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WATER LOSS MANAGEMENT IN ORDER TO PROTECT AVAILABLE WATER RESOURCES

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Abstract

Water losses are water supply systems performance indicators whose values have been rising in recent years. The paper presents an analysis of the „water loss" phenomenon in Iasi County and City, highlighting the exaggerated values in some territorial areas. The case study has made a correlation between the amount of water lost and the groundwater available in the county. The research conducted has highlighted the drastic decrease of available water volumes, simultaneously with an increase in water consumption. The available water resources in Iasi County are around 106.00 million $m^3$and the water demand is about 31% higher. The paper shows that water losses in transport and distribution networks must be drastically reduced to about 15-25%. At the same time, it is necessary to re-evaluate the water demand and to preserve the existing water sources at optimal quality parameters.

***Key words**: efficiency, physical water loss, water sources contamination, water stress.*

INTRODUCTION

National lost water volumes amount to an average of 48.3% (Racoviteanu et al., 2015). Globally, developed countries reach a level of water loss of up to 11% (Australia), while in developing countries, the losses rise up to 65% (Albania) (Danilenko et al., 2014)

Global warming, intensely felt in recent years, is largely reflected in the available drinking water resources. In this context, water resources management and control bodies, such as AWWA (American Water Works Association), IWA (International Water Association) or ARA (Romanian Water Association) draw attention to the importance of reducing water losses and describe methodologies and work procedures to protect water sources (Lambert and Hirner, 2000).

Protection of water sources is regulated internationally by each country in relation to the magnitude of the phenomena „waste water" and „water stress" recorded there.

USA legislation distinguishes itself in this area by introducing water companies' obligation to perform network audits and to regularly report performance indicators (Sturm et al., 2015). By contrast, in Romania, the water loss issue is at a primary stage, but the recorded values are steadily increasing. In this situation it is necessary to formulate legislative directions regulating the water loss aspect for each water-sewage company.

Recent events in major cities around the world attest the importance of conserving and using water resources efficiently. The lack of adequate water loss management along with the global warming phenomenon, manifested by prolonged droughts, has led to historical water crises.

MATERIALS AND METHODS

In 2008, Barcelona was on the verge of shutting off potable water distribution due to the small water volumes available in storage reservoirs. Moreover, the poor infrastructure in São Paulo fails to capitalize on Brazil's rich water resources, resulting in a water supply system dealing with frequent water shortage.

The world's first big city without water, Cape Town, faces an unprecedented situation. Despite the measures taken in recent years, „day zero", in which the supply of drinking water to consumers will be stopped, was set for June 4th 2018.

Researchers and engineers' warnings that South Africa's water reserves and Cape Town's in particular, will not be able to meet the water demand of a growing population, in the context of climate change in recent decades, have led the authorities to formulate a plan to efficiently use the available water sources. Strategies to reduce water losses and consumption as that implemented in 2007 by the municipality of Cape Town that reduced water demand by 20% to 640 million m^3/year, have proved to be insufficient in terms of scale and duration of application (Department of Water Affairs, 2013).

The „water loss" phenomenon is recorded in all components of water supply systems. The value and intensity of the phenomenon, however, varies depending on the factors that generate it. Thus, the characteristic parameters of a water loss produced by mechanical factors will be different from those due to biochemical factors (Luca and Chirica, 2017).

The water balance established through the IWA methodology groups water losses in the category of apparent and physical losses. While apparent losses quantify fraudulent consumption and measurement errors, physical losses are recorded on the ground and hold the largest share (Lambert and Hirner, 2000).

Water losses are manifested within all water supply systems components. Thus, physical water losses can be grouped according to their location in (GIZ, 2011):

- losses on water distribution and convey pipelines, displayed on pipes, joints and valves, with medium to large flows and medium and small water emission times;
- connections losses, characterized by very low flows and very high water emission times;
- losses from storage tanks, displayed through seepage and through overflow equipment discharge.

Worldwide, drinking water supplies are limited. In this context, water supply systems are put under pressure. Satisfying water demand for consumers is conditioned by issues such as population growth, urbanisation, economic context, global warming, water contamination and the age of existing networks. The UNESCO report shows that most countries in Africa, Central America and northern Asia are currently facing water shortage and others will be affected by this phenomenon within a short time period (UNESCO, 2009).

The material used in the research consists of the geographical area of the Moldavian Plain and Plateau, which covers Botosani, Iasi and Vaslui counties. This geographic area is characterised by a low number of viable, groundwater and surface water sources. Moldova, Siret and Prut rivers and their tributaries are the main water sources in this area (Figure 1).

