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WATER AND PHYSICAL PROPERTIES OF URBISOLS

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Abstract

In urban areas, the soil is exposed to dynamic changes that may lead to its degradation. Urban soil is mostly anthropogenic and polluted due to the proximity of busy roads, industrial facilities and fossil fuel combustion. Urban soil is formed by direct human activity and as such has very different properties, which are generally less favorable than properties of natural soil. Although this type of soil is not used for agriculture its importance is great because in an urban environment it is a medium in which different types of plants are grown which leads to better environment of the city. The group of the most vulnerable soil includes the soil of city roads which is almost continuously changed by human activities such as various works on infrastructure networks, as well as the roads and paths. This paper presents the results of water-physical soil properties along Car Lazar Boulevard in Novi Sad, as one of the busiest roads. Along the boulevard alley, several types of lime are present which have different requirements of the soil. The analysis shows that the soil texture ranges from clay loam to coarse sandy loam and the coefficient of filtration of the samples is in the range from $1.35x10^{-3}$ to $7.43x10^{-4}$ cm/sec in the layer of 0-30 cm, respectively from $1.42x10^{-3}$ to $6.99x10^{-3}$ cm/sec in layer 30-60 cm. The total porosity ranges from 39.41% to 49.65% in the shallow, and from 41.97% to 47.56% in the deeper layer of the soil. The results suggest disparities of soil characteristics at the sites, making them difficult to use.

Keywords: *degradation, urban soil, water-physical properties*

Introduction

Due to the accelerated development and construction of cities naturally formed soils in these areas are experiencing major changes. These newly formed soils according to the Food and Agriculture Organization (FAO) (1988) soil classification (Dugalić and Gajić, 2012), are labeled as urbisols, while World Reference Base (WRB) for soil classification (2006), defines them as an urbic anthrosol. According to the FAO classification urbisols belong to the class of technogenic soils and their profile structure depends on the profile of naturally occurring soil in this area, as well as the depth of the impact of human activity. Human activity had the most pronounced influence on the genesis of urbisols compared to the other soil forming factors.Urbisols usually have one or more horizons and thickness of at least 50 cm, and the horizons are composed of different materials that are formed by mixing, compaction, addition of substrate, synthetic materials etc. (Zemlyanitsky, 1963; Craul, 1985). As such, urbisols is most often characterized by less favorable characteristics compared to naturally formed soils, but if the area of urbisols is not significantly changed physically, then all physical properties have a basic characteristics of natural soil from the contact zone (Resulović et al., 2008). It can be said that the most vulnerable area of urban areas are soils next to road which is almost totally changed by constant human activities. During the year that includes the various works on infrastructure networks, water supply, sewerage and electricity lines, and also to the roads and paths. Large impact on the chemical properties of the soil, in addition to the nature of the material from which they originated, have the exhaust gases of vehicles and industrial facilities which through the atmosphere and dust are placed on the surface, while the physical properties that have the greatest impact is a man with their local activities (Harrison et al., 1981; Gibson and Farmer, 1986; Thornton, 1991; cit. Christoforidis A. 2009). Even though this soil is not used for agricultural production, its importance is great, because in an urban environment it is a medium in which different types of plants, especially trees, are grown. Trees along the roads are designed as a green line, which in an urban area has a technical-technological, environmental and decorative function. In this regard, the main task of alleys along the street is the isolation of pedestrian flows and lateral building of motor vehicle traffic, creating favorable sanitary-hygienic and micro-climate conditions for the residents, and they also increase the aesthetic quality of urban landscapes (Vujković, 2008). Trees along the roads are sentenced to live in artificially created environment and they are constantly exposed to the underground and over ground stress (Grey and Deneke, 1986; Miller, 1988; Bradshaw et al., 1995), and therefore their life expectancy is shorter than their biological potential (Gilbertson and Bradshaw, 1985; Insley and Buckley, 1986). It is important to note that a large impact on the growth and development of plants in addition to chemicals, and water have the physical properties of soil so that any deterioration or improvement of the physical properties of soil entails changes in plant nutrition, water supply, microbiological processes etc. The aim of this study, based on field and laboratory tests, is to determine the water and physical properties of urbisols in Novi Sad, Serbia.

