RUNOFF CHARACTERISTICS IN DOBROGEA

C. E. TELTEU[1], *F. I. STAN, O. OPREAN*

ABSTRACT. – Runoff characteristics in Dobrogea. This paper aims to highlight the main characteristics of the average liquid flow of the main rivers from Dobrogea: Albeşti, Urlichioi, Biruinţa, Agi Cabul, Slava, Casimcea, Topolog, Taiţa, Cartal, Râmnic. The evidence of these is based on the processing of monthly and yearly discharges taken from the National Institute of Hydrology and Water Management, with periods between 22 and 52 years. The methodology includes statistical analysis, investigations in the area and GIS techniques. The analysis highlights that the mean multiannual discharge ranged between 0.022 m^3 s^{-1} (Urlichioi River) and 0.657 m^3 s^{-1} (Casimcea River). The mean multiannual specific liquid discharge ranged between 0.50 l s^{-1} km^{-2} and 8.28 l s^{-1} km^{-2}, the mean multiannual volume of water ranged between 0.69 million m^3 and 20.73 million m^3 and the mean multiannual water layer ranged between 15.64 mm and 261.38 mm. The coefficient of interannual variation of the mean discharges ranged between 0.25 and 0.66. Generally, the highest discharges were recorded in June and the lowest in November. So, the richest discharges were recorded in the summer (28.5% – 39.3% of the mean yearly volume of water) and the lowest in the winter and autumn (17% – 25% of the mean yearly volume of water).

Keywords: runoff, rivers, Dobrogea, hydrological parameters, meteorological parameters.

1. INTRODUCTION

This paper aims to highlight the characteristics of the mean liquid flow of the main rivers in Dobrogea: Albeşti, Biruinţa, Urlichioi, Agi Cabul, Casimcea, Cartal, Râmnic, Slava, Taiţa and Topolog. On the one hand, are presented the previously significant results of the mean liquid flow of South Dobrogea's rivers (Păsculescu (Telteu), 2011) and, on the other hand, the results of the mean liquid flow of Central and North Dobrogea's rivers.

The analysis is based on data processing of monthly and yearly mean discharges provided by National Institute of Hydrology and Water Management (NIHWM), for the following observation periods: Cuza Vodă hydrometric station (HS), on Agi Cabul River: 1984 – 2009; Albeşti HS, on Albeşti River: 1966 – 1997; Biruinţa HS, on Biruinţa River: 1974 – 2009 (missing 1979); Biruinţa HS, on Urlichioi River: 1974 – 2007 (missing 1977 and 1979); Casian HS, on Casimcea River: 1956 – 1987; Cheia HS, on Casimcea River: 1988 – 2009; Pantelimonu de

[1] National Institute of Hydrology and Water Management, 13686 Bucharest, Romania, e-mail: elizapascu25@gmail.com.

Jos HS, on Cartal River: 1967 – 2009; Pantelimonu de Jos HS, Râmnic River: 1970 – 2009; Ceamurlia de Jos HS, on Slava River: 1967 – 2009; Saraiu HS, on Topolog River: 1967 – 2009; Satu Nou HS, on Taiţa River: 1956 – 2009.

Dobrogea's climatic conditions which influence the flow regime are highlighted by the analysis of the air temperature, the precipitations, the potential evapotranspiration (which was determined by Thornthwaite method) and the snow layer thickness. Generally, the data comes from the following weather stations (WS): Mangalia, Constanţa, Medgidia, Adamclisi, Hârşova, Tulcea and Jurilovca (for the period 1965 – 2000). These were taken from NIHWM, National Meteorology Administration (NMA), the European Climate Assessment & Dataset database (ECA&D) and literature (Torică, 2004; Sandu et al., 2008).

The analysis of the physico – geographical factors is also based on the processing of some cartographical data or digital sources, such as: Romania's topographic map, scale 1:25000 (Direcţia Topografică Militară, 1982), Romania's geological map, scale 1:200000, with *Mangalia* (Chiriac, 1967), *Constanţa* (Chiriac, 1968), *Călăraşi* (Liteanu and Chiriac, 1966), *Brăila* (Murgeanu and Liteanu, 1967), *Tulcea* (Ianovici et al., 1967) and *Sulina* (Ianovici et al., 1967b) sheets; romanian soil map, scale 1:200000, with *Constanţa* (Florea et al., 1965), *Mangalia* (Florea et al., 1965b), *Călăraşi* (Cernescu et al., 1963), *Tulcea* (Munteanu and Conea, 1969), *Brăila* (Florea and Conea, 1964) and *Focşani – Galaţi* (Conea and Gogoasa, 1969) sheets; digital terrain model with a spatial resolution of 90 m (source: geo – spatial.org, 2009); database and nomenclature of Corine Land Cover program of the European Environment Agency, 2006.

