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CONSIDERATIONS ON DRINKING WATER MANAGEMENT IN THE MOLDAVIAN PLATEAU AND PLAIN REGION

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Abstract. The Moldavian Plateau and Plain have few drinking water sources (the case of Iaşi and Vaslui Counties). The main type of fresh water sources are groundwater and surface water. The Moldavian Plateau rural settlements are affected the most by the lack of viable, unpolluted water sources to ensure a volume able to cover the consumers' demand. The pollution phenomenon induced by the non-availability of rural sewerage systems and also by the settlements' areas foundation rocks have decreased the groundwater and surface water sources quality parameters. The adduction, transport and distribution networks of water supply systems are affected by the „water loss" phenomenon. Water management in a transmission and distribution network must correlate the number of water sources, available volume, acceptable quality parameters and inherent water losses from networks with the consumers' demands. The optimisation of water management in a given geographic space has led to the establishment of „regional water supply systems". This process relies on the minimisation of water losses. The case study carried out in Iași County shows the importance of the regional water supply system development through optimal exploitation of Moldavian Plateau and Plain water sources.

Introduction

The improvement of the populations' living standards requires the increase of agricultural, industrial and drinking water consumption (Danilenko et al., 2014). The population from the majority of the developed countries had 100% access to water supply and sewerage systems in 2002, whilst only 68% of Romania's

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population benefited from this service. The repartition of water – sewerage networks in Romania is unevenly distributed, with a high deficit in the rural area, compared to the urban one. In 2016, this makes the extensions of the water supply and sewerage services to be still a challenge for our country. In Romania, it is necessary to modernise the water catchment, transmission and distribution infrastructure, the extension, rehabilitation and improvement of water supply systems.

Access to drinking water and sanitation are human rights stipulated in United Nations General Assembly Resolution 64/292 of 28 July 2010. At the same time, the state must contribute to the achievement of this right by providing investment funds for the design and execution of water supply and sewerage systems. According to the provisions of 98/83/EC Directive, by the end of 2015, about 70% of Romania's population should have been connected to centralised water services, and by 2020 the percentage should be 80%. This challenge can be achieved either by implementing new water supply systems in the countryside or by connecting rural localities to existing water supply systems. Urban and rural localities should be integrated into a regional water supply system to optimize the catchment, treatment, transmission and distribution of drinking water to the consumer.

The execution of water supply systems in the Moldavian Plateau and Plain should take into account the presence of some water sources with quality parameters accepted by current standards. However, this geographic area has limited drinking water sources due to the hydrographic and geologic site characteristics (Romanescu et al., 2014).

1. The analysis of water sources characteristics in the Moldavian Plateau and Plain area

The quality of groundwater and surface water in the Moldavian Plateau areal is determined by the geomorphology of the area. The relief of the analysed areal consists of hilly areas, with altitudes below 200 m, called "low hills", or with hills with altitudes of 350 ... 200 m, characterized as "medium hills" (Fig. 1). The relief is fragmented in the form of medium and high hills, with wide plateaus at the top, or narrow hillsides and hilly plains. The hills are bordered by numerous versants with ridge aspect (Enciclopedia geografică a României, 1982).

The area under analysis, from a geological point of view, is part of the structural unit "Scythian Platform". The base is made up of old crystallophilic and sedimentary rocks. The Scythian Platform cover, 1000 m thickness, is laid over the base, consisting of clays, sandstones, limestones, marls, sands.

From a stratigraphic point of view, the sedimentary deposits of the cover belong to Bassarabian, Cherssonian, Meotian and Quaternary. The Cherssonian is lithologically represented by clay, gray marl, compact, micaceous and gray sands,

several hundred meters thick. The Meothian is represented by clays, sands and rare interbedded cemented limestone slates lens. The Quaternary is represented by alluvial, deluvial, proluviale formations on the course of the rivers and loessoides on the slopes.

The geotechnical and hydrogeological characteristics influence the formation and physical-chemical parameters of groundwater layers, their volume, the depth of the intake, the investment costs of the catchment and water treatment (Luca et al., 2010).

