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A Study of the Calibration of Salinity Dispersion in the Thachin Estuarine

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Abstract: *This paper presents guidelines for the MIKE11 model calibration on the salinity dispersion in the Thachin River caused by the intrusion of salt water in estuaries. MIKE11 is chosen for simulating flow circulation and salinity dispersion. The data in the period of 2010 was selected in this study. The upstream boundary condition is flow rate of daily time series in the Phophaya regulator and the downstream boundary condition is tidal water level in the river mouth. To calibrate, the data obtained from observe of water quality monitoring stations with TC04 station which has a distance of 16 km from the river mouth to this station in order to compare salinity values with the model results. Regarding to salinity dispersion analysis that define the downstream salinity is the salinity of brackish water from the mixing of fresh water and sea water is equal to the value obtained from the estuary was 21.4 ppt. The study found that the dispersion coefficient is equal to 400 square meters per second and gave the best statistical methods of R2 ,NSE, and RMSE are0.9987, 0.9875, and* 0.2274*ppt respectively. That is reasonable to around the Thachin River such as Chaophaya River and Maeklong River.*

Keywords: *MIKE* 11 *Model, Dispersion Model, Salinity Dispersion*

1. INTRODUCTION

Thachin River basin is an important watershed in the central of Thailand that is a minor from the Chao Phraya River. The basin is used in industry, agriculture, fisheries and others irrigation. In the past the Thachin River is a river that has plenty that able nourished the rice areas, plantation, and farm in the riverside area as well as including as food sources and water transportation.

The degradation of water quality and the intrusion of salinity in the Thachin River, especially in the lower of the river before drained into the Gulf of Thailand is a problem that is becoming ever more serious. Because, it has a direct impact on the utilization of the waters and ecosystems will be a problem since the area of above the beach. The first problem is the shortage of fresh water for farming during the dry season there is not enough water to meet the needs of farmers. The next is the intrusion of salinity into the Thachin River a longer distance [1]. Especially during the dry season (from January to May) the salinity intrusion is increasing due to shortage of fresh water to push salt water away.The problem above will be affected to people and the environment around it. Therefore, that is necessary to study the salinity intrusion in the Thachin River which has complex is very much. And the current, the development of the program has progressed very convenient to simulate water quality with the application of mathematical models. The modeling and simulation is necessary to calibrate the model to parameters such as diffusion coefficient to the river to form the basis for the bringing of the parameters to be used to confirm the model further.

Fig. 1. Topography of the Thachin basin

Thus, this study aims to study the calibration parameters of diffusion coefficient of the model to the water quality of the river under the influence of tidal effect.

2. STUDY AREA

The Thachin River is used in the study starting from Phophraya regulator at Suphanburi up to the river mouth at Samutsakhon province at a total distance of 202 kilometers. The Thachin River is a single branch that flows through the Thachin basin.

The river has a slope at the upper part and is flat at the lower part because the topography is a plain and slope from north to south direction. Most areas are paddy fields, orchards, and vegetable gardens and fish ponds with wetlands and mangroves that are sporadic areas where the sea reaches [1] as shown in Figure 1.

3. DATA COLLECTION AND MODEL CALIBRATION INDICATOR

3.1 DATA COLLECTION

Data collection is consisted of

1. Hydrological data, including flow rates, daily water level on the Pho Phraya regulator and at the main regulator in the river as shown in Figure 2, which was collected in 2010 from the Royal Irrigation Department.
2. The physical characteristics data of the river including a cross-section, which has a total of 209 sections, which was collected from the Royal Irrigation Department.
3. Sea level at the mouth of the Thachin River in the year 2010, which collected hourly from the Marine Department.
4. Data monitoring of water quality in the Thachin River in 2010, which is collected by the Pollution Control Department as shown in Figure 3.

3.2 MODEL CALIBRATION INDICATOR

The calibrated model will be used for statistical comparisons and decisions are represented.

