Original Research

Annual Runoff and Erosion Losses of Humus-Silicate Soil from Two Specific Uses Due to Precipitation in One Part of Western Serbia

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Abstract

Erosion factors of a part of Western Serbia, that is, different precipitation amounts and intensities, influencing humus-silicate soil formed on the serpentine, with an 18% inclination toward the northwest-southeast at the altitude of 300 m, enabled quantitative runoff amounts and soil losses of the fallow and of autochthonous vegetation plot to be defined over a three-year study period. Throughout the trial, the mean annual runoff from the fallow plot amounted to 28.75 $l \cdot m^{-2}$, and erosion losses of the soil were 2648.42 $g \cdot m^{-2}$. Mean annual runoff and soil losses from the autochthonous vegetation plot were 12.37 $l \cdot m^{-2}$ and 0.98 $g \cdot m^{-2}$, respectively. The total variability of runoff from the fallow plot due to precipitations was 28.1% and that from the plot under autochthonous vegetation was 0.2%. The total variability of soil losses from the fallow plot, due to precipitation, was 43.6% and that from the plot under autochthonous vegetation was 49%.

Keywords: precipitation, runoff, erosion losses, humus-silicate soil, trial plot

Introduction

Soil erosion is referred to as a phenomenon having natural and anthropogenic properties. Erosion intensity is exerted by the interaction between climate, soil, geological substratum, relief and soil use. Provided that specific soil use is appropriately and carefully chosen, either a significant decrease or increase in soil erosion may take place, with erosion turning into an accelerated process.

Due to erosion, soil and usable water losses largely hamper the economic growth of the country.

It was emphasized [1] that the development of new more efficient production and soil and water quality technological practices, contributing both to higher yields and to improved soil conservation, would be immensely necessary to help sustain and maintain yield increases allowing for increasing population growth, food demands as well as an enormously significant role of the precisely conserved water resources to meet the needs of the world population, estimated to be 9.4 billion by 2050.

It has been suggested [7] that proper nutrient application, in this case manure, jointly with proper soil amendment and environmental concerns also favour soil sustainability.

On the other hand, it has been estimated [2] that in the area of Serbia, 44% of farmland and 67% of the total wooded area are affected by erosion, which is about 1.4 million hectares.

Accordingly, it has been established [3] that of the total eroded soil of Serbia, 90.6% (*i.e.* 31.5 million cubic meters) accounts for the annual sediment production in Serbia proper.

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Furthermore, the properties of the factors considered largely contributed to the highly expressed soil erosion in the region of Serbia [10]:70% of soils are slanted by above 5%, geological substrata and soil type proneness to erosion, with a greater soil part of Serbia belonging to highlands, with only 26.59% of wooded areas. The properties considered contributed to the invasion of 86.41% of the total soil area of Serbia by different-intensity erosion, with an annual sediment production recorded to be 35 million cubic meters. However, the soil erosion rate in Serbia due to inadequate agricultural production measures is three to four times greater than erosion caused by natural factors [11].

The Morava basin occupying 42.50% of its surface area is most affected by erosion in Serbia. More than 50.00% of the Morava basin soil is estimated to be affected by erosion. The annual discharge of sediment from the Morava into the Danube is about 6.0 million cubic meters, 4.5 million of which is fine material [20]. Annual soil losses from soils with poor properties in hilly regions of Serbia and those from soils with better properties on wavy relief are about 1000 $m^3 \cdot km^{-2}$ and about 300 $m^3 \cdot km^{-2}$, respectively, on average. An average annual soil loss from the oak wood zone, due to linear erosion types present, is 1500 $m^3 \cdot km^{-2}$. When the soil concerned is expressed in terms of soil surface and its depth, it can be concluded that 0.16 m of soil depth is eroded from 21,000 ha surface area each year [20].

Total mean annual sediment production for the Kamenica basin is 97440.87 $m^3 \cdot y^{-1}$, mean annual total sediment volume reaching the Kamenica mouth is 56515.71 $m^3 \cdot y^{-1}$, that is, erosion intensity of the Kamenica basin soil is 266.37 $m^3 \cdot km^{-2} \cdot y^{-1}$ [17].

