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学 位 論 文 要 旨

論文題名　Influence of topography, tides and freshwater discharge on saline intrusion in a deltaic estuarine system

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（ 学位論文要旨 ）

Estuaries represent the complex interaction of freshwater and seawater that affects physical, chemical, and biological processes. These areas are of importance to more than 75% of the world's population. Rapid changes in the global climate along with a recent population explosion have upset the delicate natural balance of river estuaries. The varying estuarine features are affected by the forcing action of the tide and currents, and the supply and removal of sediment. Although independent issues for single-channel estuaries have been studied by many researchers and a relatively good understanding has been gained, quantifying the discharge water system is still an ongoing problem because of the complex channel topography, tidal variation, and so on. It is even more difficult to shed light on the state of multi-channel estuaries that consist of a main channel and some branched channels. Multi-channel estuaries can be found in tide-dominated deltas. Determining the distribution of the freshwater discharge rate in such river estuaries is very challenging, because the freshwater discharge is seldom much larger than the measuring error under the influence of the tidal discharge and therefore unreliable for extreme cases in the dry season. In general, the observation of freshwater discharge must be carried out further upstream, but this observation does not reflect the actual discharge rate in the downstream branches.

Aside from the freshwater discharge, tidal variations are also useful for estimating the landward discharge. The tidal flux transports seawater into the estuary region where it mixes with freshwater. The salinity reaches a great distance from the river mouth, especially where the amount of freshwater discharge is small and the tide is high. This can contaminate water used for domestic, agricultural, and industrial purposes. Thus, prediction of tidal flow and its influence on salinity intrusion has come to the attention. Although salinity intrusion has been well studied in several types of single-channel estuaries, no predictive method applicable to branched-channel systems has yet been developed.

The objectives of this study are (i) to develop a new model for estimating the distribution of freshwater discharges in the branched channels of an estuary system, (ii) to derive a solution for estimating tidal velocity along a channel, and (iii) to develop a predictive salt intrusion model for a multi-branched estuarine system.

The study area is located in the northern part of Vietnam, where the Red River and its distributaries spread out to form a large alluvial plain, the Red River Delta (RRD). The RRD has a surface area of approximately 16,600 km^2 and occupies 4.5% of the total area of Vietnam. The Red River Estuary System (RRES) lies in the southeastern part of the RRD and includes four estuary branches: the Tra Ly, Red River, Ninh Co, and Day. In recent years, the RRES has been threatened by salt intrusion with the rapid growth of human occupancy in the region. According to the observation data, salt intrusion extended 11% further up the river in the period from 1993 to 2007 than it did in the period from 1965 to 1985. This resulted in a reduction in the amount of surface water available for agricultural use near the coast. During the wet season, as the discharge of the Red River increases, the salt intrusion stops within a distance of 4 km from the mouth; thus, most channels are occupied by freshwater. In contrast, in the dry season, saline water fills these channels. Therefore, the dry season is the crucial period for salt intrusion in the RRES.

The datasets used in this investigation are salinity, tidal velocity, and topography. A series of field measurements of salinity was conducted from January 3 to 19, 2006. Salinity was sampled simultaneously at three different elevations of 21 stations under a joint project between the Tokyo Metropolitan University and the Hanoi Water Resources University. The sampling interval was one hour during the flood tide and two hours during the ebb tide. In addition to these field data, the Institute of Meteorology, Hydrology, and Environment (IMHE) provided official dataset for salinity at the estuary mouth. The tidal information was collected from the Ba Lat station, which is located near the mouth of the RRE. Detailed information on the estuarine topography was acquired by the Ministry of Agriculture and Rural Development during the dry season in 1999-2000.

This dissertation comprises six chapters.

Chapter 1 gives a brief introduction to estuarine processes that represent the complex interaction of tides, currents, salt, freshwater, and sediment. It also includes the motivation and objective of this study.

Chapter 2 contains a view of previous work that addressed the estuary shape, tidal behavior, mixing mechanism, and salinity intrusion. First, the estuaries are classified by the notable geographical features. Second, the functional characteristics of estuaries to determine the cross-sectional area and longitudinal distribution in a river are presented. Third, the nature of tides, their generating fluxes, and the properties of tides in oceans of limited extent are examined. Fourth, the mixing types are categorized according to available references and they are related to the salt intrusion. Finally, summary on the development of theoretical salt balance equation and predictive tools for forecasting salinity distributions in estuaries are presented.

Chapter 3 presents a new salt intrusion model modified for geometrically complex estuary systems. This model is applied to the RRES, where the channel shape and size greatly vary as a

function of the tidal amplitude. A series of salinity data observed in the dry season of 2006, 2008, and 2009 are used to validate the model and predicted the saline intrusion distributions. The theoretical result is compared with a set of observed data in the Red River estuary system and with the results by the authorized salt intrusion models.

