REGIONAL CO-OPERATION IN THE DANUBE RIVER BASIN

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Between 1965 and 1974, UNESCO initiated a new chapter in the co-operation of all riparian countries, at the scientific level. The first suggestions for develop-ing a comprehensive hydrological monograph of the Danube drainage basin were issued by the Yugoslav National Committee in 1970/71. At the same time, the work of the Danube Commission Scientific Hydrology working group started. Results of this common work created the basis for a higher level overview of the general situation in this river basin - the second largest in Europe. The time period of 1941-1970 was used in this study. After very intensive work, so-called working versions of The Danube river and its basin in German and Russian were prepared and, finally, a quadrilingual publication was published in 1986.[1]

Since then, international co-operation within the Danube river basin has been co-ordinated by the German National Committee for UNESCO International Hydrological Programme (IHP). This initiative signalled a new era of co-operation, and a lot of interesting research works and publications were prepared. The main achievements between 1987 and 1992 are briefly described by K. Hofius[2]. Since 1993, specific tasks in the framework of the UNESCO IHP are managed by the Austrian National IHP Committee, headed, at present, by Oskar Behr from the Technical University of Vienna.

The Danube river has been the focus of many other organisations lately; after the political and economic changes in Europe, the PHARE Programme, the Bucharest Convention and the Sofia Agreement have played an important role.

For example, in 1990, the Environmental Programme of the Danube River Basin began. Here, hydrological data are again the basis for various more detailed studies - evaluation of river quality, total flux of pollutants, environ-mental risk analysis and early warning systems. It was found that there is a very urgent need to process new data. It is useful for all ongoing projects to extend their time frames and to evaluate hydrological support for higher level decision-making processes in the river basin, by processing, as much as possible, all the available data for the time period of 1931-1995. This is, at present, the task of the Programme on Regional Co-operation in the Danube River Basin, in the frame-work of the UNESCO IHP, at the expert level.

The first step involved the preparation of supplementary volumes on special hydrological and hydraulics questions. In 1995, and following a certain period of negotiations, common work on the new edition of the Hydrological Monograph of the Danube River Basin began. Participating institutions are - in downstream order: Bayerisches Landesamt für Wasser, München, Germany; Technical University of Vienna, Austria; Czech Hydrometeorological Institute, Prague and Brno, Czech Republic, Water Research Institute Bratislava, Slovak Republic; University of Ljubljana, Slovenia; VITUKI Budapest, Hungary; State Hydrome-teorological Institute and Split University, Split, Croatia; School of Mining and Geology, Belgrade, Yugoslavia; National Institute for Meteorology and Hydrology, Romania; Bulgarian National UNESCO IHP Committee; Hydrome-teorological Service of Moldova; Ukrainian State Committee for UNESCO IHP. In the Slovak Republic Croatia, Bulgaria and Ukraine, there are also other institutions working on the project, but only the co-ordinator is mentioned here.

The role of the Water Research Institute is to take part in the pre-processing of runoff data and in the evaluation of data for evapotranspiration estimation. The water balance refers to an internationally co-ordinated scheme of sub-basins, not all of which are gauged up to the mouth of the confluence of the Danube river. This causes some theoretical and practical problems, which also include problems of runoff data availability and the assessment of the runoff contribution of ungauged interbasins. Some preliminary results are discussed here and some of the possible solutions are shown. Specific questions and runoff data compila-tion related to the complex water balance of particular sub-basins are demonstrated.

A case study of the full hydrological balance of the Nitra basin in Slovakia draws the attention of the working team mainly to the vertical distribution of hydrometeorological elements. Evidently, processing of the data by GIS technol-ogy is necessary, but this is not commonly accepted by all the participants.

Runoff data collection

At present, not all the necessary hydrological balance component data is available. The 1997 meeting of UNESCO IHP experts in Sofia was supposed to deal with the situation, and so organisational problems in data purchasing are not discussed in this paper.

