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Research Paper

Application of Mike/Swat for simulation the salt intrusion – a case study in Ve river, Quang Ngai province

D. Le [1] and L. Bui [2]

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ABSTRACT

The coastal areas are mainly impacted via climate change. In the past century, sea level has risen averagely 10-12cm every decade and caused the serious damage in coastal region. Understanding dynamics in estuaries plays an important role in assessing physical, bio-chemical changes which are occurring, especially the salt intrusion. This research demonstrates the approach to evaluate the scope of salt intrusion at Ve estuary, Quang Ngai province via studying hydrodynamic and hydrological processes by using integrated models: SWAT/NAM/MIKE21. Based on flow, salt intrusion data measured and flow by ADCP (Acoustic Doppler Current Profilers) to validate the model. Then, the prediction of impacted scope and the level of salt intrusion in the study area are concluded.

1. Introduction

The coastal areas are mainly impacted via climate change. In the past century, sea level has risen averagely 10-12 cm every decade. The Fifth Report from IPCC proved vulnerability of coastal area in 21st century (Bush et al. 2018). The main consequences caused by seas level rise are flooding, salt intrusion, and additional impacts on water resource (Bush et al. 2018). Sea level rise leads to the increase in surface water and groundwater salinization (Paw and Thia-Eng 1991); (Bhuiyan and Dutta 2012); (Hong and Shen 2012);(Bush et al. 2018). The reverse movement of saline water will directly affect physical and ecological processes, resulting in economic development, including fresh water for domestic and industrial use. There have been many studies assessing the threats to salt intrusion due to sea level rise (Ross et al. 2014);(Yang et al. 2013); (Zander, Petheram, and Garnett 2013). Moreover, sea level rise can influence on tidal currents, which leads to changes in salt intrusion. (Hong and Shen 2008); (Bhuiyan and Dutta 2012) reported that determining the impact of sea level rise on salt intrusion is important in providing adaptation, reducing the effects of salt intrusion in coastal areas.

Numerous studies have been carried out to assess the salinity transport and disturbance in estuaries using numerical models. (Shen et al. 2018) established an one dimension salinity transport model to study salt infusion in the Pearl River network. (Wu, Zhu, and Ho Choi 2010) discussed the relationships between salt intrusion and tidal circulation in the Yangtse estuary by using ECOM-si model. (Jeong et al. 2010) used Environmental Fluid Dynamics Code (EFDC) model in evaluating saline scope depending on flow rate of upstream Geum river, Korea. (Liu et al. 2004) developed a vertical two dimension model to assess the effect of upstream freshwater flow due to salt intrusion by runoff at Danshuei estuary system

[1] Ph.D. candidate, The Southern Institute Of Water Resources Research, diepmoitruongqn@yahoo.com.vn, Vietnam
[2] Associate Professor, Hochiminh city University of Technology, longbt62@hcmut.edu.vn, Vietnam
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in Taiwan. The numerical model was evaluated by the authors as an effective tool to study salinity transport in estuaries (Bowen 2003); (MacCready 2004), (Lerczak, Geyer, and Chant 2006). The numerical model used may be 1D model (H. H.G. Savenije 1986),(Hubert H.G. Savenije 1989),(Aerts et al. 2000),(Brockway et al. 2006),(Nguyen et al. 2008), 2D model (Wu, Zhu, and Ho Choi 2010) and 3D model (Jeong et al. 2010),(Wang et al. 2019),(Chen et al. 2016). Based on topography, tidal conditions and upstream flow, to calculate the salinity distribution in the estuary, our study applies a numerical modeling approach, especially the Mike3 model. Some results have been presented in other study of the authors (Diep, Anh, and Long 2019).

The selected scope of this study is belonged to Quang Ngai province, Vietnam. Thanks to the advantages from natural and geographic conditions, the economic development of the area is fast growing up. However, in recent years, due to climate change, flooding and salt intrusion in Quang Ngai is complexly occurring. Therefore, Quang Ngai is the research subjects of many researches, projects (Diep, Anh, and Long 2019),(Long 2019) then, the level impact of salinization at Ve estuary, Quang Ngai due to sea level rise need to be estimated in framework of sustainable development. According to the research of (Hong and Shen 2012), physical transport mechanisms and salt intrusion are important for the ecological environment and water supply, however the process is difficult to be assessed due to limited observation time, as well as the impact of other factors. Therefore, mathematical model is an important approach to gain knowledge in this issue (JIANG, SHEN, And WANG 2009).