Unmanaged waters and their catchment areas are the cause of flooding of valleys around their mouths into which they discharge coarse material as well. These watercourses are torrents by character, and they include the Kamenica river, at whose basin and bed no protection measures against erosion have been taken. It is essential to work out a strategy incorporating water management as well in order to take simultaneous measurements with respect to soil use and protection in the upland part of the basin and meliorations in its lowland area, as a function of sustainable development of agriculture.

Characteristics of the Kamenica basin [17] are as follows: the basin occupies an area within coordinates $43^0 54'$ and $44^0 08'$ North latitude and $19^0 58'$ and $20^0 16'$ East from Greenwich. The basin area is 212.17 km^2, its perimeter 98.42 km, length – 32.87 km, and its shape is characterized by uniform branching of the hydrographic network through the entire course of the river.

Soil erosion is very sensitive to topographical factors [5]. Relief exerts the most crucial effect on erosion development since by topographic slope inclinations it has an indirect effect on kinetic runoff energy. The relief parameters of the Kamenica basin are the following: an average Kamenica bed inclination is 1.3%, the mean altitude of the basin is 638.32 m, mean altitudinal difference of the basin is 389.32 m, mean basin slope is 29.4% and coefficient of the relief erosion energy is 70.84 $m \cdot km^{-1/2}$.

The coefficient of permeability of the present geological substrata of the Kamenica basin of 0.96 indicates the lack of resistance of substrata to erosion due to low permeability of rocks (93.4% of all geological substrata of the basin). Of the total area of the Kamenica basin, 2.06% of rocks have medium permeability and 4.54% are highly permeable. Pedogenetic factors have given rise to the formation of different soils in the Kamenica basin, being as follows: eroded smonitza, pseudogley, eroded pseudogleic soil, loam alluvial deposit, skeletoid brown soil on diabase rock, reddish brown soil on limestone and humus-silicate soil. Soils are resistant or non-resistant to erosion depending on whether their particles are bound or not. Bound soils are mainly of loamy composition, their structural aggregates are stable, they have adequate amount of organic matter and contain $CaCO_3$.

The most crucial climatic elements causing and contributing to erosion are precipitations and air temperatures. Changes in precipitation have significant implications for runoff, soil erosion and conservation planning [14]. Mean annual precipitation sum for the Kamenica basin is 793.6 mm and mean annual air temperature is 8.5°C [17].

The distribution of cadastral crops in the basin area is an indication of specific soil use. Soil erosion caused by tillage is proportional to the local slope curvature [22]. In the Kamenica basin area forests and underbrush of good planting density occupy 56.58 km^2, which is 26.67% of the total area of the basin, with 8.68% covered by orchards, 17.73% by meadows and 35.53% by pastures and devastated forests and underbrush. Ploughland and infertile soil occupy 9.69% and 1.70% of the basin, respectively. Specific uses of the Kamenica basin soil indicate the vegetative cover coefficient (0.77), meaning that the soils of the basin are protected by vegetation. There are three zones in the Kamenica catchment area: field and vegetable crop growing zone, field crop and fruit growing, and fruit and grassland farming zone as the most widely distributed covering 106.5 km^2 of agricultural land or 50.20% of the total basin area, whereas 139.44 km^2 or 65.72% of the total basin area are productive [16].

The Kamenica basin is a hydrographic system of Serbia within the hydrographic system of the Velika Morava river. The elements pointing to hydrographic-hydrologic properties of the Kamenica basin and therefore to a great destructive potential, and an important erosion factor, are as follows: the morphological coefficient of the shape of the basin (0.20) denoting the elongated shape of the catchment area, and resulting in less favourable conditions for a rapid and simultaneous upsurge of waters from the entire area; the basin shape coefficient (0.35) is characteristic of elongated basins. The coefficient of hydrographic network density of the Kamenica catchment area (2.93 $km \cdot km^{-2}$) points to high hydrographic network density as well as to the process of erosion. According to the hydrographic class and type of torrent, the Kamenica is classified into torrent rivers since its value is greater than 20.00

km^2, being 75.79 km^2. It is an upland type of a torrent, with a wide bed, of great length and with a developed system of torrent tributaries of the types: small river, brook, streams running down cliffs, and gorges and ravines. The coefficient of erosion of the Kamenica basin is 0.33, its characteristics being as follows: the fourth category of destructiveness, deep erosion type, low strength [17].

