THE UTILIZATION OF THE WATER RESOURCES OF NISTRU RIVER WITHIN THE REPUBLIC OF MOLDOVA

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ABSTRACT. The utilization of the water resources of Nistru river within the Republic of Moldova - on the basis of the studies regarding the water funds, the regimes and characteristics of the flow of river Nistru, those internal larger and smaller ones, taking into consideration what basins exist and the ones with perspective can demonstrate the hydroenergetic potential values of the Republic of Moldova currently and for an extended period of time.The basic variant of the scheme of arrangement on Nistru r. on the basis of the requirements of today's impact on the environment, the ecological flows, hydroenergetic equipments chosen for the parameters of sufficient operation, and the hydrotechnical unit must have an appearance of a complex utilization. The assurances of the flows and head of the hydro-electric plants with operation in cascade on rivers is caused by the strength of given data and the hydrologic calculations after interstate normatives applied now.

Keywords: hydroenergetical potential, the hydro-electric plants, the hidrotehnical unit, the ecologic end hydrological warning, river safety levels,.

1. INTRODUCTION

The principal source of water for the greatest part of the Moldova Republic is Nistru river, having a length of 675 km from the North above the Naslavcea village, the district of Ocnita and to the South in the Palanca village of Stefan Voda district, discharging in the Nistrean liman and then in the Black Sea in the locality of Zatoca (Ukraine). The Nistru river takes its beginning in the Carpathian Mountains, not far from the town of Sambor in the region of Lviv, has a length of 352 km, and the area of the hydrographic pool is of 72100 km^2 with the annual average volume of flow in the Nistru liman equal to 10,2 km^3 of water. The first hydrotechnical construction on the river near Dubasari village, a dam with hydroelectrical power station, was finished in 1955 with the fall of 14m. Later, in 1983, on Ukrainian territory a hydrotechnical knot has been built on this river, composed of a barrage with the fall of 55m – 20 km from the village of Naslavcea (MD) that accumulates 3 km^3 of water and is being spread at the distance of 194 km. To avoid the variations of the debits in downstream in the hydroenergetical equipments with the power of 720 MW an accumulating pool was built in the early 90s of the previous century with the volume of 70 mln.m^3 of water with a barrage and also on the territory of Moldova in Naslavcea Dnestrovsc 2 for working CHE of accumulation 2200 MW.

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2. PRESENT DAY SITUATION OF THE WATER RESOURCES UTILIZATION.

The water resources of the Nistru river at the entrance of the Moldova territory are estimated with a middle value of annual volume of 8,51 km^3 ($P_{75\%}$ =6,55 km^3 and $P_{95\%}$ =4,61 km^3). And at the exit res**p**ectively 10,2 km^3 ($P_{75\%}$ =8,10 km^3 and $P_{95\%}$ =5,70 km^3). From those main affluents there are the rivers on the right bank of the Republic of Moldova with presented data below in table 1 for diverse assurances of P % calculation.

Table 1. ***The resources of the Nistru river affluents on the territory of Moldova***

River	Length, km	Area of BH, km^2	Average Volume, km^3	Volume P=75%, km^3	Volume P=95%, km^3
Răut	286	7,76	0,310	0,170	0,090
Bîc	155	2,15	0,080	0,040	0,020
Botna	146	1,54	0,030	0,013	0,004

The scheme of the hydrographic basin (BH) of the Nistru river for the territory of the Moldovan Republic can be found in table 1.

