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Human impact due to the capitalization of water resources within the Jiu Gorge National Park

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Abstract

Within the Jiu Gorge National Park, there was a project, which almost draws to an end, for the hydro-energetic capitalization of the river, which implies a potentially negative impact of this investment on the aquatic sector of the Jiu river in this sector. The current study analyses the hydrological regime of the Jiu river within the gorge sector (natural flow and controlled flow for the technical-economic capitalization parameters) and the impact on natural landscapes due to building and construction sites, bringing arguments and solutions for meeting the declared objective of conserving the aquatic ecosystems within the Jiu Gorge National Park. Thus, there must be ensured a minimum discharge (ecological discharge) on all rivers within the national park and Natura 2000 sit, to provide for this mere purpose of this category of protected areas.

Keywords: *national park, inner zonation, Natura 2000, water resources, hydrological regime, ecological flow, Jiu Gorge National Park*

Rezumat. Impactul antropic datorat valorificării resurselor de apă din Parcul Național Defileul Jiului

În Parcul Național Defileul Jiului s-a executat, aproape de finalizare, un proiect de amenajare hidroenergetică a râului care implică un impact potențial negativ al acestei investiții asupra mediului acvatic al râului Jiu în acest sector. Prezentul studiu analizează regimul hidrologic al râului Jiu în sectorul defileului (debit natural și debit controlat pentru asigurarea indicatorilor tehnico-economici de exploatare) și impactul asupra peisajelor naturale generat de șantierele deschise cu ocazia amenajării hidroenergetice, aducând argumente și soluții pentru îndeplinirea obiectivului declarat de conservare a ecosistemelor acvatice din Parcul Național Defileul Jiului. Se impune astfel asigurarea unui debit minim (debit ecologic) pe toate cursurile de apă din interiorul parcului național și sitului Natura 2000 care să asigure scopul acestor categorii de arii protejate.

Cuvinte-cheie: *parc național, zonare interioară, Natura 2000, resurse de apă, regim hidrologic, debit ecologic, Parcul Național Defileul Jiului*

Introduction

Due to their special status as natural protected areas from the second IUCN category, the management of water resources use within national parks must be taken into consideration for the management of riparian or aquatic species and habitats within these territories.

There are 13 national parks in Romania, covering an area of 3158 sqkm (1.32% of the national territory), and 12 of them are located in the Carpathians mountains, an area with huge potential of natural resources (woods, mineral reserves and water resources).Considering the need for the preservation of some samples of the Carpathians landscape, where the ecosystems are not yet altered by the human capitalization and settlements, these 12 national parks were established. All of them are also Natura 2000 sites, components of the ecological European network that aims to maintain the favourable conservation status for the species and habitats of community interest.

The water resources within three national parks (NP) (Retezat N.P., Domogled-Valea Cernei N.P., Cozia N.P.) are used for the production of hydro-electrical power, with large hydro-technical harnessing, such as artificial lakes (Iovan Lake and Cerna Lake - Domogled-Valea Cernei NP; Gura Apei Lake – Retezat NP; Turnu Lake, Gura Lotrului Lake - Cozia N.P.), or works for providing water to some settlements (Gozna Lake, Poneasca Lake - NP Semenic-Cheile Carașului). In some river basins, there are also detours of some rivers to supplement the discharge in neighbouring basins, providing water for the settlements (eg. The Timis and Nera – blown off course towards the Bârzava river within Semenic-Cheile Carașului NP).

These engineering works for the capitalization of water resources were made long before the respective territories were declared natural protected areas (Law 5/ 2000), and consequently, there is finally a sort of equilibrium within the ecosystems affected by these changes. The studies for the scientific foundation of national parks took into consideration the characteristics of the new aquatic and riparian ecosystems that resulted following the hydro-technical works.

In Europe a growth of hydropower production is aimed to achieve emission targets within the European Union by 2050. The most discussed European region regarding hydropower deployment is the Balkan region, with 37% of the hydropower

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projects planned to be installed in areas with a high protection status (e.g. national parks or Natura 2000 areas) (Wagner et al., 2019).

