TEMPORAL VARIABILITY OF WATER RESOURCES IN THE LOWER BUZĂU CATCHMENT

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ABSTRACT. - Temporal variability of water resources in the Lower Buzău catchment. The aim of this study is to analyse the water resources in the Lower Buzău catchment, in terms of temporal variability and of economic use of these natural assets. In the plain area of Buzău catchment, the water resources are represented mainly by the Buzău River, by the fluvial limans on the left riverside (Coșteiu, Jirlău, Amara, Balta Albă), and also by the phreatic aquifers. This study is based mainly on hydrological data regarding average streamflow of Buzău River (at Banița and Racovița gauging stations) and mean levels of the lakes Jirlău and Balta Albă. Groundwater data cover phreatic level depth measured at six monitoring wells located in the Buzău River floodplain area. In the first stage, the temporal trends of the Buzău River streamflow rate (1960-2009) and of the piezometric level depth (1980-2004), were analysed using Mann-Kendall statistical test. The second phase consisted in the analysis of the statistical correlations between hydrological and groundwater parameters, by applying Bravais-Pearson test. At multiannual scale, the quantitative reduction of water resources is observed both in the case of surface waters (decreasing trends of Buzău River discharges) and of groundwater levels, with negative implications on the water resources future availability and on their long-term using potential.

Keywords: water resources, Lower Buzău catchment, temporal variability, economic use

1. INTRODUCTION

The sustainable management of water resources in a given territory is based primarily on the knowledge of surface and underground water resources that are actively interconnected. In this context, a complete analysis of natural water resources available in a drainage basin has to take into account the temporal variation of the water volumes from rivers and lakes and also from phreatic aquifers. Thus, the present study intends to analyse the temporal variability of hydrological (average liquid discharge, mean levels of lakes) and hydrogeological parameters (piezometric level depth) in the Lower Buzău catchment, in order to asses their statistical trends (at multiannual and monthly scales) and the correlations between them.

In the specific literature, there are few researches about the Buzău River catchment in terms of water resources: *Water resources in the Buzău Drainage*

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Basin (Diaconu, 2005). In some contemporary works, the Buzău River and its drainage basin is analysed in a wider geographical context regarding the Carpathian Curvature region or, in older studies, the North-eastern part of Romanian Plain: *Water resources in Curvature Subcarpathians. Geospatial assessments* (Chendeș, 2011), *Spatial variation of stream power in the Buzău and Ialomița River catchments* (Minea et al., 2011), *Excessive humidity in the North-east Romanian Plain during 1969-1973* (Gâștescu et al., 1979), *Geochemistry and capitalization of natural waters in North-eastern Romanian Plain* (Florea, 1976).

2. STUDY AREA

The plain sector of the Buzău River catchment, with an area of 1678 km², is located in the north-east part of the Romanian Plain (Fig. 1). In the Lower Buzău catchment, the altitudes decrease from west (over 250 m) to east (about 6 m).

