Genetic Algorithms for Water Quality Management in an Urban Watershed

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ABSTRACT

This paper describes the use of genetic algorithms for water quality management in an urban watershed. This is achieved by linking a genetic algorithm-based optimization model in a disaggregated manner with a water quality simulation model.

Categories and Subject Descriptors

J.2 [**Computer Applications**]: Physical Sciences and Engineering – *earth and atmospheric sciences, engineering.*

General Terms

Algorithms, Management.

Keywords

Genetic algorithms, water quality modeling, integrated watershed management, optimization, simulation models.

1. INTRODUCTION

Increased urbanization in watersheds as a result of growth in U.S urban corridors is causing an increase in water pollution problems and a deterioration of the water quality of water bodies. Integrated watershed management approach is increasingly being used to solve such problems. Two types of mathematical models can be used to assist in the integrated watershed management framework including 1) effective and efficient water quality simulation models to characterize the watershed response for a given process or water quality constituent, and 2) effective and efficient optimization models that can work on-line or off-line with the simulation models to identify optimal strategies for water quality management. In most cases, there exists multiple feasible management strategies and determining the optimal strategy that satisfies the water quality compliance targets as well as economic objectives can be a challenging task. In such cases, the determination of an optimal management strategy or strategies requires an efficient optimization algorithm that can work either on-line or off-line with a water quality simulation model of the This paper describes the use of genetic algorithms in developing an effective optimal control strategy for water quality management in an urban watershed impaired by point and non-point sources of

pollution. This is achieved by linking a genetic algorithm-based optimization model to a macro-level mathematical simulation model for the watershed. A macro-level biochemical oxygen demand (BOD) load simulation model is first developed for the three tributary sub-basins (South Fork, Middle Fork, Muddy Fork) of the Beargrass Creek watershed in Louisville, Kentucky. A nonlinear constrained optimization framework is thus formulated to allocate biochemical oxygen demand (BOD) loads in a way that satisfies economic as well as water quality considerations in the watershed. The optimal integrated watershed management model is used to evaluate various water quality control strategies leading to the optimal water quality control strategy for the watershed. A sensitivity analysis is performed to evaluate the performance of the management model with regard to the dissolved oxygen standard enforced for the study area. The proposed optimization framework can serve as a useful management tool for watershed decision makers to formulate and evaluate different management strategies leading to effective capital improvement projects for the watershed. The cost of capital improvement projects in large urban watersheds can exceed 1.0 billion dollars and the use of such an optimization-simulation approach can result in significant savings by providing optimal solutions.

2. RESULTS OF THE OPTIMAL MODEL

The objective of the water quality-based optimal management model was to minimize costs associated with a management strategy that satisfies prescribed water quality constraints. In the Beargrass Creek watershed, the water quality problem in hand is the dissolved oxygen (DO) impairment. For demonstration, the results of the optimal management model corresponding to three DO standards (4, 5, and 6 mg/L) are summarized in Table 1. Table 2 gives the optimal cost of water quality management strategies that would result in the corresponding number of dissolved oxygen violations in the watershed (ranging from 0 to 3 violations). Each management strategy given in Table 1 is a combination of 16 decision variables defined for the study area that represent different management strategies for the three contributing sub-watersheds of Beargrass Creel watershed.

Table 1. Results of Optimal Management Model

# of Violations	Optimal Cost for 4 mg/L (M$)	Optimal Cost for 5 mg/L (M$)	Optimal Cost for 6 mg/L (M$)
0	203	304	554
1	203	257	319
2	201	257	319
3	201	232	319

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