

A NUMERICAL MODEL OF MEASURING WATER QUALITY IN A
CLOSED DISCHARGE SYSTEM FOR SHRIMP FARMING



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Thesis Title	A Numerical Model of Measuring Water Quality in a Closed Discharge System for Shrimp Farming
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Abstract

Currently, problems encountered in open-system shrimp farming are often the problem of poor water quality and chemically contaminated water into natural water sources, causing severe water pollution. The researcher, therefore, studied the farming methods for raising shrimp in a closed system and water recycling methods for circulating water for use on the farm. The researchers invented and developed a mathematical model to describe the measurement of water quality from circulating farm water and the flow rate of water pumping in and out of wells and bring the numerical methodology to help explain Runge-Kutta Method 4th order (RK4) for calculating the solution of the ordinary differential equation. In the Traditional method, the polluted water in the second pond is treated after the second pond becomes full. Form the simulations, it was found that the inlet and outlet pumping rates were different, resulting in the water volume changing according to the drainage and pumping rates. We found that with a small volume of water, the water treatment capacity was improved over a large volume of water over the same calculation time which can save energy and cost as well.

Keywords : water recycling, water circulation, water quality, closed system shrimp, farm water pollution.

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Nattinee Sittijinda

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Chapter 1

Introduction

1.1 Inception and Importance

The current problem with open-system shrimp farming is often the problem of rotten water in the shrimp ponds. Farmers have to find ways to improve water quality through the use of chemicals, thus providing quality drainage. Low and chemicals into natural water sources such as rivers and canals affect the environment as a problem of water quality deterioration. And the quality of life of various living things in water sources causes severe pollution in water resources. The researcher, therefore, studied the farming method for raising shrimp in a closed system and methods for recycling water to circulate water for use in farms , improving water quality without the use of chemicals and drainage from farms to natural water sources, extending the success of Thai farmers in shrimp production with social responsibility and the environment promotes the most cost-effective and beneficial use of water. It helps increase shrimp production efficiency and eliminates the risk of shrimp disease, enabling farmers to produce quality shrimp that are safe from the use of chemicals or antibiotics.

For this reason, the researcher is interested in studying the measurement of water quality in closed drainage systems for shrimp farming and the flow of water that affects the water quality assessment has therefore been invented and developed a mathematical model studied by the researcher to describe the measurement of water quality from water circulation in farms. And the flow rate from the drainage of various wells is to be treated and circulated to improve water quality by the researcher by mathematically modeling the rate of change of water quality and the water flow rate that depends on the time and to be closer to the water quality and the amount of water in the pond in the real situation, a numerical method was used to explain Runge-Kutta Method 4th order (RK4) for calculating the solution of the ordinary differential equation (ODEs).

In the working process of this model, the researcher has studied the real site such as a shrimp farm using the area of the shrimp pond as a simulation area and consider the amount of water in the pond from the flow rate of each drainage at

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different times. Then take to find the rate of change of water quality measurements over time. The rate of change of water quality, the researcher is interested in the value of biochemical oxygen demand (BOD) to study because it is a measure of water quality measurements over time. The rate of change of water quality, the researcher is interested in the value of biochemical oxygen demand (BOD) to study because it is a measure of water quality.

1.2 Objectives of the Study

- 1) To investigate the amount of water based on the water flow rate in a shrimp pond.
- 2) To investigate the amount of water based on several water pumping rates in a shrimp pond.
- 3) To present a mathematical model for assessing water quality in drainage shrimp pond systems.
- 4) To present numerical simulations for improving water quality in shrimp pond drainage systems.

1.3 Scope of the Study

- 1) Shrimp pond sizes and the water flow rates are given.
- 2) The water pumping rates in a shrimp pond are specified.
- 3) In the assessment of water quality processes, the BOD index is focused and all related parameters are also given.
- 4) The shrimp pond drainage rates are used at the same rate as the water pumping rates.

1.4 Benefits of the Study

The generated model can be used to look at the trend of water quality change in a closed drainage system for shrimp farming, with the water flow rate in each pond having different pumping in and outflow rates.