Due to a lack in awareness of sedimentological challenges (e.g. lack of process understanding), various huge economical, technical and ecological problems emerge with an increasing relevance for hydropower industry, water management authorities and the society in future (Hauer et al., 2018).

In Romania, following the year 2000, another two national parks were declared, i.e. Buila – Vânturarița N.P. (2004) and the Jiu Gorge N.P. (2005), protected areas that were also included in the category of Natura 2000 sites beginning with 2007, the year Romania joined the EU. From this perspective, the Jiu Gorge Natura 2000 site includes 14 habitats of community interest, of which 3 are priority habitats and 22 species of community interest, of which 4 fish species. The Jiu Gorges National Park, located in the central part of the Southern Carpathians, covers an area of 11,127 ha (of which 10,927 ha are Natura 2000 sit – SCI), and it includes the banks of the Jiu river for some 33 km, length were the river carved an impressive gorge, with numerous entrenched meander (fig.1). The minimum altitude within the park is just 305 m at the end of the gorge, while the maximum altitude reaches 1688 m. At Livezeni, where the gorge sector begins, the height reaches 555 m.

The main ecotourism activity in the national park is rafting, the gorge area having the most favourable conditions for this sport among all the mountain rivers in Romania.

Figure 1: Entrenched meander within the Jiu Gorge National Park and the main ecotourism activity (rafting)

The proposals for the inner zonation of the Jiu National Park (Stociulescu et.al., 2005) were legalized following a government decree that same year. But in 2004, works for the hydroelectrical capitalization of the Jiu hydrographical basin began, on the territory of the future national park. The environment permits were obtained before this territory was declared natural protected area (national park, Natura 2000 sit), the technical and economic indicators for the objective *Hydro-energetic harnessing of the Jiu river along Bumbești-Livezeni sector* having been approved since 2003.

After it was declared protected area, the new research undertaken for the area pointed to a major human impact on the aquatic and riparian ecosystems in case the technical-economic indicators were to be maintained, as stipulated in the initial project.

Results and discussions

The study considers two main directions regarding the human impact on the ecosystems within the Jiu Gorge National Park: 1) the analysis of the hydrological regime, the change of which greatly affects some species and habitats of community interest; 2) the impact on natural landscapes due to the construction works and building sites within the national park.

The analysis of the hydrological regime implied the quantification of multiannual mean discharge, monthly mean discharge and seasonal discharge within the Jiu basin, on Livezeni –Sadu sector. However, the minimum mean monthly discharge is the most important from the point of view of the planned 2.7 m^3/s returned flow.

The mean annual discharge is the most general index of water resources, while the mean monthly discharge is an important index for the estimation of uniformity degree of the discharge of the Jiuriver. Its variation is conditioned by the meteorological factors (precipitations, water temperature, snow layer), as well as by the retaining and restitution capacity within the Jiu basin. The climatic elements have a rather altitudinal variation within the basin, considering there is a level difference of 1383 m, with a transversal mountainous sector; consequently, the flow is dependent on the direction and precipitation charge of air masses.

In order to highlight the variation of the annual discharge (Q_{an}) along the rivers and on the whole analyzed sector, we analyzed the *modulus coefficients* (k) compared to the mean multiannual discharge (Q_o). Thus, we obtained coefficients that point to the entire range of the annual discharge variation along the time frame that was analyzed.

The two extreme modulus coefficients represent the limits of the variation amplitude.

$K_{max} = Q_{anmax} / Q_o$; $K_{min} = Q_{an\ min} / Q_o$;

Table 1 presents the values and the variation amplitude of the annual discharge for multiannual profile (Barbălată, 2005). For a better correlation, the hydrological sections of two tributaries of the Jiu river within the gorge sector were also analyzed (Polatiște, Izvor), considering that the hydrotechnical harnessing works stipulate for extra water resources apart from the Jiu river, basically two tributaries (Bratcu and Dumitra), of the same hierarchic order (Horton-Strahler) and with similar hydrological characteristics.

