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TOWARD THE REGIONALIZATION OF THE LANDSCAPE WATER POTENTIAL IN SLOVAKIA

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Dans ce rapport on montre sur le problème de l'évaluation du potentiel de l'eau dans l'environnement naturel, qui fait l'objet de l'étude des sciences géographiques. Non seulement les bus scientifiques, mais aussi l'économie nationale ont besoin de la connaissance régionale du potentiel de l'eau pour leur développement suivant. It faut étudier l'eau dans le cadre des systèmes structraux de l'entier environment naturel et dont la géographie est justement la plus proche. Les méthodes de la recherche du potentiel de l'eau sont choisies selon l'étendue du territoire, la forme morphologique et le milieu rocheux. Dans les territoires compliqués, comme est aussi le territoire de la Slovaquie, c'est une tâche difficile et très laborieuse. Cela exige de nombreuses recherches dans le terrain et un réseau dense des objets d'observation.

In the present world national economy problems the problem of water rises probably the most markingly above the other, although there is not even so much written or said about it, as about the crude oil, coal, electricity or uranium. With regard to the world water natural resources and to its quantity it seems quite paradoxal that there is little of it on the continents in the sense of the social need. It is quite justified to speak about the world water economy crisis which, however, does not come forth as a result of reduction of the water resources, but of an always increasing pressure on their always greater exploitation on the one hand and on the other hand of their deppreciation by anthropogeneous interventions in the environment. From all kinds of waters for the man the most important is the drinkable water drawn from the upper parts of the earth's crust, either by catchment of sources, or pumped from all kinds of wells, or by other technical interventions [10]. From the geological and hydrographical stand point the extension of groundwaters is very unequal on the globe. There are vast land units, big countries and states where there used to be enough of good quality groundwaters, on the other hand there are areas with insufficient groundwaters to completely passive. In the water passive areas, with a modern civilization, water reservoirs are built on rivers and the surface water is treated to a drinkable water which, however, can never reach the quality of groundwaters [1]. As we know, there are, however, also such areas where lack of water forces the people, whole tribes to migrate and frequent are also the cases of death from lack of water.

The water economy situation in the environment is not favourable either in the ČSSR, or in Slovakia (SSR). The territory of Slovakia belongs to two seas (the Baltic and the Black Sea). The rivers take their source in our country, they have great stream gradients and the water flows rapidly into the neighbouring states. It is why gigantic dams are built to catch the waters and prevent them to leave our country by the shortest way. Water reservoirs are built for their use in the water economy, energetics, agriculture and recreation [1].The water economy administration pays a considerable attention to groundwaters which by preference are used to supply the water-pipes for the inhabitants. In Slovakia more than 60 % of the inhabitants are supplied with drinkable water by means of public, municipal and group waterpiping and till 2000 it will be 90 % of the inhabitants. The drinkable water resources are already insufficient and it is why wide researches are made and new resources of drinkable waters are looked for. The present confirmed resources of groundwaters in the territory of Slovakia amount to about 60 $m^3 . s^{-1}$, but the prognostic resources amount to about 80—85 $m^3 . s^{-1}$ [9]. If the groundwaters were used only for the people's proper need, their reserves will be sufficient far after the year 2000.

The world prognosis on obtaining good quality waters is very pessimistic. Almost all the world great cities are supplied by waters of the treated surface water courses, or water reservoirs. As highly prognosticated waters for supplying the people with drinkable water are those of the fjords and glaciers and already today they serve as water reserves in many north- and west-European countries. In the future the humanity will have to make a considerable technical effort and at the cost of great financial means for the aquirement and distribution of good quality waters mainly for drinking purposes, pharmaceutical and food industry.

In the geographical water research as one of the most typical components of the environment we consider it as the unifying geological factor between the anorganic and organic components. By its specific properties and modifications it acts on the anorganic components of the environment mainly mechanically and these again on it mainly geochemically. On the other hand water by its biogeneous quality is a limiting factor of the entire bioecology and in the historical-cultural-technical sphere of the development of the society and of her civilization is a socioecological factor. Therefore it is no wonder that even the modern society has toward the water her specific and special relationships which are worsening to the water disadvantage by transforming the environment into an anthropogeneous environment [6].

