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QUANTIFYING SOIL EROSION OF THE TOM'S BROOK CATCHMENT (WESTERN SERBIA)

Gordana Šekularac[1*], Miroljub Aksić[2], Tatjana Dimitrijević[3], Mihailo Ratknić[4], Nebojša Gudžić[2]

[1]University of Kragujevac, Faculty of Agronomy, Cara Dušana 34, 32000 Čačak, SERBIA

[2]University of Priština, Kosovska Mitrovica, Faculty of Agriculture, Kopaonička nn, 38219 Lešak, SERBIA

[3]Institute of Forestry, Kneza Višeslava 3, 11000 Belgrade, SERBIA

[4]Earth Climate Change Team (ECC Team), New Jersey, USA

[*]*gordasek@kg.ac.rs*

Abstract

Soil erosion is one of the highly significant forms of the soil degradation in Serbia. In this sense, this paper may help consider better the erosion process exhibited to a greater or lesser extent on all the soil types with a slope more than 1%, which denotes to the necessity of taking anti-erosion measures towards protecting the soil as a nonrenewable natural resource. Due to a range of natural factors and human impact on the erosion process in the part of the Western Serbia as well as based on the overall condition of the torrent catchment Tom's Brook, the soil loss due to erosion could be predicted through Erosion Potential Model (EPM). As regards the torrential flow type, Tom's Brook is a landslide (E), with annual mean amount of erosion drift (W_{year}) from 539.11 m^3 $year^{-1}$. The specific annual amount of total erosion deposit ($G_{year\ sp}{}^{-1}$) reaching the confluence point of Tom's Brook from the right-hand side into the river Tinja (the left tributary of the river Kamenica within the Western Morava basin in the Western Serbia) amounted to 120.92 m^3 km^{-2} $year^{-1}$.

Keywords: soil losses to erosion, catchment, erosion factors, erosion potential method (EPM).

INTRODUCTION

The water soil erosion of various intensity conditioned by natural and antropogenous factors, is widespread in the whole world. Global climatic changes have shown that both, the time and the amount of precipitations have become lasting and disturbed, which means that even the coventional foresting technologies use will prove to be additionally ineffective [1]. Thus, soil erosion imposes a huge problem worldwide affecting the soil productivity, causing nutritional matters loss from the soil, mudding within the catchment and water quality deterioration [2].

Compared to geomorphological and climatic characteristics of the territory of Serbia, the most widespread is pluvial erosion accounting for 86% of the entire area, of which 90% accounts for the eroded soil of Central Serbia [3].

Understanding the soil erosion driving forces may detect the areas prone to erosion within the landscape, help soil management and other strategies to be used for efficient problem handling, with the most commonly used soil erosion model being the Universal Soil Loss Equation (USLE) as well as its modelfamily [2]. Accordingly, we believe that it would be important to have knowledge based on the multiple soil erosion models, rather than rely only on the USLE–type ones. Hence, the Erosion Potential Model (EPM) accounting for other erosion processes (e.g. gully erosion or soil slumps) and not just for sheet and rill ones (e.g., USLE–type models) can be an interesting option to estimate the global and large-scale soil erosion rates especially because these processes can be important for the large-scale erosion-sediment balance [4].

Protective measures modes against water soil erosion can be a significant mission, not only for the environmental conservation, but also for agricultural production capacities as a fundamental food source. The basic prerequisite for putting the protective measures to use is to study thoroughly and define accurately the catchment characteristics, being the goal of this paper.

The extent to which the water erosion process is expressed due to different agents, and the amount of the sediment produced due to erosion under the natural conditions of the Kamenica catchment resource (the part of the Western Morava's river basin), on the part of its left side tributary (Tinja), is presented for the catchment of Tom's Brook, flowing into Tinja from its right side.

MATERIALS AND METHODS

A group of methods, in the first place, a terrain analysis of the Tom's Brook entire catchment elements configuration, was utilized. The brook's natural characters were investigated using the mapping analysis records (hydrology, relief, geological substrate and soil). The maps scales were, as follows: topographic (1:25,000) (Figure 1) [5], geological (1:500,000) [6] and pedological map (1:50,000) [7]. Interpolation was used to determine how natural agents, climatic elements, rainfalls and air temperatures [8] affected erosion [9,10]. In addition, the erosion classification modules, according to which, the torrent classification was also made, were utilized, whereas the mean annual sediment amounts reaching the confluence point of Tom's Brook into the Tinja were calculated through the erosion potential module (EPM) [11].

