A Method to Estimate Buna River Discharge, Albania

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Abstract Buna is one of the biggest and most important rivers of the Mediterranean basin. Outflowing from Scutary Lake this river joins Drini River so forming a complicated and particular hydrographical system. In these conditions it is impossible to calculate Buna River discharge when it flows out of Scutary Lake by the dependence $Q_2 = f(H_2)$ because Buna discharge – Q_2, in its outflowing from the lake depends not only on the water levels – H_2, but also on the water levels – H_2 and Drini discharge – Q_4. Many particular hydrometeorological studies are made of Scutary hydrographical complex (Pano N.,Saraçi R.1963;PanoN.,Abdyli B,1984, 2002). A particular way to calculate Buna discharge in its outflowing from Scutary Lake is presented in this paper. This particular way considers specific hydraulic conditions of this river. Multi-annual cycle discharge is calculated by this way.

1. Introduction

Buna is one of the most important Mediterranean rivers. It together with Po River (Italy) are determinative on Adriatic Sea water balance. Out flowing from Scutary Lake, Buna immediately joins Drini River water and both rivers discharge into SE Adriatic Sea. Scutary Lake – Drini River – Buna River hydrographical complex is very complicated and unique for its hydraulic regime in the world hydrography. As a result of this particularity it is difficult to evaluate Buna water flow by the classical methods of engineering hydrology.

2. Methods

Flowing out of Scutary Lake, Buna discharge – Q_2 depends not only on the water level – H_2, but also on the level – H_2 and Drini discharge – Q_4. So the only way to calculate Buna discharge river – Q_2 is to find the connection: $Q_2 = f\left(H_2, Q_4\right)$. This connection is deduced by the following equation:

$$Q_2 = A_1 H_2^B \sqrt{\Delta H_{2-3}} \qquad (1)$$

$$Q_3 = \left(Q_2 + Q_4\right) = A_1 H_3^{B_1} \qquad (2)$$

The dislevel ΔH_{2-3} can be determined by:

$$\Delta H_{2-3} = \left(H_2 - H_3\right) \qquad (3)$$

If equation (1) is replaced by equation (3), it will result:

$$Q_2 = A_1 H_2^B \sqrt{H_2 - H_3} \qquad (4)$$

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From equation (4) it results:

$$H_2 = \left[\frac{Q_2 + Q_4}{A_1}\right]^{\frac{1}{B_1}} \tag{5}$$

If equation (3) is replaced by equation (5), it will result:

$$Q_2 = AH_2^B (H_2 - H_3)^{\frac{1}{2}} = AH_2^B \left\{H_2 - \left[\frac{Q_2 + Q_4}{A_1}\right]^{\frac{1}{B_1}}\right\}^{\frac{1}{2}} \tag{6}$$

From equation (6) it results:

$$Q_2 = AH_2^B \sqrt{H_2 - \left(\frac{Q_2 + Q_4}{A_1}\right)^{\frac{1}{B_1}}} \tag{7}$$

Equation (7) is equivalently transformed in the following:

$$Q_2^2 = \left(AH_2^B\right)^2 \left[H_2 - \left(\frac{Q_2 + Q_4}{A_1}\right)^{\frac{1}{B_1}}\right] \tag{8}$$

From equation (8) it results:

$$\left(\frac{Q_2 + Q_4}{A_1}\right)^{\frac{1}{B_1}} = H_2 - \frac{Q_2^2}{\left(AH_2^B\right)^2} \tag{9}$$

From equation (9) it results:

$$\frac{Q_2 + Q_4}{A_1} = \left[H_2 - \frac{Q_2^2}{\left(AH_2^B\right)^2}\right]^{B_1} \tag{10}$$

From equation (10) it results:

$$Q_2 = \left\{A_1 \left[H_2 - \frac{Q_2^2}{\left(AH_2^B\right)^2}\right]^{B_1} - Q_4\right\} \tag{11}$$

Where: - A, A_1 and B, B_1 – parameters; - ΔH_{2-3} - dislevel $(H_2 - H_3)$

3. Analyses of Results

On the using above methodology equation (12) is determined to calculate Buna River discharge:

$$Q_2 = \left\{0.025 \left[H_2 - \frac{Q_2^2}{\left(0.0073 H_2^{1.61413}\right)^2}\right]^{1.85} - Q_4\right\} \tag{12}$$

The dependence $Q_2 = f(H_2, Q_4)$ corresponds to the results obtained by the hydraulic calculation to determine the dependence $Q_3 = f(H_3)$. Topomorphometric data and the hydraulic parameters of the rivers discharge are the basic dependence of this calculation. The differences of discharge – Q2, calculated by both methods, are small, about $\delta Q_2 = \pm 3\%$.

