Editorial: Efficient water systems management

This special issue of *Journal of Hydroinformatics* presents a collection of papers initially presented at the 2nd EWaS International Conference 'Efficient & Sustainable Water Systems toward Worth Living Development'. The conference was held on June 1–4, 2016, in Platanias/Chania, Crete, Greece (http://www.ewas2.tuc.gr/). The conference was co-organized by the University of Thessaly/Civil Engineering Department and the Technical University of Crete/School of Environmental Engineering (Co-chairmen: V. Kanakoudis – University of Thessaly, G. Karatzas – Technical University of Crete, vice chairman: E. Keramaris – University of Thessaly). The EWaS series of conferences started in 2013, when the 1st EWaS Conference was held in Thessaloniki.

The 2nd EWaS International Conference highlighted the need to improve the efficiency and sustainability of water systems in a changing and fragile environment, especially under the frustrating economic conditions encountered today. Water scarcity and climate change are both considered today as the main causes of water-related problems. Moreover, it is estimated that 20–40% of Europe's available drinking water is being wasted through real (physical) losses occurring along the supply systems. This results in inefficient use of water and energy resources as well as negative economic, technical, social and environmental impacts. Efficient and sustainable management of water distribution systems asks for advanced tools and strategies for their analysis, monitoring, planning and operation. In this context, the integration with ICT innovations in the water sector offers new opportunities for water distribution systems management in urban areas, while exploiting the smart water networks paradigm.

The current special issue of *Journal of Hydroinformatics* was guest-edited by Associate Professor Vasilis Kanakoudis (University of Thessaly, Volos, Greece) and Professor Marco Franchini (University of Ferrara, Italy). The papers included in this special issue are based on the initial presentations at the conference. However, they have been extended (by at least 50%) and revised, having gone through the regular peer-review process of the journal. The topics dealt with by the papers included in the current issue are briefly presented here.

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The paper by Meniconi *et al.* (2017) explores the behavior of a pressure reducing valve (PRV) in steady-state and unsteady-state conditions through laboratory experiments. These are performed at the Water Engineering Laboratory of the University of Perugia (I). Possible and different events in water distribution systems are examined by means of a broad range of laboratory conditions based on both short and long monitoring. The results of these experiments confirm the possibility of managing pressure through the PRVs, particularly when the downstream condition is dominated by the users' water demand pattern. The paper also shows that a proper PRV modelling has to reproduce both its mechanical behavior and the characteristics of the pressure pipe system in which it is installed.

The paper by Alvisi & Franchini (2017) presents an approach for the control of a pumping plant feeding a tank at the inlet of a water distribution system, aiming at minimizing the energy costs by maximizing pumping during off-peak electricity tariff periods. Trigger levels are used as they vary during the day according to a prefixed pattern ensuring that the water level in the tank is at its minimum and maximum values at the end of the peak and off-peak tariff periods, respectively. The multi-objective problem solved minimizes the energy costs and the number of pump switches and provides the pattern of trigger levels. The methodology has been applied to real cases. Comparing these results with methodologies typically used for pump control, energy costs are lower (using fixed trigger levels) and comparable to those obtainable by using pump scheduling.

The paper by Tsakiris & Spiliotis (2017) develops and proposes methodologies for branched water supply and looped water distribution systems. Contrary to probabilistic methods found in the literature using a large amount of data, the proposed methodologies use a small amount of data. For branched water supply systems, the proposed methodology comprises the extension principle of fuzzy sets and new operations of fuzzy algebra. Provided that water velocities are kept at a medium or low level, the methodology provides useful recommendations for the design of branched water supply systems. The results showed that pipe roughness coefficient is a critical parameter in the analysis. Two methodologies

are proposed for looped distribution systems, where fuzzy inputs are from the pipe roughness coefficients and the internal pipe diameters. These methodologies are based on the extension principle and lead to several optimization problems with respect to the branches of the system. The aim of the proposed methodology is to determine the α-cuts and finally produce the shape of the membership function of flows in the branches of the system.

Agathokleous *et al.* (2017) analyze the influence of intermittent water supply operations on the vulnerability of water distribution networks. The paper presents a model simulating water distribution network behavior operating under normal and intermittent operating conditions. The model is based on regression trees and survival and cluster analysis and is applied in a water distribution network operating under intermittent supply conditions, using a dataset of breakage incidents of 8 years as well as external factors. The results showed that during and after intermittent supply, the number of water loss incidents and the deterioration rate of the network is significantly increased, indicating that intermittent water supply operations negatively impact the vulnerability of water distribution networks. Further analysis on water mains and house connections showed that intermittent water supply operations do not greatly affect water mains survival, while they significantly reduce the survival rate of house connections.

The paper by Notaro *et al.* (2017) analyzes a situation of water scarcity, which is typical in the Mediterranean area. In such a situation, rainwater harvesting is considered as an effective water supply solution to face water scarcity and partially satisfy non-potable water needs. The reliability of rainwater harvesting systems is here analyzed for a residential area of Sicily (southern Italy) with reference to information based on daily rainfall time series. The optimal capacity, in terms of water saving efficiency, of a rainwater harvesting system installed to supply water for toilet flushing, garden irrigation and both uses with reference to a single-family house is searched for. To this end, a water balance simulation of the rainwater storage tank is performed to define the tank release rule. Three different catchment surfaces, namely 100, 200 and 300 m^2, are considered for evaluating the optimal capacity. Results show that, in some areas of the region, significant water savings can be obtained even with the installation of collecting tanks of less than 10 m^3, thus ensuring important environmental and economic benefits to the house-holders.

