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We thank the author of the discussion paper on assimilative capacity and flow dilution. The main issue of the discussion is about implementing multiple runs when using evolutionary or meta-heuristic algorithms. This technique has been used by these authors in several published papers that have applied evolutionary and meta-heuristic algorithms in solving various water resources problems (Bozorg Haddad et al. 2008, 2010a, b, 2011a, b; Karimi-Hosseini et al. 2011; Bozorg Haddad and Mariño 2011; Seifollahi-Aghmiuni et al. 2011, 2013; Fallah-Mehdipour et al. 2011a, b, 2012a, b, 2013a, b; Noory et al. 2012; Orouji et al. 2013; Shokri et al. 2013). Our response to the discussion is as follows:

The widespread availability of high-speed computers has facilitated the development and implementation of evolutionary and meta-heuristic optimization (EMHO) methods. EMHO methods rely on random trial-and-error search for the solution of complex optimization problems, and they have some limitations. At the same time, EMHO methods have overcome several disadvantages of traditional optimization methods. The latter methods are often based on mathematical constructs that may render them impractical to solve complex water resources problems. In this case, EMHO methods become practical and are usually successful alternatives for solving complex optimization problems in water resources and other fields.

EMHO methods are based on concepts and laws of evolution, survival, and organization of life in the natural world. Successful organisms evolve over time and adapt to changing conditions, and those that do not evolve and adapt perish and become extinct. The nondominated sorting genetic algorithm II (NSGA-II) is a random search method based on genetic algorithm (GA) concepts, whose final result in solving an optimization problem is a near-optimal solution. Each iteration of the algorithm involves performing selection, cross over, and mutation processes. Change in the objective function of an optimization problem is evaluated in each iteration of the NSGA-II search by means of a fitness function, and this evaluation is used to continue the search toward a global optimum through multiple iterations. The NSGA-II optimization algorithm enters the next iteration, and uses selection, cross over, and mutation processes successively until a stopping search criteria is achieved, at which point a near global optimal solution has been found, provided that the random search is exhaustive over the solution space.

The optimization algorithm's performance can be assessed considering the number of fitness function evaluations (FE) made in the optimization process. The value of FE equals the number of iterations times the number of solutions evaluated in each iteration. The rate of convergence of the optimization algorithm can be traced by plotting the value of the best solution in each iteration against the value of the FE during the optimization process. The value of the objective function improves with an increasing number of iterations until convergence to a near-optimal solution is achieved.

The NSGA-II can be used with single or multiobjective problems. Multiple runs of the algorithm for multiobjective problems produce a solution, instead of one set of nondominant near-optimal solutions that form a Pareto possibility frontier (PPF). The result of each run is a Pareto solution on the PPF. The NSGA-II uses different random processes in its evolutionary search for optima. Two runs of this algorithm follow different paths to obtain optimal solutions of a given problem. In fact, single solutions to an optimization problem using one run of the NSGA-II are unreliable: It is necessary to consider multiple runs to achieve a suitable solution (a PPF). The evolutionary search of the NSGA-II and the ensuing path to obtaining the final optimization results reveals various aspects of its capabilities. The performance of an evolutionary algorithm is desirable when it can obtain a suitable solution with high speed and high reliability.

The NSGA-II was run multiple times in the discussion's paper because of its random-search nature, and the calculated results from the best run were presented in the paper. The discussion paper has two objective functions: (1) minimizing the mean unallowable concentration; and (2) minimizing the duration of the contact time of the mean unallowable concentration. Therefore, the problem has a convex Pareto possibility frontier as its optimal solution. The Pareto possibility frontier with larger convexity and nearest to the origin is the preferred one. The best run of the algorithm among multiple runs was selected in the discussion's paper according to the convexity of the obtained Pareto frontier and its proximity to the origin. The author of the discussion mentions that different calculated values of the mean unallowable concentration and the duration of contact may lead to different environmental conditions that may cause unsuitable water quality conditions. The paper's approach of selecting a Pareto frontier from several runs based on its distance from the origin identifies solutions that are optimal in the solution space considering the mean unallowable concentration and the duration of contact.

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