THE INFLUENCE OF THE HYDROTECHNICAL WORKS ON THE NATURAL REGIME OF WATER FLOW IN THE TISMANA RIVER BASIN (1966-2011)

MARIUS ARJOCU[1]*, ANDREEA MIHAELA ARBA*[2]

ABSTRACT. – The influence of the hydrotechnical works on the natural regime of water flow in the Tismana river basin (1966-2011). The Tismana river basin is located in the South-West of Romania, collecting its waters mainly from the South-West of Vâlcan mountains and, to a smaller extent, from the Tismana depression, being known for the variety of hydrotechnical works executed on it, having a complex hydrotechnical fitting. Tismana river does not have a natural flow regime because it benefits from an input of water from the water collections on the Cerna river, transferred in Motru river and, after that, in Tismana river, but also from the water coming from the Clocotiş accumulation on Bistriţa river. The only permanent accumulation on Tismana river (Tismana accumulation) was commissioned in 1983, with a hydropower purpose, taking over the turbined waters from Tismana CHE. Thus, the commissioning of the Cerna-Motru-Tismana hydropower system and, subsequently, of the Bistriţa-Tismana hydropower system, has had effects on the natural regime of water flow in Tismana river. In this river basin, the effects of the fitting works and of the water facilities have manifested after their execution. These effects could be identified in all the types of regime water flow on Tismana river.

Keywords: hydrotechnical works, hydrotechnical fitting, flow regime, natural regime, changed regime, water input, water collections, permanent accumulation.

1. INTRODUCTION

The Tismana river basin is located in the south-west part of the country, having as neighbours in the northern and eastern part the Bistriţa basin, in the west the Motru basin and in the south the Jilţului basin, summing up a total surface of 221 km^2.

Tismana river, tributary of Jiu river on the right, is part of the southern river group, springing under the calcareous massive Piatra Boroştenilor 1453 m from the altitude of approximately 1370 m, and travels a distance of 43.8 km from the spring up to its confluence with Jiu river.

The studied sector stretches from the springs to Godineşti locality, on a length of 18.5 km and a surface of 126 km^2. In the superior part of the sector, Tismana receives the tributaries Tismăniţa and Cioclovina, crosses a sector of canyons (Tismana Canyon) entering the Tismana Depression where it has as tributary

[1] Gorj Management System of Water, Târgu-Jiu, Romania, e-mail: arjocumarius@yahoo.com
[2] West University from Timişoara, Faculty of Chemistry, Biology and Geography, Department of Geography, Timişoara, Romania, e-mail: arba_andreea@yahoo.com

on the left Sohodol river with its tributary Vezieşul (Roşu, 1967, p. 22) (fig. 1). The slopes of the superior sector are larger (the average at Godineşti is of 65 m/km), but once it leaves the mountains, its slopes reduce suddenly, recording very small values up to its discharge (the average is of 1.45 m/km), which has favoured the deposits in the valley and the formation of frequent floods, before the water course straightening (Ujvári, 1972, p. 375).