Materials and methods

In this study, soil next to the road along Car Lazar Boulevard, which is one of the busiest roads in Novi Sad, has been used. Along the Boulevard there is an alley, with several types of linden which are more than 30 years old. Different types of linden require different production capacity of soil and the trees during the early summer months have evident symptoms of chlorosis on the leaves. The cause of chlorosis is attributed to the high content of soluble salts in the soil near road (Clatterbuck., 2003; Nesic, 2004). Significant impact on the ultimate effect of salinity have other environmental factors and soil properties (Shannon et al., 1994). Area in which the trial is conducted is in geomorphologic point of view of the alluvial terrace of the Danube. Urbisols, in this area of the city, are formed in natural soil type fluvisol, which is hydromorphic soil and belong to class of underdeveloped fluvial soils with soil profile (A) or G (A)-C. These soils are recent, river, sea and lake deposits with layers. Pedogenetic processes are poorly expressed due to youth of deposit or because of sedimentation prevails pedogenesis. Physical and chemical properties depend on the number of layers and their thickness, texture, origin and sequence. Some typical characteristics are rarely discussed and they are different from profile to profile (Živanov and Ivanisevic, 1986). By the construction of defensive levees leakage of the river is prevented and consequently the natural process of genesis of fluvisol is stopped.

Field studies were conducted in three representative locations, next to the busiest intersections. At these places three soil profiles 0-60 cm were opened from which the samples were taken in a natural, undisturbed state with Kopecky cylinders and in the disordered state by probe. Sampling was performed at two depths of 0-30 cm and 30-60 cm, as this is the part of the bulk of the solum developing roots. Land from a nearby park was taken as a control site. The collected samples were analyzed in the Laboratory of Soil and Irrigation, Faculty of Agriculture, University of Novi Sad. Modern, recognized methods were used for this type of research (JDPZ, 1997).

Laboratory studies include the determination of texture according to International B-pipette method with preparation in sodium pyrophosphate; determination of particle density according to Albert-Bogs method using xylol as inert liquid; determination of bulk density using Kopecky cylinders (100 cm^3); total porosity (%) calculated using values of specific and volume mass of soil; soil water permeability that is Darcy's coefficient; soil moisture, drying in an oven at 105 ^{o}C until constant weight; value of the packing density of particles; moisture retention at a pressure of 0.33 bar using porous plate; moisture retention at a pressure of 6.25 and 15 bar using pressure membranes; useful water capacity (water accessible to plants), calculated from the difference of water retained at a pressure of 0.33 and 15 bar; air capacity was calculated from the difference of total porosity and water retained under pressure of 0.33 bar (%).

Results and discussion

Physical properties of soils are important for understanding many of its properties. These properties depend mostly on water, air and soil thermal regime (Miljković, 1996). Tables 1 and 2 show the main values of three replicates for each site and depth for all tested parameters. Based on the results (Table 1) it can be stated that the soil of the examined sites belong to loam textural classes, with small variations, texture and composition which ranges from coarse sand to clay loam. In all tested samples the largest share has sand fraction. The average value of this fraction ranges from 53.97 to 78.06%. The highest content of sand fraction has a control site, 69.4% in the surface layer and 78.06% in the deeper layers of soil. The highest percentage of coarse sand is in Location 3, then Location 2, and finally in Location 1. Control site has a low percentage of this fraction. The fraction of fine sand has a maximum value at the control site which is typical for natural fluvisol near Novi Sad, which is examined by Sekulic et al. (2007) and Nesic et al. (2010). Other sites have a lower content of fine sand particles than the control site. The value of the dust particles is the smallest in the Location 3 and at the Control site, in deeper layers of soil and their values were 13.57 and 15.57%. Other sites have similar values of the dust particles as well as natural fluvisols near Novi Sad. The content of the clay fraction of the studied sites in the surface layer ranges from 13.53 to 17.50%, while the deeper layers of soil values range is from 9.83 to 16.18%. Urbisols of examined localities have a higher clay content than natural fluvisols in a protected part of the Danube at Novi Sad, while the content of this fraction in the control site is not different than natural fluvisols. According to data shown in Table 2, the average value of the specific soil mass is in range of 2.38 to 3.02 g/cm^3, and they vary in depth and on locations so they are not shown in a certain orderliness. According to Biolčevu et al. (1963) cit. Živanov (1977), the specific mass of the soil in the Danube valley is in the range from 2.53 to 2.93 g/cm^3. High values of specific mass are probably the consequence of the high proportion of coarse sand in certain locations. The values of volume soil mass were in the range of 1.38 to 1.63 g/cm^3, and they indicate that there are no significant differences between urbisols and control site. Values at Location 2 (1.38 g/cm^3) and control site (1.40 g/cm^3) in the 30-60 cm layer compared to the other sites, which have higher values of volume mass, show similarities with natural fluvisol of Novi Sad.

Tab. 1. Granulometric composition of urbisols.

