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Editorial

Water Networks Management: New Perspectives

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Abstract: Real water losses in water distribution systems may well be considered a potential water resource, as the significant water volumes being wasted through these physical losses should be replaced eventually. Advanced tools and strategies can be used for the efficient and sustainable management of water resources toward circular economy. The present Special Issue presents new perspectives for water networks management. The 10 peer-reviewed papers collected in this Special Issue have been grouped in two categories—drinking water supply systems and water resources and irrigation systems. These papers are being briefly presented in this Editorial.

Keywords: drinking water; water quality; simulation; optimization; energy

1. Introduction

Water scarcity and climate change are considered the main causes of water related problems around the globe. These problems get even worse due to the anthropogenic stresses put on water systems struggling to meet rapidly growing water demands. It is estimated that 20–40% of Europe's available water is being wasted from leakages in the supply systems. This results in the 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 requires advanced tools and strategies for the analysis, monitoring, planning, and operation of water distribution networks (WDNs). In such a context, the integration of ICT (Information and Communications Technology) innovations in the water sector offers new opportunities for WDN management in urban areas, while exploiting the smart water networks paradigm. In this context, this Special Issue aims at providing insights on new perspectives on drinking water network management. Specific topics to be included are—drinking water supply; water demand forecast and management; simulation and optimization techniques of water pipe networks; water pricing; water quality; and water and energy.

2. Highlights of the Special Issue

2.1. Drinking Water Supply Systems

The water supply system inventory is developed under the life cycle cost analysis by Lee et al. [1]. Several water supply system items were identified, such as pipelines, pumps, and distribution facilities. Pipelines were grouped based on their purposes and functions. Finally, the water supply system inventory was developed, and divided into five levels. The higher the level, the more detailed the facilities were classified. A tree-shaped structure was used for the classification of the inventory items, helping the waterworks manager to know when and which item need to be replaced, repaired, or rehabilitated. Field data acquired from the Yeong-Wol (YW) pipeline system was used.

The effect of water pressure and climatological variables (temperature and humidity) on water consumption in an administrative building in Czech Republic was examined [2]. For the identification of water consumption and its prediction, regression models were used. The effects of the studied variables on the consumption were separately evaluated; subsequently multidimensional models were discussed with the common inclusion of selected combinations of predictors. The FAVAD (Fixed and Variable Area Discharges) concept was used for the prediction of water consumption variations due to pressure. The proposed regression models were tested to evaluate their suitability; particularly, the models were compared using a cross-validation procedure. The results showed that temperature had a significantly higher effect on consumption in comparison with pressure. This finding can be used in the form of a regressive model such as in the operative management of pressure conditions in water mains. The paper concludes that dependence of water consumption on pressure and climatological factors varies for each type of user and that generalization of the results could jeopardize the studies. Therefore, separate real-life studies are necessary.

The optimal re-chlorination facility locations and doses are determined for real water supply systems, which require maintenance in order to ensure proper residual chlorine concentrations at the pipeline under the present and future conditions [3]. A meta-heuristic optimization method (harmony search algorithm, HAS) was used. The method was applied to two water supply systems in South Korea and was verified through case studies using different numbers of re-chlorination points. The study resulted in the proposed model which can be used as an efficient water quality analysis and decision-making tool. Spatial distribution of the re-chlorination points is necessary to minimize the required injection quantity. The developed model can be useful for the design of new water distribution networks and the development of their operation and management guidelines.

Contamination source identification (CSI) was examined by Adedoja et al [4]. It is a difficult task to derive the source of the contamination from the collected information, and therefore it must be tackled in order to evaluate the spread of the contamination and for immediate remedial strategies. A comprehensive review of the existing techniques used for the location of the contamination source in water distribution networks with emphasis on their importance and technical challenges was presented. The analysis showed that the existing techniques were able to locate contamination sources to a certain extent. Limitations were reported in the literature as well as associated technical challenges such as uncertainties of sensors, stochastic water demands, excessive computational time, particularly for a large network among others. The paper indicates that contamination source identification remains a topical issue in a water distribution network due to the complex nature of the system and its significance in the economy and social instability. More research efforts should be devoted to the applicability of these techniques to ascertain their efficiency in a real-life scenario in order to minimize the economic and public health consequences on the use of contaminated water.

The study of Kou et al. [5] used a water evaluation and planning model (WEAP) for Xiamen City to analyze trends in water use and demand between 2015 and 2050. The city was not analyzed as a whole but the water resources of each of the city's five districts were separately analyzed instead. The water-supply–demand relationship of these subsystems with several factors was analyzed. The water-saving potential, water shortages, and water supply alternatives were analyzed under different simulated scenarios. The results show that future water consumption will greatly increase in Xiamen City, and that there will be a water shortage after 2030 without new water supplies. Different ways to achieve water savings were analyzed, such as industry restructuring and advanced water-saving technology. Adoption of both strategies can result in a saving potential of 16.44% by 2050.