Considering the data that, of all natural erosion factors, the soil of the Kamenica basin is protected only by its plant cover, the aim of this paper was to complement the mentioned data on the state of the basin with quantitative indicators of runoff and erosion losses from the predominating soil of the basin and two specific soil uses under the effect of precipitations, during three hydrological years (1994/95-1996/97).

Material and Methods

The measurement of runoff and humus-silicate soil losses due to the erosion of the Kamenica basin under the effect of precipitations was enabled through the method of erosion, *i.e.* trial plots [4], both under fallow and under autochthonous vegetation (Figs. 1a, b).

The eroded plots were rectangular with their V-shaped lower end (Fig.1). The coefficients of the lower plot end slopes (φ) were 1:1. The lower plot end slopes (l) were 1.41 m long, equal-width (c) plots were 4.50 m long, their total length (L) was 5.50 m and width (d)

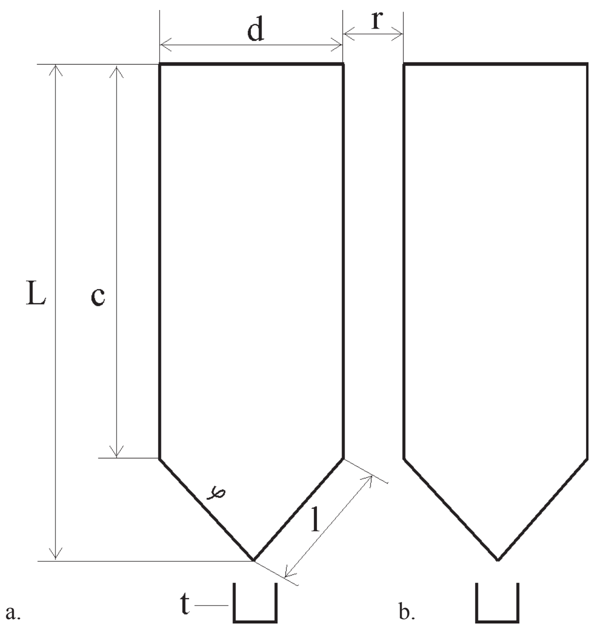

Fig.1. The trial plots patterns under the fallow (a) and autochtonus vegetation (b).
L-Total plot length, m; c-Length of equal width plots, m; d-Plot width, m; φ-Coefficients of lower plot end slopes; l-Length of lower plot end slopes, m; r-Distance between the plots, m; t-Catchment containers

2.00 m, and the surface area of each plot was 10.00 m^2. The perimeter of both plots, the one under fallow and the other under indigenous vegetation, was 13.82 m. Both faced northwest-southeast as the entire Kamenica basin and being 1.00 m away (r) from each other, with equal natural conditions provided in either one of them, and so the expected results on water runoff and soil loss from each plot could be attributed only to specific soil use. The plots were carefully bordered by metal frames of 0.50 mm thickness. The frame had sharp edges enabling the separation between precipitations on the surrounding soil from those on the trial plots. The frames were dug 0.15 m into the soil and 0.10 m of the frame height remained above the soil surface. Metal containers (t) were placed at the lower plot end to catch suspended soil material in the runoff (the so-called "totalizators") and they were 180.0 l by volume (115.0 l by estimated volume) (Fig.1). The projected volume of the containers was calculated based on the recorded maximum daily precipitation amounts which fell on the investigated area during the long-term research period. The precipitation amount concerned for the region of Cacak to which the plots administratively belong was recorded on 3 June 1931 and was 100.5 mm [15]. The runoff coefficient for the plot under fallow was 0.115 and that for the plot under pasture was 0.066 [9], and so for reasons of safety collectors with greater volume than the calculated one were provided. This all enabled throughout the trial the entire precipitation amount running off along the surface of trial plots as well as the motioned soil to be fully collected through a built-in drain at the bottom of the plot and kept in containers.

Furthemore, the method of eroded plots was applied to monitor the quantitative estimates of water erosion due to fundamental erosion factors: climate, soil, geological substrate, relief and soil use, which was the objective of the current research work.

Precipitation amounts on the trial plots were recorded using precipitation meter and precipitation duration was registered, too.

Bearing in mind that the agricultural zone in Serbia stretches as high as 500 m, the trial plots were, therefore, set up at an altitude of 300 m.

