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EFFECT OF DIFFERENT LAND USE ON MAIN SOIL PROPERTIES

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Abstract

Intensive agriculture throughout a long period is likely to cause soil degradation. Therefore, monitoring of soil quality in agricultural regions is essential for food quality and food safety. The present study is conducted in the agricultural region of Croatia (Osijek-Baranja County) where 74 samples were collected from forest land (21) and agricultural land (53). The study investigates differences between forest soils and agricultural soils (arable land and pasture) in regard of main soil properties such as pH, soil organic carbon (SOC), bulk density (BD), total nitrogen (Tot-N), available phosphorous (AL-P) and available potassium (AL-K). In addition to main soil properties, total concentrations of several micronutrients (Fe, Mn and Zn) have been observed as well. The aim of this study is to identify potential soil degradation of particular soil property. The significant differences ($p<0.001$) have been observed for all above mention soil properties (with exception of micronutrients). However, negative effect of agricultural practice has been observed only for SOC, Tot-N and BD, suggesting degradation of these soil properties. As mentioned earlier, total concentrations of micronutrients (Fe, Mn and Zn) showed no significant difference between land use, therefore there is no soil degradation due to agricultural practice with regard of these three micronutrients. However, availability of these micronutrients is largely dependent on soil properties (pH and SOC).

Keywords: agriculture, forestry, soil quality, soil properties

Introduction

Growing world population and increasing demand for food resulted with intensive agriculture practice that, as consequence, had an effect on soil quality and caused soil degradation. When addressing soil quality, it is essential to take into account that soil quality is related to particular soil function (Karlen et al. 2003), so to accurately assess soil quality first we need to know which soil function we are evaluating. For example, if we are evaluating different management practices or land uses we need to focus on soil properties directly affected by land use change (Andrews et al. 2002a; Karlen et al. 2003). Usually, the assessment of soil quality requires as many biological, physical and chemical soil properties as possible (Brejda et al. 2000a, b; Andrews et al. 2002a, b; Shukla et al. 2006; Imaz et al. 2010). In present study we had no information on biological data and physical data was represented only by BD, all other parameters were chemical properties of soil. Therefore, we focused our study on chemical properties of soil that might be influenced by land use change.

The aim of present study is to investigate differences of soil properties between forest soil and agriculture soil and to determine the influence of land use change on soil properties. The study is conducted in the eastern part of Croatia (Osijek-Baranja County), which has been agricultural region for centuries. It is our hypothesis that there will be differences between land uses.

Materials and methods

2.1. Study area

Study area (Osijek-Baranja County) is located in the eastern Croatia. It is a part of the Pannonian Valley that stretches through Hungary, Serbia and Croatia. The county consists of 9 soil types, i.e. Stagnosols, Dystric Cambisols, Luvisols, Haplic Gleysols, Chernozems, Fluvisols, Eutric Cambisols, Mollic Gleysols and Anthrosols (FAO 2006). Based on the pedological map 74 soil samples were taken from all soil types. However, since some of them cover small and insignificant area, the number of samples varied among soil types. The sampling included agricultural sites (53) and forest sites (21). Forest soils were mainly 80-year old oak forest with very little human activity, therefore forest was considered as natural site without human influence (i.e., fertilizers, pesticides, cultivation).

2.2. Soil sampling and analysis

The sampling sites were randomly chosen so that all soil types and different land uses of the sampling area were included (arable land and forest). From each sampling site, 10 subsamples from 0–25 cm depth (hereafter called surface soil) were taken within 5 m distance from each other and then combined into one sample of approximately 500 g. Samples were dried and sieved through the 2-mm sieve for the determination of soil pH, AL-P and AL-K. For determination of soil organic carbon (SOC), total nitrogen (Tot-N) and total metal concentration in soil (M_{tot}), samples were further ground to finer particle size using agate mortar. The concentration of SOC was determined by dry combustion method on a LECO Carbon Determinator EC12 (Nelson and Sommers 1982), Tot-N concentrations were determined by LECO CHN-1000 Carbon and Nitrogen Analyzer. Soil pH was determined in soil to water solution ratio of 1:2.5 (Mc Lean 1982). Available P and K were determined by ammonium lactate (AL) extraction method (Egner et al., 1960.). Bulk density (BD) was determined by core method. Analysis of soil samples for pH, SOC, Tot-N, and trace metal concentrations was conducted at the Norwegian University of Life Sciences, while the determination of BD, AL-P and K at the University of J.J. Strossmayer, Faculty of Agriculture, Osijek, Croatia.

