INFLUENCE OF ANTHROPOGENIZATION ON THE SOIL PROPERTIES DEVELOPED ON SILICATE SUBSTRATES IN THE WESTERN PART OF BOSNIA AND HERZEGOVINA

PROFESSIONAL PAPER

M. Ičanović, V. Jogić, A. Bakrač

Biotechnical Faculty University of Bihac

ABSTRACT

This paper analyzes the natural and anthropogenized soils on silicate substrates in the western part of Bosnia and Herzegovina. The aim of the research is to evaluate the impact of anthropogenization on these soils, using a method of comparing physical and chemical properties. The research was conducted in four locations in Bosanska Krajina by examining the following soil subgroups of Dystric Cambisol: Acidic brown soil on micaschist at site Šabići; Acidic brown soil on schist (Dystric Cambisol) at site Donja Lučka; Acidic brown soil on shales, site Jusufovići; Acidic brown soil on sandstone, site Baštra. In each of these sites, two profiles were opened; one on natural soil and others on anthropogenic - arable land, while the samples were taken in the profile on the horizon. We analyzed the following indicators of soil quality: soil organic matter content, pH, content of available forms of P_2O_5 and K_2O, analysis of soil adsorption complex by Kappen method. The aim of the research is to determine differences in some soil properties between anthropogenic and corresponding soils under natural forest or meadow. By comparing the sample results of the analysis from the horizons of natural and cultivated soils, it was concluded that the proper application of agro-technical measures and agro-ameliorative measurements generally did not cause negative effects on the properties of these soils, and often showed a positive impact.

Keywords: chemical properties, use, anthropogenization, soil properties.

INTRODUCTION

In the region of Bosanska Krajina so far mainly two types of soil have developed on carbonate and silicate substrates, which are distributed throughout the region as a mosaic.
On the basis of carbonate substrates (limestone and dolomite) various types of soils have developed; varying in type, origin, depth, humus content and general agro-ecological characteristics. Silicate substrates on the other hand, are throughout the region of Bosanska Krajina mainly represented by a second type of soils: aleurolites, sandstone, clay and shale. These substrates make the basis for soil more uniform in physical and chemical properties, which are generally characterized by greater depth, acidity and generally favorable water-air regime. The influence of mankind on the land, developed on the basis of silicate substrates, has left significant consequences. Namely, by continued deforestation and plowing of natural meadows in order to create arable land, mankind has changed the vegetation layer and its function as a natural ecosystem.

MATERIAL AND METHODS

This paper presents the reaserch undertaken on anthropogenized and natural soil formed on silicate substrates in the area of Bosanska Krajina. Throughout the sampling process, a soil map of B&H scaled 1:50,000 was used, and for each type of soil, two profiles were sampled. One was collected from the arable-anthropogenic soil and the other from the natural soil, which development was not affected by the influence of mankind.

The profiles were taken up to from a depth of 100 cm, in individual samples all but three replications, undisturbed samples in Kopezky rings and disturbed samples in plastic bags, and this paper illustrates the average data results from the laboratory studies, which were carried out using the standard methodology (Enger-Riehm-Domingo method). The samples were used for the determination of organic matter content, soil pH, available P_2O_5 and K_2O, and to analyze the soil adsorption complex (SAC).

RESULTS AND DISCUSSION

Acidic brown soil found on mica schists, site Šabići

The acidic brown soil, found on mica schists, was sampled on the location of Šabići in Cazin (located to the left of the regional road Cazin-Velika Kladusa) and consequently tested. A large number of the regional population is occupies it self with agricultural production, and despite the hilly terrain, a large number of plots are intensively farmed. A profile of the natural soil was taken from the ground used for pasture, never previously having been under the influence of anthropogenization. The profile was established on a plot of 0,8 ha, which is situated below the forest belonging to the Quercus cerris family, (Turkey oak or Austrian oak). Another profile was taken of the anthropogenic soil in the garden of 0,2 ha in size, located on a gentle slope under the Quercus cerris trees, about 100 m distance away from the family home. This plot of land has been used for gardening approximately for 7 years. Every fall, the basic agricultural processing (plowing) occurs, and prior to it, about 2 tons of manure is distributed equally per parcel. The results of the analysis are shown in Table 1.

