Catchment properties conditioning drought occurrence in selected catchments in Slovakia and Czechia

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Vlastnosti povodia podmieňujúce výskyt sucha vo vybraných slovenských a českých povodiach

Abstract: Drought is one of extreme events in catchments which become more and more often the cause of large economical losses. The aim of the presented study has been to analyze and compare drought occurrence development and duration in six small to middle sized catchments in the Czech Republic and Slovakia. Average daily discharges of the Rakovnický potok and Ľupčianka brooks, and the Metuje, Teplá, Žitava, and Belá rivers were used as basic input data. The threshold level method and the sequent peak algorithm were used for calculation of drought duration in discharge and base flow time series. The results showed similarities in the base flow formation and specific base flow values in the catchments of Rakovnický potok and Žitava River. Two Slovak mountainous catchments Belá and Ľupčianka differ very much from the others. Drought occurrence was very variable in all catchments; depending on the location and altitude. The obtained results confirmed the hypothesis on drought propagation from the west to the east. The total number of droughts longer than 50 days was higher in Slovakia than in Czechia.

Key words: Western Carpathians, Bohemian Massif, geological conditions, climatic conditions, groundwater runoff, drought analysis

1. INTRODUCTION

Drought is one of extreme events in catchments. Droughts are supposed to keep getting longer and more severe due to climate change. Moreover, the droughts and consequent impacts have been already experienced in Czechia and Slovakia (e.g. IPCC 2013).

The issue of drought is complex. Therefore there are many definitions of this phenomenon, e.g., Whilite & Glantz (1985) published more than 150 definitions of drought. Hydrological drought was defined and studied e.g. by Tallaksen et al. (2004). Yevjevich already in 1967 formulated mathematically hydrological drought as a stochastic process. Combined deterministic and stochastic approaches could complement each other by drought research, as it was showed by Kašpárek & Novický (1998). Combined approaches were developed also by Zelenhasić & Salvai (1987), Rossi et al. (1992) and Bonacci (1993). A review paper on drought research was presented by Smakhtin (2001). Sobíšek (1993) defined drought in the Czech Republic. Many definitions of hydrological droughts were published also by Slovak authors, as the phenomenon is considered to be important in the country, e.g., by Balco (1990) and Fendeková et al. (2010).

The sustained and regional extensive occurrence of bellow average natural water availability is presented as a general definition of drought by Tallaksen et al. (2004). The primary cause for hydrological drought development during the warm part of the year is the occurrence of meteorological drought. Lack of precipitation over a large area for an extensive time period mostly during summer – autumn period may cause reduction of streamflow and groundwater recharge. Snow lying in the catchment and frozen ground surface during the winter period may also cause hydrological drought development in both – surface and groundwater, mostly during the winter – spring period (van Loon et al., 2010).

The presented study focuses on the analysis and the comparison of surface and groundwater drought occurrence, development and duration in six small to middle sized catchments in the Czech Republic and Slovakia. Surface drought was evaluated using the discharge data, groundwater drought using the base flow reflecting recharge of surface streams by the rock environment.

Based on results, this paper aims to answer two main questions:

Are there correlations between the physical conditions in the catchments and drought occurrence?

Does the spatial trend of drought occurrence exist?

2. DATA AND METHODS

2.1. Natural conditions

Data from three Czech catchments (Rakovnický potok, Teplá, and Metuje) and three Slovak catchments (Žitava, Belá, and Ľupčianka) were processed in order to compare drought

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Tab. 1. Basic data on evaluated catchments.

Tab. 1. Základné údaje o hodnotených povodiach.

Name of the river/ gauging profile site	Area (km²)	Average altitude (m asl.)	Annual precipitation (mm)	Annual runoff (mm)
Rakovnický potok /Rakovník	302.3	407	512	64
Teplá/Teplička	272.2	686	659	334
Metuje/Hronov	247.8	561	746	334
Žitava/Vieska n. Žitavou	295.5	536	786	221
Belá/Podbanské	93.5	1,575	1,564	1,244
Ľupčianka/Partizánska Ľupča	70.4	982	1,506	682

occurrence in different natural conditions during the common period. Basic parameters of evaluated catchments are given in Tab. 1; location of catchments is in Fig. 1. Only a part of the whole catchment (mostly the upper one), up to defined gauging profile mentioned in Tab. 1, was taken into account in all evaluated catchments.

