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THE MAIN WATER RESOURCES OF THE REPUBLIC OF MOLDOVA

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Abstract
The Republic of Moldova has a small area and no direct access to the sea or ocean, so its water resources are limited and are represented by surface and underground waters. However, it has an access point to the Danube River on a 430-meter stretch, at the southernmost point of the country (Giurgiulești village), which offers potential access to the Black Sea. The country's main sources of water include rivers, lakes, and groundwater. Surface waters are represented by 3,621 rivers and streams with a total length of approximately 16,000 km and 4,261 natural lakes and artificial basins. Underground water is represented by over 7,000 artesian wells and about 179,574 wells fed from the water table. It should be noted that, in recent years, the Republic of Moldova has faced a series of problems related to water quality, including the pollution of rivers and lakes. In this sense, a more effective management of water resources is needed to ensure an adequate and sustainable drinking water supply.

Keywords: water resources, the hydrographic network, underground water

1. Introduction

Hydrology is a science that studies the general properties of water on the surface of the earth's crust, the general laws that direct the processes in the hydrosphere, the mutual influence between the hydrosphere, atmosphere, lithosphere, and biosphere, as well as the forecast of the evolution of hydrological elements, with a view to their rational use in the economy, which also includes the management of water resources. [Răuţă, et al., 1992].

The Republic of Moldova is a small country, located in the South - East of Europe. It has an area of approximately 33846 km^2. This country stands out for the beauty and diversity of its relief, being crossed by numerous rivers and their tributaries.

Compared to other European states, Moldova is a country with relatively modest water resources. Water resources are represented by surface water and underground water. Under the Water Law, the management of water resources is carried out based on the 2 districts of the Dniester, Danube - Prut and Black Sea hydrographic basins (within the territory of the Republic of Moldova). [Bejan, 2021].

Rivers represent the set of water courses of different sizes grouped in hydrographic basins and spread over the entire earth's surface with different densities, depending on the climatic conditions (especially precipitations) and those of the substrate.

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Reservoirs are artificial bodies of water created by building dams or dikes on natural watercourses to accumulate and store water. These lakes are used for various purposes such as electricity generation, agricultural land irrigation, drinking water supply, flood control and development of tourism and recreational activities.

Groundwater intended for centralized use by households and for industrial use is extracted from aquifers. Groundwater is the main source of drinking water in the Republic of Moldova for the rural population.

2. Methodology

Water plays a very important role in shaping the relief. The process of formation and evolution of the hydrographic network includes all successive stages from slope erosion to fluvial erosion.

The main big rivers of Moldova are Dniester and Prut; they are located on the Western and Eastern border of the Republic of Moldova. The purpose of this paper is to evaluate the water resources of these rivers.

The paper describes both the hydrological characteristics of the years 2019, 2021 and 2022 in general, as well as the characteristics of each month. The hydrological characteristics were taken from the data of the State Hydrometeorological Service of the Republic of Moldova. [https://old.meteo.md/mold/nsproghid.htm]

3. Results and discussion

Depending on the source, water is divided into surface water and underground water. Surface waters are classified into standing waters (seas and oceans, lakes, etc.), flowing waters (spring - stream - river - river) and stagnant waters.

Another classification of surface waters is as follows: runoff waters, torrential waters and permanently flowing waters – streams and rivers.

- ***Runoffs and torrential waters***

Runoffs are the first processes of water running off on the slopes in the form of irregular strands that follow the topography of the slopes in their lowest parts. They are only present during and immediately after the rains and most of the time, they follow different initial routes. They have a particularly important role in the washing and action of the slopes. The runoff volume depends on the amount and intensity of precipitation, the infiltration capacity of the land, the size of the slope, and the existence of vegetation and its nature.

Torrential waters represent a more developed phase of trickling waters, resulting from their gathering in a "bundle" and the establishment of well-defined routes, produced by erosion.