1.5 Research Methodology

- 1) The related articles on water quality measurement and modeling are collected.
- 2) The specifications of water pumping machines used in shrimp farming are collected.
- 3) Mathematical modeling and the parameter setting technique are considered.
- 4) Practical numerical methods will be used to approximate the model solution.
- 5) The numerical simulations that were created will be used to find a better water quality in the shrimp farming that is being considered.



Chapter 2

Preliminaries

The content of this chapter deals with basic knowledge and research related research to be developed and furthered in the work process.

2.1 Water Pollution

Water pollution refers to the condition in which natural water is contaminated with pollutants and causes deterioration or deterioration in the quality of the water. As a result, the utilization of the water is reduced or may not use it at all.

2.1.1 Cause of water pollution

- 1) Community resources such as houses, offices, commercial buildings, hotels, and hospitals release mass mixed with wastewater most of which are organic and detergents used for cleaning.
- 2) Industrial plants such as sugar and fish sauce factories, washing factories, coloring factories, tanning factories, and a soft drink factory Discharge of waste into the water from various factories. These tend to have a high rate, making the water rotten easily.
- 3) Farmers Sources At present, various farmers are more commonly used to suppress enemies. Causing residues on plants and on the soil surface and will be washed with rainwater flowing through various water sources. The slow decomposition of water sources will accumulate in more water sources that are harmful to the environment and humans.
- 4) Various water sources which may spontaneous spoilage when in a lack of oxygen Most of them are caused by the accumulation of plankton and die together.

2.1.2 The effects of water pollution

- 1) Public health Wastewater is a breeding ground for pathogens causing outbreaks of diseases such as cholera, typhoid, and a breeding ground for mosquitoes which is a carrier of many diseases.
- 2) In fisheries, water pollution causes various aquatic animals to decrease in number until they may be extinct in the end because they cannot live and reproduce normally. Due to the oxygen used to breathe.
- 3) Consumer and consumer water that has a lot of additives must add more decontamination systems to produce standard water. This makes it cost more to buy quality water for consumption.
- 4) In agriculture, wastewater is acidic and alkaline. Most of them are not suitable for cultivation. In addition, cages can be toxic to pets in agricultural areas.
- 5) The scenery Water pollution will destroy the beauty of nature. Causing humans to have no place to relax In addition, human emotions and minds have changed from the original.

2.1.3 How to prevent water pollution problems

- 1) Raise awareness among youths to learn and see the value of water conservation.
- 2) Raise awareness among people about the importance of maintaining the quality of water resources.
- 3) Campaign for the agency Organizations treats and remove toxins before they are released into the water.
- 4) Campaign to help reduce the amount of water use and reduce the amount of household waste.
- 5) Help prevent spoilage. Do not dispose of garbage and sewage or toxic substances into the water source or sewer.

2.2 Closed System Shrimp Farm

Shrimp farming is another career that, if done, is successful will be able to make a beautiful income for the farmer. Before investing in the shrimp farming business, they should have basic knowledge of shrimp or sufficient experience in raising shrimp and it's important to have a basic understanding of the problems that can arise during raising including taking into account the causes and solutions so as not to cause damage to the produce and must consider the environment in the discharge of waste into natural water sources.

The researcher, therefore, studied the data from Charoen Pokphand Company (CP) developed a model of shrimp farming using the Recycle system for use in farms without releasing water into the environment building on the success of Thai farmers in shrimp production with social and environmental responsibility. The company continually emphasizes the development of environmentally-friendly shrimp farming patterns by developing a shrimp farm in a closed system and using a water recycling method to recycle it for use on farms without releasing water from the farm into the environment (Zero Discharge) promote the most cost-effective and beneficial use of water It improves production efficiency and eliminates the risk of shrimp disease.

