Irrigation Water Management Strategies for Salinity Control in the Chao Phraya River Using Sualyev Finite Difference Method With Lagrange Interpolation Technique

Pornpon Othata, and Nopparat Pochai

***Abstract*—The problem of salinity in tap water is a very important problem. Drinking water that is higher than the World Health Organization designation can greatly affect people's health. In this research, a salinity management model is also applied in a river with a dam with an interpolation process for initial and boundary conditions. An unconditionally stable explicit finite difference scheme with the Lagrange interpolating polynomials for the initial and boundary conditions is utilized to estimate the saltiness level with a few conditions of a proposed model. The suggested computational technique allows for a clear consensus on the effects of realistic implementations for water supply processes.**

***Index Terms*—Salinity, Barrage dam, Water quality, Interpolation method, Sualyev method**

I. Introduction

To supply tap water, water supply frameworks may utilize surface water or crude water. The salinity of the water is an important aspect impacting the quality of the water. As it can not be processed in the traditional way, this is a very critical factor in production. As such, it is required to have a salinity level to bring the water to the treatment process.

Thailand's Waterworks Authority has seven observation stations for water quality located along a river. Distance from the estuary of each station as appeared in Table 1.

TABLE I
Distance from the estuary of each observation stations

Stations	Distance
S_1	0
S_2	12
S_3	23
S_4	52
S_5	79
S_6	84
S_7	90

In Bangkok, the water supply handle for use includes a water saltiness issue above the norm. It has a salinity up to standard that impacts the quality of water generated. By measuring the salinity as of December 14, 2019 and December 25, 2019, the salinity value is as appeared in the table 2.

P. Othata is a PhD candidate of Department of Applied Mathematics, Faculty of Science, King Mongkuts Institute of Technology Ladkrabang, Bangkok, 10520, Thailand (e-mail: pornpon.othata@gmail.com).

N. Pochai is an Assistant Professor of Department of Applied Mathematics, Faculty of Science, King Mongkuts Institute of Technology Ladkrabang, Bangkok, 10520, Thailand (corresponding author to provide phone: 662-329-8400; fax: 662-329-8400; e-mail: nop_math@yahoo.com).

TABLE II
The salinity as of December 14, 2019 and December 25, 2019

Stations	Salinity level at 14/12/2019	Salinity level at 25/12/2019
S_1	24.74	23.78
S_2	19.64	18.72
S_3	14.6	17.34
S_4	8.82	11.72
S_5	3.99	5.79
S_6	0.25	1.73
S_7	0.2	0.79

At present, the pumping station has an excess of salinity, which affects the quality of tap water in Bangkok. This impacts the quality of water produced.

In [1], the finite difference method was utilized to explain water contamination models. In [13], the interpolation method was utilized to initial and boundary conditions. In [20] and [21], the three dimension advection diffusion model was proposed. In [18], the water pollution model was introduced. In [14], the implicit finite difference method was to solve the water pollution model. In [16], [17] and [19], the fluid flow model was proposed. In [15], the numerical method was used to solve the fluid flow problem. Research reports on the effect of salt drinking water on standards have been undertaken, such as [6]. The water was excessively salty, up to levels that influence the body. In this way, look into has been introduced on the expansion of salt water, for example, [7]. In [8], the one-dimensional salinity water was proposed,

$$A(x)\frac{\partial S}{\partial t} + Q(x,t)\frac{\partial S}{\partial x} = \frac{\partial}{\partial x}\left[A(x)D_x\frac{\partial S}{\partial x}\right], \tag{1}$$

where $A(x)$ is the river cross-sectional area (m^2), $Q(x,t)$ is flow rates (m^3/s), The coefficient of water diffusion is D_x (m^2/s), S is water salinity level (ppt), x is the length of river (m) and t is times (s)

To solve this problem, a salinity management model is also introduced in a river with a barrage dam with an interpolation process suggested for the initial and boundary conditions. Under a few conditions from the suggested model, the Sualyev scheme is used to estimate the saltiness level. The suggested evaluation method for water supply forms can be used in reasonable circumstances.

II. Governing equations

2.1 One-dimensional salinity water measurement model

The fluid one-dimensional advection-dispersion equation is the governing equation in the salinity dispersion model.

Simpler representation, The equation is measured over the waters, as appeared in [11]

$$\frac{\partial c}{\partial t} + u(x,t)\frac{\partial c}{\partial x} = D\frac{\partial^2 c}{\partial x^2}, \tag{2}$$

where $(x,t) \in [0,L] \times [0,T]$, u is the speed of the salinity flow and D is coefficient of diffusion.

Expecting that the saltiness is weakened by the fresh water. These are then the saltiness shift in weather conditions level is decreased by the fresh water speed. The rate of fresh water efficiency to weaken saltiness is accepted by $k \in [0,1]$. In [11], the model for salinity problem was proposed

$$\frac{\partial c}{\partial t} + (u_s - ku_w)\frac{\partial c}{\partial x} = D_s\frac{\partial^2 c}{\partial x^2}, \tag{3}$$

where $c(x,t)$ is the salinity level of water(kg/m^3), k is the efficiency rate of water salinity removal, u_s is the salinity water advective velocity (m/s) and u_w is the velocity of fresh water flow

2.2 Initial conditions

A Lagrange interpolating polynomials of the salinity data of Chao Phraya River is defined as the initial condition, along 90 km of the river form the estuary is taken into consideration using salinity data, defined by

$$c(x,0) = f(x), \tag{4}$$

where $x \in [0,L]$ and $f(x)$ is a measured salinity data interpolation function.

