CONSIDERATION REGARDING THE MEAN RUNOFF OF THE MAIN RIVERS FROM THE SOUTH DOBROGEA

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ABSTRACT. – Consideration regarding the mean runoff of the main rivers from the South Dobrogea. This paper investigates the specific features of the runoff of the main rivers from the South Dobrogea. The evidence of these is based on the processing of monthly and yearly discharges, for the next stream gauging stations: Cuza Vodă, Albeşti, Biruinţa. The used methodology includes statistical analysis (employed to determine frequencies and exceeding probabilities), correlations, investigation and observation made in the area. In the South Dobrogea the mean multiannual discharge ranged between 0,08 m^3/s and 0,27 m^3/s, the mean multiannual specific liquid discharge ranged between 0,50 $l/s.km^2$ and 2,56 $l/s.km^2$, the mean multiannual volume of water ranged between 697.525 m^3 and 8.491.284 m^3, the mean multiannual water layer ranged between 15.67 mm and 80,87 mm. In the studied area the largest discharges were in the months: June, July and September. The lowest discharges were in February, December, July and November. The richest discharges were in the summer and the lowest discharges in the winter.

Keywords: mean runoff, rivers, Dobrogea, rainfall, evapotranspiration.

1. INTRODUCTION

The water resources of the rivers can be synthetically appreciated by the assessment of the mean liquid discharge parameters and the analysis of their spatial and temporal variability. This type of flow can be expressed as liquid discharge (Q in m^3 / s), specific liquid discharge (q in l/skm^2), water layer (h in mm) and volume of water carried by the rivers (W m^3) (*Zaharia, 1999*).

The aim of this study is to present the features of the mean liquid flow of the main rivers from South Dobrogea: Agicabul, Albeşti, Biruinţa and Urlichioi. It is mainly based on the processing of data regarding the monthly and yearly mean liquid discharges from The National Institute of Hydrology and Water Management, for the next period: the hydrometric station Cuza Vodă, on the Agicabul River: 1984–2007; the hydrometric station Albeşti, on the Albeşti River: 1966–1997; the hydrometric station Biruinţa, on the Biruinţa River: 1974–2009; the hydrometric station Biruinţa, on the Urlichioi River: 1974–2007.

For the analysis of the meteorological data was assessed the data regarding the air temperature and the precipitation from the weather stations Mangalia, Constanţa, Medgidia and Adamclisi, for the period 1965-2000. This data was taken

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from the paper *Condiţiile climatice şi influenţa lor asupra cadrului geografic din Dobrogea de Sud* (*Torică, 2004*). The analysis of the potential evapotranspiration and of the snow layer is based on the processing of data taken from the paper *Clima României, 2008* (for the period 1961-2000). The used methodology includes statistical analysis (employed to determine frequencies and exceeding probabilities), correlations, investigation and observation made in the area.

The important contributions regarding the knowledge of the hydrological and hydrochemical features of the rivers from the South Dobrogea can be found in the synthesis papers, as *Monografia hidrologică a râurilor şi lacurilor din Dobrogea* (1968) or in papers of authors like L. Zaharia and I. Pişota (2003) ş. a.

2. THE MAIN FACTORS INFLUENCING THE FLOW OF THE RIVERS FROM THE SOUTH DOBROGEA

The flow of the rivers from the South Dobrogea is the result of the combination of the specific natural and anthropogenic factors of the area. Among them more important are the meteorological, geological and morphological factors.

2.1. THE CLIMATIC FEATURES

The climatic features are the decisive factors which influence the variability of the liquid discharge of the rivers. A major role is held by the air temperature regime, the rainfall regime and the evapotranspiration regime. The South Dobrogea has a temperate climate characterized by dryness, with sea influences in the eastern side, determined by its geographical location and the features of the meteorological parameters (*Geografia României, 2005).*

In the research area, the mean multiannual air temperature ranges between 10.8°C/year (the Adamclisi weather station) and 11.7°C/year (the Constanţa weather station). In the summer months, the mean values of the air temperature range between 20°C/month – 22°C/month; in the winter months the temperature reach even - 0.7°C/month.