Help farmers to produce quality shrimps that are safe by reducing the use of chemicals or antibiotics leading to sustainable success for farmers and the Thai shrimp industry. Closed system shrimp farm without releasing water into the environment at all and stored sediment in the farm this helps to reduce the environmental impact of shrimp farms by 100%, increasing the capability of Thai farmers in terms of quality, freshness, cleanliness, and most importantly, shrimps that come from sustainable production processes.

Closed system shrimp farm the treated water recirculation method is used in shrimp ponds. Can be adapted to farms of all sizes by increasing the proportion of the area used as a treatment pond apply the sedimentation principle of tap water production together with the technology to improve water quality to be suitable for shrimp farming reduces the amount of water taken from water sources. Furthermore, the sediment is stored on farms and not released into water sources. Control the spread of disease from farms to the outside environment. In the shrimp farming plan, there will be a pond for raising shrimp, a sludge pond, a ready-to-use.

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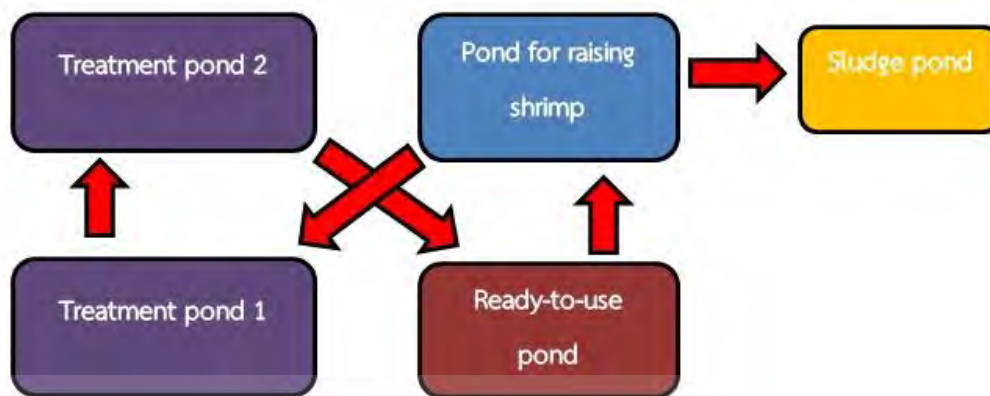


Figure 2.1: Water treatment diagram of a closed shrimp farm.

2.3 Water quality index

Indicators of good water or wastewater are Biochemical Oxygen Demand and Dissolved Oxygen. In determining the quality of water from various water sources whether it is good water or wastewater, it can be viewed from the Biochemical Oxygen Demand (BOD) and Dissolved Oxygen (DO) with high accuracy and can also check the cost of the wastewater treatment system and the wastewater treatment pond on a daily basis. It will make know the quality of water as well.

2.3.1. Biochemical Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is the amount of oxygen that microorganisms need for their livelihood and decomposition of organic and inorganic substances in water. Water with a Biochemical Oxygen Demand (BOD) of more than 100 mg/l is wastewater. Water with a high Biochemical Oxygen Demand (BOD) indicates a large amount of organic matter in the wastewater. Microorganisms require oxygen (O_2) dissolved in that water for use in the subsistence and decomposition of various wastes in the water. Biochemical Oxygen Demand (BOD) is another of the many parameters used to measure the quality of water and wastewater in wastewater treatment systems that have been set as an international standard around the world. It is another indicator of good water or wastewater that is very important in the wastewater treatment system.

For drinking water that we use generally, there will be a standard Biochemical Oxygen Demand (BOD) value of about 5-8 mg/l or 5-8 ppm. Each source is not equal, This material is reserved for educational use only, not allowed for commercial use.

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for example, the standard for effluent from general factories, the Biochemical Oxygen Demand (BOD) does not exceed 20 mg/l, while the Biochemical Oxygen Demand (BOD) standard for the effluent from the condominium with the number of rooms from 100 - 499 rooms will have the Biochemical Oxygen Demand (BOD) of not more than 30 mg /l, etc.

