Applied Mathematical Modelling 60 (2018) 592–605

Contents lists available at ScienceDirect

Applied Mathematical Modelling

journal homepage: www.elsevier.com/locate/apm

Mathematical model of tidal water transport by a partial blockage of a coastal lagoon

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ARTICLE INFO

Article history:
Received 2 May 2017
Revised 22 March 2018
Accepted 29 March 2018
Available online 5 April 2018

Keywords:
Hydrodynamic model
Non-linear equation
Estuary connectivity

ABSTRACT

In this paper, an analysis is done on the tidally forced dynamical behavior of a partially blocked coastal lagoon. A non-linear differential equation has been deduced for the evolution of the water depth in the blocked part of the lagoon as a function of the tidally driven water depth in the ocean connected part. This dynamical problem depends on two non-dimensional parameters: the relative amplitude of tidal wave and the non-dimensional tidal period (related to the filling time of the blocked part). For very small values of the relative amplitude of the tidal wave, the problem depends only on one parameter. The evolution equation is numerically solved for a wide range in the parametric space, obtaining the relative amplitude of the water depth oscillations in the blocked part, its phase lag and the mean water depth behind the bridges. The specific case of the Chelem lagoon has been studied, which has been divided by a road with only two small bridges. Water flows from the open ocean-connected part of the lagoon to the enclosed part only through the bridges. The analysis shows the response if a new bridge is built or one of the actual bridges is removed.

1. Introduction

One of the most important features of global environmental changes, together with anthropogenic change in local landscape [1–6], is that estuarine connectivity regimes are modified. As water levels in coastal lagoons are inherently linked to the state of the entrance, and the state of the latter has a large impact on the ecology of the lagoon, the relationship between the construction of hard structures and groynes and how they affect the estuarine connection to the ocean is a knowledge gap that needs to be addressed. In coastal lagoons, one of the most important variables is the residence time, which plays a key role in the functioning of estuarine ecosystems and should be one of the first known parameters of coastal lagoons processes [7–19]. This variable governs the behavior of sump and trap pollutants, controls the fate of organic matter, and determines whether these elements will reside within the body of water long enough to affect biogeochemical processes [20]. Mudge et al. [21] performed surveys of temperature and salinity to measure evaporation rates in a salt extraction pond

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https://doi.org/10.1016/j.apm.2018.03.033