Original paper DOI:10.5937/ZemBilj2001012M

Testing soil quality level parameters in villages in the Vranje city

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Abstract. The soil is a superficial, fertile, loose layer of earth's crust. Soil is characterized by fertility and the presence of substances necessary for the growth and development of plants such as water, oxygen, minerals and organic matter. Soil quality depends on the content of these substances in the soil. Since the soil is a source of food for human and a condition for the survival of the living world on earth, its quality needs to be maintain at an appropriate level. This paper presents the quality parameters in soil samples taken from agricultural plots in the districts of several villages on the territory of the Vranje city. The pH values were in the range from 4.28 to 6.18, which means that the soils are acidic to weakly acidic and correspond to the planting of most arable crops. The highest values of pH were found in the soil samples from the Vrtogoš village. The values for available K_2O and P_2O_5 were greater than 40%, this indicates that no additional fertilizers should be used in these plots. This research is important for these villages' residents and farmers in terms of making a right choice for cultures to grow.

Keywords soil quality, fertility, sampling, analysis

Introduction

The soil is thin to loosen the surface layer of the earth resulting from long-lasting interaction of the parent rocks (geological substrate), climate (macro, meso and micro climate) and living organisms (plants, animals and microorganisms). It can be said that it belongs to the renewable resources in view of the long-term processes of creation and development. The soil is characterized by fertility, presence of substances (water, mineral and organic matter, oxygen), which are necessary for the growth and development of plants (Vidojevic et. al., 2013). By providing primary production in terrestrial ecosystems, the soil provides about 90% of human food and is a condition of survival of the living world on earth. For this reason it is necessary to maintain its functions and quality. There are many methods on the basis of which soil quality can be determined. The quality of the soil itself and the content of mineral

elements depend on its fertility, as well as the quality of plant crops. Proper soil sampling and testing are necessary to make good soil analyzes (Markovic, 2015(.

Ecological and Pedological factors such as soil depth, soil erosion, fertility, slope and climate often affect agricultural production. However, the major driving force behind agricultural land abandonment, especially in Europe, is socioeconomic marginality (Brouwer, 2004). These social and economic factors include loss of labor to industrial and service divisions, loss in productivity of farmland, reduction in subsidies and incentives for certain crops or regions, and poor market of agricultural products and technology (Benayas et al., 2007).

Materials and methods

Kotzman method for determining humus

Determination of humus content includes oxidation of the organic substance with a solution of $KMnO_4$ (where oxalic is used for the titration), whereby the carbon from the humus is oxidized and converted to carbon dioxide. The content of liberated carbon dioxide from humus is not calculated directly, but determined by the amount of oxidizing agent that is destroyed in the oxidation of carbon from organic substances in the analyzed soil sample, and then the amount of carbon is calculated through the coefficient the formula:

$$\% \text{ humus} = \frac{A \cdot 0{,}514 \cdot 1{,}72 \cdot 100}{C}$$

A- ml of spent 0.1n KMnO4 solution on carbon oxidation in the test sample

0,514 – the coefficient indicating that each ml of 0,1n KMnO4 oxidizes 0,514 mg C into CO_2

1.72 – the conversion coefficient from C to humus

C - soil test taken in mg

100 – conversion to the %.

Table 1. Soil division according to the content of humus (Varga, 2015)

Soil designation - category	Humus content
Very poor humus	< 1%
Poor humus	1-3%
Pretty humus	3-5%
Very humus	5-10%
Very very humus	> 10%

Table 2. Limit values for the total nitrogen supply of soil by Wohltmann (Pantovic et al., 1989)

The class security	Content of total nitrogen	Limit % N
I	Very rich	> 0.3
II	Rich	0,2 - 0,3
III	Good	0,1 - 0,2
IV	Middle	0,06 - 0,1
V	Poor	0,03 – 0,06
VI	Very poor	0,02 – 0,03
VII	Limited N for cultivation of plants	< 0,02

Potentiomertric method of pH determination

The formula for calculating the pH value is: $\mathrm{pH} = -\log_{10}[H^+]$, where

[H +] denotes the hydrogen ions equivalents measured in the molar unit, or the number of hydrogen ions of one liter of the given solution. This method was used to determine the soil pH, to examine whether the soil is acidic or basic and what measures should be taken on the basis of the results obtained. Based on the pH in KCl calculation, the land is divided into five groups: Alkaline (> 7.20 pH); Neutral (6.51 - 7.20); Slightly acidic (5.51 - 6.50); acidic (4.51 - 5.50) and Very acidic (4.50).

