SOIL EROSION ASSESSMENT USING EPM: A CASE STUDY IN THE CATCHMENT AREA OF THE TURKISH BROOK, WESTERN SERBIA

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Abstract

Soil erosion involves detachment and transport of soil particles from the upper parts of a slope and their deposition at its lower parts. Erosion causes soil degradation and reduces soil productivity. Soil eroded from the upland catchment causes depletion of fertile agricultural soil and the resulting sediment deposited at the river networks creates river morphological change and reservoir sedimentation problems. As regards the initiation of the wearing away of soil particles from the catchment slope, EPM - Erosion Potential Method were used to quantify soil erosion. The aim of this study was to evaluate erosion factors in the catchment area of the Turkish brook, classified as a dry valley and a smaller torrent. The annual erosion intensity is 94.33 m^3 km^{-2} of soil. Based on natural and anthropogenic factors, the Turkish brook catchment area belongs to erosion category IV, weak intensity, mixed type, with the erosion coefficient of 0.25.

Keywords: Gavrilović, analytical method, erosion intensity, catchment

INTRODUCTION

Soil is the basis of agricultural production, and thus for the survival of the human race. Formation of soil is a continuing process, but at the same time, there are processes of soil degradation. Process of soil regeneration is very slow. Soil erosion by water is the detachment and transport of soil particles by rainfall or runoff. Several mechanisms contribute to both processes [1]. The effects of different factors of erosion change the soil and geological substrate. Changes in soil can be slow or fast, as a result erosion characteristics are slow or fast. In Serbia more than 90% of the total soil area is affected by erosion of various types and intensity [2]. In the Republic of Serbia, it is registered that each year from an area of 21,000 ha layer of soil depth of 16.0 cm has been removed [3]. In the Republic of Serbia (Central Serbia) there is 1.221 million ha of eroded soil and 36,000 ha is steady now [4].

In the region of Čačak trends of increase in temperature and decrease in rainfall are evident [5]. That climatic changes cause deterioration of the physical characteristics of the soil, increasing its erodibility, reducing the role of protective vegetation, and aggravated its natural and artificial regeneration. All this affects intensification of the process of erosion, both surface and deep forms. Negative impact of the erosion endangers agriculture, forestry and water management, thus there is an increasing need for erosion protection and soil reclamation.

Quantitative amount of erosion and regarding how much sediment it causes, is shown on the part of the river basin Kamenica (part of the Western Morava river basin), its sub-basin, the area of which is its left tributary of the first order, Turkish brook.

MATERIALS AND METHODS

The Turkish brook is located near Čačak (43°53' N; 20°21' E), Western Serbia, and belongs to the catchment of the Western Morava river (Figure 1).