2.3 Left boundary condition

The left boundary condition is a Lagrange interpolating polynomials of the raw data measured, dependent on the river's salinity at the first station, defined by

$$c(0,t) = g(t), \tag{5}$$

where $t \in [0,T]$ and $g(t)$ is a given Lagrange interpolating polynomials at the first observation station via calculated salinity data.

2.4 Right boundary condition

The right boundary condition were determined by the change in salinity at the last station, defined by

$$\frac{\partial c}{\partial x} = C_R, \tag{6}$$

where $t \in [0,T]$ and C_R is an estimated the rate of change of the water salinity level at the last station.

III. Numerical technique

3.1 Lagrange interpolating polynomial

The problem of evaluating the first degree polynomials that passes through the (x_0,y_0) separate points (x_0,y_0) and (x_1,y_1) is the same as estimating a f function for which $f(x_0) = y0$ and $f(x_1) = y1$ by means of a first degree polynomial interpolation at the specified points with the values of f. Using this polynomial for approximation is called polynomial interpolation within the interval provided by the endpoints. Define the functions

$$L_0(x) = \frac{x - x_1}{x_0 - x_1}, \;\; L_1(x) = \frac{x - x_0}{x_1 - x_0}, \tag{7}$$

The linear Lagrange interpolating polynomial through (x_0,y_0) and (x_1,y_1) is

$$\begin{aligned} P_n(x) &= L_0(x)f(x_0) + L_1(x)f(x_1) \\ &= \frac{x - x_1}{x_0 - x_1}f(x_0) + \frac{x - x_0}{x_1 - x_0}f(x_1). \end{aligned} \tag{8}$$

Note that

$$L_0(x_0) = 1, \;\; L_0(x_1) = 0, \;\; L_1(x_0) = 0, \;\; L_1(x_1) = 1, \tag{9}$$

which implies that

$$\begin{aligned} P(x_0) &= 1 \cdot f(x_0) + 0 \cdot f(x_1) = f(x_0) = y_0, \\ P(x_1) &= 0 \cdot f(x_0) + 1 \cdot f(x_1) = f(x_1) = y_1. \end{aligned} \tag{10}$$

Then, P is the most unique polynomial of degree that passes through (x_0,y_0) and (x_1,y_1). In this case, we construct first, for every $k = 0,1,2,...,n$, a function $L_{n,k}(x) = 1$ with the property that $L_{n,k}(x_i) = 0$ when $i \neq k$ and $L_{n,k}(x) = 1$. To satisfy $L_{n,k}(x_i) = 0$ for each $i \neq k$,it is required that the numerator of $L_{n,k}(x)$ includes the term $(x - x_0)(x - x_1)...(x - x_{k-1})(x - x_{k+1})...(x - x_n)$.

To satisfy $L_{n,k}(x) = 1$, The $L_{n,k}(x)$ denominator must be the same term but must be valued at $x = x_k$. Thus,

$$\begin{aligned} &L_{n,k}(x) \\ &= \frac{(x - x_0)\dots(x - x_{k-1})(x - x_{k+1})\dots(x - x_n)}{(x_k - x_0)\dots(x_k - x_{k-1})(x_k - x_{k+1})\dots(x_k - x_n)} \end{aligned} \tag{11}$$

Theorem 1. *If $x_0, x_1, ..., x_n$ are $n+1$ distinct numbers and f is a function whose values are given at these numbers, then a unique polynomial $P(x)$ of degree at most n exists with $f(x_k) = P(x_k)$, for each $k = 0,1,...,n$.*

This polynomial is given by

$$\begin{aligned} P(x) &= f(x_0)L_{n,0}(x) + ... + f(x_n)L_{n,n}(x) \\ &= \sum_{k=0}^{n} f(x_k)L_{n,k}(x), \end{aligned} \tag{12}$$

where, for each $k = 0,1,...,n$,

$$L_{n,k}(x) = \prod_{i=0, i\neq k}^{n} \frac{(x - x_i)}{(x_k - x_i)}, \tag{13}$$

We can write $L_{n,k}(x)$ simply as $L_k(x)$ when there is no doubt as to the degree.

The approximation error of Lagrange interpolation polynomial is $\left|P(x) - \tilde{f}(x)\right|$, where $\tilde{f}(x)$ is the polynomial interpolating.

3.2 Saulyev scheme

The Saulyev scheme is unconditionally stable [2]. Obviously the non strictly dependability prerequisite of Saulyev scheme is the principle of preferred position and conservative to utilize. Taking the Saulyev scheme into Eq.(3), it appears to have the following discretization:

$$c(x_m, t_n) \cong C_m^n, \tag{14}$$

$$\left.\frac{\partial c}{\partial t}\right|_{(x_m,t_n)} \cong \frac{C_m^{n+1} - C_m^n}{\Delta t}, \tag{15}$$

$$\left.\frac{\partial c}{\partial x}\right|_{(x_m,t_n)} \cong \frac{C_{m+1}^n - C_{m-1}^{n+1}}{2\Delta x}, \tag{16}$$

$$\left.\frac{\partial^2 c}{\partial x^2}\right|_{(x_m,t_n)} \cong \frac{C_{m+1}^n - C_m^n - C_m^{n+1} + C_{m-1}^{n+1}}{(\Delta x)^2}, \tag{17}$$

$$u_{s_m}^n \cong u_m^n, \tag{18}$$

$$u_{w_m}^n = u_w(x_m, t_n). \tag{19}$$

Substituting Eqs.(14-19) into Eq.(3), We obtain the equation of finite difference,

$$\frac{C_m^{n+1} - C_m^n}{\Delta t} + (u_{s_m}^n - k u_{w_m}^n)\left(\frac{C_{m+1}^n - C_{m-1}^{n+1}}{2\Delta x}\right) = D_s\left(\frac{C_{m+1}^n - C_m^n - C_m^{n+1} + C_{m-1}^{n+1}}{(\Delta x)^2}\right). \tag{20}$$

