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Morphometric analysis of debris-flow catchments in Middle Struma Valley (Zheleznitsa Gorge, Bulgaria)

Морфометричен анализ на селеви потоци в долината на Средна Струма (Железнишки пролом, България)

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Introduction

Debris flows are very common phenomenon in the valley of the Middle Struma River. Several streams and rivers, left and right tributaries of the Struma River were recognized and characterized as debris flows causing often floods and damages of the infrastructure (Kenderova, Vasilev, 1997; Kenderova et al., 2013; Baltakova et al., 2018; Nikolova et al., 2018). The main factors that control these processes are climate conditions (dry and warm period and extreme rainfall), tectonics, lithology, topography and vegetation cover. In previous researches geological and geomorphological features have been mainly considered as a consequence of different events (Bruchev et al., 2001; Dobrev, Georgieva, 2010; Kenderova et al., 2013). Other studies have linked climate, synoptic situation and debris flows (Kenderova, Vasilev, 1997; Kenderova et al., 2013, Nikolova et al., 2018).

The aim of this study is to analyze selected morphometric properties of two debris-flow catchments in the area of Zheleznitsa Gorge and to identify the relationship between the specific topography and the processes of debris flow. To evaluate the susceptibility of these processes, the following morphometric parameters were considered: area and shape of the catchment, slopes, local elevation range (LER), drainage network length, drainage density, stream frequency, etc.

Study area and methods

The study catchments are located in the Zheleznitsa Gorge, part of the valley of the Middle Struma River, Southwest Bulgaria (Fig. 1). The two streams (named Stream 1 and Stream 2) are adjacent to each other and are left tributaries of the Struma River. Both basin have SW direction which follows the main slope orientation of this part of the Rila Mountains. Stream 1(St1) has an area of 8.33 km² and Stream 2 (St2) – 7.56 km². The source of the two

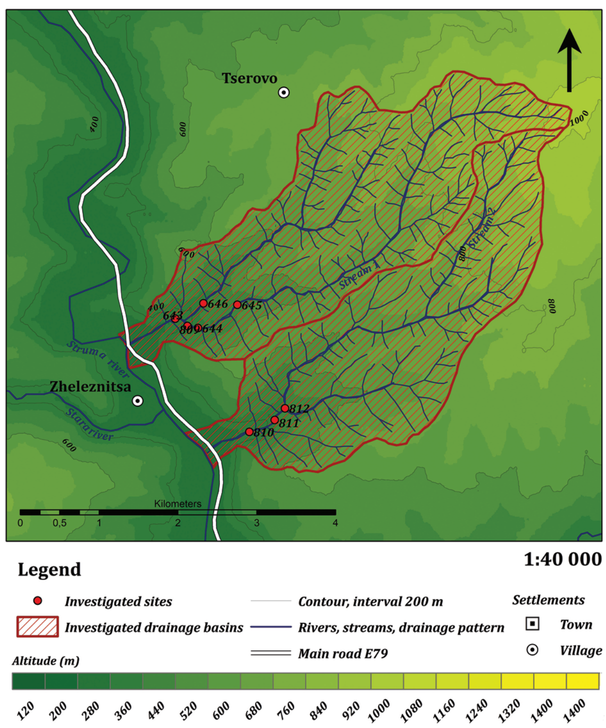

Fig. 1. Map of the study area

Table. 1. Morphometric parameters of the catchments of the Stream 1 and Stream 2

Morphometric properties	Stream 1	Stream 2
Catchment area (km²)	8.33	7.56
Source of the river (m asl)	1028	1017
River outflow (m asl)	308	302
Mean altitude of the basin (m)	703	690
Mean local elevation range of the basin (m/km²)	196	185
Mean slope inclination of basin	14°	13°
Length of the basin (km)	6.33	6.07
Maximum width of the basin (km)	2.35	1.93
Length of the river long profile (km)	7.23	6.75
Types of drainage pattern	dendritic, parallel	dendritic, parallel
Drainage network length (km)	49.4	40.25
1st order (km)	31.23	24.4
2nd order (km)	6.34	7.93
3rd order (km)	4.35	4.26
4th order (km)	6.62	3.66
5th order (km)	0.85	-
Total count of the tributaries	162	115
Count of 1st order tributaries	130	93
Count of 2nd order tributaries	24	17
Count of 3rd order tributaries	5	4
Count of 4th order tributaries	2	1
Count of 5th order tributaries	1	-
Mean length of the 1st order tributaries (km)	0.24	0.26
Mean length of the 2nd order tributaries (km)	0.26	0.46
Mean length of the 3rd order tributaries (km)	0.87	1.06
Mean length of the 4th order tributaries (km)	3.31	3.66
Mean length of the 5th order tributaries (km)	0.85	-
Drainage density (km/km²)	5.93	5.32
Stream frequency (count/km²)	19.44	15.21

streams starts from the same location about 1020 m asl and flow into the Sruma River at about 305 m.

In order to calculate and analyze the morphometric parameters of the two catchments 30 meters STRM digital elevation model (DEM) [USGS, NASA] was used which was converted into 10 m in ArcGIS environment. The drainage network was digitized from topographic maps at M 1:50 000 and 1:25 000 scales. Then all the calculations were performed in GIS environment.

Results and discussion

The morphometric data show that the basins of the two streams have approximately the same parameters (Table 1). Most of the catchments area are developed in height between 600 m and 900 m (about 73%). The slopes at this height are gentler and vary between 5° and 20°. Also the LER is lower than the average for the territory of the two basins and it is below 150 m/km². The drainage network at this height is well developed and in some places the density exceeds 6–6.5 km/km², much more than the average. The cross sections of the main tributary (3rd an 4th order) show that in the higher part of the basins the stream bed is much wider than in the lower part and the slopes are much more gentle.

The lowest parts of the catchments, between 300 m and 600 m, are only 20% of the territory of the basins but morphometric analysis shows some differences. Here, the slopes are very steep exceeding 35–40°, and LER is between 250 m/km² and 350 m/km². In some places, at a height of about 400–420 m the bed of the main tributary is very narrow and the distances between the slopes do not exceed 10 m. A possible explanation is that at this point the basins are crossed by a fault with direction NNW-SSE (Marinova, Zagorčev, 1990). This is a precondition for the occurrence of streams with high energy and velocity. The main debris flow processes occur after that point where the main tributary inflows at about 380 m and the river channel exceeds 5th order for St1 and 4th order for the St2.

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