Nagy P., Minea I., Zeleňáková M. (2021) Baseflow in Hornád Basin on the Eastern Slovakia, pp. 91-96. In Gastescu, P., Bretcan, P. (edit, 2021), *Water resources and wetlands*, 5th International Hybrid Conference Water resources and wetlands, 8-12 September 2021, Tulcea (Romania), p.235
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5th International Hybrid Conference Water resources and wetlands, 8-12 September 2021, Tulcea (Romania)

BASEFLOW IN HORNÁD BASIN ON THE EASTERN SLOVAKIA

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Abstract. Drought is a worldwide phenomenon that arises from lack of precipitation. Drought can be divided into hydrological drought, climatological drought and soil moisture. In this paper I deal with hydrological drought. Although the lack of rainfall is the main cause of drought, it manifests itself later than in meteorological drought. It takes longer for the lack of precipitation to manifest itself in the hydrological system. Long-term lack of rainfall can cause the development of hydrological drought and thus cause below-average water flows in the basins, drying up of lakes and reservoirs, reducing soil moisture, to run out of groundwater supplies. Water scarcity has a negative impact on various sectors of industry, agriculture, water supply, energy production and many other socio-economic aspects. Drought increases the risk of fires in the country. Another such phenomenon is extreme tidal floods, which arise from above-average precipitation. Recently, we have witnessed alternating dry periods with wet periods. The majority of the Hornád River Basin is located in eastern Slovakia. The Hornád River Basin consists of the Hornád River and Hnilec River and other smaller tributaries. The Hornád River in the upper part of the river flows through the Slovak Paradise where it cuts through a canyon valley called the Hornád Gorge. At the confluence of the Hornád and Hnilec rivers there is a water reservoir Ružín, which is used for electricity production and water supply for industry. At Kysak the river turns sharply to the south where it flows through Košice. Near the village Nižná Hutka river Torysa flows into Hornád. Torysa is a significant left tributary of the Hornád, then continues south and continues to Hungary. The Hornád River flows into Slaná. The Hornád River Basin is a sub-basin of the Danube River. The water reservoir Palcmanská Maša is created on the Upper course of the Hnilec river, this water reservoir is used mainly for electricity production and tourism. This study is focused on classical baseflow separation. Data were provided by the Slovak Hydrometeorological Institute. Baseflow for selected hydrological stations in the Hornád basin were calculated using sliding interval methods. Average values of BFI were 0.77-0.83.
Keywords: Hornád river basin, baseflow, drought, hydrology drought, rainfall, water resource management

1.INTRODUCTION

In recent decades, we have witnessed more frequent and severe occurrences of extreme weather and hydrological events, such as heat waves and extreme storms, and an increasingly frequent occurrence of dry periods. Drought is caused by a lack of precipitation and can last for days, months to years (Wilhite, 2000; Fendeková, 2018) In this paper I deal with hydrological drought. Long-term lack of precipitation will affect the development of hydrological drought and cause below-average water flows in river basins. Baseflow knowledge is important for water resource management and better use of water resources during droughts and better accumulation of water in river basins during wet periods. The base flow component is traditionally associated with groundwater discharges and the surface runoff component with precipitation entering the stream as ground runoff. (Joo, 2007)

Baseflow analysis is an essential element for reasonable hydrograph analysis. The baseflow study is a valuable tool for water management. In many studies, the definition of baseflow is inconsistent. Several scientists have defined baseflow as groundwater runoff, others have defined flow that comes from groundwater or other delayed components (Tallaksen & van Lannen, 2004; Nathan & McMahon, 1990).

Hydrographic analysis was done manually in the 20th Century. Two common baseflow-recession-methods (Olmsted and Hely, 1962; Riggs, 1963) and curve-fitting methods (Petty John and Hemming, 1979) were used. These methods require lengthy analysis (Posavec and Parlov, 2010; Arnold, Allen, 1995). Based on this, researchers have made efforts to automate graphical techniques for analyzing long-term streamflow data. Baseflow can be analyzed using various programs. (Cheng and Zhang, 2016; Rivera-Ramirez and Warner, 2002). the aim of this work was to calculate and evaluate the baseflow and BFI index using the program BFI 3.0+ from hydroofice by classical separation.