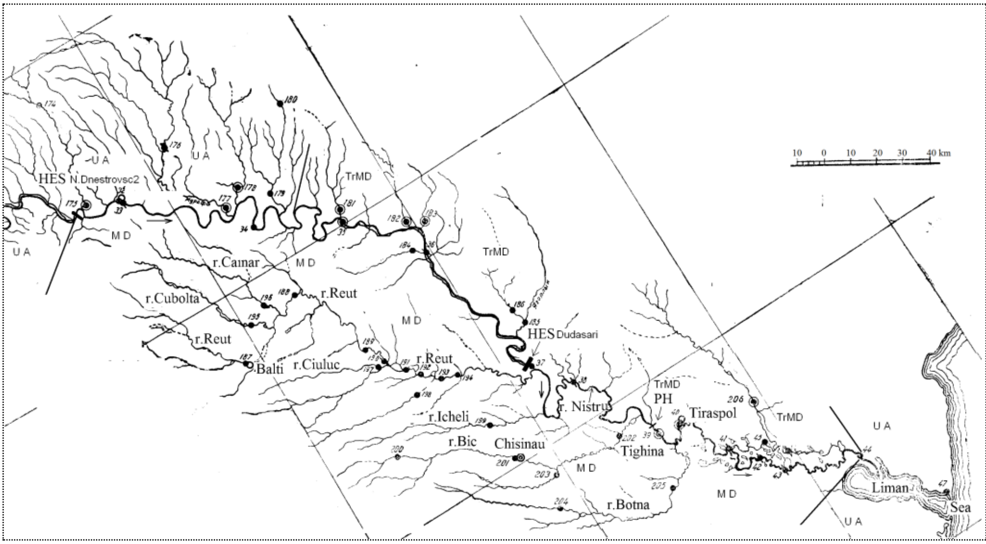

Fig. 1. ***The rivers scheme in the hydropgraphic basin of r. Nistru within Moldova Republic. MD- the territory of Rep. Moldova, TrMD- the territory of Transnistria, UA- the territory of Ukraine.***

The determination of the annual flow norm through the presence of hydrometric observations data is being done on the basis of the data table. For the necessary variation it is being taken into account the information about the hydropgraphic pool flow debit, calculated in the multiannual period of observations (1956-1999) that are introduced in table 3 for their subsequent processing. Hydrometric points on the r.Nistru are at CHE Dnestrovsc, Dubasari, loc.Hrusca from the Camenca district in Transnistria, Bender, among other places. The size of the annual flow norm throughout the presence of over 40 years at the chosen hydrometric section is determined under the formula:

$$Q_0 = \sum_{i}^{n} \frac{Qi}{n} \quad (1)$$

where: $\sum_{i}^{n} \frac{Qi}{n}$ - is the sum of annual debits, of the flow, m^3/s; n –number of observations years that is always being taken over 40 years.

The determined scope of the multiannual debit of flow is usually expressed by diverse numeric characteristics of the flow which are mutually connected with the represented relations in table-2.

Table 2. ***The parameters of the water flow applied in the determining of the water resources.***

Characteristics of the flow	The capitalization of the flow	Q, m^3/s	W, m^3	M, l/s km^2	h,mm
Debit of water	Q, m^3/s		*W/T*	$10^{-3}MF$	$10^{-3}Fh/T$
Volume	W, m^3	QT		$10^{-3}MFT1$	$10^{-3}Fh$
Modue	M, l/s km^2	$10^3Q/F$	$10^3W/FT$		$10^{-3}h/T$
Layer	h,mm	$10^{-3}QT/F$	$10^3W/F$	$10^{-6}MT$	

where: $T=31,54*10^6$ sec.(year); $T=2,63*10^6$ sec(month); T=86400 sec(day)

The statistic parameter calculation of the annual flow (of the coefficients of variation Cv and the coefficient of the top sided Cs), when the observation data was presented, is determined under the given formulas in the approved normative in RM.

$$Cv = \sqrt{\sum_{i=1}^{n}(Ki-1)^2} /(n-1) \quad (2)$$

$$Cs = \left[n\sum_{i=1}^{n}(Ki-1)^3 \right] / \left[Cv^3(n-1)(n-2) \right] \quad (3)$$

where: Ki – the annual flow module coefficient determined by the formula:

$$Ki = \frac{Qi}{Qo} \tag{4}$$

where: *Qi* – debit of annual flow (of first year),
Qo–multiannual size of the flow debit, determined from (1).

Regarding the graphoanalytical method, to determine the variation coefficient and the asymmetric coefficient, there was a need to construct an assurance empirical curve, using a special nomogram. (fig.2).

