THE INFLUENCE OF WATER WORKS ON THE FLOW REGIME OF TAITA CATCHMENT

INFLUENŢA LUCRĂRILOR HIDROTEHNICE ASUPRA SCURGERILOR MEDII ÎN BAZINUL HIDROGRAFIC TAIŢA

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Abstract. *Taita is the most important fluviatile system in Dobrudja, flowing into Babadag Lake through a 22.5 km long arranged channel. The surface of the catchment of Taita is 591 km^2 and 0.18 km^2 arranged with various developments. The methodology presented in this paper and applied to Taita catchment consists of the analysis of the temporal characteristics and the identification of discontinuities in flow time series in order to determine the influence of water works on the flow regime of this river.*

Key words: statistical analysis, flow regime, impact, hydraulic works

Rezumat. *Taita este cel mai important sistem fluviatil din Dobrogea, ce se varsa in lacul Babadag printr-un canal amenajat cu o lungime 22,5 km. Bazinul hidrografic Taita are o suprafata de 591km^2, din care 0,18km^2 sunt suprafete amenajate cu diverse lucrari. In aceast articol se va prezenta o metodologie statistica de determinare a discontinuitatilor in seria temporala de debite medii cu scopul de a determina inflenta lucarilor hidrotehnice asupra regimului curgerii medii a acestui rau.*

Cuvinte cheie: analiza statistica, regimul debitelor, lucrari hidrotehnice, impact

INTRODUCTION

One of the main stakes in hydrology is the characterization and the quantification of the human influence on the hydrological regime. The improvement of the available knowledge in this matter is slow, due to the huge complexity of the matter.

Over the past several years, a number of studies have been published on the analysis of instrumental records mainly to seek temporal changes in river flow regimes; examples include Lins and Slack (1999), Ouarda et al. (1999), Hisdal et al. (2001), Robson (2002), Burn and Hag Elnur (2002), Yue et al. (2003), Lindstrom and Bergstrom (2004), Kundzewics et al. (2005), Rood et al. (2005), Hannaford and Marsh (2006), among many others.

The methodology presented in this paper and applied to Taita catchment consists of the analysis of the temporal characteristics and the identification of discontinuities in flow time series in order to determine the influence of water works on the flow regime of this river.

MATERIAL AND METHODS

Dobruja or Dobrudja (Dobrogea in Romanian) is a region situated in the South – East of Romania (Fig.1). Generally, Dobrudja's climate is temperate - continental and is divided in 2 units (Fig.1): a unit (I) consisting of the Danube Delta, its south, the too lagoons (Razim Lake and Sinoe Lake) and the eastern region; and another unit (II) consisting of the rest of territory, while the climate is influenced by the moderate continental belt [17].

