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The Soils of Serbia and Their Degradation

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Summary: In view of the topicality of the subject of soil protection from degradation, the paper discusses some basic considerations concerning soil genesis, pedogenetic processes, and soil degradation caused by human activity in Serbia. It can be said that at present the main processes connected with soil loss and soil degradation in Serbia are as follows: 1) change in the intended use of the soil (soil loss and damage due to industrial, mining, and power-producing activities) 2) loss of soil organic matter, 3) acidification and salinization of soil, 4) different forms of soil contaminations (as a result of the excessive use of agrochemicals, heavy metals, industrial pollution, etc.), 5) aeolian and water erosion, and 6) compaction and other types of physical degradation of agricultural soil. The most important aspects of soil protection from degradation are preventive measures, the identification of potential dangers, and the finding of ways to overcome them. Only usage of systematic monitoring of soil quality and other tools provide proper results in the protection of the soil from degradation.
Key words: degradation, soil, sustainable use

Introduction

Technically, the soil is a renewable natural resource, because its formation goes on perpetually. However, due to the fact that pedogenesis is a very slow process, the soil is non-renewable for all practical purposes, which is why scientists classify it as a conditionally renewable resource (Varallyay 2000, Montanarella 2007). Soil formation and restoration on the geological substrate take thousands of years, whereas the processes of soil degradation and soil loss are sometimes much more rapid and might occur in a matter of seconds or minutes, such as is the case with soil erosion or other kinds of natural or anthropogenic accidents.

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As a dynamic polydisperse system with its many functions, the soil provides support for the entire ecosystem, as it has a large influence on other elements of the environment (including ground and surface waters), human health, and food safety. Therefore, the issue of the maintenance of soil resources is not merely an academic question; it is also an obligation owed to nature by both the individual and society as a whole.

The objective of this paper was to analyze the present state of available soil resources in Serbia, the various ways in which the soil is used in Serbia, and processes that lead to soil degradation as well as to examine the environmental aspects of soil conservation efforts. The European Union has elevated the status of soil protection to that of air and water protection. To this end, the Thematic Strategy for Soil Protection (COM 2006 231) has been devised as the key document, which stipulates that soil protection should be based on the cornerstones of sustainable soil management, avoidance of any kind of soil damage, and approach to soil use that follows the principles of the protection of soil functions. The Thematic Strategy of the EC has defined soil degradation as the loss of soil or loss of soil quality for a particular function.

Basic Information on Serbian Soils

Soil genesis and evolution in Serbia have been crucially influenced by the geomorphological structure of the terrain – the land relief and its variable petrographic composition (Hadžić et al. 2002). The Soil Map of Serbia represents a rich assemblage of numerous soil types and their subclasses, each of which possesses a unique set of morphological, chemical, and water-physical properties, which results in them having different production characteristics.

According to the 1996 Spatial Plan of the Republic of Serbia, agricultural soils account for about 65% of the country's total area (60.2% in Serbia, 82% in Vojvodina, 53.5% in Kosovo and Metohija). In 2005, the Statistical Office of the Republic of Serbia published data indicating that of the total 5,112,000 hectares of agricultural land in Serbia proper and Vojvodina combined, 4.24 million (82.98 %) are arable. Of the total arable land in the country, 61.13% are in Serbia proper and 38.87% in Vojvodina. Over the past 15 years, a certain proportion of the arable land (around 8,000 ha of plowland and garden land) has been converted into meadowland (about 4,000 ha) and pastureland (4,000 ha) (Fig. 1).

From the point of view of their suitability for use in agriculture (land quality), the soil resources of Serbia have been divided into eight classes of land quality, the first four of which incorporate better soils, while Classes 5–8 include soils that are by and large unsuitable for cultivation. In Serbia as a whole, the proportions of soils that are fit and unfit for cultivation are almost identical. Soil limitations for intensive agricultural production are least pronounced in Vojvodina and most pronounced in Kosovo and Metohija. The soils of Kosovo and Metohija are like most of Serbia soils and they are characterized by presence of wide variations in natural soil fertility from one geomorphological area to the next.

Table 1. Soil types in Serbia and their basic land quality characteristics
Tabela 1. Tipovi zemljišta na prostoru Republike Srbije sa osnovnim podacima o bonitetnim karakteristikama