Our study uses a model approach to the flow of water at the estuary of the river, in particular, a system of hydrodynamic and hydrological models are used to find the optimal set of hydrodynamic and hydrological parameters, and in combination with a reasonable set, the advection-diffusion model is used to model the salt intrusion at the estuary of the river. The research is different from the previous ones: using the system of models SWAT/NAM/MIKE 21 HD for establishing hydrological, hydrodynamic parameters of the study area. To simulate the salt intrusion, on-site measurement was done, then the result of salt intrusion simulation was validated using on-site measurement. Furthermore, the future salt intrusion prediction was displayed based on climate change scenarios provided by Vietnam Ministry of Natural Resources and Environment (MONTRE 2016).

2. Methodology

2.1 Study area

Ve river flows from Western mountain area with main direction from South West to North East, and comes to the East Sea at Co Luy and Duc Loi estuaries. Ve river is bounded by Tra Khuc river on the North and West; Binh Dinh province on the South; and sea on the East. The area of river basin is about 1,260 km^2. The main river has 90km length with 2/3 the length flows in mountain area with the height of 100-1000m. The density of rivers and streams in the basin reaches 0.79km/km^2, the average slope of the basin is about 19.9% (Diep, Anh, and Long 2019). The vegetation that covers surface of river basin in the upstream area is mostly old growth forest, scrub, and downstream is mainly agricultural land. Fig.1 displays the location of study area.

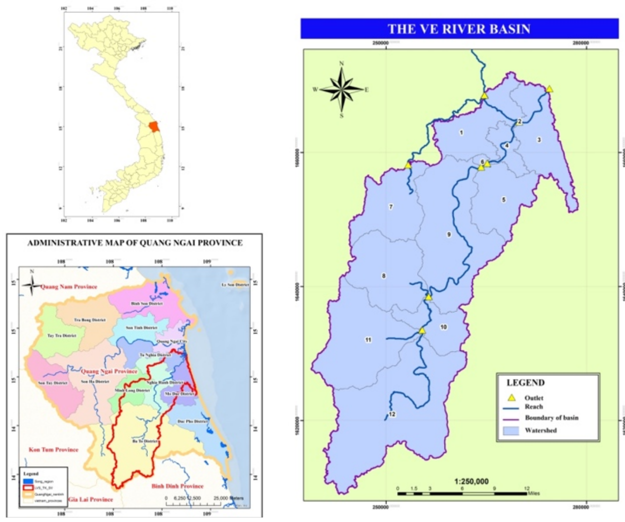


Fig. 1. Location, study area – downstream of Ve River, Quang Ngai

2.2 SWAT, MIKE NAM, MIKE 21/3 models

2.2.1 SWAT model

SWAT (Soil and Water Assessment Tool) is an evaluating tools for water and soil (Arnold et al. 2013). The model is used for assessing, predicting land uses impacts on water, sedimentation. SWAT simulates many physical process at once time with very detail simulation via dividing river basin into sub-basin according to geography and hydrological systems. Then, each sub-basin is divided in to Hydrological response units – HRUs which has unique characteristic in soil, and land use based on kind of land, vegetation cover in sub-basin. This research inherits the research results of authors (Diep, Anh, and Long 2019), in which SWAT is combined with ArcGIS to divide river basin, analyzing hydrological units, edit the meteorological data such as: wind velocity, precipitation, max/min temperature, humidity, radiation intensity.

2.2.2 NAM model

The NAM hydrological model simulates the rainfall-runoff processes occurring at the catchment scale. NAM forms part of the rainfall-runoff (RR) module of the 1D river modelling system. NAM is the abbreviation of the Danish "Nedbør-Afstrømnings-Model", meaning precipitation-runoff-model, also named RDII in English standing for Rainfall Dependent Inflow and Infiltration model. This model was originally developed by the Department of Hydrodynamics and Water Resources at the Technical University of Denmark. The basic input requirements for the NAM model consist of: model parameters; initial conditions; meteorological data; streamflow data for model calibration and validation. The basic meteorological data requirements are: rainfall; potential evapotranspiration. Basic modelling components are: surface storage; lower zone or root zone storage; evapotranspiration; overland flow; interflow; interflow and overland flow routing; groundwater recharge and baseflow. A mathematical hydrological model like NAM is a set of linked mathematical statements describing, in a simplified quantitative form, the behavior of the land phase of the hydrological cycle (DHI 2017), (Odiyo, Phangisa, and Makungo 2012). In this study, inheriting NAM application results is done in the study (Diep, Anh, and Long 2019) used to create hydraulic boundaries for the MIKE3 HD hydraulic model.