Accuracy is a Root mean square error (RMSE), which is calculated using the equation.

$$RMSE=\sqrt{\frac{\sum(x-y)^2}{n}} \tag{1}$$

The results of the estimation method, goodness-of-fit with the parameter coefficient of determination (R^2) and Nash coefficient (E) which is calculated using the equation.

$$R^2=\left(\frac{\sum_{i=1}^{n}\left(x_i-\bar{x}\right)\left(y_i-\bar{y}\right)}{\sum_{i=1}^{n}\left(x_i-\bar{x}\right)^2\times\sum_{i=1}^{n}\left(y_i-\bar{y}\right)^2}\right)^2 \tag{2}$$

$$NSE=1.0-\frac{\sum_{i=1}^{n}(x_i-y_i)^2}{\sum_{i=1}^{n}\left(x_i-\bar{x}\right)^2} \tag{3}$$

Where y = the water level of the model

x = the water level of the measurement

$\bar{y}$ = average water level of the model

$\bar{x}$ = average water level of the measurement

i = Sequence data

n = number of data

Acceptable values of the test statistic RMSE and Nash coefficient (NSE) be the minimum value (close to 0) and the coefficient of determination (R^2) is close to 1 [2].

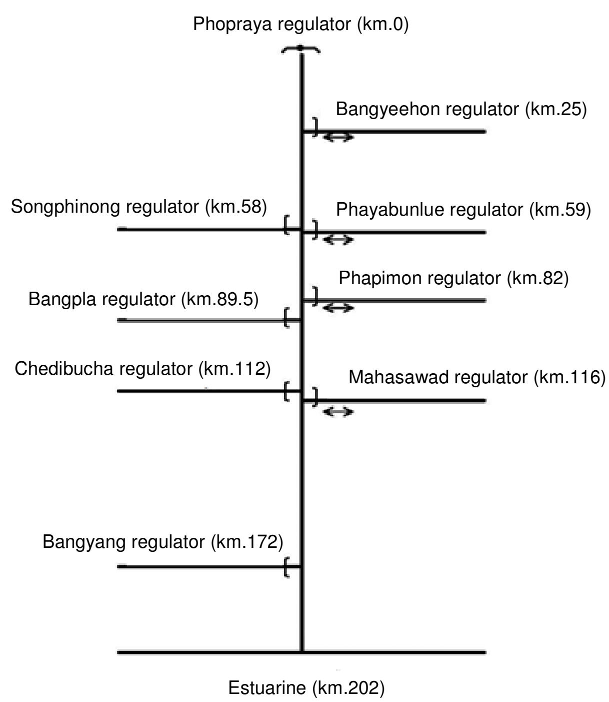

Fig. 2. Main regulator in the Thachin River

4. MATERIALS AND METHODS

4.1 MATHEMATICAL MODELS

The model used in this study is MIKE11-HD / AD. This model was developed by DHI Water Environment and Health. It can simulate the flow in one dimension and simulates the Advection-Dispersion in the river as well (DHI, 1995) and has been applied in many basins of the country. For example, the Thachin Basin [3] Upper Ping Basin[4], and the Bangpakong Basin [5].