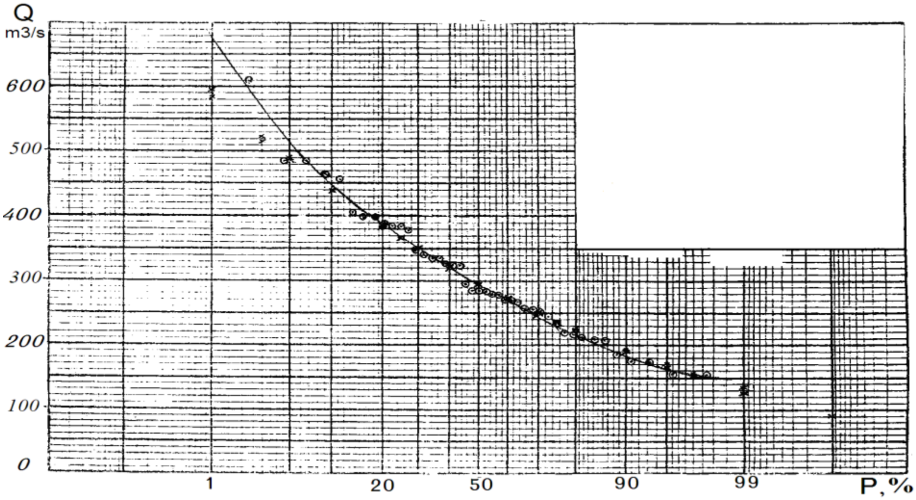

Fig. 2. ***The ensurance curve of the water flow parameters Nistru river PH Bender***

The empirical probability of the annual flow coefficient of surpassing P met in discharging order (Ki ↓) is determined under the formula:

$$p = \frac{m}{n+1}100\% \tag{5}$$

where: m- is the order number of the situated numbers in discharging order;
n –the common number of the range members.

Table 3. ***The statistic parameter calculation of water flow Nistru river PH***

N.	Years	$Q_{an.average}$ m^3/s	Q	K	(K-1)	$(K-1)^2$	$(K-1)^3$	P%
1	1956	278	610	1,9778	0,9778	0,9561	0,9349	2,27
2	1957	220	487	1,5790	0,5790	0,3352	0,1941	4,55
3	1958	280	486	1,5758	0, 5758	0,3315	0,1909	6,82
4	1959	209	466	1,5110	0, 5110	0,2611	0,1334	9,09
5	1960	271	456	1,4785	0,4785	0,2290	0,1096	11,4
6	1961	173	406	1,3164	0,3164	0,1001	0,0317	13,6
7	1962	285	399	1,2937	0,2937	0,0863	0,0253	15,9
8	1963	218	398	1,2905	0,2905	0,0844	0,0245	18,2
9	1964	258	390	1,2645	0,2645	0,0700	0,0185	20,5
10	1965	384	386	1,2516	0,2516	0,0633	0,0159	22,7
11	1966	379	384	1,2451	0,2451	0,0601	0,0147	25,0