- If Biochemical Oxygen Demand (BOD) ≥ 100 mg/l, it is waste water, if Biochemical Oxygen Demand (BOD) < 100 mg/l, it is bile (good start effluent).
- If the Biochemical Oxygen Demand (BOD) is higher in wastewater. It shows that in the wastewater there is a large amount of organic matter.
- Wastewater with a high Biochemical Oxygen Demand (BOD) is highly acidic.
- A high Biochemical Oxygen Demand (BOD) leads to a sharp drop in pH. Resulting in a group of microorganisms that use oxygen to die in the treatment pond.

2.3.2. Dissolved Oxygen (DO)

Dissolved Oxygen (DO) is the amount of dissolved oxygen in the water. The standard value of good quality water (usable water) generally has a DO value of about 5-8 mg/l or 5-8 ppm. For effluent (treated water), $DO \geq 3$ mg/l or more, but in general effluent, standard parameters do not include DO value, but it is useful in evaluating the value of bile or wastewater as well. If $DO < 3$ mg/l means starting water rotten. The lower the DO value, the more water will multiply, adding more critical spoilage.

2.4 Numerical Method

Numerical methodology is a tool for finding solutions to complex and complex mathematical equations. Therefore, there are many studies to solve various problems. However, the solutions obtained by the numerical method are approximate only. In this section, we will show one topic, which is the estimation of

the ordinary differential equation (ODE) using Runge-Kuta 4th order method the RK4 method.

2.4.1 The Runge-Kutta 4th order method (RK4)

The Runge-Kutta 4th order method (RK4) is the most commonly used method for solving ordinary differential equations (ODEs) because of its high accuracy and precision. Let an initial value problem be specified as follows:

$$\frac{dy}{dx} = f(x, y), \quad y(x) = y_0 \dots \quad (2.1)$$

Here y is an unknown function (scalar or vector) of time x and $\frac{dy}{dx}$ is the rate at which y changes. It is a function of x and of y itself. At the initial time x_0 the corresponding y value is y_0 . The function f and the initial condition x_0, y_0 is given

Now let's pick a step size $h > 0$ and define, for $x_{n+1} = x_n + h$
where $n = 0, 1, 2, 3, \dots$

$$y_{n+1} = y_n + \frac{1}{6}h(k_1 + 2k_2 + 2k_3 + k_4), \quad (2.2)$$

Where

$$\begin{aligned} k_1 &= f(x_n, y_n), \\ k_2 &= f\left(x_n + \frac{h}{2}, y_n + h \frac{k_1}{2}\right), \\ k_3 &= f\left(x_n + \frac{h}{2}, y_n + h \frac{k_2}{2}\right), \\ k_4 &= f(x_n + h, y_n + hk_3). \end{aligned}$$

Here y_{n+1} is the RK4 approximation of $y(x_{n+1})$ obtained by the current value $y(x_n)$ plus the weighted average of four increments, where each increment is the item of the size of the interval, h , and an approximated slope specified by function f on the right hand side of the equation.

- the term k_1 is the slope at the starting of the interval, using y (Euler's method)
- the term k_2 is the slope at the midpoint of the interval, using y and k_1 .
- the term k_3 is again the slope at the midpoint, but now using y and k_2 .
- the term k_4 is the slope at the end of the interval, using y and k_3 .

In averaging the four slopes, a greater weight is given to the slopes at the midpoint. If f is independent of y , so that the differential equation is equivalent to a simple integral, then RK4 is Simpson's rule.

The local truncation error is on the order of (h^5) , while the total accumulated error is on the order of $O(h^4)$.

Example 2.1 Solve the differential equation using the Runge-Kuta 4th order method

$$f(x, y) = 4e^{0.8x} - 0.5y, \quad 0 \leq x \leq 1$$

Using step size is $h = 0.25$ and the initial condition is $x = 0, y_0 = 2$

Form the RK4 method $y_{(n+1)} = y_n + \left[\frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4) \right] h$