Chapter 4 gives a new approach that estimates the temporal and spatial freshwater discharge distributions from the salinity values in a multi-connected estuarine system. The salinity data measured in the RRES during the dry season of 2006 are used to evaluate the discharge model. The computed result of freshwater discharge value is compared with the corresponding results by a hydraulic model (MIKE11) and an empirical method by Savenije.

Chapter 5 presents a case study for the salt intrusion problem due to the accelerated sea level rise. An empirical formula is developed based on the relationship among the quantifiable hydraulic, hydrologic, and geometric parameters. By making use of the modified salt intrusion model and the derived formula, salinity distributions along the branches of the RRES are estimated for some different scenarios of sea level rise and released water from the upstream reservoir.

Chapter 6 presents the conclusions and recommendations of this investigation. Conclusions are given to remark the fulfillment of the present work to the objective. Recommendations are made for further considerations on application of the proposed methods to predict salinity intrusion, dispersion coefficient, and freshwater discharge in other deltaic estuarine systems.

注意　２０００字程度、１２ポイントで記載

研究業績一覧

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研　究　業　績　一覧

*印は，本論文に直接関係するものを示す

１．論文（フルペパー査読）

No.	論文名	掲載誌	巻，号，頁	発行年	著者名
1*	Importance of geometric characteristics for salinity distribution in convergent estuaries	Journal of Hydrology, ELSEVIER	Vol.448-449, pp.1-13	2012. 7	D.H. Nguyen M. Umeyama T. Shintani
2*	Variation in fresh-water discharge due to geometric influences in Red River estuary, Vietnam	Journal of Environmental Hydrology, IAEH	Vol.20 (9), pp.1-19	2012. 7	D.H. Nguyen M. Umeyama T. Shintani
3*	Effect of topography on salinity distribution: A case study in a high-tidal range estuary	Journal of JSCE (B1), JSCE	Vol. 68 (4), pp.I_271 -I_276	2012. 2	D.H. Nguyen M. Umeyama T. Shintani C. Nakaza
4*	Estimation of freshwater -discharge distribution for multi-estuary branches in the Red River system in Vietnam	Proc. of World Congress, IAHR	Vol.34 pp.1054 -1061	2011. 6	D.H. Nguyen T. Shintani M. Umeyama
5*	A comprehensive approach for estimating hydraulic quantities in a multi-branched estuarine system	Journal of Hydraulic Engineering, ASCE	In review		M. Umeyama D.H. Nguyen

２．国際会議（アブストラクト査読）

No.	論文名	掲載誌	巻，号，頁	発行年	著者名
1*	Using flushing rate to estimate the longitudinal distribution of tide-driven and density-driven mixing in the Red River Estuary System	Proc. of 4th International Conference on Estuaries & Coasts	Accepted	2012. 10	D.H. Nguyen M. Umeyama T. Shintani
2*	Analytical estimation of longitudinal dispersion coefficient in the Red River estuary, Vietnam	Proc. of 13th International Summer Symposium	Vol.13 pp.151-154	2011. 8	D.H. Nguyen M. Umeyama T. Shintani
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5	Assessment of land use activities to erosion and sediment transport on Dong Nai river basin	Proc. of Regional Conference on Environments & Earth Resources	pp.118-130	2009. 12	D.H. Nguyen T. H. L Pham

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No.	論文名	掲載誌	巻，号，頁	発行年	著者名
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3	Some current research results on flash flash-flood in the northeastern mountainous areas, Vietnam (in Vietnamese)	6th Annual Meeting on Hydrology and Environment, National Institute of Meteorology, Hydrology & Environment	6 pages	2008	L.T.H. Pham C.M. Vu D.H. Nguyen
4	Simulation the morphological processes of an idealized coastal inlet using 2DH processed-based morphodynamic modeling system (in Vietnamese)	14th Conference on Hydrology & Water Resources, WRU	10 pages	2007	T.T. Tran D.H. Nguyen
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No.	論文名	掲載誌	巻，号，頁	発行年	著者名
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2	Investigation of water quality in the Northern provinces (in Vietnamese)	Tech. Rept., Power Engineering Consultant Co.	No.4, 41 pages	2007	D.H. Nguyen D.M. Tran
3	Analysis of hydrodynamics and morphology of the Tra Khuc estuary (in Vietnamese)	Tech. Rept., Transport Dept. of Quang Ngai Province	74 pages	2007	C.M. Vu D.H. Nguyen D.M. Vu D.D. Bui
4	Solutions on stabilization of Central Vietnam estuaries (in Vietnamese)	Tech. Rept., National Program on Management of Coastal Zones, Ministry of Sc. & Tech.	206 pages	2006	Q.N. Pham C.M. Vu T.T. Do L.T.H. Pham T.T. Tran D.H. Nguyen H.T. Nguyen

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6	Databank for reservoirs in Vietnam (in Vietnamese)	Tech. Rept., Ministry of Agriculture & Rural Development	118 pages	2004	T.T. Do L.T.H. Pham D.H. Nguyen H.T. Le

上記のとおり相違ありません。

平成 24年 7月 11日

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