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SMALL MONTHLY WATER BEARING VALUES OF THE STREAMS OF THE CZECH SOCIALIST REPUBLIC

The increasing off-take of water from rivers and of groundwater for the satisfaction of the needs of industry, agriculture and the population in towns and villages results in an increasing interest in a better knowledge of the regime of small water bearing values of streams. Their occurrence and long duration can cause serious not only operation and production difficulties but owing to considerable pollution of streams even health and hygienic ones, especially below places of point pollution by waste water where their necessary dilution for the sake of a more efficient self-cleaning process is impossible. Owing to the fact that small water bearing values can occur simultaneously on all streams of extensive territorial units, the damages caused by them can attain a higher extent than those evoked by floods. These reasons as well as the effort of getting better acquainted with the elements of the discharge regime of Czech rivers led me to the investigation of the spread in space and time of small run-off and its regional dependences in the rivers of the Czech Socialist Republic in the period between 1931 and 1970.

For the purpose of temporal delimitation of small water bearing values discharges exceeded in average 355 days in a year were used in our country until lately. But it appeared that this limit ceased to be suitable not only for water supply planning focussed on the utilization of rivers as water resources and economically advantageous ways of liquidation of waste, but even for the study of the regime of small water bearing values. Their main disadvantage as a criterion of small discharges was that the substance of this discharges contradicted the different natural conditions of the Czech rivers affecting the magnitude and frequency of the small water bearing values. If the discharges mentioned above are used, the frequency of occurrrence and the average duration of the small water bearing values would be absolutely equal not only in our rivers but in general in all streams of the world which contradicts the different conditions for river feeding and, accordingly, even for the run-off from the river basin.

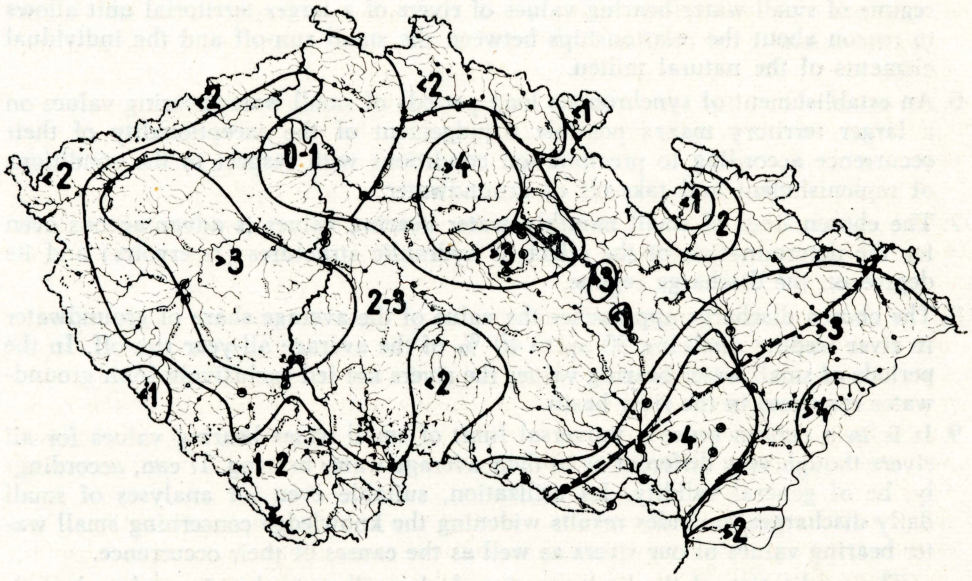
The first task of research was to find a more suitable limit for the analysis of the small water bearing values of rivers be it judged according to the values of daily or monthly discharges. The task was tackled on the rivers of the Morava River basin and the results were published (R. Netopil 1976). In the publication the analysis was described of the frequency of occurrence and the distribution in time of small monthly water bearing values for which the monthly run-off corresponding to 3 % of the annual average run-off appeared to be suitable. It corresponds in substance to the discharge attaining 36 % of the long-term average discharge (normal). It has the following advantages:

1. It comports with the character of the small water bearing of rivers for it is mostly lower than the average of the series of discharges of the months of smallest water bearing values in the individual years.
2. It allows to find out the agreement or disagreement in the distribution in time of the periods of small water bearing values and with rivers with analogical natural and geological conditions in the river basin affecting the run-off and even the agreement or similarity in the duration of those periods.
3. In the case of rivers with diverse natural and geological conditions in the river basin it gives a true picture of the deviations caused by them both in the average duration and in the duration of the individual periods of the small water bearing values.
4. In rivers with very steady run-offs the monthly discharges do not fall to the limit of small water bearing values at all or only exceptionally. This is in line with the properties of these streams in which even minimum discharges need not have the character of a small water bearing.
5. The possibility of a cartographical representation of the diverse features of the regime of small water bearing values of rivers of a larger territorial unit allows to reason about the relationships between the small run-off and the individual elements of the natural milieu.
6. An establishment of synchronous long periods of small water bearing values on a larger territory makes possible a judgement of the exceptionality of their occurrence according to precipitation conditions with respect to the conditions of replenishment and take-off of groundwater.
7. The chosen limit of small monthly water bearing values is advantageous even for the determination of the effect of hydraulic structures (reservoirs) and its degree on the discharge regime.
8. The chosen discharge approaches the value of the average share of groundwater in river feeding attaining 30 up to 40 % of the average all-year run-off. In the periods of small water bearing values the rivers are fed exclusively from groundwater resources in the river basin.
9. It is in a certain sense a universal limit of small water bearing values for all rivers though very different as to their average water bearing. It can, accordingly, be of general validity. Its utilization, suitable even for analyses of small daily discharges, provides results widening the knowledge concerning small water bearing values of our rivers as well as the causes of their occurrence.

The application of the limit mentioned of small water bearing values has allowed to get a completely new idea of the considerable differences both in average duration and in the distribution in time of the small water bearing values, of their regional deviations and, accordingly, even to determinate the territorial units, in which the rivers are endangered by a distinct fall of discharges to a diverse extent and in a diverse time. The 40 years sequences of monthly discharges from 133 water gauging stations and from 26 stations with at least 20 years sequences are certainly sufficient for objective conclusions both as to the regime of small water bearing values in our streams and as to possible effects of some properties of the natural milieu on the regime.

An analysis of the occurrence of small monthly water bearing values has shown that their average duration changes in the rivers of the Czech Socialist Republic from more than 4 months to less than 1 month with cases when the monthly discharges did not fall to the limit of the small water bearing values in

the whole period at all or only sporadically. A sporadic or zero occurrence was established in rivers with basins on permeable sandstones of the Czech Plateau and in rivers below larger reservoirs with power generation and protective function. The first case is in line with the high natural equalizing ability of run-off in a permeable rock milieu in which groundwater resources originate, replenish and are equally taken-off, appearing as an important resource of river feeding. The dissected relief of the sandstone plateaus contributes to a more intense exchange of groundwater resources. The fact that in the same Czech Plateau where outcrops of impermeable rocks occur (clays, claystones) the average duration of small water bearing values attains 4. 7 months proves that the degree of permeability of the rock milieu is a first-rate factor for the frequency of occurrence of small water bearing values. In the second case water reserves in water basins controlled from the point of view of water supply are concerned, the utilization of which according to plan causes considerable oscillations in discharge in the course of the day which do not manifest themselves in monthly run-off.



1. Average duration of small monthly water bearing values (1, 2, 3, 4 = average duration expressed in months).

In the other rivers the average duration of small monthly water bearing values decreases with increasing altitude of the river basin above mean sea level sinking in the highest mountain chains below 1 month. But this conclusion is valid only for the rivers of the territory of the Czech Massif. In the Carpathian part of the Morava and Odra river basins the changes mentioned were not confirmed. Even this second law governing the spatial deviations of the average duration of small monthly water bearing values is connected to a certain extent with the rate of the run-off of groundwater and its share in river feeding. In mountainous regions built of relatively less permeable rocks i. e. crystalline or diagenetically strongly consolidated sedimentary rocks numerous authors established