Table 1. Chemical properties of the soil, site Šabići

Use	Horizon	Depth in cm	Humus %	pH		P_2O_5	K_2O
				H_2O	1MKCl	mg/100g soil	
Natural soil	A	0 – 17	1,8	5,3	4,3	1,4	11,5
	Bv	17 – 60	0,4	5,6	4,2	0,8	5,7
	BC	60 -100	0,1	5,3	4,7	1,1	9,7
Arable land	Ap	0 -33	3,3	6,3	5,2	1,6	25,6
	Bv	33 – 75	0,5	6,0	4,4	1,7	7,6
	BC	75 - 100	0,2	6,0	4,5	1,0	12,6

The Ap-horizon in the anthropogenic soil spreads throughout the depth of 33 cm, a result of tillage at a certain depth, where after a while Ap-horizon had formed. The A-horizon in the natural soil however, continues at a much shallower depth of 17 cm. The humus content measured within the anthropogenic soil was highest in the Ap-horizon (3,3%), whereas it was measured only 1,8% in the A-horizon within the natural soil. The increasing amount of humus in the Ap-horizon is attributed to the anthropogenic activities, or to adding manure to the soil, a trait common to every anthropogenic horizon found in plots of land used for farming or gardening purposes. The value in the Ap-horizon is moderately acidic, and in natural soil under grazing land, very sour. The pH value in H_2O in the Ap-horizon belonging to the anthropogenic soil lies in the range of 6,2 to 6,4 while the pH value in H_2O in the A-horizon of the natural soil is somewhat lower, falling into the range of between 5,3 and 5,6. The reason for this difference in pH values between the same soil types is simply land use, and introduction of organic and mineral fertilizers to the land used for gardening, for the purpose of adding nutrition to the growing vegetables. There was no difference in the content of available phosphorus, and the values were in the range of 1,7 - 10 mg P_20_5/100 g soil. The potassium content was the highest in the Ap-horizon of the anthropogenic soil, at 25,6 mg potassium per 100 g soil, twice as higher than at the same depth of natural soil. These differences in the content of potassium can be viewed as a result of fertilization with mineral and organic fertilizers. The results of the analysis are shown in Table 2.

Table 2. Analysis of the soil absorption complex according to Kappen

Use	Depth in cm	Hydrolytic acidity (H)	Content of exchangeable bases (S)	Total absorption capacity (T)	Degree of base saturation related to Total absorption capacity (V)
		$cmol/kg^{-1}$	$cmol/kg^{-1}$	$cmol/kg^{-1}$	%
Natural soil	0 - 10	8,1	16,4	24,5	66,9
	10 - 20	7,1	14,7	21,8	67,4
Arable land	0 - 10	2,9	21,5	24,4	88,0
	10 - 20	3,2	17,5	20,7	84,3

When talking about the properties of soil adsorption complex by Kappen method, the hydrolytic acidity (H) is higher in the natural soil than in the anthropogenic soil. Furthermore, the degree of base saturation (V) in the anthropogenic soil throughout the depth of 0 to 20 cm is considerably higher, than in the natural soil. Since the pH reaction values, observed in the anthropogenic soil, are more favorable, than the ones in non-arable soil, we can deduce that these parameters indicate a positive anthropogenic influence on the land used for gardening. As by definition, brown soil, found in the region, has a pH value of 5,5 below water and degree of saturation below 50%, and due to its specific features, we opted for a term used in the pedological map of BiH, when classifying this type of soil.