Table 1 Characteristics of the mean multiannual and annual discharge within the Jiu basin in Livezeni-Sadu sector

Station (river)	Q_0 m^3/s	Maximum mean discharge			Minimum mean discharge			C_v
		$Q_{anual.\ max}$	K_{max}	Year	$Q_{anual.\ min}$	K_{min}	Year	
Livezeni (Jiul de Est)	**8.18**	12.4	1.51	1975	5.33	0.65	1990	2.32
Iscroni (Jiul de Vest)	**10.70**	17.4	1.62	1970	6.42	0.60	1993	2.71
Strâmbuța (Izvor)	0.752	1.09	1.50	1975	0.358	0.47	1996	3.04
Polatiște (Polatiște)	1.67	2.46	1.47	1967	0.940	0.56	2002	2.61
BorziiVineți (Jiu)	**21.60**	31.8	1.47	1970	13.5	0.62	1990	2.35
Sadu (Jiu)	**22.90**	32.4	1.41	1981	13.9	0.60	1990	2.33

The maximum modulus coefficients (K_{max}) vary between 1.41 – 1.62, while the minimum modulus coefficients (K_{min}) vary between 0.47 – 0.65, which reflects a compensatory situation of the most important physical-geographical factors for discharge (Tab. 1). The discharge variation coefficient (C_V) varies between 2.32 (Livezeni) and 3.04 (Strâmbuța), a fact explained by the controlled retention of water resources within Petroșani Depression (Valea de Pești Lake – Uricani).

The multiannual variation of mean discharge is better reflected in the rapport of these modulus coefficients (K_{max} / K_{min}), which in the case of the Jiu in this sector, has similar values for the two extreme sections (2.32 at Livezeni and 2.33 at Sadu). The lowest amount of precipitations (drought years) were registered in 1990, 1993, 1996, 2000, 2002, 2003, 2012, while the highest discharge was registered in 1967, 1970, 1975 şi 1981 (1960-2012 being the analyzed period). The mean monthly discharge varies from one month to another, being dependent on the climatic conditions, which differ within the same sector. The highest mean monthly discharge is registered during April-June, with a share of 15.3% in April to 17.6% in May, the month with the highest discharge at Livezeni, while in June it drops to 12.65% (Tab. 2, 3) (Barbălată, 2005). At Sadu hydrometric station, the highest discharge is registered in May, accounting for 17.1% of the annual discharge.

The mean seasonal discharge highlights the contribution of the feeding sources of the river under the influence of the climatic conditions proper for each season. Spring accounts for the highest input (some 41% of the water quantity that flow through this section), as a result of the frequent spring rains overlapping snow layer thawing due to positive temperatures. The lowest shares are registered during autumn and winter (16.3% and 15.5%, respectively), caused by the humidity deficit during autumn, while in winter, there is basically only snow, especially on the southern slopes of the Parâng and Vâlcan mountains. The uneven distribution of the discharge causes a considerable hydro-dynamic aggressiveness, which influences the intensity of the active processes within the Jiuriver bed and its tributaries within the gorge sector (Izvor, Polatiște, Dumitra, Chițiu, Bratcu),

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which is also visible in the rapport between the discharge from the rainiest season (Rs) and the dry season (Ds) (Tab. 4) (Savin, 2008).

Table 2 Mean monthly multiannual discharge and the mean multiannual discharge within Jiu hydrographical basin (Livezeni-Sadu sector)

Hydrometric station (river)	Q_0 (m^3/s)	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Livezeni (Jiul de Est)	**8.18**	4.38	4.98	7.67	14.2	17.7	14.0	9.07	5.98	5.57	5.21	4.64	4.84
Iscroni (Jiul de Vest)	**10.70**	6.47	6.81	10.1	21.3	21.1	14.7	9.29	7.03	6.8	7.74	8.17	8.51
Livezeni(Jiu)	**18.88**	10.85	11.7	17.77	35.5	38.8	28.7	18.36	13.01	12.37	12.95	12.81	13.35
Strâmbuţa (Izvor)	0.752	0.36	0.51	0.79	1.33	1.46	1.39	0.85	0.52	0.53	0.48	0.36	0.41
Polatişte (Polatişte)	1.67	0.82	0.83	1.37	3.22	3.43	2.81	1.79	1.26	1.21	1.15	0.994	0.991
BorziiVineţi (Jiu)	**21.60**	12.4	13.7	20.7	41.3	44.9	34.6	21.0	14.1	12.7	14.4	14.6	14.3
Sadu (Jiu)	**22.90**	13.8	14.4	23.1	44.6	47.2	36.2	22.2	16.0	15.0	15.5	16.1	16.8