The geographical sciences deal in the greatest detail with the mentioned relationships, which solve the spatial relationships of the geospatial systems and synthetize not only the relationships of knowledge, but also the optimization of the landscape arrangement so as to permit their components to develop symbiotically to the advantage of man. It is why also water as one of the subsystems whether of natural or anthropogeneous environment is and must be also the object of a detailed geographical study, in spite of the fact that there are certain specialized sciences which deal with the water analytical research, but do not synthetize its ecological relationships, or in an incomplete measure with the other components of the landscape environment. The humanity and the entire biosphere are simply dependent on the water.

Therefore one of the fundamental tasks of the modern geography is to examine the time and spatial relationships of the water circulation in the planetary system, as well as in the individual landscape units. The geography must examine the landscape in the full extent of its dynamics and potential and take into consideration the systems approach of evaluation of all elements of the environment.

THE WATER POTENTIAL AND ITS FACTORS

The water potential of each environment is the real water quantity found in the given environment. In hydrogeology this quantity is frequently indicated as natural reserves [2] and it can be stated that the geographical terminology of the „water potential" expresses better the reality. The water potential in the natural system is a dynamic, mobile component, changing in the time and in the space and depends also on the other components in the system of natural components. Then the geographical sciences do not delimit this potential only according to the substratum, but on the complex principles of regionalization in the dynamic process of the whole environment.

From the above mentioned methodic considerations it results that only after knowing the spatial and time distribution of the individual kinds of surface and ground waters (which are divided into fresh, mineral and thermal to hot waters) we can start up with their balancing and typification. The object of water typification may be the genetic, dynamic, morphologic, chemical, geochemical, but also the static factors (the natural water reservoirs and the accumulations of the groundwaters) and the substratum factors [8].

The balancing of waters starts from the hydrological balances which based on the measurements of real balance elements, obtained by the hydrological methods of research (rainfalls, surface run off and the total losses) give us the values of discharges in the rivers, of the groundwater table and their fluctuation as well as the fluctuation of the spring yields. This fundamental, today current balance serves mostly the fundamental problems of the water economy and remains much indepted to the regional balance of the complex water potential. There has not been sufficiently developed methods for the determination of the run-in and runoff of groundwaters, for their balance relationships between shallow and deep flow and do not consider the portion of waters, which are metamorphosed into mineral and thermal waters. This problem remains open even in our country [8].

The water structural systems have partially a universal holding and partially a regional one with different structural forming elements, which are the rainfalls, morphology, elements of the substratum, the vegetation cover, soils, climate, etc. Large areas with relatively equal climatic regions and morphological elements of the surface and the substratum — i. e. equalized structural forming elements for the water have also balanced hydrological laws of surface and groundwaters, evapotranspiration and total losses. On the opposite small areas with a varied morphological structure and different structural elements for the water, which change frequently even in areas with a few kilometres, there hold in detail different laws of water flow — here the structural systems are delineated in detail [7].

A typical example of small areas for water with different structural elements changing in relatively small areas, is the territory of Slovakia covering a surface something above 49 000 km^2. Two thirds of the territory form mountain ranges and hilly countries with a varied vertical and horizontal articulation, morphology and tectonics, with strongly differentiated elements, vegetation cover, soils, etc. All this has for the result a considerable differentiation of extension, quantity and intensity of rainfalls which, apart from Danube, Uh and Latorica, are the only suppliers of water to our territory. Brooks and rivers have a considerable gradient. Their hydrological and dynamic activity from the balance stand point is disadvantageous for the area and as we have already mentioned, the water economy activity must be bettered by the construction of dams and of small and big water reservoirs which, apart from the energetic exploitation, help to average and distribute the discharge waters throughout the whole hydrological year [1]. The river aquosity depends on the yearly rainfalls and snow melting. Dependently on these factors the greatest long-lasting are the big discharges in the first half of the year—March to May, with the highest percentage of runoff. The minimum discharges are shifting to the winter period — November to February [4, 12]. The regime of ground waters (fluctuation of water tables) and the yield of springs change parallely with these courses. In the territory of Slovakia there are registrated more than 63 000 springs, but their yield is by 50 % smaller than 2.0 $1 . s^{-1}$.

The geographical methods of water researches do not follow only their regional distribution, but also their amount and origin in individual regionalized types. The knowledge of the origin of waters in the individual regions of the natural, but nowadays mainly of the anthropogeneous environment is of a great significance for the creation and protection of the environment. When we know the origin of waters in the individual natural basins we know how to protect their quality and in the case of its deppreciation we know how to identify the individual sources of pollution and in general we can follow all the potential resources of the surface and groundwater pollution.