The explicit equation of finite difference then becomes

$$C_{m+1}^{n+1} = \left(\frac{1}{1+\lambda}\right)\left[\left(\lambda + \frac{1}{2}r_m^n\right)C_{m-1}^{n+1} + (1-\lambda)C_m^n + \left(\lambda - \frac{1}{2}r_m^n\right)C_{m+1}^n\right]. \tag{21}$$

where $i = 1, 2, 3, ..., M-1$, $\lambda = \frac{D_s \Delta t}{(\Delta x)^2}$ and $r_m^n = \frac{(u_{s_m}^n - k u_{w_m}^n)\Delta t}{\Delta x}$. For $i = M$, replaced the unknown value in Eq.(5), we obtain

$$C_{M+1}^n = \left(\frac{C_{M_2}^n - C_{M_1}^n}{L_2 - L_1}\right)\Delta x + C_{M-1}^n. \tag{22}$$

The truncation error of Sualyev scheme is $O\left\{(\Delta x)^2 + (\Delta t)^2 + (\Delta t/\Delta x)^2\right\}$.

IV. Numerical simulations

4.1. Simulation 1 : Interpolation for the initial condition and left boundary conditions.

The observation stations with 90 km along the river and data on salinity level are considered, as appeared in Table 1 and Table 2 respectively. We simulated the boundary and initial conditions by using Eq.(7-8). The comparison of interpolation of boundary and initial condition with the measuring salinity data as appeared in Fig 1-2 respectively.

4.2. Simulation 2 : the spread of salinity water into rivers.

We will to find the approximate solution of Eq.(3) for all observation stations with 90 km along the river, as appeared in Table 1. Provided that saltiness water coefficient of diffusion is 0.1 m^2/s, the speed of saltiness water flow $u_s = 0.06\ m/s$, the efficiency of eliminating salinity of fresh water discharge is $k = 30\%$, and time of simulation is 9 days. The physical parameters are appeared in Table 3. The approximate solution of salinity along the river and the salinity at observation station S_6 compare with the real data as appeared in Fig 3-4 respectively.

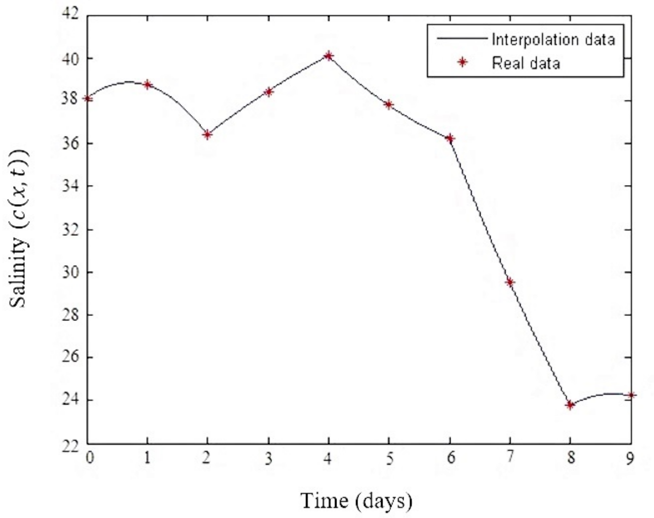

Fig. 1. The comparison of interpolation in initial condition with the measuring salinity data

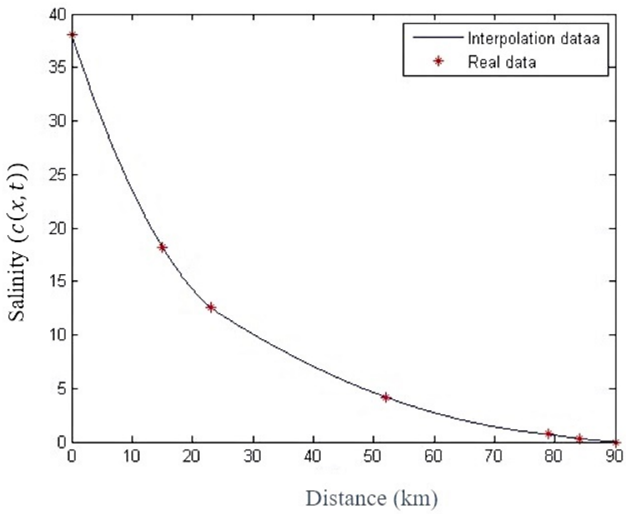

Fig. 2. The comparison of interpolation in left boundary condition condition with the measuring salinity data

TABLE III
THE PARAMETERS OF PHYSICAL OF SIMULATION 2.

D_s (m^2/s)	u_s (m/s)	u_w (m/s)	K	L (km)	T (days)
0.1	0.06	0.3	0.3	90	9

4.3. Simulation 3 : release fresh water from the barrage dam to dilute the salinity.

We will to find the approximate solution of Eq.(3) for all observation stations with 90 km along the river, as appeared in Table 1. Provided that saltiness water coefficient of diffusion is 0.1 m^2/s, the speed of saltiness water flow $u_s = 0.06\ m/s$, the efficiency of eliminating salinity of fresh water discharge is $k = 30\%$, and time of simulation 9 days. The physical parameters are appeared in Table 4. The approximate solution of salinity along the river and the salinity level at the observation station S_6 as appeared in Fig 5-6 respectively.