The brook Rakovnický potok has its spring in the hilly land Rakovnická pahorkatina. The major part of the catchment is built by Upper Palaeozoic sediments (Carboniferous and Permian), consisting of lower grey coal-bearing layers, lower red, upper grey to upper red layers. Palaeozoic sediments are partially covered by Cretaceous and Neogene (gravels, loamy sands) sediments and finally by Quaternary alluvial deposits. The area represents a close hydrogeological structure; groundwater recharge is poor due to alteration of permeable and impermeable layers. Surface is covered by cropland (59 %), grass land (10 %), and by forests (28 %). Runoff is dominated by rainfall, quite heavily influenced by water uptakes in the catchment.

The Teplá River originates in peat meadows in the western part of the Czech Republic. Major part of the catchment is built up by crystalline rocks (Teplice Palaeorhyolite Complex, granitic rocks of Karlovy Vary Pluton). Crystalline rocks are covered by very thin layer of Quaternary sediments. Large part of the Teplá catchment belongs to nature reserve with forest slopes, debries ecosystems and ravines. Runoff is dominated by rainfall.

The upper part of the Metuje catchment has a basin structure and it is filled with Mesozoic (Triassic to Cretaceous) rocks (limestones, sandstones) overlying the impermeable Permian-Carboniferous basement. Two main aquifers are developed – the deep (Triassic and Cenomanian layers) and the shallow one (the Middle Turonian sandstones). They are separated by lower Turonian marlstones. The headwater part is typical by deeply incest valleys, table mountains, and pseudokarst caves. The land cover in the downstream part consists predominantly of forests, cropland, and grassland. The discharge is fed dominantly by groundwater.

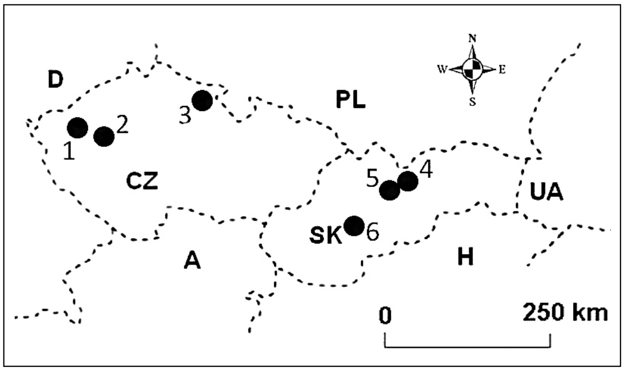


Fig. 1. Location of evaluated catchments.

Obr. 1. Lokalizácia hodnotených povodí.

The Žitava catchment is located in the central western part of Slovakia. The river spring is located in the Tribeč Mts. in the altitude of 575 m asl. The geological structure in the headwater part consists of Tatric crystalline basement with Mesozoic sedimentary cover. Neovolcanic rocks of the Pohronský Inovec Mts. cover the north-eastern border of the catchment. Central and lower part of the catchment is filled with Neogene, mostly clayey sediments, being covered by Quaternary alluvial deposits (Priechodská et al., 1988). Runoff is dominated by rainfall (Lapin et al., 2002), but the contribution of snow melting during the spring period is also important.

The Belá River catchment is located on the contact of Západné and Vysoké Tatry Mts. in the north of Slovakia. The major part of the catchment is built by Palaeozoic crystalline rocks belonging to the Tatric Unit, only a small part in the north-west is built by Mesozoic sedimentary cover (Nemčok et al., 1993). The central and lower part of the catchment up to the Podbanské profile is covered by Quaternary glacial sediments. The upper part of the catchment has typical high mountain character without any vegetation cover, or with dwarf pine areas, the rest is covered by spruce forests. The runoff is snow to snow-rain combined type (Lapin et al., 2002).