Puleo *et al.* (2017) deal with the complex problem of optimization and management of integrated urban wastewater systems. The paper presents a complete multicriteria analysis of the system performance in several fields of interest (energy, environment, quality of service, operation, economy and financial resources). For the analysis, the authors used a prototype developed during the ALADIN project. A Performance Indicators panel, together with the water and energy balances, provided information about the system or subsystem efficiencies in terms of water leakage, reduction, energy consumption, environmental impact, quality of service, and operational, economic and financial aspects. Composite indicators were also used to obtain the global system performances for different scenarios. To demonstrate the potential of such an approach, it was tested on an actual integrated urban wastewater system in Sicily. The comparison analysis allowed the authors to improve the performance of the system from 60 to 300% for the different performance fields.

The paper by De Paola *et al.* (2017) deals with an interesting problem related to the pump optimal scheduling in order to obtain significant energy saving in water distribution systems. Among the many global algorithms currently considered in the scientific literature, the authors propose a modified Harmony Search Multi-Objective optimization algorithm coupled with the hydraulic solver EPANET 2.0 to assess the feasibility of the achieved solutions. The space of feasible solution is defined through the introduction of hydraulic constraints coupled with penalties that are activated in the case of violation of these constraints. Application to synthetic but realistic cases shows the high performances of the proposed approach for pumping optimization, which can identify near optimal solutions with short computational times.

Both the papers by Chondronasios *et al.* (2017) and by Gonelas *et al.* (2017) cope with the problem of forming district metered areas (DMAs) in water distribution systems, which is a technique used for pressure management and real losses reduction.

Chondronasios *et al.* (2017) deal with this topic, considering water age as a further aspect to be taken into account during the formation of DMAs. The goals to be obtained through the segmentation are in fact: (a) reduction of the operating pressure; and (b) reduction of the water age, thus avoiding growth of disinfection byproducts. Such optimal results are produced by using techniques based on genetic algorithms, which are shown to be a way to provide

a very good solution to optimization problems. The objective functions are here minimized and tested through Matlab's optimization toolbox. The numerical application is performed with reference to a real network by using two different packages represented by EPANET and Bentley's WaterGEMS. For each scenario considered in the numerical example, the morphology of the DMAs is presented, as well as the results of the network's segmentation to the operating pressure and the water age.

Gonelas *et al.* (2017) deal with the topic of district formation, considering water residual chlorine concentration as a further aspect to be taken into account during the formation of DMAs. In fact, this paper utilizes optimization methods to achieve the desired segmentation conditions in terms of: (a) operating pressure reduction; and (b) residual chlorine concentration reduction, thus preventing the growth of disinfection byproducts. This multi-objective optimization problem is solved by implementing two algorithms in C ++ language. The first algorithm calculates the optimal allocation of a given number of closed isolation valves in order to reduce water losses. The second algorithm calculates the optimal formation of DMAs in terms of water quality improvement. The outcome is the optimal set of closed pipes that leads to the optimal formation of DMAs in a given network.

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REFERENCES

Agathokleous, A., Christodoulou, C. & Christodoulou, S. E. 2017 Influence of intermittent water supply operations on the vulnerability of water distribution networks. *Journal of Hydroinformatics* **19** (6), 838–852.

Alvisi, S. & Franchini, M. 2017 A robust approach based on time variable trigger levels for pump control. *Journal of Hydroinformatics* **19** (6), 811–822.

Chondronasios, A., Gonelas, K., Kanakoudis, V., Patelis, M. & Korkana, P. 2017 Optimizing DMAs formation in a water pipe network: the water aging and the operating pressure factors. *Journal of Hydroinformatics* **19** (6), 890–899.

De Paola, F., Fontana, N., Giugni, M., Marini, G. & Pugliese, F. 2017 Optimal solving of the pump scheduling problem by using a harmony-search optimization algorithm. *Journal of Hydroinformatics* **19** (6), 879–889.

Gonelas, K., Chondronasios, A., Kanakoudis, V., Patelis, M. & Korkana, P. 2017 Forming DMAs in a water distribution network considering the operating pressure and the chlorine residual concentration as the design parameters. *Journal of Hydroinformatics* **19** (6), 900–911.

Meniconi, S., Brunone, B., Mazzetti, E., Laucelli, D. B. & Borta, G. 2017 Hydraulic characterization and transient response of pressure reducing valves. 2 laboratory experiments. *Journal of Hydroinformatics* **19** (6), 798–810.

Notaro, V., Liuzzo, L. & Freni, G. 2017 Evaluation of the optimal size of a rainwater harvesting system in Sicily. *Journal of Hydroinformatics* **19** (6), 853–864.

Puleo, V., Notaro, V., Freni, G. & La Loggia, G. 2017 Multicriteria performance analysis of an integrated urban wastewater system for energy management. *Journal of Hydroinformatics* **19** (6), 865–878.

Tsakiris, G. & Spiliotis, M. 2017 Uncertainty in the analysis of urban water supply and distribution systems. *Journal of Hydroinformatics* **19** (6), 823–837.