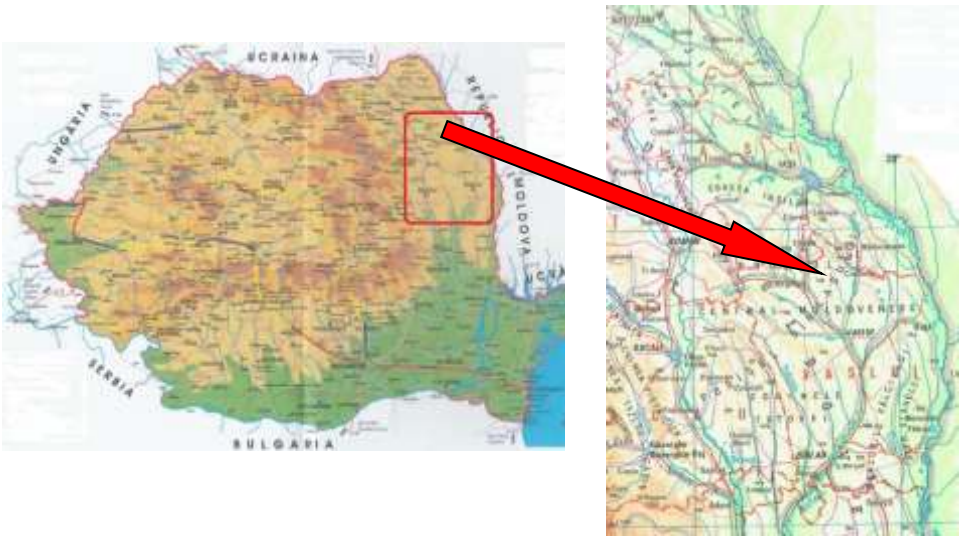

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Fig. 1 - The framing of the study areas in the Moldavian Plateau and Plain: a – location of the study area; b – physical map of the study area (Enciclopedia geografică a României, 1982)

The geotechnical and hydrogeological characteristics influence the location and field adjustment of the constructions and installations within the urban or rural water supply system. The hilly relief in this geographic area has an increased sliding potential, which leads to a high operational risk for the constructions and hydraulic installations. The presence of ravines and non-permanent watercourses requires additional measures to be taken for the execution of transmission and distribution network.

The Moldavian Plateau and Plain area are located in two large hydrographic basins: Prut and Siret. Prut – Bârlad hydrographic area covers the counties of Botoşani, Iaşi, Vaslui and Galaţi and partly the counties of Neamţ, Bacău and Vrancea. The population in this geographic area is about 2.2 million inhabitants, of

which 1.04 million (48%) live in urban areas. Only 40.5% of the total population is connected to centralized water supply systems (76% in urban areas, 8.53% in rural areas). Likewise, 24.1% of the inhabitants (50.17% in urban areas and 0.53% in rural areas) are connected to wastewater treatment plants. The high percentage of inhabitants benefiting from sewerage influences the quality of the groundwater.

The total theoretical water resource in the Prut - Bârlad hydrographic area is 3661 Mm^3/year, out of which the usable resource is 960 Mm^3/year and the specific resource is 437 Mm^3/inhabitant/year. These values position the hydrographic area under the national average (ABA Prut-Bârlad, 2016).

The period between 2000 - 2017 in the Moldavian Plateau and Plain is characterized by the execution of a large number of water supply systems in the rural area and the extension of the urban ones. The execution of the water supply systems in this geographic space is conditioned by the existence of water sources with an available volume and quality parameters accepted by the current standards. Urban water supply systems are connected to viable and high quality water sources.

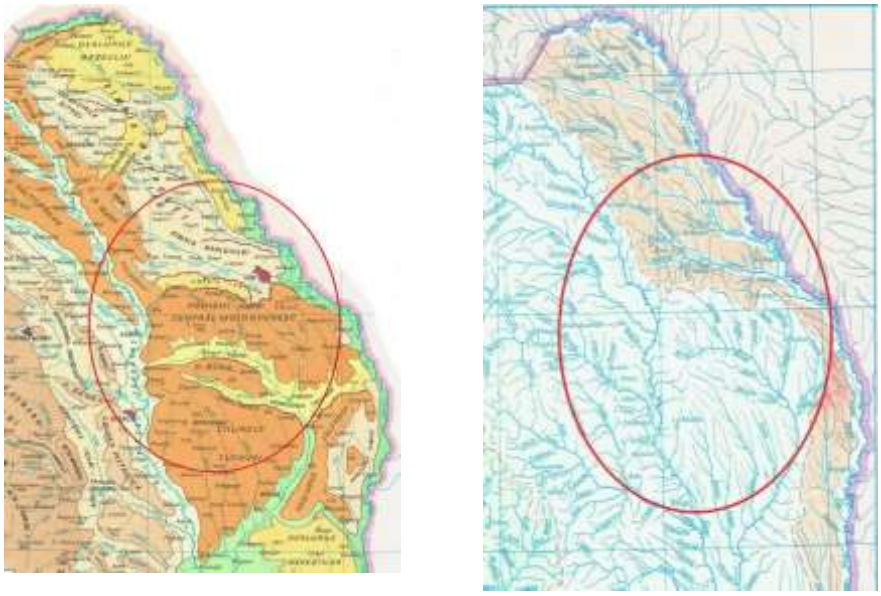

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Fig. 2 - The framing of the study areas in the Moldavian Plateau and Plain relief and hydrography: a – relief features in the study area; b – hydrography of the study area (Enciclopedia geografică a României, 1982)

Most rural localities are supplied with water from local sources (village wells and springs catchments), which have low flow rates and relatively uncontrolled quality parameters (Alexandrescu et al., 2012). In the Moldavian Plateau the coastal springs are also exploited, and the water from rivers, streams and lakes are used for zootechnical consumption. The wells from rural areas are built in a rudimentary way and do not provide a flow rate adequate to the population's needs. In many cases, organic substances and inorganic substances (nitrites, chlorides, sulphides or calcium) are found in water sources, which makes the water non potable from a physical, chemical and bacteriological point of view (Sedrati et al., 2017).