The Ľupčianka catchment is located on the northern slopes of the Nízke Tatry Mts. in the northern part of central Slovakia. The upper part of the catchment is built by crystalline rocks – fylites, tonalities, granodiorites of Ďumbier and Prašivá type. Mesozoic rocks, belonging partially to the Choč and mostly to Krížna nappes occur in the central part of the catchment. They are represented by Triassic up to lower Cretaceous rocks as quarzites, limestones, dolomites, detritic muddy limestones and sandstones. The lower part of the catchment (app. one third of the total area) is built by Palaeogene sediments of the Borové (breccias, conglomerates and sandstones) and Huty (claystones) formations, being covered by Quaternary sandy gravels, fluvial gravels, slope sediments and sometimes also travertines (Biely et al., 1997). The runoff regime is snow-rain combined in the upper part of the catchment, being covered by spruce forests, and of rain-snow type in the rest of catchment (Lapin et al., 2002), which is covered mostly by grassland.

2.2. Data

Daily discharges were used as the basic input data. The length of time series was as follows:

- Rakovnický potok, gauging station No. 1901 Rakovník: 1. 1. 1970–31. 10. 2010;
- Metuje, gauging station No. 180 Hronov: 1. 1. 1961–31.10.2010;
- Teplá, gauging station No. 2109 Teplička: 1. 11. 1992–31. 10. 2006 complemented by station No. 2110 Cihelny for the period 1. 11. 1961–31. 10. 1992;
- Žitava, gauging station No. 6820 Vieska nad Žitavou: 1. 11. 1961–31. 10. 2010;
- Belá, gauging station No. 5400 Podbanské: 1. 11. 1931–31. 10. 2010;
- Ľupčianka, gauging station No. 5730 Partizánska Ľupča: 1. 11. 1961–31. 10. 2007.

Three common periods 1971–1980, 1981–1990, and 1991–2000 were selected for the base flow separation for all six catchments. Drought periods occurrence was estimated within the entire available length of each time series.

2.3. Methods

The streamflow drought was characterized using discharge data, the groundwater drought using the base flow values. Daily base flow values were calculated from the daily discharges using the HydroOffice 2010 program (Gregor, 2011, 2013). The local minimum method was used for the base flow separation. The minima of 20-days non overlapping consecutive periods were calculated and turning points in this minima sequence were identified. A minimum became the turning point when its value was less than or equal to the neighboring minima. Values of base flow index (BFI) were calculated as a measure of the river's runoff that derives from stored sources and characterizes the groundwater recharge (Institute of Hydrology, 1980). The index is calculated as the ratio of the base flow to total streamflow. Values over 0.9 characterize a permeable catchment with a very stable flow regime. On contrary, values in the range 0.15–0.2 characterize an impermeable catchment with a flashy flow regime (Tallaksen et al. 2004).

The threshold level method and the sequent peak algorithm were used for calculation of drought duration in the discharge and base flow time series. The threshold level method is the most frequently applied quantitative method for drought periods identification in time series. It is based on defining a threshold value Q_0, below which the discharge is considered as a hydrological drought. The time of drought occurrence is given by the starting and the termination date of drought, the total length and deficit volume is also calculated. The threshold value was calculated as the Q_{80P} value from the master flow duration curve. The Q_{80P} represents the average value of the 80th percentiles of the flow duration curves constructed for each hydrological year within the evaluated period. Moreover, value of the 97th percentile was also used for assessment of the most severe droughts. The fixed threshold for individual catchments during the whole study period was used in this study.

The sequent peak algorithm (SPA) was the second procedure used for hydrological drought estimation. The procedure was preliminary designed for reservoirs. The method can be used also for drought analysis, if the processed data are of volumetric character (e.g., discharge Q or base flow BF). Let us label the daily discharge as Q_t and the requested discharge as Q_0, than the storage requested in the beginning of the evaluated period S_t is defined as (1) either:

$$S_t = S_{t-1} + Q_0 - Q_t \tag{1}$$

if the result is positive, (2) or:

$$S_t = 0 \tag{2}$$

in all other cases.

The undisturbed series of positive values S_t $\{S_t, t - \tau_0, \dots, \tau_{end}\}$ defines the period with depletion, followed by the recharge of the storage. The requested storage in this period max {S} defines the deficit volume v_i. The time interval d_i defines the discharge/base flow drought duration from the beginning of the depletion period τ_0 up to the time of maximum depletion τ_{max}. The relation between d_i and τ is defined as (3):

$$d_i = \tau_{max} - \tau_0 + 1 \tag{3}$$

This technique differs from the threshold level method in that those periods when the discharge/base flow exceeds the threshold value do not necessarily negate the storage requirement, and that several deficit periods may pass before sufficient inflow has occurred to refill the missing volume of the streamflow (Tallaksen et al. 2004) or base flow. The values of Q_{80P}/BF_{80P} were used by sequent peak algorithm method application as the requested discharge Q_0 or base flow BF_0.