- ***Permanent flowing waters - rivers***

Rivers originate from atmospheric precipitation and from springs that drain linearly, according to the slope, along valleys on the surface of the land, which flow either into another river or river (as its tributary) or into a lake, in a sea or an ocean.

The Republic of Moldova has a fairly developed hydrographic network; more than 3,000 rivers and streams cross the territory of the country. All the rivers of R. Moldavia belong to the Black Sea basin and almost all of them, following the slope of the surface, flow

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from northwest to southeast. Small tributaries have various directions, but still, rivers, flowing to the north and west are almost non-existent. Figure 1 shows the hydrographic network on the territory of the Republic of Moldova and the most important hydrographic basins of the Republic of Moldova.

Figure 1. Map of the hydrographic network and hydrographic basins of the Republic of Moldova (web page no. 1).

The hydrographic network of the Republic of Moldova consists of 3,621 rivers and streams with a total length of approximately 16,000 km and four hydrographic basins. The most important rivers are the Dniester and the Prut. Table 1 shows the most important rivers of the Republic of Moldova and their characteristics.

Table 1. The main rivers of the Republic of Moldova (web page No. 3).

River	The total length (km)	Length on the territory of the R. of Moldova (km)	The total area of the hydrographic basin (km²)	Water flow in the lower course (m^3/sec)	The flow annual (ml. m^3)
Nistru/Dniester	1352	657	72100	3180	9997
Răut	286	286	7760	5,99	189
Ichel	101	101	814	0,51	16,1
Bâc	155	155	2040	1,08	34,1
Botna	152	152	1540	0,47	14,8
Prut	953	695	27500	150,0	2400

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Cogâlnic	243	125	3910	. . . . .	. . . . .
Ialpug	142	135	3280	. . . . .	. . . . .

❖ ***Dniester River***

The Dniester River has a length of 1,352 km and a total area of the hydrographic basin of 72,100 km². Of the total area of the Dniester basin, 73% is on the territory of Ukraine, almost 27% in Moldova, and less than half a per cent (232 square kilometres in the area of the source of the left tributary of the Dniester, the Strwiąż river) belongs to Poland (web page No. 8). It originates in Ukraine, in the Carpathian Mountains near the border with Poland and flows into the Black Sea downstream of the town of Cetatea Alba. Its main tributaries are: Bistrita, Strâi, Svicia, Răut, Ichel, Bâc, Botna (right) and Vereșciția, Siret, Usâtia, Liadva, Iagorlâc, Camenca, Cuciurgan (left). The Dniester is one of the nine most important watercourses in Europe and is one of the most interesting rivers in Eastern Europe.