In terms of quantity, the rivers cover the consumers' water requirement. However, from a qualitative point of view, water treatment processes are required in order to meet the requirements imposed by existing regulations.

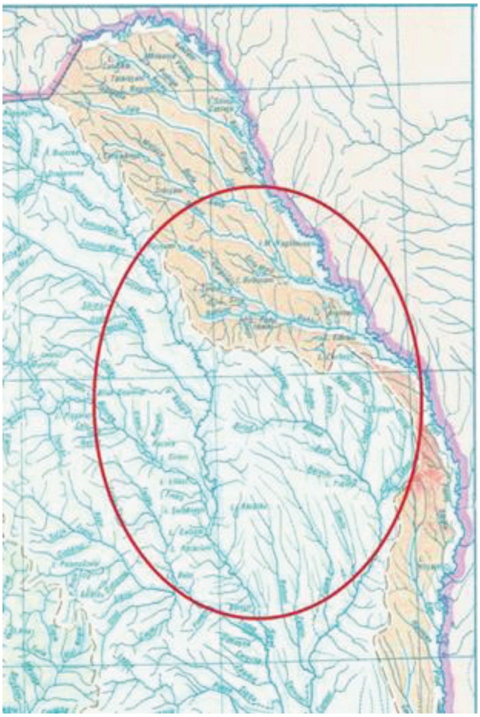

Figure 1. Study area hydrography

The research methodology consisted in documenting and collecting data on the quality of underground and surface water resources available in the study area and the influence of the contamination phenomenon.

The data processing was achieved through comparative analysis, specific statistical computation programs and the use of pipe networks water loss interpretation models.

RESULTS AND DISCUSSIONS

Watersheds are often defined by high levels of chemical content. The degradation of water quality parameters highlights the need to protect available water volumes and make water supply systems more efficient by reducing water losses.

Data from Table 1 shows that out of the total volume of surface water sources, only 26.22% can be used to ensure water demand for consumers. Compared to the available volume of surface water, groundwater resources are up to 75% lower. Given that groundwater quality is superior to that of surface water, requiring minimal treatment processes, measures must be taken to ensure minimal water losses on the lay-out between the catchment and consumption points.

Table 1. Existing and available water volumes in Prut – Barlad catchment area

Water source type	Total volume (mil. m^3/an)	Available volume (mil. m^3/an)	Available volume (%)
Surface	3661	960	26.22
Groundwater	251.4	35.7 phreatic	100
		216.7 depth sources	

The available water resources in Iasi County are around 105.000 million m^3. Figure 2 shows the variation of the water resource in dry and rainy years. The values registered in 2012 are below the annual average, and those in 2013 exceed it by about 12%. The share of surface water sources accounts for 65% - 75% of the total available resources, while groundwater accounts for 25% to 30% of the total water supply.

The variation in water volumes extracted from 2011 to 2014 shows that the demand for water is steadily increasing. Figure 3 shows that the volumes extracted do not cover the water requirement of all consumers. The study data highlights the distinct evolution of consumption categories. While agricultural water consumption increased by about 45% in 2013, maintaining itself at about 57- 58 million m^3, water volumes for the population decreased in the same year by about 8% and continued to decline in 2014 by 25%. The same downward trend is also observed in the extractions for industrial consumption.

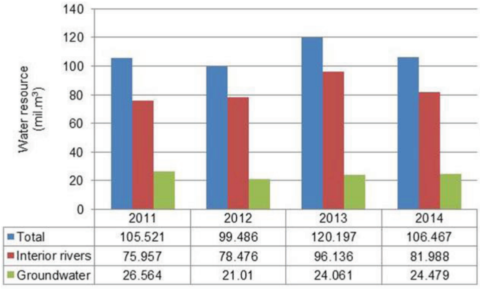

Figure 2. Iasi County available water resources during 2011 - 2014 (ABA Prut-Barlad, 2016)

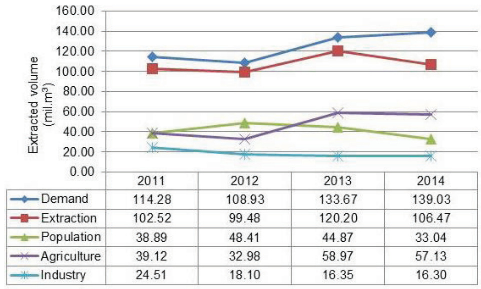

Figure 3. Volumes extracted by activity type (ABA Prut-Barlad, 2016)

The evolution of recorded values is justified for each consumption category. Thus, agricultural extractions have increased due to the development and implementation of irrigation systems, industrial water consumption has declined as a result of the collapse of industry in recent years, and water volumes for the population consumption continue to decline as a result of massive investments in water infrastructure, rehabilitation and replacement works, and intensive water reduction measures.