Data quality verification creates an important role for the need to keep as precise a level of processing as possible. At the experts' working group meeting in Graz, held in August 1996, material describing a methodological theoretical approach to data verification - using all the available runoff data for each particular node following the main river channel - was distributed (Figure 1-2).

Figure 1. Scheme for the evaluation of runoff contribution from selected areas

Figure 2. Real scheme of node between Bratislava and Komárno
(The total area of this lowland landscape is 16,082 sq.km)

From the available data for the node on the main river channel between Bratislava and Komárno, the period of 1963 to 1972 was chosen for the follow-ing tributary profiles: Arpas at Raba, Hegyeshalom at Lajta, Šala at Váh and Nové Zámky at Nitra. The equations presented in Graz[3] were as follows:

$$Q(K) = Q(B) + Q(H) + Q(A)+ Q(S) + Q(N) + Q(T)$$

where Q(T) is the runoff contribution of the selected territory T, and is equal to the sum of Q for K in Komárno, B in Bratislava, H in Hegyeshalom, S in Šala and N in Nové Zámky. The equation can also be written as:

$$Q(T) = Q(K) - Q(B) - Q(H) - Q(A) - Q(S) - Q(N)$$

Theoretically, for $Q(T)>0$ precipitation is higher than evapotranspiration and, for $Q(T)<0$, evapotranspiration seems to be higher than precipitation. If the runoff contribution varies too much, the data has to be verified. In the scheme shown in Figure 3 it is possible to see, that the non-gauged area is crossed also by four brooks, flowing to the Lajta, Raba or directly to the Danube river.

Figure 3. The river node between Bratislava and Komárno

Runoff differences (Figure 4) for the test territory range from 389 m3/s to -935 m3/s, in absolute units. Expressed as a percentage of the runoff in Komárno, for the period of 1962-1973, figures range from 8.2 to -14 only. A detailed study of the data shows that the runoff of the Arpas on the Lajta river seems to be signifi-cantly influenced by the discharge in the Danube, especially during flooding.

Figure 4. Runoff differences between the discharge in Komárno and the sum of discharges at the nearest upstream profiles

It seems that probably all of the considered rivers in their lower sections are draining the surrounding area. The water infiltrating the inundation area south of Bratislava enriches groundwater reserves and it is therefore possible that this infiltrated and drained water could be measured twice. The discharge in Komárno is lower than sum of measured discharges above the downstream profile.

Significant differences can be seen in June and July 1965 when flooding caused the breakage of flood protection dams and, therefore, discharge in Komárno is partially shifted. However, Figure 5 shows that cumulative monthly mean discharge in Komárno and the cumulative sum of monthly mean discharge in upstream profiles, differs by less than 3%.

This result is not favourable for data error analysis, but the study of daily discharges, which are not available for all the profiles, can be somewhat helpful in this situation. It is also possible to study extreme values and plot all the standardised Qs discharges by applying the Qs = (Q-ì) ó –1 transformation, where m is the mean discharge for a given period and ó is the standard deviation of the sample.

Figure 5. Comparison of the cumulative discharge for Komárno and the cumulative sum of discharges at the nearest upstream profiles

If the runoff data set has a normal distribution, values for Qs lie between -3 and +3, the range of 3ó. In the standardised data set, only data pertaining to the flood period of 1965 was out of the expected range. Individual data sets for Sala - the Váh river - and Nové Zámky are showing some extreme values which have not been reconfirmed by similar studies carried out in Hungary, but which are probably accurate. Standardised data values reach or exceed +3, but this discrep-ancy is due to sample size.

Data collection and related problems are discussed for one particular node lying in the first Danube delta area. It is evident that the hydrological situation is influenced by so many factors, that it is difficult to set up a standard procedure for data verification. Hopefully, the data set standardisation method presented above can be used for obtaining a more complete picture of the nature of some of the extreme differences in data assessment preparation.