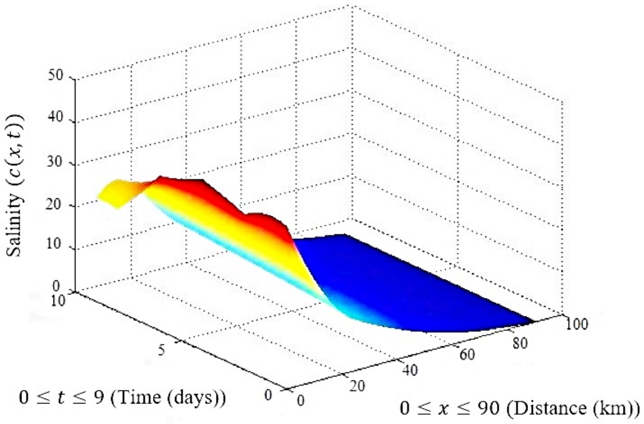

Fig. 3. The estimated saltiness level of simulation 2 where $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $x \in [0, 90]$ and $t \in [0, 9]$.

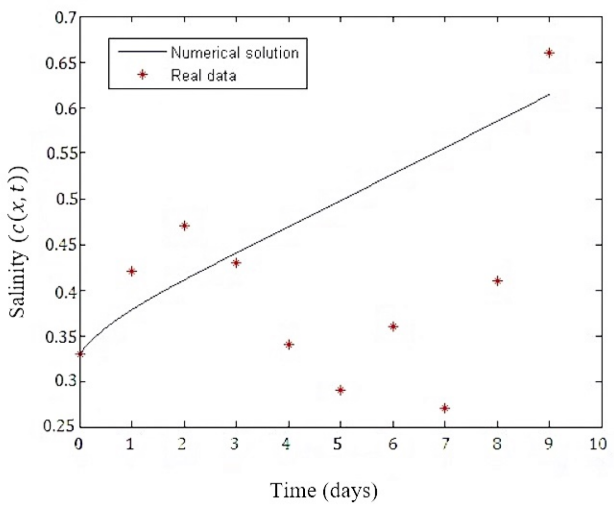

Fig. 4. The estimated saltiness level at station S_6 of simulation 2 where $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $x \in [0, 90]$ and $t \in [0, 9]$.

TABLE IV
THE PARAMETERS OF PHYSICAL OF SIMULATION 3.

D_s (m^2/s)	u_s (m/s)	u_w (m/s)	K	L (km)	T (days)
0.1	0.06	0.3	0.3	90	9

4.4. Simulation 4 : Maintaining a constant level of salinity to the standard by reducing the speed of water discharge from the barrage dam.

We will to find the approximate solution of Eq.(3) for all observation stations with 90 km along the river, as appeared in Table 1. Provided that saltiness water coefficient of diffusion is 0.1 m^2/s, the speed of saltiness water flow $u_s = 0.06\ m/s$, the efficiency of eliminating salinity of fresh water discharge is $k = 30\%$, and time of simulation is 9 days. We want to monitor the salinity of the water at the station S_6 to be less than the specified salinity $C_{ST} = 0.72\ kg/m^3$ by the controlled release of water from barrage dams with the following process:

1) Release at high speed when the salinity level $c(84, t) > C_{ST}$ at the station S_6.

2) Release at low speed when the salinity level $c(84, t) < C_{ST}$ at the station S_6.

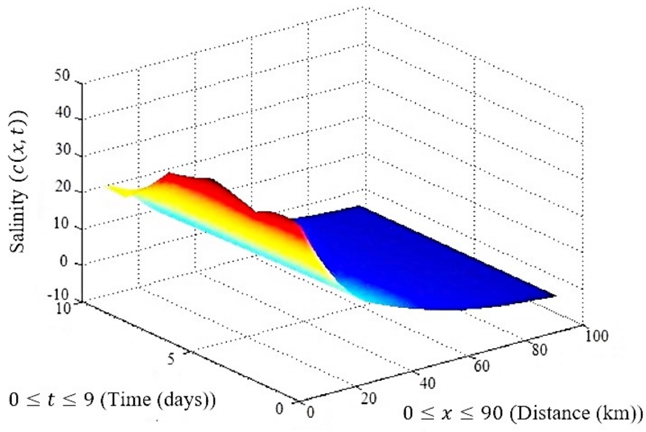

Fig. 5. The estimated saltiness level of simulation 3 where $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $x \in [0, 90]$ and $t \in [0, 9]$.

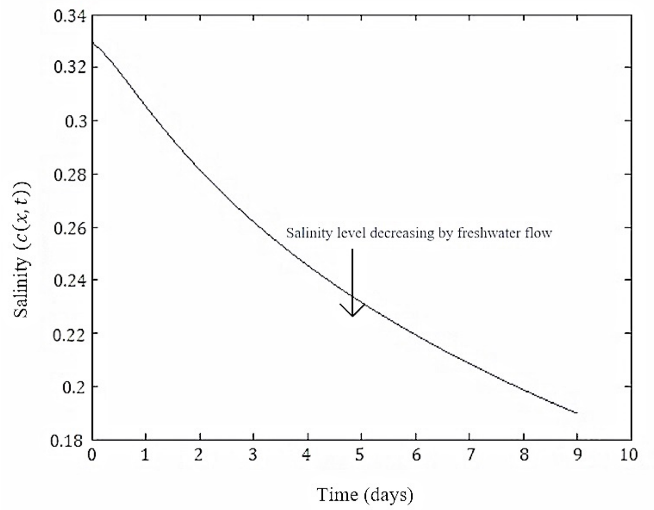

Fig. 6. The estimated saltiness level at station S_6 of simulation 3 where $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $t \in [0, 9]$.

