3rd International Conference - Water resources and wetlands. 8-10 September, 2014 Tulcea (Romania);
Available online at http://www.limnology.ro/wrw2016/proceedings.html
Editors: Petre Gâștescu, Petre Bretcan; ISSN: 2285-7923; Pages:153-157; Open access under CC BY-NC-ND license

FLOOD OCCURRENCE EVALUATION BASED ON THE HEIGHTS OF WATER LEVEL IN THE RIVERS

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ABSTRACT
Flood situation have a long history on the territory of the Slovak Republic. Danger of the treat of the flood was underestimated until the mid-90s of the 20th century. Currently, there is a significantly negative impact on the landscape and inhabitants caused by floods, so it is necessary to focus primarily on preventive measures to protect against flooding. The most problematic area in Slovakia is the eastern part of country. The reason is the flysch bedrock and frequent forests cut downs, which means reduced storage capability area. The aim of paper is analysis of flood events in eastern Slovakia and evaluation of flood grades in relation to the height of water levels in selected river stations in Bodrog watershed. The significance of adverse effects is evaluated based on the flood grades (Ist or IInd or IIIrd) occurrences. The result of evaluation in the Bodrog watershed is determination of consequences – flood duration in river stations.

Keywords: floods, flood grades, flood duration

1 INTRODUCTION

In recent years, the growth of population and diffusion of settlements over flood vulnerable areas have increased the impact of the floods worldwide. The increase in damage due to natural disasters is directly related to the number of people who live and work in hazardous areas and who continuously accumulate assets (Zeleňáková 2011; Hanák 2014).

The Slovak Republic have a long history of flood situations. In the mid-90s of the 20th century was looming threat underestimated. Currently there is a significant negative impact on the landscape and life of its inhabitants caused by floods, so it is necessary to focus primarily on preventive measures to protect against flooding. Flood damages that arose on watercourses and hydraulic structures on the territory of the Slovak Republic have been huge. The most affected is eastern part of Slovakia, where the most complex situation is in Laborec, Topľa, Ondava, Torysa, Latorica and Hornád river basins in the recent years. The reason is the flysch bedrock and frequent cutting of forests, which means reduced storage capability of the territory.

The paper focuses on the heights of water levels in rivers during floods. The main objective of this work is to evaluate the heights of water levels in selected river stations in the eastern Slovakia. Flood risk is assessed based on the frequency and level of flood grade.

2 METHODS

The heights of water levels in rivers (hydrometric stations) in Slovakia are recorded by Slovak Hydrometeorological Institute (SHMI). They are measured at hourly intervals using automated stream gauge device (device registering the height of water level in the stream in time), or once a day by gauging slats (Figure 1).

Selection of hydrometric station is influenced by the choice of the location where the flow is symmetrical, smooth slope and regular river profile. Area must be free of boulders, vegetation and other obstacles, and no backwater. The station must be accessible for repeated measurements.

According to the report of SHMI in 2014 there were 419 hydrometric stations with monitored height of water level. Spatial distribution of gauging stations in the various sub-basins of the Slovak Republic is shown in Figure 2.

Heights of water levels are influenced by a particular season. Especially by the melting of snow, storms with torrential rains, or dry periods.

Figure 1. Hydrometric station and automated stream gauge device (SHMI)

