

Water balance evaluation and regularization of Albanian rivers basins

Niko PANO¹, Bardhyl AVDYLI¹, Marenglen BUKLI², Koco GJOKA²

¹Albanian Academy of Sciences, Hydro meteorological Institute, Tirana, Albania

²Albanian Academy of Sciences, Institute of Informatics and Applied Mathematics, Tirana, Albania

e-mail: bavyli@icc-al.org; mbuk@inima.al; kgjo@inima.al

Abstract- Albanian river basin is one of the main and most complicated natural territories in Europe: mountainous regions of an average altitude of 785m above the sea level, particular lithological structure with an important calcareous formation, typical Mediterranean climate regime, etc. This basin is 43 305km², where 28 500km² is inside the Albanian state and the rest outside it (Greece, FYROM, Kosovo, Monte Negro). Albanian catchments area water discharges into Adriatic and Ionian Seas. In this paper it is attempted to present a general evaluation of the water balance in the Albanian river system, including regionalization of the catchment's area of this system, according to the correspondent types of the water balance.

Key word: water balance components, potential and real evapotranspiration, global territory humidity, rationalization.

1. Introduction

Water balance evaluation and its rationalization is one of the main and most complicated problems because of the natural specific conditions of Albanian rivers basin (mountainous regions, particular lithological structure with important calcareous formation, the presence of the important lake system, the Mediterranean typical climate regime etc.)

In Albania many particular studies were performed to evaluate different components of the water balance of the rivers basins (Pano 1984, 1985, 1993 and 1995; Mustaqi 1986; Saraçi 1989; Kazazi 1985, etc.). In this paper (from the existing partial studies) it is attempted to present a general evaluation of the water balance in the Albanian rivers system, including regionalization of its catchments area, according to the corresponded types of water balance.

In the Albanian hydrographical network there are 11 principal rivers together with their numerous branches such as Buna River with the catchment's area of the $F= 5750 \text{ km}^2$; Drini River $F= 14137 \text{ km}^2$; Vjosa River $F= 6706 \text{ km}^2$; Semani River $F= 5640 \text{ km}^2$ etc. There are 125 other rivers with a small catchment's area $F>50 \text{ km}^2$.

2. Materials and methods

Water balance evaluation was based on the multi-annual archival data of the Albanian hydro meteorological institute of the Academy of the Sciences.

The monitoring network consists of more than 175 hydrometric stations for the evaluation of the river run-off for an observed period of 20-50 years; 160

pluviometer and pluviograph stations for evaluations of the precipitation for an observed period of 15-40 years and 9 experimental station type GGJ for the evaporation evaluation from the water surface for an observed period of 20-25 years. These stations are located all over the territory.

All the maps of the water-balance components and their principal hydrological parameters are compiled to the rational topographical maps of 1:750 000 scale. For the natural specific conditions of the Albanian rivers basin, particularly, for mountainous areas, values of both hydrological elements were computed on basis of their vertical gradients and their altitudes above sea levels.

The methodology of the water balance components valuation used in the paper consist in:

- computation of annual precipitation with $p=50\%$ probability for the representative meteorological stations - x_i , classification of the Albanian territory by gradients: $P_M = x_i/z_i$ and composition of geographical distribution map for annual precipitation;
- Computation of annual run-off level $y_{0,i}$ for the representative hydrometrical axes. These stations are divided in principal categories, depending on the hydrographical, hydrological and the hydraulically specific natural conditions.

- 1) Drini, Mati, Ishmi, Semani, Vjosa rivers, etc., where the run-off discharge – Q_i is computed as a function $Q_i = f(H_i)$, where H_i is altitude of water level river section i .
- 2) Water system: Scutary Lake – Drini River – Buna River. This hydrographical complex with great catchment's surface of about 20 000 km², as is well known, is very complicated and unique for its hydraulic regime in the Mediterranean hydrograph. This particularity has made necessary the particular modeling for estimation of the water flow of Buna Rives. The discharge of the Buna River that flows away from the Scutary Lake – Q_2 , depends upon the lake level – H_2 , and the River discharge into the Buna River – Q_4 . The Buna discharge was calculated by the following equation (Pano 1973, 1984, 1994, 1997, 2003):

$$Q_2 = \left\{ 0.025 \left[H_2 - \frac{Q_4^2}{(0.073 \cdot H_2^{1.61413})^2} \right]^{1.85} - Q_4 \right\}$$

The $Q_2 = f(H_2, Q_4)$ values correspond to the results that have been obtained through the hydraulic calculations. The differences of the values of discharge – Q_2 , which have been calculated by both methods, are small, about $\delta Q_2 = \pm 3\%$.