Acidic brown soil found on schists, site Donja Lučka

The village of Donja Lučka is located on the border of the municipality of Cazin and Velika Kladusa, to the left of regional road Cazin to Velika Kladusa. The geographical profile varies between being hilly to mountainous, and large areas of the region are used for agricultural purposes, as arable land. A profile of the natural soil was sampled at the top of the slope, which falls at about 15%. The entire plot is covered by a layer of moss of 2 to 5 cm thickness, and on the east side of it, an oak and beech forest is located, where the water source is much poorer. The profile of the anthropogenic soil was collected on the plot of 1 ha, which is located at the bottom of a slope, just below the oak and beech tree forest, on the left side of main road Cazin to Velika Kladusa. The terrain has a slight decrease of 3%, and is used for farming purposes. During wheat sowing months, basic fertilization (10 tons of cattle manure) and basic farming tools, are used. The owner stated that the crop's growth progress was amplified by using four bags (200 kg) of KAN 27% fertilizer. No other chemical were used, or introduced in any other form, to this plot of land. The results of the analysis are shown in Table 3.

Table 3. Chemical properties of the soil, site Donja Lučka

Use	Horizon	Depth in cm	Content measured in organic matter %	pH		P_2O_5	K_2O
				H_2O	1MKCl	mg/100g soil	
Natural soil	A	0 – 29	2,9	5,2	4,2	2,3	15,1
	Bv	29 - 64	0,4	4,8	3,8	0,3	7,4
	BC	64 - 100	0,2	4,6	3,6	1,8	10,0
Arable land	Ap	0 – 20	2,9	6,4	5,5	3,0	18,7
	Bv	20 - 54	0,8	6,1	5,2	2,6	8,6
	BC	54 - 100	0,4	5,8	4,6	0,7	8,5

The pH value in 1 M KCl measured in the anthropogenic soil ranges between 5,5 within the Ap-horizon to 4,6 in the BC-horizon, while the pH value in 1 M KCl measured in the natural soil ranges between 4,2 in the A-horizon to 3,6 in the BC-horizon. The cause for the noticeably higher pH values in the anthropogenic soil may be found in the nature of the paternal substrate which can be mosaic in small intervals, as well as in the land use, meaning, the use of mineral fertilizer KAN 27% and manure. Observing the values of humus content measured in the anthropogenic and natural soil, one must conclude that these values are identical, which is still a good indicator that no reduction of organic matter, caused by tillage (an occurrence symptomatic of adding natural fertilizer/manure to the soil), has occurred. The content of physiologically active phosphorus in the anthropogenic and the natural soil are almost identical, and the differences in the potassium content are small as well. The results of the analysis are shown in Table 4.

Table 4. Chemical properties of the soil absorption complex according to Kappen, site Donja Lučka

Use	Depth in cm	Hydrolytic acidity (H)	Content of exchangeable bases (S)	Total absorption capacity (T)	Degree of base saturation related to Total absorption capacity (V)
		cmol/kg^{-1}	cmol/kg^{-1}	cmol/kg^{-1}	%
Natural soil	0 – 10	10,0	14,7	24,8	59,3
	10 – 20	9,1	17,5	26,6	65,8
Anthropogenic soil	0 – 10	3,5	3,8	7,3	51,6
	10 – 20	5,5	2,7	8,3	33,5

The values of H, S and T are twice as high in the natural soil, than in the anthropogenic soil. The degree of base saturation in the anthropogenic soil measured 51,6% at the depth of 0 to 10 cm, and 33,5% at the depth of 10 to 20 cm. When it comes to natural soil, values vary, so the degree of base saturation measured 59,3% at the depth of 0 to 10 cm and 65,8% at the depth of 10 to 20 cm.