The methodology includes, on the one hand, simple statistical analysis, synthesis and comparison, and, on the other hand, cartographical representation and spatial analysis performed with ArcGIS 9 software.

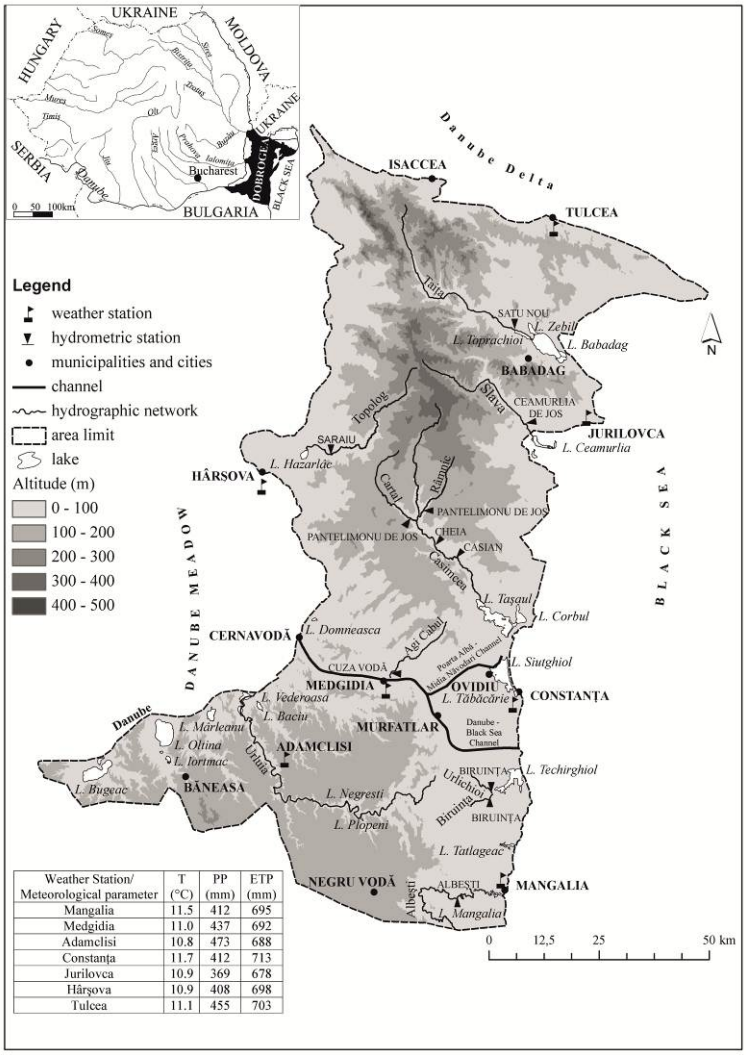
Studies on the hydrological characteristics of the Dobrogea's rivers were made by Popovici et al., 1984, Pişota and Zaharia, 2001; Posea et al., 2005, Teodorescu, 2007 and others.

2. PHYSICO – GEOGRAPHICAL FACTORS WHICH INFLUENCE THE FLOW REGIME

The main physico – geographical factors which influence the runoff in Dobrogea are: the climatic, geological, morphological and morphometrical, soil and vegetation conditions.

Climatic conditions. Dobrogea is characterized by an excessive continental climate (Ielenicz and Săndulache, 2008). The mean multiannual air temperature (TºC) ranges between 10.8 °C (Adamclisi WS) and 11.8 °C (Constanţa WS) (Păsculescu (Telteu), 2011). At the seasonal scale, the average values of the air temperature oscillate between 19.0 °C – 22.5 °C, in summer, and between -1.2 °C – 2.0 °C, in winter (Fig. 1).

The average multiannual precipitation (PP mm) range between 369 mm (Jurilovca WS) and 473 mm (Adamclisi WS). Regarding the monthly variability of the precipitations, the lower amounts are recorded during January, February and October (less than 27 mm) and the highest during May, June and November (higher than 41 mm).