Soil samples for total metal concentration of Fe, Mn and Zn (M_{tot}) were digested in concentrated ultra pure HNO_3 (1:15 solid:solution ratio) by stepwise heating up to 250°C using a Milestone Ultra CLAVE for 1 hr and 15 min. The concentrations of trace metals were than determined by using a Perkin Elmer Optima 5300 DV Inductively Coupled Plasma Optic Emission Spectrometer (ICP-OES). Standard reference material (SRM) used was the SRM 2709 (National Institute of Standards & Technology 2003).

2.3. Statistical analysis

Descriptive statistics, analysis of variance (ANOVA) and Tukey pairwise comparison of means was conducted using Minitab® Statistical Software version 15 (Minitab 2007). Analysis of variance and Tukey pairwise comparison was done between land uses to determine soil parameters with significant differences. In addition, GIS technique was used to create maps of the area and to visualize the results. The maps were created in ArcGis version 9.2. (ArcGis 9.2. 2006), a software that combines table data with spatial data, allowing us more comprehensive insight into a particular area of interest (Hutchinson and David 2000).

Results and discussion

The results show that all of the investigated soil properties (with exception of trace metals) differ between forest and agricultural soils. Forest soils have better BD, SOC and Tot-N while agricultural soils have higher values of available P and K, as well as pH (Table 1.). Better pH in agricultural soils is a result of liming practice which helps in keeping the pH at desirable levels for agricultural production, while better AL-P and AL-K is due to the P and K fertilization. Forest higher SOC is mainly due to constant input of organic materials such as leaves and fallen branches (forest litter). Decrease in SOC, which is organic matter, in agricultural fields can affect nutrient cycling, pesticide and water retention as well as soil structure (Karlen et al. 1997). Information on BD is showing that agricultural soils are more compact, which means they are degraded compared to forest soils since BD can effect root penetration, water- and air-filled space and biological activity.

Table 1. Descriptive statistics of soil properties for different land use (n = 74)

	Land use	n	Mean	StDev	Min	Max
pH	Agri. field	53	6.8	1.003	4.3	8.02
	Forest	21	5.2	0.825	4.4	7.40
	ALL	**74**	**6.3*****	**1.180**	**4.3**	**8.02**
SOC	Agri. field	53	1.5	0.7	0.46	4.4
(%)	Forest	21	2.3	0.8	0.94	5.1
	ALL	**74**	**1.7*****	**0.8**	**0.46**	**5.1**
Nitrogen	Agri. field	53	0.15	0.07	0.04	0.44
(%)	Forest	21	0.23	0.10	0.10	0.56
	ALL	**74**	**0.17*****	**0.09**	**0.04**	**0.56**
AL-P	Agri. field	53	25.5	29.8	0.00	174.2
mg/100kg	Forest	21	5.9	6.5	0.00	29.0
	ALL	**74**	**19.91*****	**26.91**	**0.00**	**174.2**
AL-K	Agri. field	53	23.8	12.8	8.5	84.6
mg/100kg	Forest	21	13.5	5.4	7.6	28.7
	ALL	**74**	**20.9*****	**11.6**	**7.6**	**84.6**
BD	Agri. field	53	1.46	0.13	1.14	1.71
	Forest	21	1.27	0.15	0.91	1.45
	ALL	**74**	**1.42*****	**0.16**	**0.91**	**1.71**
Fe	Agri. field	53	29736	3423	23909	40221
$mgkg^{-1}$	Forest	21	27769	5624	19642	41034
	ALL	**74**	**29178**^{ns}	**4220**	**19642**	**41034**
Mn	Agri. field	53	639	200.6	237.8	1144
$mgkg^{-1}$	Forest	21	713	299.5	218.5	1459
	ALL	**74**	**660**^{ns}	**233.2**	**218.5**	**1459**
Zn	Agri. field	53	80.88	14.06	58.29	119.5
$mgkg^{-1}$	Forest	21	78.57	22.34	52.29	122.4
	ALL	**74**	**80.23**^{ns}	**16.69**	**52.29**	**122.4**

*** indicate significant difference between land uses at p<0.001 respectively while *ns* stands for “not significant”

As mentioned earlier the significant differences ($p<0.001$) have been observed for all investigated soil properties with exception of micronutrients. However, total concentration of micronutrients does not represent the available fraction. Bioavailability of these micronutrients is largely dependent on soil properties such as pH and SOC (Ivezic et. al, 2012; Sauvé et al. 2000). Therefore, influence of liming on pH and negative effect of agricultural practice on SOC can have effect on availability of micronutrients (Fe, Mn and Zn). Thus, we can argue that availability of micronutrients is also affected by land use change (Ivezic et al. 2011).