No.	Soil type / Tip zemljišta	Area / Površina (ha)	Land quality
1	Lithosol	77,757	Serious limitations –unproductive soil
2	Arenosol	86,000	Considerable limitations – poor to medium soil productivity
3	Calcomelanosol and Calcocambisol	910,000	Considerable to medium limitations – poor to medium soil productivity
4	Rankers	324,000	Moderate to considerable limitations – good soil productivity for use as meadow/pasture
5	Chernozem	1,200,000	No limitations – highly productive soil
6	Vertisol	680,000	Moderate limitations - highly productive soil
7	Eutric Cambisol	437,000	Moderate limitations - productive soil
8	Dystric Cambisol	2,607,000	Considerable limitations – poor to medium soil productivity
9	Rankers and Eutric Brown Soil	268,000	Considerable to medium limitations – poor to medium soil productivity
10	Pseudogley	500,000	Moderate to considerable limitations – conditionally productive soil
11	Fluvisol and Humogley	675,000	No limitations to serious limitations – conditionally highly productive soil (amelioration)
12	Solonchak and Solonetz	233,000	Considerable limitations – poor to medium soil productivity
Total 1-12		8,836,757	

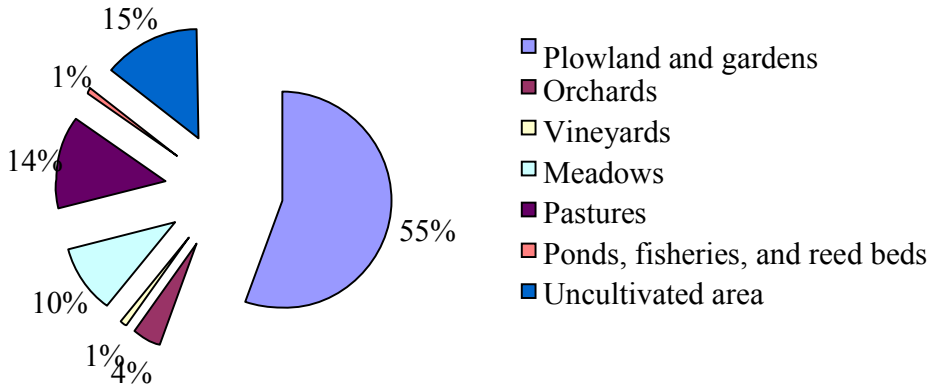

Figure 1. Agricultural land in Serbia – 5,112,000 ha (without Kosovo and Metohija)
Slika 1. Poljoprivredno zemljište Srbije – 5.112.000 ha (bez Kosova i Metohije)
Source: Statistical Yearbook of the Republic of Serbia, 2005

Soil Loss and Degradation in Serbia

In line with the Thematic Strategy for Soil Protection (Communication COM 2006 231), it could be said that at present the main processes connected with soil loss and degradation in Serbia are as follows: 1) soil loss and damage due to industrial, mining, and power-producing activities, 2) loss of soil organic matter, 3) acidification and salinization of soil, 4) different forms of soil pollution (excessive use of agrochemicals, heavy metals, industrial pollution, etc.), 5) aeolian and water erosion, and 6) compaction of agricultural soils.

In general, all these processes lead not only to the physical loss of soil but also to soil degradation and are very often interconnected, so that, for example, soil acidification leads to a loss of soil organic matter, soil erosion reduces soil biogenicity, and so on. Historically speaking, between 1957 and 1993, Serbia irreversibly lost around 220,000 ha of mostly fertile agricultural land due to various industrial, mining, power-producing, and traffic activities (Rudić et al. 1995). It will be crucially important to see if Serbia will pay the price of urbanization and economic progress at this pace and whether or not the decline of quality of this conditionally renewable resource will continue to be so drastic.

1. Soil Loss and Damage Due to Industrial, Mining, and Power-Producing Activities

The exploitation of mineral raw materials, especially in surface coal mines, leads directly to the loss of soil. Note has been taken of all the problems pertaining to soils affected by this process in Serbia, but it is not known whether or not they have been subject to statistical analyses, nor is it known how soil degradation of this type is treated, i.e. whether it is regarded as a change in the intended use of the soil or as an instance of soil loss, given the fact that the current legislation mandates that the users of such soils are obligated to eventually revert the soil to its original use. The surface coal mines of the Electric Power Industry of Serbia are currently spread across 10,000-12,000 ha of high-quality agricultural land. The bulk of this acreage is in the areas of the Kolubara and Kostolac mines. Both these areas can be regarded as environmental black spots, since for reasons described above, virtually no soil remediation efforts have been undertaken in them since the 1990s (Vujić 2004, Ličina et al. 2005).

Soil quality is under threat in other mining areas as well. Besides exploiting the soil, due to the inadequate disposal of tailings containing metallic ingredients and a complete lack of planned land rehabilitation, mines in these localities also cause degradation in the outlying areas of the Timočki, Kosovski, and Kopaonički mining basins, in which the tailings mass is several tens of times larger than the mass of the ore dug out (circa 3,000 ha). A change in the intended use of the soil also occurs when a soil is used as a borrow pit to provide raw material for the clay industry, especially in Vojvodina (areas of the towns of Kikinda, Kanjiža, Sremski Karlovci, Bečej, and others). In this manner, around 1,000 ha of agricultural soil have been destroyed so far due to a lack of soil remediation. Lately, sand and gravel pits located alongside rivers have also been contributing to the degradation of low-grade alluvial soils found on the banks of rivers such as the Danube, Sava, Drina, Morava, Ibar, and Pek. There are 125 or so gravel pits currently in operation in Serbia that are responsible for the destruction of around 60 ha of agricultural soil each year. Similar is

the case with rock quarries and ceramic and fire clay pits (Rudić et al. 2005).