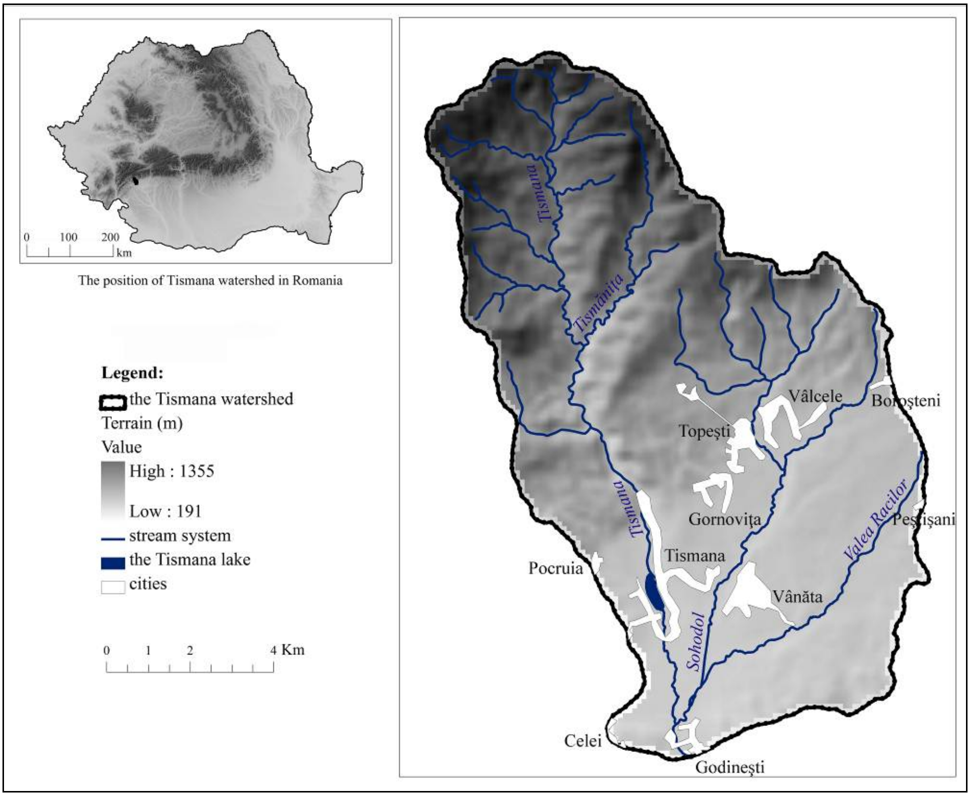

Fig. 1. ***The map of the Tismana river basin.***

The Tismana river basin presents a great relief variety, with several relief steps on its course, such as: a mountainous area, represented by Vâlcan mountains, an intermediate step formed of the Subcarpathian piedmont hills, as well as a lower portion filled by the Subcarpathian depression, the last two forming two component parts of the Subcarpathians of Oltenia (Baranovsky, Niculina, Neamu, 1971, p. 10).

The commissioning of the Cerna-Motru-Tismana and Bistriţa-Tismana hydropower systems has had strong influences on the natural regime of water flow on Tismana river, because it is supplemented with water coming from the water collections on Cerna river and its tributaries, transferred in Motru river and, then, in Tismana river, as well as from the collections of Clocotiş accumulation, on Bistriţa river. The Tismana accumulation (V_u= 0,6 mil.mc) does not have a reduction or retention of water flows role, but only a hydropower one, taking over the turbined waters of Tismana CHE (fig. 2).

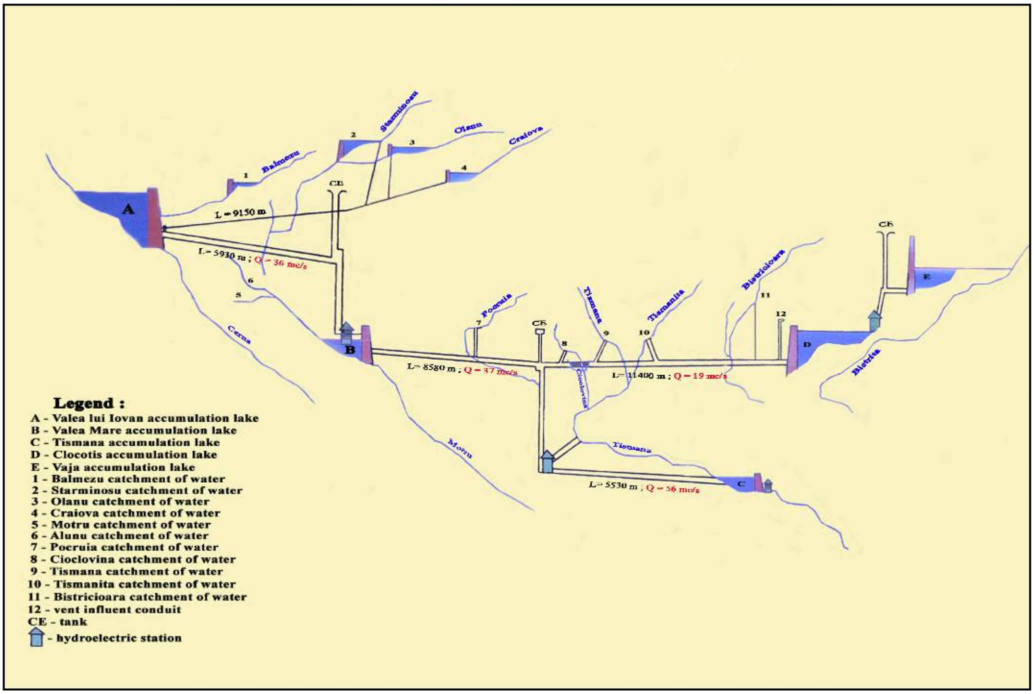

Fig. 2 ***The fitting chart of the Cerna-Motru-Tismana and Bistriţa-Tismana hydropower systems (source S.C. Hidroelectrica S.A.).***