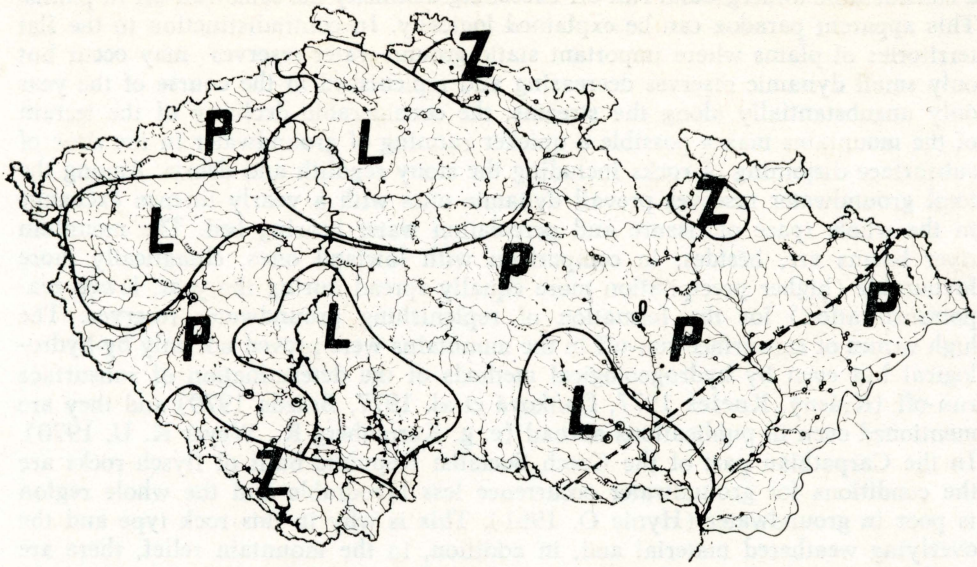
a considerable underground run-off exceeding distinctly the same run-off in plains. This apparent paradox can be explained logically. In contradistinction to the flat territories of plains where important static ground-water reserves may occur but only small dynamic reserves decreasing and replenished in the course of the year only unsubstantially along the streams, the considerable declivity of the terrain of the mountains makes possible a quicker running of groundwater in the zone of subsurface disjoining of rocks including the stony regolith and debris. Among the total groundwater reserves prevail dynamic ones with a yearly intense exchange in the whole space of fissure and percolation water bearing bed. The mountain river basins are, besides, in comparison with lowland ones, climatically more favourable (higher precipitation more equally spread during the year, lower evapotranspiration) for the formation of replenishing groundwater reserves. The high values of subsurface run-off in the mountains were proved not only by hydrological but even by hydrogeological methods of the determination of subsurface run-off (Krásný, Kněžek 1977, Daňková et al. 1977, Brázda 1970) and they are mentioned even in publications abroad (e. g. Karrenberg R., Weyer K. U. 1970). In the Carpathian part of the Czech Socialist Republic built of flysch rocks are the conditions for groundwater occurrence less favourable and the whole region is poor in groundwater (Hynie O. 1961). This is why in this rock type and the overlying weathered material and, in addition, in the mountain relief, there are no favourable conditions for a more uniform feeding of rivers not even in a climatically more favourable terrain (river basin in the summit zone of mountain ridges).

The pointed out properties of the natural milieu of the river basins manifest themselves even in the deviations of the distribution of the small monthly water bearing values in the course of the year. The following laws follow from their analysis:

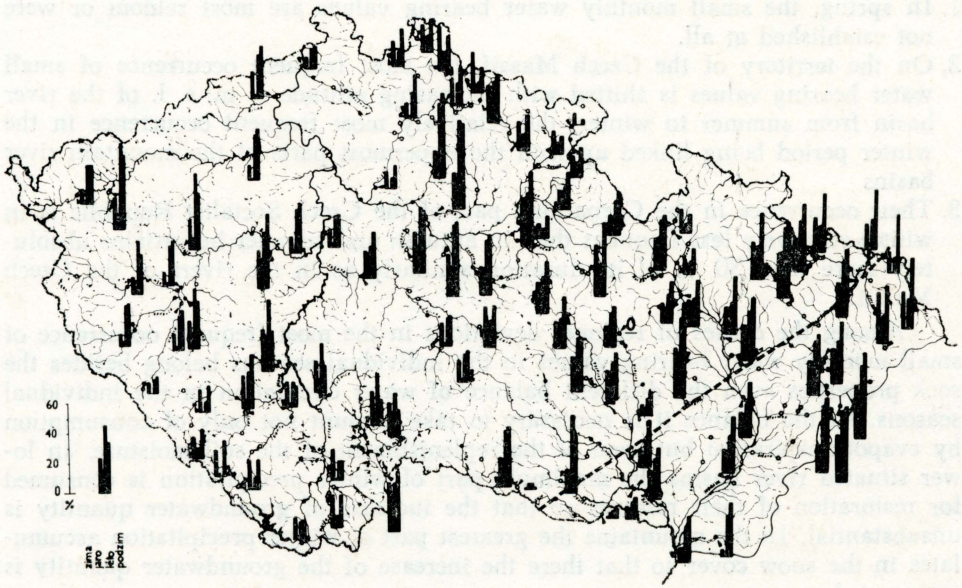
1. In spring, the small monthly water bearing values are most seldom or were not established at all.
2. On the territory of the Czech Massif, the most frequent occurrence of small water bearing values is shifted with increasing altitude a. m. s. l. of the river basin from summer to winter, the relatively most frequent occurrence in the winter period being linked up with the uppermost parts of the mountain river basins
3. Their occurrence in the Carpathian part of the Czech Socialist Republic is in winter relatively less frequent than in autumn and summer but attains absolutely more than 30 % of its duration similarly as in the rivers of the Czech Massif.