Kjeldahl method for determining nitrogen

The classical Kjeldal method is used to determine the total nitrogen content. The determination of nitrogen by this method is based on the destruction of the samples to convert the nitrogen to ammonia and the determination of ammonia in digest. The degradation is done by heating the samples with concentrated H_2SO_4 and substances that help oxidation of organic matter and the conversion of organic nitrogen to ammonia. Then nitrogen determination is carried out by the titration of ammonia liberated by the distillation of the remains of the destruction with a strong base. By distillation using aqueous vapor and a strong base at a high level, nitrogen is pumped out in the form of ammonia and "catches" in boric acid solution. The amount of nitrogen in boric acid is determined by the titration of the sulfuric acid of the known normality, and by calculation the content of the total nitrogen in the soil expressed in percent (% N) is calculated (Belic et al., 2014):

$$\%N = \frac{(a-b)\cdot 0{,}14}{P}\cdot 100$$

Table 2 shows seven classes of total nitrogen supply in soil.

Determination of available phosphorus and potassium in the soil Al-method

The Al-method is considered more advantageous than the others, since the same extract determines both available phosphorus and potassium. The method is based on the extraction of alkaline phosphorus and potassium with Al solution. From the extract the phosphorus is determined by colorimetric and potassium by flame-photometric methods.

Colorimetric methods. The method is based on the fact that some elements or substances, when dissolved in a particular solvent, give characteristically colored solutions, or coloration arises as a result of the reaction of the given substance and the corresponding reagent. The intensity of the resulting coloration depends on the concentration of the test substance in the solution. By measuring the intensity of the coloring, the concentration of the test element in the solution can be quantitatively determined. The intensity of the developed color is measured by the colorimeter or the spectrophotometer. Based on the concentration of available phosphorus in the soil, Al-method, for the individual cropping cultures is divided into three classes (Predic, 2011)

Table 3 Classification of soil based on the hard-to-reach phosphorus in soil (Varga, 2015)

Security class Soil	Content of phosphorus content mg P_2O_5/100g
III – poor	0 –10
II – medium	10 – 20
I – well	>20

Table 4 Conditional limit values of the content of available phosphorus depending on the pH (Pantovic et al., 1989)

Phosphorus level	mg P_2O_5/100g	
	pH in KCl < 6,00	pH in KCl > 6,01
Very low	<6,0	<10,0
Low	6,1 - 10,0	10,1 - 15,0
Middle	10,1 - 16,0	15,1 - 20.0
High	>16	> 20

The content of plant available phosphorus in the soil depends on a number of factors. Today it is discussed about the low, medium and high content of phosphorus in the soil, and not about the good, medium or poor supply of plants by P_2O_5. Due to the differences in phosphorus adsorption by different plants, the conditions of mobilization of phosphorus in the soil are different; low content must not always be insufficient for a particular crop or vice versa, etc. One of the most important factors determining accessibility of phosphorus to plants is soil reaction (pH).

Results and discussion

The paper examines soil samples in the territory of the Vranje Municipality, in the villages Vrtogos, Tibuzde, Rataje, Zapsko and Kumarevo. At each sampling site, soil samples were taken in three replications from 0-10 cm and 0-20 cm depths.

Table 5. The content of parameters pH, humus, N, P, K in the tested soil samples at different locations and depths.