In Iasi County, at the end of 2016, the regional operator S.C. APAVITAL S.A. managed water supply networks with a length of 3,164 km, out of which 2,293 km of distribution networks and 871 km of main supply pipes (Figure 4).

Iasi County regional water supply system draws raw water from Timisesti and Prut sources. The Timisesti groundwater source is located in Neamt County, about 100 km from Iasi, in the Siret catchment area. The water collected through drains and catchment areas reaches Iasi storage tanks from Timisesti by gravity. Prut surface source is located 15 km from Iasi City. The water conveyed from this point reaches Chirita treatment plant by pumping. Comparing the two water sources, Timisesti source is superior to Prut source. The groundwater quality does not require complex treatment processes, and the flow by gravity reduces energy consumption to minimum values. Considering these aspects, the protection of the Timisesti source and its optimal exploitation is a priority for the water - sewer operator.

The technical expertise works conducted on the Timisesti - Iasi main supply pipes located in the Moldova River undercrossing in Soci area revealed important aspects regarding the structural and hydraulic integrity of the pipes.

The research revealed the physical degradation of the building materials, following the great operational period (over 100 years).

The hydrodynamic phenomena in the riverbed have manifested themselves by uncovering the protective layers covering the pipes and exposing them to environmental factors.

The morphological transformations recorded in the river bed of Moldova River have caused the advanced degradation of the hydro-technical constructions from the site (Luca et al., 2015; Luca et al., 2017).

The results obtained from the main supply pipes' technical expertise showed the magnitude of the water losses recorded from them. Awareness of the real values of physical water losses on this component has led to measures to ensure the limitation of lost water volumes.

The main directions of action consisted of (S.C. APAVITAL S.A., 2017):

- rehabilitation works of the Timisesti - Iasi main supply pipes with a length of 2,690 m, in the Moldova River undercrossing and Siret River overpassing;
- rehabilitation works on 6,351 m of main supply pipes;
- extension works on 5,409 m of main supply pipes.

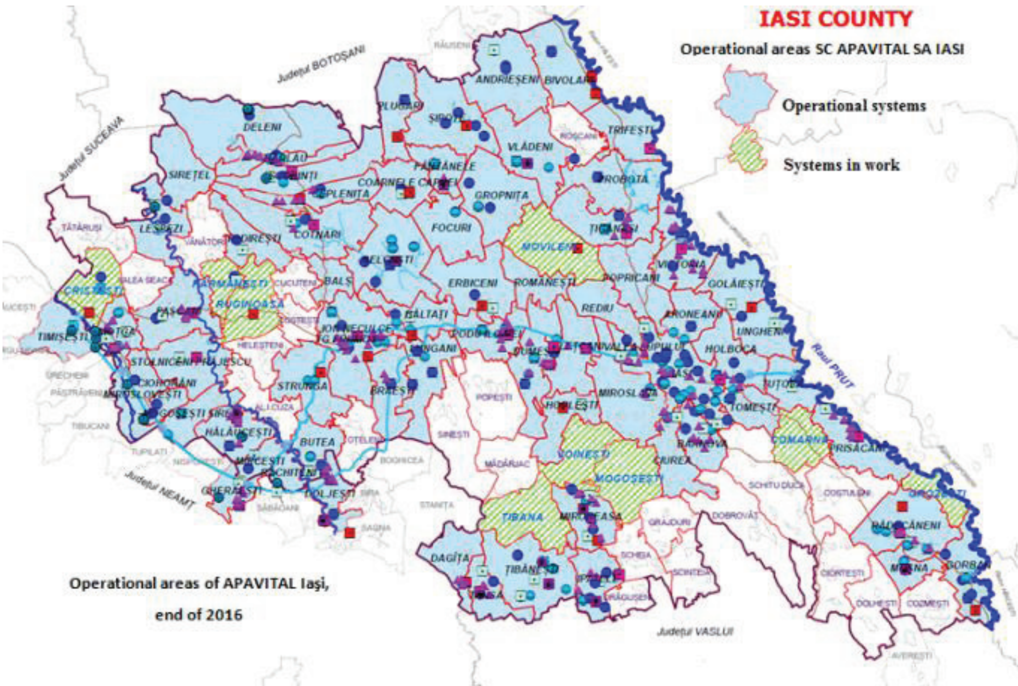

Figure 4. Iasi County S.C. APAVITAL S.A. operational area; colour code: blue - systems operated; green - systems in work; white - systems not operated (S.C. APAVITAL S.A., 2017)