Water flow of Scutary Lake catchment area is determined by the correlation of different factors of the geographical landshaft: climate, relief, territory, litological structure, vegetation, etc. As a result of the influence of all these factors in the catchment area, the water flow is different not only during month's seasons and difference periods of the years, but also in the multi-annual cycle.

The principal parameters of the water flow in Scutary Lake hydrographic system are:

-Total water potential is about $W_0^T = 9.4 \cdot 10^{90}\, m^3/year$.

-Precipitation in Scutary Lake catchment area – x_0, is *1600 ÷ 2500mm* in the coastline area, *3500 ÷ 4400mm* in the mountainous area, having an average of about $\overline{x} = 2000mm$.

-The annual run-off discharge – q_0, of Scutary Lake catchment area varies : $q_0 = 75 \div 85\, l/s \cdot km^2$, with an average $\overline{q_0} = 50 \div 60\, l/s \cdot km^2$.

-The annual coefficient of run-off discharge - α_0 of Scutary Lake catchment area varies from: $\alpha_{0,1} = 0.40 \div 0.50$ to $\alpha_{0,2} = 0.85 \div 0.95$, with an average about $\overline{\alpha_0} = 0.90$. High values of run-off discharge coefficient - α_0 are as the result of the fact that the hydrogeological basin of Scutary Lake is larger and more potential than the geographical basin of this lake.

-The water flow during the wet period of the year (X-V) is about 75-80% of the annual water flow and 20-25% during the dry period (VI-IX). Considering seasonal distribution, winter is the wettest season with 35-45% of the water flow in Buna River, followed by spring with 25-35%, summer with 10-15% and autumn with 13-17%. Mediterranean climate influence with a continental climate impact is observed in the annual distribution.

The underground flow – Q_0^N represents about 70% of the global water potential of Scutary Lake hydrographic system that corresponds to a discharge – $Q_0^N = 200\, m^3/s$, a layer – $y_0^N = 1300mm$, a module – $q_0^N = 40\, l/s \cdot km^2$, and a run-off discharge coefficient $\alpha_0^N = 0.60$.

The surface flow – Q_0^S represents about 30% of the global water potential of Scutary Lake hydrographic system that corresponds to a discharge – $Q_0^S = 90\, m^3/s$, a layer – $y_0^S = 650mm$, a module – $q_0^S = 20\, l/s \cdot km^2$, and a run-off discharge coefficient $\alpha_0^S = 0.30$. Water supply types of the hydrographic network are presented in Table 1.

Table 1. Water Supply Types of The Hydrographic Network (Scutary Lake)

Nr	Presentation	Unit	Water Supply Types		
			a) Surface	b) Underground	c) Total
1	Water volume - W_1	km^2	2.8	6.6	9.4
2	Discharge - Q_0	m^3/s	90	210	About 300
3	Layer - y_0	mm	650	1300	1950
4	Module - q_0	$l/s \cdot km^2$	15	45	60
5	Percentage - p	%	30	70	100
6	Coefficient - α_0	-	0.30	0.60	0.90

Buna River together with the other rivers of the hydrographic network of Albania, discharge a total water volume of $W_0 = 41.27 km$ in Adriatic Sea. This volume corresponds to an average discharge of $Q_0 = 1308 m/s$. This value is nearly equal to the discharge of Po River. So there are two zones with powerful discharge of the continental water: North Adriatic (Po River), South East Adriatic (the Albanian rivers).So Albania is one of the countries of a high specific water potential in Europe. The hydrogram of Albanian rivers total discharge is presented in Figure 1.

The rivers of the Albanian hydrographic network, with a total surface of 43305km^2, discharge in SE Adriatic Sea, in a narrow area (113km wide) that is the distance between Buna and Vjosa river mouths.

In Albanian hydrographic network the annual flow distribution is generally characterized by a typical Mediterranean nature (Tab. 2).