Where

$$k_1 = f(x_n, y_n)$$

$$= f(x_0, y_0)$$

$$= f(0, 2)$$

$$= 4e^{0.8(0)} - 0.5(2)$$

$$= 3$$

$$k_2 = f\left(x_n + \frac{h}{2}, y_n + \frac{h}{2}k_1\right)$$

$$= f\left(x_0 + \frac{0.25}{2}, y_0 + \frac{0.25}{2}k_1\right)$$

$$= f\left(0 + \frac{0.25}{2}, 2 + \frac{0.25}{2}(3)\right)$$

$$= f\left(\frac{1}{8}, 2.375\right)$$

$$= 4e^{0.8\left(\frac{1}{8}\right)} - 0.5(2.375)$$

$$= 3.2332$$

$$k_3 = f\left(x_n + \frac{h}{2}, y_n + \frac{h}{2}k_2\right)$$

$$= f\left(x_0 + \frac{0.25}{2}, y_0 + \frac{0.25}{2}k_2\right)$$

$$= f\left(0 + \frac{0.25}{2}, 2 + \frac{0.25}{2}(3.2332)\right)$$

$$= f\left(\frac{1}{8}, 2.4042\right)$$

$$= 4e^{0.8\left(\frac{1}{8}\right)} - 0.5(2.4042)$$

$$= 3.2186$$

$$k_4 = f(x_n + h, y_n + hk_3)$$

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$$\begin{aligned}
 &= f(0.25, 2.8047) \\
 &= 4e^{0.8(0.25)} - 0.5(2.8047) \\
 &= 3.4832
 \end{aligned}$$

$$y_{(n+1)} = y_n + \left[\frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4) \right] h$$

We have

$$\begin{aligned}
 y_1 &= y_0 + \left[\frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4) \right] 0.25 \\
 &= 2 + \left[\frac{1}{6}(3 + 2(3.2332) + 2(3.2186) + 3.4832) \right] (0.25) \\
 &= 2.8078
 \end{aligned}$$

We will repeat this until we get $y(1)$ and use the Matlab program to estimate the rest.

Table 2.1: The solution to the differential equation is estimated by the RK4 method.

n	0	1	2	3	4
x_n	0	0.25	0.5	0.75	1
y_n	2	2.8078	3.7515	4.8664	6.1947

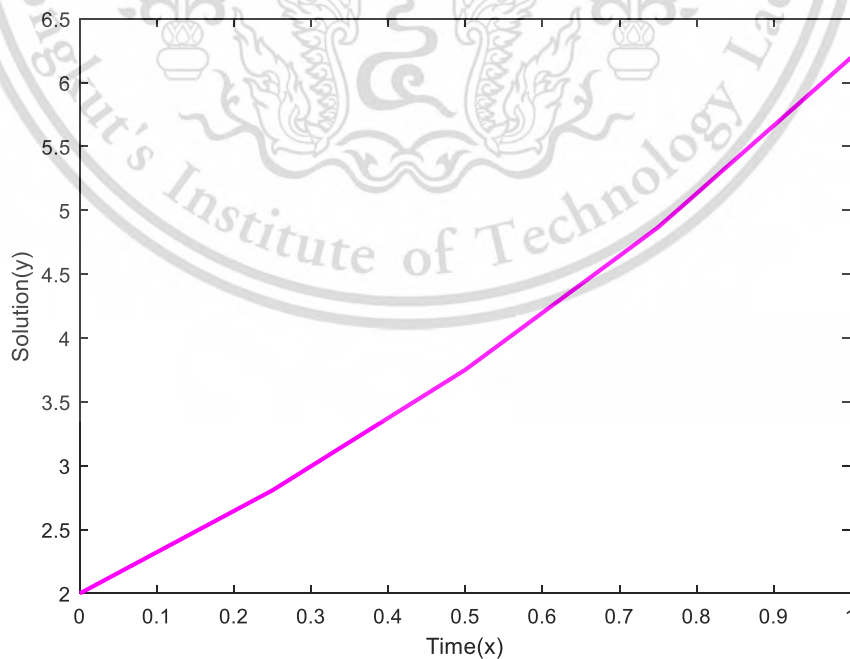


Figure 2.2: Graph of ODE estimation using RK4 method.