2.METHODS AND STUDY AREA

2.1.Methods

A number of methods have been developed for baseflow separation. We know three basic baseflow separation methods: fixed interval method, sliding interval method and local minimum method. A high BFI value means that the catchment area has a stable flow regime and therefore has the ability to maintain a sufficient flow rate during the dry season. Baseflow analysis and separation was done using BFI + 3.0 software. The module development methodology is based on Tallaksen and Van Lannen. The software allows you to choose from eleven baseflow separation methods and then analyze the results in graphical or tabular form. I analyzed the baseflow in the Hornád basin at selected water stations. The output of the thesis is the analysis and separation of baseflow in the Hornád basin. For baseflow analysis, I used historical daily average flows over a period of forty years. Data provided by Slovak hydrometeorological Institute.

I processed Baseflow using the BFI + 3.0 program. To calculate the Baseflow and BFI index, I had daily data from selected water meter stations in the Hornád basin for the period 1970-2011. Many methods have been developed for baseflow separation. We know three basic methods (Sloto & Crouse, 1996):

- Fixed interval method
- Sliding interval method
- Local minimum method

The sliding interval method was used for baseflow separation. The sliding interval method detects the highest outflow in one half of the interval minus 1 day [0.5 (2N * -1) days] before and after the considered day and assigns it to the given day. The method can be visualized by changing the 2N * rod wide up until the hydrograph is continuous. Discharge at this point is assigned to the middle day at intervals. The bar is then moved to the next day and the procedure is repeated. (Sloto & Crouse, 1996)

2.2.Study area

Selected evaluated water stations are located in eastern Slovakia in the Hornád basin. The Hornád basin in Slovakia consists of the rivers Hornád, Torysa, Hnilec, Olšava and other smaller tributaries. On the river Hornád is the water reservoir Ružín, which serves as a water supply for industry and electricity generation. Palcmanská Maša is the largest water reservoir in the Slovak Paradise, which is located in the upper reaches of the river Hnilec. (Miklós, 2002) In the Hornád basin, I evaluated the following water meter stations: Ždaňa, Margecany, Spišská nová ves - river Hornád, Košické olšany, Prešov - torysa river, Švedlár - Hnilec river (Figure 1).

In Table 1 sú priemerné denné prietoky, priemerné denné maxima a priemerné denné minima za obdobie 1970-2011.

Table 1. Hydrologic stations in basin Hornád for seasons 1970-2011

Stations	Average [m^3/s]	Max[m^3/s]	Min [m^3/s]
Ždaňa 8930	29,4	772,25	4,28
Margecany 8510	7,75	282,09	0,99
Spišská nová ves 8410	2,87	106	0,23
Švedlár 8540	3,49	110	0,3
Košické olšany 8870	8,05	292,3	0,9
Prešov 8780	4,42	216,41	0,35

The highest maximum and minimum flows are in the Hornád station and the smallest flows are in the Spišská nová ves station. Data provided by the Slovak Hydrometeorological Institute.