- 3) Lake system: Micro Prespa – Macro Prespa – Ohri Lake the run-off discharge – Q_i is computed by the water balance method, $Q_i = W_p/t$, where W_p is the volume water annual, t - time in second.

- Computation of the annual river run-off level – y_0 in the mm, y_0 is computed by the formula: W_e/F , where F is the catchment's area in km^2 . Albanian territory classification by gradient $PA_M = y_e/h$ and composition of the geographical distribution map for y_0 , according to values of gradients $PM_I = y_0/h$.
- Computation of the Potential evotranspiration – E_p by the formula: Penman, Thornthwaite, Turc, etc. for the representative meteorological stations, classification of the territory by gradients $R_i = E_p/h$ and the composition of the geographical distribution map for E_p according to respective values of gradient – R_i .
- Computation of the real evotranspiration – E_R for the representative meteorological stations and deficit of the flow – Z_0 for the representative hydrometric stations. The E_R is computed by the formula: Turc, Contage, Thornthwaite, and Konstandinos. The deficit of the flow - Z_0 , is calculated by: $Z_0 = (x_0 - y_0)$ and is verified by GG Information. Albanian territory classification by gradient $P_i = E_R/h$ and the composition of the geographical distribution map for E_R according to respective values of gradient P_i .
- Computation of the deficit of the evotranspiration – DE , DE is computed as the difference $DE = (E_p - E_R)$
- Computation of the deficit of the precipitation – Dx_0 , Dx_0 is computed as the difference $Dx_0 = (E_p - x_0)$
- Computation main parameters of the river discharge for representative hydrometric axes, such as: module of river run-off – $Q_0 = W_p/t$ in l/s km^2 , run-off coefficient - $\alpha = y_0/x_0$, evotranspiration coefficient – $a_z = z_0/x_0$, etc.
- Evaluation of the groundwater run-off discharge by determining the type of the water supply of the Albanian rivers system, respectively by: surface water discharge – Q_i^S and groundwater run-off discharge – Q_i^N , where $(Q_i^N + Q_i^S) = Q_{0,i}$. This evaluation is based on computation of the dynamic coefficient of the run-off discharge - η by Kudlina's method (Kudlina B.J. 1966)
- Computation of the main parameters of the groundwater run-off discharge such as: module of groundwater run-off discharge – $q_0^N = W_0^N/t$ in l/s km^2 , the annual groundwater run-off level - $y_0^N = W_0^N/F$ in mm, annual groundwater run-off coefficient - $\alpha_0^N = y_0^N/x_0$, groundwater run-off volume: $W_0^N = Q_0 t$, global territory humidity - $\mu_0 = (x_0 - \mu_0^S)$, where: y_0^S is the annual level surface water and infiltration coefficient - $\beta_0 = \mu_0/x_0$

Evaluation of the water balance in the Albanian river system including regionalization of the catchment's area of this system, according to the correspondent types of the water balance. One of the important representative integral indicators to estimate the water potential formation process in the rivers basin is the annual module run-off discharge – q_0 in l/s km^2 . The global humidity of the territory - μ_0 in mm is also an important indicator.

3. Analyses of the results

This division scheme of the Albanian territory in homogeneous regions, based on evaluation and determination of the natural factors influencing the water balance process formation.

Analyzing and dividing the Albanian territory in homogeneous areas, region is accepted as the smallest tacionometric unit.

Considering the physical-geographical conditions, the Albanian territory is heterogeneous, but homogeneous areas, having the same water balance nature and where the corresponding values of the elements of this water balance are the same, may also be determined.

Classification of the Albanian rivers basin is carried out for the following water balance types:

- I- Type I, A_1B_1 – Low global territory humidity (module $q_0=10\div 20$ l/s km^2)
- II- Type II, A_2B_2 – Mean global territory humidity (module $q_0=20\div 40$ l/s km^2)
- III- Type III, A_3B_3 – High global territory humidity (module $q_0=40\div 80$ l/s km^2)

Regionalization of the Albanian river basin according to the corresponded types of water balance is presented in Tab. 1.