The mean multiannual values of the rainfall are weak and in this area these were ranged between 412 mm/year (the Mangalia and Constanţa weather stations) and 473 mm/year (the Adamclisi weather station). The yearly analysis of the rainfall show years with richer rainfalls over 700 mm/year (e.g. at the Adamclisi weather station in the year 1997 have been measured 717.5 mm) and years with lower rainfalls below 223 mm/year (e.g.: at the Medgidia weather station in the year 2000 have been measured 222.7 mm).

The yearly analysis show that the richer rainfalls are specific for the months May and June (over 50 mm/month) and the weaker rainfalls are specific to the months January and February (below 30 mm/month).

In the South Dobrogea, an important meteorological parameter of the water resources is the evapotranspiration. This ranged in mean 725.6 mm/year at the Constanţa weather station, exceed 120 mm/month in the interval June-August at the Constanţa weather station, in the period 1961-2000 (*Clima României, 2008*). Regarding the snow layer, because of the climatic features specific of the South

Dobrogea and because of the sea influences, it is present in a smaller number of days (the mean 15 days, the maximum 44 days – *Clima României, 2008*) and it has a mean monthly thickness which doesn't exceed 1 cm/month.

2.2 THE GEOLOGICAL AND MORPHOLOGICAL FEATURES

The South Dobrogea is a structural plateau, with almost plane layers, overlapping in many sedimentary cycles, over the eastern side of the Moesian Platform (*Popescu, Ielenicz, 2003*). It is a platform, with plane or wavy interfluve and with altitude ranging between 200 m (in west) and 100 m (in east) (*Ciulache, Torică, 2003*). From petrographical point of view, in this area 90% of the outcrop are loessoid deposits followed by limestone, marl-limestone (7% outcrop, 75% based on loessoid deposits), sandstones, conglomerates, sands, gravels and clays (*Geografia Românie, 2005*). These lithological deposits, and also the gentle slopes are favorable to the infiltration of the rain water and those of the river bed, favoring the draining phenomena and therefore reduction of the water resources of the rivers.

3. GENERAL DATE ON THE RIVERS FROM THE SOUTH DOBROGEA

In the South Dobrogea, because of the specific features of the area, the density of the drainage network is very weak (under 0.1 km/km²).The rivers have an intermittent pattern, sometimes even accidentally, becoming active only after powerful rainfalls (*Zaharia, Pişota, 2003)*. In the table 1 are presented the main morphometric data of the analyzed rivers from this paper: Agicabul, Albeşti, Biruinţa şi Urlichioi. The Albeşti, Urlichioi (Dereaua) and Biruinţa belong to the Seaside Basin and are the tributaries of the lagoons and fluvial-sea lakes: Albeşti River is a tributary of Mangalia lake, the Urlichioi and Biruinţa Rivers are tributary of the Techirghiol lake (Fig. 6). From these rivers an important role has the Albeşti Rriver because it's upper sector develops on the surface of Bulgaria (Prebalcanic Plateau). The lengths of these rivers range between 7 km and 25 km. After analysis, we find out that on Romania's surface the largest catchment area with 326 km ² belongs to the Albeşti River and the lower catchment area belongs to the Urlichioi River with 25 km².

Tabel 1. ***The morphometric data specific to the rivers from the South Dobrogea****

Stream	Data regarding the main streams					The catchment area (km²)
	Length (km)	Elevation (m)		The mean slope (‰)	The sinuosity coefficient	
		upstream	downstream			
AgiCabul	22	72	4	3	1.24	118
Biruinţa	7	40	0	6	1.17	90
Urlichioi	7	68	0	10	1.18	25
Albeşti	25	100	0	4	1.69	326**

** According to Atlasul Cadastrului Apelor din România, vol. I, 1992; **The partial catchment area–without the catchment area from the Bulgaria*