Table 2. River Run-off Annual Distribution in Albania (m^3/s)

Rivers	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Q_0
Scutary	576	442	403	372	363	296	169	92	65	154	372	350	320
Drini	493	459	446	507	490	293	155	104	141	228	396	501	351
Buna – sea	1067	899	850	879	861	588	322	195	210	382	770	1030	682
Seman	143	156	161	143	116	52	20	12	22	41	100	117	90
Vjosa	305	263	261	240	183	96	61	43	41	79	170	290	171

River water flow of the Albanian hydrographic network differs in wide limits, not only in different periods of the year, but also in the multi-annual cycle because of the physico-geographical conditions of the catchment area of this network and especially the regime of atmospheric precipitation and evoprenspiration.Probability distribution parameters of the rivers annual water flow are presented in Table 3.

During the multi-annual cycle Albanian rivers discharge in the Mediterranean sea varies in very wide limits, from 700-850m^3/s for the hydrological years of low precipitation (1948-49; 1953-54) to 1850-2150 m^3/s for the years of high precipitation (1969-70; 1962-63).

Discharge variation coefficient is $C_V = 0.32$ in Vjosa River, $C_v = 0.24$ in Buna River, $C_v = 0.34$ in Seman River, etc.

Correlation between annual water discharge $Q_{0,p\%}\left(in\ m^3/s\right)$ and annual precipitation - $x_{0,p\%}\,(in\ mm)$ of the same probability - $(p\%)$ is presented Figure 2.

Correlation between monthly water discharge - $Q_{0,p\%}\left(in\ m^3/s\right)$ and respectively precipitation - $x_{0,p\%}\,(in\ mm)$, and precipitation difference - $\Delta x_0 = \left(x_0 - E_p\right)(in\ mm)$ is shown in Figure 3.

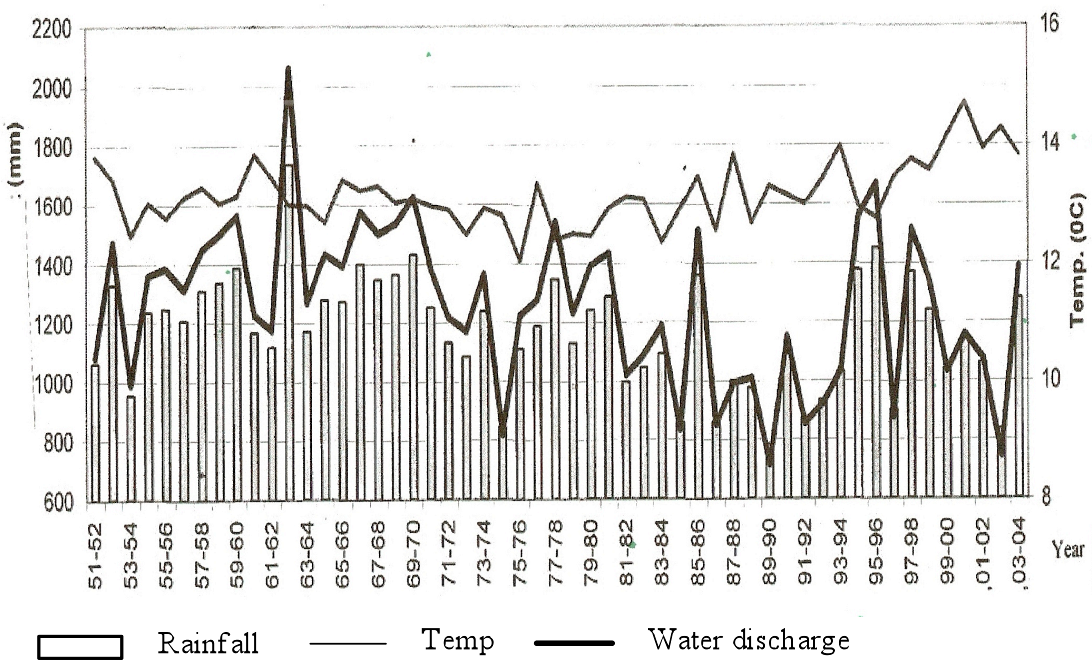

Figure 1. Fluctuation of the Albanian river flow

Table 3. Probability distribution parameters for annual water flow (m^3/s)

Nr	Rivers	Parameters		Probability (%)									
		Q_0	C_V	1	2	5	10	20	50	80	90	98	99
1	Buna Scutary	320	0.20	540	510	468	433	394	330	276	251	213	201
2	Drini	331	0.30	612	564	498	433	394	330	276	251	213	192
3	Buna Sea	672	0.24	1119	1110	1000	912	815	659	532	477	390	364
4	Seman	90.9	0.34	178	165	147	132	115	87	72	54	47	35
5	Vjosa	171	0.32	345	316	277	244	212	159	130	111	102	94