Soil distinguishment for setting up the trial was made on the basis of the most predominant soil type within the Kamenica river basin area. The soil considered was humus-silicate soil (Ranker) which was distributed in the total basin surface area of 117.37 km^2, or 55.32%, and formed on serpentine, a low-permeability rock enabling greater water runoff per soil surface area [17]. The following soil properties of both trial plots were studied: mechanical composition (by the pipette method with Na pyrophosphate) and chemical composition (pH in 1nKCl using potentiometric method; $CaCO_3$ contents were determined by means of 10% HCl, those of organic matter, N, P_2O_5 and K_2O, following Kotzman, Kjeldahl and Egner-Riehm, respectively).

The trial plots were set up at the slope inclined to

18.0%, the mean slope of the Kamenica river basin being 29.4% and the mean slopes of its individual geomorphological units ranging from 8.8% to 36.2% [17].

As the term fallow refers to ploughed but unseeded land, the plot was constantly maintained in such condition by weeding throughout the trial. The plot would otherwise, over time, evolve into a plot under autochthonous cover. After intensive rainfalls, small furrows made in the surface of the fallow plot were carefully levelled so that each successive precipitation caused new water runoff along the plot surface. Any successive runoff was simultaneously prevented from draining down the previously formed furrows which would otherwise certainly deepen.

The second plot was under autochthonous, grass or meadow cover with native common juniper (*Juniperus communis*) growing on its upper end. The natural condition of the plot was maintained during the growing season till the cutting time and further on till the next cutting. Although there were no statistical differences in runoff volumes between cut canopy and full canopy covers within a single forage species, runoff volumes were reduced by full canopies, for all seasons, by an average of 18% for almost all species [19]. The average annual amount of hay from the experimental plot under autochthonous vegetation was 2500 $kg \cdot ha^{-1}$[17].

The experimental plots enabled monitoring and comparison of the surface runoff and soil losses based on appropriate laboratory procedures (filtration of the soil, having been suspended in the runoff, followed by its drying at 105°C and measuring up to reaching constant weight).

The recorded precipitations and calculated water runoff and soil loss values were processed by the ANOVA rang test statistical analysis and Statistics 5.

Results and Discussion

In order to gain better insight into the physico-chemical properties of the trial humus-silicate soil, the two profiles were dug, one being fallow and the other indigenous vegetation. The mechanical composition and chemical properties are clearly outlined in Tables 1a and 1b, respectively.

The granulometric composition of the humus-silicate soil under fallow and under autochthonous vegetation showed that the coarse sand share was below 2.00%, namely, 1.54% and 1.69%, respectively, whereas the share of fine sand was much higher than that of coarse sand, being 14.46% and 20.71%, and total sand share was 16.00% and 22.40%, respectively (Table 1a).

Furthermore, total clay amounted to 84.0% and 77.6%, and as regards its constituents the share of colloid clay was 52.0% and 55.4%, and that of silt 32.0% and 22.2%, for the fallow and autochthonous vegetation plot, respectively (Table 1a).

Table 1. Mechanical composition (a) and chemical properties (b) of the humus-silicate soil under fallow and under autochthonous vegetation.

a	Fallow							
Horizon	Depth cm	Coarse sand > 0.2 mm %	Fine sand 0.2-0.02mm %	Silt 0.02–0.002mm %	Clay < 0.002 mm %	Total sand >0.02 mm %	Silt+Clay < 0.02 mm %	Texture mark
A_h	0-10	1.54	14.46	32.00	52.00	16.00	84.00	Clayey soil
C*								
	Autochthonous vegetation							
Ah	0-10	1.69	20.71	22.20	55.40	22.40	77.60	Clayey soil
C*								

b	Fallow						
Horizon	Depth	$CaCO_3$	pH	Organic matter	Total N	Soluble	
						P_2O_5	K_2O
	cm	%	KCl	%	%	mg per 100 g soil	
A_h	0-10	0.0	5.16	1.51	0.08	4.0	27.5
C*							
	Autochthonous vegetation						
Ah	0-10	0.0	5.13	2.21	0.11	4.2	30.0
C*							

*Geological substrata - serpentine

The fraction ratios considered indicated the humus-silicate soil, formed onto the serpentine, to belong to clayey soils according to its textural designation (Table 1a). This was obviously due to the soil being formed on the more expressed serpentine parts of heavier granulometric composition.