Table 3 The percentage of mean monthly liquid discharge compared to the mean multiannual volume within the Jiu hydrographic basin (Livezeni – Sadu sector)

Hydrometric station (river)	Months											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Livezeni (Jiul de Est)	4.5	4.7	7.9	14.2	18.4	14.0	9.4	6.2	5.6	5.4	4.7	5.0
Iscroni (Jiul de Vest)	5.1	4.9	8.0	16.4	16.8	11.3	7.4	5.6	5.2	6.2	6.3	6.8
Livezeni*(Jiu)	4.8	4.8	7.95	15.3	17.6	12.65	8.4	5.9	5.4	5.8	5.5	5.9
Strâmbuţa (Izvor)	4.0	5.3	8.9	14.5	16.5	15.2	9.7	5.9	5.9	5.5	4.0	4.6
Polatişte (Polatişte)	4.2	3.9	7.0	15.9	17.6	13.9	9.1	6.5	6.0	5.9	4.9	5.1
BorziiVineţi (Jiu)	4.9	4.9	8.1	15.7	17.7	13.2	8.3	5.5	4.8	5.7	5.6	5.6
Sadu (Jiu)	5.0	4.7	8.4	15.7	17.1	12.7	8.1	5.8	5.2	5.6	5.6	6.1

Table 4 Variation of mean multiannual discharge and seasonal discharge of the Jiu river

Hydrometric station (river)	Q_0 m^3/s	Months								Rs /Ds
		Spring		Summer		Autumn		Winter		
		m^3/s	%	m^3/s	%	m^3/s	%	m^3/s	%	
Livezeni (Jiul de Est)	**8.18**	3.37	41.2	1.98	24.3	1.39	17.0	1.37	16.8	2.46
Iscroni (Jiul de Vest)	**10.70**	4.33	40.5	3.16	29.6	1.67	15.7	1.51	14.2	2.87
Livezeni (Jiu)	**18.88**	7.70	40.8	5.07	26.9	3.07	16.3	2.92	15.5	2.64
Strâmbuţa (Izvor)	0.752	0.30	39.9	0.23	30.8	0.11	15.4	0.10	13.9	3.00
Polatişte (Polatişte)	1.67	0.67	40.5	0.49	29.5	0.28	16.8	0.22	13.2	3.04
BorziiVineţi (Jiu)	**21.60**	8.96	41.5	5.83	27.0	3.47	16.1	3.32	15.4	2.70
Sadu (Jiu)	**22.90**	9.43	41.2	6.09	26.6	3.75	16.4	3.61	15.8	2.61

The minimum mean monthly discharge (Tab. 5) (Barbălată, 2005) is very important from the perspective of ensuring a minimum returned flow but especially for a minimum *ecologic discharge* (*salubrions discharge*) to secure the survival of fish, and especially the four species of fish and a mammal (*Lutra lutra),* of community importance. The *returned flow* is the minimum discharge that must be kept at all times in any section of the valley, downstream a dam, made up of the ecological discharge and the minimum discharge required by the users downstream. The minimum discharge on the Jiu river represents a hydrological phase that is extremely important for the evaluation of the impact on the aquatic ecosystems following the use of water resources for hydro-electrical purpose. Although from a methodological point of view and the means for measuring the minimum discharge there are no significant problems, it should be mentioned that there is no possibility for measuring the exact minimum daily discharge since there is no way to know exactly the water consumption for daily discharge. Consequently, the hindcast for natural flow during low waters was carried on only for the spent mean monthly discharge.