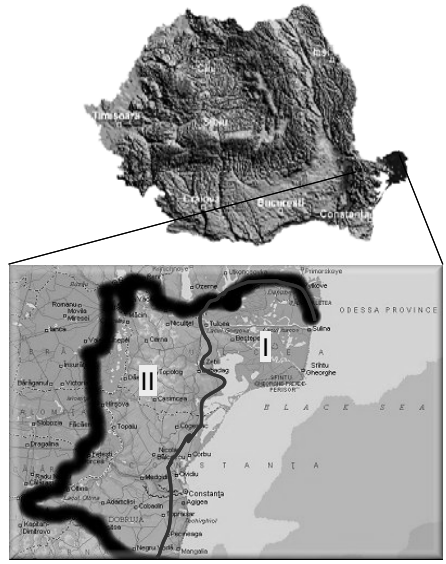

Fig. 1 – Dobrudja region

Due to the sinkhole relief, the climate, and by anthropic factors, Dobrogea has a reduced hydrographical network potential (density varies from 0.01 km/km^2 in Southern Dobrudja to 0.23 km/km^2 in Northern Dobrudja and 1.97 km/km^2 in the Danube Delta). The hydrographical network of Dobrudja is made up of two drainage basins groups: one of the Danube and the other of the seaside. In the seaside river group there are the rivers from the central-north part (NE subgroup) and those from SE group. The NE subgroup is formed of the following rivers: Tulcea (14 km), Telita (48 km), Taita (57 km), Slava (38.8 km), Hamangia (33 km), Nuntasi (10 km) and Casimcea (58 km). The NE subgroup is formed of the following important rivers: Dereaua (7 km), Dulcesti and Albesti. The hydrological data that we have used in this paper were obtained from the archives of the Company "Apele Romane – Dobrogea Litoral". Taita is the most important fluviatile system in Dobrudja, flowing into Babadag Lake through an arranged channel. Taita has a catchment with a surface of 591 km^2 and is 57 km long. Taita has an asymmetrical catchment, with a 0.28 coefficient of asymmetry, well developed on the left, which is where most of the confluents come from. The quota at the river head is 240 m, and at the mouth 0 m, with a medium fall of 4%. The sweep coefficient of the catchment is 1.35 [16]. Precipitations are one of the main sources of supply of this river – 74%, compared to the subterranean supply – 24% [17]. The main affluents of the river and their characteristics are presented in the table 1. The anthropic works of the Taita catchment are presented in Table 2. From the total of 591 km^2, the surfaces arranged with various water works sum up to 0.18 km^2. On Taita catchment there are 2 hydrometric stations, the characteristics of which are presented in Table 3.

Table 3

Characteristics of the hydrometric stations of Taita catchment

River	Station	Quota	Surface (mp)
Taita	Hamcearca	210	102
Taita	Satu Nou	151	565

The methodology presented in this paper and applied to Dobrudja region consists of an analysis of the temporal characteristics and the identification of the discontinuities in flow time series. In order to determine the discontinuities in flow regime in the period 1965 (1968) – 2005, some homogeneity and break test are performed. We defined break as a change of the probability low at a certain moment [5]. The break tests permit the detection of a change in a time series mean. The methods used to detect a break are: Pettitt test [11], the test "U"- Buishand [1], Lee and Heghinian test [8] and the segmentation procedure of Hubert [5].

Pettitt test is a non-parametric one. The null hypothesis that must be tested is: H0: There is no break in the series $\left(X_i\right)_{i\in\overline{1,N}}$.

Hubert's segmentation procedure detects the multiple breaks in time series. The principle is to cut the series in m segments (m>1) such that the calculated means of the neighbours sub-series significantly differ. To limit the segmentation, the means of two contiguous segments must be different. This constraint is satisfied by the Scheffe's test application. This method gives the moment of the breaks.

RESULTS AND DISCUSSIONS

The variation of the annual mean flow at the two stations, Hamcearca and Satu Nou, is presented in the figures 2 and 3. At Hamcearca station we observe that the mean annual flows are higher than the multi-annual mean (0.066 mc/s) in the periods 1965-1974, 1997-2000 and 2004-2005. The values of the mean annual flows are beneath the multi-annual mean in the periods 1974-1997, with two exceptions, 1981 and 1982, when the values of the flow are 0.082 and 0.084 mc/s respectively, and 2001-2004.

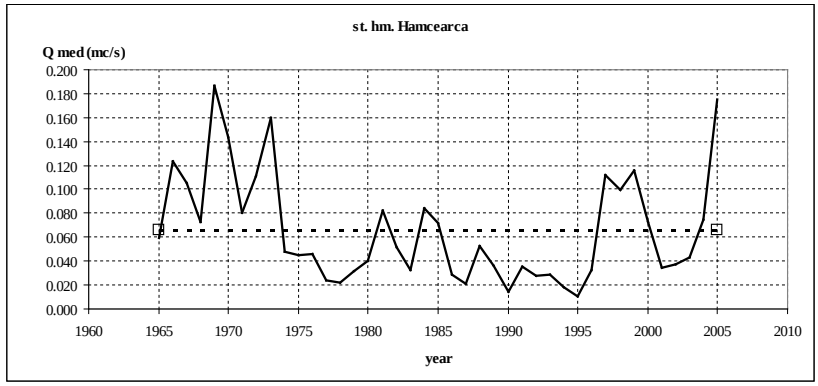

Fig. 2– The mean multi-annual flow (period 1965-2005) for the Hamcearca hydrometric station