Chemical analyses (Table 1b) indicated that the humus-silicate soil did not contain $CaCO_3$ at all and that it thereby fell under weakly acid soils (pH in nKCl being 5.16 and 5.13, respectively). The result of this analysis corresponds with the data on the non-calcareous character of the Rankers soil of South-East Serbia [13] and of the Republic of Macedonia [12]. The organic matter share was, therefore, low, amounting to 1.51% and 2.21%, respectively, due to low altitudes, higher slanted slopes with or without poorer plant canopy where the intensive soil losses occurred, leading to lower organic matter content, accordingly. The organic matter share was found to be related to a low share of total nitrogen (0.08% and 0.11%, respectively, Table 1b). The soluble phosphorous acid amounted to 4.0 and 4.2 $mg \cdot 100g^{-1}$ soil and available potassium to 27.5 and to 30.0 $mg \cdot 100g^{-1}$ soil, respectively (Table 1b).

Over the three-year study period, all precipitation, both rainfalls and snow, was recorded (Table 2). During the period considered a total of 270 incidents of precipitation occurred, of which only 102 caused runoff on the plot under fallow, while 103 did the same on the plot under autochthonous vegetation.

Figs. 2 and 3 show temporal variability of the mean values of the runoff and erosion losses of the soil from the fallow plot and plot under autochthonous vegetation recorded over a two-month period and the relationship between the values and precipitation.

Importantly, the research results recording runoff amounts and eroded soil loss from the trial plot under fallow and runoff from the plot under autochthonous vegetation had been strongly influenced by soil moisture before the next rainfalls fell, so that the rainfalls having fallen previously, particularly due to their longer duration, saturated soil with water to such an extent that even low rainfall and low intensity amounts could not be infiltrated into the soil. Being so, the runoff taking place over the fallow plot slope surface eroded the soil, causing its losses. Such a phenomenon could occur most often during the spring months (Fig. 2). Thus, studies of the relation of saturated hydraulic conductivity with soil losses with 10 different soil types in Poland showed that dealing with measuring saturated hydraulic conductivity could be applied to assess soil erosion losses [8].

The average two-month precipitation amount of 102.5 mm for February and March and of 102.0 mm for April and May caused the highest average runoff from the fallow plot, which amounted to 9.77 $l \cdot m^{-2}$ during February and March and 7.80 $l \cdot m^{-2}$ during April and May, as well as from the plot under autochthonous vegetation which was 5.02 $l \cdot m^{-2}$ and 1.04 $l \cdot m^{-2}$, respectively (Fig. 2).

In contrast, during summer months, the runoff eroding soil from the fallow plot slope surface could be attributed only to high-intensity precipitation. The precipitation sum for June and July (131.2 mm) and for August and September (98.8 mm) caused runoff from the fallow plot of 5.49 $l \cdot m^{-2}$ during the former and 2.00 $l \cdot m^{-2}$ during the latter period. The runoff from the plot under autochthonous vegetation was 0.91 $l \cdot m^{-2}$ during June and July and 1.10 $l \cdot m^{-2}$ during August and September (Fig. 2). Precipitation in December and January amounted to 92.1 mm and that occurring in August and September (64.6 mm) caused runoff of 2.92 $l \cdot m^{-2}$ from the fallow plot during December and January and of 2.92 $l \cdot m^{-2}$ during October and November, and a total of 3.63 $l \cdot m^{-2}$ from the plot under autochthonous vegetation during December and January and 0.68 $l \cdot m^{-2}$ during October and November (Fig. 2).

The correlation between precipitation and runoff from the fallow plot was strong (r=0.53) (Table 2). The determination coefficient (r^2) was 0.281, indicating that the percentage of total variability, associated with the correla-

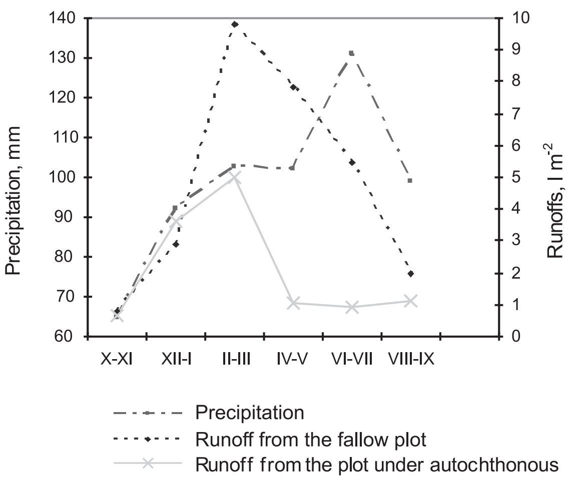

Fig. 2. Precipitations and runoffs from the trial plots over a two-month period. Mean values (1994/95 – 1996/97).