2.2.3 MIKE 21/3

The modelling system is based on the numerical solution of the three dimensional incompressible Reynolds averaged Navier – Stokes equations subject to the assumptions of Boussinesq and of hydrostatic pressure (Pietrzak et al. 2002). Thus, the model consists of continuity, momentum, temperature, salinity and density equations and it is closed by a turbulent closure scheme. The density does not depend on the pressure, but only on the temperature and the salinity. The equations are written in a Cartesian co-ordinate system, *(x, y, z, t)*, with the *x* – axis directed to the east and the *y* – axis towards the north. The *z* – axis is positive up away from the bed ranging from – *H(x,y)* at bottom to *ξ(x,y,t)* at the free surface. The continuity equation is given by

$$\frac{\partial u}{\partial x}+\frac{\partial v}{\partial y}+\frac{\partial w}{\partial z}=S$$

where *u, v* and *w* are the velocity components in the x-, y- and z- directions, respectively. The momentum equations are written in flux form as

$$\frac{\partial u}{\partial t}+\frac{\partial u^2}{\partial x}+\frac{\partial vu}{\partial y}+\frac{\partial wu}{\partial z}-fv+g\frac{\partial \xi}{\partial x}+\frac{1}{\rho_0}\frac{\partial p_{amt}}{\partial x}+$$
$$\frac{g}{\rho_0}\int_z^{\xi}\frac{\partial \rho}{\partial x}dz-F_x-\frac{\partial}{\partial z}\left(\upsilon_t\frac{\partial u}{\partial z}\right)-u_sS$$
$$\frac{\partial v}{\partial t}+\frac{\partial v^2}{\partial y}+\frac{\partial uv}{\partial x}+\frac{\partial wv}{\partial z}+fu+g\frac{\partial \xi}{\partial y}+\frac{1}{\rho_0}\frac{\partial p_{amt}}{\partial y}+$$
$$\frac{g}{\rho_0}\int_z^{\xi}\frac{\partial \rho}{\partial y}dz-F_y-\frac{\partial}{\partial z}\left(\upsilon_t\frac{\partial v}{\partial z}\right)-v_sS$$

Where ρ is the density, ρ_0 is a reference density, g is the gravitational acceleration, p_{atm} is the Coriolis parameter, p_{atm} is the atmospheric pressure which for simplicity is assumed constant, v_t is the vertical turbulent eddy viscosity and

$$F_x=\frac{\partial}{\partial x}\left(2v_H\frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(2v_H\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)\right)$$

The conversation equations for salinity and potential temperature can be written as

$$\frac{\partial S}{\partial t}+\frac{\partial uS}{\partial x}+\frac{\partial vS}{\partial y}+\frac{\partial wS}{\partial z}=\frac{\partial}{\partial x}\left(D_H\frac{\partial S}{\partial x}\right)$$
$$+\frac{\partial}{\partial y}\left(D_H\frac{\partial S}{\partial y}\right)_s+\frac{\partial}{\partial z}\left(D_t\frac{\partial S}{\partial z}\right)+S_{ss}$$

Where *S* is the salinity (PSU) and T is the potential temperature (°C), D_H is the horizontal turbulent diffusivity coefficient, D_t is the vertical turbulent diffusivity coefficient and S_{ss} refers to sources and sinks and Q_H refers to the heat exchange (Pietrzak et al. 2002), (DHI 2017).

2.3 Data

2.3.1 Basin data

In this research, DEM data of study area is provided by the website http://gdex.cr.usgs.gov/gdex/. SWAT is applied for dividing basin and GIS is used for digitalizing the river. After dividing, the data is displayed as shapefile of sub-basin. In this study, land use map, hydrological map, basin map and map of administration are used for calculating hydrological parameters of the river basin (Diep, Anh, and Long 2019).

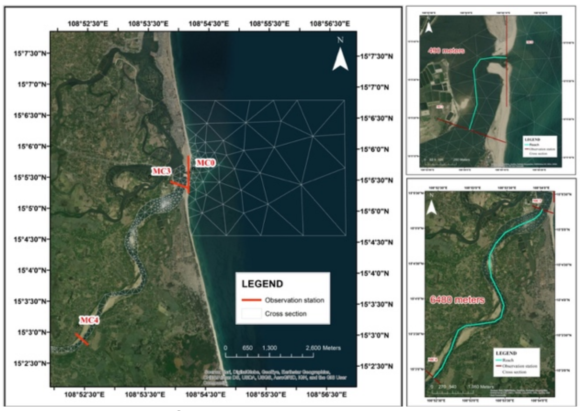


Fig. 2. Terrain of estuary, hydrological and salt intrusion measure locations at Ve estuary

Data required for running MIKE 21/3 HD in the research consist of: the first group relates to coastal area is collected, analyzed and input to MIKE21 (GEBCO 2018), the second group relates to land part and estuary including observation data of 28 cross sections which is given by the previous research (Diep, Anh, and Long 2019). The part of Ve river in this study is limited from the upstream of Cua Lo river with the length of 21.47 km (Fig. 1). The measured flow rate and salinity locations are signed MC0, MC3, MC4 with the distance between cross sections is identified to clear the scope of salt intrusion at Ve estuary (Fig. 2).