Table 5 Minimum mean monthly discharges within the Jiu hydrographic basin

Hydrometric station (river)	Q_0 (m^3/s)	Months											
		I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
Livezeni (Jiul de Est)	**8.18**	0.168	0.196	3.06	3.95	5.78	4.16	2.95	1.91	1.22	1.43	1.46	1.61
Iscroni (Jiul de Vest)	**10.70**	1.87	1.93	3.36	7.38	2.91	3.06	2.48	1.88	1.42	1.55	1.46	1.98
Livezeni (Jiu)	**18.88**	2.03	2.12	6.42	11.33	8.69	7.22	5.43	3.79	2.64	2.98	2.92	3.59
Strâmbuța (Izvor)	0.752	0.046	0.068	0.162	0.305	0.440	0.090	0.053	0.011	0.035	0.008	0.008	0.037
Polatiște (Polatiște)	1.67	0.163	0.156	0.579	0.636	0.580	0.756	0.634	0.432	0.370	0.340	0.317	0.286
BorziiVineți (Jiu)	**21.60**	4.76	5.89	10.2	12.3	29.3	19.0	12.0	7.76	6.58	7.43	6.99	6.53
Sadu (Jiu)	**22.90**	4.88	4.58	10.5	12.5	11.4	8.83	6.43	5.26	5.31	4.07	4.13	4.86

In order to highlight the impact, we also analysed the mean discharge on gliding 5-year intervals (Tab. 6) (Savin, 2008). Thus, the decreasing values for these discharges (eg. from 10.2 m^3/s for the entire observation period to 8.62 m^3/s for the last 5 years that were analyzed). This drop can be correlated with the current climatic changes, and especially the temperature increase (favoring the evaporation on water bodies) and a draught tendency. From the perspective of ensuring a *returned flow* on the Jiu river bed of only 2.7 m^3/s at Livezeni section, overlapping a period with minimum monthly discharge, it must be mentioned that for three months a year (January, February and September), the hydrographical section will have a negative input (there is no possibility for providing this discharge), while for other two months (October and November), there will be a close call to cover it (0.28 m^3/s and 0.22 m^3/s, respectively, productive discharge for the hydro-energetic harnessing plant (Tab. 7).

Table 6 Mean discharge of the Jiu river (Livezeni – Sadu sector) for gliding time intervals (1950-2004)

Hydrometric station (river)	Mean discharge for gliding time intervals										
	1950-2004	1955-2004	1960-2004	1965-2004	1970-2004	1975-2004	1980-2004	1985-2004	1990-2004	1995-2004	2000-2004
Iscroni (Jiul de Vest)	10.20	10.20	10.20	10.30	9.96	9.49	9.09	8.87	8.84	9.29	8.62
Sadu (Jiu)	21.70	21.80	21.70	21.90	21.30	20.50	19.40	19.10	19.40	20.50	18.60

Table 7 Productive discharge overlapping the period with minimum monthly discharge within Livezeni Sector (the Jiu river)

Livezeni section	Months											
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
Minimum mean monthlydischarge	2.03	2.12	6.42	11.33	8.69	7.22	5.43	3.79	2.64	2.98	2.92	3.59
roductive mean montlydischargeafter-coveringtheservitutedischarge	- 0.67	- 0.58	3.72	8.63	5.99	4.52	2.73	1.09	-0.06	0.28	0.22	0.89

We chose to analyse the least favourable situation, i.e. the minimum monthly discharge. After covering the servitude discharge (2.7 m^3/s) that was stipulated as technical-economic indicator, the productive discharge from the hydro-energetic point of view will vary between 0.89 m^3/s and 8.63m^3/s, on average 3.93m^3/s.

In this case, due to the morphometric features of the sections along the Jiu river within the gorge sector (*entrenched meander*),the turbulent flow regime that naturally characterizes the entire length of the river in this sector, will have a laminar character (laminar flow regime, with wet film between 7.1 and 10 cm related to the low-water discharge and the mean rapport of 1/1.4 between the minimum and maximum registered section).

Fish fauna will be most affected by this minimal regime flow. It includes four species of fish of community interest: steingressling (*Gobio uranoscopus*), southern barbel (*Barbus meridionalis*), Balkan spined loach (*Sabenejewia balcanica*), European bullhead (*Cottus gobio*) and a mammal species of community interest: european otter (*Lutra lutra*) (Habitats Directive 92/43/EEC). The habitat of priority community interest 91E0* alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* is also affected. To ensure a favorable conservation status for the fish species, a minimum ecologic discharge of 9.44 m^3/s is highly

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necessary (this amount represents half of the modulus multiannual discharge at Livezeni and downstream). This brings to an increase of water level in the section with an average coefficient of 3.49, and a mean level of 24.77 – 34.9 cm, respectively.