2. THE WORKING METHODOLOGY

In order to draw up the study herein, we have used meteorological data (precipitations) and hydrological data (liquid flows, solid flows, winter phenomena, and floods) from the Godineşti hydrometric station, on a period of 45 years: 1966-1982 and 1983-2011. The analysis of these hydro-meteorological parameters has led to the identification of the influence that all the hydrotechnical works from the Tismana river basin have on the natural regime of water flow.

The Godineşti hydrometric station was set up in 1946 and it is located on Tismana river, downstream at 200 m from the confluence of Tismana river with its tributary, Sohodol, at 192 m altitude, having as geographical coordinates of 45º01'00" N latitude and 22º55'00" E longitude (table 1).

Table 1. ***The morphometric elements of Tismana basin at the Godineşti hydrometric station***

River	Location	The distance from the spring (km)	Altitude (m)	The hydrographical basin		
				$F \frac{am}{av}$ [1] km^2	$Hm \frac{am}{av}$ [2] m	$Imed \frac{am}{av}$ [3] m/km
Tismana	Izvor	0	1460	-	-	-
Tismana	Godineşti	18,5	192	126/221	680/521	169/467

Sursa: Ujvári, 1972, p. 382, with modifications.
[1]the surface of the collection basin upstream/downstream from the confluence
[2]the average altitude of the collection basin upstream/downstream from the confluence
[3]the average slope of the collection basin upstream/downstream from the confluence.

3. RESULTS

In the Tismana river basin, the natural flow of the water is the result of the Mediterranean air masses circulation and of the variety of relief forms: the high area (1453 m), the Subcarpathian area (500-800 m) and the depression area (190 m). The multiannual precipitation area (1977-2011) at Godineşti is of 801.2 mm.

The anthropogenic influence in Tismana basin, on the natural hydrological regime, has been achieved through important hydrotechnical works (approximately 48 km of subterranean galleries), which have steered water flows, starting with 1983, from the Cerna, Motru, Pocruia river basins and, from 2008, from the superior basin of Bistriţa.

After the hydrological data analysis from the period 1966-2011, the following conclusions can be drawn:

- the daily average flows have been strongly influenced after 1983 (e.g.: the daily average flow on 6 August 1979 was of 0.596 m^3/s, and on 6 August 1999 was 14.1 m^3/s). The analysis of the annual average flow from the period 1966-1982 leads to a classical classification with: low waters in winter, high waters in spring, low waters in summer with short-term floods, as well as low waters in autumn with small floods in the second part of the season.

The water input transferred to Tismana basin and the turbining from the two hydropower plants on Tismana have increased the values of the daily average flow, being difficult to separate the natural flow from the influenced one (fig. 3).

