Research Article

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Integration of numerical models to simulate 2D hydrodynamic/water quality model of contaminant concentration in Shatt Al-Arab River with WRDB calibration tools

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Abstract: The hydrodynamic model is essential for building a water quality model for rivers, lakes, estuaries, and other water systems. Most model software, such as HEC-RAS, can perform a complex hydrodynamic surface water body and limitations to represent water quality for the corresponding area. In contrast, other models, like WASP, can simulate a wide range of contaminants in a multidimensional geometry of rivers, estuaries, lakes, and reservoirs. Still, it requires flow information from separate hydrodynamic models. This article aims to develop a comprehensive water quality model of the Shatt Al Arab River south of Iraq by linking HEC-RAS with WASP. A variety of software techniques has sequentially been used. This software includes GIS for DEM modification, HEC-RAS for the hydrodynamic model, Python code with PyCharm to run the external coupler, WASP software for advective and dispersive contaminant transport, and finally, WRDB software for full calibration process and results display. The results showed successful transportation of flow information had been achieved. Moreover, the article described an effective calibration process by plotting comparison graphs and statistical summaries to make the appropriate decision. Another goal of this work is to collect the equations and associated reaction rates of source/sink kinetic for eutrophication's state variables.

Keywords: hydrodynamic modeling, water quality modeling, HEC-RAS, WASP, WRDB, external coupling, Shatt Al-Arab modeling

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1 Introduction

The modeling of surface water is complex and developing [1]. Professionals disagree with the "optimal" way of modeling rivers, lakes, estuaries, and coastal waters [2]. Even after more than a century, the basic approach to surface water modeling has not altered because all models are built on three fundamental principles: mass, momentum, and energy conservation [3,4]. The most general classification of modules used in surface waters modeling is analytical or numerical models [1]: An analytical model has an exact mathematical solution to the governing equations that describe processes in a body of water. An analytical solution example for estimating the concentrations of dissolved oxygen (DO) along rivers is the Streeter–Phelps (1925) equation [5]. A numerical model is a discretized representation of a mathematical equation system that explains processes in a water body. The computing domain is discretized into cells, and the partial differential governing equations are approximated by a set of algebraic equations solved by the iteration or the matrix inversion method. In recent years, computer simulation techniques have gained popularity in scientific studies, particularly regarding studies of the aquatic environment. Many computer models have been created and are effectively used in many countries today [1]. Review research studies from the Web of Science focused on the fate and transport of water quality modules in waterbodies, such as EFDC, CE-QUAL-W2, WASP, Delft3D, AQUATOX, and MIKE, are listed in Table 1. The highest models utilized in uses and citations were EFDC and CE-QUAL-W2. The United States and China were the most frequent users of such models [6]. Fu et al. [7] searched the Scopus database for 50,530 publications on water quality models published between 1935 and 2018. 76% of the publications (38,542) were published between 2003 and 2018. Most of these articles were published by authors with locations in the United States, followed by China, the United Kingdom, Germany, Canada, and Australia.