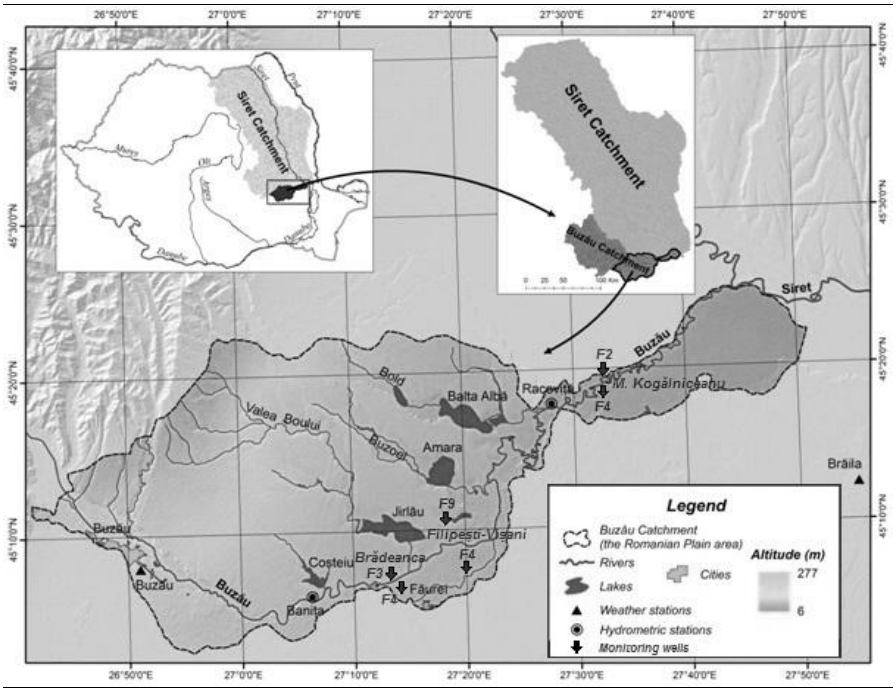

Fig. 1. ***Location of the study area and of weather, hydrometric and groundwater stations***

Buzău River covers in the lower sector a distance of 162 km, more than a half of its total length (308 km). The plain sector of the watercourse features a high sinuosity with many meanders, due to the low flow velocity and to the mild slopes.

In terms of climate, the Lower Buzău catchment is located in the temperate region. Average multiannual temperatures recorded at the Buzău and Brăila weather stations (1960 – 2009) fall around 11°C. Average multiannual rainfall

amounts range from 450 mm at Brăila to 520 mm at Buzău, while the annual potential evapotranspiration is around 700 mm.

Buzău River's annual streamflow variation features a highly prominent spring peak and an autumn minimum. Average multiannual streamflow values are of 28.2 m³/s at the Banița gauging station and of 27.5 m³/s downstream at Racovița.

The lithology of the study field comprises generally sands, gravels and boulders with clay intercalations (Cândești layers). These highly permeable quaternary formations allow the underground accumulation of important water resources. In the floodplain of the Lower Buzău River, the phreatic level regime is influenced both by rainfall and the flows from the neighbouring areas (Pascu, 1983). In the Lower Buzău catchment area, there are two phreatic groundwater bodies (RO-IL 05 and RO-SI 05), made of sands and gravels.

Buzău Municipality (130000 inhabitants) is the only major urban settlement in the Lower Buzău catchment. The study area belongs to the Buzău and Brăila Counties, where the water resources can be estimated as slightly poor (Gâștescu, 2010) in terms of socio-economic demands.

3. DATA AND METHODS

This study is based mainly on hydrological data regarding average streamflow rates of Buzău River, recorded at the Banița and Racovița gauging stations between 1956 and 2009 (ABA Buzău-Ialomița, 2014) and mean levels of the lakes Jirlău and Balta Albă between 1956 and 1970 (Hydrological Yearbook, 1956-1970). Groundwater data cover phreatic level depth measured between 1980 and 2004 at six monitoring wells located in the Buzău River floodplain area (SGA Brăila, 2014). The climate data, represented by average precipitation (mm) and mean temperatures (°C), were recorded at the Buzău (Klein Tank et al., 2002) and Brăila (Vișinescu et al., 2003; ANM, 2011) weather stations between 1960 and 2009. Climatic water balance (CWB), represented by excess or deficit, resulted from the subtraction between precipitation and potential evapotranspiration (CWB = P - PET); potential evapotranspiration values (PET) (mm) were computed using Thornthwaite's methodology (Thornthwaite, 1948).

In the first stage, the temporal trends of the Buzău River streamflow rate (1960-2009) and of the piezometric level depth (1980-2004), detailed at annual and monthly scales, were analysed using Mann-Kendall statistical test (Salmi et al., 2002). In the case of lakes, the limited data series (covering only 15 years) did not allow the assessment of long-term trends. The statistical correlations between hydrological and groundwater parameters showed the extent to which the Buzău River streamflow variability influenced the phreatic levels. In order to assess the statistical significance of the *r* correlation coefficient, the Bravais-Pearson statistical test was applied (Minvielle and Souiah, 2003). The second working step consisted in the analysis of economic use of the water resources, with quantitative data regarding only the groundwater exploitations from the study field.

4. RESULTS AND DISCUSSIONS

4.1. Buzău River liquid discharge variation

Climatic water balance adjusts better than rainfall amounts to the Buzău River liquid discharge variability, because it takes into account also the water loss by evapotranspiration. Thus, a positive water balance (which resulted only at the Buzău weather station) corresponds to annual peaks in streamflow rate fluctuation (recorded in 1970, 1991 and 2005), while the negative values (expressing water deficit) are associated with lower discharges (Fig. 2).