A framework for improving the robustness of water distribution systems using the optimal valve installation approach with regard to system reinforcement was developed by Choi et al [6]. To improve the robustness in valve design, three approaches were applied, namely segment finding algorithm, critical segment selection technique, and valve location determination. To select the critical segment, a multicriteria decision technique was applied by considering the hydraulic, social, and economic effect. Finally, the optimal valve locations and the number of additional valves were determined by pipe failure analysis through the trade-off relationship with the number of additional valves and the maximum damage under pipe failure situations. To verify the results, two WDSs were applied.

Although the study's results are verified, there are several limitations and future work is suggested to develop more realistic valve installation techniques considering the pressure driven analysis.

Kossieris and Makropoulos [7] studied the statistical and distributional properties of residential water demand at a 15-minute and an hourly scale, which were the temporal scales of interest for the majority of urban water modeling applications. To achieve this large residential water demand, records of different characteristics were investigated. In particular, 11 long records from single households in Greece were analyzed. The analysis indicated that the studied characteristics of the marginal distribution of water demand varied among households and among different time intervals. The study showed that both month-to-month and hour-to-hour analysis revealed that the mean value and the probability of no-demand exhibited a higher variability while the changes in the shape characteristics of the marginal distributions of the nonzero values were significantly less. The investigation of performance of 10 probabilistic models revealed that Gamma and Weibull distributions can be used to adequately describe the nonzero water demand records of different characteristics at both time scales.

Arregui et al. [8] presented a methodology to assess the economic level of apparent losses (ELAL) in a water distribution system of a water utility. The economic point is the point where the marginal benefit of increasing the frequency of apparent losses reduction activities breaks even with the marginal cost of their implementation. Two categories of intervention measures were identified—water meter replacement and customers' connection inspections. It had been found that the ELAL was influenced by intervention costs, the degradation rate of the accuracy of water meters, and water tariffs. Performance indicators were set to benchmark apparent losses' performance relative to the minimum achievable and optimum levels of losses. Two case studies were used to apply the proposed methodology.

2.2. Water Resources and Irrigation Systems

Three multifunctional weirs in the Geum River Basin in Korea were investigated to analyze the environmental effects of multifunctional weir operation on downstream flow [9]. The paper examined how the multifunctional weirs impacted on water quality under drought conditions and water flow. The Palmer drought severity index (PDSI) was used to determine seasonal vulnerability to drought, based on precipitation and temperature data observed from 1983 to 2008. The downstream flow regime and the effect on water quality improvement of a coordinated dam–multifunctional weir operation controlled by (a) a rainfall–runoff model; (b) a reservoir optimization model; and (c) a water quality model, were examined. The results showed that although the water quality was improved by the coordinated operation of the dams and weirs, when the discharged water quality was poor, the downstream water quality was not improved. Improvement of the water quality of main stream in the Geum River is important, but water quality from tributaries should also be improved. By applying the estimated runoff data to the reservoir optimization model, these scenarios will be utilized as basic parameters for assessing the optimal operation of the river.

The next research was focused on the proposal and development of a novel optimization strategy for increasing the energy efficiency in pressurized irrigation networks by energy recovering [10]. The study showed how the installation of micro hydropower machines improved the water-energy nexus management in pressurized systems. The optimization was based on optimizing the Pump As Turbine (PAT) operation, analyzing the best efficiency line of the machine, and changing the rotational speed as a function of the flow at each time. The machines were allocated in the best place by maximizing the considered objective function and selecting suitable machines. The strategy was applied to a real network when the farmers' habits were known. The results in the case study showed that a maximum recovered energy of 41.66% of the available energy was achieved. Thus, the recovered energy values were improved by 141 to 184% when compared to energy recovery considering a constant rotational speed. This study shows that the successful selection of the best hydraulic machine by the proposed optimization strategy is possible.

3. Conclusions

This Special Issue provides insights in the integration of ICT innovations in the water sector, offering new opportunities for water management. In particular, two papers on water resources and irrigation systems and eight papers on drinking water supply systems are included in this Special Issue. ICT tools such as optimization tools, water evaluation and planning models, statistical techniques, performance indices, life cycle cost analysis, etc. are some of the tools used in the papers included in this Special Issue. Optimization tools can be used to achieve energy efficiency in pressurized irrigation networks [10] and also to indicate the optimal re-chlorination locations and doses in water supply systems [3]. Optimization tools can be also used to identify the optimal valve installation for improving the robustness of water distribution systems [6]. Statistical tools and techniques were used to examine residential drinking water demand [7], while water evaluation and planning models were used to analyze trends in water use and demand [5]. Performance indices were developed to assess the economic level of apparent losses in WDNs [8]. Several models such as rainfall-runoff model, reservoir optimization model, and water quality model can be used to assess water and environmental effects in multifunctional weirs operations [9]. Finally, Life Cycle Cost Analysis can be a helpful tool for the replacement and repair of water supply systems infrastructure [1].

The use of ICT tools in the papers included in this Special Issue shows that these tools can be used in the whole water supply chain, from water resources to the water distribution networks and irrigation networks. Such ICT tools can provide new perspectives in the context of "smart water" paradigm, covering various topics in water management.

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