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Research Article

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Research on numerical model of seawater intrusion at Beibu Gulf, China

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ABSTRACT

For risk assessment of seawater intrusion at the Beibu gulf in southern China, numerical simulation model was adopted. According to complex river network, we carried out researches on the influence of seawater intrusion between river runoff and tidal. The results showed that, the salinity peak value was influenced mighty and reversed during the Nanliu river runoff and sea current encounter at the center of the bay. And with the gradient which altering from south to north, the salinity distribution mainly showed a great correlation between river runoff and ocean current.

Key words: Numerical Models; Seawater Intrusion; Beibu Gulf; Risk Assessment

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INTRODUCTION

As a new kind of environmental pollution, seawater intrusion of the estuary has been attracting people's attention. Seawater intrusion not only endangers people's health and industrial & agricultural production, but also severely restricts the economic development in the coastal and estuary areas. It's urgent to master the method of preventing seawater intrusion. There are various factors that influence seawater intrusion disasters, such as runoff, tide, wave, wind, and evolution of estuary, fluctuation of sea-level, human activities etc. The risk assessment index of seawater intrusion disasters must be able to reflect these factors.

Three methods are general: prototype observation, physical model and numerical simulation method. The latter would be the main research method while data lacked. Essen[1] simulated the distribution of fresh water, brackish water and saltwater in Nether island and studied three-dimensional seawater intrusion by MOCDENS3D[2,3]. Morgan[4,5] established one-dimensional mathematical model to simulate water stage, salinity and TON in Ythan estuary[6,7], combined upwind difference and central difference together to simulate tide race, and conducted the simulation research on saltwater distribution in Ythan estuary. Canestrelli[8] studied seawater intrusion of Fly estuary by simulation method and data analysis method, and discussed the influence of shallow water effect[9,10], tidal wave, surface gradient etc. On seawater intrusion. Duc[11] studied features of intruded saltwater in the Red River system combined with recent actual measured salinity data and mathematical model (one-dimensional) from every site of estuaries. These studies enhance the computational accuracy of seawater intrusion of estuary to a large extent. Prandle[12] introduced "single-point" mathematical model that "emphasized the relationship between tidal variation in circulation during medium wave and vertical salt gradient during short term" and applied it to researches on seawater intrusion of hybrid estuaries. Tracking Gorai estuary system in Bengal as the example[13]. Güler[14,15] Studied how to use GIS tools and rapid assessment techniques to determine seawater intrusion. Ralston[16,17] studied the changing process of salinity through the volume integration of isohaline surface to calculate salinity flux of the estuary. Chua[6] and Moyle[18] proposed a GA used to optimize ANN, and adopted this method to conduct relative researches on seawater intrusion of San Francisco Bay estuaries.

But some problems have not been satisfactorily addressed. For example, discrete solutions of most former models are made by finite difference method[19,20] which cannot better meet conservatives, wave and wind etc. was not been considered in salinity model. This paper carried out further researches on seawater intrusion of estuary. We focused on estuary areas and gives consideration to runoff and tidal influence. Hydraulic model and salinity mathematical model were adopted Comprehensively considering ubiquitous factors in these estuaries, such as waves, wind, tide and runoff.

EXPERIMENTAL SECTION

The domain of this model consists of all Nanliu River estuaries below Changle Station, including Nangan River, Nanxi River and Nandong River. The model grids in severe changed terrain are locally refined, so that it's better match boundaries of Nanliu River and its natural shorelines. The minimum grid step near the project is about 50 m.