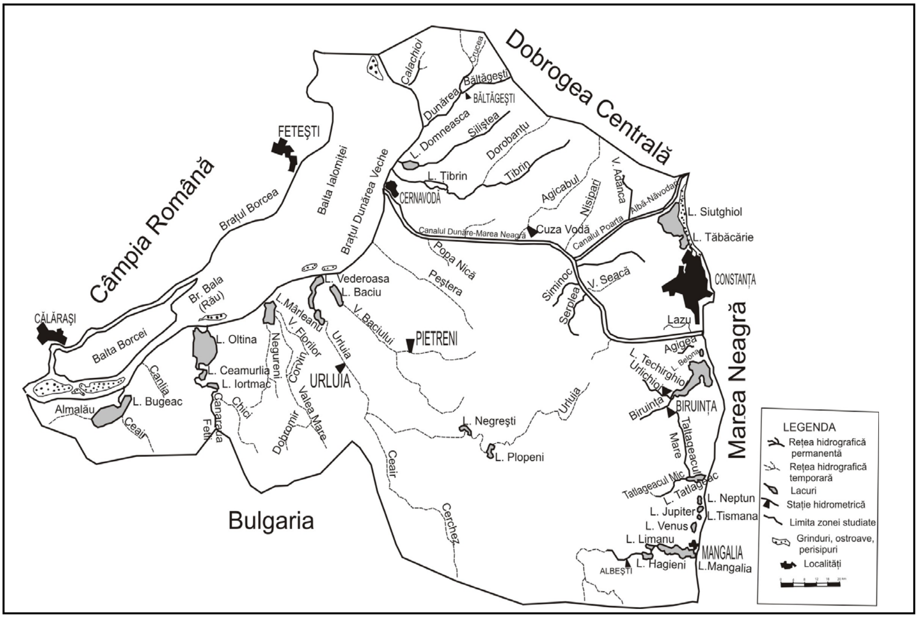

Fig. 6. ***The South Dobrogea – Hydrographical map***
(built upon L. Zaharia and I. Pişota, 2003)

4. THE MEAN MULTIANNUAL LIQUID DISCARGE AND ITS SPATIAL VARIABILITY

The mean multiannual runoff is highlighted by the values of the multiannual discharge, the specific liquid discharge, the volume of water and the value of the layer water. As a result of the physical and geographical conditions specific to South Dobrogea, the rivers that drain these areas show a weak liquid flow that is reflected by all the parameters of the mean flow. This way, the multiannual discharges of the four analyzed rivers are smaller than 0,3 m^3/s, the biggest value being the one of the Agicabul River (0.27 m^3/s) (table 2). The mean multiannual specific liquid discharge ranges between 0,50 $l/s.km^2$ and 2,56 $l/s.km^2$, the mean multiannual water volume ranges between 697.525 m^3 (Urlichioi River) and 8.491.284 m^3 (Agicabul River), and the mean multiannual water layer ranges between 15.67 mm (Albeşti River) and 80.87 mm (Agicabul River). The coefficient of interannual variation of the mean discharges ranged between 0.36 (Agicabul River) and 0.66 (Albeşti River). The values below 0.4 could be caused by the relatively short analysis time and also by the influence of the lithological substratum and a possible underground supply. Generally, the small values of the mean multiannual discharge mirror the climatic conditions, with weak precipitations and high evapotranspiration.

Table 2. ***Morphometric and hydrologic characteristics of the main rivers in South Dobrogea.***

River	Hydrometric station	Surveillance period	F (km²)	H (m)	L (km)	Q0 (m³/s)	q0 (l/s.km²)	W0 (m³)	h0 (mm)	Cv
Agicabul	Cuza Vodă	1984-2007	105	23	20	0.27	2.56	8.491.284	80.87	0.36
Albeşti	Albeşti	1966-1997	349*	160	25	0,17	0.50	5.468.085	15,67	0.66
Biruinţa	Biruinţa	1974-2009	47	49	7	0.08	1.63	2.416.820	51.42	0.38
Urlichioi	Biruinţa	1974-2007	22	53	8	0.022	1.00	697.525	31.71	0.51

**partial surface, without „F" from Bulgaria; Data source – N.I.H.W.M.*
F – the catchment area (corresponding to the hydrometric station); H – average altitude of the catchment area (at the level of the hydrometric station); L – the length of the stream (spring- hydrometric station); Q0 – the mean multiannual liquid discharge; q0 – the mean multiannual specific liquid discharge; W0 – the mean multiannual volume of water ; h0 – the mean multiannual water layer; Cv – The coefficient of interannual variation of the mean runoff

Analysing the correlation between the mean specific liquid discharge and the catchment surface we notice a weak dependence between the variables (table 3). This is because of the short working time of the stations and the action of some local factors that influence the flow.

