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Analysis of domestic consumption of drinking water and performance of distribution networks in the region of Medea (Algeria)

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Abstract :
In Algeria, most cities are experiencing at least one water-related problem, either in distribution (networks, storage) or in supply (resources and adduction). Technical, natural, demographic and economic factors combine to create the worst conditions for access to
Drinkingwater.
In the region of Médéa and like several agglomerations in Algeria, the generalization of the distribution of drinking water in the network is real and as the connection of the population, questions arise as to the endowment of new meter subscribers. Today, a large part of subscribers do not have meters and their consumption is assessed on a flat-rate basis. The lack of a reliable metering system is a major constraint in estimating demand and performance parameters. The objective of this research is to provide extrapolated values of water demand in the Medea region (60 km west of Algiers) from data collected on a limited number of subscribers as well as estimates of water demand. technical performance indicators of the tested drinking water distribution systems. The results obtained showed that almost all of the systems tested suffered from a lack of reliability and performance.
We will thus try to formulate the recommendations necessary to achieve a better knowledge of the demand and the reliability of the water distribution systems.
Keywords*: Consumption, Drinking water, Water network, Pertes d'eau, Distribution; Losses.*

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I. INTRODUCTION

The performance of systems needs to be evaluated both more globally and more precisely [10, 5]. The use of performance indicators to measure the functional conditions of the system allows a more pragmatic inventory to be made of the gaps or progress of this distribution system. These indicators, and more particularly those covering the technical field, constitute, in a way, the dashboard devoted to infrastructure management. They are used by operators in formulating the objectives to be achieved by becoming support for decision-making and bases for evaluating the efficiency of their management strategy [8, 6]. They allow regulatory and supervisory authorities to measure the efficiency of the service and to make comparisons between different distributors. They convey precise information for the user who, rather than continuing to feel the quality of service in a personal and global way, then has quantifiable elements to build a real judgment.

II. OBJECTIVES AND METHOD

Within a large space of operating parameters, performance indicators are defined as the functional characteristics related to the behavior of the drinking water system, effectively measurable for the evaluation of these criteria. The International Water Association (IWA) congresses: Leakage 2016 and 2018, Waterloss 2018 and 2020 devoted their work to examining water losses in the supply system as well as its performance indices [7, 1, 9, 3, 2].

However, very little work is devoted to distribution systems where the metering system for the volumes consumed is not generalized and the supply is often discontinuous.

In this context and in the Medea region, an attempt has been made to develop an ambitious scheme to monitor changes in the condition and operation of drinking water distribution systems and to analyze their reliability. The proposed approach could be adapted to the relatively specific conditions in which the drinking water supply systems in Algeria arise and operate.

The indicators sought in this analysis as well as other indicators that we can, however, see in this work are, in terms of performance measurement, complementary, sometimes interdependent and sometimes even

redundant. It is through their combination, their comparison, their confrontation, their contradiction that we can establish a more or less precise view of the system. Moreover, it is the quantifiable global parameters that allow the operator and the user to look at the water distribution system. These indicators thus constitute the grid for perceiving the infrastructure and analyzing the functioning of the network.

The approaches to assessing consumption and the methods of analyzing drinking water supply systems used by designers are increasingly becoming aids for managers. These new uses result in greater requirements in the field of calculation precision. These findings led to the undertaking of fieldwork and reflection on the determination by measurement of characteristics relating to consumption and drinking water distribution networks. To do this, we relied on a particular form of measurement of the volumes produced, consumed and distributed. This form consisted in measuring the domestic consumption of the three agglomerations tested through three panels of subscribers for which the basic conditions are verified.

The objectives of this research were:

- define a process for assessing consumption and analyzing drinking water systems and identifying the constraints of insufficient data. Highlight that knowledge of the physical characteristics of pipelines alone is insufficient to assess the reliability of distribution systems.

- establish a new approach for the technical assessment of drinking water supply systems based on the information that the operator may have.

III. RESULTS AND INTERPRETATIONS

3.1. ASSESSMENT OF CONSUMPTION

The data deduced from the flat-rate invoicing established by the operator involves too many uncertainties and their use may not reflect the reality of the distribution system. These uncertainties have led us to assess the volumes actually consumed and the water losses to be based, initially on the measurements of consumption from a panel of domestic subscribers for whom an assessment of water demand has been made. was carried out through the metering system already in place and then extrapolate the results to the entire population and then, secondly, to measurements of the flows distributed in three towns in the Medea region.