A water supply solution for urban and rural areas are deep well drillings. They can cover the users' daily consumption and hourly flow rate variations. Groundwater resources in the Prut – Bârlad hydrographic area are estimated at 251,4 Mm^3, 34,7 Mm^3 of which come from phreatic water sources and 216,7 Mm^3 from deep water sources (ABA Prut-Bârlad, 2016). However, in this case also, the layers with exploitation potential are scarce and water quality is affected by the existence of excess salts. The deep groundwater treatment process becomes more expensive than that of surface water treatment (NP 133-2013).

The only viable surface water sources in this area are Prut, Moldova and Siret rivers. These sources do not comply with the quality requirements according to the current standards in all of the catchment sections or throughout the year. Groundwater and surface water sources in the Prut River basin have a variable degree of chemical components (Romanescu et al., 2013). There are 72 water storage basins in the Prut - Bârlad hydrographic area, with a total capacity of 615 Mm^3 of water intended for various uses. However water resources in this hydrographic space are reduced in volume, unevenly distributed over time and space, and sometimes of poor quality (ABA Prut-Bârlad, 2016).

In the process of groundwater characterization is noted the insufficient data on chemical and biological monitoring. Many water bodies are at risk given the degradation of quality parameters and the absence of continuous monitoring.

In Romania, in many localities, especially in rural areas, the aquifer has been contaminated with noxious substances due to chemical fertilizers and lack of centralized sewerage systems. Therefore, water in many public wells has chemical properties that can put consumers' health at risk. The State of the Environment in Romania - Annual Report mentions that "the majority of wells monitored by the County Public Health Directorates have exceeding levels for almost the entire nutrient group". Among the hydrographic basins in which the highest concentrations of nitrates were recorded are those of the Jijia and Bahlui rivers (Raport Starea Mediului județul Iași, 2015).

The analyses carried out in the area of Iaşi municipality on stored underground water (samples taken from drillings executed for investigation purposes) highlighted a high sulphate concentration. The sulphate concentration exceeds the standardised value, thereby that groundwater is not suitable for human or animal drinking water purpose. In the Bahlui River alluvial plain, in Iaşi area, the water stored in the aquifer horizon of the Holocene age formations fall under the category "*with intense sulphate aggressiveness*" according to the provisions of 3349/1-83 STAS.

2. Water loss management in the regional supply and distribution system of Iaşi County

According to the guidelines on the regionalisation of water supply and sewerage services, the "Regional Water Supply System" is a technological, operational and managerial assembly set up formed by connecting at least two local water supply systems (Alexandrescu, 2013). Such system must serve an area covering at least 100,000 inhabitants and as many as possible urban and rural localities in a county or river basin. In the regional system the water sources, treatment plants, transmission mains, pumping stations and tanks are interconnected, thus resulting in a more efficient water usage than in the case of the local systems (Alexandrescu, 2013). The main purpose of this form of structure consists in the optimisation of the services provided by using common resources and facilities.

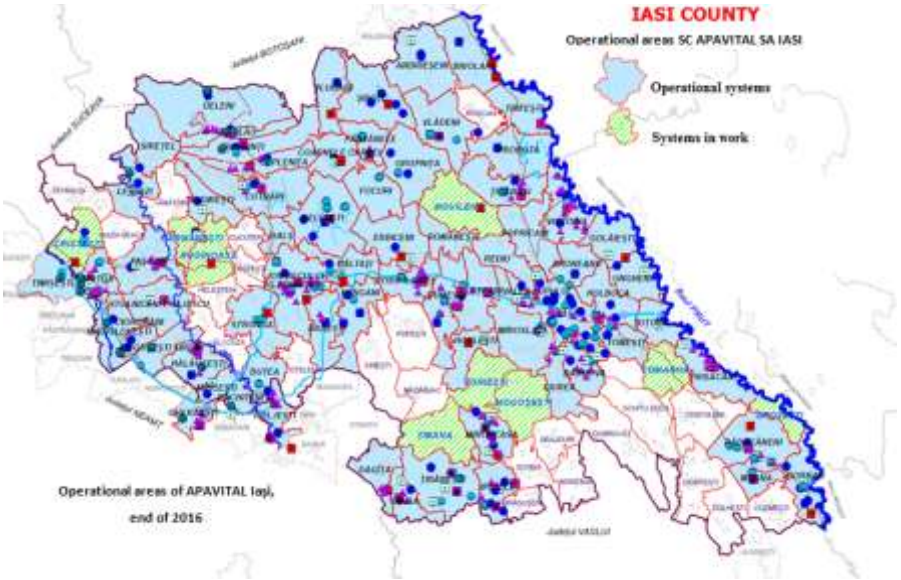

Fig. 3 – Iași County regional water supply system layout (S.C. APAVITAL S.A., 2017a)