Weather Station/ Meteorological parameter	T (°C)	PP (mm)	ETP (mm)
Mangalia	11.5	412	695
Medgidia	11.0	437	692
Adamclisi	10.8	473	688
Constanţa	11.7	412	713
Jurilovca	10.9	369	678
Hârşova	10.9	408	698
Tulcea	11.1	455	703

Fig. 1. ***Hydrographic network in Dobrogea and mean multiannual values of some meteorological parameters. Data is obtained with GIS processing of the Romania's topographic map (1:25000)***

Potential evapotranspiration (ETP mm) has values which range annually between 678 mm (Jurilovca WS) and 713 mm (Constanţa WS). The lowest multiannual monthly average values are recorded in winter (less than 10 mm) and

the highest in summer (higher than 110 mm). Generally, the ETP exceeds the rainfall between April and October, at all the analyzed weather stations.

Because of the pontic influences and of the climatic conditions presented above, the snow layer has a reduced role in the formation and variability of the liquid flow. It has a monthly average thickness which is less than 2 cm (1 cm at the Constanţa WS and 2 cm at the Medgidia WS – Sandu et al., 2008; NMA).

Lithological conditions. The analysis highlights a very high percent of the leossoide deposits (71.86%), from Middle and Upper Pleistocene, which facilitate the infiltration of the rainwater and water from the riverbed. These are followed by gravels and sands from Holocene (6.08%). The studied area presents a very high percent of the proluvial – deluvial deposits (71.61%) which facilitate the Dobrogea's *seluri*.

Morphological conditions. Dobrogea is characterized by a very high percent of altitudes lower than 150 m (80.75%) which reveal the lower amounts of precipitation that influence the flow regime.

Land cover. The arable land has a very high percent (66.73%), which facilitates the erosion and the floods (Corine Land Cover, 2006). This is followed by the deciduous forests (8.77%).

Soils. Other natural conditions which influence the flow regime in Dobrogea are the soil's structure and texture. From this point of view, Dobrogea stands out, on the one hand, by the high percent of the cernisoils (80.3%) and, on the other hand, by the high percent of the loamy soils (65.86%) which, mainly, facilitate the rainwater infiltration. The Dobrogea's *seluri* are facilitated by the loamy – clay soils which represent 21.95%, from the studied area.

3. MORPHOMETRICAL AND HYDROLOGICAL FEATURES OF THE MAIN RIVERS IN DOBROGEA

Dobrogea is characterized by an average density of the drainage network which ranged between 0.1 km km^{-2} – 0.2 km km^{-2}, mainly due to the areas geological, geomorphological and climatic conditions (Zaharia and Pişota, 2003).

The studied area represents 10400 km^2. In this area, the rivers belong to the *Seaside basin* (Albeşti, Agi Cabul, Biruinţa, Urlichioi, Slava, Casimcea, Cartal, Râmnic, Taiţa) and to the *Danube basin* (Topolog). Generally, these are tributaries to the lagoons, fluvial lakes and marine lakes, as follows: Taiţa River is tributary to the Toprachioi lake (than to the Babadag lake), Slava River to the Ceamurlia lake (than to the Goloviţa lake), Casimcea River to the Taşaul lake, Topolog River to the Hazarlâc lake, Albeşti River to the Hagieni lake (the upper part of the Mangalia lake), Biruinţa and Urlichioi Rivers are tributaries to the Techirghiol lake. The Agi Cabul River is tributary to the Danube – Black Sea Channel. The Cartal and Râmnic rivers are tributaries to the Casimcea River.

The analysis of the table 1 highlights that the river lengths are very low and range between 7 km (Biruinţa River) and 76 km (Casimcea River). The largest

romanian catchment area belongs to the Casimcea River (738 km²) and the smallest to the Urlichioi River (25 km²), but, in the south, the Albeşti River has the upper part developed on the Bulgarian surface and has a catchment area of almost 1060 km^2 (Ujvári, 1972). The average altitudes ranged between 58 m and 169 m.

Table 1. ***The morphometrical features of the main rivers in Dobrogea***

No.	River	Hydrometric station	F_a* (km²)	F** (km²)	H_b* (m)	H** (m)	L_c* (km)	L_d** (km)
1.	Agi Cabul	Cuza Vodă	105	117	23	76	20	22
2.	Albeşti	Albeşti***	349	328	160	98	25	40
3.	Biruinţa	Biruinţa	47	90	49	64	7	7
4.	Cartal	Pantelimonu de Jos	127	127	150	143	26	29
5.	Casimcea	Casimcea	78	738	263	144	16	76
		Cheia	500		163		50	
6.	Râmnic	Pantelimonu de Jos	87	86	166	166	20	22
7.	Slava	Ceamurlia	350	356	177	169	34	38
8.	Taiţa	Satu Nou	565	591	151	147	54	54
9.	Topolog	Saraiu	264	314	181	159	41	58
10.	Urlichioi	Biruinţa	22	*25*	53	58	8	8

F = catchment area (a = corresponding to the hydrometric station); H = average altitude of the catchment area (b = at the level of the hydrometric station); L = length of the stream (c = spring – hydrometric station; d = source – river mouth); *italic* = minimum values; **bold** = maximum values; *Data source = NIHWM. **values obtained from GIS spatial analysis of the Romania's topographic map, scale 1:25000, second edition, DTM, 1982; ***partial surface without „F" from Bulgaria.

