Intermittent Operation of Water Distribution Networks Considering Equanimity and Justice Principles

Mohammad Solgi[1]; Omid Bozorg Haddad[2]; Samaneh Seifollahi-Aghmiuni[3]; and Hugo A. Loáiciga[4]

Abstract: Water shortages cause intermittent operation of distribution networks in many developing countries. Under limited economic resources and frequent water shortages, the expansion of water supply for municipal use is slow and sometimes infeasible, hence supply management becomes a viable solution for operating water supply networks. One form of demand management is intermittent supply, wherein some parts of the water supply network are cut off from service during certain times and the entire network is in service at other times. Because intermittent water supply causes consumer dissatisfaction and complicates the operation of water supply networks, it is crucial to consider the principles of equanimity and justice in its implementation. This paper develops an optimization model to find the optimal scheduling of intermittent supply that reaches the maximum number of network nodes with desired pressure under various conditions of water shortage and considering the principles of equanimity and justice in a water distribution network. The network operation optimization problem is solved using the honey bee mating optimization (HBMO) algorithm linked to in a hydraulic simulator. The efficiency of the developed scheduling method is demonstrated by implementing it to two distribution networks considering different scenarios of water shortage. **DOI: 10.1061/(ASCE)PS.1949-1204.0000198.**

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Introduction

The main challenge for municipal water supply systems is that of meeting existing demands. This challenge is aggravated by hydrological droughts, natural hazards (such as earthquakes), human events (such as war), and pollution accidents (Hou et al. 2013). If the expansion or repair of a compromised water supply system is infeasible, water rationing may become inevitable. One of the rationing methods is intermittent water supply. A continuous water supply system features a distribution network that is pressurized 24 h every day and meets consumer demands permanently. On the other hand, when the total amount of available water is less than users' demands, operators must reduce the water supply to some parts of the network regularly during parts of the day. This is the mode of operation of an intermittent water supply system, which this paper seeks to optimize by introducing novel methodology.

Several optimization techniques have been recently reported and applied in many fields of water resources systems such as reservoir operation (Bozorg Haddad et al. 2011a; Fallah-Mehdipour et al. 2011b, 2012a, 2013a), hydrology (Orouji et al. 2013), project management (Bozorg Haddad et al. 2010b; Fallah-Mehdipour et al. 2012b), cultivation rules (Bozorg Haddad et al. 2009; Noory et al. 2012; Fallah-Mehdipour et al. 2013b), pumping scheduling (Bozorg Haddad et al. 2011b), hydraulic structures (Bozorg Haddad et al. 2010a), water distribution networks (WDNs) (Bozorg Haddad et al. 2008; Fallah-Mehdipour et al. 2011a; Seifollahi-Aghmiuni et al. 2011, 2013), operation of aquifer systems (Bozorg Haddad and Mariæo 2011), site selection of infrastructures (Karimi-Hosseini et al. 2011), and algorithmic developments (Shokri et al. 2013). Only a few of these works dealt with the intermittent operation of water distribution networks considering the equanimity and justice principles.

Batish (2003) presented a method for designing the intermittent water supply networks in northern India. Sashikumar et al. (2003) analyzed intermittent water supply using field experiments. Totsuka et al. (2004) described problems of intermittent supply and classified them. Jeong and Abraham (2006) developed a model to identify intermittent supply optimal programs using the genetic algorithm (GA) and *EPANET* (Rossman 2000). Andey and Kelkar (2009) studied effects of continuous and intermittent supply of municipal water consumers in four Indian cities. Ameyaw et al. (2013) developed a multiobjective optimization model to improve equanimity and minimize costs in intermittent water distribution networks.

In the cited studies the intermittent supply was zonal. The zoning method has several important quantitative and qualitative problems such as rise of pollution through seepage due to low pressure and the creation of negative pressures, the uneven distribution of water pressure in the pipe network, drastic pressure changes, network failure to supply fire demands in zones of water cutoff, variations of the Hazen-Williams coefficient due to mixing of air and water in the network's pipes, inappropriate performance of water measuring equipment, and lack of existing simulation software for modeling of these networks (Batish 2003; Sashikumar et al. 2003; Totsuka et al. 2004; Soltanjalili et al. 2013).

[1]M.Sc. Student, Dept. of Irrigation and Reclamation Engineering, Faculty of Agricultural Engineering and Technology, College of Agriculture and Natural Resources, Univ. of Tehran, Karaj, 3158777871 Tehran, Iran. E-mail: Solgi_Mohammad@ut.ac.ir

[2]Associate Professor, Dept. of Irrigation and Reclamation Engineering, Faculty of Agricultural Engineering and Technology, College of Agriculture and Natural Resources, Univ. of Tehran, Karaj, 3158777871 Tehran, Iran (corresponding author). E-mail: OBHaddad@ut.ac.ir

[3]Ph.D. Candidate, Dept. of Irrigation and Reclamation Engineering, Faculty of Agricultural Engineering and Technology, College of Agriculture and Natural Resources, Univ. of Tehran, Karaj, 3158777871 Tehran, Iran. E-mail: Seifollahi@ut.ac.ir

[4]Professor, Dept. of Geography, Univ. of California, Santa Barbara, CA 93106-4060. E-mail: Hugo.Loaiciga@ucsb.edu

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