The threshold level method and sequent peak algorithm method were applied on discharges, representing the streamflow drought and on the base flow, representing the groundwater drought.

3. RESULTS

The average base flow values in all evaluated catchments were calculated for the same three decades of the common period (1971–1980, 1981–1990, and 1991–2000) with the local minimum method. The results were re-calculated into specific base flow values (ratio of the base flow value to the catchment area of the respective catchment).

The results of catchment runoff parameters calculation – the long-term average discharge, average base flow, specific discharge and base flow and BFI values are given in Tab. 2.

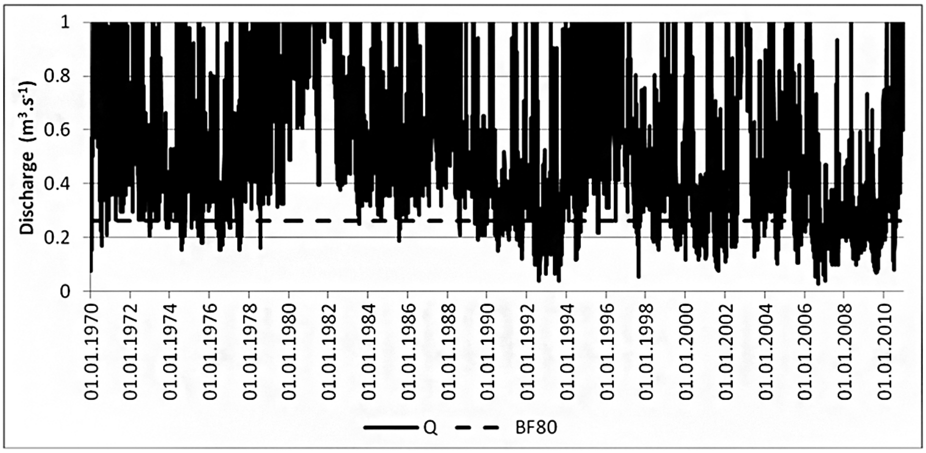
The lowest values of the specific discharge were obtained for catchments of Rakovnický potok, Teplá, and Žitava, range

Tab. 2. Results of runoff parameters estimation.

Tab. 2. **Výsledky výpočtu odtokových parametrov.**

River	Average discharge (m^3.s^{-1})	Average base flow (m^3.s^{-1})	Specific discharge (l.s^{-1}.km^{-2})	Specific base flow (l.s^{-1}.km^{-2})	BFI
Rakovnický potok	0.602	0.333	2.1	1.10	0.55
Teplá	2.531	0.848	9.1	3.05	0.34
Metuje	2.786	1.423	11.2	5.70	0.51
Žitava	1.491	0.586	5.1	2.00	0.39
Belá	3.525	1.685	37.7	18.00	0.48
Ľupčianka	1.633	0.952	23.2	13.50	0.58

BFI – base flow index



Example of base flow drought estimation in the Rakovnický potok catchment by the threshold level method.
Obr. 2. Príklad vyčlenenia sucha v povodí Rakovnického potoka metódou hraničnej hodnoty.

from 2.1 to 9.1 l·s^{-1}·km^{-2}. The lowest values of the specific base flow, equal to 2.0 and 1.1 l·s^{-1}·km^{-2} respectively, were estimated for Žitava and Rakovnický potok, quite low specific base flow with the value of 3.05 l·s^{-1}·km^{-2} was estimated also for Teplá catchment.

Runoff values estimated for the Metuje catchment are higher than those of the Rakovnický potok, Žitava, and Teplá catchments, but importantly lower than values estimated for the Belá and Ľupčianka catchments.

Slovak mountainous catchments – Belá and Ľupčianka with the high values of specific runoff values (both, specific discharge and base flow) differ importantly from all other evaluated catchments. The values of specific discharge reached more than 20 l·s^{-1}·km^{-2}, the value of specific base flow was higher than 10 l·s^{-1}·km^{-2}.