A case study - the Nitra river basin

The way of evaluating all the water balance elements is a question of further negotiation. Precipitation data will be processed by the Technical University of Vienna. A special projection plane defined for this purpose will be used in a GIS study. Assessment of areal evapotranspiration will be performed by the Water Research Institute in Bratislava. Monthly data on air temperature and humidity, runoff - in the closing profiles of balanced subbasins - and precipitation measured in internationally agreed upon units, will be used as input in the study.

Table 1. Monthly hydrometeorological elements for the Nitra river basin (1951-1980)

MONTH	TEMP	RAH	PRE	FLOW	PET	AET	SM
1	-2.12	82.67	36.08	16.21	11.38	7.72	114.79
2	-0.26	80.00	38.40	19.90	17.37	10.87	103.92
3	3.48	75.23	35.96	28.64	38.99	30.10	119.90
4	8.79	69.20	46.11	26.45	73.62	52.19	97.81
5	13.58	69.43	59.88	16.53	102.17	67.85	82.15
6	17.10	70.40	88.47	12.29	122.17	77.69	72.31
7	18.25	71.33	87.38	11.19	119.72	76.53	73.47
8	17.70	72.60	74.03	9.17	101.75	66.51	80.99
9	13.83	75.70	51.17	6.39	70.18	44.19	87.97
10	9.03	76.87	46.04	8.81	44.48	30.26	103.75
11	4.21	81.43	55.37	10.29	23.12	18.61	131.39
12	-0.18	83.83	55.17	16.79	12.22	8.88	122.51
SUM			674.06	182.65	737.17	491.41	
MEAN	8.62	75.72					99.25

TEMP air temperature; RAH relative air humidity; PRE precipitation; FLOW runoff; PET potential evapotranspiration; AET actual evapotranspiration; SM soil moisture

To study the impact of a possible climate change in Slovakia, a water balance model for the Nitra river basin was set up as a first step. The methodology is discussed in a Slovak report dealing with the impact of climate change on hydrology and water management.[4] Some conclusions, in English, can be found in the contribution to the Slovak Country Study on Climate Change, Element II, prepared by the Slovak Hydrometeorological Institute, in co-operation with the US Environmental Protection Agency.[5] This "case study" can be considered as one of the possible methodological approaches to solving the problem. To estimate monthly precipitation, different methods - Thiessen polygons, vertical layering and grid/GIS - were tested. For areal mean evaluation purposes, the obtained monthly data of areal precipitation was used in further modelling as a simple input, because of the lack of other in-space distributed data and parameters. This study was based on the hypothesis that the hydrological balance of a watershed is equal to the hydrological balance of a virtual point located at the centre of gravity of the watershed. The input meteorological elements are represented within the elevation weighted areal mean of air temperature and humidity, and areal precipitation totals. Basin runoff is measured at the lowest measuring station. Evapotranspiration and soil moisture values are obtained from the model. Results - mean values for 1951-1980 - are shown in Table 1.

Further steps have to focus on the areal distribution of specific runoff and actual evapotranspiration. Knowing the areal distribution of precipitation, it may be possible to apply a model similar to the one used for the whole watershed and to use a do-loop for areal layers, or direct for pixels, considering land cover and elevation/slope influence on distributed parameters for runoff coefficient values. Tuning of the model, with the aim of obtaining an integral runoff value as close as possible to the one measured in the balance profile, will be the next step. Such chosen processing is leading to the need for obtaining terrain data for the whole Danube basin, and this is the second important problem, which has to be solved. Local data is supposed to be used where available and, for the rest of the watershed, some more general input has to be chosen.

The hydrological monograph of the Danube river basin has to create a common basis for all water management and environmental studies. The regional experts group provided step by step methodological approaches. Some particular problems - i.e. terrain data and/or common GIS approach - are, at present, still not fully solved and any contribution from the international level or from the Danube Environmental Programme would significantly help to accelerate the progress of this study. Co-operation in this field falls under the umbrella of the UNESCO International Hydrological Programme and constitutes a contribution not only to the environmental study of the largest European river, but also to the improvement of human and scientific relationships in this historical area.

References

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