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Chapter 3

Predicting changes in water content and water quality using mathematical models

In this chapter, we'll create a mathematical model to predict the amount of water change in ponds in a closed shrimp farm where the water flow rate varies over time and water quality is projected to change.

3.1 Water circulation model

The amount of water in the shrimp farm affects the water quality in the pond due to the constant flow of water. We therefore use mathematical models to predict the amount of water that affects water quality as show in Figure 3.1. We will determine the rate of change of water level from the equation as follows.

$$\left(\frac{\text{change in the water level}}{\text{water level}}\right) = \frac{(\text{inflow})-(\text{outflow})}{A}, \quad (3.1)$$

or

$$\frac{dy}{dt} = \frac{(\text{inflow})-(\text{outflow})}{A}, \quad (3.2)$$

where

- y (m) is the water level,
- inflow (m^3/s) is the inflow rate,
- outflow (m^3/s) is the outflow rate,
- A (m^2) is the water surface area,
- t (s) is time.

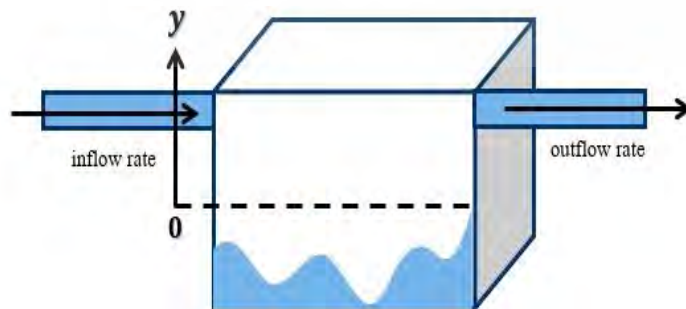


Figure 3.1: diagram showing water flow rate.

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We have the volume of water is

$$v = A \times y \quad , \quad (3.3)$$

where

$$\begin{aligned} v \text{ (m}^3\text{)} & \text{ is the volume water,} \\ A \text{ (m}^2\text{)} & \text{ is the water surface area,} \\ y \text{ (m)} & \text{ is the water level.} \end{aligned}$$

3.2 Numerical simulation of water circulation

We simulated events to use mathematical models to predict water levels when there were different water flow rates at different times. The pumping rates popularly used in agriculture may be driven by electric motors or motors depending on their needs. Optimized by an electric motor driven pump will have an average pumping rate of 25,000 - 30,000 L/hr and the engine-powered water pump has an average pumping rate of 20,000 - 50,000 L/hr and we will define the water surface area width 10 m and length 10 m and will set other conditions as follows:

Table 3.1: Determination of the pumping rate and the water surface area.

The pumping rate	25,000 (L/hr)
The inflow rate	$\frac{25,000 \times 10^{-3}}{60 \times 60} \text{ (m}^3\text{/s)}$
The outflow rate	0 (m ³ /s)
The water surface area	$10 \times 10 = 100 \text{ (m}^2\text{)}$

When we simulated events under the above conditions, we next recalled the change in water level in the shrimp pond using mathematical modeling.

We substitute the parameters into Equation (3.2)

$$\frac{dy}{dt} = \frac{25,000 \times 10^{-3}}{60 \times 60} - (0) \quad (3.4)$$

$$= \frac{25,000 \times 10^{-3} \times 60^{-2}}{100} \quad (3.5)$$

Thus, we have

$$f(t_n, y_n) = \frac{25,000 \times 10^{-3} \times 60^{-2}}{100} \quad (3.6)$$

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If step size is $h = 1$ and the initial condition is $t = 0$ we have $y = 1$, $0 \leq t \leq 36,000$. We would like to estimate the solution of Equation (3.6) by the RK4 method,

Table 3.2: Water level change with pumping rate = 25,000 l/hr.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The water level (m)	1	1.2500	1.5000	1.7500	2.0000	...	3.5

