. in a liquid nitrogen-free media according to Chan (Vojinović et al, 1966) and oligonitrophiles on a nitrogen-free media according to Fyodorov (Sarić, 1989).

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The pH of soil was determinedby pH-meter (in 1M KCl) according to SRPS ISO 10390. The content of soil organic matter was determined according to SRPS ISO 10694. Available P and K in the soil samples were determined by the Al-method (Riehm, 1958). The 0.1 mol L^{-1} ammonium lactate (pH = 3.7) was used as an extract. After extraction, K_2O was determined by a flame emission photometry and P_2O_5 by spectrophotometer after color development with ammonium molybdate and $SnCl_2$.

Results and Discussions

Results of basic agrochemical analyses of the examined *Fluvisol* soils are shown in Table 1. The reaction of tested samples (pH) was uneven and ranged from strongly acidic to neutral, with the largest number of samples showing a weakly acidic to neutral reaction, which is favourable from the aspect of the number and activity of soil microflora. It has been known that soil pH directly affects the mobility of nutrients by altering their accessibility for plants and the composition of soils microbial population (Tintor et al., 2009). Regarding the content of organic matter, which is important as a source of necessary carbon and energy, the largest number of samples showed a low to medium content, which is in accordance with literature data (Ćirić, 1991). The content of easily available phosphorus and potassium varied from very low to very high.

Table 2. shows the results of microbiological analyses of the tested fluvisol samples. The representation of the total microflora was quite uneven and ranged from 0.67×10^6 g^{-1} to 51.00×10^6 g^{-1} and was not correlated with pH and content of organic matter in the analysed samples. Previous researches carried out at the Institute of Soil Science in Belgrade have shown that the number of microorganisms in the soil is characterized by great dynamism in a relatively short period. Therefore, their number can change significantly because of the dynamics of soil temperature and humidity, as well as plant cover (Vojinović et al., 1990; Delić et al., 2005).

Table 1. Basic agrochemical properties of the examined Fluvisol soils

Type of soil usage	Location	pH (KCl)	Organic matter (%)	P_2O_5 ($mg10^{-2}g^{-1}$)	K_2O ($mg10^{-2}g^{-1}$)
PLOUGH FIELD	1	5.35	2.35	11.56	14.2
	2	3.9	3.10	9.22	21.8
	3	4.8	2.48	41.94	28.3
	4	3.9	3.04	2.62	21.4
	5	6.8	2.04	10.07	9.20
	6	6.7	2.46	17.88	22.20
	7	4.7	3.30	4.98	22.5
	8	6.8	2.24	19.13	19.00
	9	6.9	2.18	9.08	13.00
	10	6.9	2.30	15.1	12.00
	11	5.3	3.87	34.56	45.00
	12	5.9	3.22	11.20	27.00
	13	6.7	2.06	44.94	24.00
	14	6.7	1.39	27.55	11.80
	15	7.1	5.15	2.13	45.00
	16	5.85	1.85	3.71	13.60
MEADOW	1	4.45	2.97	0.71	16.10
	2	7	1.73	5.96	11.20
	3	6.25	2.84	32.44	36.60
	4	7.05	3.25	22.29	12.80
	5	7.1	1.07	46.6	2.56
	6	6.5	2.30	44.4	31.60
	7	5.7	3.98	4.03	23.20
	8	7.1	1.29	3.68	7.00

The representation of actinomycetes as very important transformers of organic matter in the soil also showed unevenness and ranged from 0.33×10^4 g^{-1} to $59.67\times10^4 g^{-1}$ and, as in the case of the total microflora, it was not correlated with the chemical properties of the samples. A slightly higher prevalence was observed in samples under meadow than under plough field crops.

As for fungi, as well as key microorganisms in the transformation of organic matter in the soil, it can be said that their representation was also uneven, but to a lesser extent than in the case of actinomycetes and ranged from 2.33×10^4 g^{-1} to 36.67×10^4 g^{-1}. Fungi, as acidophilic microorganisms, showed a greater abundance in samples with a lower pH than neutral.