Their parameters of physical are appeared in Table 5.

The approximate salinity level for all observation station can be obtained, as appeared in Fig 7 and Table 6. The saltiness level at the various observation stations S_6, as appeared in Fig 8.

TABLE V
THE PARAMETERS OF PHYSICAL OF SIMULATION 4.

$c(x,t)$ at S_6	D (m^2/s)	u_s (m/s)	u_w (m/s)
$> C_{ST}$	0.1	0.06	0.23
$< C_{ST}$	0.1	0.06	0.205
K	T (days)	L (km)	c(0,t)
0.3	9	90	g(t)
0.3	9	90	g(t)

TABLE VI
THE ESTIMATED SALTINESS LEVEL FOR ALL OBSERVATION STATIONS OF SIMULATION 4.

t	S_2	S_3	S_4	S_5	S_6
1	18.2300	12.5500	4.2000	0.7200	0.3300
5000	17.6659	12.4890	3.9232	0.5884	0.2765
10000	17.1508	12.1402	3.6688	0.5191	0.2385
15000	16.7113	11.7453	3.4336	0.4653	0.2113
20000	16.3177	11.5042	3.2701	0.4392	0.2025

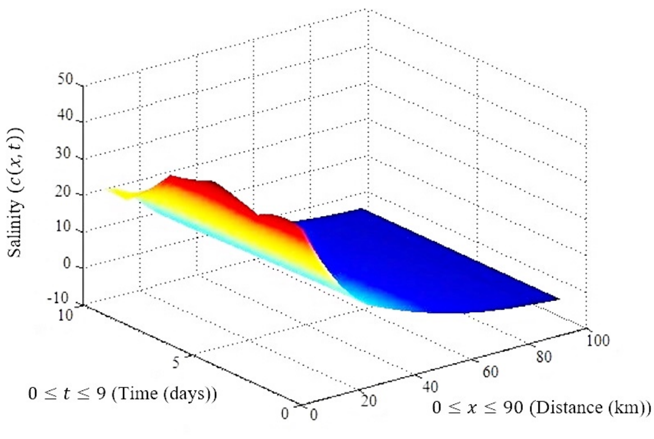

Fig. 7. The estimated saltiness level of simulation 4 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $x \in [0, 90]$ and $t \in [0, 9]$.

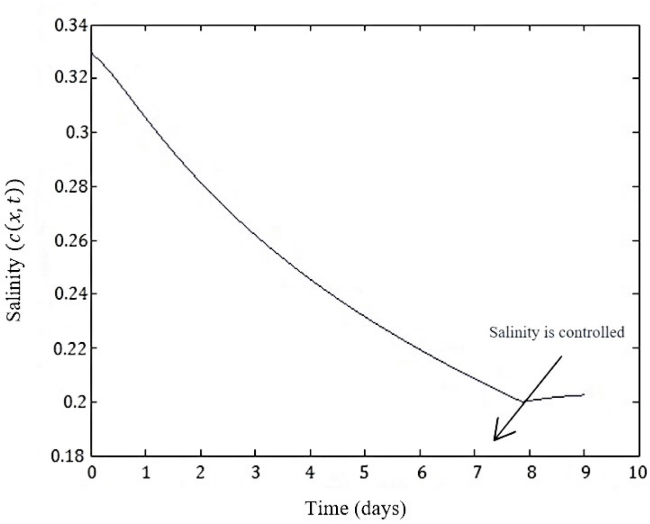

Fig. 8. The estimated saltiness level at station S_6 of simulation 4 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $t \in [0, 9]$.

4.5. Simulation 5 : reduce the level of salinity before the salinity exceeds the standard.

We will to find the approximate solution of Eq.(3) for all observation stations with 90 km along the river, as appeared in Table 1. Provided that saltiness water coefficient of diffusion is 0.1 m^2/s, the speed of saltiness water flow $u_s = 0.06\ m/s$, the efficiency of eliminating salinity of fresh water discharge is $k = 30\%$, and time of simulation is 9 days. We want to monitor the salinity of the water at the station S_6 to be less than the specified salinity $C_{ST} = 0.72\ kg/m^3$ about 3 days by the controlled release of water from barrage dams with the following process:

1) Release at normal speed when the salinity level $c(79, t) < C_{ST}$ at the station S_5.

2) Release at high speed when the salinity level $c(79, t) > C_{ST}$ at the station S_5

Their parameters of physical are appeared in Table 7.

The approximate salinity level for all observation station can be obtained, as appeared in Fig 9 and Table 8. The saltiness level at the various observation station S_5 and S_6, as appeared in Fig 10 and 11.

TABLE VII
THE PARAMETERS OF PHYSICAL OF SIMULATION 5.

$c(x,t)$ at S_5	D (m^2/s)	u_s (m/s)	u_w (m/s)
$< C_{ST}$	0.1	0.06	0
$> C_{ST}$	0.1	0.06	0.22
K	T (days)	L (km)	c(0,t)
0.3	9	90	g(t)
0.3	9	90	g(t)

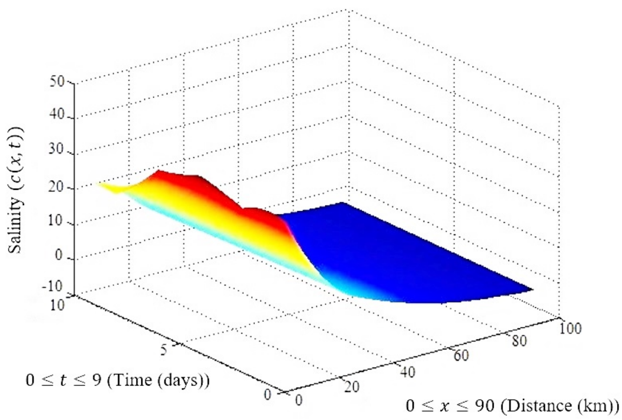

Fig. 9. The estimated saltiness level of simulation 5 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $x \in [0, 90]$ and $t \in [0, 9]$.

