METHODS OF RIVER CLASIFICATION ON THE CRITERIA OF THE RESERVOIRS AND DIKES INFLUENCES OVER NATURAL FLOW AND WATER BALANCE

Ph. Dr. Ion Pasoi

National Institute of Hydrology and Water Management – Romania, Bucuresti, Romania,
e-mail: ion.pasoi@hidro.ro

Abstract: Between 1960 and 2000 Romania's rivers have been intensely modified with hidrotechnical constructions for different purposes (energetical, water supply, deviations from one basin to another, deviations for protecting certain objectives from floods, deviations for water supply of dry areas and digs). All these constructions have modified the natural flow regime and the parameters of balance equation of basin zones and river sections.

In the conditions of Romania's joining to the European Community specific methods are necessary in order to evaluate the impact of the pressure factor over the water balance. The methods which will be elaborated should allow:

- the classification of rivers on categories of river influence from the quantitative point of view (low influence, high influence, very high influence)
- the calculation of the natural flow regime of the river, in the case of the rivers with many hydro technical constructions
- the improvement of exploitation rules of the hydro technical constructions in order to provide the optimum flow regime necessary for the sufficient water supply and flood prevention

The paper is based on the "Directive of the European Council and Parliament 60/200/EC" concerning the establishment of an European frame in water domain.

It presents the criteria of river/river sectors classification based on the influences of reservoirs and dikes towards natural flow and water balance for low/high/very high influence on the river's natural flow.

The paper has the following structure:

The identification of principal pressure factors which command the degree of the influence.

The definition of influencing indicators and their way of representation.

Generally the influencing factors are defined by:

$I=X_{mod}/X_{nat}$ where X_{mod} – the parameter/element determined in modified flow regime; X_{nat} – the parameter/element determined in natural flow regime

The degree of influence is defined by

The methods for quantification of influencing indicators

Criteria of rivers classification concerning the degree of natural flow regime influence. For this we propose a matrix consisting of:

- the way of expressing the pressure indicator
- the value given to the degree of influence
- the frequency of the influence degree showing
- the space distribution of the influence degree

In the end it is presented a case study from Romania

Keywords: impact, indicator, reservoir, dyke, water balance

METHODEN UND KRITERIEN ZUR KLASSIFIZIERUNG DER GEWÄSSER IN BEZIEHUNG ZUM EINGREIFEN DER STAUANLAGEN UND DER DEICHEN AUF DEN WASSER-ABFLUSS

Kurzfassung: Seit dem Jahr 1960 bis 2000 wurden die Gewässer Rumäniens von zahlreichen hydrotechnischen Bauten mit mannigfaltigen Benützungen (Strom erzeugung, Wasserversorgung, Überleitungen aus einem Einzugsgebiet zu einem anderen, Umleitungen für Hochwassergeschutz oder Wasserversorgung und Deiche) stark beeinflusst. Alle diese Bauten haben den natürlichen Abfluss-Regime der Gewässer und die Parameter der Wasserbilanzgleichung für das Einzugsgebiet oder manche Wasserlauf- Strecken verändert.

Die Bediengungen für den Anschluss Rumäniens zur E.U. erfordern die Ausarbeitung neuer Bewertungs Methoden für das Eingreifen der Stauanlagen und der Deiche auf den Wasserbilanz.

Die neuen Methoden müssen gestaten:

- die Klassifizierung der Gewässer bezieungsweise des Einflusses auf die Qualität (unbedeutendes Ergreifen, bedeutendes und sehr bedeutendes);
- die Berechnung des natürlichen Regims der Gewässer für die stark verbauten wasserläufe;
- die Verbesserung der Betriebs-Regeln der hydrotechnischen Bauten um den nötigen Abfluss-Regime für Wasserversorgung und Hochwasserschutz zu sichern.

Das Werk stüzt sich auf die ” Directive des Europäischen Parlament und Rat 60/200/E.C” für die Festsetzung eines europäischen Rahmen im Bereich der Gewässer.

Das Werk bringt die Kriteriums für die Klassifizierung der Gewässer und der Wasserlaufstrecken vor gemäss dem Kriterium des Eingreifen der Stauanlagen und Deiche auf den natürlichen Wasser-Abfluss-Regime für die Wasserläufe mit unbedeutenden, bedeutenden und sehr bedeutenden Ergreifen.

1.Introduction

Between 1960 and 2000 Romania’s rivers have been intensely modified with hidrotechnical constructions for different purposes (energetical, water supply, deviations from one basin to another, deviations for protecting certain objectives from floods, deviations for water supply of dry areas and digs).

The reservoirs affect the flow by redistributing the amount of water in every hydrological regime faze (minimum, average, maximum flow) and the balance of water, especially in hill and plain regions – by the quantity of evaporation from the lake’s surface – and by the discharge generated by ice in mountainous regions. A major factor in the flow influence is the variation in time of reservoir’s water volume.

The dykes have a high influence over the maximum flow by modifying the water speed in relation with the level and discharge and discharge, thus modifying the way in which the flow is generated in the basin. This modification can result in major floods, especially in the case of the inappropriate exploitation of the reservoirs which are situated on rivers with dykes.

As Romania prepares to enter The European Union, it is necessary to classify the rivers from the point of the impact of the pressure factors over the natural flow, that is reservoirs and dykes.

Based on the above mentioned facts the paper proposes a method and criteria of classification of the rivers and river sectors from the point of view of the impact of dykes and reservoirs over natural flow. Based on these the rivers and river sectors are classified in low, highly and very high influenced

2.Defining the impact factors

In order to quantificate the impact of reservoirs and dykes over the natural flow, the following impact indicator is defined:

$$I = \frac{X \text{ mod}}{Xnat} \quad (1)$$

Where:
X_{mod} – the parameter determined in modified flow regime
X_{nat} – the parameter determined in natural flow regime
For the period with natural, unmodified flow regime it is obvious that I=1
The impact indicator can be expressed either directly, or indirectly by equation (1) as $X_{mod}=f(X_{nat})$ or as percent of an element of the water balance.