Acidic brown soil found on clay schist, site Jusufović

The village of Jusufović is located in the municipality of Bužim, just left from the main road Cazin to Bužim. The geographical profile varies from hilly to mountainous, and the land is covered by forests or natural grazing land. The soil is characterized by low production capacity and the erosion in this area is very emphasized due to the high inclination of the field. A profile of the natural soil was taken from a clearing located 50 m distance from the oak tree forest, which lies to the west at the very top of the hill. The forest is sparsely populated by relatively thin trees, indicating a younger forest, and because their roots consist of densely knotted thin and thick vessels, making the soil hard, it made the sampling of the soil profile somewhat problematic. A second soil profile was sampled in the garden, located beneath the oak tree forest. This plot of land is strictly used for agricultural purposes, and one of the mandatory tillage measures is certainly basic fertilization using manure (about 2 t per ha), and plowing conducted with a tractor plow at a depth of about 25 cm. The results of the analysis are shown in Table 5.

Table 5. Chemical properties of the soil, site Jusufovići

Use	Horizon	Depth in cm	Content measured in organic matter %	pH		P_2O_5	K_2O
				H_2O	1MKCl	mg/100g soil	
Natural soil	A	0 – 12	2,6	4,3	3,3	1,0	36,1
	ABv	12 – 39	1,5	4,6	3,4	0,7	20,5
	Bv	39 – 80	0,7	5,1	3,4	0,2	19,7
Arable soil	Ap	0 – 23	2,0	6,2	5,5	5,3	129,0
	ABv	23 – 50	1,4	6,0	5,2	1,0	56,8
	Bv	50 - 100	0,3	5,7	4,3	0,4	9,6

Looking at the depth of the individual horizon, primarily the surface horizon, one can notice the difference in their depth. The plots of land used for gardening indicate a depth of 23 cm in the Ap-horizon, the same depth necessary for tillage process, while the soil beneath a forest indicates in much shallower depth of the A-horizon, with measured depth of 12 cm. Resulović et al. 2008, states that the acidic brown soil found in the forest makes the basis for a layer of litter ranging 2 to 4 cm in thickness, while the A-horizon is quite shallow, about 10 cm in depth, (in very few cases up to 30 cm). The pH values in 1M KCl are strongly acidic (pH 3,3-3,4) throughout the entire depth of the natural soil, while the pH values in the soil, found on the plot used for gardening, indicate lesser, though still strong, acidity; being moderately acidic in the Ap and the ABv- horizon, and highly acidic in the BC-horizon.

It can be deduced therefore that the favorable pH values observed in the soil, found on the plot of land used for gardening purposes, is a positive reaction to mankind influence and activity in comparison to natural soil found beneath the forest area. The humus content within the surface horizon was observed to be higher on the forest soil, measuring 2,6%, in comparison to the 2,0% measured on the plot of land used for gardening purposes. However, it is important to note that the Ap-horizon spreads 23 cm in depth throughout the plot used for gardening purposes, whereas the A-horizon spreads 12 cm in depth throughout the forest soil which ultimately means a more uniform amount of carbon.

The content of available phosphorus varied in values, thus the maximum values (5,3 mg per 100 g soil) were measured in the anthropogenic soil throughout the Ap-horizon, while the values were at its lowest (1,0 mg per 100 g soil) within the A-horizon belonging to the natural soil. The anthropogenic activities have contributed to increased potassium content in the soil on the plot of land used for gardening purposes, indicating thus values of 129,0 mg per 100 g soil in the Ap-horizon belonging to the soil on the plot of land used for gardening purposes, whereas the values (36,1 mg per 100 g soil) measured significantly lower on the surface horizon of the forest soil. The results of the analysis are shown in Table 6.