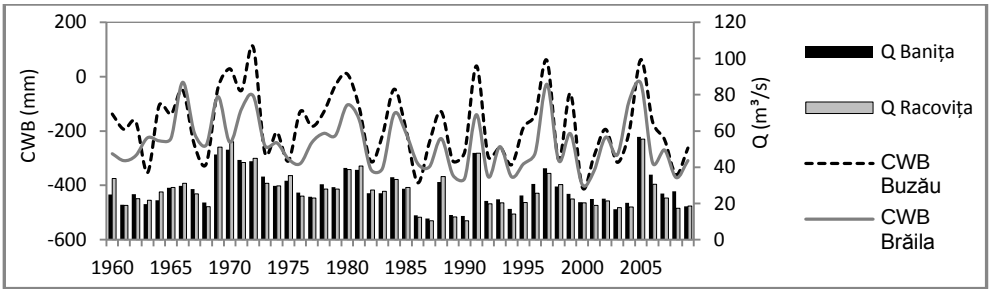

Fig. 2. ***Climatic water balance (CWB) at Buzău and Brăila weather stations and average river discharge (Q) at Banița and Racovița gauging stations (1960-2009)***

The annual streamflow variation of the Buzău River generally shows a downward trend (Table 1), more strongly marked at the Racovița gauging station.

Table 1. ***Average discharge Q (1960-2009) and piezometric level depth H (1980-2004) trend slopes (according to Mann-Kendall test)***

Time scale		Q Buzău		H Brădeanca		H Filipești-Vișani		H Kogălniceanu	
		Banița	Racovița	F3	F4	F4	F9	F2	F4
ANNUAL		-0,10	-0,21*	1,78	3,51***	2,65^{+}	-2,00*	10,91***	2,44*
MONTHLY	Jan	0,04	0,01	1,36	3,26**	1,59	-2,43*	9,26***	1,28
	Feb	-0,07	-0,14	1,14	3,07*	2,17	-2,62*	9,92***	0,99
	Mar	-0,05	-0,18	1,63^{+}	3,40**	4,02**	-2,44*	11,01***	1,97^{+}
	Apr	-0,19	-0,17	1,30	3,84***	4,81**	-2,06^{+}	13,24***	2,97**
	May	-0,42*	-0,40^{+}	1,32	4,18***	4,76**	-1,73^{+}	12,82***	3,35**
	Jun	-0,25	-0,34^{+}	1,47*	4,34***	3,93*	-1,64^{+}	12,68***	3,05**
	Jul	-0,04	-0,03	1,55	4,29**	2,99*	-1,65	12,02***	2,69*
	Aug	0,03	-0,02	2,36*	4,07**	1,90	-1,59^{+}	10,58***	2,19^{+}
	Sep	0,16	0,08	2,50*	3,78**	1,17	-1,68*	9,23***	1,75^{+}
	Oct	0,18*	0,13	2,22^{+}	3,02*	0,39	-1,70*	8,73***	1,07
	Nov	0,12	0,02	1,77^{+}	3,10*	0,87	-2,08^{+}	8,58***	1,00
	Dec	0,06	0,05	1,90^{+}	2,87*	1,40	-2,25^{+}	8,75***	0,61

Note: +', *, ** and *** indicate significance level of 0.1, 0.05, 0.01 and 0.001

Regarding the flow rate at monthly scale, significant downward trends resulted in May for both river sections, and in June only at the Racovița gauging

station; significant positive trends were recorded in October for the upstream section (at a significance level $\alpha = 0.05$).

4.2. Groundwater level variation

At annual scale, the piezometric level depth in the Lower Buzău catchment has an increasing tendency over the past three decades, more statistically significant at Brădeanca F4 and M. Kogălniceanu F2 monitoring wells (Table 1). The strongest monthly trends (with significance levels of 0.001) resulted again for the values measured at M. Kogălniceanu F2 well, where the phreatic level lowered dramatically. At Filipești-Vișani F9 well, the negative trends, recorded both annualy and monthly, mean an increasingly higher water table in the limans area.