The measurements carried out and the results obtained showed that:

- the average domestic consumption per subscriber varies between 485 and 668 l / d / subscriber and that the daily variation coefficients are quite low: (0.88 and 1.12).
- the average endowments of drinking water consumption for the three populations during the period 2011 - 2017 are as follows (Table 1) :

Table 1 : Individual consumption in Medea region

	Individual consumption (l/d/person)	
	By meter	measured
Medea	60 – 74	77
Berrouaghia	58 – 76	76
Ksar El Boukhari	62 - 72	70

- the variations in daily consumption are generally small and their modulations compared to the average have made it possible to calculate the daily peak factors whose values are between 1.05 and 1.12. (Table 2)

Table 2 : Daily variation coefficients and the peak factors in Medea region

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Medea	0.82	0.89	0.92	0.96	1.11	1.12	1.02
Berrouaghia	0.80	0.80	0.93	1.02	1.03	1.10	1.04
Ksar El Boukhari	0.92	0.93	1.00	0.92	1.05	1.01	0.95

- the hourly variations are determined for the agglomerations tested according to the same hourly division and that the hourly peak factors are between 2.20 and 2.94.

Table 3 : Hourly variations coefficients and the peak factors in Medea region

	12am - 7am	7am - 10am	10am - 1pm	1pm - 8pm	8pm - midnight
Medea	0.30	1.55	2.20	1.20	0.60
Berrouaghia	0.38	1.98	2.74	0.99	0.38
Ksar El Boukhari	0.41	2.35	2.94	0.88	0.31

- the peak coefficients of domestic consumption of drinking water in Medea, Berrouaghia and Ksar El Boukharis are respectively: 2.46, 3.01 and 3.09
- water losses in the networks are around 48 to 59%.
- losses in the cities tested are estimated at 48% in Medea, 59% in Berrouaghia and 56% in Ksar El Boukhari by the comparative study between production and demand for water and 49% in Medea, 40% in Berrouaghia and 39% in Ksar El Boukhari by measuring night-time flows.
- the overconsumption due to the lack of meter could be around 25% but that this value had to be taken with precaution, because resulting from uncertainties on public and industrial consumption. The estimates of overconsumption expressed as a percentage of the volumes produced are: Medea: 17% - Berrouaghia: 22% - Ksar El Boukhari: 15%

3.2 OPERATING AND PERFORMANCE RATIOS OF DISTRIBUTION SYSTEMS

3.2.1. Primary technical performance

The approach adopted led to the calculation of the yield using the extrapolated volume of domestic consumption with metering. The volume counted is the sum of the volumes: domestic with extrapolated metering, commercial, public and industrial (Table 4).

Table 4: Yields of Médéa's drinking water systems during the period 2011-2017

Year	City	Volume (m^3/day)		Primary yield (%)
		Accounting	Distributed	
2011	Medea	16652	35401	47
	Berrouaghia	5187	9899	52
	Ksar El Boukhari	4182	8365	50
2012	Medea	16892	37504	45
	Berrouaghia	5622	10263	55
	Ksar El Boukhari	5300	11105	48
2013	Medea	17105	38548	44
	Berrouaghia	5788	10555	54
	Ksar El Boukhari	65950	11302	53
2014	Medea	17892	40146	45
	Berrouaghia	5963	10699	56
	Ksar El Boukhari	6225	11215	56
2015	Medea	18115	41256	43
	Berrouaghia	6655	10879	61
	Ksar El Boukhari	6589	11358	58
2016	Medea	19215	42556	45
	Berrouaghia	6885	11879	57
	Ksar El Boukhari	7575	11979	63
2017	Medea	20345	43574	46
	Berrouaghia	7200	12159	59
	Ksar El Boukhari	7656	11059	69

These results show that whatever the valuation method used, the technical performance of all the networks is low. Although the town of Ksar El Boukhari presented some abnormally high primary yields. This is explained by the unreliability of the data used, in particular the consumption in this locality.
The yields from the results of extrapolations of domestic consumption volumes with meter are of the order of 50%, which once again demonstrates the lack of performance of these distribution systems.