Location/depth	Sample No.	Available P, mg/100g	total N, %	pH	Humus (%)	Available K, mg/100g
Vrtogos 0-10 cm	1	13,48	0,14	5,54	2,78	11,02
	2	15,02	0,16	5,38	2,98	14,87
	3	21,04	0,12	6,01	3,41	9,76
Vrtogos 0-20 cm	1	14,57	0,13	5,51	2,38	12,71
	2	18,41	0,17	6,01	3,02	15,17
	3	20,56	0,12	6,23	3,24	13,42
Tibuzde 0-10 cm	1	14,21	0,13	5,21	2,41	14,01
	2	15,85	0,13	5,78	2,76	>40
	3	19,41	0,15	6,03	3,02	20,18
Tibuzde 0-20 cm	1	15,02	0,12	5,18	3,81	14,02
	2	16,29	0,11	5,72	2,76	>40
	3	>40	0,13	6,00	2,71	21,05
Rataje 0-10 cm	1	12,52	0,17	5,46	2,82	14,18
	2	10,41	0,22	5,98	3,04	18,21
	3	15,57	0,18	6,15	3,12	21,49
Rataje 0-20 cm	1	16,28	0,13	5,85	3,12	17,03
	2	18,74	0,21	6,18	2,85	18,56
	3	20,98	0,18	5,76	3,02	20,39
Upper Zapsko 0-10 cm	1	12,98	0,14	5,18	2,64	20,21
	2	13,56	0,16	5,66	2,91	>40
	3	16,38	0,17	5,93	3,18	21,03
Upper Zapsko 0-20 cm	1	14,18	0,14	5,48	2,74	19,04
	2	15,21	0,17	5,83	2,81	21,52
	3	18,34	0,23	6,22	3,08	21,91
Kumarevo 0-10 cm	1	11,49	0,15	4,28	2,67	19,03
	2	13,21	0,16	5,08	3,08	21,04
	3	14,84	0,20	5,19	3,31	23,98
Kumarevo 0-20 cm	1	12,95	0,17	5,43	2,81	13,94
	2	15,81	0,18	4,87	3,34	>40
	3	18,03	0,23	4,91	3,75	18,05

The results are shown in Table 5. Soil samples were examined in a laboratory at the Agricultural Institute in Vranje. Content of P_2O_5 ranged from 10.41 to > 40%; content of N ranged from 0.11 to 0.23%; content K_2O ranges from 9.76 to > 40%; the humus content ranged from 2.38 to 3.81%; the pH value ranged from 4.28 to 6.23. The results obtained for the pH in the soil samples coincide with the pH values obtained in Bratislava where similar soil tests were performed (pH/KCl 4.81–5.21) (Krnacova et al., 2013).

The soil sample at the location in the village of Tibuzde at a depth of 0-20 cm has the highest content of available phosporus, more than 40%. At the locations in the village of Upper Zapsko and in the village Kumarevo at a depth of 0-20 cm, the highest content of N of 0.23% was found. The highest content of available potassium was recorded at locations in the Tubuzde village at depths 0-10 cm and 0-

20 cm, followed by the Upper Zapsko village at a depth of 0-10 cm and in the Kumarevo village at a depth of 0-20, where K_2O was more than 40%. The highest content of humus was recorded at the location Tibuzde at a depth of 0-20 cm in the amount of 3.81%. The highest 6.23 pH value was measured at the location Vrtogos at a depth of 0-20 cm (Markovic and Stevovic, 2016).

Among the location there was not found major deviation of analyzed soil quality parameters: pH, humus, N, P_2O_5 and K_2O. So the soil is mainly suitable for growing agricultural plants.

The soil containing more than 40% of available P and K in Tubužde at a depth of 0-10 and 0-20 cm, and in Upper Zapsko at a depth of 0-10 cm as well as at in Kumarevo at a depth of 0-20 cm for K, are well supplied with plant available P and K and do not need in additional fertilization with this nutrients.

Table 6. Mean content of soil nutrients in studied locations and depths

Location and depth (cm)	Available P (mg/100g)	The content N (%)	pH	Humus (%)	Available K (mg/100g)
Vrtogos (0-10)	16,51	0,14	5,64	3,06	11,88
Vrtogos (0-20)	17,85	0,14	5,92	2,88	13,77
Tibuzde (0-10)	16,49	0,14	5,67	2,73	24,73
Tibuzde (0-20)	23,77	0,12	5,63	3,09	25,02
Rataje (0-10)	18,67	0,17	5,86	2,99	17,96
Rataje (0-20)	18,67	0,17	5,84	2,99	18,66
Upper Zapsko (0-10)	124,31	0,16	5,59	2,91	27,08
Upper Zapsko (0-20)	15,91	0,18	5,84	2,88	20,82
Kumarevo (0-10)	13,18	0,17	4,85	3,02	21,35
Kumarevo (0-20)	15,60	0,19	5,07	3,30	23,99

Based on data from Table 6, the soils are satisfactory supplied with the nutrients and that plant crops such as potatoes, peppers, vines and other plant crops can be cultivated on those soil.

