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GULLY AND RILL EROSION IN THE NATIONAL PARK „CENTRAL BALKAN"

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Abstract

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Soil erosion is a widespread soil degradation process and a widely recognized problem. In recent decades, increased use of motor vehicles for hiking in the high mountains has contributed particularly for accelerated anthropogenic gully erosion The article presents results for the soil losses, caused by gully and rill erosion as a result of the traffic of vehicles. The obtained data are from two-year and three-year field measurements of gullies and rills in the pilot sites of National park "Central Balkan". The measurements were carried out at the beginning of the summer after snowmelt and at the end of autumn before the first snowfall. The coefficient of the annual increase of the gully volume is 1.121, of the right rill it is 3.118 and of the left rill it is 1.367. These data reveal the intensive development of erosion in the rills and their rapid transition to gullies. The results obtained can be used for evaluation of the contemporary soil erosion degradation and selection of soil protection practices for the purpose of sustainable management of the Park.

Key words: water erosion, soil loss, assessment

Introduction

Protecting the soil from the most disruptive degradation process, which is water erosion is part of the global ecological problem of conservation, recovery and sustainable management of environment. In its two basic forms of appearance – sheet and gully water erosion appears to be a multi-factor process, linked to the appearance of accidental erosion processes. The most worldwide-spread models of assessment and prediction of the factors and risks of sheet water and wind erosion of soil for the territory of the country of an altitude not more than 1200 m have been developed and introduced in Bulgaria (Rousseva et al., 2010a; Rousseva et al., 2010b, Rousseva et al., 2016).

With the separation of regions of substantial area into National parks and creation of prerequisites for intensive development of tourism, conditions appeared in Bulgaria for, on one hand, optimal ecologically friendly management and development, and on the other, for anthropogenic intervention into the more and more accessible and potentially most threatened by appearance of rill water erosion high mountainous terrains. The territory of National Park "Central Balkan" appears to be of the above type and it occupies a large part of the most important mountain in the country – the Balkan Chain System. The park was created in 1991 and it is among the largest European national parks. It preserves unique nature, characterized by exclusive biological variety of rare and threatened with extinction species, the existence of which is inevitably linked to the conservation of soil 2 resources (Karatoteva, 2016; Karatoteva et al., 2016; Malinova, 2016; Malinova et al., 2016). The park covers 23% of the national territory, it spreads over an area of 71 826. 27 ha and includes 9 reserves of a total area of 20 000 ha.

The development of gully and rill water erosion is related to a lot of factors – relief, climate, soil-geological conditions, plant cover and economic activity of man. The relationship

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between them and the development of erosion were studied by a large number of authors in Bulgaria (Dzhodzhov et al., 2003; Zakov, 1990, 1993; Lazarov et al., 1983; Malinov et al., 1998; Malinov et al., 2003; Marinov, 2009; Tepeliev et al., 1986) and abroad (Ivonin, 1989; Benediktsson et al., 1990; Casali et al., 2006; Govers, 1991; Graham, 1992; Poesen et al., 2002; Srinivasan and Richards, 1990; Story and Congalton, 1986;1992; Poesen et al., 2002; Srinivasan and Richards, 1990; Story and Congalton, 1986; Zeheng et al., 2002).

The aim of the research is determining the intensity and dynamics of development of gully and rill erosion of soil in the pilot sites of the treeless area of the National Park "Central Balkan".

Materials and Methods

An object of research are gully erosion forms – gullies and rills from the treeless area of the National Park "Central Balkan". Two pilot sites have been selected for the aims of assessment of the active contemporary anthropogenic gully water erosion:

A) Pilot site "Bratanitsa – Bolovanya" of an altitude of 1600-1650 m, located in the area of Mount Vezhen. Modern anthropogenic gully erosion occurs in 5 basic gullies, situated in the shape of a unilateral herringbone. Erosion is determined from data of fixed cross sections (Figure 1) of a representative functioning gully (selected from a system of uniform functioning gullies). The measurements were performed at the end of spring, after the final melting of snow and in autumn, before the beginning of snowfall in the high parts of the mountain .

B) Pilot site "Pirovi Livadi" of an altitude of 1800-1850 m, located in the area of Mount Botev. Modern anthropogenic gully erosion occurs as a number of erosion rills, caused by tracks of motor vehicles, using direct routes bypassing the main road to Mount Botev. Rill erosion is defined by using data from fixed cross sections of a couple of representative former transport tracks (Figure 2).

Fig. 1. General view of gullies

Fig. 2. General view of rills

The amount of eroded soil is calculated for every segment of erosion form through its cross sections and the distance between them – like the volume of a truncated pyramid.:

$$V = \sum_{i=1}^{n} Vi = \sum_{i=1}^{n} L * (S_{i=1} + S_{i+1} + (S_{i=1} * S_{i+1})\hat{}0.5)/3 \qquad (1)$$

where : V – volume of the measured section of the erosion form (m^3); i to n – serial number of the segment; Vi – volume of the segment – i (m^3); $S_{i=1}$ – area of the cross section of the bottom part of the segment i (m^2); S_{i+1} – area of the cross section of the top part of the segment i (m^2); L – length of the segment i (m).