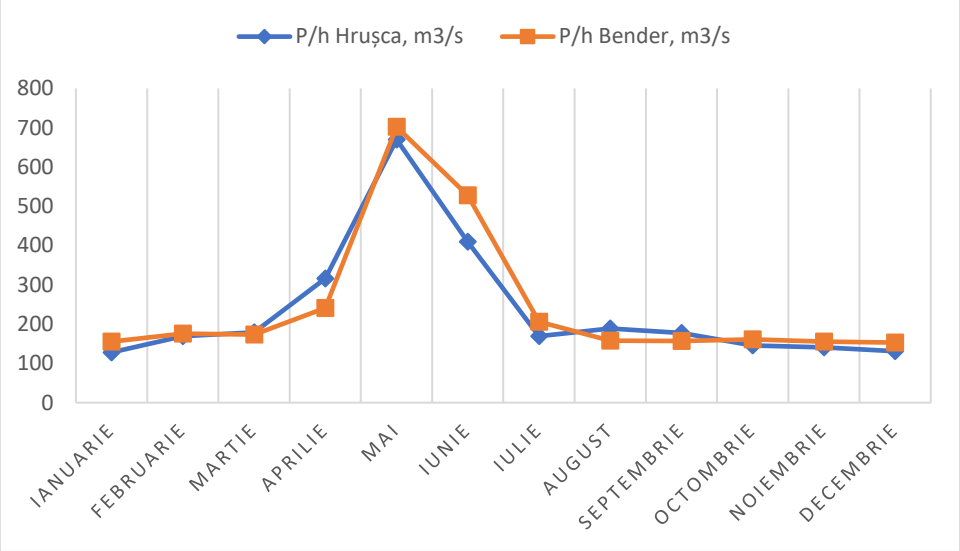

Figure. 2. The monthly average of the debits of R. Dniester in 2019

The hydrological regime of 2019 was characterized as follows:
During the winter period, the water flow in the Dniester River constituted 50-80%; in the spring period on the Dniester River in connection with the water discharge above the norm, it was 60-80% (except May with 190-210%); during the summer, the flows on the Dniester River in June and July were above the norm and amounted to 80 - 160% (except August with 40-60%); during the autumn, the flows on the Dniester River were below the norm and constituted 55-75%.

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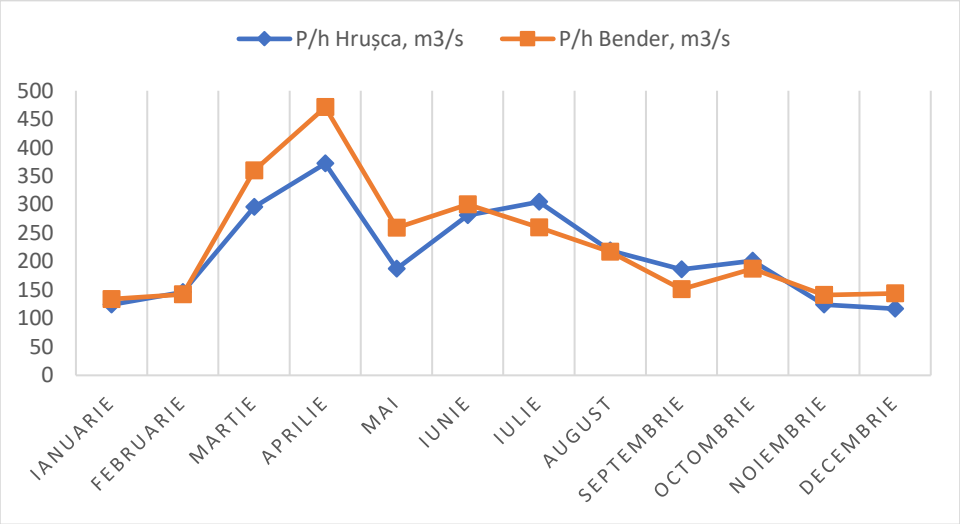

Figure. 3. The monthly average of the debits of R. Dniester in 2021

The hydrological regime of 2021 was characterized as follows:
During the winter period, the water discharge in the Dniester River was 65-80%; in the spring period, the flows were 70-130%; during the summer, the flows on the Dniester River constituted 75-100%; during the autumn, the flows on the Dniester River were 60-75%.