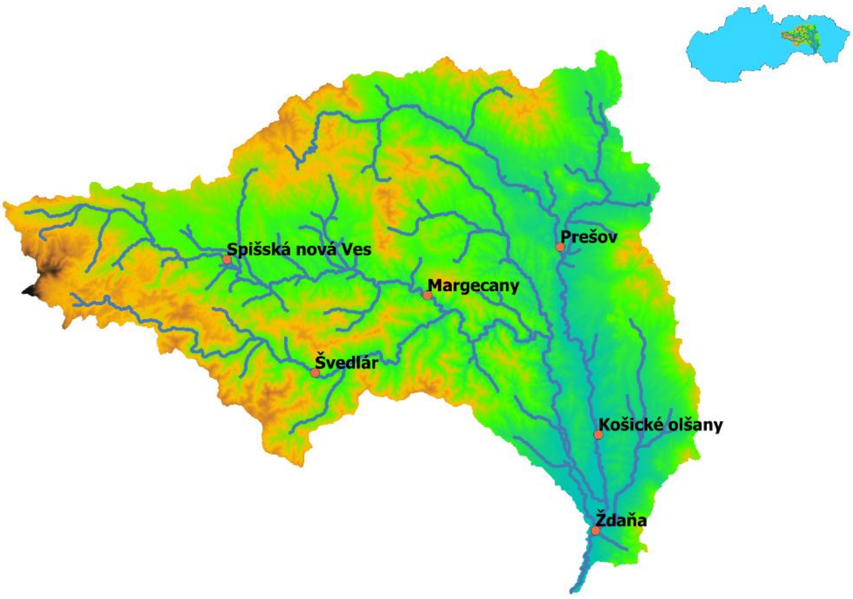

Figure 1. Basin Hornád and hydrologic stations

3.RESULTS

Evaluated baseflow in selected hydrological stations. In the Ždaňa station on the Hornád river, which is the last station on the Hornád river, the baseflow ranged from 8.95 to 42.56 m3 / s. (Figure 2.) As can be seen from the graph, streamflow and baseflow were heavier in the early 70's and in 2010, the early 90's were drier. The course of baseflow was uniform throughout the observation period.

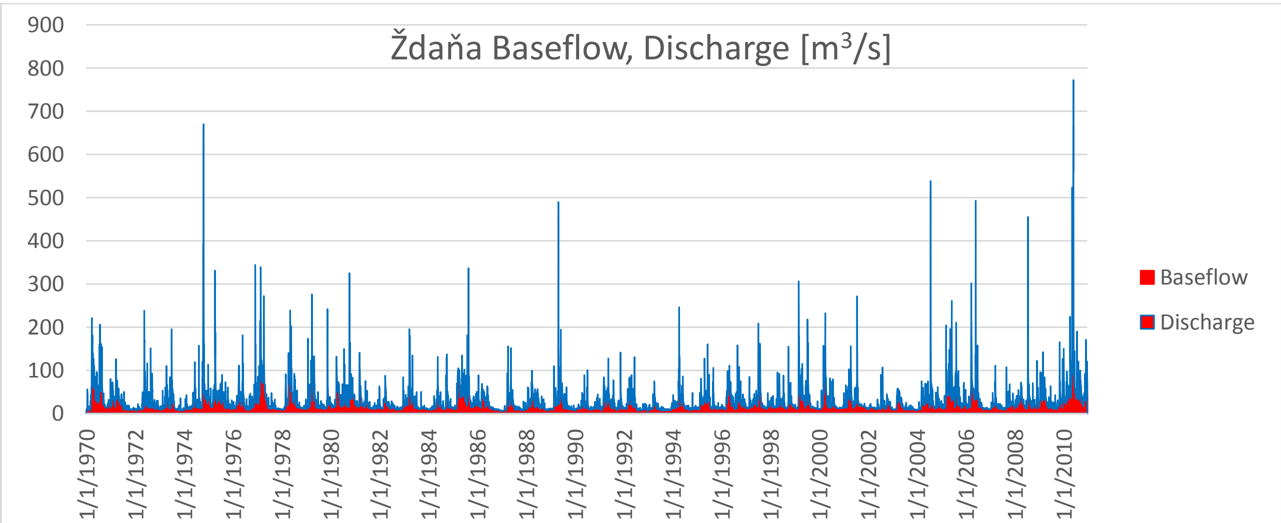

Figure 2. Station Ždaňa 8930 Baseflow and Discharge for season 1970-2011

At Margecany the baseflow was in the range of 0.99 - 28.3 m3 / s and the average baseflow was 5.1 m3 / s (Figure 3)