TABLE VIII
THE ESTIMATED SALTINESS LEVEL OF SIMULATION 5 FOR ALL OBSERVATION STATIONS.

t	S_2	S_3	S_4	S_5	S_6
1	18.2300	12.5500	4.2000	0.7200	0.1500
5000	19.4352	13.5555	4.3278	0.6805	0.3248
10000	19.5986	13.7948	4.2646	0.6784	0.3252
15000	18.7978	13.3153	3.9964	0.5969	0.2759
20000	17.8724	12.8036	3.7464	0.5321	0.2426

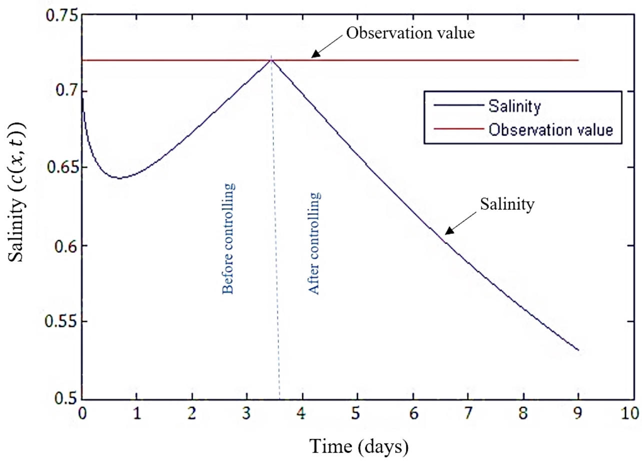

Fig. 10. The estimated saltiness level at stations S_5 of simulation 5 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $t \in [0, 9]$.

4.6. Simulation 6 : reduce the salinity before the salinity exceeds the standard and reduce the emission from the dam when the salinity is low.

We will to find the approximate solution of Eq.(3) for all observation stations with 90 km along the river as, appeared in Table 1. Provided that saltiness water coefficient of diffusion is 0.1 m^2/s, the speed of saltiness water flow $u_s = 0.06\ m/s$, the efficiency of eliminating salinity of

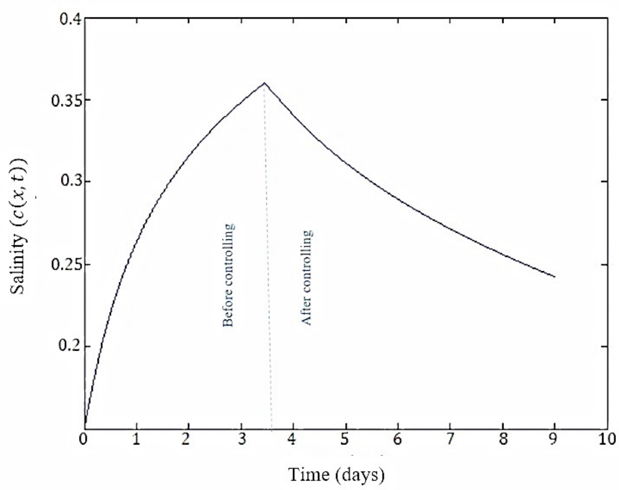

Fig. 11. The estimated saltiness level of simulation simulation 5 at station S_6 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $t \in [0, 9]$.

fresh water discharge is $k = 30\%$, the fresh water dilution efficiency is 30%, and time of simulation is 9 days. We want to monitor the salinity of the water at the station S_6 to be less than the specified salinity $C_{ST} = 0.72\ kg/m^3$ about 3 days by the controlled release of water from barrage dams with the following process:

1) Release at normal speed when the salinity level $c(79, t) < C_{ST}$ at the station S_5.

2) Release at high speed when the salinity level $c(79, t) > C_{ST}$ at the station S_5 and change normal speed when S_5 $c(79, t) < C_{ST}$.

Their parameters of physical are appeared in Table 9.

The approximate salinity level for all observation station can be obtained, as appeared in Fig 12 and Table 10. The S_5 and S_6 level at the various observation station S_5 and S_6, as appeared in Fig 13 and 14.

TABLE IX
THE PARAMETERS OF PHYSICAL OF SIMULATION 6.

$c(x,t)$ at S_5	D (m^2/s)	u_s (m/s)	u_w (m/s)
$< C_{ST}$	0.1	0.06	0
$> C_{ST}$	0.1	0.06	0.25
K	T (days)	L (km)	c(0,t)
0.3	9	90	g(t)
0.3	9	90	g(t)

TABLE X
THE ESTIMATED SALTINESS LEVEL FOR ALL OBSERVATION STATION OF SIMULATION 6.

t	S_2	S_3	S_4	S_5	S_6
1	18.2300	12.5500	4.2000	0.7200	0.1500
5000	19.2985	13.4818	4.3009	0.6688	0.3107
10000	19.3886	13.6694	4.2232	0.6614	0.3138
15000	19.4798	13.7761	4.1554	0.6549	0.3110
20000	19.4353	13.9705	4.1413	0.6656	0.3215