In this research, to run MIKE21/3 HD for coastal area, hydrodynamic boundary data is used. This data is taken Tide Prediction of Height tool in MIKE 21 Toolbox (.21t) in 2015, 2017, 2018 (GEBCO 2018). This data is applied for running MIKE21 HD for coastal area in scope of study.

2.3.2 Observed data

Equipment used for measurement includes: ADCP (Acoustic Doppler Current Profiler) hydroacoustic current meter; hydro leveling machine NA2 Leica: LEICA (TC805); echo sounding apparatus HONDEX PS-7; salinity meter; handheld GPS device; compass. Hydrological elements are recorded from 0 o'clock on 7th October to 23 o'clock on 8th October in particular year, 2018. Moreover, cross section and chainage level were measured from 9th October to 10th October 2018. Besides, water level, salinity factor were taken examples and measured in 24/24 hours from 0 o'clock on 7th October to 23 o'clock on 8th October 2018 in 3 cross sections: Cross section 0, 3 and 4 (Fig. 3). Water flow measured by ADCP automatic meter (US) which was conducted in 3 sections in 24/24 hours from 0 o'clock on 7th October to 23 o'clock on 8th October 2018 (happening simultaneously with measuring water level and salinity).

Fig. 3. The measurement of rectal and salinity

2.3.3 Evaluating criteria

The correlation index between simulating data and observation data are defined as the following equation:

$$\mathrm{NSE} = \frac{\sum_{i=1}^{n}\left(Q_i^{sim} - Q_i^{obs}\right)^2}{\sum_{i=1}^{n}\left(Q_i^{obs} - \overline{Q}\right)^2} \quad PBIAS = \frac{\sum_{i=1}^{n}\left(Q_i^{obs} - Q_i^{sim}\right)\times 100}{\sum_{i=1}^{n}\left(Q_i^{obs}\right)}$$

$$\mathrm{RSR} = \frac{RMSE}{STDEV_{obs}} = \frac{\sqrt{\sum_{i=1}^{n}\left(Q_i^{obs} - Q_i^{sim}\right)^2}}{\sqrt{\sum_{i=1}^{n}\left(Q_i^{obs} - \overline{Q}\right)^2}}$$

The evaluation criteria for each of the above indicators are shown in Table 1, the study (Moriasi et al. 2007) will be used in this study.

2.3.4 Setup for hydrological parameters

The steps to set up a model for making hydrological parameters are as follows: input data including topographic map (DEM), meteorological - hydrological data and land use map which are included in SWAT. The results extracted after running SWAT include the area of the sub-basins combined with rainfall data at stations in the area that continues setting to NAM (Diep, Anh, and Long 2019) to perform the step of calibrating parameters of NAM model. Using the criteria in section 2.3.3 to assess the precision of the parameter set. In order to conduct the calibrating step, from the initial parameters, NAM performed automatic calibration by testing method to increase the accuracy to a stable level with the acceptable errors. After that, the parameter set is used to calculate discharge in the next hydrodynamic module. Some results of this content are presented in (Diep, Anh, and Long 2019). The monitoring hydrological data set at An Chi station in the period of 2013 – 2015 which was used to calibrate and validate NAM. In order to assess the level of correlation, in this study, use the Nash index. The observation data collected in 2013 was used to calibrate achieve a NASH at 92%. The validation step was conducted according to the observe discharge data in 2014 and 2015 (QNG 2018), reaching NASH index of 90% and 93%, respectively. The result set of parameters selected to simulate the flow shown in Table 1 (Diep, Anh, and Long 2019).

Table 1. Parameters in MIKE NAM model

Parameter	Description	Value
U_{max}	Upper limit of the amount of water in the surface storage (mm)	17
L_{max}	upper limit of the amount of water in this storage (mm)	172
CQOF	Overland flow runoff coefficient (0≤ CQOF ≤ 1), dimensionless	0.185

TOF	Threshold value for overland flow (0≤ TOF ≤ 1)	0.531
TIF	Root zone threshold value for interflow (0≤ TIF ≤ 1)	0.114
TG	Root zone threshold value for groundwater recharge (0≤ TG ≤ 1)	0.404
CKIF	Time coefficient of surface water flow	655.8
CK12	Constant transmission time of surface water flow	19
CKBF	Constant transmission time of groundwater flow	3972

2.3.5 Setup for hydrodynamics parameters

Time series for boundary data are chosen: Time to choose for calibrating: January 1, 2015 to February 28, 2015; time for validating: March 1, 2015 to May 31, 2015, as indicated in section 2.3.2. Observed data at Tam Quan station used for calibration and validation (QNG 2018). Results of are shown in Table 2. As a result, the set of parameters selected as follows: viscosity coefficient is equal 0.28 (m^2/s), resistance coefficient is equal 30 ($m^{1/3}/s$).