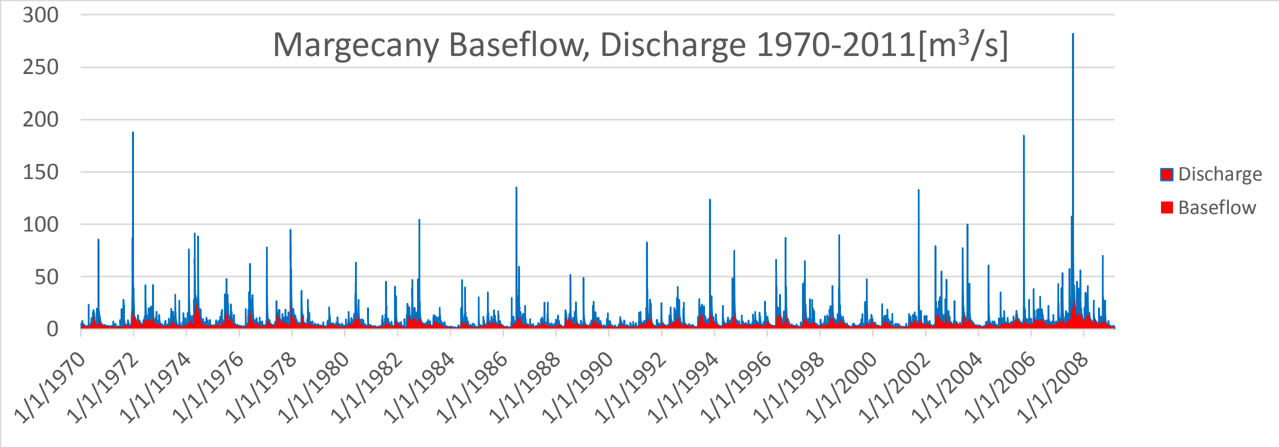

Figure 3. Station Margecany 8510, Baseflow and Discharge for season 1970-2011

Spišská nová ves baseflow was 0.24 - 10.2 m3 / s. (Figure 4) The average baseflow in the observed period was 10.2 m3 / s, which was twice as large as at the Margecany station.

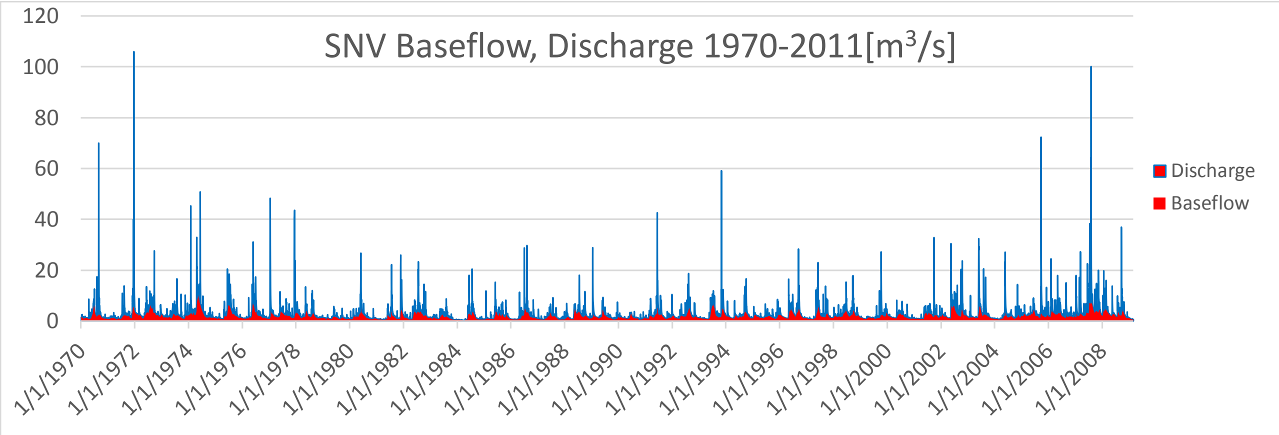

Figure 4. Station Spišská nová ves 8410, Baseflow and Discharge fo seasaon 1970-2011