RESULTS AND DISCUSSION

Within the Kamenica torrent land catchment, on the slopes of the Mountain Maljen's southern part, Tom's Brook, springing in the Great Field (718 m of altitude), flows into the Tinja from the right side (the left tributary of the first order of the river Kamenica), into its middle part, being of a mildly winding course, with a narrow valley near the village Kneževići (624 m of the altitude; 44°3'39" N; 20°6'8" E), the settlements of Bogdanica, Gornji Milanovac, Moravički District (Figure1).

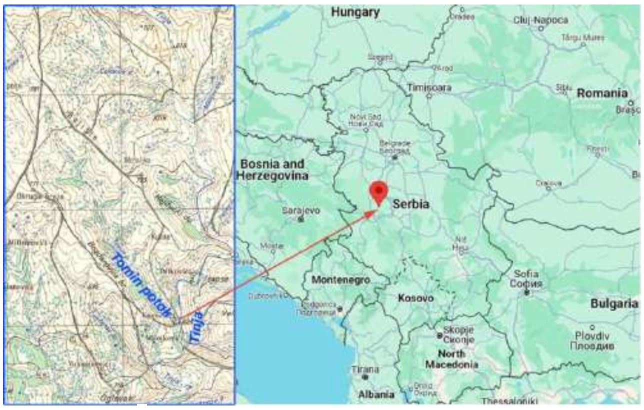

Figure 1 *Tom's Brook catchment (mouth in the river Tinja)*

The Tom's brook basin area amounts to 1.07 km^2, extent 5.50 km, length 2.12 km. The possibility of a sudden concentration of flood water reaching from the entire area depends on the basin's shape, which affects the development of the accelerated process of soil erosion in the basin, and the total amount of runoff water on the basin`s size. By their shape, the basins may be categorized into four types [12]. By its surficial shape, the Tom's brook catchment belongs to the type four (IV). This basin's shape is featured by a uniformly bifurcated hydrographic network through the upper, middle and lower course, meaning that the soil and geological substrate material are also uniformly taken away from the entire basin.

Drift production from the Tom's Brook shares the entire annual substrate magnitude, both of the Tinja and the Kamenica. Thus, the whole substrate production of the Tom's Brook basin depends on the soil erosion natural factors and on the human influence if any. The extent to which the erosion natural factors exhibit their impact is conditioned by the basic catchment relief parameters, areal geological substrate, soil features, climate, and none the less by land cultures in which the humans play an essential part.

The relief parameters of the Tom's Brook are shown in the Table 1.

Table 1 *The basic parameters of the Tom's Brook catchment relief*

Catchment Name: The Tom's Brook	
The lowest point of the main watercourse and catchment (B), m	624
The highest point of the main watercourse (C), m	766
The highest point of the catchment (E), m	781
Average slope of the main watercourse in the catchment (I_a), %	6.0
Mean catchment altitude (A_m), m	725.41
Mean catchment altitudinal difference (D), m	101.41
Mean catchment slope (I_m), %	17.9
Coefficient of catchment relief erosion energy (E_r), m km$^{-1/2}$	49.22

The lowest point of the Tom's Brook (the confluence point into the Tinja) is at 624 m of altitude and the highest at 766 m of the altitude. The highest point of the Tom's Brook catchment is 781 m. The average riverbed slope of the major basin amounts to 6.0%. The mean basin's altitude (A_m) amounts to 725.41 m with the mean catchment height difference (D) being 101.41 m. The Tom's Brook basin was found to have the mean slope (I_m=17.9%).

The already mentioned values along with the relief parameters magnitudes were found to contribute to the relief erosion energy coefficient (E_r) being 49.22 m $km^{-1/2}$ (Table 1).

The presence of a particular geological substrate is denoted by the soils of the areas formed on that substrate. Thus, the soils were formed within the Tom's Brook catchment basin on a serpentine of a poor water permeability spread on 1.07 km^2, Table 2. Water permeability coefficient (S_1) for the basin underway amounts to 1.00, due to which he humus silicate soil is present in the basin, with the profile of A_h–C type and prone to erosion (Table 2).