Among the causes of regional deviations in the most frequent occurrence of small monthly water bearing values in the individual seasons belong besides the rock properties even the different balance of water circulation in the individual seasons. In the balance it is necessary to take account not only of consumption by evapotranspiration but even of the replenishment of the soil moisture. In lower situated river basins the maximum part of winter precipitation is consumed for restoration of their reserves so that the increase of groundwater quantity is unsubstantial. In the mountains the greatest part of winter precipitation accumulates in the snow cover so that there the increase of the groundwater quantity is interrupted.

Following knowledge follows from the analysis of the regional deviations in the frequency of occurrence of small monthly water bearing values:



2. Most frequent occurrence of small monthly water bearing values in seasons (Z = Winter, P = Autumn, L = Summer).



3. Occurrence of small monthly water bearing values in seasons (percentage). Winter, Spring, Summer, Autumn.

1. In spite of the differences in the relative duration of small water bearing values in winter, their total occurrence in this season is similar in lowland as well as mountain rivers. The small water bearing values can last the whole winter once in three up to five years in average.
2. In spring, the frequency and even probability of the occurrence of small water bearing values decreases with the altitude a. m. s. l. of the river basins; in rivers flowing from the highest mountains their occurrence was established either not at all or isolatedly in March which has in such places rather properties of a winter month.
3. In summer, great regional deviations in the frequency of occurrence of small water bearing values were established. Rare cases show that they need not occur at all, in other rivers they can last in average every second year the whole summer. The frequency of their occurrence decreases with the increasing altitude a. m. s. l. But this rule is not valid in the Carpathian part of the Morava and Odra river basins.
4. In autumn, the regional deviations in the frequency of occurrence of small water bearing values decrease but the relationship between the frequency of their occurrence and the altitude a. m. s. l. of the river basin keeps preserved.

As to the continous duration of small monthly water bearing values, i. e. their periods, it appeared that in rivers with their basin in plains, hilly lands and lower highlands they can exceptionally exceed one year, in mountain rivers usually only 4 up to 6 months. In the former, their occurrence for more than 6 months is more frequent, in the latter ones it is rather rare. In both cases the long periods of small water bearing values are connected with lack of precipitation, especially in the autumn and winter periods. Owing to the fact that with the said lack of precipitation is connected even the insufficient increase of groundwater reserves, they can draw out even for the following spring and summer seasons.

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Résumé

MALÉ MĚSÍČNÍ VODNOSTI NA ŘEKÁCH ČESKÉ SOCIALISTICKÉ REPULIKY

Za hranici malých měsíčních vodností řek autor používá měsíčních průtoků, odpovídajících 36 % dlouhodobého průměrného průtoku, odvozeného z období 1931—1970. Ukázalo se, že tato hranice má mnoho předností před dosud používaným denním průtokem průměrně překročeným 355 dnů v roce. Mezi nimi je i ta, že jí lze použít i pro vymezování období malých denních průtoků. Zhodnocením měsíčních průtoků čtyřicetileté řady ze 133 vodoměrných stanic a nejméně dvacetileté řady z 26 stanic v povodí Labe, Odry a Moravy na území ČSR dospěl autor k závěru, že průměrné trvání malých měsíčních vodností se může měnit v rozsahu od méně nežli 1 měsíce na horských řekách až po více nežli 4 měsíce v roce na řekách rovin, pahorkatin a nižších vrchovin. U řek s povodím na propustných pískovcích a pod některými vodními nádržemi se nevyskytly buď vůbec, nebo jen zcela ojediněle. Jejich časové rozložení je takové, že nejčetnější výskyt se posunuje s rostoucí nadmořskou výškou povodí od léta do zimy. V regionálních odchylkách průměrného trvání i časového rozložení malých měsíčních vodností, ale i v extrémní délce a četnosti výskytu jejich period lze pozorovat zákonitost vertikální zonálnosti a výrazného účinku míry propustnosti nejen hornin, ale i zvětralin na nich. Jejich vlastnosti spolu s reliéfem podmiňují tvoření i dynamiku vyčerpávání zásob podzemní vody, která je jediným zdrojem napájení řek v době výrazného poklesu jejich vodnosti. Přiložené kartogramy poskytují přehled o regionálních odchylkách v průměrném trvání a časovém rozložení malých měsíčních vodností.