The rainy periods have a direct influence on the phreatic level variation (Fig. 3).

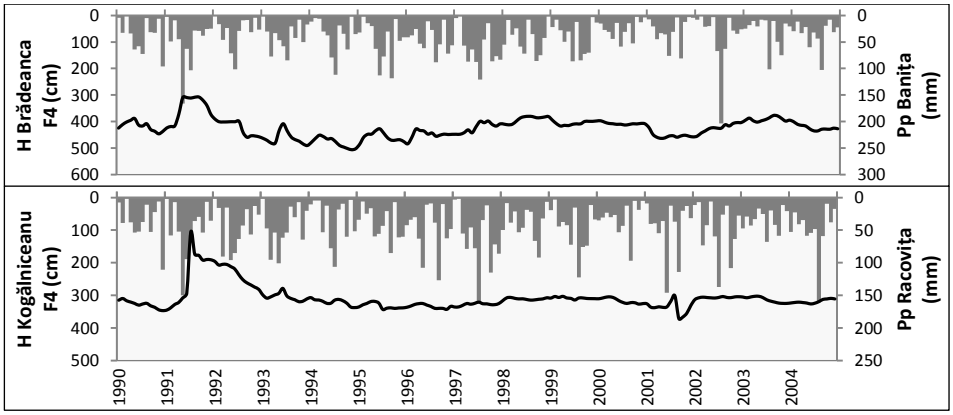

Fig. 3. ***Monthly values of rainfall amounts (columns) and piezometric level depth (lines)***

For instance, the high rainfall rates recorded at the Banița and Racovița hydrometric stations in 1991 caused groundwater level rises, especially in the case of Brădeanca F4 and Kogălniceanu F4 wells.

The analysis of the relationship between Buzău River liquid discharge and groundwater level was performed based on mean annual values (Fig. 4).

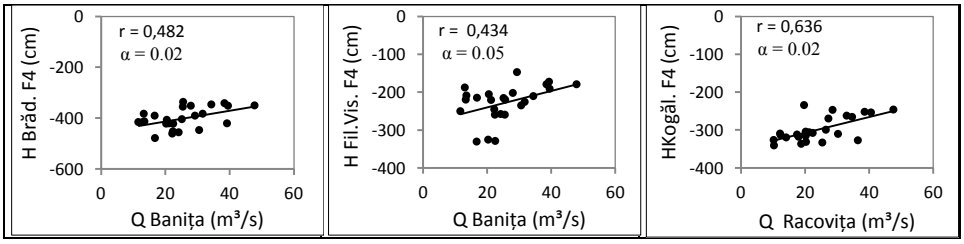

Fig. 4. ***Correlations between river discharges and piezometric level depth (1980-2004)***

Statistically significant correlations (with significance level $\alpha = 0.02$) resulted in the case of monitoring wells located close to the watercourse (Brădeanca F4 and M. Kogălniceanu F4), where the phreatic level is strongly influenced by the Buzău streamflow variation.

4.3. Lake water level variability

The graphs rendering the water level variation of the lakes Jirlău and Balta Albă (Fig. 5) show a close connection with the Buzău River discharges.

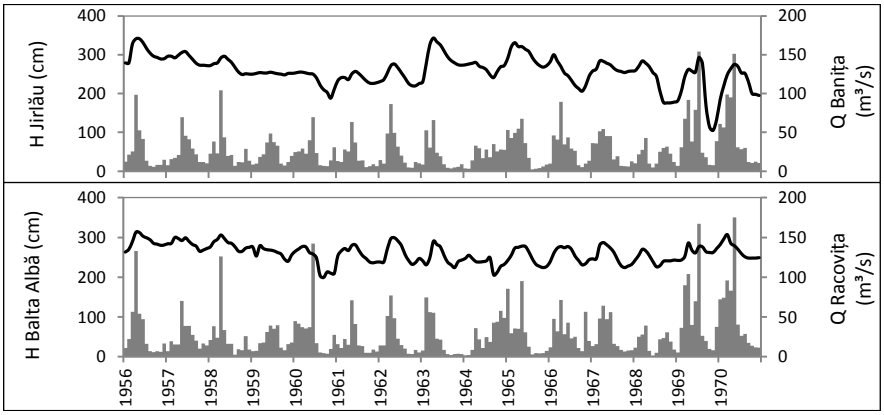

Fig. 5. ***Multiannual variation of mean levels of the lakes (blue line) and of Buzău River discharges (red columns). Average monthly values between 1956 and 1970***