2. Decline in Soil Organic Matter Content

This type of soil degradation has not systematically been monitored in Serbia. Instead, it has been inferred as the expected outcome of the acidic nature of most soil types found in Serbia proper as well as of the exclusive incorporation of mineral (nitrogen) fertilizers (in insufficient or excessive amounts), burning of crop residues, and growing crops with high biological potential, all of which generally deplete the soil of plant nutrients. Over the last two decades of economic decline in Serbia, the use of farmyard manure in agriculture has been marginalized, even in the private sector. This has primarily been due to the additional inputs that organic fertilizer requires (fuel and machinery) as well as declining livestock numbers in the country. A comparison has been made between the findings of two soil studies of chernozems in Vojvodina, one of which was conducted in the 1990s and the other in 2002–2004 (Hadžić et al. 2004). Both studies analyzed the same locations (Bečej, Bačko Gradište, Futog, Kać, Adaševci) and their results indicate there has been a trend of a decline in the soil organic matter content at the sites of about 0.05-0.2%. It should be noted that this decrease of soil organic matter must definitely be much more negligible than the decline in the organic matter content of most acidic soils in Serbia (Soils 4,7,8,9,10,11), the degradation of which has not been systematically recorded, but can be inferred from research data.

3. Acidification and Salinization

Acidification and salinization can significantly contribute to the degradation of soils by reducing their production capability. The majority of agricultural soils in Serbia proper are acidic. Out of the total area surveyed so far, 43% (1,197,000 ha) have increased levels of exchange acidity and belong in the class of highly acidic to acidic soils, 20% are acidic to weakly acidic, while no more that 35% are in the group of weakly acidic to neutral soils. Only 2% of the surveyed soils in Serbia proper have been found to be alkaline. Under particular threat are the areas of south-eastern Serbia ("Ključka Terasa"), Šumadija, Kolubarski basin, Jadar, Pocerina, and the town of Leskovac. Among the factors that intensified soil acidification in decades past were reduced organic matter incorporation into the soil and the exclusive use of mineral (nitrogen) fertilizers. Aware that excessive soil acidity is one of the factors that reduce overall soil quality and fertility, the Serbian government has put in place a series of stimulatory measures aimed at achieving pH neutralization (calcification) in soils. This program has primarily targeted the private sector and around 50,000 ha of arable land have been covered by it. However, the level of implementation of these measures does not even come close to being able to fulfil the need for the remediation of acidic soils in Serbia.

The saline and alkaline soils of Serbia are for the most part located in the province of Vojvodina (233,000 ha). The salinization of these soils is becoming an increasingly topical issue because of the ever-increasing amounts of salt that are being introduced into them via irrigation water, the quality of which is not controlled in any way (Dragović 1993).

4. The Different Forms of Soil Contamination

The different forms of soil contamination leading to soil degradation in Serbia (heavy metals, excessive use of agrochemicals, industrial pollution, etc.) have been gaining increasing attention in the country as of late. In addition to a number of pieces of legislation regulating almost all aspects of these instances of pollution, it is also evident that a lot has been accomplished in the practical sense as well, including extensive work on the remediation of sites contaminated by drilling fluid used for oil exploration between 1996 and 2003 (Sekulić et al. 2003, Hadžić et al. 2004, 2005, Nešić et al. 2006), reclamation by afforestation of some parts (971 ha) of the Kolubara surface mines (completed in 1997), changes in ash disposal technology (2005), lignite drying (2005), remediation of soil contaminated by depleted uranium at the Pljačkovica site near Vranje and the Bratoselce site near Bujanovac (2003-2004), and so on. Nevertheless, some of the problems of this kind are not so apparent as to elicit a strong public reaction and the undertaking of clear and visible measures.

The first relevant pieces of data on the heavy metal content of Serbian soils have come from a large-scale project of the Serbian Ministry of Agriculture, Forestry, and Water Management entitled "Control of Soil Fertility and Levels of Hazardous and Harmful Substances in Serbian Soils", which was conducted in 1992. Thus far, the project has covered the territory of Vojvodina (1992-1997) and 80% of the territory of Serbia, while data for a portion of southern Serbia and the province of Kosovo and Metohija are yet to be obtained.