Results of the BFI estimation showed that the Teplá and Žitava catchments (0.34 and 0.39) belong to less permeable catchments; however not to the impermeable ones.

Drought occurrence was estimated using the threshold level method (TLM) and the sequent peak algorithm (SPA). Results were processed in the form of graphs. The value of the 80th percentile was used in both methods as the threshold value below which the drought conditions occur. As an example, base flow drought occurrence estimation for Rakovnický potok is showed in Fig. 2.

Number of drought periods with the duration from ≥ 50 to 99 days and ≥ 100 days estimated by TLM and SPA methods for discharges is in Tab. 3. It is obvious that number of drought periods estimated by threshold level method (D_{TLM}) and sequent peak algorithm (D_{SPA}) method differs (Tab. 3), as it is based on the algorithm of the drought duration period calculation. The similar results were obtained also for base flow values.

The total number of drought periods with duration of 50 days and more estimated by SPA method is higher in all catchments than that estimated by TLM method. At the same time, the total numbers are higher for the Slovak catchments than for the Czech ones. The longest drought in discharges was estimated for Rakovnický potok where the method of SPA showed drought with duration of 1569 days (12. 6. 2006 – 27. 9. 2010). It can be seen in Fig. 3 that among the Czech catchment only in the Rakovnický potok catchment the drought occurred within the whole period 2006–2010.

Deficit discharge (drought estimated by SPA method) simultaneously occurred in four evaluated catchments (except of the Rakovnický potok and Belá) in 1973–1974 and 1983. The next drought appeared in 1984 in the Metuje and in all Slovak catchments. Summer drought in 1990 and summer-autumn drought in 1991 occurred in all catchments except of the Belá. Droughts appeared mostly first in Czech catchments and then drought appeared in Slovak catchments.

The situation in base flow drought occurrence estimated by SPA method in Slovak catchments is in Fig. 4. It can be seen, that the longest periods with the base flow deficit volume occurred

Tab. 3. Number of droughts of different duration D in discharges.

Tab. 3. Počet výskytov sucha v prietokoch s dĺžkou trvania D.

River	No. of droughts $D_{TLM} \geq 50$–99 days	No. of droughts $D_{TLM} \geq 100$ days	No. of droughts $D_{SPA} \geq 50$–99 days	No. of droughts $D_{SPA} \geq 100$ days
Rakovnický p.	3	0	6	11
Teplá	5	0	7	10
Metuje	4	1	6	12
Žitava	5	0	10	15
Belá	19	7	19	13
Ľupčianka	12	7	11	14

D_{TLM} – drought duration estimated by the Threshold level method, D_{SPA} – drought duration estimated by the Sequent peak algorithm method

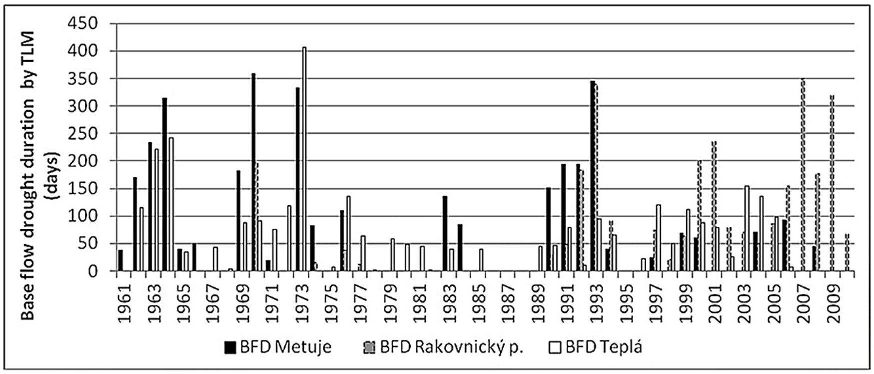


Fig. 3. Base flow drought duration in evaluated Czech catchments.

Obr. 3. Trvanie sucha v podzemnom odtoku v hodnotených českých povodiach.