In the hydrological station Švedlár, on the river Hnilec the baseflow was 0.48 - 5.22 and the average baseflow 5,22 m^3/s (Figure 5)

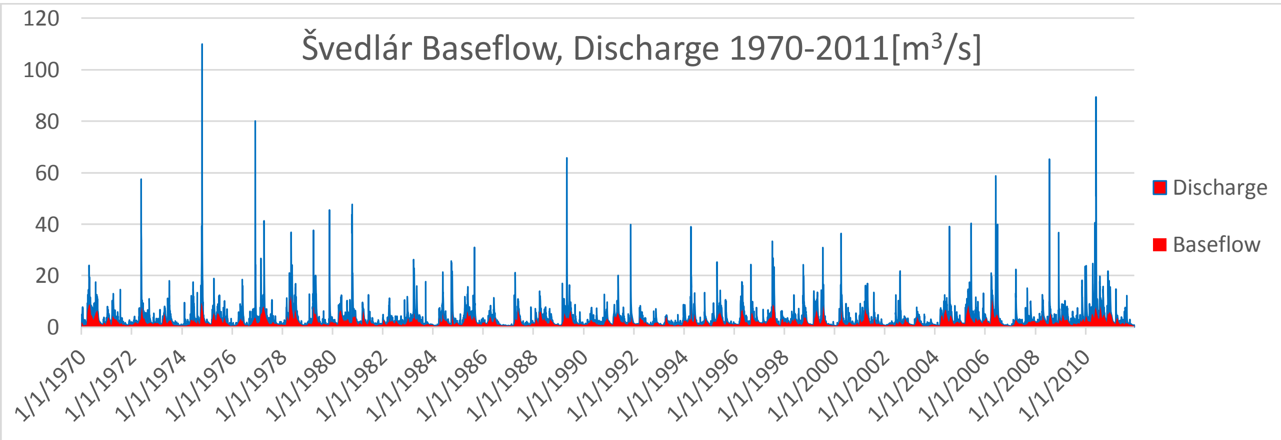

Figure 5. Station Švedlár 8540, Baseflow and Discharge for season 1970-2011

On the river Torysa in the hydrological station Košické olšany the average baseflow was 4.26 m3 / s and ranged from 1,82 -10,67 m^3/s.

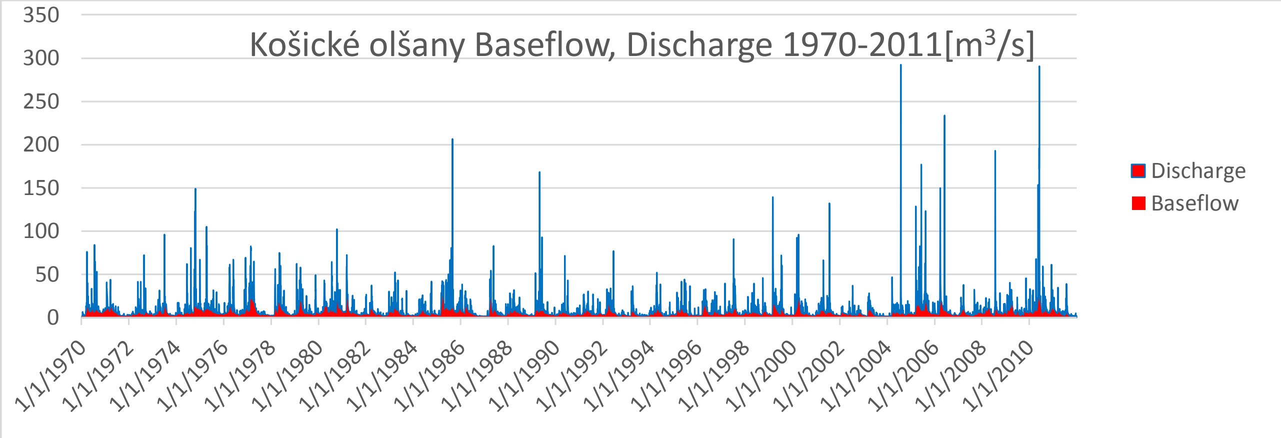

Figure 6. Station Košické olšany 8870, Baseflow and Discharge for season 1970-2011