The climatic elements are considered to be a significant factor imparting the soil erosion, with water runoff leading to it. The sum of the mean annual precipitations (P) of the Tom's Brook basin amounts to 804.3 mm and the mean annual air temperature of the area underway to 8.0°C.

Table 2 *Geological substrate of the Tom's Brook catchment, coefficient of water permeability (S_1) and erosion resistance*

Catchment name: The Tom's Brook	**km²**	**%**
F_{ppr} – Poorly permeable rocks	1.07	100
• Serpentine	1.07	100
Coefficient of geological substrate water permeability (S_1)	1.00	
Resistance of geological substrate to erosion	Non-resistant	

The vegetation canopy coefficient (S_2) depends on the presence of land cultures on the soil of the area considered. Through calculation, the canopy coefficient (S_2) of the Tom's Brook catchment was found to amount to 0.80, which means that there are more bare earth grasses, i.e. pastures and devastated forests and bushes (84.11%), further the forests and bushes of a good pattern (6.54%), and meadows (3.74%), orchards (0.94%) with barren land with 4.67% (Table 3). Overall, this shows that the area of Tom's Brook basin is protected from the soil erosion from the aspect of land cultures.

Table 3 *The structure of the Tom's Brook catchment according to type of land use and vegetative cover coefficient (S_2)*

Type of land use		**Surface area**	
		km²	**%**
$\sum F_f$	Forests and coppice of good spacing	0.07	6.54
F_g	Orchards	0.01	0.94
	Meadows	0.04	3.74
	Pastures and devastated forests and coppices	0.90	84.11
$\sum f_g$		0.95	88.79
F_b	Arable land	0.00	0.00
	Infertile soil	0.05	4.67
$\sum f_b$		0.05	4.67
Vegetation cover coefficient (S_2)		0.80	

The soil erosion coefficient value of the basin surveyed, pointed to the type of the prevalent erosion related to the particular erosion strength, i.e. to its destructiveness category.

The erosion coefficient (Z) of the Tom's Brook basin amounted to 0.35, inhering to the fourth (IV) destructiveness category, being of a poor strength and of a deep type of erosion process.

The established index of the hydrographic class (H_c) of the torrential flows, can further determine their types against the classes. Tom's Brook pertains to the class E, i.e. to the landslide flows.

So featured factors of the Tom's Brook, gave rise to the particular sediment amounts produced along with the particular erosion intensity exhibited.

The erosion magnitude of the Tom's Brook catchment, is shown through the mean annual amount (produced) of the erosion process (W_{year}) of 539.11 m^3 $year^{-1}$.

The calculated mean annual volume of the total sediment (G_{year}), reaching the mouth of the Tom's Brook into the river Tinja, amounted to 129.38 m^3 $year^{-1}$, with the specific annual amount of the entire erosion sediment reaching the mouth into the Tinja ($G_{year\ sp}{}^{-1}$), quantitatively expressed erosion intensity, amounting to 120.92 m^3 km^{-2} $year^{-1}$.

Therefore, the given data clearly show that Tom's Brook catchment erosion caused 0.27 ha land area the power of up to 0.20 m to disappear annually, and the average catchment soil to disappear by 0.05 mm, annually, too.

Given that the mean volume mass value is 1.5 g cm^{-3}, 0.40 t ha^{-1} of the soil is lost annually. Although any soil loss of more than 1t ha^{-1} yr^{-1} can be considered to cause irreversible damages within the time span of 50–100 years, it is commonly accepted that agricultural soil can tolerate a certain amount of erosion, which typically ranges from 1 t ha^{-1} yr^{-1} on shallow sandy soils to 5 t ha^{-1} yr^{-1} on deeper soils [13].

CONCLUSION

Based on the natural features of the Tom's Brook catchment, it may be inferred that the fundamental relief parameters are expressed, further, that geological substrate (serpentine) nonresistant to erosion, humus silicate soil prone to erosion favoured by the basic climatic elements (annual precipitation sums) and the mean air temperature, are exhibited, as well as the soil saturation by the existing vegetation. Therefore, such analysis suggests that the landslide Tom's Brook be featured as follows: IV class of destructiveness, with the erosion coefficient (Z) of 0.35, being of poor strength, deep type of erosion process. These and other factors of the basin erosion studied, contributed to the mean annual erosion sediment to amount to 129.38 m^3 $year^{-1}$, and erosion intensity to 120.92 m^3 km^{-2} $year^{-1}$.

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