Water loss management at S.C. APAVITAL S.A. consists of a series of measures and working procedures. These are (Doruş et al., 2015):

- GIS and SCADA software developing and hydraulic network modelling implementation;
- constant updating of the system's technological lay-out;
- facilitating real-time data transmission by field personnel (interventions, observations, findings etc.);
- the possibility to access SCADA and GIS databases remotely;
- the delimitation of distribution areas through valves in order to create district metered areas (DMA), enabling consumption monitoring;
- drawing up the water balance and assessing the water volumes conveyed into the system;
- periodic inspection and calibration of field equipment;
- the establishment of working procedures to ensure the monitoring of pumping stations, storage tanks, treatment plants etc., in order to detect water losses from early stages;
- regular networks inspection with water loss detection equipment;
- analysing the field data gathered with the specialised equipment and establishing the areas to be excavated in order to carry out remediation works for the damages detected.

In terms of water losses identified and repaired, 2016 is characterized by a number of 7,451 interventions. Of these, more than 35% were found in the metropolitan area, respectively 2,660 damages and 4,791 interventions, representing 65%, in the rest of the county (S.C. APAVITAL S.A., 2017).

In table 2 it can be seen that the recorded water losses on the entire operating area were 30.41%, below 48.30% - the national average. The values obtained in Iasi City and metropolitan area is close to the average value recorded over the entire surface of the operational area. Values 50% lower than the county average were recorded in Podu Iloaiei and Targu Frumos towns. The phenomenon is explained through the massive investments made in the water supply systems of the two cities, where the storage tanks and the drinking water treatment plants were rehabilitated and the distribution networks with overdue life usage were replaced. Overall, the SOP Environment financing has allowed the extension of 27,335 m of distribution networks and the rehabilitation of 53,326 m in Iasi City and county towns, together with the rehabilitation of 10 storage tanks.

Table 2. Performance indicators achieved during 2016

Operational area	CDWQ (%)	ML (%)	WL (%)
Iasi Metropolitan Area	97.5%	99.88%	29.80%
Iasi City	99.6%	99.73%	30.93%
Podu Iloaiei City	99.1%	99.78%	14.50%
Targu Frumos City	99.0%	99.97%	13.10%
Operational area overall	99.36%	99.74%	30.41%

CDWQ -compliance with drinking water quality; ML – metering level; WL- water loss

In terms of quality parameters of water provided to consumers, the compliance rate amounts to 99.36% in the operational area. Values above 99% are also recorded on the surface of Iasi municipality and Podu Iloaiei and Targu Frumos towns. The degree of compliance with drinking water quality in the metropolitan area of 97.5% suggests the presence of disturbing factors in the distribution system. Given that the area is in an intensive real estate development process, excavations for placing public utilities on the same route as water pipes can accidentally affect the structural integrity of the latter. Damages produced in this way facilitate the entering of substances that change water quality parameters into pipes.

The high metering rate achieved ensures an optimal degree of monitoring of the water supply systems operated.

Measuring the conveyed water volumes enables the detection of early network anomalies, allows control of the extracted water quantities, limits the amount of water losses and ensures the efficient use of drawn water volumes.

The effectiveness of water loss reduction measures results from the percentages obtained from the implementation of rehabilitation and replacement programs for degraded and aged pipes.

The projects initiated through SOP Environment led to the reduction of lost water volumes by over 11%, from 59% to 47.87%. The complementary SOP Environment investment programs, through which storage tanks and main supply pipes have been rehabilitated, have lowered the percentage of water losses to 30% (Dorus et al., 2015). Thus, in about 7 years, the lost water volumes were halved, increasing the efficiency of the regional water supply system.

CONCLUSIONS

1. The water loss complex phenomenon is addressed worldwide in relation with the characteristics of each water supply system.
2. Economically developed countries are implementing ample water loss management models based on rigorous legislation in this area, thus ensuring optimal results.
3. Policies regarding the efficient usage of available water resources should not be confined solely to the current situation, but must rely on complex scenarios related to future situations.
4. The global warming phenomenon, emphasized in recent years, highlights the need to adopt measures and strategies that lead to the efficient use of available water sources through balanced consumption and the lowest possible value for water losses.
5. The quality of drinking water supplied to consumers is affected by the infiltration of outside contaminants through degraded pipe walls.
6. Water loss management at national level reveals the lack of rigorous water loss law regulation to control the activities of water - sewer agencies in this aspect.

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