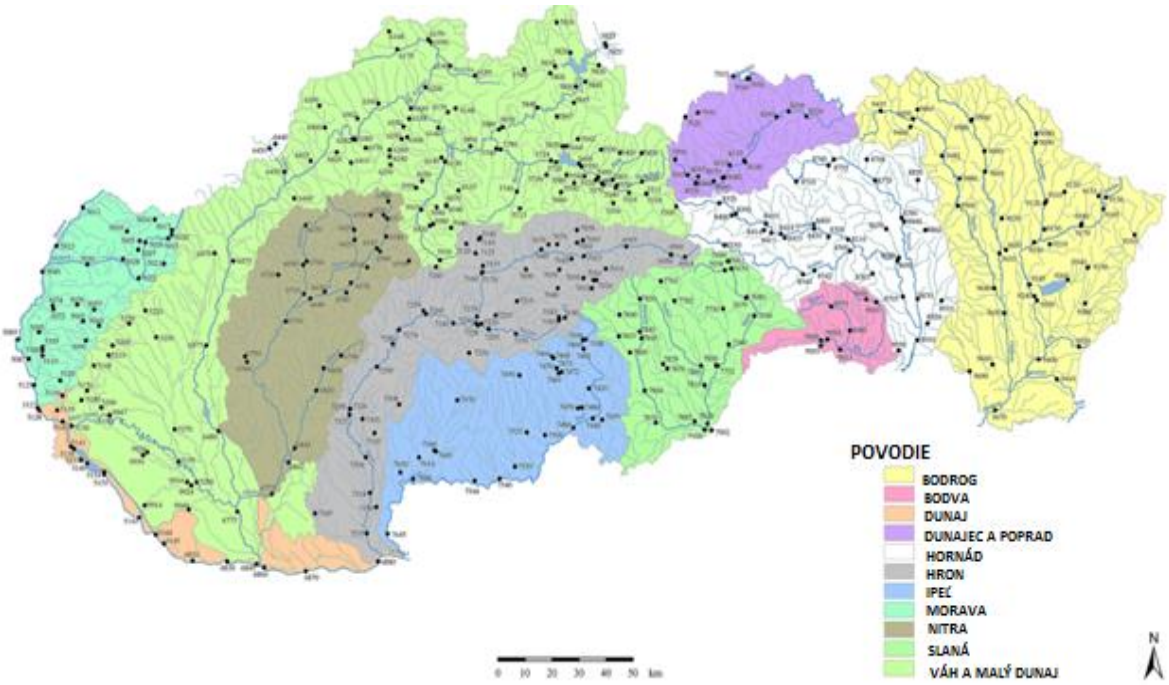

Figure 2. Hydrometric stations in Slovakia in 2014 (SHMI, 2014)

2.1 Study area

Study area is the Bodrog river basin, which is located in eastern Slovakia. The most important river is Bodrog, which is formed by the confluence of river Ondava and river Latorica. Major tributaries of Ondava and Latorica are the rivers Uh, Laborec and Topľa. The area of the catchment has a fan-shape. Bodrog basin area is 7,272 km^2 (MoE SR) and is illustrated in Figure 2 in yellow colour.

Figure 3 shows the evaluated hydrometric stations at Bodrog river basin.

Calculation of flood risk is based on recorded observations of the heights of water levels in the period 1996 - 2014 at the hydrometric stations: Snina, Ižkovce, Michalovce, Humenné, Krásny Brod, Veľké Kapušany, Čop, Mukačevo, Horovce, Stropkov, Svidník, Hanušovce, Bardejov, Lekárovce, Žornava, Užgorod. Data were provided by the Slovak Water Management Enterprise, s.c. (SWME).