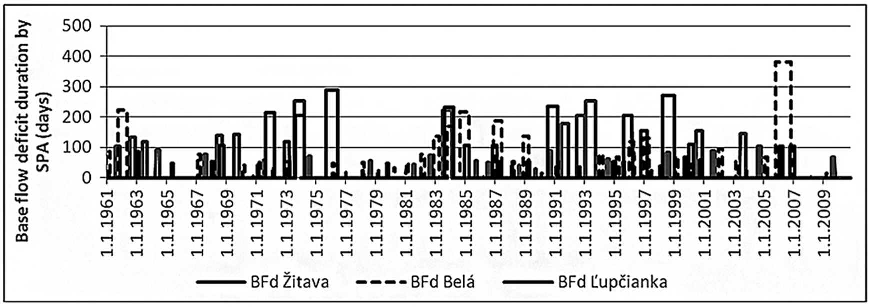


Fig. 4. Duration of deficit volume periods estimated by SPA method in base flow (BFd) in Slovak catchments

Obr. 4. Trvanie období nedostatkových objemov určených metódou SPA v podzemnom odtoku (BFd) v slovenských povodiach.

in 1973–1974 period in Žitava and Ľupčianka catchments, in 1993–1994 period again in the Žitava catchment and in 2006–2007 period in the Belá catchment.

At the same time, the 1973–1974 base flow droughts were estimated for the Rakovnický potok catchment, the 1993–1994 droughts for the Metuje catchment and the 2006–2007 droughts for the Rakovnický potok, having lasted up to 2010, following the longest discharge drought.

Evaluation of discharge drought occurrence with threshold level equal to 97th percentile, which corresponds app. to Q_{355}, showed that such a drought with the duration of more than 50 days occurred in the Metuje catchment in 1963, in the Teplá in 1973, in the Žitava in 1961 and 1992, in the Ľupčianka in 1996 and in the Belá catchment in 1944 (123 days), 1984 and 2006.

Typical starting time of discharge drought longer than 50 days in evaluated Czech catchments was summer; drought was often prolonged to autumn period. Similar character has the occurrence of drought periods in the Žitava catchment. Two other Slovak catchments can be characterized by typical winter droughts, often prolonged up to the next spring period. The winter-spring droughts were the most frequent in the Belá catchment.

4. DISCUSSION

Low values of specific runoff parameters estimated for the Žitava, Rakovnický potok, and Teplá catchments, especially what the specific base flow is concerned, can be explained by differences in precipitation amounts and by geological conditions.

Important catchment parameter influencing low runoff values is amount of precipitation, conditioned either by low altitude (Rakovnický potok) and/or by catchment location in the precipitation shadow. The evaluated part of the Žitava catchment is shaded by the Tribeč Mts., the Teplá catchment is located on the eastern (leeward) slopes of the Krušné hory Mts. The

Rakovnický potok is the catchment with the lowest amount of average annual precipitation among all evaluated catchment.

The higher permeabilities of the geological environment condition a bit better runoff parameters in the Metuje catchment in comparison with the Žitava catchment where the precipitation totals and altitude are comparable. The less permeable sediments occur in the Rakovnický potok, Teplá, and Žitava catchments. They are represented by alternation of clayey and sandy sediments in the Rakovnický potok catchment, Neogene clayey sediments in the Žitava catchment and crystalline complexes in the Teplá catchment almost without important Quaternary cover.

The reason of high runoff parameters in the Belá and Ľupčianka catchments is the most probably in different climatic and physical conditions – high amounts of average annual precipitation (Tab. 1) and lower evapotranspiration values due to lower temperatures in higher altitudes (Tab. 1). High values of the specific base flow are influenced also by specific geological conditions. Water bearing Mesozoic sediments are present in the Ľupčianka catchment and permeable glacial sediments in the Belá catchment.

The values of the specific base flow obtained for the Belá catchment are comparable with other catchments with similar geological conditions in the Tatry Mts. Machlica et al. (2010) estimated values of the specific base flow for the Poprad at Štrbske Pleso on 19 $l \cdot s^{-1} \cdot km^{-2}$ for the period 1981–2000. Results of Fendekova et al. (2014) also confirmed similar values in the Poprad at Štrbské Pleso (17.1 $l \cdot s^{-1} \cdot km^{-2}$), the Račkov potok at Račkova dolina (18.26 $l \cdot s^{-1} \cdot km^{-2}$) and the Smrečianka at Žiarska dolina (15.14 $l \cdot s^{-1} \cdot km^{-2}$). However, it should be mentioned, that all these values were estimated for the period 1981–2012.