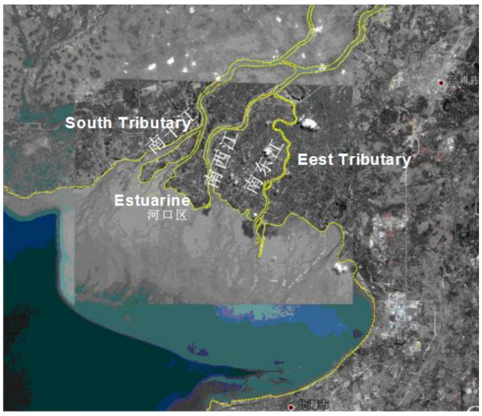


Fig.1 Schematic diagram of model region

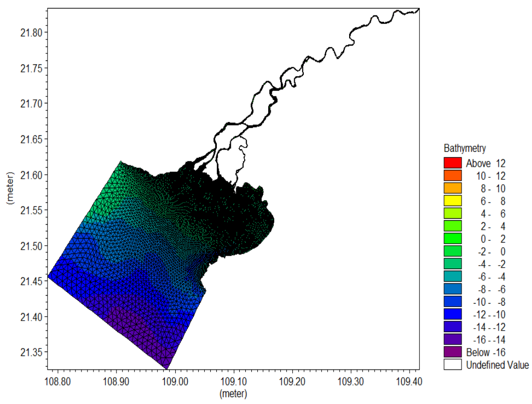


Fig.2 Grid schematic diagram

The basic equation of one-dimensional flow model[22,21] is:

$$\frac{\partial z}{\partial t}+\frac{1}{B}\frac{\partial Q}{\partial x}=q \tag{1}$$

$$\frac{\partial Q}{\partial t}+\frac{\partial}{\partial x}\left(\beta\frac{Q^2}{A}\right)+gA\left[\frac{\partial z}{\partial x}+S_f\right]+u_1 q=0 \tag{2}$$

$$\frac{\partial (AS)}{\partial t}+\frac{\partial}{\partial x}\left(\beta\frac{QS}{A}\right)-\frac{\partial}{\partial x}\left(AD_K\frac{\partial S}{\partial x}\right)+AKS=S_m \tag{3}$$

$$\sum_{i=1}^{m} Q_I=0 \tag{4}$$

Boundary conditions could be divided into two parts: water stage boundary & flow boundary. The monthly average flow at Changle Station of Nanliu River in flood season is 928.41m^3s^{-1}, which is selected as verification flow.

Table 1. Parameter between computations and survey

Section	Distance to estuary(km)	Computations of mean water level elevation(m)	Mean water level elevation in measured data(m)	Deviation(%)
Dang River hydrometric station	8.00	1.86	2.10	6.12
Zonghjiangkou hydrometric station	14.10	4.60	4.80	3.02

The observed salinity values were measured at Dang River hydrometric station from 28 to 29 October 2007 for calibration.

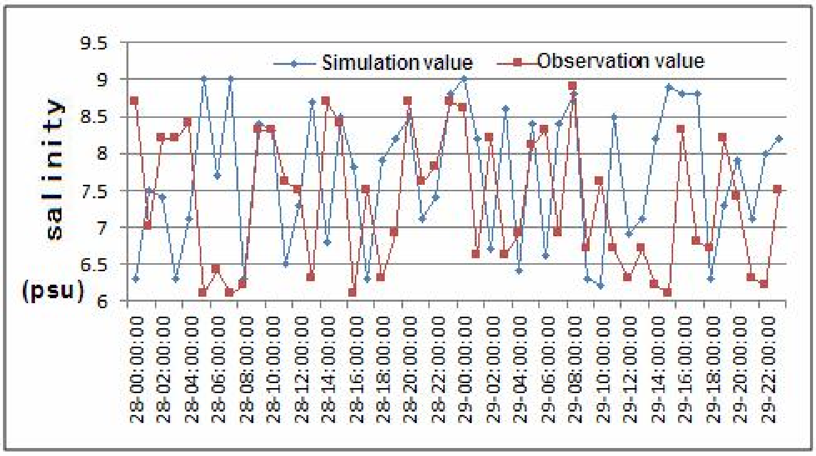


Fig3. Comparison diagram between salinity of computations and survey data

It showed the model was fit. Average flow rate of Nanjing River is 163 m^3s^{-1} rang from 2007 to 2010. The summer takes account of 49.1%, the winter 7.8%, the autumn 21.4% and the spring 21.7%. According to runoff data of Changle hydrometric station, Nanliu River runoff can be generally divided into two periods: 2007 is low flow period while from 2008 to 2010 high flow one.