The levels of heavy metals in the soils of Vojvodina are far below the Maximum Allowable Concentration (MAC) (Vasin et al. 2005). Generally,

the province of Vojvodina has been found to be suitable for organic agriculture even when more stringent criteria (lower MAC threshold) on the tolerable levels of total heavy metals in the soil have been used (Sekulić et al. 2005, Nešić et al. 2008, 2009).

In Serbia proper, however, the situation is somewhat different, because its total heavy metal content exceeds the MAC by a significant margin in some locations. These increased levels are not of anthropogenic nature, but have instead been linked to the geochemical origin and genesis of certain types of soil (Antić-Mladenović 2004). When it comes to the usability of these soils, however, opinions vary, since analyses of plant materials coming from crops grown in these areas have shown that the soils concerned only have high total (pseudo total) levels of heavy metals and that the fractions of these elements that are actually available to plants are minor (Ličina et al. 2006).

5. Erosion

Erosion is one of the primary and most common causes of soil degradation and reduction of the soil quality in most countries. It has been estimated that erosive processes of different severity are at work on about 80% of agricultural land in Serbia. In central, upland areas of the country water erosion is prevalent, whereas in Vojvodina the predominant type of erosion is aeolian erosion, caused by the movement of air masses (wind). According to data from 2003, a total of 284 km^2 of upland area in the country are under threat from water erosion. The soil has stabilized on 199 km^2 of that area. In Vojvodina, about 85% of agricultural land is affected by aeolian erosion, which causes an average annual loss of 0.9 t of soil per hectare.

6. Compaction of Agricultural Soil

The use of tillage in intensive agriculture leads to a series of processes that may in some cases result in soil compaction and degradation. Soil compaction causes the deterioration of soil structure, which determines total and differential porosity and hence the water, air, heat, biological, and nutritional regimes of the soil. The deterioration of these soil regimes has an unfavourable effect on the achievement of high, stable, and economically justifiable yields of adequate quality. In Serbia, the problem of soil compaction was first noted several decades ago and has become especially prominent since the large-scale introduction of intensive mechanized agriculture (Hadžić et al. 1999)

Conclusions

In line with the Thematic Strategy for Soil Protection (Communication COM 2006 231), which has defined the notion of soil degradation as a loss of soil or loss of soil quality for a particular function, it could be said that at present the main processes connected with soil loss and soil degradation in Serbia are as follows: 1) change in the intended use of the soil (soil loss and damage due to industrial, mining, and power-producing activities) 2) loss of soil organic matter, 3) acidification and salinization of soil, 4) different forms of soil pollution (excessive use of agrochemicals, heavy metals, industrial pollution, etc.), 5) aeolian and water erosion, 6) compaction and other types of physical degradation of agricultural soil.

As part of performing soil characterization by monitoring soil production capability and soil contamination, it is necessary that a number of activities be carried out the aim of which is to achieve better and more orderly soil utilization within the framework of sustainable development of agriculture and the ecosystem as a whole. It could be said that the goals of the sustainable development of soil utilization in Serbia are as follows:

- Prevention of any further soil loss and maintenance of soil quality during its use, especially in the fields of industry, mining, power production, and so on.
- Rehabilitation of already degraded soils to such degree that they can be regarded at a minimum as environmentally ordered systems if not productively capable ones.
- The passing and implementation of legislation regulating soil use and management and of a Law on Environmental Protection, both of which must be in accordance with the European and global standards of environmental protection.
- Since agriculture is still the prime mover of rural development and the main user of soil, the productive capacity of Serbian soils needs to be increased in the upcoming period.

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Zemljišta Srbije i prisutni degradacioni procesi

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Izvod: Imajući u vidu aktuelnost problematike zaštite zemljišta od degradacije, u ovom radu su prikazana osnovna razmatranja vezana za postanak zemljišta, pedogenetske procese, kao i procese degradacije zemljišta u Srbiji izazvane aktivnošću čoveka. Danas bi se moglo reći da su glavni procesi vezani za gubitak i degradaciju zemljišta na teritoriji Srbije sledeći: 1) promena namene korišćenja zemljišta (gubitak i oštećenja zemljišta usled industrijskih, rudarskih i energetskih aktivnosti), 2) smanjenje sadržaja organske materije zemljišta, 3) zakišeljavanje i zaslanjivanje zemljišta, 4) različiti oblici zagađivanja (kontaminacije) zemljišta (prekomerna primena agrohemikalija, teški metali, industrijska zagađenja i sl.), 5) eolska i vodna erozija, i 6) sabijanje i drugo fizičko propadanje zemljišta. U zaštiti zemljišta od degradacije najznačajnije su preventivne mere, uočavanje opasnosti i iznalaženje odgovarajućih rešenja za njihovo prevazilaženje. U tom cilju, predlaže se sistematska kontrola, tj. monitoring kvaliteta zemljišta.
Ključne reči: degradacija, održivo korišćenje, zemljište