Table 1

The Characteristics of the affluents of Taita River

Water flow	Order	Position of confl.	L (km)	l (km)	H head (m)	H mouth (m)	Medium fall (m/km)	Ks coefficient of sinuosity	F (kmp)	Network density (km/kmp)
Curaturi	1	d	7	5	186	109	11	1.23	34	0.21
Parlita	1	s	10	3	270	93	17	1.3	32	0.31
Islam	1	s	7	2	160	53	15	1.13	15	0.47
Lodzova	1	s	15	3	200	47	10	1.24	45	0.33
V. Teilor	2	s	5	3	246	137	22	1.15	16	0.31
Alba	1	s	11	3	170	35	12	1.24	34	0.32
Tilchilic	2	s	6	2	190	66	21	1.33	13	0.46
V. Carierei	1	d	11	7	152	45	10	1.14	79	0.14
Luparia	2	d	7	2	250	45	29	1.81	16	0.44
Taita	1	s	17	5	126	18	6	1.14	80	0.21

Table 2

The arrangements on Taita River

No.	Water Work	Flow	Locality	Characteristics	Owner	Year of functioning
1	Attenuation dam	Taita	Up-river from Horia (TL)	1670 ha lake	ANIF (TL)	1971
2	Regularization	Taita	Conf. lake Zebil (Razim) up to Horia	L 22.5 km		1983
3	Irrigations		Izvoarele	14 ha		Approx. 1970-1975
4			Iulia	20 ha		
5			Balcescu	30 ha		
6			Turda	14 ha		

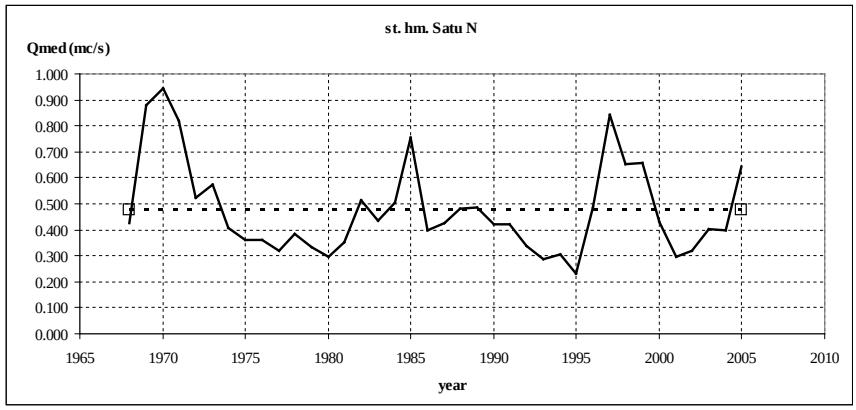

Fig. 3. The mean multi-annual flow (period 1965-2005) for the Satu Nou hydrometric station

At Satu Nou station, downstream, close to the mouth, the situation is almost identical: the periods in which the values of the mean annual flows are higher than the multi-annual mean (0.477 mc/s) are 1968-1974, 1996-2000 and 2004-2005, while the periods in which the values of the mean annual flows are lower than the multi-annual mean are 1974-1996 (with one exception – 1985 – 0.75 mc/s) and 2000-2004. The highest values of the annual mean flows were registered in 1969 (0.187 mc/s) at Hamcearca station and in 1970 (0.945 mc/s) at Satu Nou station.

Only the Pettitt and the Hubert tests were applied for the two stations, as the other tests require the normality test, or, generally, debit flow values don't follow a normal law.

At Satu Nou station, the application of the Pettitt test leads to the inexistence of any discontinuity in the series of values. The Hubert test identifies a break in 1971, thus the values at this station may be divided in two sub-series: 1968-1971 – with a mean multi-annual flow of 0.750 mc/s and 1972-2005 with a mean multi-annual flow of 0.441 mc/s, closer to mean multi-annual flow of the whole series (0.447 mc/s). If we disregarded the condition of normality the Lee and Heginian test leads to the same result, namely a break in the year 1971.

For the Hamcearca station, the results of Pettitt and Hubert tests are the following: Pettitt test identifies a break in the year 1973, the null hypothesis being rejected for the 90% probability; Hubert test also identifies a discontinuity in the year 1973, thus resulting two series of values: 1965-1973 (with a multi-annual mean of de 0.122 mc/s) and 1974-2005 with a multi-annual flow mean de 0.052 mc/s.