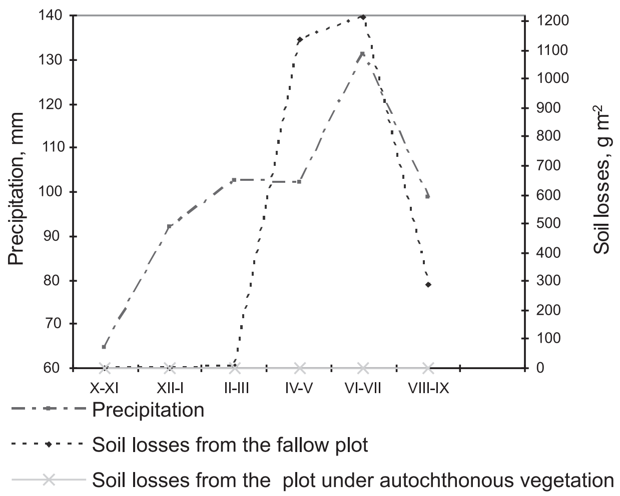

Fig.3. Precipitations and soil losses from the trial plots over a two-month period. Mean values (1994/95 – 1996/97).

tion between runoff from the fallow plot and precipitation was 28.1%. There was a lack of or negligible correlation between precipitation and runoff from the plot under autochthonous vegetation (r=0.04) (Table 2). The percentage of the total variability associated with the correlation between precipitation and runoff from the plot under autochthonous vegetation was 0.2% (r^2=0.002), meaning that there was no interdependence of variations in the values of the properties. The properties were not linearly interdependent.

Intensive summer precipitation at the level of mean two-month precipitation sums of 131.2 mm during June and July caused the highest erosion-related soil loss from the fallow plot being 121,246 g·m^{-2} and soil loss from the plot under autochthonous vegetation of (0.53 g·m^{-2} (Fig. 3). A similar occurrence took place during April and May, when precipitation of 102.0 mm caused soil losses of 1137.7 g·m^{-2} and 0.08 g·m^{-2} on the fallow plot and on the plot under autochthonous vegetation, respectively. The precipitation amount in August and September caused soil losses of 292.14 g·m^{-2} and 0.09 g·m^{-2} from the fallow plot and from the plot under autochthonous vegetation, respectively (Fig. 3). Winter precipitation brought about lower soil losses from both plots, namely during February and March they amounted to 102.5 mm 3.70 g·m^{-2} and 0.06 g·m^{-2} of soil from the fallow plot, and during December and January (92.1 mm) and during October and November (64.6 mm) 0.93 g·m^{-2} and 1.49 g·m^{-2} of soil was eroded from the fallow plot, respectively, and 0.09 g·m^{-2} *i.e.* 0.13 g·m^{-2} of soil eroded from the plot under autochthonous vegetation.

The precipitations exerted a strong impact on soil loss from the plot under fallow (r=0.70) and from the plot under autochthonous vegetation (r=0.66) (Table 2). The total variability of the soil loss from the fallow plot due to precipitation was 43.6% (r^2=0.436), and that from the plot under autochthonous vegetation was 49.0% (r^2=0.49).

The coefficient of variation (CV) for water runoff from the fallow and autochthonous vegetation plot was 73.28% and 87.86%, respectively (Table 2). The distribution of soil loss from both plots had a high variability (CV=131.25% and CV=112.50%, respectively) (Table 2).

The statistical difference between the runoff from the fallow plot and that from the plot under autochthonous vegetation was not significant ($t_{0.01}$=1.70), nor was the difference between the soil amount eroded from the fallow plot and from the plot under autochthonous vegetation ($t_{0.01}$=1.86) (Table 2), which could be attributed to the high temporal variability of precipitations expressed through their higher or lower intensity causing runoff and soil loss from the plots.