Table 2. Results of calibrating and validating hydraulic models in coastal areas

	Correlation	Nash	PBIAS	RSR
Calibrate	0.916	0.988	7.323	0.460
Validate	0.919	0.991	7.933	0.490

Time series selected to calibrate and validate the hydraulic model of Ve river as follows: time for calibrating: from April 1, 2017 to April 30, 2017; time for validating from April 1, 2018 to April 4, 2018. Boundary of discharge collected from running NAM on two different time 1st to 30th in April, 2017 and 1st to 30th in April, 2018. The boundary (water level) is extracted from the hydraulic module running for the marine area described in section 2.3.5 of this paper. The measurement data used to calibrate and validate the model is data in the form of time series for measuring the water level at Song Ve station (QNG 2018) (1 hour for each step). The result of this section is to select the parameter set of viscosity coefficient equal to 0.28 and roughness coefficient (Manning) at 32 $m^{1/3}/s$. Results of calibration and verification are shown in Table 2 based on (Moriasi et al. 2007) it can conclude that the results are reliable.

Time series selected to calibrate and validate the hydraulic model of Ve river as follows: time for calibrating: from April 1, 2017 to April 30, 2017; time for validating from April 1, 2018 to April 4, 2018. Boundary of discharge collected from running NAM on two different time 1st to 30th in April, 2017 and 1st to 30th in April, 2018. The boundary (water level) is extracted from the hydraulic module running for the marine area described in section 2.3.5 of this paper. The measurement data used to calibrate and validate the model is data in the form of time series for measuring the water level at Song Ve station (QNG 2018) (1 hour for each step). The result of this section is to select the parameter set of viscosity coefficient equal to 0.28 and roughness coefficient (Manning) is equal 32 $m^{1/3}/s$. Results of calibration and validation are shown in Table 3. Based on (Moriasi et al. 2007) it can conclude that the results are reliable.

Table 3. Results of calibrating and validating hydraulic models in the area Ve river

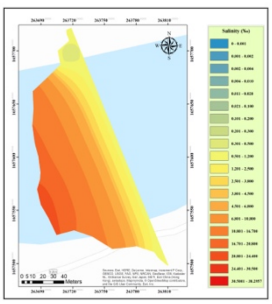
	Correlation	Nash	PBIAS	RSR
Calibrate	0.939	0.970	-2.290	0.490
Validate	0.901	0.953	-16.763	0.490

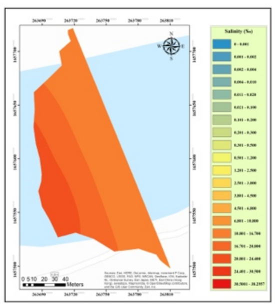
3. Results and Discussion

Based on measurement data and simulating results in the above section, this section analyzes the salt intrusion mechanism and validate the results of salt intrusion simulated by using MIKE21 AD model. Then simulating and forecasting of salt intrusion of the Ve river and take care of climate change scenarios RCP4.5 and RCP8.5.

3.1 Salt intrusion mechanism

The hydrological measurement and salinity factors according to the 24/24 regime from 0 o'clock on October 7 to 23 o'clock on October 8 in 2018 in all 3 sections: section 0, section 3 and section 4 (Fig. 2) used to validate two models that are hydraulic model and saline transmission model. The measurement data used to calibrate and validate the model is data in the form of time series for measuring the water level at Song Ve station (QNG 2018) (1 hour for each step). The result of this section is to select the parameter set of viscosity coefficient equal to 0.28 and roughness coefficient (Manning) at 32 $m^{1/3}/s$. Each section took 3 samples with different depths representing surface water, middle layer and the bottom layer. The output results allow the determination of the saline transmission mechanism. Results of salinity intrusion from the sea to the river are shown in Fig. 4, 5.