Table 6. Chemical properties of the absorption complex according to Kappen, site Jusufovići

Use	Depth in cm	Hydrolytic acidity (H)	Content of exchangeable bases (S)	Total absorption capacity (T)	Degree of base saturation related to Total absorption capacity (V)
		$cmol/kg^{-1}$	$cmol/kg^{-1}$	$cmol/kg^{-1}$	%
Natural soil	0 - 10	18,5	8,3	26,8	31,0
	10 - 20	15,2	8,3	23,6	35,3
Anthro-pogenic soil	0 - 10	1,3	38,2	39,5	77,3
	10 - 20	0,9	17,1	18,0	76,5

The degree of base saturation in the anthropogenic soil at a depth of 0 to 10 cm is 77,3%, while the values at the second depth of 10 to 20 measure 76,5%. In the soil found on the forest soil these values are not as high, so at a depth of 0 to 10 cm, the degree of base saturation is observed to be at 31,0%, while at the depth of 10 to 20 cm it is 35,3%. Thus, by comparing the soil found on the plot of land used for gardening purposes and the soil found on the forest soil, it can be concluded that the anthropogenic measures have had a positive impact on increasing the values S, T and V.

Acidic brown soil found on sandstone, site Baštra

The acidic brown soil, found on sandstone, the sample was taken in the village of Baštra (belonging to the municipality of Bosanska Krupa, just to the right of the regional road of Bosanska Krupa - Bužim) and then tested. The geographical profile of the area varies from hilly to mountainous. The soil formed on sandstones is characterized by being well water absorptive, well aerated and poorly retaining water and nutrients. The soil on this location tends to heat up due to the low water capacity in the spring. For the geographic profile, cultivated fields are characteristic, while meadows are less represented. The plot on which the natural soil profile is open is distant from the village about 500 m, covered with woody shrubs such as birch, bracken, blackberry, which makes the plot unsuitable for sheep grazing, which otherwise occurs throughout the year. When sampling the profile, it was taken into a count that the surface layer of the soil is covered with a layer of moss, 3 to 5 cm thick. A profile of the anthropogenic soil was taken from a pit at the bottom of the slope, just 50 m below the chestnut, hornbeam, birch forest, which is located to the right side of the road from the direction of Bosanska Krupa to Bužim. On the chosen location, one was able to observe the remains of wheat harvest, and as stated previously, during the basic tillage process prior to wheat sowing, about 10 t of manure per ha was used. The results of the analysis are shown in Table 7.

Table 7. Chemical properties of the soil, site Baštra

Use	Horizon	Depth in cm	Content measured in organic matter %	pH		P_2O_5	K_2O
				H_2O	1MKCl	mg/100g soil	
Natural soil	A	0 – 28	2,8	5,0	3,7	0,7	13,5
	Bv	28 – 69	0,5	5,1	3,8	0,2	8,6
	BvC	69 - 100	0,2	5,0	3,7	0,4	7,7
Arable soil	Ap	0 – 20	1,9	6,2	5,7	0,8	10,8
	Bv	20 – 43	0,4	6,1	5,3	0,5	6,9
	BvC	43 - 100	0,1	5,0	3,6	0,4	9,6

The pH in 1M KCl, reveal itself as being extremely acidic in the natural soil, while pH values in the anthropogenic soil show a moderate acidity. Likewise, the pH of the H_2O in anthropogenic soil ranges from 5,7 to 6,2 within the Ap-horizon and as the depth increases so does the acidity; while the pH values in H_2O measured in the natural soil are much lower, thus it ranges in the A-horizon from 3,7 to 5,0, and the depth does not change. The humus content in the non-arable pastures can be characterized as moderately humified (2,8%), while the anthropogenic soil has been revealed to be poorly humified (1,9%). This phenomenon can be considered as a negative byproduct of anthropogenization, during which a loss of humus in the anthropogenic soil has occurred. The content of physiologically active phosphorus in both profiles is at 1mg per 100 g of soil throughout every horizon, and it can thus be concluded that a shortage in phosphorus content within the soil has occurred. The potassium values vary very low, although the natural soil shows a slightly higher content of potassium than the anthropogenic soil. Potassium values are highest in the topsoil, decreasing in the other horizons, but it can generally be said that the medium layer of the soil is well endowed with potassium. The results of the analysis are shown in Table 8.