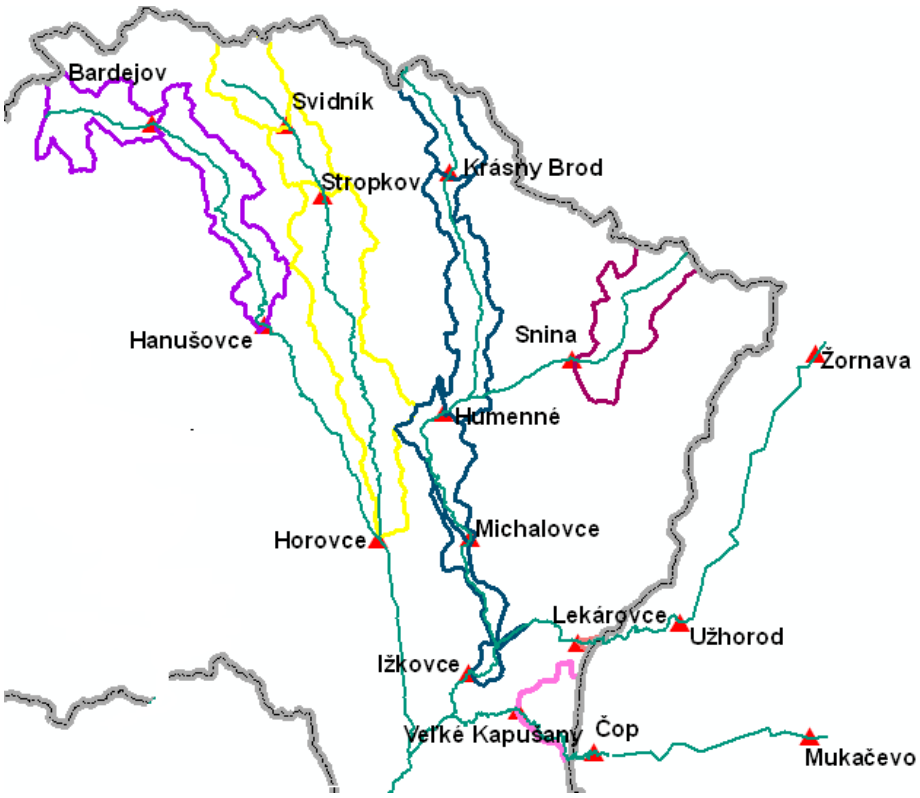

Figure 3. Hydrometric stations with sub-basins in Bodrog river basin

3 RESULTS

Flood risk relates to the likelihood of flooding and the consequences of floods. Relationship that is calculated flood risks is as follows (1):

$$R = P \times C \quad (1)$$

where: R - flood risk, P - the probability of flooding, C - a consequence of floods.
Table 1 shows the hydrometric stations and the height of water levels for different levels of flood grade.

Table 1. Flood grades in different river stations

River	Hydrometric station	Ist Flood Grade Height of water level (cm)	IInd Flood Grade Height of water level (cm)	IIIrd Flood Grade Height of water level (cm)
Cirocha	Snina	200	250	300
Laborec	Ižkovce	700	750	800
	Michalovce	500	600	700
	Humenné	250	300	400
	Krásny Brod	150	200	230
Latorica	Veľké Kapušany	500	600	750
	Čop	400	470	600
	Mukačevo	450	520	570
Ondava	Horovce	400	500	600
	Stropkov	220	250	280
	Svidník	200	250	300
Topľa	Hanušovce	150	200	250
	Bardejov	250	300	350
Uh	Lekárovce	600	700	800
	Žornava	100	130	150
	Užhorod	70	110	150

A result of the risk of flooding is calculated from the number of days that have exceeded particular height of water level in the river; it means the flood occurred. *C*1 expresses number of days when the first flood grade was occurred, *C*2 expresses number of days when the second flood grade was occurred and *C*3 expresses number of days when the third flood grade was occurred. Rated hydrometric stations are listed in Table 2. The average number of flood days during evaluated period from 1996 – 2014 (19 years) is presented in the last column and was calculated according to equation (2):

$$C = (C1 + \mathrm{D}\ C2 + C3) / 19 \qquad (2)$$

Table 2. Number of flood grades (days with flood)

River	Hydrometric station	*C*1	*C*2	*C*3	Average
Cirocha	Snina	0	0	1	**0,05**
Laborec	Ižkovce	22	27	4	**2,8**
	Michalovce	12	1	0	**0,7**
	Humenné	14	9	1	**1,3**
	Krásny Brod	8	0	1	**0,5**
Latorica	Veľké Kapušany	711	453	50	**63,9**
	Čop	458	654	404	**79,8**
	Mukačevo	1	2	0	**0,2**
Ondava	Horovce	11	10	6	**1,4**
	Stropkov	12	16	6	**1,8**
	Svidník	2	3	0	**0,3**
Topľa	Hanušovce	24	16	4	**2,3**
	Bardejov	14	3	2	**1**
Uh	Lekárovce	19	16	9	**2,3**
	Žornava	19	2	7	**1,5**
	Užhorod	15	2	4	**1,1**

From Table 2 and Figure 4 it is clear that the most problematic are hydrometric stations situated at the river Latorica, where every year the floods are occurring.

Figure 4 presents the number of flood degree occurrence (in days) for each month during evaluated period (1996 – 2014) in hydrometric station Veľké Kapušany situated at river Latorica. The first flood degree (when the height of water level exceeds 500 cm) is shown in green colour; the second flood degree (when the height of water level exceeds 600 cm in the river) is shown in yellow colour; the third flood degree (when the height of water level exceeds 750 cm) is shown in red colour.