V. DISCUSSION

In simulation 1, approximate solutions of the initial and boundary conditions are obtained using the interpolation method. In simulation 2, the calculated solutions can be obtained by demonstrating the salinity level along the river with a maximum error of less than 30%, as appeared in Fig 3 and Fig 4. In simulation 3, the salinity value will decrease

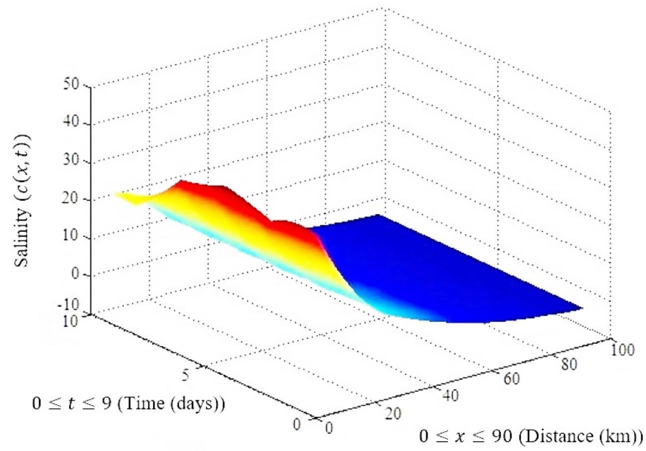

Fig. 12. The estimated saltiness level of simulation 6 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $x \in [0, 90]$ and $t \in [0, 9]$.

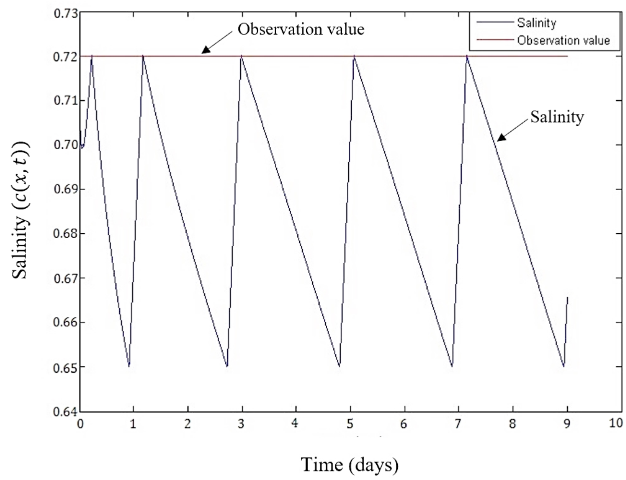

Fig. 13. The estimated salinity level at station S_5 of simulation 6 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $t \in [0, 9]$.

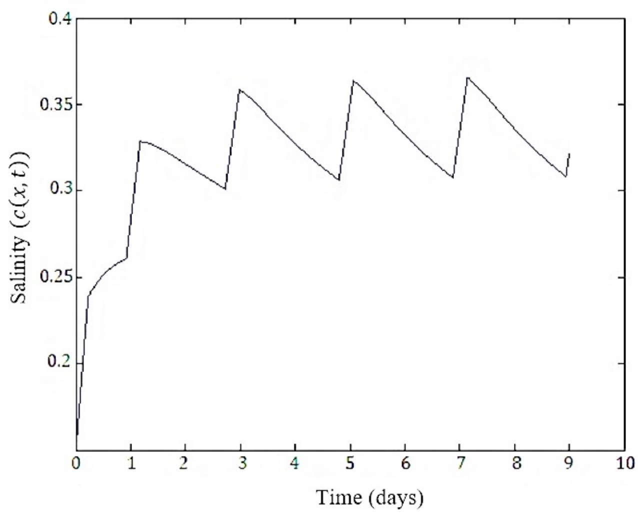

Fig. 14. The estimated salinity level of simulation simulation 6 at station S_6 by $\Delta x = 0.1$ and $\Delta t = 0.05$ for all $t \in [0, 9]$.

as the velocity of fresh water flow increases, as appeared in Fig 5 and Fig 6. The salinity control process is simulated in simulation 4. If the salinity level becomes normal after that, the speed of fresh water flow should be lowered to preserve salinity at the normal level, as appeared in Fig 7 and Fig 8. The salinity control mechanism is simulated in simulation 5. Salinity reduces until the saltiness level reaches the standard. The suggested process could reduce saltiness by at least releasing fresh water from the dam, as appeared in Fig 9, Fig 10 and Fig 11. The salinity control mechanism is simulated in simulation 6. The salinity decreases to less than the standard value and increases as the velocity of fresh water decreases alternately. The suggested technique is to reduce salinity by at least an amount and fresh water is released when salinity levels become standard as appeared in Fig 12, Fig 13 and Fig 14.

VI. Conclusion

We also suggested a mathematical model for saltiness water measurement in one-dimension. The proposed model concerns the salinity advection to the river and the effect of the dam's release of fresh water. Also, some practical problems are being simulated. For many practical salinity measurements, the proposed simulation can be used. The proposed process may decrease the level of salinity in the salinity control aspect until the level reaches the requirement. The proposed numerical simulation can be extended to the practical management of salinity. From each simulation, we can determine that the efficiency is appeared in Table 11.

TABLE XI
THE EFFICIENCY OF THE SIMULATION.

	Salinity level
Simulation 3	The salinity level decreased to much less than the standard value.
Simulation 4	The salinity level decreased to less than standard value for acceptable level.
Simulation 5	Salinity level is not more than and is much less than the standard.
Simulation 6	Salinity level not more than and less than standard value for acceptable level.
	Quantity of released fresh water
Simulation 3	High
Simulation 4	Quite high
Simulation 5	High
Simulation 6	Not too high

As a result, we can apply it to the salinity water problem in different rivers to reduce the impact of people on drinking water with salinity over the standard and help save fresh water used to reduce salinity levels in rivers.