Table 2. Microbiological properties of the examined *Fluvisol* soils

Type of soil usage	Location	Total microflora (×10^6)	Actinomycetes (×10^4)	Fungi (×10^4)	Ammonifiers (×10^5)	*Azotobacter* sp. *MPN*	Oligonitrophiles (x10^5)
Plough field	1	41.00	18.33	22.00	45.00	95	75.33
	2	2.00	0.33	27.67	0.40	250	3.67
	3	6.33	1.33	16.00	9.50	15	26.67
	4	1.33	2.00	33.00	7.50	1400	59.33
	5	22.00	0.33	15.00	110.00	45	63.33
	6	7.33	40.00	5.67	4.50	95	47.00
	7	12.00	23.33	16.67	0.70	250	69.33
	8	14.00	17.00	9.67	25.00	250	55.00
	9	51.00	2.00	12.33	4.00	250	125.33
	10	45.00	0.33	16.00	1.40	95	104.33
	11	20.33	2.00	14.33	3.00	20	146.33
	12	44.33	26.67	7.67	110.00	45	151.67
	13	42.00	20.67	2.33	45.00	250	97.67
	14	8.67	36.33	13.00	1.50	250	23.33
	15	10.33	1.00	11.67	3.00	45	35.00
	16	18.67	27.33	10.00	45.00	250	38.33
Meadow	1	14.67	20.67	36.33	20.00	250	41.33
	2	0.67	25.00	6.00	0.70	450	22.00
	3	21.00	29.67	6.33	140.00	45	35.00
	4	26.00	18.33	13.00	4.00	150	40.67
	5	7.33	2.67	10.67	0.90	25	10.33
	6	33.00	26.33	5.67	25.00	250	58.00
	7	49.33	22.67	18.33	4.00	250	122.00
	8	22.00	59.67	11.67	15.00	150	82.33

Number of microorganisms was calculated per gram of absolutely dry soil. MPN: most probable number.

Ammonifiers, as decomposers of organic nitrogenous matter and as one of the most represented physiological groups of microorganisms in the soil, were poorly represented with the exception of samples 5 and 12 in plough field (110,22×10^5g^{-1}) and sample No. 3 under the meadow (140.00×10^5g^{-1}). This representation of ammonifiers can be said to be weak, considering that in chernozem type soil their number ca go up to 10^9 (Tintor et al., 2009; Marinković et al., 2018.). Not was the number of ammonifiers correlated with pH and organic matter content.

Azotobacter sp., the strongest associative nitrogen fixer and as an indicator of soil fertility, showed relatively good representation, both in samples under plough field and in samples under meadow. The number of *Azotobacter* sp. was relatively good, considering that according to researches in plough field its number was up to 10^3 (Kuzevski et al., 2011).

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Oligonitrophiles, as fixers of atmospheric nitrogen to meet their own needs, also showed an uneven representation that ranged from 3.67×10^5 do $151.67\times10^5 g^{-1}$ and did not depend on the chemical properties of the examined soil. A large number of oligonitrophiles may indicate an unfavourable soil nitrogen regime (Marković and Veselinović, 1979).

Conclusion

The largest number of examined *Fluvisols* along the Western Morava basin showed slightly acidic to neutral pH, low to medium content of organic matter und uneven content of easily available phosphorus and potassium. The number of the examined groups of microorganisms was also uneven and did not depend on the chemical properties of the analysed samples. No difference in biogenity was observed between plough field samples and samples under meadows which are the most common ways of using *Fluvisol* in the Republic of Serbia.

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Mikrobiološke i osnovne agrohemijske osobine fluvisola duž sliva Zapadne Morave

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Izvod

Najzastupljeniji tip zemljišta u dolinama velikih ravničarskih reka je fluvisol ili aluvijalno zemljište. U cilju utvrđivanja biogenosti ovog tipa zemljišta duž sliva Zapadne Morave, ispitana je zastupljenost ukupne mikroflore, gljivica, aktinomiceta, amonifikatora, *Azotobacter* sp. i oligonitrofila. Uzorci su uzeti iz zemljišta korišćenih na najčešća dva različita načina (oranice i livade). Korišćene su standardne mikrobiološke metode zasejavanja određenog decimalnog razređenja na odgovarajuće hranljive podloge. Nije ustanovljena korelacija između broja ispitivanih grupa mikroorganizama i načina korišćenja zemljišta, kao ni korelacija sa hemijskim osobinama, pre svega sa pH i sadržajem organske materije. Utvrđena je dobra zastupljenost *Azotobacter* sp., kao indikatora plodnosti zemljišta. Agrohemijske analize su pokazale kiselu do neutralnu reakciju, nizak do srednji procenat organske materije, vrlo nizak do vrlo visok sadržaj lako pristupačnog fosfora i lako pristupačnog kalijuma.

Ključne reči: biogenost zemljišta, fluvisol, mikroflora

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