METHODS OF WATER RESOURCES BALANCING AND INVESTIGATION OF THE WATER POTENTIAL

Even when the rain waters are the only resource of all kinds of waters — surface, groundwaters, mineral and thermal in our territory, yet the balance portion in the direct recharge mainly of groundwaters is very variable with regard to the terrain morphology, vertical articulation, hydrophysical properties of the substratum (geological environment), terrain cover (soils and vegetation) and others. Typolologically with regard to the mentioned problems we can divide the groundwaters in the individual regions, or in the geomorphological units into regions, whose groundwaters are recharged to 100 % only from the rainfalls (mountain ranges), into regions whose grounwaters are recharged to 80 % by the inflow from the mountain ranges (piedmonts, hilly countries and deeper artesian horizons of lower hilly countries and the deeper parts of the basins), into regions where the groundwaters can be recharged from rainfalls equally as from inflows from the neigh-

bouring areas (terraces, alluvial cones, blown sands) and into regions where the groundwaters are recharged to 80 % from the brook beds, and rivers and only to 20 % also from the rainfalls (flood lands of basins and plains [10]. The potential resources of pollution and worsening of the water quality may be in the first case mainly the rain waters with the content of exhalations, in the second case exhalations and grazing, less agriculture, in the third case agriculture, communal equipment, less industry and in the last case mainly the agriculture and industry directly. It is necessary to start from the laws that the waters can be qualitively worsened by the autochtonous resources in the region, or by the allochtonous resources outside the region, for ex., by inflowing waters from the neighbouring regions (more distant) in the surface water courses and by their infiltration to the groundwaters. The examples of them are but too many and it is not necessary to mention them [11].

Another task of the geography in the research of waters is the hydrographic regionalization of the water fund by the regionalization balance. Water as the „natural raw material" by its dynamics and regeneration capability is beyond the normal balance evaluations of „statistical raw materials" (the so-called reserves), which do not migrate, they form a firm geometrically limited mass and after exploitation they regenerate no longer [8]. In a similar research and evaluation of waters all waterstructural systems and waterstructural elements must be evaluated. Said only figuratively that no substantial role is played here only by the quantity of rainfalls, or only by the size of the morphologic unit, by the geologic whole or hydrogeological structure. In the territory of Slovakia the greatest number of rains fall for instance on the Vysoké Tatry mountain range, but with regard to its relatively small surface and relatively unfavourable hydrophysical properties of the substratum rocks, or morphologic structure, they are poorer in waters, for example the Nízke Tatry or the Veľká Fatra mountain ranges, where the rainfalls are represented by smaller values, but they have other suitable waterstructural elements — area, calcareous-dolomitic rocks, vegetation of the Alpine zone with polygonal soils, etc. A typical example of similar regionalization are the mountain ranges built by rocks of the outer flysch, which are the biggest in extension, they have also good rainfall conditions, but for water occurrence they are indicated as with a passive water balance. If we look in the geographical and mainly geomorphological map of the territory of Slovakia we see the alternation of mountainous to hilly country relief with deep valleys, intramontane basins, furrows and narrow valleys or plains of rivers [6, 7]. At a look on the geological map (uncevered -without the Quaternary formation) we see the maximum geological variety with rocks from the Algonkian to the upper sedimentary and volcanic Neogene. These rocks present a different variation of hydrophysical properties and with a varied tectonic structure they form a mosaical geological structure of the individual regions. The vertical articulation of the territory of Slovakia is about from 100 m a.s.l. to 2655 m a.s.l., meanwhile in the horizontal articulation are visible the morphostructures of zonal mountain ranges of the inner West Carpathians with alternating basins and long river valleys. The geographical methods of research in similar complicated natural conditions give a truer picture on the differentiation of individual hydrostructural elements than the other sciences. As an example we would like to state that on the geological maps each rock