The principal water balance components hydrological parameters are presented in the Tab. 2.

The annual precipitation on the Albanian rivers basin range from the 750 mm in the coast area to 4444 mm in mountain with an average all over the catchment's area is $x_0=1544$ mm.

The water potential of Albanian river system is $W_0= 41,249*10^9$ m³, that corresponds to a discharge of $Q_0= 1304$ m³/s, and a module of $q_0= 30.1$ l/skm². So Albania is one of the countries of a high specific water potential in Europe. The run-off level – y_0 range from the 250-600 mm to 1250-2800 mm, with an average all over catchment's area $y_0=600-1250$ mm.

The Real Evotranspiration on the Albanian rivers basin range from 300 to 800 mm average all over the catchment's area is $E_R=500-600$ mm.

The regional water potential in Albania is presented in Fig. 1.

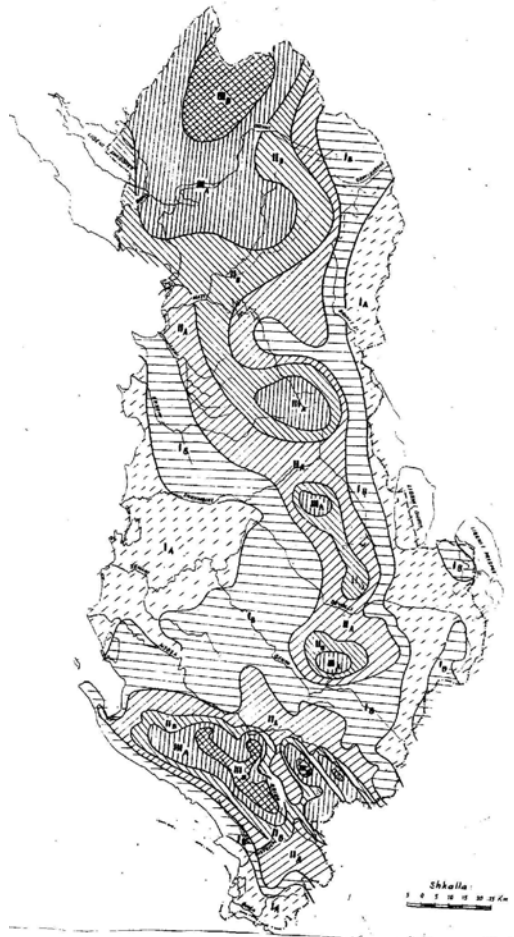


Figure 1. – The regional water potential in Albania.
– module $\rho=10-20$ l/s.km² II A₂,B₂ – module $\rho = 20 - 40$ l
III A₃, B₃ module $\rho = 40-80$ l/s.km².

The annual distribution of Evotranspiration Potential – E_p , Real Evotranspiration - E_p , Deficit Evotranspiration – D_E and Deficit Pluviometric – Dx_0 for Region I, are presented in Fig. 2.