The average precipitation levels, their mean intensities, runoff, eroded soil as well as sediment concentration from both trial plots for all three hydrological years are presented in Table 2.

The total precipitation sum was the highest during the first hydrological year at 680.6 mm, followed by 608.0 mm and 484.0 mm for the second and third years, respectively. The average annual precipitation sum for Cacak was 714.0 mm with a declining trend [18], and the sum for Belgrade was 681.0 mm [21].

With respect to runoff and, therefore, soil erosion, precipitation duration (*i.e.* its intensity) was observed to be highly significant, its values being recorded during each precipitation, thereby causing an adequate runoff and soil erosion with, however, nearly identical precipitation intensity mean values recorded throughout the three hydrological research years: 0.1 mm·min^{-1}, 0.07 mm·min^{-1} and 0.1 mm·min^{-1}, respectively, during the first, second, and third research year, respectively (Table 2).

Although the total precipitation sum was the highest (680.6 mm) during the first research year, runoff was recorded to be the highest during the second one (from both trial plots), the one relating to fallow amounting to

Table 2. The average precipitation levels, mean precipitation intensities, runoff, soil losses and sediment concentration from the trial plots (1994/95-1996/97).

Hydrological year	Precipitation		Fallow			Autochthonous vegetation		
	Level, mm	Mean intensity, mm·min^{-1}	Runoff, l·m^{-2}	Soil loss, g ·m^{-2}	Sediment concentration g l^{-1}	Runoff, l·m^{-2}	Soil loss, g·m^{-2}	Sediment concentration g l^{-1}
1994/95	680.6	0.1	16.70	2879.31	172.41	4.07	2.74	0.67
1995/96	608.8	0.07	39.53	3428.57	86.73	20.06	0.19	0.01
1996/97	484.0	0.1	30.03	1637.37	54.52	12.98	0.00	0.00
Total			86.26	7945.25		37.11	2.93	
Average			28.75	2648.42		12.37	0.98	
CV%			73.28	131.25		87.86	112.50	
r			0.53	0.70		0.04	0.66	
$t_{for\ runoff}$ 1.70; $t_{for\ the\ soil\ loss}$ 1.86								

39.53 $l \cdot m^{-2}$ and the other referring to indigenous vegetation amounting to 20.06 $l \cdot m^{-2}$ (Table 2).

Throughout the third hydrological year (1996/97), when the rainfalls that fell on the fallow plot were lowest (484 mm), the runoff from the fallow plot was higher (30.03 $l \cdot m^{-2}$) than that recorded during the first research year (1994/95), when total rainfall of the fallow plot was highest, with the runoff, however, being the lowest (16.70 $l \cdot m^{-2}$) (Table 2).

Likewise, the trial plot under the autochthonous vegetation behaved similarly so that total runoff recorded during the third research year amounted to 12.98 $l \cdot m^{-2}$ and that registered during the first one amounted to 4.07 $l \cdot m^{-2}$ (Table 2).

The ratio between total runoff from the autochthonous vegetation plot and that from the fallow plot was 1:1.97; 1:2.31 and 1:4.10, respectively, for the second (1995/96), third (1996/97) and first hydrological year (1994/95), respectively.

As regards land use and runoff, it was pointed out that conventional tillage showed the greatest runoff, whereas no-till rye plots had 34% to tenfold less runoff than that from other tillage systems [23].

Accordingly, a total of 86.26 $l \cdot m^{-2}$ runoff was recorded from the fallow and 37.11 $l \cdot m^{-2}$ from the autochthonous vegetation plot during all three hydrological years (Table 2).

As regards the average annual runoff, 28.75 $l \cdot m^{-2}$ was recorded for the fallow and 12.37 $l \cdot m^{-2}$ for the indigenous vegetation plot. Given the conditions considered, the runoff from the fallow plot was manifestly 2.32 times higher than that from the autochthonous vegetation plot.

The runoff quantitative values were in favour of an erosion of particular intensities in both plots, and the values of erosion intensities were not directly proportionate to total runoff values per individual years.

Thus, the highest soil loss from the fallow plot was recorded in the second research year (3428.57 $g \cdot m^{-2}$), which was somewhat lower (2879.31 $g \cdot m^{-2}$) in the first and the lowest (1637.37 $g \cdot m^{-2}$) in the third research year (Table 2).