Acknowledgement

This paper is being sponsored by the Centre of Excellence in Mathematics, the Commission on Higher Education, Thailand. We are very grateful to experts for their appropriate and constructive suggestions to improve this paper.

References

[1] Tabuenca, P., Vila, J., Cardona, J., "Samartin, A., Finite element simulation of dispersion in the bay of santander," Advanced in Engineering Software, vol. 28, pp313–332, 1997

[2] Pochai, N., Tangmanee, S., Crane, L.J., Miller, J.J.H., "A water quality computation in the uniform channel," Journal of Interdisciplinary Mathematics, vol. 11, pp803–814, 2008

[3] Pochai, N., "A numerical computation of non-dimensional form of stream water quality model with hydrodynamic advection-dispersion-reaction equations," Journal of Nonlinear Analysis: Hybrid Systems, vol. 13, pp666–673, 2009

[4] Pochai, N., "A numerical computation of non-dimensional form of a nonlinear hydrodynamic model in a uniform reservoir," Journal of Nonlinear Analysis: Hybrid Systems, vol. 3, pp463–466, 2009

[5] Thongtha, K., Kasemsuwan, J., "Analytical solution to a hydrodynamic model in an open uniform reservoir," Advances in Difference Equations, vol. 2017, 2017

[6] Nahian, M.A., Ahmed, A., Lazar, A.N., Hutton, C.W., Salehin, M., "Streatfield, P.K., Drinking water salinity associated health crisis in coastal bangladesh," Elementa: Science of the Anthropocene, vol. 6, 2017

[7] Leewatchanakul, K., "Salinity intrusion in chao phraya river," PhD thesis, Chulalongkorn University, 1988

[8] Chapra, S.C., "Surface Water-Quality Modeling," McGraw-Hill, vol. 6., 2018

[9] Pochai, N., "A numerical treatment of nondimensional form of water quality model in a nonuniform flow stream using saulyev scheme," Mathematical Problems in Engineering 2011, vol. 2011, pp1–16, 2011

[10] Subklay, K., Pochai, N., "Numerical simulations of a water quality model in a flooding stream due to dam-break problem using implicit and explicit methods," Journal of Interdisciplinary Mathematics, vol. 20, pp461–495, 2017

[11] Othata, P., Pochai, N., "A one-dimensional mathematical simulation to salinity control in a river with a barrage dam using an unconditionally stable explicit finite difference method," Advances in Difference Equations, vol. 2019, 2019

[12] Akbari, G. and Firoozi, B., "Implicit and Explicit Numerical Solution of Saint-Venent Equations for Simulation Flood wave in Natural Rivers," 5th National Congress on Civil Engineering, Ferdowsi University of Mashhad, Iran, 2010

[13] Samalerk, P. and Pochai, N., "Numerical Simulation of a One-Dimensional Water-Quality Model in a Stream Using a Saulyev Technique with Quadratic Interpolated Initial-Boundary Conditions," Abstract and Applied Analysis, vol. 2018, 2018

[14] Kraychang, W. and Pochai, N., "Implicit Finite Difference Simulation of Water Pollution Control in a Connected Reservoir System," IAENG International Journal of Applied Mathematics, vol. 46, no.4, pp47–57, 2016

[15] Salah, F. and H. Elhafian, M., "Numerical Solution for Heat Transfer of Non –Newtonian Second – Grade Fluid Flow over Stretching Sheet via Successive Linearization Method," IAENG International Journal of Applied Mathematics, vol. 49, no.4, pp505-512, 2019.

[16] Christodoulides, P., Grimshaw, R. and Demetriades, C., "Three-fluid System Short-wave Instability and Gap-solitons," IAENG International Journal of Applied Mathematics, vol. 41, no.3, pp235-240, 2011

[17] Klankaew, P. and Pochai, N., "Numerical Simulation of a Nonlinear Thin Fluid Film Flow Velocity Model of a Third Grade Fluid on a Moving Belt using Finite Difference Method with Newton Iterative Scheme," Proceedings of The International MultiConference of Engineers and Computer Scientists 2019, pp318-321, 2019

[18] Timpitak, W. and Pochai, N., "Numerical Simulations to a One-dimensional Groundwater Pollution Measurement Model Through Heterogeneous Soil," IAENG International Journal of Applied Mathematics, vol. 50, no.3, pp558-565, 2020

[19] Kraychang, W. and Pochai, N., "A Simple Numerical Model for Water Quality Assessment with Constant Absorption around Nok Phrao Island of Trang River," Engineering Letters, vol. 28, no.3, pp912-922, 2020

[20] Konglok, S.A. and Pochai, N., "Numerical Computations of Three-dimensional Air-Quality Model with Variations on Atmospheric Stability Classes and Wind Velocities using Fractional Step Method," IAENG International Journal of Applied Mathematics, vol. 46, no.1, pp112-120, 2016

[21] Suebyat, W. and Pochai, N., "A Numerical Simulation of a Three-dimensional Air Quality Model in an Area Under a Bangkok Sky Train Platform Using an Explicit Finite Difference Scheme," IAENG International Journal of Applied Mathematics, vol. 40, no.4, pp471-476, 2016

N. Pochai is a researcher of Centre of Excellence in Mathematics, CHE, Si Ayutthaya Road, Bangkok 10400, Thailand.

P. Othata is an assistant researcher of Centre of Excellence in Mathematics, CHE, Si Ayutthaya Road, Bangkok 10400, Thailand.