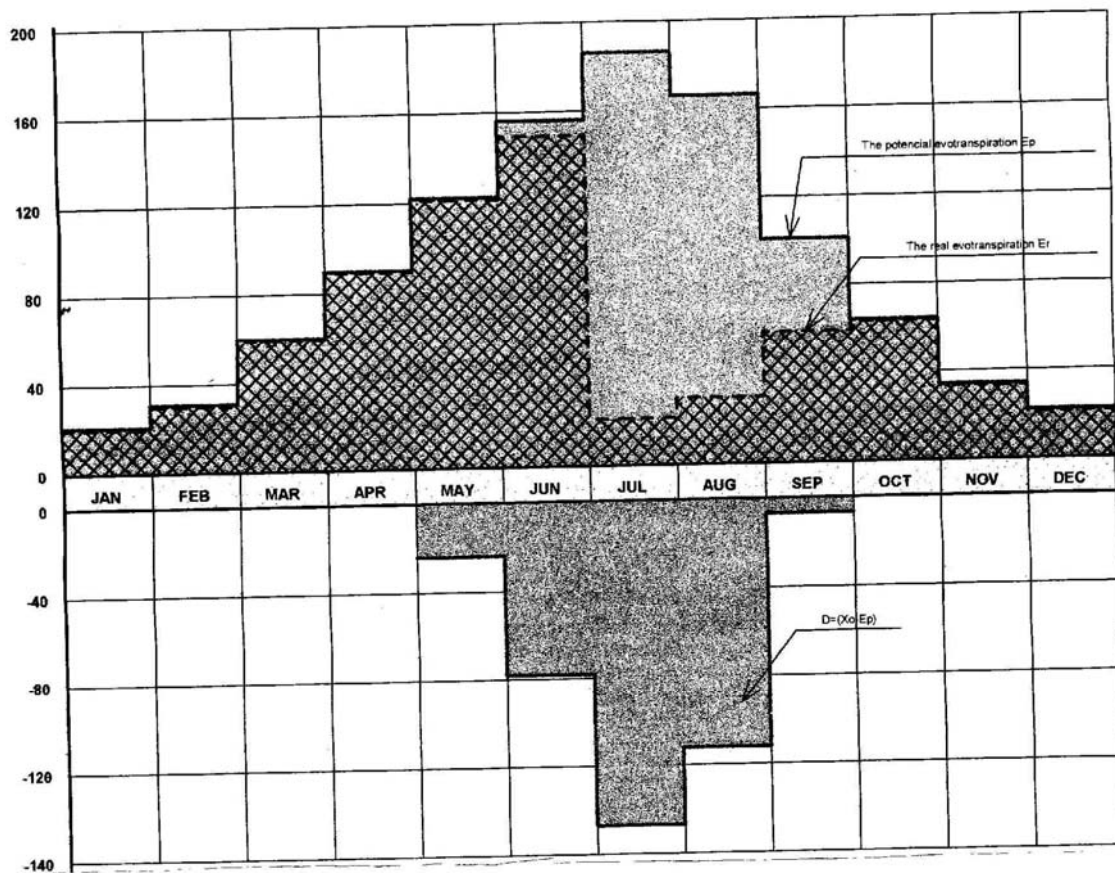


Figure 2 – Evapotranspiration in Albania
 (Annual distribution of evapotranspiration Potential E_p , Real Evapotranspiration E_r ,
 Deficit Evapotranspiration $DE=(E_p-E_r)$ and Deficit pluviometric $Dx_0=(X_0-E_p)$)

REGIONALIZATION OF THE ALBANIAN RIVERS BASIN ACCORDING TO THE CORRESPONDED TYPES OF WATER BALANCE

Tab. 1

Precipitation X (in mm)	$a_z < 0.30$	$a_z = 0.30 \div 0.50$	$a_z > 0.50$
	$\alpha_0 > 0.45$	$\alpha_0 = 0.45 \div 0.30$	$\alpha_0 < 0.30$
1	2	3	4
>1750	I _{A1, B1}	-	-
1250 ÷ 1750	-	II _{A2, B2}	-
<1250	-	-	III _{A3, B3}

PRINCIPAL ELEMENTS AND PARAMETERS OF THE WATER BALANCE

Tab. 2

N°	ELEMENTS	UNIT	REGION		
			I _{A1, B1}	II _{A2, B2}	III _{A3, B3}
1	X _o	mm	< 1250	1250 – 1750	> 1750
2	Z _o	mm	< 600	501 - 600	> 300
3	Y _o	mm	< 600	600 – 1250	> 1250
4	E _R	mm	< 500	500 – 600	> 600
5	η _o	-	< 0.55	0.55 – 0.75	> 0.75
6	α _z	-	< 0.35	0.35 – 0.45	> 0.45
7	D _{xo}	mm	< 200	200 – 1000	> 1000
8	DE	l/s.km ²	< 250	250 – 400	> 400
9	q _o	mm	< 0.25	0.25 – 0.35	> 0.35
10	Y _o ^s	mm	< 620	620 – 660	> 660
11	U _o	mm	< 750	750 – 1000	> 1000
12	y _o ^N	mm	< 280	280 – 315	> 315
13	q _o ^s	l/s.km ²	< 18	18 – 22	> 22
14	q _o ^N	l/s.km ²	< 7	7 – 12	> 12
15	η _o ^N	-	< 0.16	0.16 – 0.25	> 0.25
16	Ku	%	< 26	26 – 35	> 35
17	β _o	-	< 0.21	0.21 – 0.35	> 0.35

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