However, the total soil losses from the autochthonous vegetation plot were negligible, with 2.74 $g \cdot m^{-2}$ recorded in the first and 0.19 $g \cdot m^{-2}$ in the second hydrological year, with none of the soil found to have been eroded in the third study year, thereby substantiating the fact that indigenous vegetation does protect soil from erosion.

Sediment concentration in equal water amounts increased with the increasing soil amount in it. Sediment concentration in the runoff water from both experimental plots (Table 2) was the highest in the first hydrological year from both the fallow plot 172.41 $g \cdot l^{-1}$ and the plot under autochthonous vegetation 0.67 $g \cdot l^{-1}$. A considerably lower sediment concentration in the runoff water from the fallow plot was registered in the second hydrological year although during the experiment soil loss was the highest in 1995/96, as the runoff was the highest during that hydrological year. The lowest sediment concentration from the fallow plot was recorded in the third hydrological year and it was 54.52 $g \cdot l^{-1}$. During the second hydrological year, sediment concentration in the runoff from the plot under autochthonous vegetation was completely negligible (0.01 $g \cdot l^{-1}$), and during the third year, there were no soil losses.

The total soil loss of 7945.25 $g \cdot m^{-2}$ was estimated for the fallow and 2.93 $g \cdot m^{-2}$ for the vegetation plot during all three hydrological years.

With respect to the average annual eroded soil losses, 2648.42 $g \cdot m^{-2}$ applied to fallow and 0.98 $g \cdot m^{-2}$ to vegetation plot, denoting that, in such conditions, soil losses were 2702.5 times higher with fallow than those with vegetation plot.

As regards soil losses, within the strip intercropping system with simulated rainfall applied for one-hour duration at an intensity of approximately equal to 64 $mm \cdot h^{-1}$, soil losses were less than or equal to 1.5 $t \cdot ha^{-1}$ from each of the individual and multiple strips [6].

If humus-silicate volume mass were, for example, 1.50 $g \cdot cm^{-3}$, its intensity of erosion from the fallow plot would be 1765.33 $m^3 \cdot km^{-2} \cdot year^{-1}$, denoting that an average of 1.76 mm soil would be lost per year, thereby implying that such existing erosion, under the conditions considered, would be 17.6 times faster than the natural soil regeneration process.

Conclusions

- The current research, to monitor annual runoff and erosion soil losses on the trial plots of humus-silicate soil, being clayey by textural mark, within part of Western Serbia, were performed for the purpose of water and soil sustainability requiring appropriately and timely conservation practices which would also help protect the environment;
- due to particularly intense rainfalls, the mean annual runoff from the fallow plot amounted to 28.75 $l \cdot m^{-2}$ and that from the vegetation plot to 12.37 $l \cdot m^{-2}$, denoting that the climatic element considered exerted erosion jointly with remaining natural instigators considered at which land use must not be avoided;
- the mean annual soil losses on the fallow plot were 2648.42 $g \cdot m^{-2}$, being 2702.5 times higher than those on the vegetation, *i.e.* 0.98 $g \cdot m^{-2}$, strongly suggesting that the vegetation canopy nearly entirely protected the soil from erosion;
- summer precipitation over the two-month period caused the highest erosion soil losses from the fallow plot, whereas the highest runoff was caused by spring precipitation, being a result of soil saturation with water originating from winter precipitation;
- spring and winter precipitation caused the highest runoff from the plot under autochthonous vegetation. Though negligible, the soil loss amounts from the plot were caused by summer precipitation;
- there was an interdependence between variations of property values due to a strong correlation between

precipitation and runoff from the fallow plot (r=0.53) and precipitation and erosion losses from both the fallow plot (r=0.70) and the plot under autochthonous vegetation (r=0.66), and there was little or no interdependence between precipitation and runoff from the plot under autochthonous vegetation (r=0.04);

– there was no statistical significance of differences between runoff from the fallow plot and from the plot under autochthonous vegetation, nor between erosion losses of the soil from both plots. The reason for this was the high variability of runoff from both plots and particularly the distribution of soil losses from both plots, as a consequence of temporal variability of precipitation;

– if soil losses and runoff are properly and holistically managed with unavoidably used amendment and cultural practices, as substantiated by valuable references, they will be assessed as precisely as possible in the future.

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