Two-dimensional finite volume modeling of Damietta Port, Egypt

A G ABUL-AZM [1], A H DAOUD [2] & K A RAKHA [3]

[1] Department of Irrigation and Hydraulics, Faculty of Eng., Cairo Univ.,
E-mail: ecma@access.com.eg
[2] Suez Canal Research Center, Ismailia, Egypt
[3] Department of Irrigation and Hydraulics, Faculty of Eng., Cairo Univ.

1. Introduction

The determination of the flushing characteristics of harbor basins with small tidal range and the associated water quality implications are particularly important when conducting environmental impact assessments of a harbor basin. When constructing new basins or quaywalls in a port, harbor or marina, one of the most important considerations is to study that there is adequate flushing in order to prevent gross deterioration of the water quality.

Damietta Port which is one of largest container ports on the Mediterranean handling over 450 000 TEU per year, is located 8.5 km west of Damietta branch of River Nile on the Mediterranean Sea. Damietta harbor was planned and constructed in the early 1980's as semi closed water body (finger type port) with water depth of 15.0 m. Under the expansion plan of the port, a new basin (1500 m × 280 m × 17.0 m) is planned to be constructed to accommodate giant container vessels.

It must be assured that the proposed extension of the harbour will not lead to the development of stagnant water areas, there by ensuring water movement and exchange throughout the entire harbour area. In order to assess these problems, a two-dimensional finite volume (hydrodynamics HD and advection-dispersion AD) model was set up for the harbor basin for the existing configuration and after constructing the new basin.

2. Models Development

The Finite Volume Model is a comprehensive two-dimensional model for the simulation of flows, distribution of pollutant concentration, and flushing time in coastal areas, harbors, marinas, and lagoons. The HD module is based on the depth-averaged shallow water equations where the effects of Coriolis, surface wind stress, and waves were included (1, 2). The AD module solves the equation of conservation of mass for dissolved or suspended substance to simulate the spread of such substances in an aquatic environment under the influence of the fluid transport. Currents and water depths are provided by the hydrodynamic model as input data. Data on substance concentrations within the domain and at the boundary have to be specified to the model (3).

3. Model Application

The HD and AD models are first set up for the existing configuration of the Port. To assess the time scale associated with dilution of pollutants, an initial tracer concentration of 100% was introduced in the port basin with clean water outside the port boundary. The effects of tides and surface wind on the flow pattern is utilized to estimate the required flushing time. The HD simulation results showed that stagnation areas could only be formed near the closed end of the existing port basin and the flushing time needed for the existing port configuration is calculated as a reference flushing time.

Both HD and AD models are then set up with the proposed new basin. The AD model is set up for three different scenarios: (1) Pollution exists in the whole port basin and clean water enters from the port entrance; (2) Pollution exists only at the new planned basin; and (3) Pollution exists in the the whole port basin except the new basin.

Simulation results using the 2D finite volume model showed that constructing the new basin will increase the flushing time of the existing terminal basin. Results of the other scenarios will also be presented and compared with the reference flushing time needed to flush the port prior to the construction of the new basin. The model results for the different scenarios had shown to be a useful tool to understand the impacts of constructing a new port extension on the existing water quality and assess the impacts. Results are discussed in more details in the paper.

References

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