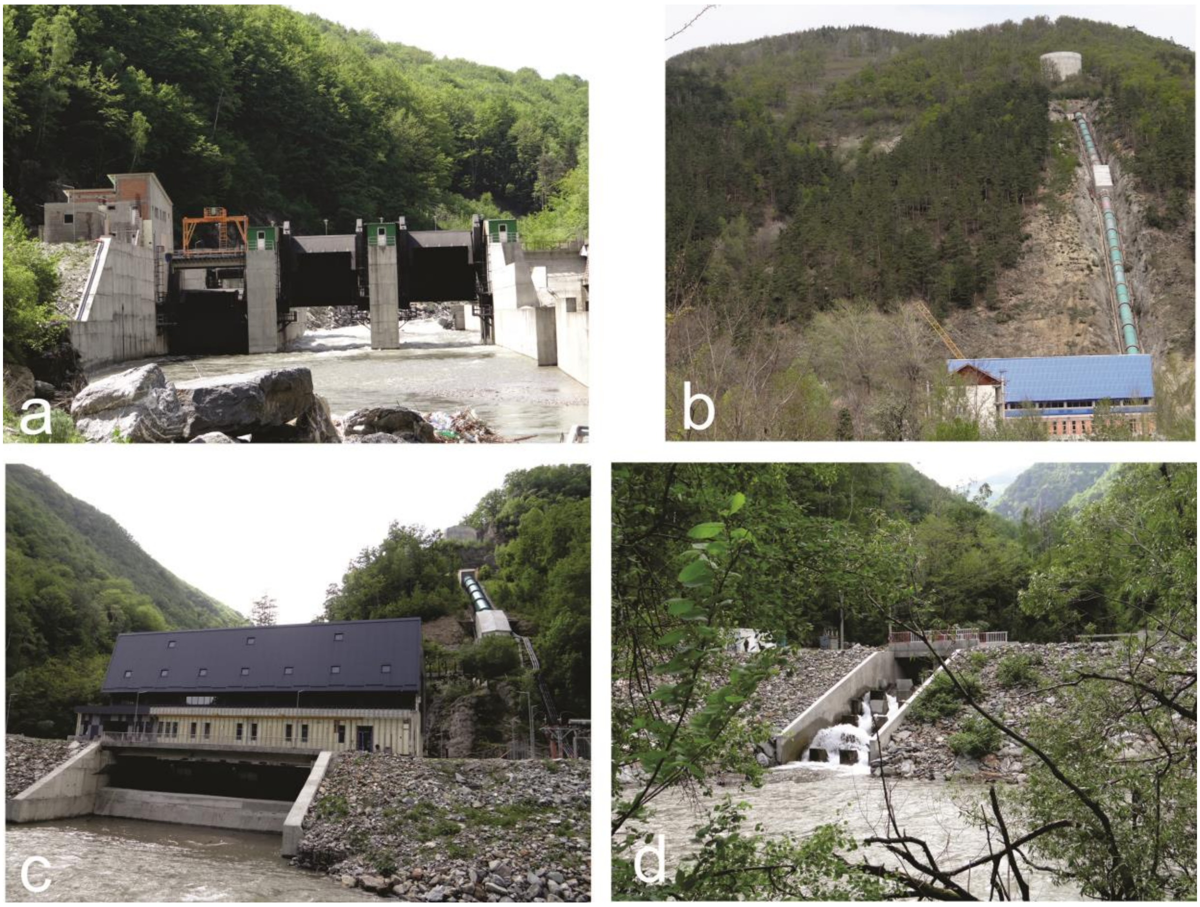

Figure 2: The main endpoints of the hydro-energetic harnessing of the Jiu river that were finalized (a. Livezeni dam, b. Bumbești hydro-energetic power plant, c. Dumitra hydro-energetic power plant, d. Dumitra tailboard)