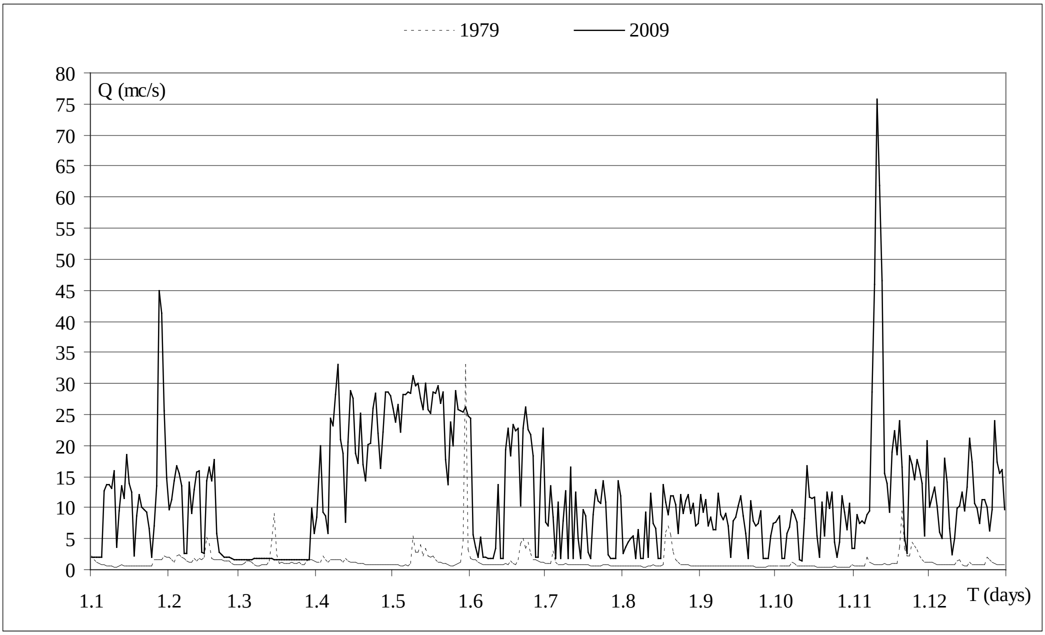

Fig. 3. ***The daily average flow hydrograph from the Godineşti hydrometric station.***

The daily average flows contribute significantly to the industrial water supply for the Rovinari and Turceni steam power plants.

- the multiannual monthly average flow is closely connected to the variation of the daily average flow (table 2).

Table 2. ***The multiannual monthly average flows from the Godineşti hydrometric station***

Period	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Q_{mma}
1966-1982	1.61	2.40	1.88	2.23	2.12	1.41	1.35	0.905	0.821	1.45	1.44	2.10	1.64
1983-2011	8.16	8.39	7.79	10.8	12.7	12.3	10.1	8.80	7.07	8.10	9.50	8.56	9.36

- the annual average flow until 1983 is closely connected to the climate variability of the area. After 1983, the annual average flows have shown significant increases as a consequence of the water input from the neighbouring river basins (e.g.: the annual average flow in 1973 was 1.06 m^3/s and, in 2010, 14.6 m^3/s) (fig. 4).

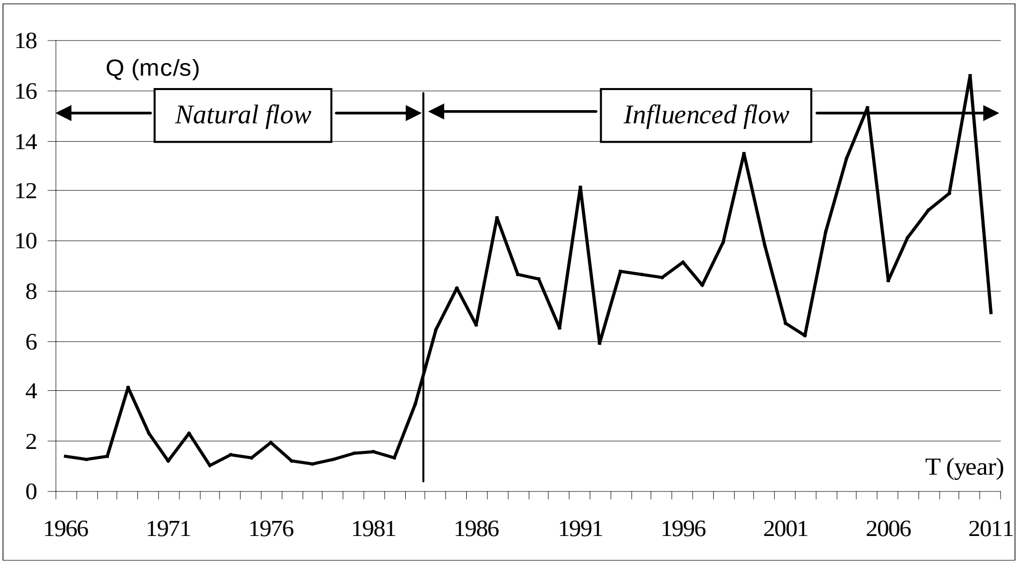

Fig. 4 ***The annual average flows from the Godineşti hydrometric station.***

The variation of the average flow before and after 1983 is emphasised by the maximum (K_M) and minimum (K_m) module coefficients, calculated as a ratio between the maximum and minimum annual average flows and the multiannual average flow (Q_{mma}) (table 3).