In order to characterize the degree of influence over the flow, indicator A is defined as fallows:

$$A = |1 - I| * 100 \quad (2)$$

The quantification of the impact of reservoirs and dykes is usually made at reservoirs and gauging stations. This quantification is also made in sections near confluences and inhabited areas, when it is possible to reconstruct the natural flow.

3.The impact of reservoirs over the flow regime and water balance

In the section of a reservoir there are practically two equations which refer to the water balance. One refers at the total :

$$Q_{afl\ tot} = Q_{arv} + Q_p + Q_{gt} + Q_r + DW_{(')}/DT \quad (3)$$

Where:
$Q_{afl\ tot}$ – total inflow
Q_{arv} – total inflow from river and valley sides
Q_p – the flow generated by rain on the reservoirs surface
Q_{gt} – the flow generated by molten ice
Q_r – the flow which comes by deviations
$DW_{(')}/DT$ - the volume variation when the initial water volume is greater than the final one

$$Q_{deftot} = Q_{defr} + Q_e + Q_{ga} + Q_c + DW_{('')}/DT \quad (4)$$

Where:
Q_{deftot} – the total outflow in reservoir's section
Q_{defr} – the outflow in the reservoir's barrage section
Q_e – the flow generated by evaporation from reservoir's surface
Q_{ga} – the flow generated by the ice from reservoir's surface
Q_c – the flow taken from the reservoir for different purposes (water supply for industry and towns, irrigation, etc.)

The graphic representation of the parameters from the equations 3 and 4 is:

Fig.1

In order to evaluate the impact of reservoirs over natural flow and water balance the following impact indicators are proposed:

$$I_e = \frac{Q_e}{Q_{deftot}} \quad (5)$$

$$I_{def} = \frac{Q_{defr}}{Q_{deftot}}$$

(6)

In the case of calculating I_{def} at gauging stations Q_{defr} is replaced by Q_{masr} where Q_{masr} is the measured discharge in modified regime at the gauging station. The former indicator is more important in the case of the reservoirs situated in plain and hill regions. The latter indicator characterizes the degree of influence of the flow regime no matter where the reservoir is situated. The greater the I_{def} the smaller the influence is.

In order to classificate the rivers (river sectors) from the point of the reservoir's impact over natural flow it is necessary to make time series from I_e and I_{def} as long as the natural flow has been influenced.

Impact of dykes over water flow

The quantification of dykes impact over water flow can be done with the relation:

$$Q_{dig}=f(Q_{ndig}) \quad (7)$$

Where: Q_{dig} = the possible discharge (T_p – flood routing time, X – coefficient of the water flow reduction in river valleys) on rivers with digs

Q_{ndig} = the possible discharge (T_p – flood routing time, X – coefficient of the water flow reduction in river valleys) on rivers without digs

The determining of the relation $Q_{dig}=f(Q_{ndig})$ has been realized with hydrological models which simulate the same floods in conditions with digs and without digs.

The impact indicator I_d is calculated based on the relation (7).

Usually between Q_{dig} and Q_{ndig} there is a linear variation:

$$I_d = \frac{Q_{dig}}{Q_{ndig}} \quad (8)$$

The indicator I_d practically varies according to the length of the dykes and the distance between them. Another major modification which dykes bring is the cut of the meanders and the changing of confluence points, modifications which affect the way in which the flow on the basin is formed.

4.Criteria of river classification from the point of view of the reservoirs and dykes influences over natural flow and water balance

The classification of the rivers/river sectors from the point of view of the reservoirs and dykes influences over natural flow and water balance is proposed to be done with multidimensional matrix such as:

- the criteria of influence that is the expression of impact indicator I : for reservoirs I_e and I_{def} should be taken into account and I_d for dykes
- the value of influence indicator A
- the frequency of A indicator appearance
- the space repartition of A indicator

Based on the above mentioned the classification should be:

Nr.	Way of expressing impact indicator I	Impact indicator A	Unaffected or low affected river/river sector	Medium affected river/river sector	Highly affected river/river sector
1	I_e	The value of A	<20%	20-50%	>50%
		The appearance frequency of A	<20% from the total number of values	20-50% from the total number of values	>50% from the total number of values
		Space repartition of A indicator	<20% from the river length	20-50% from the river length	>50% from the river length
2	I_{def}	The value of A	95-100%	90-95%	<90%
		The appearance frequency of A	50% from the total number of values	50% from the total number of values	50% from the total number of values
		Space repartition of A indicator	90-100% from the river length	75-90% from the river length	<75% from the river length
3	I_d	The value of A	<20%	20-50%	>50%
		Space repartition of A indicator	<10% from the river length	10-25% from the river length	>25% from the river length

Note: in the case of dykes influence of the flow regime is not conditioned by the appearance frequency of A

5.Conclusions:

1. In the conditions of intense river course modifications it is necessary to identify the major influencing factors
2. This identification can be done only by an appropriate quantification of the influence degree over natural flow. The paper made a proposition in this respect.
3. Based on the indicators proposed in the present paper it is necessary to classify the rivers/river sectors from the point of view of the degree of influence. This classification should be used for taking the appropriate measures in order to protect the natural river life. The present paper proposes a series of classification criteria from the point of view of influence over natural flow.
4. The rivers classificated in this way are recommended to be seen in GIS, thus having an image of the degree of influence at local, national, and river basin level.