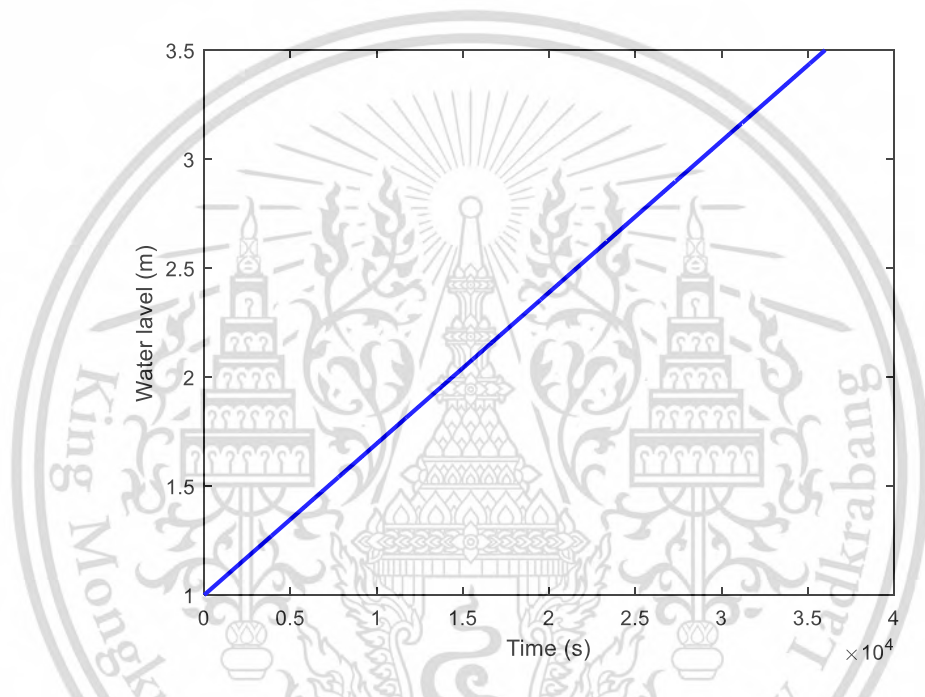


Figure 3.2: Shrimp pond water level graph when water level change at pumping rate = 25,000 l/hr.

Therefore, we get the volume of water from equation (3.3) as follows:

Table 3.3: Volume of water in the pond according to the rate of change of water level with pumping rate = 25,000 l/hr.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The volume of water (m ³)	100	125.0000	150.0000	175.0000	200.0000	...	349.9931

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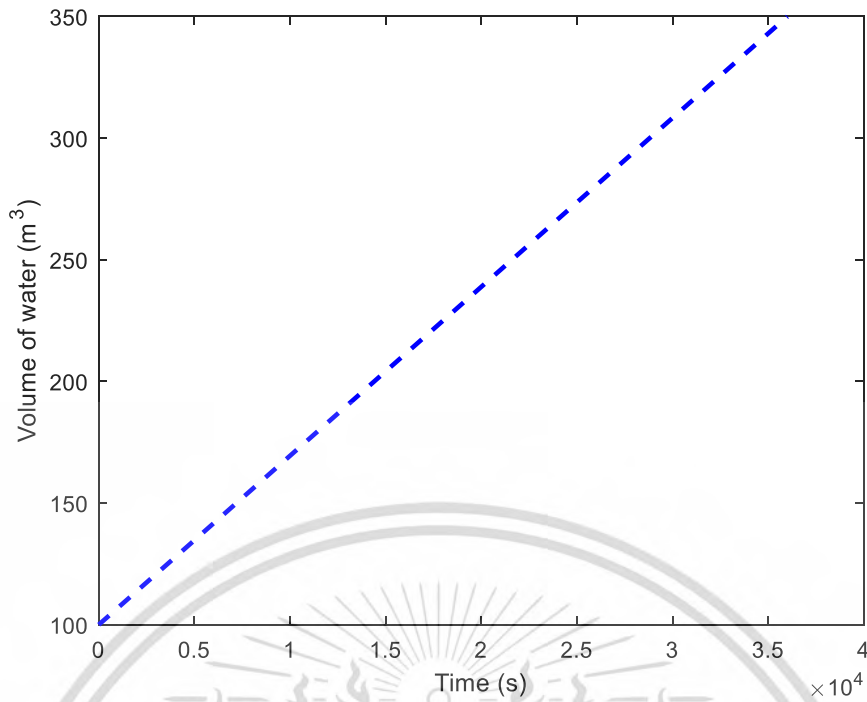


Figure 3.3: Graph of the volume of water in the well according to the rate of change in water level with pumping rate = 25,000 L/hr.