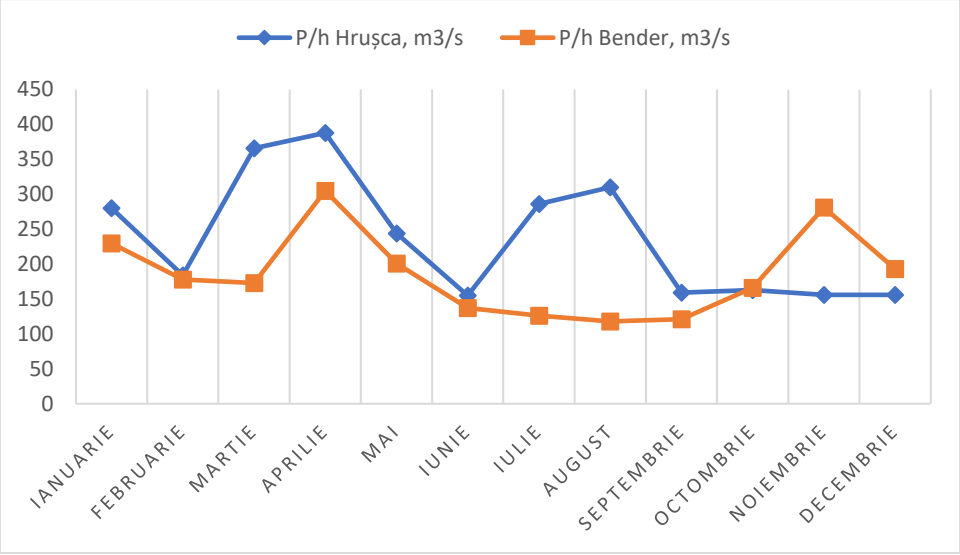

Figure. 4. The monthly average of the debits of R. Dniester in the year 2022

The hydrological regime of the year 2022 was characterized as follows:
During the winter period, the water discharge in the Dniester River was 80-105%; in the spring period, the flows were 60-80%; during the summer, flows on the Dniester River were 40-45%; during the fall, the flows on the Dniester River were 55-145%.

- ***Prut River***

The Prut has a length of 953 km and a hydrographic basin area of 27,500 km². Of the total area of the basin, 28% is on the territory of the Republic of Moldova, 33% on the territory of

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Ukraine, and 39% on the territory of Romania (web page No. 9). It originates in Ukraine, in the Wooded Carpathian Mountains from the Hoverla peak and flows into the Danube River near Giurgiulesti in the Republic of Moldova. On the territory of Moldova, the Prut River has only left tributaries, among which are Racovaț, Larga, Vilia, Lopatnic, Draghiște, Ciuhur, Camenca, Nârnova, Lăpușna, Sârma, Sărata, Tigheci and Larga. The other two watersheds that make up 9%, are the tributaries of the Danube that flow directly into the Black Sea. [web page No. 2].

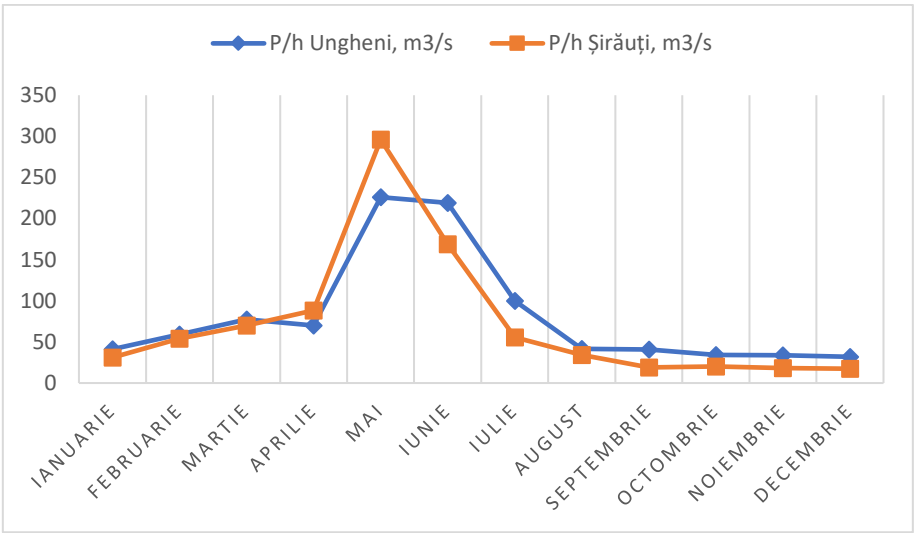

Figure. 5. Monthly average flows of the Prut River in 2019

The hydrological regime of 2019 was characterized as follows:
In the winter period, the water flow in the Prut River was 90-140%; in the spring, the flows were 50-90% (except for May with 130-220%); in the summer period, the months of June and July were significantly above the norm and constituted 110-230% (August: 30-50%); during the autumn, the flows were below the norm and constituted 35-65%.