The high values of average monthly discharges, identified especially in 1969 and 1970, indicate the occurrence of flash floods in the Lower Buzău catchment, phenomena that generated obvious peaks in the oscillations of lake stages. Thus, the levels of lakes have variation amplitudes of more than 200 cm (in the case of Lake Jirlău). The lakes on the left riverside have been isolated from the Buzău River and, therefore, their areas diminished in the last decades. The water balance of these fluvial limans tends to be negative, in the context of climate changes; as a result, during the summers of 2007 and 2008, the lakes Coșteiu, Amara and Balta Albă dried up almost completely (Minea et al, 2010).

4.4. Economic use of water resources

In the case of Buzău River, the water use for irrigation during the growing season, contributes, to some extent, to the reduction of liquid discharge downstream the water abstraction site. The liman-type lakes are used for pisciculture (Costeiu, Jirlău and Amara) or in balneotherapy (Câineni and Balta Albă). In 2006, there were 27 groundwater exploitation wells functioning in the Lower Buzău catchment area for different uses, such as domestic water supply, industry, agriculture and zootechny (Table 2). The intercepted flows totalled a

volume of 177506 m³; one third (54000 m³) was used for the domestic water supply in the Buzău Municipality. The Buzău River alluvial fan (RO-IL 05 groundwater body) provides good quality water supply from drilling depths ranging between 6 and 51 m.

Table 2. ***Groundwater exploitation drillings in the Lower Buzău Catchment (2006)***

Well No.	County	Groundwater body	Locality	Drilling depth (m)	Intercepted flows		Use sector
					l/s	10^3m³/yr	
F1	BZ	RO-IL 05	Buzău	18	4,0	41,8	Industry
F1	BZ	RO-IL 05	Buzău	12	0,18	1,32	Agriculture
F1	BZ	RO-IL 05	Buzău	40	1,71	54,0	Domestic supply
F1	BZ	RO-IL 05	Buzău	30	0,096	1,0	Industry
F1	BZ	RO-IL 05	Buzău	12	0,0095	0,164	Industry
F1	BZ	RO-IL 05	Buzău	51	0,094	1,404	Industry
F1	BZ	RO-IL 05	Vernești	30	0,099	2,891	Industry
F1	BZ	RO-IL 05	Vernești	36	2,85	30,0	Industry
F1-2	BZ	RO-IL 05	Lipia	H1,2=50	1,05	32,8	Zootechny
F1	BZ	RO-IL 05	Mărăcineni	40	0,007	0,045	Industry
F1	BZ	RO-IL 05	Gălbinași	20	0,49	5,13	Industry
F1-3	BZ	RO-IL 05	Spătaru	H1,2,3=15	0,14	1,092	Industry
F1	BZ	RO-IL 05	Merei	14	0,142	3,3	Industry
F1	BZ	RO-IL 05	Merei	40	0,0165	2,45	Industry
F1	BZ	RO-IL 05	Maxenu	50	0,0104	0,11	Industry
F3-4	BZ	RO-IL 05	Zoița	H3=35; H4=12	0,480	3,0	Industry
F1	BZ	RO-SI 05	Balta Albă	15	0,038	0,225	Industry
F5-7	BZ	RO-IL 05	Balta Albă	H5-7=12	0,360	2,250	Industry
F3	BZ	RO-IL 05	Lanuri	6	0,024	0,181	Zootechny
F1	BZ	RO-SI 05	Cochirleanca	12	0,716	5,397	Industry
F1	BR	RO-SI 05	Deduleşti	8,5	0,030	1,0	Industry
TOTAL					**12,5424**	**177,506**	

Data source: ABA Buzău-Ialomița, 2014

5. CONCLUSIONS

The decreasing trend of Buzău River discharge over the past decades implies, theoretically, a gradual reduction of surface water resources available in the Lower Buzău catchment at a given time. The water resources in the studied field are exposed to a natural vulnerability, induced by the rainfall deficit, and also to an anthropogenic vulnerability, as a result of human interventions.

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