Table 3. ***The module coefficients of the annual flows from the Godineşti hydrometric station***

No.	The hydrometric station	Period	F (km²)	H_{med} (m)	Q_{mma} (m^3/s)	K_M	K_m
1	Godineşti	1966-1982	126	680	1,64	2,52	0,65
		1983-2011			9,36	1,77	0,37

- the multiannual average flow after the commissioning of the water collections has increased 5.7 times, from the multiannual average flow of 1.64 m^3/s to a flow of 9.36 m^3/s, a flow input summing up 243 mil. m^3 annually.

- the maximum flow, on a river that has not been anthropogenically influenced, may occur in any period of the year, but with different intensities, causes and spatial distributions (Zăvoianu, 2002, p. 167).

The high waters and the floods on Tismana river, in a non-influenced regime, are the direct reaction to a temperate-continental climate with Mediterranean influences, the floods having an ordinary shape, with a sudden increase period followed by a slow decrease of the water flows (fig. 5a). The transfer of water flows from other river basins has led to the modification of the flood shape, their occurance depending sometimes on the climate factors from the respective basins (fig. 5 b).

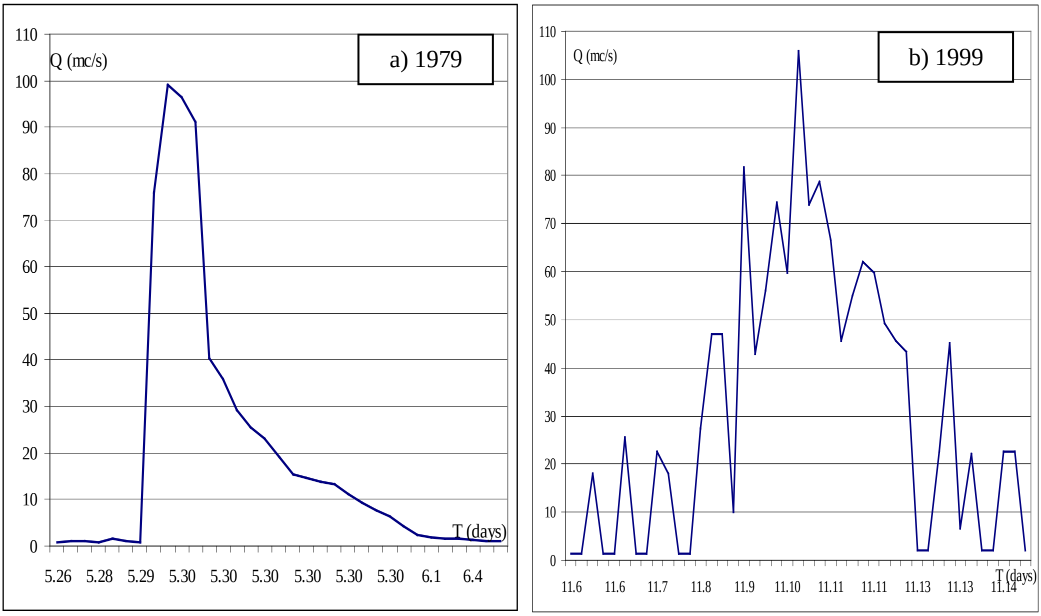

Fig. 5 ***The floods shape at the Godineşti hydrometric station (1979 and 1999).***

After 1983, the maximum flow has been significantly changed because the existing accumulations on Cerna, Motru and Bistriţa rivers reduce significantly the maximum flow on these rivers. The operation of the Tismana and Tismana Aval hydropower plants has radically changed the maximum flows, these having hourly and daily variations according to the exploitation system, there occurring a higher turbined flow than the rest of the basin flow.

- the minimum flow is recorded especially in the summer-autumn period, as well as during winter, the multiannual minimum average flow has increased from 1.06 m^3/s to 3.50 m^3/s.

- the flow of deposits – the water supply from the superior basins of Cerna, Motru and Bistriţa rivers, as well as the building of Tismana Aval accumulation have led to the decrease of the quantity of deposits carried through the section of the Godineşti hydrometric station (fig. 6).

