Assimilative Capacity and Flow Dilution for Water Quality Protection in Rivers

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Abstract: Industrial and urban development is a common cause of increased pollution. Pollutants are in many instances discharged untreated to rivers due to lack of adequate treatment facilities and high treatment cost. In many cases, the detriment of pollution discharge to a river exceeds its self-purification capacity, and it may cause irreparable damages to the riverine environment. In this regard, water flow in a river is an effective characteristic behind its assimilative capacity that can be used to decrease pollution damages. Determining a river's assimilation capacity and the flow necessary for dilution of pollutants are important tasks. In this paper, pollution damage to a riverine environment is a function of the pollutant's concentration and the contact duration with river water. Pollutant transport in a river is simulated based on mathematical equations of pollutant advection-dispersion. The optimum values of a river's assimilation capacity and the dilution flow required in a river to mitigate pollution are determined using a nonlinear programming (NLP) method and the nondominated sorting genetic algorithms II (NSGA-II). The optimum assimilation capacity of a river was calculated in an application example for different reservoir releases. The results show that the magnitude of river flow can improve the total riverine assimilation capacity by up to 80%. Optimal Pareto boundaries were obtained for pollutant concentration and the duration of pollutant contact by means of river flow adjustment. **DOI: 10.1061/(ASCE)HZ.2153-5515.0000234.**

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Introduction

Rivers provide an important water supply for human activities. Population growth, economic development, and water demand increase, encouraging humans to construct dams on rivers and build human settlements nearby. Human settlements near rivers cause pollution in rivers through multiple sources, such as industrial and municipal wastes, impairing river water quality. Using the rivers' self-purification capacity for pollution treatment can be an effective and low-cost method. There are numerous examples of pollutant discharges to rivers that have caused irreparable damages to plant and animal species, and posed risks to humans. Therefore, assessing a river's capacity to assimilate pollutants through adjustment of its flow is an important water-quality management tool.

Recently, many techniques have been developed and applied in all aspects of water resources systems such as reservoir operation (Afshar et al. 2010; Bozorg Haddad et al. 2008a, b, 2009, 2011a; Fallah-Mehdipour et al. 2011a, 2012a), cultivation rules (Moradi-Jalal et al. 2007; Noory et al. 2012), pumping scheduling (Bozorg Haddad and Mariño 2007; Bozorg Haddad et al. 2011b; Rasoulzadeh-Gharibdousti et al. 2011), water distribution networks (Bozorg Haddad et al. 2008c; Soltanjalili et al. 2010; Fallah-Mehdipour et al. 2011b; Seifollahi-Aghmiuni et al. 2011; Ghajarnia et al. 2011; Sabbaghpour et al. 2012), operation of aquifer systems (Bozorg Haddad and Mariño 2011), and site selection of infrastructures (Karimi-Hosseini et al. 2011). Only a few of these works dealt with the assimilative capacity and flow dilution for water-quality protection of surface water resources systems.

Several studies have dealt with pollution control methods in rivers. Chang et al. (1997) used fuzzy and gray programming to minimize existing uncertainties in the riverine pollution control systems. Jobson (1997) proposed an approach for the quick estimation of the pollution travel time along the river.

Seo and Cheong (1998) proposed a method estimating the dispersion coefficient in rivers using a nonlinear regression approach, and hydraulic and geometric data. Wen and Lee (1998) presented a neural network-based multiobjective optimization of water quality management within river basins and applied it for the Tou-Chen River Basin in Taiwan.

Karamouz et al. (2003) developed an optimization model for river water quality management using a sequential dynamic genetic algorithm (SDGA). Their proposed model was applied to manage water quality of the Karoon River in Iran. Meuleman et al. (2004) assessed pollution reduction along a river before achieving the De Meije wetland in The Netherlands. They evaluated high pollution concentrations of chloride, sulfate, calcium, and bicarbonate, and showed that a ditch system with aquatic vegetation could successfully remove nutrients from polluted river water.

Kerachian et al. (2005) presented a stochastic genetic algorithm (GA)-based optimization model that exploits the stochastic dynamic programming principle for pollution load allocation within a river system. To solve existing disagreements among river-using

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