To make the issue of soil quality more understandable to non-experts and policymakers, mapping of soil quality can provide simple visual insight in the current situation of soil. Mapping is a useful approach in describing spatial and temporal dynamics of soil properties (Cambardella and Karlen 1999; Wanyama et al. 2005). Considering above mentioned results, GIS technique of mapping soil properties is a reliable tool for spatially presenting the results (Figure 1.) and potential changes in land use through time.

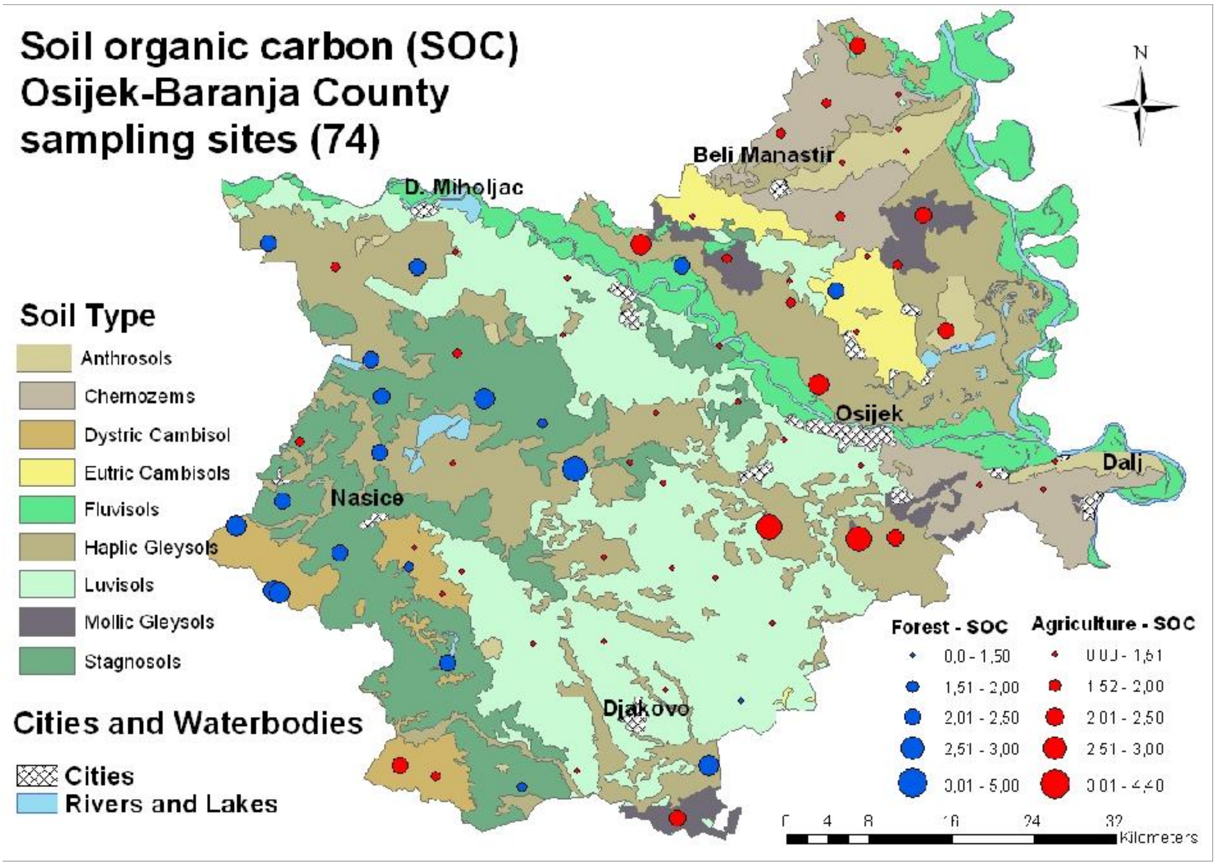

Figure 1. Soil organic carbon concentrations in Osijek-Baranja County

The dependence of SOC on land use can be observed from the maps (Figure 1). However, statistical analysis is necessary for confirmation of significant differences seen in the map. In a same way other soil properties can be presented as well.

Conclusion

In present study, investigated soil properties showed significant differences between land use (forest and agriculture). Negative results of some soil properties (SOC and BD) in agricultural soils indicated soil degradation due to agricultural practice. However, it is our opinion that the situation is not alarming and that there is no overall degradation of soil quality as agricultural soils showed better results for some other soil properties (AL-P and AL-K, as well as for pH which was adjusted for agricultural practice). In conclusion, we can say that the soils of main agricultural region of Croatia have not been seriously degraded due to long period of agricultural activity.

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