The lower values of the mean multiannual discharges (0.022 m³ s^{-1} – 0.657 m³ s^{-1}) make obvious the influence of the geological and climatic conditions on the hydrologic regime (Table 2). The mean multiannual specific liquid discharge ranges between 0.50 l s^{-1} km^{-2} (Albeşti River, Albeşti HS) and 8.28 l s^{-1} km^{-2} (Casimcea River, Casian HS) and the mean multiannual water volume ranges between 0.70 mil. m³ (Urlichioi River, Biruinţa HS) and 20.73 mil. m³ (Casimcea River, Cheia HS).

Table 2. ***The hydrological features of the main Dobrogea rivers***

No.	River	Hydrometric station	Q_0 (m³ s^{-1})	q_0 (l s^{-1} km^{-2})	W_0 (mil. m³)	h_0 (mm)	C_v
1	Agi Cabul	Cuza Vodă	0.253	2.41	8.0	76.04	0.43
2	Albeşti	Albeşti	0.173	*0.50*	5.4	*15.64*	**0.66**
3	Biruinţa	Biruinţa	0.077	1.64	2.4	51.70	0.38
4	Cartal	Pantelimonu de Jos	0.137	1.08	4.3	34.05	0.51
5	Casimcea	Casian	0.646	**8.28**	20.4	**261.38**	0.51
		Cheia	**0.657**	1.31	**20.7**	41.47	*0.25*
6	Râmnic	Pantelimonu de Jos	0.081	0.93	2.6	29.38	0.46
7	Slava	Ceamurlia de Jos	0.180	0.51	5.7	16.23	0.51
8	Taiţa	Satu Nou	0.437	0.77	13.8	24.41	0.43
9	Topolog	Saraiu	0.314	1.19	10.0	37.54	0.46
10	Urlichioi	Biruinţa	*0.022*	1.00	*0.70*	31.56	0.51

Q_0 = mean multiannual liquid discharge; q_0 = mean multiannual specific liquid discharge; W_0 = mean multiannual volume of water; h_0 = mean multiannual water layer; C_v = coefficient of interannual variation of the mean flow; *italic* = minimum values; **bold** = maximum values. Data source: the values were obtained processing the data from the NIHWM.

The mean multiannual water layer oscillates between 15.64 mm (Albeşti River, Albeşti HS) and 261.38 mm (Casimcea River, Casian HS). The interannual coefficient of variation of the mean flow has values between 0.25 and 0.66 (the lower values < 0.40 reflect the relatively uniform flow) and the module coefficient ranges between 0.01 – 3.36.

In the table 3 are presented the mean annual discharges with different probabilities of exceedance (1%, 5%, 10%, 20%, 50%, 80%, 90%, 95%, 97%) which have been computed using the Pearson III theoretical binomial distribution to create an overview of the average annual flow variability. The asymmetry coefficient (C_s) has been considered as being the double of the coefficient of variation (C_v) for mean annual flow series (Diaconu and Lăzărescu, 1965) (Table 3).

Table 3. ***The mean annual discharges with different probabilities of exceedance of the main Dobrogea rivers***

River	Qmedp% (the mean annual discharges with different probabilities of exceedance)								
	1%	5%	10%	20%	50%	80%	90%	95%	97%
Albeşti	0.540	0.393	0.327	0.256	0.149	0.077	0.052	0.137	0.102
Biruinţa	0.158	0.129	0.115	0.099	0.073	0.052	0.042	0.035	0.031
Urlichioi	0.056	0.043	0.037	0.031	0.020	0.013	0.009	0.007	0.006
Agi Cabul	0.568	0.454	0.399	0.338	0.239	0.159	0.126	0.103	0.087
$Casimcea_a$	1.642	1.266	1.088	0.896	0.593	0.365	0.266	0.200	0.160
$Casimcea_b$	1.104	0.952	0.877	0.792	0.643	0.515	0.453	0.423	0.380
Cartal	0.351	0.271	0.232	0.191	0.126	0.077	0.056	0.042	0.033
Râmnic	0.194	0.152	0.132	0.111	0.076	0.067	0.038	0.030	0.026
Slava	0.459	0.353	0.304	0.250	0.165	0.101	0.073	0.055	0.044
Topolog	0.742	0.583	0.508	0.425	0.292	0.259	0.148	0.119	0.101
Taiţa	0.976	0.780	0.687	0.582	0.413	0.276	0.219	0.179	0.153

a = Casian HS; b = Cheia HS. The missing data: *1979; ** 1977 and 1979. Data source: the values were obtained processing the data from the NIHWM.