Table 3. ***Correlation coefficients and determination coefficients of different relationships between the main parameters of the runoff and the main parameters of the catchments or climatic features***

Relationship	Correlation coefficient	Determination coefficient
q0 – F	0,1	0,012
q0 – H	0,91	0,828
Cv – H	0,81	0,663
P1 – Q1	0,72	0,515
P2 – Q2	0,58	0,336
P3 – Q3	0,21	0,044
P4 – Q4	0,45	0,206

q0 – the mean multiannual specific liquid discharge of the main rivers from the South Dobrogea (l/s.km²; 1984-1997); **F** – the catchment area (km²; corresponding to the hydrometric station of the main rivers from the South Dobrogea); **H** – average altitude of the catchment area (m; at the level of the hydrometric station of the main rivers from the South Dobrogea); **Cv** – the coefficient of interannual variation of the mean runoff of the main rivers from the South Dobrogea (1984-1997); **P1** – the annual amounts of precipitations at Mangalia weather station (mm; 1984-1997); **Q1**- the mean annual discharges of the river Albeşti (Albeşti station) (m³/s; 1984-1997); **P2** the annual amounts of precipitations at Constanţa weather-station (1984-1997); **Q2** – the mean annual discharges of the river Urlichioi (Biruinţa station) (m³/s; 1984-1997); **P3** – the annual ammounts of precipitations at Constanţa weather station (1984-1997); **Q3** – the mean annual discharges of the river Biruinţa (Biruinţa station) (m³/s; 1984-1997);
P4 – the annual ammounts of precipitations at Medgidia weather station (1984-1997); **Q4** – the mean annual discharges of the river Agicabul (Cuza Vodă station) (m³/s; 1984-1997).

By analysing the correlation between the mean multiannual specific liquid discharge and the average altitude of the catchments (at the level of the gauging stations) we see a connection between the variables at level of significance $\alpha=0.05$, for the common period for all the gauging stations (1984-1997). There is also a tight connection between the coefficient of interannual variation of the mean runoff and the average altitude of the catchments (at the level of the gauging stations) (table 3).

For highlighting the influence of the precipitations over the mean discharge we did correlations between the mean annual discharges and the annual amount of the precipitations. This way, the correlation between the mean annual discharges from Albeşti and Biruinţa (Urlichioi River) gauging stations and the annual amount of precipitation shows a connection between the variables , at level of significance $\alpha=0.05$. There is a poor connection is between the mean annual discharges for Cuza Vodă and Biruinţa gauging stations and the annual amounts of precipitations (Medgidia and Constanţa gauging stations). This could be because of some local conditions that influence the drainage (possibly underground supply).

5. THE MEAN YEARLY LIQUID RUNOFF

Across the analysis period, the mean yearly flow has had higher and lower oscillations from one year to another mainly generated by the non-uniformity of the climatic features. The analyses of the mean multiannual flow reveal that the highest mean yearly discharges were in the years 1984 (0. 426 m^3/s; Agicabul River), 1989 (0.345 m^3/s; Albeşti River), 2005 (0.157 m^3/s; Biruinţa River), 1996 (0.043 m^3/s; Urlichioi River). The highest values of the mean yearly discharges are the consequence of the richer amounts of precipitations specific to each year. The lower mean yearly discharges during the analyses were recorded in the years 1970 (0.0017 m^3/s; Albeşti River), 2007 (0.08 m^3/s; Agicabul River), 1977 (0.027 m^3/s Biruinţa River) and 1976 (0.0008 m^3/s; Urlichioi River), with values which ranged between 0.0008 m^3/s and 0.08 m^3/s and were mainly generated by the high evaporation, by the lower amounts of precipitations (for example: almost 285 mm in the year 1976) and by the specific lithological features. For a more precisely analysis regarding the variability of the mean interannual liquid flow the yearly discharge coefficient was determined, a parameter which represent the variability of the mean yearly discharge against the mean multiannual discharge. The analysis reveals that the highest values of the yearly discharge coefficient ranged from 1.5 to 2.05 in the years with the richest yearly mean discharges. The analysis regarding the frequency of the yearly mean discharges with some interval of discharges reveals that the higher frequency had the discharges with values between 0.001 m^3/s to 0.05 m^3/s at the Albeşti hydrometric station; 0.01 m^3/s to 0.015 m^3/s at the Biruinţa hydrometric station, on the Urlichioi River; 0.30 m^3/s to 0.35 m^3/s at the Cuza Vodă hydrometric station and between 0.05 m^3/s to 0.1 m^3/s at the Biruinţa hydrometric station, on the Biruinţa River.