We can express flood risk on the basis of flood occurrence and consequently identify areas at risk of flooding. Appropriate measures against recurrent floods are water stream regulations and constructions of dry basin that follows "green" flood mitigation measures.

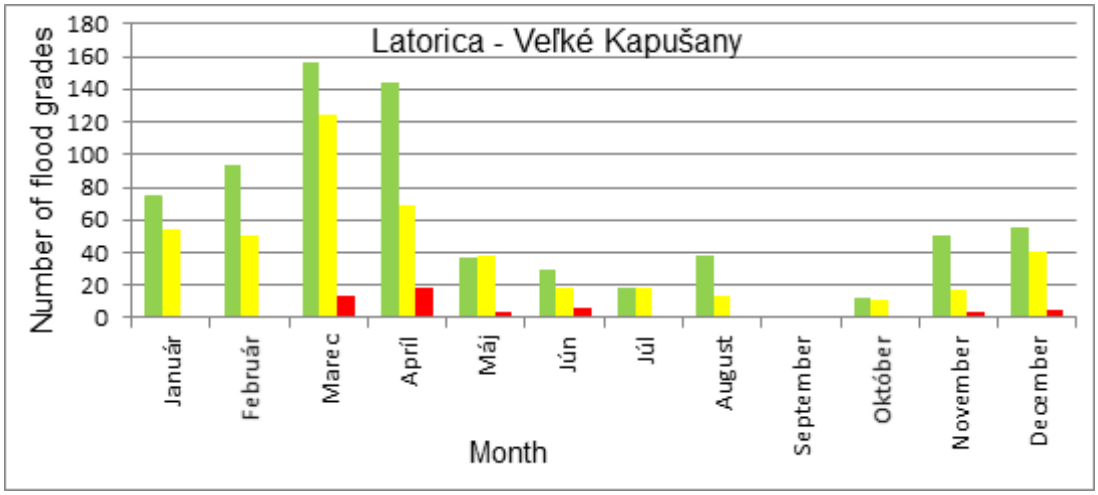

Figure 4. Number of floods (in days) in hydrometric station Veľké Kapušany at Latorica river

4 CONCLUSION

This work deals with floods in eastern Slovakia and flood conditions in relation to the water level. Rated territory is Bodrog, which is located in eastern Slovakia. River basin's flood punished more often than the rest of Slovakia and was therefore selected for evaluation.

The work was evaluated the most problematic hydrometric stations in the basin through the expression result. The final result was calculated according to the procedures described.

Using the evaluation, it was determined that the most problematic Latorica watercourse and its hydrometric stations (Veľké Kapušany, Čop). In this area frequently affected by floods, it is necessary to carry out effective measures to protect against flooding.

ACKNOWLEDGEMENT

The contribution is written thanks to support of project VEGA 1/0609/14.

REFERENCES

Findoráková, L. (2014). *Evaluation of the heights of water levels at selected rivers of Slovakia*. Thesis. Košice: SvF.

Gaňová, L. (2014). *Assessment and management of flood risk in the selected river basins in respect of Directive 2007/60/EC*. 2014. Thesis. Košice: SvF.

Hanák, T., Korytárová, J. (2014). Risk zoning in the context of insurance: Comparison of flood, snow load, windstorm and hailstorm. *Journal of Applied Engineering Science* **12** (2), 137-144.

Ministry of the Environment of the Slovak Republic (MoE SR) 2011 *Preliminary flood risk assessment in partial basin of Bodrog*. [online]. [cit. 2015-11-21]. Available at: <http://www.minzp.sk/files/sekcia-vod/bodrog.pdf>.

Slovak Hydrometeorological Institute (SHMI) *Map of hydrometric stations for surface water location*. [online]. [cit. 2015-11-22]. Dostupné na internete: <http://www.shmu.sk/File/kvantPV2011/49-50_mapSR.pdf>.

Zeleňáková, M. (2011). Flood risk assessment and management in Slovakia, pp. 61-69. In: *River Basin Management 6*: *6th International Conference on River Basin Management including all aspects of Hydrology, Ecology, Environmental Management, Flood Plains and Wetlands: 25 - 27 May, 2011, Riverside, California, USA. Southampton: WIT*.