Soil acidity ranged between the acidic and the slightly acidic among studied sites, indicating that these soils are suitable for growing cabbage, tomatoes and different fruit types. The obtained results from Table 6 and Table 2, indicate that the studied soils are rather well humified and well supplied with nitrogen. According to the supply of plant available phosphorus, the studied soils were medium-supplied (Tables 3 and 4).

In the studies of soil quality, parameters such as climate change, soil type, plant requirements and the level of applied agro-technology must be taken into account. Depending on the above conditions, the percentage of nitrogen, phosphorus, potassium, humus and pH can be varied and varied in the optimal - normal. (Markovic, 2016).

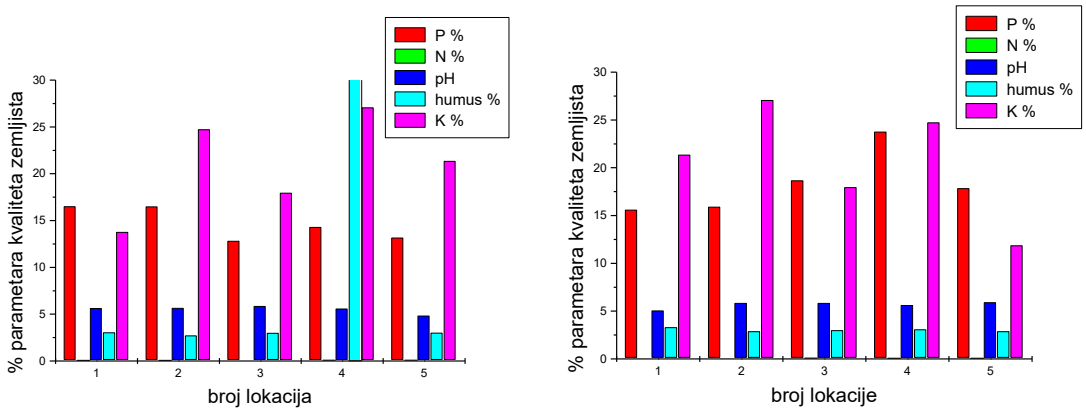

Figure 1. Content of K, P, N, pH and humus at a depth of 0-10 cm (left) and 0-20 cm (right) at different locations

Figure 1 shows the relationship between soil quality parameters at different locations and different depths. It can be noted that there are no major discrepancies in the results, but on site no. 4 the humus content is significantly higher at a depth of 0-10 cm, compared to a depth of 0-20 cm**.**

Conclusion

The topsoil is thin as a results of long-lasting interaction of the parent rock (geological substrate), climate (macro, meso and micro climate) and living beings (plants, animals and microorganisms). Accordingly, it is necessary to examine all the parameters influencing soil quality changes. The aim of the paper was to analyze the parameters that influence the quality and improvement of the composition of the soil. The research was carried out in phases: soil samples were collected from different locations and from different depths, tubular probes to test soil quality, which included content of K, P, N, pH and humus. The results of the tested garden soil samples show that the soil is mainly well supplied in potassium, phosphorus, nitrogen, humus and has acidic character. It has been shown that the content of P_2O_3 ranges from 10.41 to> 40%, the content N ranges from 0.11 to 0.23%, the content K_2O ranges from 9.76 to> 40%, the humus content ranges from 2.38 to 3.81%, the pH value ranges from 4.28 to 6.23.

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Original paper DOI:10.5937/ZemBilj2001012M

Testiranje parametara kvaliteta zemljišta u selima u gradu Vranje

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IZVOD

Zemljište je površan, plodan, labav sloj zemljane kore. Tlo karakteriše plodnost i prisustvo supstanci potrebnih za rast i razvoj biljaka kao što su voda, kiseonik, mineralne i organske materije. Kvalitet tla zavisi od sadržaja ovih supstanci u zemljištu. S obzirom da je tlo izvor hrane za čovečanstvo i uslov opstanka živog sveta na zemlji, potrebno je da održi kvalitet tla na odgovarajućem nivou. Prvo je potrebno izvršiti uzorkovanje tla, zatim koristiti odgovarajuće metode za analizu tla i na osnovu dobijenih rezultata tretirati tlo odgovarajućim agrohemijskim resursima da bi se poboljšao njegov kvalitet.

Ključne reči: kvalitet zemljista, plodnost, uzorkovanje, analiza

Primljeno 18.11.2019
Primljeno sa ispravkama 06.04.2020
Odobreno 08.04.2020