MINIMUM RESIDENTIAL FLOW ANALYSIS: PRELIMINARY RESULTS

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KEY POINTS:

- *The minimum water demand characterization is of fundamental importance for water distribution systems management. During the residential minimum consumption, maximum pressures are on network pipes and tank levels rise.*
- *The legitimate water consumption analysis during period of low demand and high pressure is of great interest for leakages estimation due to the increase of the water loss with the pressure.*
- *Relationship for minimum residential flow analysis, with 1 hour interval time of discretization, are provided in function of the supplied users for different District Metering Areas.*

1 INTRODUCTION

Minimum water demand characterization is of fundamental importance for Water Distribution Systems (WDSs) management, being the lower residential consumption responsible of higher pressures on the system pipes and of increase of tank levels. This reflects also in an increase of leakages in the system, being the water loss usually greater during the high-pressure period respect to the low-pressure one. The knowledge of the legitimate minimum residential consumption (i.e. the minimum consumption due to the users), thus, is of great interest for the leaks quantification, being usually known from the water companies solely the total flow supplied to the urban area during the different time of the day. Several approaches in scientific literature are estimating leakages by means of the minimum night flow (i.e. Farah & Shahrour, 2017; Farley & Trow, 2003; Garcia et al. 2006) in which the legitimate consumption is usually assumed as a given percentage of the total flow.

This work aims to contribute to the characterization of the legitimate minimum flow consumption by analyzing real water consumption data recorded with a mean of 1 hour interval time in 14 District Metering Areas (DMAs) in Campania region.

2 DEMAND DATA ANALYSIS

The DMAs considered in this study are characterized by a users number ranging about 600 to 23000. Data considered in this study are referring to the winter period, from September to February, and to solely weekly days. Data are recorded continuously with a mean interval time of 1 hour.

The considered DMAs were characterized by an high leakage level due also to the high pressures present in the systems. Because of this, in some districts a Pressure Reduction Valve (PRV) has been introduced and a deep study on the flow-pressure Water Utility data has been done in order to estimate the leaks value in the analyzed period and their daily patterns (Figure 1). Data recorded have been thus cleaned from the physical leakages in order to estimate effectively the water requirements.

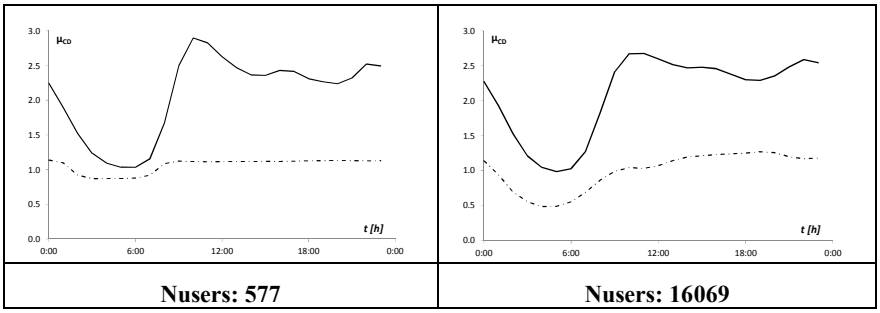

Figure 1. Example of mean measured daily C_D pattern (-) and leakage flow pattern (-·-) for two DMAs with a different number of users

Water demand has been represented dimensionless by means of the demand coefficient C_D (t):

$$C_D(t) = \frac{Q(t)}{\mu_Q} \quad (1)$$

where μ_Q is the mean water demand of the examined period and $Q(t)$ the value of water demand at time t.

The study of the water demand of aggregate users, as in the case herein proposed, requires a trade-off between the need of characterize the water requirement as close as possible to the real consumption by considering a shortest interval time and the necessity of recording and collecting a big amount of data. Several contributions (i.e. Alvisi *et al*. 2014; Gargano *et al*., 2017; Moughton *et al*., 2007; Vertommen *et al*., 2005) are reporting the incidence of the interval time of discretization on the water demand estimation. Tricarico *et al*. (2018) and Gargano *et al*. (2016), showed the importance of considering a short interval time, ranging among 1-10 min, for studying the probability of null water demand (F_0) in reference to a number of users ranging in between 500-1250, being for greater intervals the F_0 almost null.

