UNIVERSITI TEKNOLOGI MARA

SHALLOW WATER HYDRODYNAMICS AND TRACER TRANSPORT IN JOHOR RIVER ESTUARY

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ABSTRACT

Malaysian coastal development posed a high pressure on the water quality and aquatic ecosystem. The planning for the construction of a tidal barrage across Johor River in Kota Tinggi is to prevent saline intrusion from reaching the Johor River Waterworks (JRWW) and also the large reclamation at Tekong Island, Singapore are expected to alter the hydrodynamics in Johor River Estuary (JRE) and East Tebrau Strait (ETS). The coupled effect of the two developments is likely to affect the advection and diffusion of pollutant in the area, which is important not only for navigation but also fishery and aquaculture. The flow field is simulated using shallow water model and validated against the tidal water level at JUPEM tidal station 48484 at Jeti Kastam, Johor Bahru. Results show excellent agreement in water level fluctuation and the simulated velocities at selected sampling location also agree well with observation. It is thus concluded that the numerical model realistically represent the actual hydrodynamics of JRE, include the ETS region. For the three scenarios considered, it is shown that there are changes in velocity due to reclamation at Tekong Island causes the channel width on its side to become narrower and causes the flow to accelerate around the island (significantly) In addition, construction the tidal barrage at Kota Tinggi cause discharge into JRE to reduce and consequently, the flushing rate of the estuary is reduced. For the study of tracer transport, the method of Lagrangian particle tracking is used to simulate the advection of passive tracers in the domain. The trajectories are analysis to identify the escape rate and resident time.

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INTRODUCTION

1.1 BACKGROUND STUDY

Development in the coastal region exerts high stress on coastal water quality. Pollution sources from economic activities such as sewage, wastewater, chemical waste, oil pollution etc. causes deterioration of the aquatic ecosystem. Consequently, organisms living and interacting in this water is increasingly threatened. This indirectly also affects human being especially in terms of water use for recreational purpose and safety of fishery produce.

Pollutant transport due to coastal current and related processes is one of the main area of concern in research on aquatic environment. An understanding of the link between ecosystem properties and the way in which human activities can alter the interactions between the physical, chemical, and biological processes of the ecosystem is vital for the well being of the coastal environment.

Ubiquitous free surface flows such as ocean tides, wind waves, dam breaches, river floods and tsunamis are of great interest to many scientists and engineers. These flows are near-horizontal with negligible vertical variation and thus can be described using the non-linear shallow water equations. Shallow water flows can be defined as flows where the vertical dimension is much smaller than the typical horizontal scale. The shallow water equations are derived from depth-integrated Navier-Stokes equation, reducing the problem of three-dimensional fluid motion to simplified two-dimensional description with an averaged depth-field representation.

Problems of pollution transport in coastal water can be simulated and studied using these set of well-established equations comprising conservation laws of mass, energy and momentum. When applied to fluid motion in natural water body, these equations typically treat the fluid as a continuous substance which is incompressible. They form the backbone of hydrodynamics, an important branch of engineering related to the study of how fluid interacts with energy and forces, and thus the environment and vice versa.