Taking into account the deterioration of the Q= ∫(R) relation, determined by the clearing of the water transferred to Tismana basin starting with 2003, the activity of solid flow measurement has been removed from the schedule of the Godineşti hydrometric station.

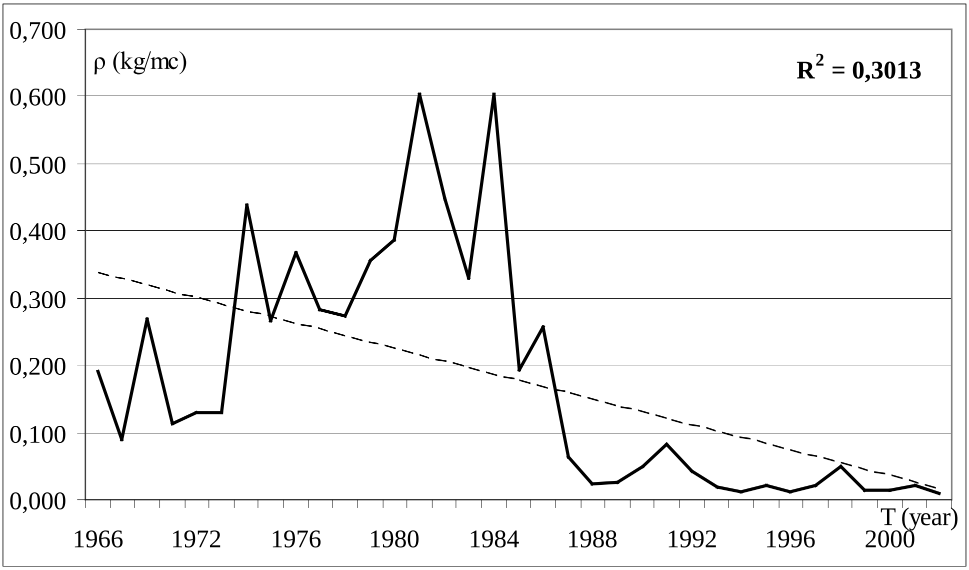

Fig. 6 ***The annual average turbidity trend from the Godineşti hydrometric station.***

- the winter phenomena, in their complexity, until 1983, developed and influenced the water flows on Tismana river. The additional supply of warmer water from the inferior layers of the accumulations, as well as the water turbined by the hydropower plants have favoured the disappearance of the winter phenomena on Tismana river.

4. CONCLUSIONS

The execution of the Cerna-Motru-Tismana hydropower system and, subsequently, of the Bistriţa-Tismana hydropower system, has had effects on the natural regime of water flow on Tismana river. In this river basin, the effects of the fitting works and of the water facilities have manifested after their execution. These effects could be identified in all the types of water flow on Tismana river.

The hydropower fitting has changed all the stages of the natural flow, through the 5.7 time increase of the multiannual average flow, from 1.64 m^3/s (1966-1982) to 9.36 m^3/s (1983-2011).

The transition of the turbined water flows through the Tismana riverbed has imposed the creation of an artificial bed, with a trapezoidal shape, with a lateral and bottom pitching, up to the confluence with Jiu river (length 25.3 km).

The economic importance of the hydropower system is given by the energy potential with an installed power of 169 MW and by the transition of a water volume of 243 mil. m^3 annually, 1^{st} category of quality water, representing a significant source of drinking water for the localities in the area. The need to complete this power complex has been imposed by the increase of Jiu river flow, in order to ensure the industrial water of the Rovinari and Turceni steam power plants.

REFERENCES

1. Baranovsky, Niculina, Neamu, Gh., (1971) – *Judeţul Gorj*, Institutul de Geografie al Academiei Republicii Socialiste România, Editura Academiei Republicii Socialiste România, Bucureşti, p. 10;
2. Roşu, Al., (1967) – *Subcarpaţii Olteniei dintre Motru şi Gilort. Studiu geomorfologic*, Editura Academiei Republicii Socialiste România, Bucureşti, p. 22;
3. Ujvári, I., (1972) - *Geografia apelor României*, Editura Ştiinţifică, Bucureşti, 591 p.;
4. Zăvoianu, I., (2002) – *Hidrologie*, Universitatea „Spiru Haret", Facultatea de Geografie, Editura Fundaţiei „România de Mâine", Bucureşti, p. 190.