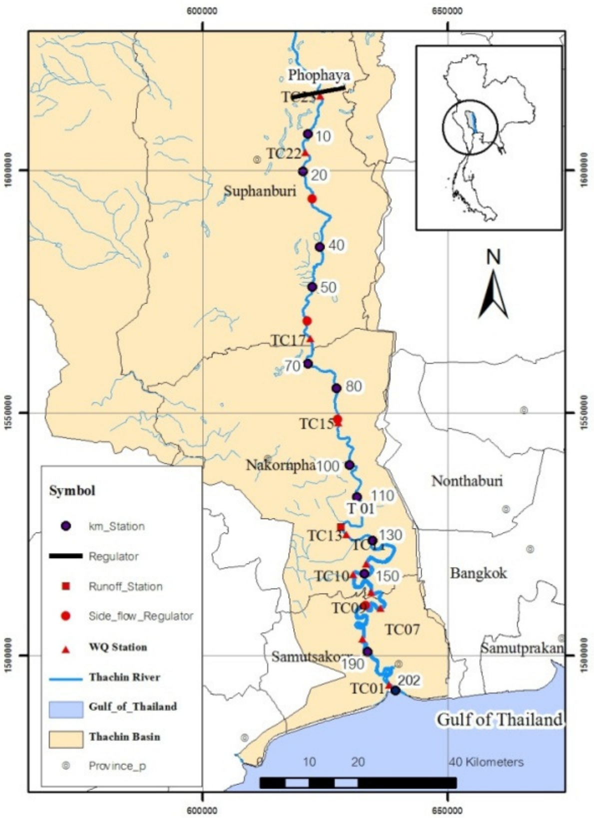

Fig. 3. Locations of water quality monitoring stations

MIKE11-HD, Hydrodynamic Module

Calculation of hydrodynamic in one-dimensional flow is important in the theory of mass conservations, which can be written as the following equation.

$$\frac{\partial Q}{\partial x}+\frac{\partial A}{\partial t}=0 \qquad (4)$$

$$\frac{\partial Q}{\partial t}+\frac{2\partial}{A}\frac{\partial Q}{\partial x}+\left(g\frac{A}{B}-\frac{Q^2}{A^2}\right)\frac{\partial A}{\partial x}+gA\left(S_f-S_0\right)=0 \qquad (5)$$

When Q is flow rate, A is the area of the river, t is the time, x is the distance, B is the width of the channel, g is the acceleration of gravity, S_f is the friction slope, S_o is the slope of bed river.

Advection-Dispersion Module

Advection-Dispersion model explains the mechanism of mass transport in the river in two transport mechanisms 1) Adventive (or convective) transport with the mean flow and 2) Dispersive transport due to concentrations gradients.

In the simulation of mass transport, the mass conservations are used in one-dimensional. This model uses flow rate, water level, cross-section, and hydraulic radius of the MIKE11-HD.

$$\frac{\partial AC}{\partial t}+\frac{\partial QC}{\partial x}+\frac{\partial}{\partial x}\left(AD_f\frac{\partial C}{\partial x}\right)=-AKC+C_S.q \qquad (6)$$

Where C is the concentration, D is the dispersion coefficient, A is the cross-sectional area, K is the linear decay coefficient, C_S is the source/sink concentration, q is the lateral inflow, x is the space coordinate and t is the time coordinate.

Model calibration

For parameters of the AD Module in the calibration is diffusion coefficient. The calibration is used until the concentration of mass calculated by the model is similar to the data collected from the observed. The study was simulated to calibrate the salinity dispersion and considering the daily flow at Pho Phraya regulator is upstream boundary conditions and changing in sea level at the mouth of the Thachin River is the downstream boundary conditions. The data collected of water quality at stations TC04 is used to calibration, which is 16 kilometers distance from the river mouth. The salinity of estuaries, the salinity of sea water is obtained from has the highest salinity estuary of 21.4 ppt.

In the study will be calibrated the model to find the diffusion coefficient (D_f) by varying the values D_f at 300 400 500, and 1000 m^2 / s. The results of a study using a representative statistical data to compare and decide contain.

5. RESULTS AND DISCUSSION

The calibrated MIKE11-AD model uses observed data of salinity at station TC04 (km 186) from Pollution Control Department. It is located at MuangSakhon at a distance of 16 kilometers from the mouth of the river to make a comparison with the salinity of the model. The diffusion coefficient of variation (D_f) is 300 - 1000 m^2 / s. The results showed that the D_f suitable to the Thachin River is equal to 400 m2 / s which is the best statistical indexes for the decision, including R^2, NSE, and RMSE, equal to 0.9987, 0.9875, and 0.2274 ppt respectively, as shown in Figure 4 and Table 1.

From the model calibration is founded the diffusion coefficient in the Thachin River is equal to 400 m^2 / s. That is reasonable to around the Thachin River such as Chaophaya River and Maeklong River, as shown in Figure 5. The study of [6] founded diffusion coefficient in the Chaophaya River is equal to 400 m^2 / s also. However, the study of [6] includes the time because the diffusion coefficient for a river varies with location as well as time. And the study of [7] founded diffusion coefficient in the Maekolng River is equal to 300 – 1,200 m^2 / s in the lower part of that river.