The highest mean multiannual monthly discharges ranged between 10.6% and 15.5% from the mean annual volume of water and have been produced in different months, due to the local conditions which influence the flow: *February* (15.5%, Casian HS), *March* (12.2%, Satu Nou HS, and 11.0%, Ceamurlia de Jos HS), *June* (10.9%: Cuza Vodă HS; 11.7%: Biruinţa HS, on the Urlichioi River; 12.5%: Pantelimonu de Jos HS, on the Râmnic River; 15.5%: Pantelimonu de Jos HS, on the Cartal River), *July* (10.6%, Cheia HS; 11.8%, Saraiu HS; 14.6%, Albeşti HS), *September* (10.9%, Biruinţa HS) (Fig. 2). The lower mean multiannual monthly discharges oscillated between 5.0% and 7.3% from the mean annual volume of water and have been produced during autumn and winter (for example: November = 4.97%, Cartal HS).

The analysis of the seasonal variability of the mean liquid flow mainly highlights the influence of the climatic conditions over the river water resources. These present the richest flow, as follows: in the *winter* (28.7% from the mean volume of water, Casian HS), *spring* (25.2%, Biruinţa HS on the Biruinţa River; 30.3%, Satu Nou HS; 30.8%, Ceamurlia de Jos HS), *summer* (between 28.9% and

39.3%), and the lowest during *autumn* (18.7% – 20.9%) and (17.0% – 24.8%) (Fig. 3).

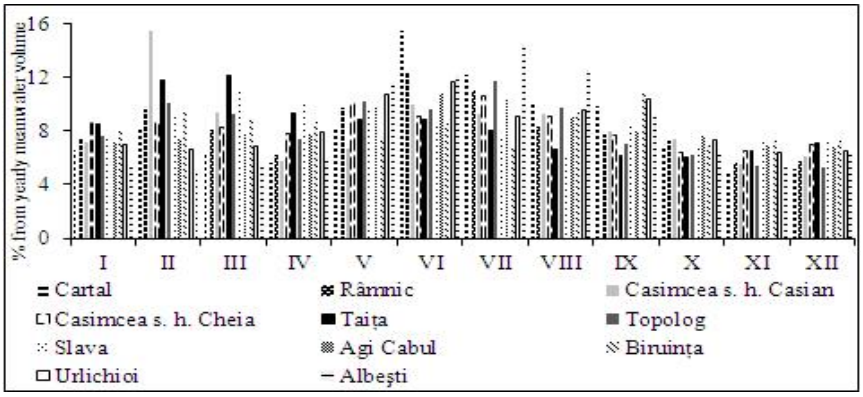


Fig. 2. ***The variability of the mean monthly discharges at the studied hydrometric stations***

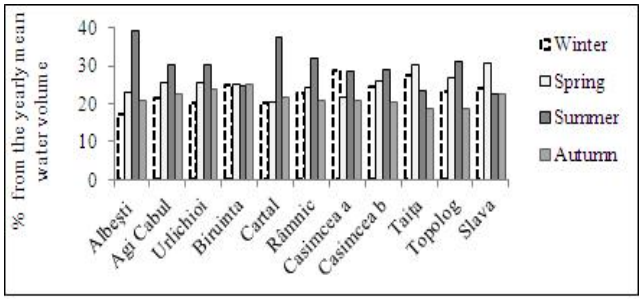


Fig. 3. ***The seasonal variablity of the mean monthly discharges at the studied hydrometric stations***

4. CONCLUSIONS

The hydrologic regime of the Dobrogea rivers is mainly influenced by the climatic and geological conditions. The mean multiannual discharges don't exceed 0.7 $m^3 s^{-1}$. Generally, the studied rivers have the higest flow during summer due to the rain showers. At the seasonal scale, the highest flow is in summer (28.5% – 39.3% from the mean volume of water) and the lowest is in autumn and winter (17.0% – 25.0% from the mean volume of water).

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