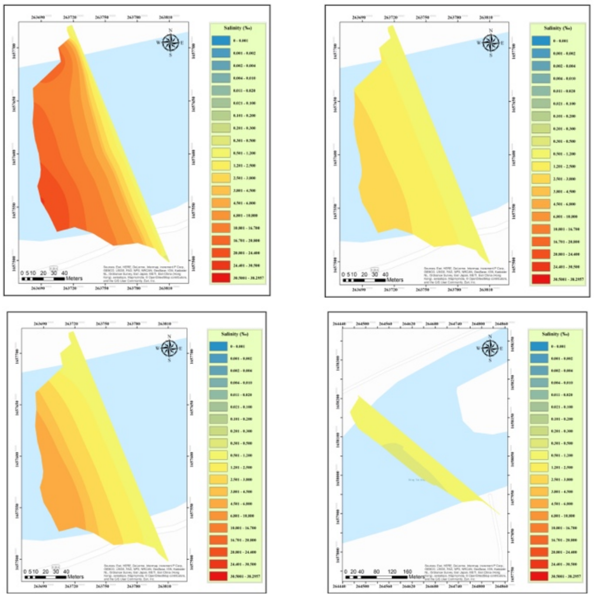
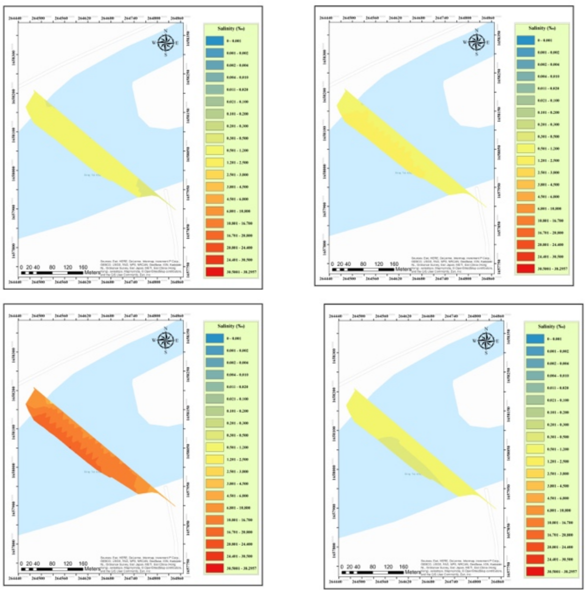


Fig. 4. Results of salinity measurement at cross section MC0 on October 7, 2018 with 4-hour time step

At the cross section MC0, on October 7 salinity tends to increase over time from 1 to 5 o'clock (average salinity at 0 o'clock is $5^0/_{00}$ and at 5 o'clock is $14.71^0/_{00}$), then decreasing in the time of 5 o'clock to 7 o 'clock (from $14.71^0/_{00}$ down to $7.04^0/_{00}$ at 7 o'clock). At 7 to 9 o'clock salinity increase from $7.04^0/_{00}$ to $13.49^0/_{00}$ .At 9 to 12 o'clock salinity tends to have downward trend that declines from 13.49 to 1.49 and keep stable from 12 to 17 o'clock. From 17 to 22 o'clock salinity tends to increase from 1.03 to 13.5. From 22h on October 7 to 2h on October 8 the value of salinity declines from 13.5 to 1.65.



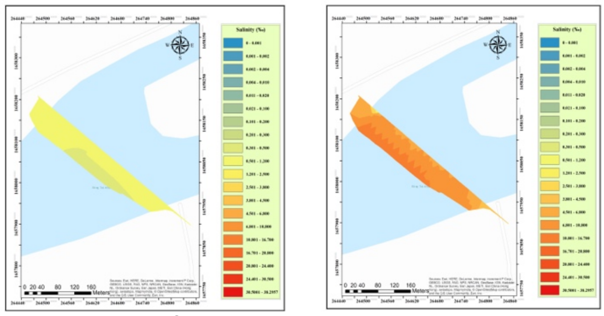


Fig. 5. Results of salinity measurement at cross section MC3 on October 7, 2018 with 4-hour time step

3.2 Validating results of salt intrusion simulation

Monitoring data of salinity measurement according to the 24/24 regime from 0h on October 7 to 23h on October 8 in 2018 in all 3 sections: section 0, section 3 and section 4 (Fig. 2) are available that are used to test both hydraulic model and saline propagation. The results are shown in Fig. 6, 7 in graph form with Nash coefficient and correlation coefficient greater than 0.7 and Fig. 8 and Fig. 9 results in spatial distribution.

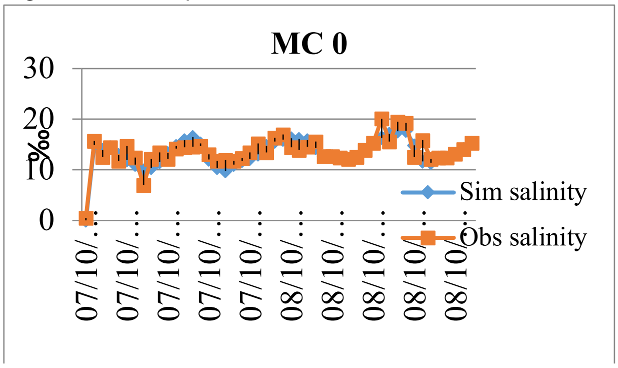


Fig.6. The results of salinity concentration between measured value and simulating value at cross section MC0.

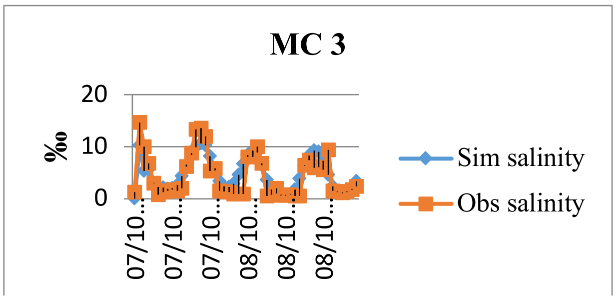


Fig.7. The result of salinity concentration between measured value and simulating value at cross section MC3.