6. THE MEAN MONTHLY LIQUID RUNOFF

The analysis regarding the variability of the mean monthly discharges reveal a hydrological regime with higher and lower oscillations from one month to another mainly generated by the influence of the climatic features on the supply sources.

On the whole area, the richest mean discharges occurred, generally, in the summer months, with a frequency to 15% from the mean yearly volume of water. These values are the consequence of the rain showers specific to this season although the values of the evapotranspiration are higher, according to the knowledge presented in Chapter 2.1. The analysis of the hydrological regime reveals some differences from one river to another, which can be the consequence of the influence of specific local features in the formation of the runoff. The lowest mean discharges are specific for the months from the cold season of the year, when the frequencies of the mean runoff from the mean total volume of water ranged between 5%-7%. These values reveal the lower rainfall supplies from this season and the insignificant snow supply (fig. 16).

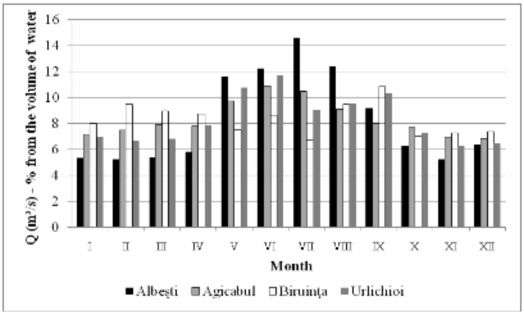

Fig. 16. ***The variability of the mean mountly discharges from the Albeşti, Cuza Vodă, Biruinţa (Urlichioi and Biruinţa Rivers) hydrometric stations***

7. THE SEASONAL VARIABILITY OF THE MEAN RUNOFF

The seasonal variability of the water resources transported by the rivers is a consequence of the contribution of supply sources which are generally influenced by the climatic features.

The analysis reveal that in the summer was the richest flow, when there were transported between 24.85% and 39.27% from mean yearly volume of water. The studied rivers had the lowest mean discharges in the winter, between 17.04% and 24.82% from the mean yearly volume of water. The richer discharges from the summer are the consequence of the rain shower and the lower discharges from the winter are the consequence of the weaker amounts of liquid precipitations. In the spring, the mean runoff ranged between 22.87% and 25.60% from mean yearly runoff. The rivers are supplied in this season from the melting snow. In the autumn, the mean runoff ranged between 20.82% and 25.11%, because of the lower amounts of precipitations specific to this season.

On the whole area has been found that the variability of the mean runoff at the seasonal scale is lower compared with other regions of the country. The values of the report between mean runoff from the season with a rich flow (Ap) and a low flow (As) are smaller than 3: 2.30 in the case of the Albeşti River; 1.51 in the case of the Urlichioi River; 1.42 in the case of the Agicabul River; 1.02 in the case of the Biruinţa River (table 4).

Tabel 4. ***The data regarding the seasonal variability of the mean liquid runoff from the South Dobrogea*****

River	Hydrometric station	The seasonal mean liquid runoff (% from the yearly volume of water)				Ap/As*
		Spring	Summer	Autumn	Winter	
Agicabul	Cuza Vodă	25.46	30.47	22.59	21.48	1.42
Albești	Albești	22.87	39.27	20.82	17.04	2.30
Biruința	Biruința	25.22	24.85	25.11	24.82	1.02
Urlichioi	Biruința	25.60	30.28	24.01	20.11	1.51

**Ap=the season with a rich flow, As=the season with a low flow; ** According to N.I.H.W.M. data.*

CONCLUSIONS

As a consequence of the specific climatic and lithological features of the studied area the rivers from the South Dobrogea have lower discharges highlighted by the values of the multiannual discharges which don't exceed $0.3m^3/s$. The higher volumes of water transported in the interval June-July are caused by the rain showers specific to these months. Among the seasons, the summer has the richest flow, when are transported between 24.85% and 39.27% from the volume of water, while the winter is the season with the lowest flow (between 17.04% and 24.82%). However the ratio between the mean runoff in the season with the richest flow and the season with the lowest flow is weaker (the maximum 2.30) which reveals a relatively uniform seasonal regime.

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