When comparing the results for the Belá catchment and the Teplá catchment, both of them are built by crystalline complexes. The permeable cover of glacial sediments is missing in the Teplá catchment when comparing with the Belá catchment. This fact, together with the almost three times lower precipitation amounts causes almost six times lower specific base flow values in the Teplá catchment.

Surface and groundwater drought occurrence in evaluated Czech and Slovak catchments reflects very variable physical conditions in catchments, first of all the location of the catchments (latitude and altitude) but also the geological and hydrogeological conditions.

The latitude difference reflects itself in starting time of drought which often propagates from the west to the east. The altitude is reflected in the seasonal pattern of drought, where drought in higher altitudes occurs much often in winter-spring period whereas in lower altitudes the summer-autumn droughts prevail.

The total number of droughts with duration of more than 50 days was much higher in Slovak than in Czech catchments, which could reflect the more continental character of climate in Slovakia. Drought occurrence in the Žitava catchment often coincided with the drought in Czech catchments; especially with the drought in the Teplá catchment. On the other hand, drought occurrence in the Metuje catchment was in many cases closer to drought development in Slovakia than in other two Czech catchments. The longest drought in discharges, estimated for the Rakovnický potok by the method of SPA lasting for 1,569 days in 2006–2010 period was caused probably by the human activities, because in none of other evaluated catchments such a long discharge drought in the same or similar period occurred.

5. CONCLUSION

The study of the influence of selected catchment parameters on runoff conditions and drought occurrence in three Slovak and three Czech catchments was performed.

It showed that the most important catchment parameters influencing the runoff conditions in evaluated catchments are (1) the amount of precipitation, conditioned by the altitude and catchment location in windward/leeward position, and (2) the geological and hydrogeological conditions. These parameters conditioned the differences in the specific runoff and base flow values varying in the range 2.1–37.7 $l \cdot s^{-1} \cdot km^{-2}$ for discharges and 1.1–18.0 $l \cdot s^{-1} \cdot km^{-2}$ for the base flow.

What the occurrence of drought periods is concerned, they mostly started first in Czech and then appeared in Slovak catchments, being typical by longer duration in Slovakia. The total number of droughts was higher in Slovak than in Czech catchments. The seasonal pattern of droughts was influenced by the altitude.

Another feature observed was the uniqueness of drought periods occurrence. None of drought periods longer than 50 days occurred simultaneously in all evaluated catchments. The only one long-term drought period, which occurred in five out of six evaluated catchments (except of the Belá catchment) was the 1990–1991 drought.

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7. RESUMÉ

Hlavným cieľom výskumu bolo analyzovať rozdiely vo veľkosti podzemného odtoku a výskyte sucha vo vybraných malých a stredných povodiach Českej republiky a Slovenskej republiky. Ako povodia Českej republiky boli vybrané: povodie Rakovnického potoka po profil Rakovník, povodie Teplej po profil Teplička a povodie Metuje po profil Hronov. Ako slovenské povodia boli vybrané povodie Belej po profil Podbanské, povodie Ľupčianky po profil Partizánska Ľupča a povodie Žitavy po profil Vieska n. Žitavou.

Povodie Belej a Teplej sú budované prevažne horninami kryštalinika, v povodí Belej sa však v dolnej časti toku vyskytujú nadložné kvartérne glaciálne a glacifluviálne sedimenty, ktoré v povodí Teplej chýbajú. Pre povodia Metuje a Ľupčianky je charakteristický výskyt karbonatických hornín, ktoré v dolnej časti tokov prechádzajú do relatívne menej priepustných sedimentov neogénu (v povodí Metuje), resp. paleogénu (v povodí Ľupčianky). Všetky štyri povodia sú málo postihnuté antropogénnou činnosťou. Spoločnou črtou zvyšných dvoch povodí – povodia Rakovnického potoka a povodia Žitavy sú relatívne nízke úhrny zrážok (v dôsledku ich lokalizácie v relatívnom zrážkovom tieni okolitých povodí) a prevládajúce nižšie priepustnosti horninového prostredia. U Rakovnického potoka ich zapríčiňuje striedanie priepustných a nepriepustných vrstiev a tým obmedzená dotácia podzemných vôd vytvárajúca zatvorenú hydrogeologickú štruktúru, u povodia Žitavy je to v jeho nížinnej časti výskyt neogénnych sedimentov tvorených prevládajúcimi ílovými súvrstviami.