The results of salinity concentration between measured value and simulating value at cross section MC0 with Nash coefficient equal to 0.728 and correlation coefficient equal to 0.749. The result of salinity

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concentration between measured value and simulating value at cross section MC3 with Nash coefficient equal to 0.719 and correlation coefficient equal to 0.733. The result of salinity concentration between measured value and simulating value at cross section MC4 with Nash coefficient equal to 0.728 and correlation coefficient equal to 0.752.

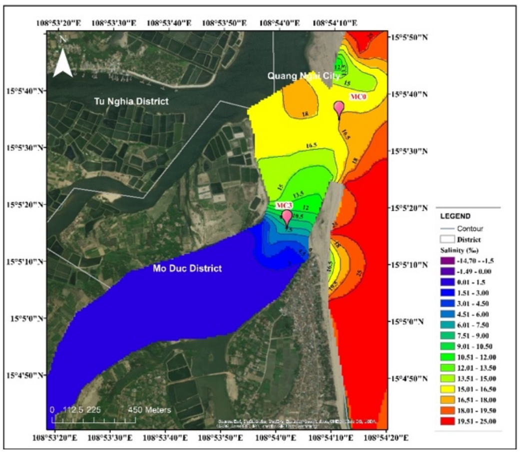

Fig. 8. Simulation results of saline intrusion at 14:00 on October 7, 2019.

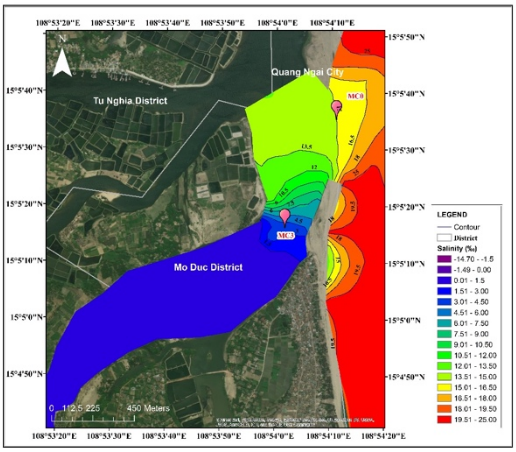

Fig. 9. Simulation results of saline intrusion at 22:00 on October 7, 2019.

Simulation results show that, at 14:00 on 2030/10/07, high tidal, at 14:00 on 2018/10/07, the scope of salinity is 500m, the concentration at MC0 is 16‰ and decreases to 7.5‰ at MC3; when the scope reaches 800m, the concentration is 3‰. Then, the saline intrusion continues to go in North direction to 1.9 km and the concentration is very low (0.02‰). At 22:00, in low tidal time, MC0 views a 500m salinity with the concentration at 15‰. At MC3, the concentration is 3‰, and 200m farther, the concentration is only 0,02‰ – approximately zero. The difference between two tidal times (14:00 and 22:00) is the range of concentration from 16‰ to 1.5‰, declining 100m.

3.3 Climate change scenario

Climate change and sea level rise scenarios in Vietnam were established and published in 2016 by Vietnam Ministry of Natural Resources and Environment - MONRE (MONTRE 2016). These two scenarios based on the Fifth Assessment Report (AR5). In this subsection, the climate change senario was used for Quang Ngai province, with the sea level rise data. The result simulates salt intrusion for PCP4.5 scenario, which are displayed in Fig. 10, 11 and Fig. 12,13 are the results of PCP8.5 scenario.

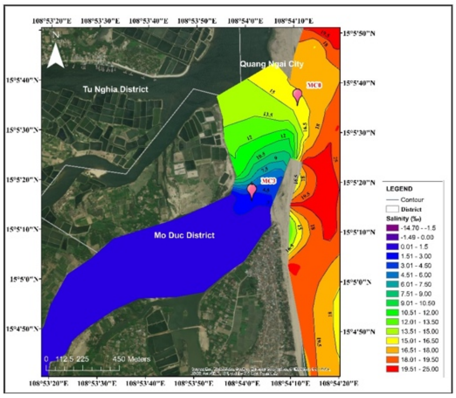

Fig.10. Simulation of saline intrusion at 14:00 following PCP4.5 scenario on 2030/10/07.