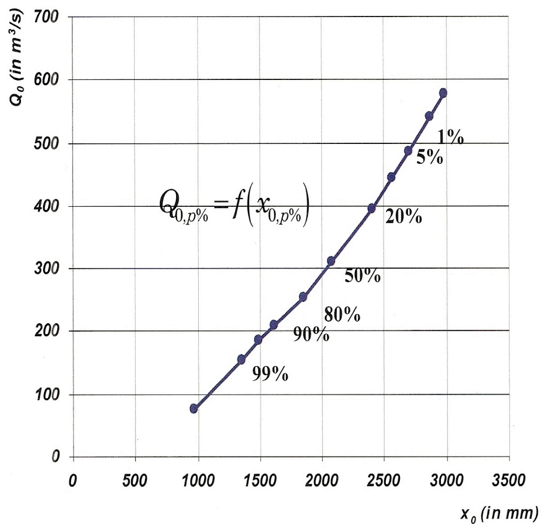

Figure 2. Correlation between annual water discharge - $Q_{0,p\%}\left(in\ m^3/s\right)$ and annual precipitation - $x_{0,p\%}\left(in\ mm\right)$ of the same probability - $(p\%)$

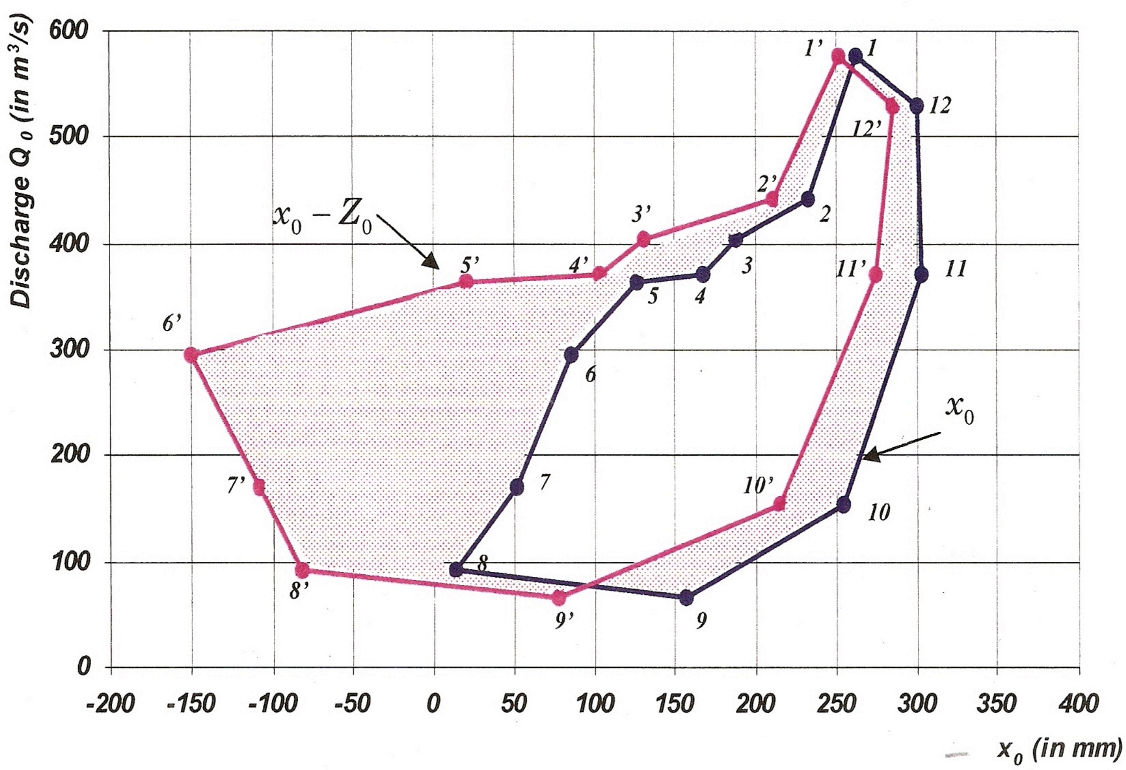

Figure 3. Correlation between monthly water discharge - $Q_{0,p\%}\left(in\ m^3/s\right)$ and respectively precipitation - $x_{0,p\%}\left(in\ mm\right)$ and Precipitation difference - $\Delta x_0 = \left(x_0 - E_p\right)\left(in\ mm\right)$.

4. References

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