The average baseflow at the station of the crossing on the river Torysa was 2.4 m3 / s. Baseflow was in range 0,35 -14,24 m^3/s. (Figure 7)

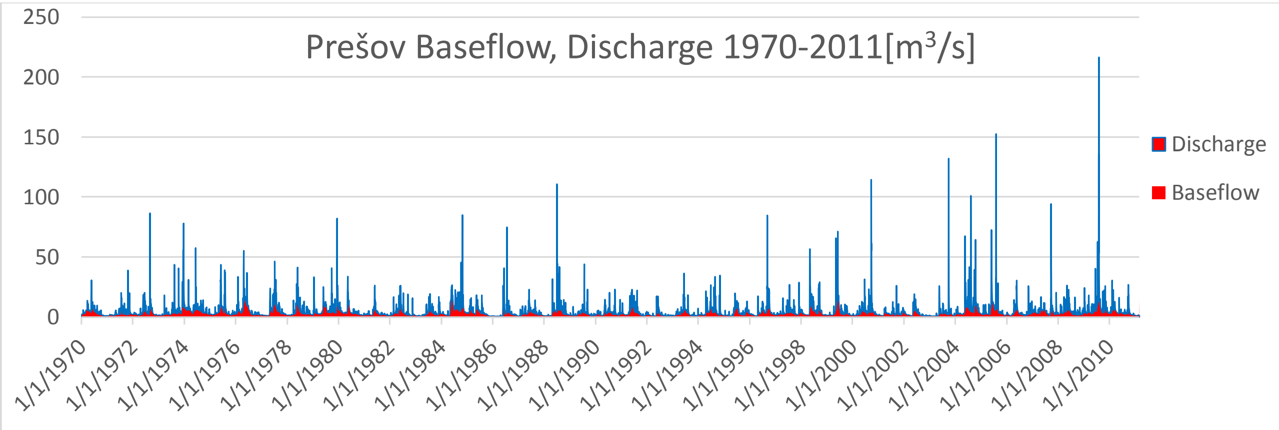

Figure 7. Station Prešov 8780, Baseflow and Discharge for season 1970-2011

In the Hornád basin, in selected water meter stations, the course of baseflow was even. It was more pronounced at the beginning of the observation in the 70s and in 2010 which was very abundant in precipitation.

Table 2. Baseflow index in catchment Hornád

Stations/BFI index	Average BFI Index	Max BFI index	Min BFI index
Ždaňa 8930	0,81	1	0,15
Margecany 8510	0,82	1	0,03
Spišská nová ves 8410	0,81	1	0,03
Švedlár 8540	0,79	1	0,12
Košické olšany 8870	0,83	1	0,1
Prešov 8780	0,77	1	0,01

In Table 2. are the Baseflow index values in the Hornád river basin. The average values in water meter stations ranged 0,8.

CONLUSIONS

In this study, the baseflow and baseflow index in the Hornád basin were evaluated. The average values of the BFI index in the upper part of the river basin were lower than <0.8 at the Švedlár and Prešov stations. The evaluated Baseflow shows that an increase in air temperature does not affect the air flow. We assume that the source of baseflow in the Hornád basin is groundwater, which is drained from aquifers along the rivers in the basin. The consequence of these findings is that future differences in the river basin scheme should take into account time differences in flow, such as proposed changes in water accumulation, water retention measures. In the future, it would be necessary to evaluate the baseflow for other stations in the Hornád basin and take into account precipitation and the impact on baseflow.

Acknowledgements
This work was supported by project of the Ministry of Education of the Slovak Republic VEGA 1/0308/20 and project of the Slovak Research and Development Agency APVV-20-0281.

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