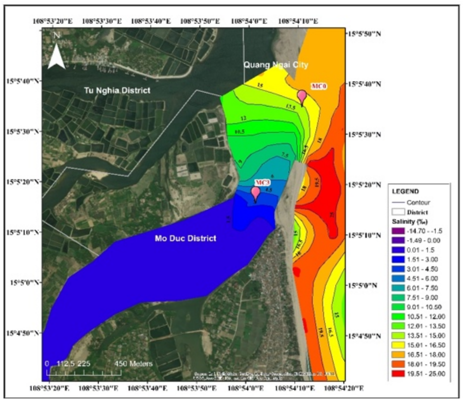

Fig.11.Simulation of saline intrusion at 22:00 following PCP4.5 scenario on 2030/10/07.

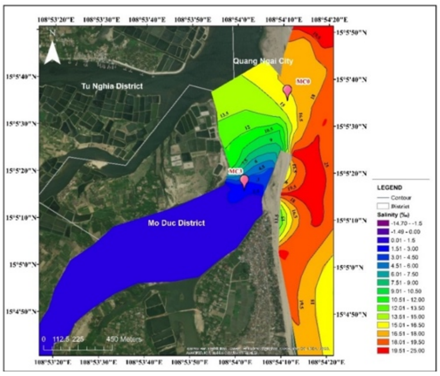

Fig.12. Simulation of saline intrusion at 14:00 following PCP8.5 scenario on 2030/10/07.

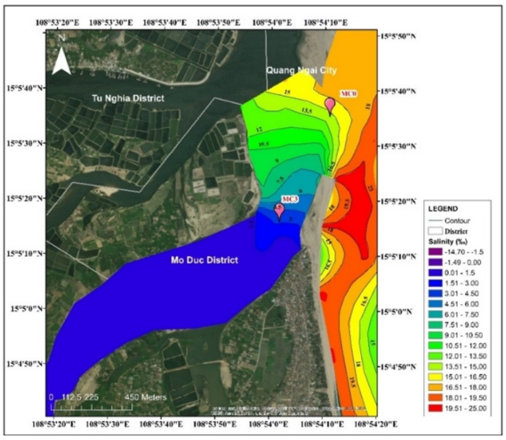

Fig.13. Simulation of saline intrusion at 22:00 following PCP8.5 scenario on 2030/10/07.

According to the result from simulation of saline intrusion based on PCP4.5 scenario, at 14:00 on 2030/10/07, the salinity area is 500m. There is a decrease of concentration from 16‰ at MC0 to 3‰ at MC3. At 22:00, low tidal, at MC0 the concentration is 13.5‰ with the length of 500 m, at MC3, the concentration is 3‰. In this scenario, at 14:00, the concentration at estuary is 16‰ and saline intrusion scope is 820m, concentration declines to 1,5 ‰. From that, salinity comes more 2.1km, the concentration decreases continuously to 0,02 ‰ and be stable at this value. At 22:00, the area is 650m and concentration goes down from 13.5 ‰ to 1.5‰; the area increases to 1.5km the concentration is 0,02‰.

The simulation of PCP8.5 scenario shows that, at 14:00 on 2030/10/07, when tidal rises, salinity comes from the sea and transports up to 500m, concentration decreases from 16‰ at location MC0 to 2.5‰ at location MC3. At 22:00, in low tidal condition, the saline intrusion changed. At MC0, concentration is 13.5‰ (at 500m), at MC3. PCP8.5 expresses a result: at the similar time with the two others scenarios, the saline area increase up to 770m with the decrease in concentration from 16,5‰ to 1,5‰. Then, the area increase to 2km and the concentration declines to 0,02‰. At 22:00, the saline intrusion area is 700m and 1.5km, respectively with the similar concentration to 14:00.

3.4 Discussion

Comparing the results of scenarios, at 14:00, the high tidal leads to the largest scope of salt intrusion with total length is 2.92km in PCP4.5 scenario while current scenario has 2.7km length and PCP8.5 has 2.77km length. However, in low tidal, PCP4.5 shows the smallest result with only 2.15km is salinity while that value of current scenario is 2.6km and PCP8.5 reaches 2.35km. In both high and low tidal, PCP8.5 is in the middle, between PCP4.5 and current scenario.

4. Conclusion

This research applied a system of SWAT/NAM in establishing hydrological parameters which is suitable to Ve river, Quang Ngai. The hydrological observed data is used for calibration and validation. Then, the calibrated hydrological parameters take the responsibility in creating time series parameter to build the boundary for model. In saline simulation, this study used measured hydrodynamic and hydrological data for calibrating and validating and building the parameters for Ve river. Authors finished simulating salinity at Ve estuary in both space and time via MIKE21 AD. The result was compared with observed data and Nash index is 0.7.

Following the climate change senarios PCP4.5 and PCP8.5, provided by MONRE, Vietnam, authors calculated salinity in Ve river. The results according to two future senarios are compared with current senarios. It is a clear evidence shows that in PCP4.5 the highest saline scope is belonged to high tide, on contrast when the tidal goes down, the saline area is smallest. In PCP8.5, the saline scope is average.

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