is expressed superficially, without the cover and soil and without the morphological structures. Thus in the hydrogeological conditions and balance relationships may easily enter elements which misrepresent the natural value of the studied region. Without a good knowledge of the numerous hydrostructural elements it is impossible to make a balance delineation reliably neither of the ground flow, nor of the total real evapotranspiration. Then from the members of the balance equation we know the most exactly [but not quite exactly] only the rainfalls and the surface runoff, to measure them we have direct methods for finding them. We do not know in substance quite exactly the values of the rainfalls, because of the small number of raingaging stations and their directly unsiutable geographical position. Directy in the mountain ranges where there is the greatest number of ranfalls, there is the least number of observation stations, because it is impossible to ensure their regular attendance mainly if the winter months with regard to the great distance of residential quarters. By modern methods of measuring the rainfalls at the experimental stations it has been proved that the presently measured yearly sums of rainfalls have a smaller value from 20—22 % as against the reality. On the other hand there are discussions again about the overestimation of the values of the total evapotranspiration which is determined by methods taking not into consideration the character of the cover, hydrophysical properties of rocks, character and thickness of soils, dipping of the terrain and its exposition, etc. From the above discussed problems it results that the problem of water balancing in the regional sense is quite difficult and mainly when we evaluate the waters as a real natural component [2]. In this connection it will probably be well to recall that a slightly different view on the water balancing, mainly underground waters, have the water economists and hydrogeologists [not only in our country]. They see the water economy positiveness and by it also the „good" hydrogeological conditions of the region through the presence of economically exploitable water quantities, which again for the mining hydrogeologist are indicated as negative with regard to the threat of water inflows to mines. Therefore it remains with the geographer-hydrologist to have the landscape objectively valued on the basis of its natural position, i. e. even the water in it without special aims for its categorization through positivity or negativity in the quantitative sense of the water economists. This problem must be solved consequently in the sense of the needs of the national economy.

IN THE REGIONALIZATION SENSE OF EVALUATING THE SPRINGS

of fresh waters the starting point was and still is the fluctuation of springs, their altitude position or the temperatures of their waters [1]. The knowledge of the values gives a certain sight on the regional distribution of springs, but in a lesser measure on their dynamics and regime, and still less on their relationships to the origin of their waters in the sense of the konwledge of the infiltration area and circulatory paths. It appeared that our time observation series of spring yields of 5—10 years do not bring forth objective facts on the springs regime in relation with the climatic conditions. This applies, for instance, to karst springs. We have facts that our valued fluctuation of

yield from long-term observations was 80—800 $1 . s^{-1}$ and the winter came suddenly with considerable snowfalls and at their melting the spring maximum yield was up to 1300 $1 . s^{-1}$ (the Strážovská hornatina mountain range — the Vrchovište spring in Slatinka nad Bebravou, supplying the Nitra water mains). Similar facts were obtained also in water discharges of the surface water courses, for example, on the Hron river.

A considerable problem in the geographical landscape research quite frequently forgotten is the regional evaluation of mineral and thermal waters [3]. In evaluating them mainly in the balancing sense, but also in the synergetic relation to the other components of the natural environment we must see them as one balancing element in the distribution of ranfalls. They belong to the whole water balance equally as the remaining waters and where they occur they are an equivalent component of the water system. Their qualification criteria in the regional, but also in the balance sense against the fresh waters are most frequently accompanied by their mineralization, presence of gases, temperature and genesis which the geochemistry deals with in more detail [3].

A further balance problem in the regionalization sense of water evaluation in the territory of Slovakia are the passages of groundwaters from mountain ranges into the surface water courses and vice versa, the water losses from the surface water courses into the substratum. These mutual relations are known mainly in the areas where the surface waters cut through the rock masses of limestones and dolomites, or their beds are built (quite frequently) on tectonic lines. This problem can be studied well mainly in the Nízke Tatry mountain range and in that of the Veľká Fatra, but also in other karstic areas [9].

Little are still developed the hydrological and hydrographical theories and the balance evaluation of the groundwater reserve recharge of floodplains of the basin and plain regions from the flood waters, bringing waters from the rains fell in the mountainous regions. As an example of these relations we give the Váh river basin. The snow and storm waters of the Vysoké and Nízke Tatry mountain ranges cause high waters in the Váh river bed, from which they infiltrate to the river flat ground waters along the entire length of the bed and recharge their „reserves" without their own region rainfalls. A specific position in this sence of the water fund balance in Slovakia has the Danube whose waters in the Bratislava-Gabčíkovo sector recharge the groundwater of the Žitný ostrov at water levels [10].

CONCLUSION

In this short report it is not possible to sum and methodically elaborate on all the problems of the regionalization water balance. It was intended solely to point to the problems of the water balance whose solution falls also within the geographical landscape research and its potential. Further on it is necessary to point to the need of the systems approach in the water research as one of the fundamental elements in the geosystem. It is also in the interest of the optimum landscape use and its resources, but equally in that of the creation and protection of the environment.