Pre všetky hodnotené povodia boli stanovené hodnoty podzemného odtoku rovnakou metodikou za rovnaké obdobie (1981–2010). Podzemný odtok bol v dennom kroku separovaný metódou lokálneho minima. Výsledky ukázali, že najnižšie merné podzemné odtoky boli stanovené pre povodie Rakovnického potoka (1,1 l.s^{-1}.km^{-2}) a Žitavy (2,0 l.s^{-1}.km^{-2}), o niečo vyššie, ale stále relatívne nízke hodnoty boli získané pre povodie Teplej (3,05 l.s^{-1}.km^{-2}). Od ostatných hodnotených povodí sa výrazne odlišovali dve slovenské horské povodia – povodie Belej a Ľupčianky, pre ktoré boli stanovené najvyššie hodnoty merného pozemného odtoku, a to 18,0 l.s^{-1}.km^{-2} pre povodie Belej a 13,5 l.s^{-1}.km^{-2} pre povodie Ľupčianky. Merné podzemné odtoky v povodí Metuje dosiahli 5,7 l.s^{-1}.km^{-2}. Výpočet indexu podzemného odtoku BFI jednoznačne priradil povodia Žitavy a Teplej k málo priepustným povodiam. Všetky ostatné povodia s hodnotami medzi 0,48–0,58 možno na základe tohto indexu klasifikovať ako stredne priepustné. Neočakávane sa medzi ne zaradilo aj povodie Rakovnického potoka s hodnotou BFI rovnou 0,55.

Sucho bolo hodnotené dvomi metódami, a to metódou lokálneho minima a metódou nasledujúceho vrcholu (sequent peak algorithm). Ako hraničná hodnota bola u oboch metód zvolená hodnota 80-teho percentilu čiary prekročenia prietokov a podzemného odtoku.

Výsledky dokumentovali veľmi variabilný výskyt sucha v jednotlivých povodiach, a to vo všetkých jeho atribútoch – časovom výskyte, dĺžke trvania a deficitnom objeme. Možno ich však zovšeobecniť nasledovne.

Sucho v prietokoch a podzemnom odtoku odráža veľmi variabilné fyzickogeografické pomery hodnotených povodí, predovšetkým ich geografickú polohu (zemepisná dĺžka a nadmorská výška), ale aj geologické a hydrogeologické podmienky. Zemepisná poloha vplýva na dobu začiatku sucha, ktoré sa často šírilo zo západu na východ. Nadmorská výška sa prejavila v rozdielnom type sezónnosti, pričom suchá v povodiach s vyššou nadmorskou výškou sa omnoho častejšie vyskytovali v zimno-jarnom období, zatiaľ čo v nižších nadmorských výškach prevládali letno-jesenné suchá. Celkový počet periód sucha s dĺžkou trvania viac ako 50 dní bol omnoho vyšší v slovenských povodiach, čo môže odrážať kontinentálnejší charakter klímy na Slovensku. V povodiach s výskytom menej priepustných neogénnych sedimentov, resp. v kryštaliniku bez výrazného kvartérneho pokryvu sa suchá vyskytovali častejšie ako v povodiach tvorených kryštalickými horninami s glaciálnym pokryvom, resp. prítomnosťou mezozoických komplexov, aj keď menšieho plošného rozsahu.

Najvyšší počet – päť povodí (s výnimkou Belej) bolo zasiahnutých suchom v rovnakom, resp. podobnom období v rokoch 1990 a 1991. V povodí Žitavy sa sucho často vyskytovalo v rovnakých rokoch ako v českých povodiach, hlavne v povodí Teplej. Naopak, sucho v povodí Metuje bolo často synchrónnejšie s výskytom sucha v slovenských povodiach, než v ostatných českých povodiach. Najdlhší výskyt sucha bol určený v povodí Rakovnického potoka, kde v období rokov 2006–2010 trvalo sucho stanovené metódou SPA 1569 dní. Keďže v ostatných hodnotených povodiach sa také dlhé sucho v tej istej, resp. podobnej časovej periódе nevyskytlo, bolo toto sucho pravdepodobne zapríčinené nadmerným využívaním vodných zdrojov povodia.