Table 8. Chemical properties of the absorption complex according to Kappen, site Baštra

Use	Depth in cm	Hydrolytic acidity (H)	Content of exchangeable bases (S)	Total absorption capacity (T)	Degree of base saturation related to Total absorption capacity (V)
		cmol/kg^{-1}	cmol/kg^{-1}	cmol/kg^{-1}	%
Natural soil	0 - 10	11,3	11,5	22,9	50,3
	10 - 20	9,7	7,9	17,6	44,9
Arable soil	0 - 10	3,2	20,3	23,5	86,2
	10 - 20	3,2	18,3	21,5	84,9

The degree of base saturation in the anthropogenic soil was measured 86,2% at the depth of 0 to 10 cm, and 84,9% at the depth of 10 to 20 cm. When it comes to natural soil, values are different, so the degree of base saturation at a depth of 0 to10 cm was 50,3% and 44,9% at the depth of 10 to 20 cm. These differences are a reaction to twice as large values measured within the exchangeable bases. Higher values measured in the degree of base saturation, higher pH values, and a lower humus content observed in the soil on the arable land, can be explained by the location where the soil profile was sampled, namely at the bottom of the slope, where bases,washed down from higher parts of the slopes, had accumulated.

CONCLUSIONS

The land used for gardening in general, from where samples for testing were taken, is characterized by fertilization with high doses of organic fertilizers, and as the tests confirm, the impact of anthropogenization on these soils can be considered positive. It is also important to point out that the content of phosphorus and potassium, as well as pH values is higher in the anthropogenic soil, than in the natural soil. And finally, it is important to mention that no increase in the content of heavy metals was observed in the sampled and tested soil profiles.

Thus, all this can be characterized as favorable anthropogenic activities which occurred on the sampled and tested soil.

Observing it from the agro-ecological standpoint, whilst taking most of the field study parameters and the above listed data into account, it can be concluded that the anthropogenic soil is a convenient medium for the cultivation of most field and vegetable crops. In order to improve the fertility and productivity of natural soils, which have been tested, certain measures are recommended; namely pedo-meliorative calcification with humization steps in order to enhance the quality of the soil. A byproduct of this measure would be a reduction in the acidity, toxic effects of Al^{3+} ions (as a symptom of a very strong acidity), chemical immobilization of phosphates, and lastly, an increase of the Ca^{2+} ion in the absorptive complex of the soil. By maintaining the afore mentioned measures, along with regular fertilization on the basis of a strong P-formulation, implementing the use of KAN and other regular agro-measures, and lastly, planting the seed of a high genetic potential, one would achieve a higher crop yields on these plots of land.

REFERENCES

[1] H. Čustović, M. Tvica, *Practical parameters for soil research,* Faculty of Agricultural and Food Sciences, University of Sarajevo. Sarajevo (2005).
[2] O. Košanin, M. Knežević, Edafski uslovi nekih hrastovih zajednica na silikatnim supstratima Srbije, Originalni naučni rad UDK 630*144, Srbija (2006).
[3] V. Kovačević, Poboljšanje iskorištenja kiselih zemljišta agromeliorativnim mjerama. Unapređenje poljoprivredne proizvodnje na Kosovu i Metohiji, Poljoprivreni fakultet, Priština (2007).
[4] D. Miličić, M. Jarak, Popravak kiselih zemljišta primjenom mikrobnih inokulanata i kalcifikacije, Ljetopis naučnih radova, Originalni naučni rad UDK 631.425.2 Novi Sad (2008).
[5] Resulović, H., Čustović, H. *Paedology*, University textbook, Faculty of Agricultural and Food Sciences University of Sarajevo, Sarajevo (2002).
[6] H. Resulović, H. Čustović, I. Čengić, *Systematical properties of the soil*, Faculty of Agricultural and Food Sciences University of Sarajevo, Sarajevo (2008).
[7] B. Šaćiragić, *Agrochemistry*, Student print shop, University of Sarajevo, Sarajevo (2000).