12	1967	341	379	1,2288	0,2288	0,0525	0,0120	27,3
13	1968	328	349	1,1316	0,1316	0,0173	0,0023	29,5
14	1969	487	341	1,1056	0,1056	0,0112	0,0012	31,8
15	1970	456	337	1,0927	0,0927	0,0086	0,0008	34,1
16	1971	337	337	1,0927	0,0927	0,0086	0,008	36,4
17	1972	270	328	1,0635	0,0635	0,0040	0,0003	38,6
18	1973	296	327	1,0602	0,0602	0,0036	0,0002	40,9
19	1974	390	325	1,0538	0,0538	0,0029	0,0002	43,2
20	1975	386	296	0,9597	-0,0403	0,0016	-0,0001	45,5
21	1976	398	286	0,9273	-0,0727	0,0053	-0,0004	47,7
22	1977	325	285	0,9241	-0,0759	0,0058	-0,0004	50,0
23	1978	406	283	0,9176	-0,0824	0,0068	-0,0006	52,3
24	1979	399	280	0,9079	-0,0085	0,0085	-0,0008	54,5
25	1980	610	278	0,9014	-0,0986	0,0097	-0,0010	56,8
26	1981	466	271	0,8787	-0,1213	0,0147	-0,0018	59,1
27	1982	349	270	0,8754	-0,1246	0,0155	-0,0019	61,4
28	1983	257	268	0,8689	-0,1311	0,0172	-0,0023	63,6
29	1984	234	258	0,8365	-0,1635	0,0267	-0,0044	65,9
30	1985	268	257	0,8333	-0,1667	0,0278	-0,0046	68,2
31	1986	210	252	0,8171	-0,1829	0,0335	-0,0061	70,5
32	1987	172	244	0,7911	-0,2089	0,0436	-0.0091	72,7
33	1988	283	234	0,7587	-0,2413	0,0582	-0.0140	75,0
34	1989	286	220	0,7133	-0,2867	0,0822	-0,0236	77,3
35	1990	154	218	0,7068	-0,2932	0,0860	-0,0252	79,5
36	1991	252	211	0,6841	-0,3159	0,0998	-0,0315	81,8
37	1992	211	210	0,6809	-0,3191	0,1018	-0,0325	84,1
38	1993	244	209	0,6777	-0,3223	0,1039	-0,0335	86,4
39	1994	157	185	0,5998	-0,4002	0,1602	-0,0641	88,6
40	1995	185	173	0,5609	-0,4391	0,1928	-0,0847	90,9
41	1996	327	172	0,5577	-0,4423	0,1956	-0,0865	93,2
42	1997	337	157	0,5090	-0,4910	0,2411	-0,1184	95,5
43	1998	486	154	0,4993	-0,5007	0,2507	-0,1255	97,7
		13262		43	0	4,4746	1,0383	
		308,4186						

C_V=0,32 GC_V=11,32% C_S=0,74 GC_S=48,2%

3. THE PERSPECTIVES OF THE WATER RESOURCES CAPITALIZATION.

The essential hydrometric observation point on the Nistru river is placed above Bender town, where measurements are being performed, surpassing a long standing of one hundred years.

Here the water level is being measured in comparison with the „0" quota and is determined by both the limnimetrical curve Q=f(H) and the living section area F,m^2, the average speed of the water V,m/s presented in fig.3**.** The debit variation in the Nistru river at the entrance in RM up to the start of the first hydroaggregate at CHEA of accumulation placed with plug between CHE Dnestrovsk 1 and CHE Dnestrovsk 2 (Naslavcea), one can notice, under the debit measurement data in fig.4 between 1995-2001, large variations that negatively influence the ecological aspect to the fauna and flora by low temperatures of the water and also on taking over of water for water supplies and irrigations.

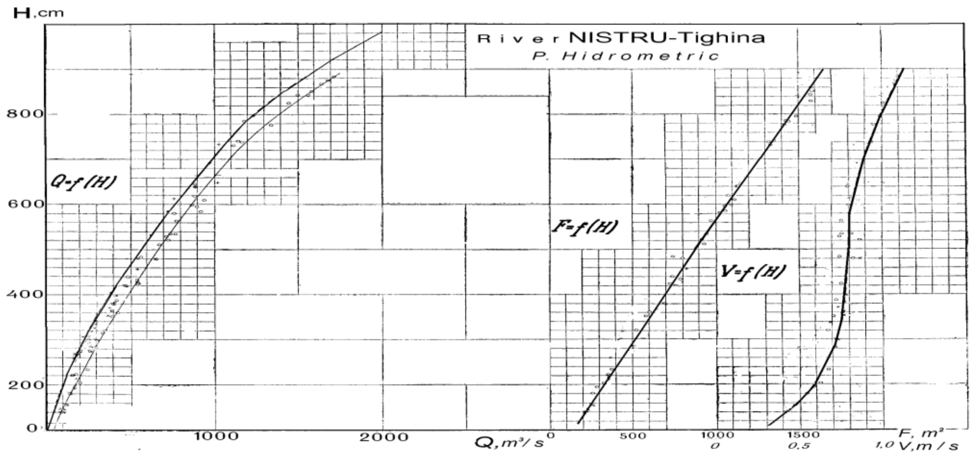

Fig. 3. ***The relationship between the debit (Q), surface of the cross profile (F), mean speed (V) and the level (H) of the river***