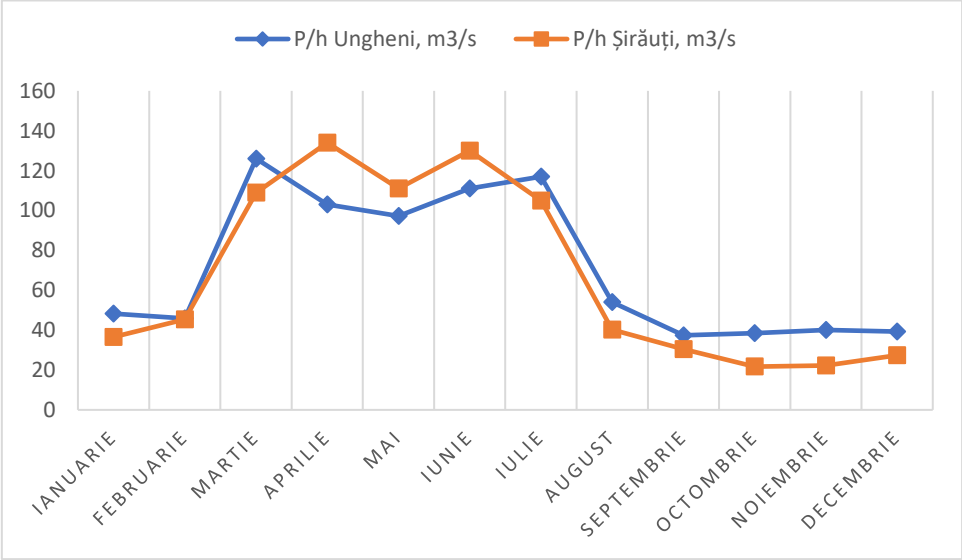

Figure. 6. Monthly average flows of the Prut River in 2021

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The hydrological regime of the year 2021 was characterized as follows:
In the winter period, the water flow in the Prut River constituted 65-80%; in the spring, the flows were 75-145%; in the summer, they constituted 50-95%; during the autumn the flows were 45-65%.

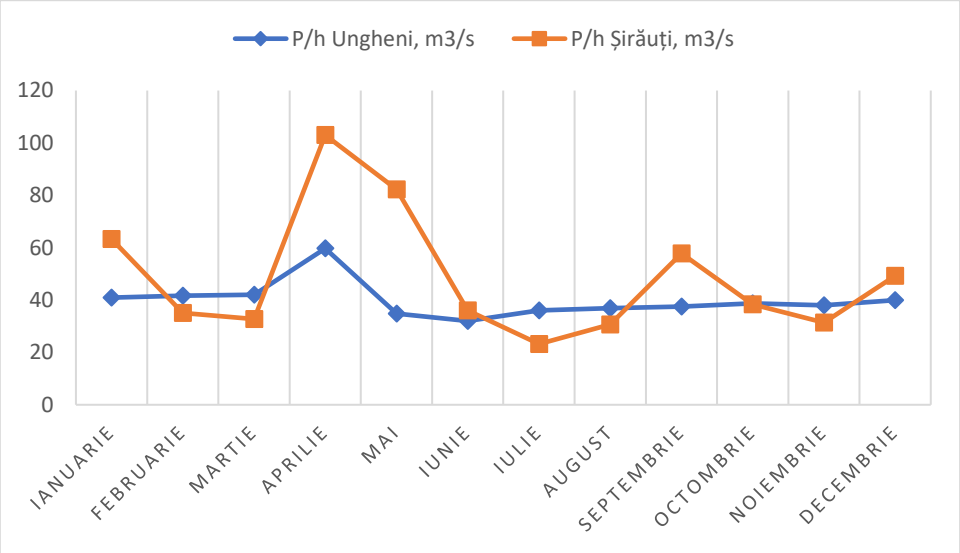

Figure. 7. Monthly average flows of the Prut River in 2022

The hydrological regime of the year 2022 was characterized as follows:
In the winter period, the water flow in the Prut River was 70-115%; in the spring, the flows were 50 - 65%; in the summer, they constituted 25-35%; during the autumn the flows were 60-65%.