A peculiarity in the analysed area is given by the Iaşi County water volumes available from Timişeşti groundwater source (1200 l/s availability) and Prut surface source (500...700 l/s availability). Considering this, part of the transmission mains flows from Timişeşti source was distributed to the local water supply systems of the localities and communes that had the possibility to be supplied.

In Iaşi County, the regional operator ensures the proper functioning of the water supply system through 8 treatment plants, 179 storage tanks, 871 km of transmission mains and 2,293 km of distribution networks (Fig. 3). The population served amounts to 435,570 inhabitants, for which the water supply is covered from 12 sources (S.C. APAVITAL S.A., 2017b).

One of the main problems faced by operators in the exploitation process of water supply systems consists of water losses, which obstruct the optimal use of available water sources (Doruş et al, 2015; Luca et al., 2015). At a national level, the average non revenue water percentage amounts to 48.30% and the losses are placed at 11.65 m^3/year,m (Racoviţeanu et al., 2015).

The International Water Association (IWA) sorts water loss into apparent losses and real (physical) losses (Lambert and Hirner, 2000). Apparent losses are materialised into fraudulently used water volumes or by unauthorised consumers and technical errors on meters and measuring devices (Ministerul Mediului şi Pădurilor, 2010). The real losses, also known as physical losses, consist of lost volumes from the water supply system components, such as: transmission mains and distribution pipes, storage tanks, water treatment plants and pumping stations.

Tab. 1. Performance indicators achieved in 2016 (S.C. APAVITAL S.A., 2017a)

No.	Operational area	Drinking water compliance rate (%)	Consumers metering rate (%)	Unbilled water (m^3)	Water losses (%)
1	Iaşi Metropolitan Area	97,5%	99,88%	8.143.899	29,80%
1.1	Iaşi City	99,6%	99,73%	7.432.947	30,93%
2	Prut-Bârlad Dept.	97,8%	99,99%	176.811	16,67%
3	Bahlui Dept.	98,5%	99,86%	678.279	20,67%
3.1	Hârlău	94,7%	100%	312.990	53,04%
3.2	Podu Iloaiei	99,1%	99,78%	47.027	14,50%
3.3	Târgu Frumos	99,0%	99,97%	60.908	13,10%
4.	Siret Dept.	99,2%	98,42%	1.845.310	46,15%
4.1	Paşcani	99,3%	99,75%	1.555.859	46,54%
5	TOTAL	99,36%	99,74%	10.844.299	30,41%

Table 1 summarizes the main performance indicators achieved in 2016 by the regional operator. It can be seen that the system is divided into four major

departments: Iaşi metropolitan area (ZMI), Prut - Bârlad, Bahlui and Siret departments. Throughout the whole water supply system in Iaşi County, the losses are at 30.41%, thus placing under the national average of 48.30%.

The quality of the drinking water delivered to consumers is carefully monitored. Samples are taken from the distribution network, storage tanks and sources. Among the quality parameters monitored there are free residual chlorine, nitrites, nitrates, sulfates, hardness, etc. Compliance with drinking water quality over the entire operational area amounts to 99.36% (Tab. 1), this being a good indicator of the high performances of the water supply system.

In terms of measuring the water volumes conveyed, water volumes transported from the Timişeşti source are monitored only at Săbăoani intermediate point and water taken from Prut River is metered at the departure towards Iaşi City and at Chiriţa treatment plant entrance. For a more efficient control over the volumes of water conveyed and a closer monitoring of the network, more metering points are required, especially along the Timişeşti route.

Conclusions

1. The execution of urban and rural water supply systems is in continuous development in the eastern part of Romania, which requires a complex analysis on how to utilize viable sources of potable water, extremely limited in the Moldavian Plateau and Plain.

2. The implementation of regional water supply systems is a good solution in the context of a geographic space that has reduced water sources adequate for domestic consumption.

3. The design and execution of the water supply system transport and distribution network should take into account the concept of limiting water losses in order to capitalise on the existing sources.

4. The structure of a local water supply system is determined by the consumers' specificity and the quality of the water delivered. The use of alternative supply sources is an optimal solution in the extremely difficult situation of the Moldavian Plateau.

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