On the Nistru river within Moldova there are 53 pumping stations for irrigation with a summary debit of Q_i=93,2 m^3/s and a total volume in warm periods (1.04-1.10) of up to 303,7 mln.m^3 of water supplying with taking over of water from the Prut river and interior accumulating pools watering of 310 thousand of ha of land. Recently, under the programme Compact, 10 irrigation systems were rehabilitated with modern equipment: Criuleni, Lopatna, Jora de jos, Puhaceni, Talmaz among others.

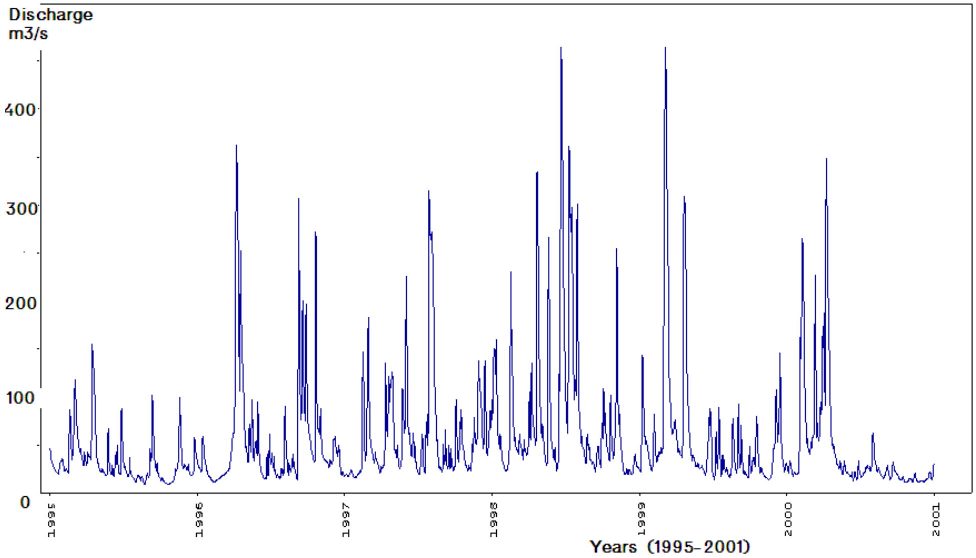

Fig. 4.***The hydrographer of the water flow at the entrace the RM on the Nistru river up the starting at CHEA.***

The taking over of the water from the Nistru river for centralized systems of water supplies 13 pumping stations were foreseen with a summary debit of Qa=8,3 m^3

/s and an annual total volume of 148.3 mln.m^3. Among the ones with a bigger capacity is the aqueduct towards mun.Chisinau with the plug on the Nistru river above the Vadul lui Voda town, with the possibility of taking over 5 m^3/s (at present it is being pumped with three steps about 200 th.m^3/24h); and Soroca – Balti aqueduct with the highest plug of the village of Cosauti and STA of Soroca, which with 4 steps supplies the systems from Soroca, mun. Balti and with the possibility in the future to provide water pumping to Floresti, Singerei, Riscani, Telenesti, Drochia and other localities. Resulting from the exploitation rules of the Dnestrovsk complex hydrotechnical knot, it is foreseen that the minimun debit ecologically admitted at the entrance of the territory of Moldova is of 100 m^3/s, and at the way out of 80 m^3/s. Fig.5 presents the hydrographer at the entrance of Moldova at CHE Dnestrovsc 2 at the barrage with buffer pool of accumulation and downstream through CHE Dubasari for year 2005.