Portable equipment (Figure 3) was used for defining the characteristics of the cross section of the erosion rills. The

Fig. 3. Micro-topographic profiler for measuring cross sections of rills and small gullies

data for every cross section were filmed by a digital camcorder and the cross sections were subsequently assessed and analyzed.

Results and Discussion

The data from the measurements are presented in Table 1. It displays the seasonal and annual dynamics of the growth of the gully from the three measurements in the period of October 2012 – October 2013. The data make it evident that:

– The co-efficient of erosion of the gully (i. e. the growth of the gully per annum) is 1.123;

– the amount of eroded soil in the period of measurement is 5.134 m^3;

– the erosion of the gully in spring is 1.024 m^3, which is approximately 4 times less than its growth in summer and autumn;

– the co-efficient of erosion of the gully is not high in absolute value, but having in mind the dimensions of the gully (length of 30 m), in this case it shows a substantial annual amount of eroded soil – 5.123 m^3.

Table 1

Volumes of the gully in separate sections and periods of measurement in the "Bratanitsa – Bolovanya" area

№ of segment	Date of measurement		
	10. 2012	07. 2013	10. 2013
	Volumes (m^3)		
1	0.71	0.785	1.229
2	3.219	3.325	4.410
3	6.916	6.394	8.422
4	10.084	8.215	11.951
5	20.714	23.937	20.765
Volume of the gully (m^3)	41.644	42.656	46.777
Co-efficient of growth	1.000	1.024	1.123
Growth in winter and spring (m^3)	1.012		
Growth in summer and autumn (m^3)	4.121		
Annual growth (m^3)	5.134		

Rill erosion is defined from data of fixed cross sections of two representative active rills. The data from the measurements are presented in Table 2 and Figure 4. They display the seasonal and annual dynamics of rill growth in the three measurements for the period October 2012 – October 2013. They make it evident that:

– the co-efficient of erosion (a two-year growth) is 3.188 for the right rill and 1.367 for the left one.;

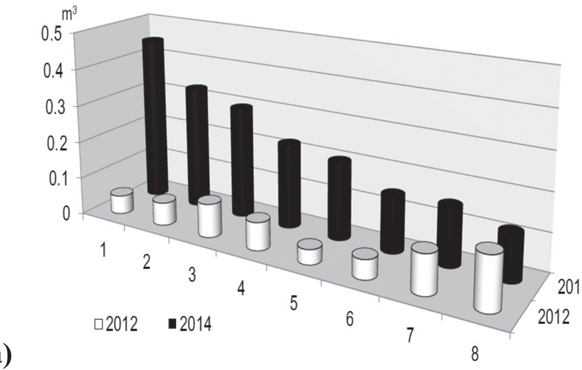
– the amount of eroded soil for the period of measurement of October 2012 –October 2014 is 1.32 m^3 for the right rill and 0.373 m^3 for the left one.

– the results for the volumes of the separate cross sections of rills display that the process of erosion runs parallel and with deposition of eroded soil, but as a whole the amounts of erosion exceed those of deposition. A high intensity of erosion processes is observed, i.e. fast development of the rill and its transition to the form of a small gully.

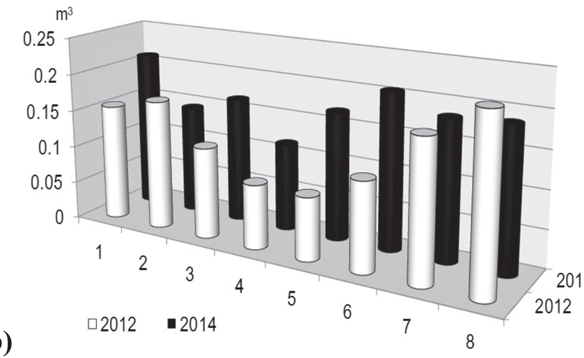
Table 2

Volumes of the rills in the "Pirovi livadi" area, a) b)

Erosion rills	10. 2012	10. 2014
Right rill		
Volume of the rill (m^3)	0.603	1.9225
Co-efficient of growth	1	3.188
Growth of the rill (m^3)	-	1.32
Annual growth (m^3)	-	0.66
Left rill		
Volume of the rill (m^3)	1.017	1.39
Co-efficient of growth	1	1.367
Growth of the rill (m^3)	-	0.373
Annual growth (m^3)	-	0.187



a)



b)

Fig. 4. Volumes of the right (a) and the left (b) rills in the separated segments in initial and final periods of measurement (m^3)

Conclusions

The process of gully erosion of a particular slope proceeds identically. During the summer-autumn period as compared to the spring, there are more intensive erosion processes, which lead to larger amounts of eroded soil – erosion co-efficient of 4.121 in comparison to a spring erosion co-efficient of 1.012. The annual co-efficient of gullies is insignificant in absolute value, but the amount of eroded soil is substantial due to its large dimensions. Rill formation in motor vehicle tracks is simultaneous to processes of erosion and deposition with substantial prevalence of erosion. The annual growth of the volume of rills display intensive development (mostly from immersion through multiple thresholds) and their transition from rills to the form of small gullies.

For the first time in the country experimental research was performed for assessment of modern gully water erosion of soil, influenced by the impact of traffic of vehicles in the National Park "Central Balkan". The data of the intensity of gully erosion could be used for the prediction of soil erosion loss and the optimization of measures for soil protection from erosion in similar conditions.

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