Consequently, some measures are highly needed: a) regularization of the discharge within the upper basin of the Jiu by the catchment of new rivers upstream, including the neighboring basins (the Strei, Sebeș and Lotru); this is also justified from a medium term perspective of industrial revival of the economic area of the Jiu Valley; any further development will trigger an increase water consumption for economic units. b) re-evaluation of opportunities for water deviations that were built in the previous decades in order to supplement the water discharge in the neighboring basins (such as Jieț deviation toward the Lotru); c) changing the technical-economic indicators for the hydro-energetic system functioning (micro-power plant at Livezeni should not function permanently, giving up the energetic intake on the right bank, adjacent to the dam and changing of spillway from the dam body at its upper part; d) relinquish the secondary catchment for two tributaries within the Jiu gorge (Dumitra and Bratcu), for which no servitude discharge were envisioned, which leads to a disruption of their direct connection with the Jiu, thus affecting the aquatic systems. The contribution of the two tributaries on the gorge sector between the two hydro-electrical power plants (Dumitra and Bumbești) is 1.6 m^3/s.

The impact on natural landscapes due to constructions, the building sites that were abandoned within the national park is another aspect that affects the integrity of the national park.

The main objectives that were required constructions sites along the Jiu river are: 9m dam with a micro-hydroelectrical power plant at Livezeni, holding up to 130,000 $m^3$of water; two ground power plants (Dumitra and Bumbești), each one with a pressure knot comprising the surge chamber, gate house and pressure pipe-line (Fig.2); socket case with tailboard at Dumitra receiver, two main adductions (first step Livezeni-Dumitra – 7 km long and inner diameter of 3.80 m and the second step Dumitra-Bumbești, 12.5 km long and inner diameter of 4.00 m); secondary catchments at Dumitra and Bratcu. Currently, the works were suspended, but the construction sites remained, causing a great prejudice to the natural landscape, especially in three locations within the national park: Livezeni – Măgura Tunnel, Dumitra Valley – Păiuș Tunnel and Păiușu Valley – Cerbanașu Mare Valley (Fig. 3). Such changes to the ground cover are not compatible with the national park status.

Figure 3: Abandoned construction sites that were opened for the hydro-energetic harnessing of the Jiu river (a-b, d. Dumitra valley – Păiuș tunnel, c. Cerbănașu Mare)

Conclusions

Currently, in some national parks, water resources are also used for the production of electrical energy, considered a renewable resource (green energy). However, the water resource is, at the same time, a component of the ecosystem that ensures a favourable preservation status for the species and habitats that are the object of conservation (especially those of community interest). Thus, there must be ensured a minimum discharge (ecological discharge) on all rivers within the national parks, to provide for this mere purpose of this category of protected areas. Within the Jiu Gorge National Park, there was a project, which almost draws to an end, for the hydro-energetic capitalization of the river, which implies a potentially negative impact of this investment on the aquatic sector of the Jiu river in this sector. The works were brought to a stop, the beneficiary being forced to reduplicate the procedures for environment approval, since the project was carried on within a national park and Natura 2000 site. It also emphasizes the extent of the potential negative impact of the hydro-energetic harnessing of the Jiu river within the gorge sector on the aquatic environment, as a result of a drastic decrease of river discharge, most of the habitats occupied by the rheophile species as well as by the riparian habitats will be affected to a great extent.

The catchment of Dumitra and Bratcu tributaries, without ensuring a servitude discharge, will break the direct connection with the Jiu, thus affecting the salmonide population that is find in these tributaries.

The most valuable fish species in the area, i.e. the four species of community interest (*Gobio uranoscopus, Barbus meridionalis, Sabenejewia balcanica, Cottus gobio*) will be ranked as unfavourable conservation status. The habitat of a mammal species of community interest (*Lutra lutra)* will be affected.

The change of the flow regime, from turbulent flow, with rapids and small waterfalls, to laminar flow in narrow wet film will render impossible any ecotourism activities (rafting) along the gorge sector of the river. All these effects must be considered for the re-evaluation of the technical and economic indicators for the hydro-electrical harnessing of the Jiu along Bumbești-Livezeni sector in order to assess the environment according to the new environment legislation (establishment of the Jiu Gorge National Park and Natura 2000 ROSCI0063 site).

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