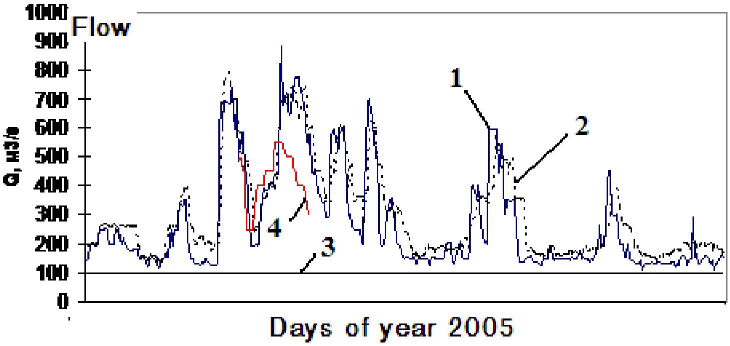

Fig. 5. ***The water debit variation in the Nistru river at the entering(1) and exiting(2) from the Moldova territory, debit ecologically admitted(3) and debit coordone(4)***

Due to the energetical crisis in our region increases the interest to also capitalize the hydroenergetical potential of the Nistru river, not only at CHE, with the accumulating pools of Dubasari with a total volume now being of 277,4 mln.m^3(initial project of 435 mln.m^3, of which one third of it is presently covered in mud with useful volume of only 203,4 mln.m^3 . Actually the hydropower belongs and is being exploited only by the transnistrean part.

4. BORDER PROBLEMS OF THE UTILIZATION ON THE NISTRU RIVER

The water resources, like the hydroenergetic potential, are not uniformly distributed on the Moldova's territory. If realized, all technical potential of the rivers in our republic would produce 1,2 mld. kWh of energy. The economical potential is smaller and reaches 0,7 mld. kWh, making up one third of the theoretical one. The theoretical potential of the small rivers in Moldova under some data is equal to 0,8 mld.kWh, from which only the fourth part is technically arranged. Throughout the years, on the RM territory, on the river Nistru were constructed and are functioning the following: CHE Dubasari (1954) with the capacity of 48 MW and CHE Dnestrovsc 2 , the village Naslavcea of 40,8 MW which is only being utilized by the Ukrainian part. Apart from these, a series of small power CHE were built(40-400kW) in Cazanesti, Jeloboc, Floresti and another one on the river Raut-over 20 are currently not functioning. According to the energetic development plans of our republic, the construction of a series of CHE on the Nistru river at Otaci, Cremenciug, Soroca, Camenca, Grigoriopol, Speia and others had been foreseen; however those plans have not been achieved. It had also been foreseen the construction of CHE with hydroaccumulation in Camenca (912MW), on the evacuation canal from the accumulating pool of Novodnestrovsc above towards the Ochiul Alb pool (11,2MW). There was also an initial plan to increase the energy production at CHE Dubasari (650MW) through hydroaccumulation and a CHE of accumulation with water pumping from the Dunare river in the lake Ialpug (41MW). Yet, the potential realization has border problems with the Ukrainian part as well as with the transnistrean part. In the second pool of accumulation the Moldovian part should pretend to a half of the hydrotechnical knot in the North at Dnestrovsc 2 Naslavcea, where, according to the rules of exploitation, 50% of water resources and a half of the produced energy at this knot, resulting from the set power, must be equally divided by 20,4MW with UA. At present, in our republic it does not exist a general plan of development of the great hydroenergetics, except the Government Decision Nr.1092 from 30.10.2000, where there are directions for the development of small hydroenergetics and other renewable sources of energy.

5. CONCLUSIONS

The surface water resources of the Nistru river are available for complex utilization in water supplying irrigations , fishing, navigation and hydroenergetics. The water resources value should be determined on the basis of measurements of PH and the observation data to be processed with the determination of the hydrological characteristics. The increase of resources is being able to produce at the hydrotechnical knot Dnestrovsc that is now placed at 3,9 km above the Dnestrovsc 2 barrage, belonging to Moldova.

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