❖ ***Natural lakes and artificial pools***

Reservoirs, whether natural or artificial, have the basic role of retaining a volume of water that can be used to supply water for energy or non-energy uses. Artificial reservoirs are water reservoirs created by building dams or dykes on natural watercourses to accumulate and store water. This water is used for various purposes, such as electricity generation, agricultural land irrigation, drinking water supply, flood control, and the development of tourism and recreational activities [Cebotari, 2018].

The recent evolution of reservoirs in the Republic of Moldova was marked by the construction and modernization of such lakes, as well as by various projects and initiatives related to the sustainable use of water resources [Băjenaru, 2015].

Table 2 shows the most important reservoirs in the Republic of Moldova with their basic functions, as well as their other characteristics.

Table 2. Reservoirs from the Republic of Moldova (web page No. 4,5).

Reservoir lake	Year of construction	River	Total volume, (*mil. m^3*)	Water surface (*km^2*)	The depth near the dam (m)	The main goal
Costești	1976	Prut	1085	92,0	34,2	I-200; II-8000; III

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Novodnestrovsk	1982	Dniester	400	140	60	I-3; II-2500; III
Dubăsari	1954	Dniester	266	67,5	19,9	I-29; II-1500; III; IV
Cuciurgan	1963	Cuciurgan	75	28,0	3,0	I-2520; II; III
Ghidighici	1963	Bâc	40	8,0	9,9	II; III
Congaz	1961	-	9,9	4,9	5,4	II; III
Călărași	1977	Bâc	7,0	-	-	I-6; II-3000
Ulmu	1961	Botna	2,1	0,7	6,8	II; III
Goteşti	1962	-	3,3	1,8	4,1	II; III
Răzeni	1963	-	3,4	1,9	4,2	II; III
Comrat	1957	Ialpug	4,0	1,7	4,5	II; III

Note: I-Electricity production (MW); II-Irrigation of agricultural land (ha); III-Flood control; IV-Drinking water supply

The natural lakes of Moldova are few and insignificant in terms of the volume of stored water. The three largest natural lakes are Beleu, Manta and Bîc, with lengths between 4000 and 5000 m, widths between 1000 and 2000m and average depths between 1 and 4 m.

- ***Groundwater***

The underground waters of the Republic of Moldova do not meet the national standard for drinking water. Often the hardness of the water in the wells exceeds the standards by twice or even more. The samples taken from the unfenced aquifers exceed the maximum allowed concentrations for nitrates; this aspect may be due to the raising of animals in households.

Groundwater is represented by springs, wells and mineral waters. Of the several thousand springs with potable underground water (7000), one can mention the Jeloboc spring, the Valea Morilor spring and the Cricova spring and about 179574 wells fed from the water table.

In the Republic of Moldova, there are springs with drinking mineral water and mineral underground waters with curative qualities (Cahul, Camenca).

4. Conclusions

The main sources of water supply for the Republic of Moldova (safer and better quality) remain the Dniester and Prut rivers. The smaller rivers, besides having low flows, are polluted and/or very polluted. For the two rivers, Dniester and Prut, the probable change in the volume and seasonal distribution of the discharge stands out as one of the critical consequences of climate change.

However, most of the population (approximately 100%) living in rural areas only has access to underground water, either from springs or wells. The urban population depends on this water source only in a percentage of 30%. For the total population of the Republic of Moldova that only has access to underground water as drinking water, the percentage is 65%. About 44% of the country's population does not have access to safe drinking water.

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