CONCLUSIONS

In this paper we tried to identify the influence of the water works in Taita catchment on the Taita River flows. The influence of these works was shown through statistical tests that determine break points in temporal flow series. We chose 4 categories of tests, of which 2 have been used: Pettitt and Hubert.

We observed that, at both stations, we fond a break in the analyzed series. The break was in approximately the same period for both Satu Nou station and Hamcearca station (in 1971 and in 1973 respectively). This situation is certainly due to the building of the upriver dam of Horia, in 1971 and to its functioning the next years, and to the realization of the irrigation systems at that time.

For this reason, at Hamcearca station we noticed a drop to almost a half in the multi-annual mean flow and at Satu Nou station the value of the flow dropped 0.3 mc/s.

REFERENCES

1. **Buishard T. A.**, **1984** - *Tests for detecting a shift in the mean of hydrological time series*. Journal of Hydrology vol. 58, pp. 51-69.
2. **Burn D.H., Hag Elnur M.A., 2002 -** *Detection of hydrologic trends and variability*. J. Hydrol. 255, 107–122.
3. **Hannaford J., Marsh T., 2006 -** *An assessment of trends in UK runoff and low flows using a network of undisturbed catchments*. Int. J. Climatol. 26, 1237–1253.
4. **Hisdal H., Stahl K., Tallaksen L.M., Demuth S., 2001 -** *Have streamflow droughts in Europe become more severe or frequent*. Int. J. Climatol. 21, 317–333.
5. **Hubert P., J. P. Carbonnel**, **1993** - *Segmentation des séries annuelles de débits de grands fleuves africains.* Bulletin de liaison du CIEH 92, pp. 3-10
6. **Ins H.F., Slack, J.R., 1999**. *Streamflow trends in the United States*. Geophys. Res. Lett. 26 (2), 227–230.
7. **Kundzewics Z.W., Graczyk D., Maurer T., Pinskwar I., Radziejewsky M., Svensson C., Szwed M., 2005 -** *Trend detection in river flow series: 1. Annual maximum flow*. Hydrol. Sci. J. 50 (5), 797–810.
8. **Lee A. F. S., Heghinian S. M.**, **1977** - *A Shift of the Mean Level in a Sequence of Independent Normal Random Variables - A Bayesian Approach.* Technometrics vol.19, n°4, pp. 503-506.
9. **Lindstrom G., Bergstrom S., 2004 -** *Runoff trends in Sweden, 1807–2002*. Hydrol. Sci. J 49, 69–83.
10. **Ouarda T.B.M.J., Rasmussen P.F., Cantin J.F., Bobée B., Laurence R., Hoang V.D., Barabé G., 1999 -** *Identification of a hydrometric data network for the study of climate change over the province of Quebec*. Rev. Sci. l'eau 12 (2), 425–448.
11. **Pettitt A. N.**, **1979** - *A non - parametric approach to the change-point problem*. Applied Statistics vol.28, n°2, pp. 126 - 135.
12. **Robson A.J., 2002 -** *Evidence for trends in UK flooding*. Philos. Trans. Roy. Soc. London Ser. A 360, 1327–1343.
13. **Rood S.B., Samuelson G.M., Weber J.K., Wywrot K.A., 2005** - *Twentieth-century decline in streamflows from the hydrological apex of North America.* J. Hydrol. 306, 215–233.
14. **Yue S., Pilon P., Phinney B., 2003 -** *Canadian streamflow trend detection: impacts ofserial and cross-correlation.* Hydrol. Sci. J. 48 (1), 51–63.
15. *****, 1971 -** *Raurile Romaniei – Monografie hidrologica*, Institutul de Meteorologie si Hidrologie, Bucuresti
16. *****, 1968 -** *Studii de hidrologie XXIII – Monografia hidrologica a raurilor si lacurilor din Dobrogea*. Bucuresti
17. *****, 1983 -** *Geografia Romaniei I Geografia Fizica*. Edit. Academiei, Bucuresti