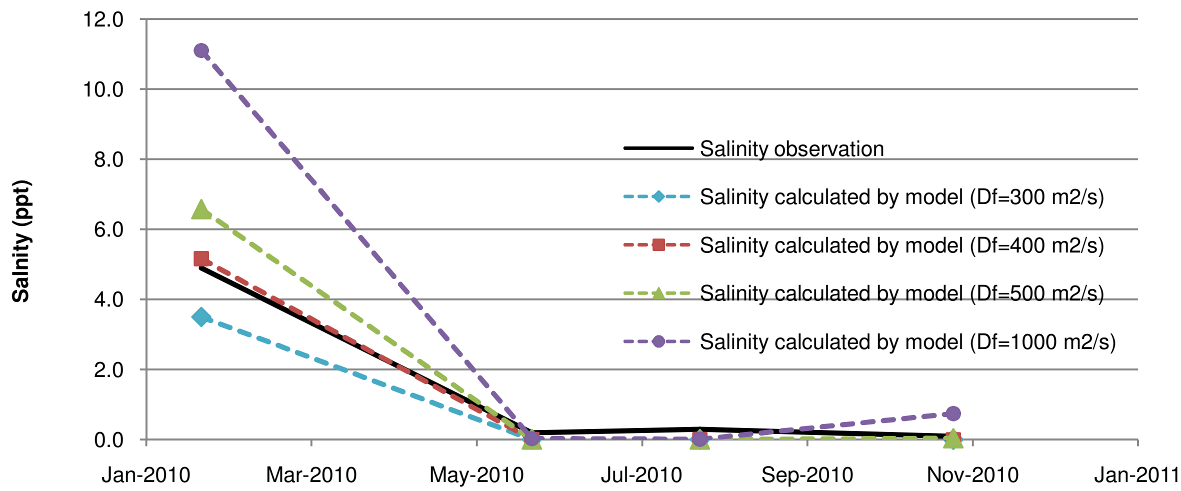

Fig. 4. Comparison of salinity at the TC04 station

TABLE 1: Comparisons of model calibration of salinity at TC04 station (km.186)

Diffusion coefficient	Statistical measures		
	R^2	RMSE	NSE
D_f = 300	0.9988	0.7216	0.8744
D_f = 400	0.9987	0.2274	0.9875
D_f = 500	0.9984	0.8592	0.8220
D_f = 1000	0.9911	3.1275	-1.3587

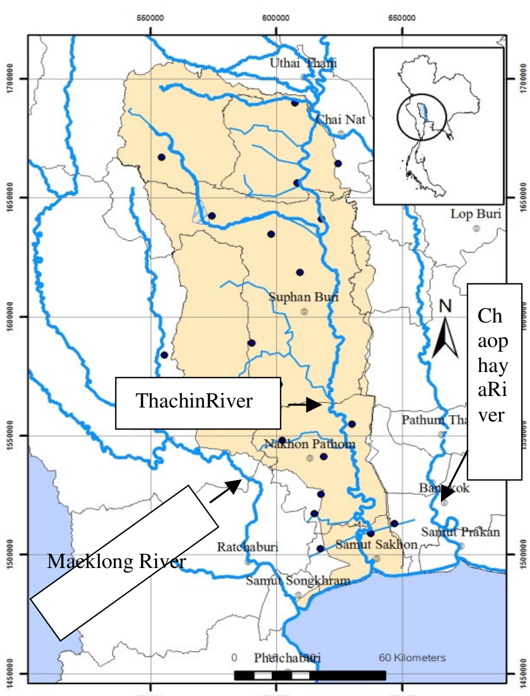

Fig. 5. The river around the Thachin River

6. CONCLUSIONS

The model calibration is determined the suitable of diffusion coefficient in the Thachin River is equal to 400 m^2/s which is the best statistical indexes for the decision, including R^2, NSE, and RMSE, equal to 0.9987, 0.9875, and 0.2274 ppt respectively. However, this study is selected TC04 for calibration only station that made diffusion coefficient some discrepancy and the time as a result in a discrepancy also. Because in the time of spring tide and neap tide as a result the salinity in river mount is different. Therefor in the simulation for calibration of diffusion coefficient should be consider all effect above.

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