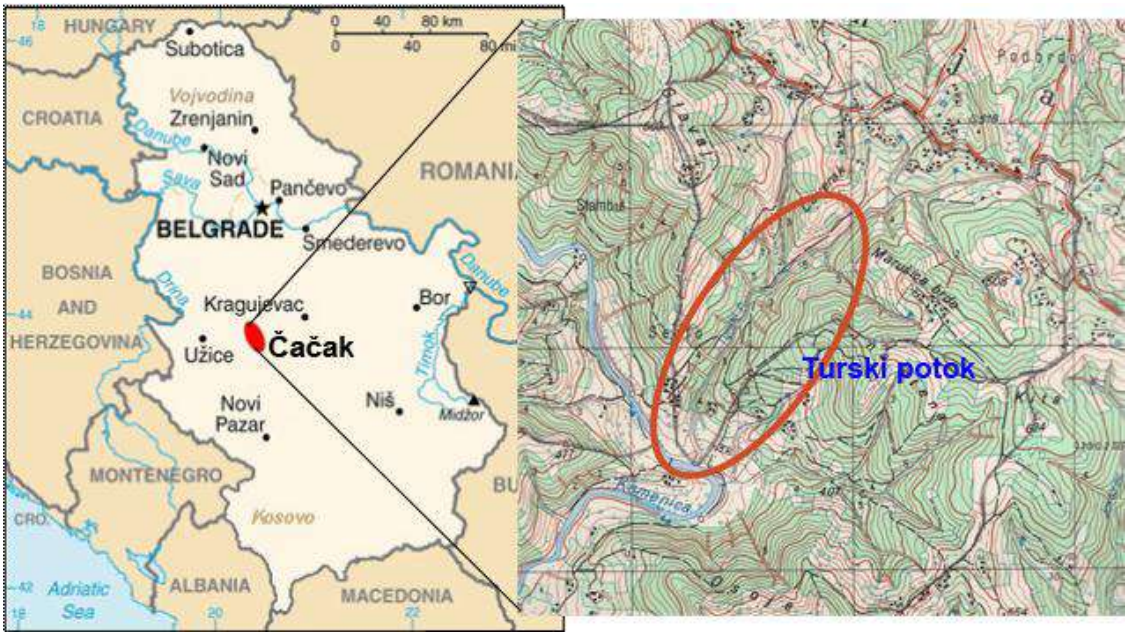

Figure 1 *The Turkish brook catchment*

Using the method of reconnaissance of the ground, the elements of the configuration of the basin were monitored and shown. This basic method is complemented by the use of topographic, geologic and soil maps of certain scales, allowing for defining the nature and impact of natural erosion agents in the studied basin. Using the method of rainfall interpolation by rain-gradient [6] and calculation of air temperature for any altitude [7], meteorological parameters were calculated for the basin. Quantitative indicators of soil erosion were calculated using the analytical method (Erosion Potential Method – EPM) [8], according to the equation (1):

$$G_{yr \times sp'^{1}} = T \times H_{yr} \times \pi \sqrt{Z^{3}} \times R_{u} \quad (1)$$

where: $G_{yr\ sp}^{-1}$ - specific annual total erosion-induced sediment yield reaching the confluence, $m^3\ yr^{-1}\ km^{-2}$; T - temperature coefficient of the catchment; H_{yr} - amount of rainfall, mm; π - 3.14; Z - coefficient of erosion; R_u - coefficient of retention of soil in the catchment.

The Erosion Potential Model (EPM), also known as Gavrilović method, is a widespread empirical model used for estimating sediment yield and soil erosion severity on catchment scale. The method considers six individual factors, depending on geology and soil properties, topographic features, climate, soil use and degree of erosion. It has been widely implemented in several countries (Serbia, Croatia, Slovenia, Italy etc), with Greece being one of them, providing reliable results [9].

RESULTS AND DISCUSSION

The basic elements of the basin, which are important for the occurrence of soil erosion, are size, length and its shape. The characteristics of the Turkish brook catchment: area (F) is 1.96 km^2, length (L) 1.87 km, circumference (C) 7.07 km. According to size, Turkish brook is classified as type I [10] as its bed branches mostly in the upper course. Soil and loose geological substrate are washed off this part of the catchment. The middle and lower course of such catchments have no tributaries and are hydrographically undeveloped.

The presented basic elements of Turkish brook catchment and the special features of its relief, the geological substrate, the distribution of soil, climate, and the soil use have contributed that the process of erosion of the basin has specific quantitative indicators.

The main parameters of the Turkish brook catchment relief, agents which have the primary responsibility for the occurrence of erosion, are shown in the Table 1.

Table 1 *The basic parameters of the Turkish brook catchment relief*

Catchment Name: The Turkish brook	
The lowest point of the main watercourse and catchment (B), m	359
The highest point of the main watercourse (C), m	465
The highest point of the catchment (E), m	603
Average slope of the main watercourse in the catchment (I_a), %	5.2
Mean catchment altitude (A_m), m	496.63
Mean catchment altitudinal difference (D), m	137.63
Mean catchment slope (I_m), %	26.1
Coefficient of catchment relief erosion energy (E_r), m $km^{-1/2}$	65.41

Table 1 presents the Turkish brook relief which plays a primary role in the occurrence of soil erosion. The mean altitude (A_m) of the Turkish brook is 496.63 m and the mean altitudinal difference (D) is 137.63 m. The mean slope (I_m) is 26.1%. Relief of a region can also be determined by the coefficient of relief erosion energy (E_r), the value thereof for the Turkish brook catchment being 65.41 m $km^{-1/2}$. An increase in relief parameter values results in increasing intensity of soil erosion in the catchment.

The following agents of erosion, geologic substrates, with their characteristics and diversity contributed to the emergence of the process of erosion in the Turkish brook catchment (Table 2).