Location	**Depth**	**Coarse sand %**	**Fine sand %**	**Dust %**	**Clay %**	**Total sand %**	**Total clay %**	**Texture class**
		2-0.2 mm	0.2-0.02 mm	0.02-0.002 mm	<0.002 mm	2-0.02 mm	0.02 mm	
Location 1	0-30 cm	6.67	47.30	28.53	17.50	53.97	46.03	Clay loam
	30-60 cm	8.00	51.47	24.36	16.17	59.47	40.53	Clay loam
Location 2	0-30 cm	18.83	38.97	28.32	13.88	57.8	42.2	Loam
	30-60 cm	34.67	37.53	18.20	9.60	72.2	27.8	Fine sandy loam
Location 3	0-30 cm	39.00	29.03	18.43	13.53	68.03	31.96	Coarse sandy loam
	30-60 cm	37.33	36.03	13.57	9.73	73.36	23.3	Coarse sandy loam
Control	0-30 cm	7.03	62.37	26.17	4.23	69.4	30.4	Fine sandy loam
	30-60 cm	8.73	69.33	15.57	6.36	78.06	21.93	Fine sandy loam

Tab. 2. Water and phisycal proprieties of urbisols.

Location	**Depth**	Sm g/cm^3	Vm g/cm^3	Total porosity vol%	Soil compaction	Moisture retention at 33.77 kN/m^2		Moisture retention at 633.28 kN/m^2		Moisture retention at 1519.87 kN/m^2		Useful water %	Air capasity %	K-Darcy cm/sec
						mas.%	vol.%	mas.%	vol.%	mas.%	vol.%			
Loc. 1	0-30 cm	2.69	1.51	43.60	1.66	22.11	33.38	15.98	24.13	16.57	25.02	8.36	10.22	$7.43 \cdot 10^{-4}$
	30-60 cm	2.82	1.44	45.03	1.59	19.63	28.27	8.85	12.74	12.52	18.03	10.24	16.76	$4.41 \cdot 10^{-3}$
Loc. 2	0-30 cm	3.02	1.50	49.65	1.62	18.43	27.65	8.04	12.06	12.67	19.01	8.64	22.00	$1.35 \cdot 10^{-3}$
	30-60 cm	2.38	1.38	41.97	1.46	14,57	20.11	10.45	14.42	9.92	13.69	6.42	21.86	$1.42 \cdot 10^{-3}$
Loc. 3	0-30 cm	2.61	1.55	40.61	1.67	19.28	29.88	1.99	3.08	10.38	16.09	13.79	10.73	$2.84 \cdot 10^{-4}$
	30-60 cm	2.92	1.57	46.23	1.65	16.76	26.31	9.05	14.21	8.91	13.98	12.33	19.92	$6.99 \cdot 10^{-4}$
Control	0-30 cm	2.69	1.63	39.41	1.66	17.32	28.23	14.86	24.22	15.75	25.67	2.56	11.18	$2.78 \cdot 10^{-3}$
	30-60 cm	2.67	1.40	47.56	1.46	10.73	15.02	5.28	7.39	5.18	7.25	7.77	32.54	

Soil compaction in all analyzed samples is in range from 1.46 to 1.67 g/cm^3 and according to Racz (1981), they are classified as medium compacted. It is notable that there are no significant differences in soil compaction between urbisols and control site. The values of total porosity are ranged from 39.41 to 49, 65%. There are no significant differences in total porosity between urbisols and control site. According to Kacinski (1965) cit. Vucic 1987, studied soil has a satisfactory or good porosity and compared to the fluvisol of Novi Sad (Sekulic et al. 2007), these values are lower by 10 percent or more. Low values of field capacity, 15.02 to 33.38%, and the small difference between these values and the values of wilting humidity result in low-physiologically beneficial soil water. In percentages, the physiologically useful water ranges is in interval from 2.56 to 13.79%. On the other hand the capacity of soil to air tested at these sites, according to the English criteria (Dugalic and Gajic 2012), is very good, or even too high. Filtration coefficient of tested samples ranged from 1.35 x 10^{-3} cm/sec to 7.43 x 10^{-4} cm/sec, and the soil according to Vukasinovic (JDPZ, 1997), is classified as highly to moderately leaky.

Conclusion

Based on the detailed research of urbisols along Car Lazar Boulevard in Novi Sad we came to the following conclusions:

The research results are heterogeneous and it cannot be noticed regularities in the properties of urbisols. One reason for this is that urbisols in this part of the city lies on the natural soil fluvisol, whose properties are uneven due to the nature of the material which was deposited, and the second cause is a human who disrupts the schedule of the particles in the soil during anthropogenization.

Common to the all of test samples is that they belong to the loam textural class, as this land is classified as soil with good physical characteristics.

Texture of tested urbisols does not significantly differ from the texture of natural fluvisol.

The sand fraction has a highest shareand unlike fluvisol, these soils have a higher content of clay fraction.

As the consequence of the high content of sand fraction in the soil, the high values of particle density has appeared, as well as, low value of FWC and physiologically useful water.

Unfavorable water regime of soil has a negative impact on cultivated plants, which are suffering from lack of water during the summer months..

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