Despite of this, Water Companies, have the need to manage a big amount of data and then the assumed sampling interval time is usually of the order of one hour. In order of modelling the water demand for practical application, thus, it is necessary to estimate and characterize the water demand at hourly time step. In this case it will be almost impossible, even for the lower number of users of the examined range, to detect an hour of the day in which there is the probability that a user is not requiring water, even more when the number of users increases. Under this consideration, it is of interest to model the hourly minimum consumption at varying the users number.

The mean value of the minimum C_D recorded in each day of the examined period (μ_{CDmin}) has been plotted at varying the users number (N_{users}), i.e. for the different DMAs analyzed, and it is reported in Figure 2.

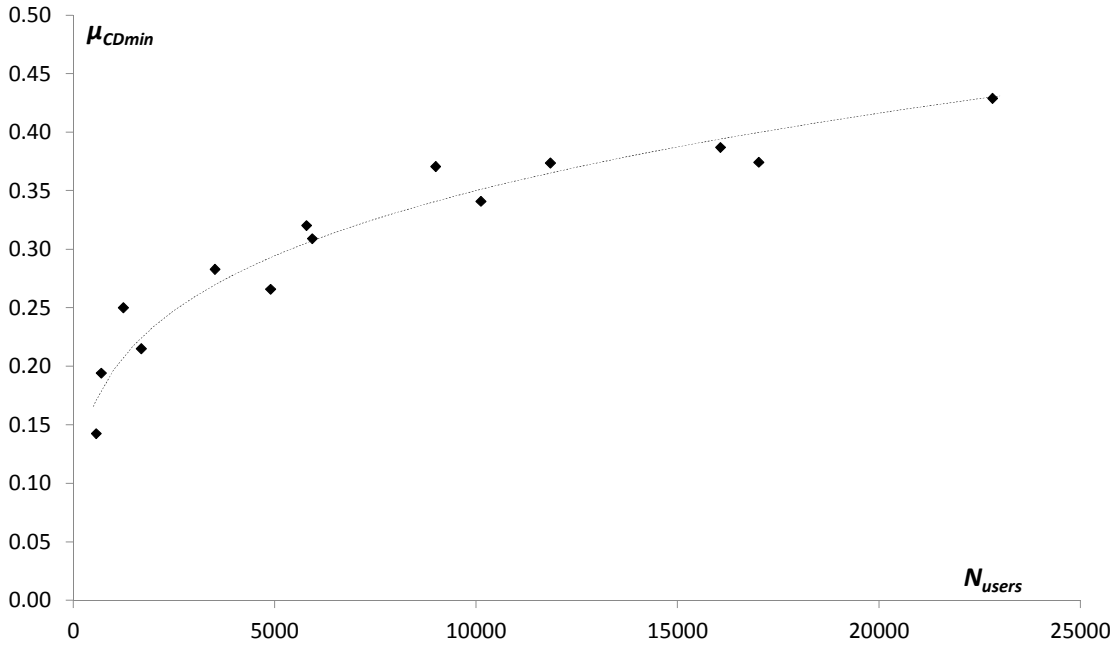

Figure 2. DMA mean C_D minimum (μ_{CDmin}) at varying the number of users

The minimum demand coefficient is increasing with the number of users, as it was expected. For the analyzed DMA, the experimental data show the trend proposed in relationship (2):

$$\mu_{CDmin} = 0{,}035\ N_{users}^{0,25} \tag{2}$$

3 CONCLUSION

In present study the minimum water demand characterization has been investigated on 14 different DMAs of Campania Region with a number of users ranging in between 600-23000. Winter weekly water demand data at hourly time step have been analyzed and the hourly minimum consumption at varying the users number has been modelled. For the number of users investigated, a relationship for the minimum legitimate consumption in function of the users supplied has been proposed. The knowledge of the legitimate minimum residential consumption could be also of great interest for the leaks quantification, being usually known from the water companies solely the total flow supplied to the urban area during the different time of the day.

In future works this topic will be investigated using a probabilistic approach and a larger number of DMAs, in order to overcome the limitations of present deterministic study.

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