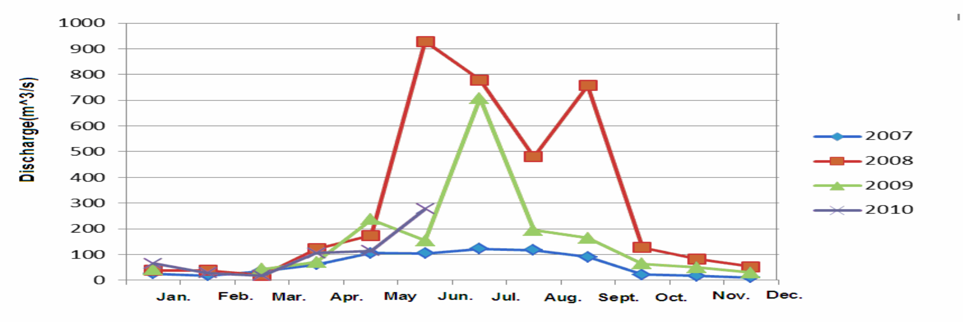
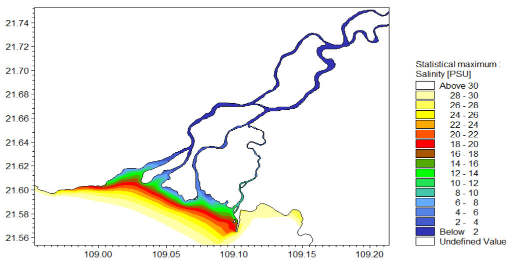


Fig4. Monthly flow diagram at Changle Hydrometric Station (2007-2010)

So the following conditions including: Changle Station was the upstream, the high flow period discharge was 122.7 m^3s^{-1} in July 2007, the low flow period discharge was 11 m^3s^{-1} in December 2007.

RESULTS AND DISCUSSION

The salinity is relatively high with weak runoff during low flow period, and reverse during high flow period. The range of salinity values was 2~12psu. Nangan River, Nanxi River and Nandong River were intruded by seawater to different degree, with prominent decline trend toward south. The relatively strong runoff of Nanliu River pushed gulf waters from north to south. The salinity peak value generated by Nanliu River runoff just arrived at the center of bay, then was stroked by powerful sea current. This powerful runoff and sea current generated strong composite action of river water and sea water at the center of bay, as a result, the salinity peak value was sharply reversed. Salinity in estuary areas was 12~30psu, its distribution mainly showed a great correlation between river runoff and ocean current.



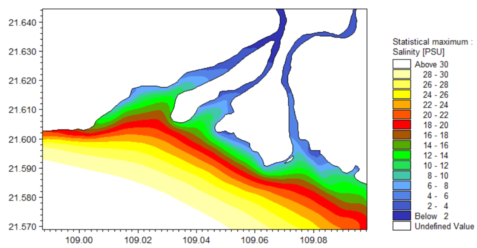


Fig5. Seawater intrusion during high flow period in July, 2007

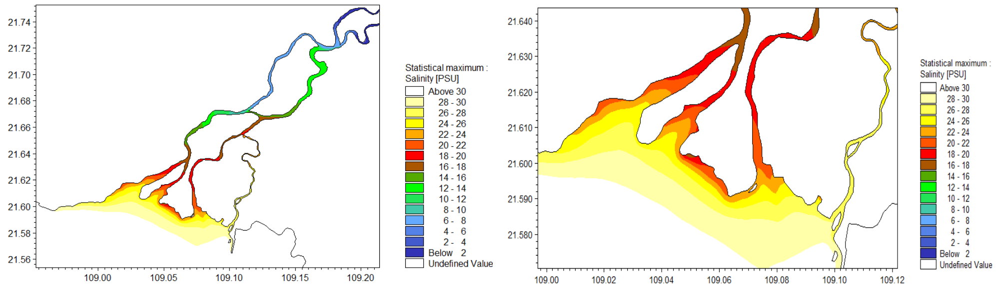


Fig6. Seawater intrusion during low flow period in December, 2007

Seawater intrusion was seem more serious during low flow period. The range of salinity values was 2~28psu. High salinity values moved northward, and it seemed that a little river runoff and strong tides in this season were the key factors.