3.2.2 Linear loss indices

The loss index is a technical indicator that validates several functions that the drinking water supply system must perform.
The calculation of the linear loss indices for the three cities was undertaken based on the loss volumes determined by extrapolation of consumption with meter. This calculation led to the following values:
In table 5 are presented the linear indices of losses (Volumes of losses evaluated by balance: Production - Total consumption, by extrapolation of domestic consumption with metering).

Table 5: Linear loss indices in 2017

City	Volume of losses (m^3/d)	Network length (km)	Linear loss indices LLI (m^3/d/km)
Medea	23500	289	81
Berrouaghia	5800	110	53
Ksar El Boukhari	4800	95	51

Table 6: Guide values of the linear indices of losses [4]

Population size (Person)	linear loss indices LLI (m^3/d/km)
< 5000	5
5000 - 10000	9
10000 - 20000	10
20000 - 50000	12
50000 - 100000	19
> 100000	23

The comparison of the calculated loss indices and the guide values shows that whatever the method used, the values of the linear loss indices of the networks tested greatly exceed the standard values. In Medea, for example, the calculated LLI is of the order of 80 m3 / d / km, while the corresponding guide value is of the order of 20 m3 / d / km.
This large lag confirms, once again, that drinking water systems in this region suffer from poor performance and reliability.

3.2.3 Linear consumption index

These indices calculated for all the drinking water systems in the region make it possible to assess the performance of the operation and the distribution of consumers on the network. The consumption indice, expressed as the ratio between the volumes consumed and the total length of the supply and distribution nework, is calculated by various procedures. The same approach was thus used as when calculating the loss indices. The calculation led to the following results (table 7) :

Linear consumption indices (Total volume consumed: the sum of domestic consumption with counting extrapolated to the entire population, commercial-public consumption and industrial consumption).

Table 7: Linear drinking water consumption indices LCI in 2017

City	Consumption (m^3/d)	Network length (km)	Indice LCI (m^3/d/km)
Medea	20345	289	70
Berrouaghia	7200	110	65
Ksar El Boukhari	7656	95	80

Table 8: Guide values of linear consumption indices LCI [4]

Network	LCI (m^3/d/km)	ILC with connection (m^3/d/km)
Rural	LCI < 10	LCI < 9
Intermédiaire	10 < LCI < 30	9 < LCI < 27
Urbain	LCI > 30	LCI > 27

The results of linear consumption indices compared to guide values lead to acceptable indices. These performance indicators constitute a tool for verifying and monitoring the proper operation of the distribution networks. The values achieved were: 70 m3 / d / km in Medea, 65 in Berrouaghia and 80 in Ksar El Boukhari.

IV. CONCLUSION

This analysis highlighted the importance of knowing the operation of drinking water distribution systems in the absence of a generalized metering system in the Medea region.
The measurements carried out showed :
- that the average domestic consumption per subscriber varies between 485 and 668 l / d / subscriber and that the daily variation coefficients are quite low: (0.88 and 1.12).
- that the water losses in the networks are around 48 to 59%

- that the overconsumption due to the lack of a meter could be around 18% but that this vlue should be taken with caution, because it results from uncertainties about public and industrial consumption.
The results of this study provide a basis for assessing domestic water needs in the urban agglomerations of northern Algeria to be taken into account in future developments.
The study also indicates an abnormally high loss rate in faulty networks and overconsumption, which requires additional investigations to locate the most leaky sections. It therefore seems essential, in the very short term, to generalize the use of meters and to undertake network rehabilitation. The incomparable values of the linear loss indices with the reference quantities put the operator in the obligation to reduce the loss rate and improve the tightness of drinking water systems by:

- Installation of domestic meters,
- Installation of general meters by sector or by zone,
- Proceed in the short term to the detection of leaks on the network,
- Repair of leaks and rehabilitation and renovation of the network,
- Training of maintenance and intervention staff,
- Make users aware of the waste of water.

The effectiveness of these measures can be demonstrated by repeating all or part of the study presented here, immediately after the implementation of the corrective measures.

In the long term, it is imperative to proceed with the development of master plans to plan and prioritize network renewal operations and plan future investments.

It is strongly recommended that the use of water resources be closely linked to user demands. This alternative means, for providers, to precisely study the parameters of water demand, and possibly to involve users in demand control operations when a quantitative scarcity of water resources arises.

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