Our present facts on the evaluation of the water potential enable us solely to realize this problem in the full extent. From a more detailed analysis of research of this problem it appears that the natural potential of all kinds of waters, mainly underground waters, is substantially greater, as stated by the present balances and that by more complex methods we must arrive to regionally balance relationships between all kinds of waters. In our conditions, but also in the world ones, it is necessary to make a balance concentration mainly on the exact establishment of the real evapostranspiration, surface water passages into the groundwaters and the contrary, on the passage of waters between the individual geomorphological and tectonic units and on the balance part of waters of deep horizons — among the mineral and thermal waters.

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K REGIONALIZÁCII VODNÉHO POTENCIÁLU KRAJINY NA SLOVENSKU

Typickým príkladom malých území pre vodu s rozdielnymi štrukturotvornými prvkami, meniacimi sa na pomerne malých plochách, je územie Slovenska o rozlohe niečo väčšej ako 49 000 km^2. Dve tretiny územia tvoria pohoria a pohorkatiny s rôznou členitosťou, a to vertikálnou i horizontálnou, morfológiou, geológiou a tektonikou so silne diferencovanými prvkami, vegetačným pokryvom, pôdami a pod., čo všetko má za následok veľkú diferencovanosť rozloženia, množstva a intenzity zrážok, ktoré sú okrem vôd Dunaja, Uhu a Latorice jedinými dodávateľmi vody nášmu územiu. Potoky a rieky majú veľké spády. Ich hydrologická a dynamická aktivita je bilančne v neprospech územia, a preto vodohospodárska aktivita sa musí vylepšovať výstavbou priehrad, ako aj veľkými i malými vodnými nádržami, ktoré popri energetickej využiteľnosti pomáhajú spriemerňovať a distribuovať prietokové vody počas celého hydrologického roka.

Typologicky, vzhľadom na uvedenú problematiku, môžeme podzemné vody členiť v jednotlivých regiónoch, resp. v geomorfologických celkoch na regióny, ktorých podzemné vody sa doplňajú na 100 % iba zo zrážok (pohoria), ďalej na regióny, kto-

rých podzemné vody sa až na 80 % dopĺňajú podzemným prítokom z pohorí (podhoria, pahorkatiny a hlbšie artézske horizonty nižších pahorkatín a hlbších častí kotlín), ako aj na regióny, kde sa podzemné vody môžu dopĺňať tak zo zrážok, ako aj z prítokov zo susedných území (terasy, náplavové kužele, viate piesky) a konečne na regióny, kde podzemné vody sa až na 80 % dopĺňajú z koryta potokov, riek a iba do 20 % aj zo zrážok (nivné územia kotlín a nížin).

Úlohou geografie vo výskume vôd je hydrografická regionalizácia vodného fondu formou regionalizačnej bilancie. Voda ako prírodný nerast so svojou dynamikou a regeneračnou schopnosťou sa vymyká z normálnych bilančných hodnotení statických nerastov (tzv. zásob), ktoré sa nesťahujú, ale tvoria pevnú, geometricky ohraničenú masu a po vytažení sa viac neregenerujú. Pri takomto výskume a hodnotení vôd sa komplexne musia hodnotiť všetky vodnoštruktúrne systémy a prvky.

V regionalizačnom zmysle hodnotenia prameňov obyčajných vôd sa vychádzalo, ba sa aj vychádza z rozkolísanosti prameňov, z ich výškovej pozície alebo teploty ich vôd. Poznanie týchto hodnôt poskytuje určitý pohľad na regionálne rozloženie prameňov, ale už menej na ich dynamiku a režim a ešte menej na ich vzťahy k pôvodu ich vôd v zmysle poznania infiltračného územia a obehových ciest.

Značným problémom v geografickom výskume krajiny, na ktorý sa dosť zabúda, je regionálne hodnotenie minerálnych a termálnych vôd. Pri hodnotení, a to najmä v bilančnom smere, ale aj v ekologickom vzťahu k ostatným zložkám prírodného prostredia, musíme na ne hľadieť ako na jeden bilančný prvok v distribúcii zrážok.

Ďalším bilančným problémom v regionalizačnom zmysle hodnotenia vôd sa na území Slovenska prestupy podzemných vôd z pohorí do povrchových tokov a naopak, straty vôd z povrchových vôd do substrátu. Tieto vzájomné vzťahy sú známe najmä v územiach, kde povrchové toky prerezávajú masívy vápencov a dolomitov alebo kde korytá majú vybudované na tektonických líniách (čo býva tiež dosť časté).