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REFERENCES

[1]Oude Essink G H P. *Physics and Chemistry of the Earth, Part B: Hydrology, Oceans and Atmosphere*, **2001**, 26(4): 337-344.
[2]Gaaloul N, Pliakas F, Kallioras A, etc. *The Open Hydrology Journal*, **2012**, 6: 31-44.
[3]Lu W, Yang Q, D MARTÍN J, etc. *Journal of Earth System Science*, **2013**: 1-15.
[4]Morgan L, Stoeckl L, Werner A, etc. *EGU General Assembly Conference Abstracts*. **2013**, 15: 2496.
[5]Morgan L K, Werner A D. *Journal of Hydrology*, **2013**, 508: 322-327.
[6]Chua V P, Fringer O B, Monismith S G. *Influence of sea level rise on salinity in San Francisco Bay*. **2011**.
[7]Zhang W, Feng H, Zheng J, etc. *Journal of Coastal Research*, **2012**, 29(2): 372-382.
[8]Canestrelli A, Lanzoni S, Fagherazzi S. *Sedimentary Geology*, **2013**.
[9]Gehrke P C, Sheaves M J, Terry J P, etc. Vulnerability of freshwater and estuarine fish habitats in the tropical Pacific to climate change. **2011**.
[10] Lefebvre J-P, Ouillon S, Vinh V D, etc. *Geo-Marine Letters*, **2012**, 32(2): 103-121.
[11] Duc N H, Umeyama M. Saline Intrusion Due to the Accelerative Sea Level in the Red River System in Vietnam. *Reston, VA: ASCE [at] Proceedings of the 2011 World Environmental and Water Resources Congress*; May 22. 26, 2011, Palm Springs, California| d 20110000. **2011**.
[12] Prandle D. Estuaries: dynamics, mixing, sedimentation and morphology. *Cambridge University Press*, **2009**.
[13] Bhuiyan M J A N, Dutta D. *Estuarine, Coastal and Shelf Science*, **2012**, 96: 219-227.
[14] Güler C, Kurt M A, Alpaslan M, etc. *Journal of Hydrology*, **2012**, 414: 435-451.
[15] Sigda J M, Deeds N, Jordan D L, etc. Assessing Current and Future Performance of the Alamitos Gap Seawater Intrusion Barrier with a New Flow and Transport Model, Los Angeles and Orange Counties, CA. *AGU Fall Meeting Abstracts*. **2010**, 1: 1209.
[16] Ralston D K, Geyer W R, Lerczak J A. *Journal of Geophysical Research: Oceans (1978-2012)*, **2010**, 115(C6).
[17] Aristizábal M, Chant R. *Journal of Physical Oceanography*, **2013**(2013).
[18] Moyle P B, Lund J R, Bennett W A, etc. *San Francisco Estuary and Watershed Science*, **2010**, 8(3).
[19] Flores-Márquez E L, Campos-Enríquez J O, Chávez-Segura R, etc. *Geofísica Internacional*, **2012**, 37(3).
[20] Ortuño F, Molinero J, Custodio E, etc. Seawater intrusion barrier in the deltaic Llobregat aquifer (Barcelona, Spain): performance and pilot phase results. *SWIM21 – 21st Salt water intrusion meeting, Azores, Portugal*. **2010**: 21-25.
[21] Herckenrath D, Odlum N, Nenna V, etc. *Ground Water*, **2012**.
[22] Xu M, Van Overloop P J, VAN DE GIESEN N. *Model selection for salt water intrusion in delta areas*. **2011**.