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MODELLING OF SALINITY INTRUSION FOR TRANSVERSE FLOW DURING EXTREME FLOOD EVENT IN KUALA SELANGOR

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This thesis has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

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ABSTRACT

Estuaries are bodies of water along the coasts that are formed when fresh water from rivers flows into and mixes with salt water from the ocean. The density of seawater is greater than fresh water and it varies with salinity and temperature. Fresh water tends to float on top of the seawater because of its lower density. Human-induced activities like dredging of shipping lanes along the bottom estuarine, the dumping of industrial wastes into the water system and shoreline development influence estuarine dynamics which include mixing process. These activities lead to salinity changes and further adversely affect the estuarine ecosystem. In the first part of this study, the characteristics of the mixing between salt water (estuary) and fresh water (river), had been investigated in laboratory experiments. The experimental observation of saline-fresh water mixing using Particle Imaging Velocimetry (PIV) have been carried out to analyse the Reynolds Stress, Turbulence Intensity, U for speed, V for velocity and Vorticity of salinity mixing pattern. Fresh water was released from one end of the flume channel and overflowing over weir at the other end. Meanwhile, salt water was represented by the red dye tracer released slowly through a weir and intruded horizontally to the upstream as a gravity current. The isohalines are plotted to identify the salinity patterns. The salinity levels were measured at selected stations along the channel/ longitudinal (x-axis), and also in transverse (y-axis) and vertical directions (z-axis) within the time duration. The observed salinity profile showed that the bottom salinity is higher than the salinity at the water surface in a typical salt-wedge estuary characteristics. In the second part of the study, a shallow water model of salinity intrusion had been developed for a case study of the Selangor river estuary. The Shallow Water Model (SWM) had covered the river stretch from Kuala Selangor estuary up to Kg. Asahan station as the limit of saline water intrusion point. The boundary conditions included sea water level, salinity, and river discharge. The model was calibrated and validated using measured water depth and salinity data at Lembaga Kemajuan Ikan Malaysia (LKIM) Jetty, Kuala Selangor for selected events occurred in year 2000 until 2017. Later the SWM model was used to simulate the flood events at Kuala Selangor to investigate the transverse flow salinity intrusion during extreme flood event. Based on model performance using statistical analysis in terms of Root Mean Square Error (*RMSE*), Mean Absolute Error (*MAE*) and R^2 values from the model calibration and validation results, it indicates that the model was able to predict the hydrodynamic and transverse flow salinity intrusion characteristics of the study area either during normal season or during extreme flood event. The analysis of salinity and water level/water depth changes due to high flood peak discharge for 50-, 100-year return periods and Probable Maximum Flood (PMF) years were presented in details. The upstream region gets a high impact on high fresh water flow due to high flood discharge as compared to the downstream where the water depth range clearly increases from the range of 4.37 to 4.59 m (50-year return period) to the range of 4.40 to 4.62 m (100-year return period), and continuously increases in the range of 4.59 to 4.83 m (PMF).

TABLE OF CONTENTS

CHAPTER ONE
INTRODUCTION

1.1 Introduction

Estuary can be defined as an area where there is an interaction between fresh water (river) and salt water (ocean). However, there are various definitions of estuary depending on perspective of different groups or parties. Estuaries are semi-enclosed coastal bodies of water where fresh water and salt water meet and mixed (Weisberg and Zheng, 2003; Cao et al., 2008). Based on mixing characteristics, estuaries can be classified as vertically-mixed, slightly-stratified, highly-stratified or saline-wedge (Fischer et al., 1979). The fresh water from river lighter than salt water, so it had a tendency to remain on top of the salt water. If the estuary was deep enough, the salt water from the sea will travelled up the estuary by passing under the fresh water while the fresh water going down the river will stay above the salt water layer and enter the sea. This was called a salt-wedge estuary. When the mixing process occurs, distribution of salinity in the estuary change slowly depending on space and time. The important factors that lead to the salinity changes are the tidal effects, stream flow, dissimilarity of water density, estuary characteristics, wind effect, and Coriolis effect.

Interactions between fresh water and salt water in estuary influence the water cycle and the mixing process caused by density differences between the two water masses will occur (Kuijper and Rijn, 2011). The sea water density depends on the salinity levels and temperature values. In an estuary, the range of salinity is large but the temperature range is low. When this happens, it will contribute to significant differences in density, as temperature has only a small influence on the density. Mixing in a shallow flow, such as in estuaries and rivers, is an important topic in the field of environmental engineering. The related examples include the spread of pollutants, suspended sediment movement in rivers and coastal waters, algal blooms in lakes, and transportation of suspended mining material in the pond due to the wind. These processes directly affect water quality and they can give significant impact to the ecosystem as well.