Table 2 *Geological substrate of the Turkish brook catchment, coefficient of water permeability (S_1) and erosion resistance*

Catchment name: The Turkish brook	**km^2**	**%**
F_{ppr}- Poorly permeable rocks	1.96	100
• Serpentine	1.10	56.00
• Lake sediments of tertiary clay and loam	0.86	44.00
Coefficient of geological substrate water permeability (S_1)	1.00	
Resistance of geological substrate to erosion	Non-resistant	

The geological substrates of the Turkish brook catchment are: serpentine (1.10 km^2, i.e. 56.00%), lake sediments of tertiary clay and loam (0.86 km^2, i.e. 44.00%), characterized by properties that are poorly permeable rocks, which contributes to the nonresistance soil erosion process. Coefficient of geological substrate water permeability (S_1=1.00), indicates nonresistance of the Turkish brook catchment (Table 2).

The soil and their properties as an agent of erosion, to a lesser or greater extent, contributed to this process. In the area of the Turkish brook catchment, effects of pedogenetic factors are present as well as following soils: eroded vertisol and humus-silicate soils.

Eroded vertisol is profile type A_h–A_hC–C. Eroded vertisol belongs to the deep soil, in the Turkish brook catchment low level of process erosion is expressed. Group of shallow soil of the Turkish brook catchment belongs to humus-silicate soils, with the profile type of Ah-C. In this soil of the studied basin a strong degree process of erosion was represented [11].

The elements of climate which contribute to the occurrence of the process of soil erosion are rainfall, air temperature and soil temperature. The average annual rainfall (R) in the Turkish brook catchment is 751.1 mm, and the mean annual air temperature (t) is 9.3°C, which indicates thet these two elements of climate play an important role on soil erosion in study area.

Representation of the another factor of the process erosion, vegetation, both domestic as well as those of anthropogenic origin, and vegetation cover coefficient (S_2), are shown in Table 3.

The total area under forests and coppice of good spacing ($\sum F_f$) in the Turkish brook catchment is 0.79 km^2 (40.31%), the amount of grasses vegetation ($\sum F_g$) is 0.71 km^2 (36.22%), and the barren land ($\sum f_b$) is 0.46 km^2 (23.47%), so the study area is protected from the effects of erosion (coefficient of vegetative cover, S_2 = 0.77), Table 3.

Table 3 *The structure of the Turkish brook catchment according to type of land use and vegetative cover coefficient (S_2)*

	Type of land use	Surface area	
		km^2	%
$\sum F_f$	Forests and coppice of good spacing	0.79	40.31
F_g	Orchards	0.30	15.31
	Meadows	0.16	8.16
	Pastures and devastated forests and coppices	0.25	12.75
	$\sum f_g$	0.71	36.22
F_b	Arable land	0.46	23.47
	Infertile soil	0.00	0.00
$\sum f_b$		0.46	23.47
	Vegetation cover coefficient (S_2)	0.77	

In which scope the potential of Turkish brook catchment presents great destructive power and a factor of erosion, can be indicated by elements of hydrographic and hydrological characteristics of the study area. Characteristics of family of torrential flow (F_{tf}) of the Turkish brook catchment are: D; IV; Z=0.25 which means that Turkish brook as a dry valley and a smaller torrent is IV class with erosion coefficient (Z) of 0.25 (weak intensity of erosion processes, of the mixed type). Due to all these characteristic of the Turkish brook catchment a certain amount of sediment is produced and certain intensity of erosion is manifested. Size of process erosion of the the Turkish brook catchment is shown by mean annual erosion sediment (W_{year}=560.25 m^3 year^{-1}). Measured midterm total volume of sediment (G_{year}), which reachs the mouth of Turkish brook is 184.88 m^3 year^{-1}, and the total specific annual erosion sediment that reaches the mouth of the Kamenica ($G_{yr\ sp}^{-1}$), is 94.33 m^3 km^{-2} year^{-1}. These data indicate that from the Turkish brook areas disappear per year 0.28 ha of soil by the effect of erosion, the depth of 0.2 m, and 0.06 mm soil disappears from the basin area per year, i.e. 0.42 t ha^{-1} of soil. 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 [12].

CONCLUSION

Turkish brook a dry valley and a smaller torrent has its own specific features: IV class destructiveness, coefficient of erosion (Z) 0.25, which indicates the strength of weak erosion of the mixed type. The above, and other factors of erosion of the basin has contributed that annual erosion sediment was 184.88 m^3 year^{-1}, while the intensity of erosion was 94.33 m^3 km^{-2} year^{-1}.

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