From the graph above we can observe the trend of the water level and water content within the surface area = 100 m^2 . It can be seen that over time the water level and volume will increase until the time we set. We will simulate the rate of pumping water into different wells to compare the water level and the volume of water.

Table 3.4: The water level changes according to different pumping rates at 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The pumping rate = 25,000 (L/hr)	1	1.2499	1.4999	1.7499	1.9999	...	3.5000
The pumping rate = 35,000 (L/hr)	1	1.3499	1.6999	2.0499	2.3999	...	4.5000
The pumping rate = 50,000 (L/hr)	1	1.4999	1.9999	2.4999	2.9999	...	6.0000

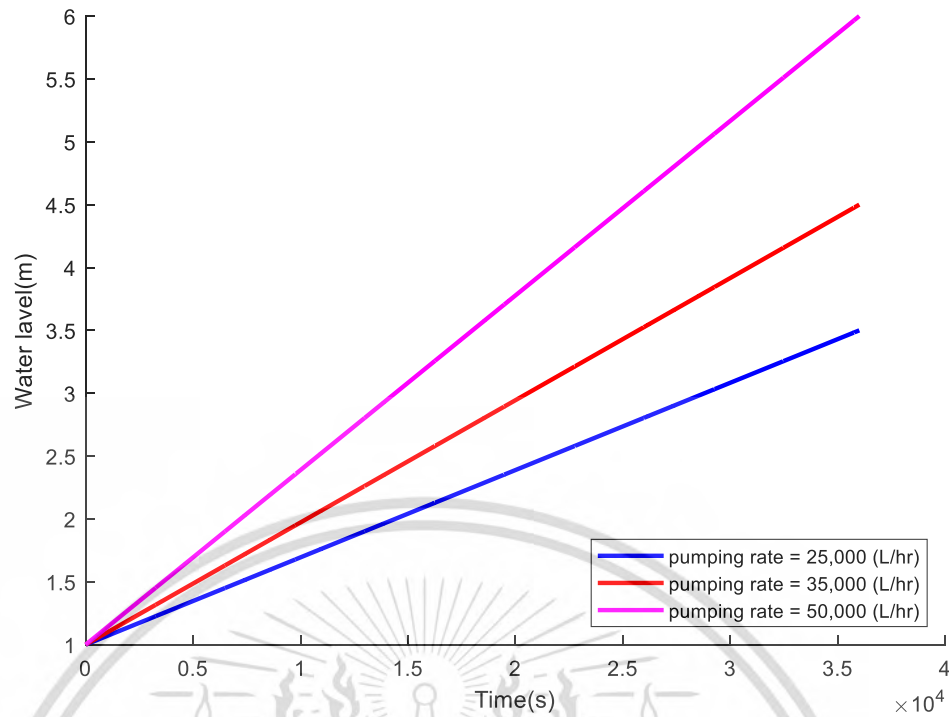


Figure 3.4: Shrimp pond water level graph when water level changes with multiple pumping rates.

and the volume of water as follows :

Table 3.5: The volume of water in the well according to the rate of change in water level when water is pumped in at different pumping rates at 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The pumping rate = 25,000 (L/hr)	100	124.9931	149.9931	174.9931	199.9931	...	349.9931
The pumping rate = 35,000 (L/hr)	100	134.9903	169.9903	204.9903	239.9903	...	449.9903
The pumping rate = 50,000 (L/hr)	100	149.9861	199.9861	249.9861	299.9861	...	599.9861

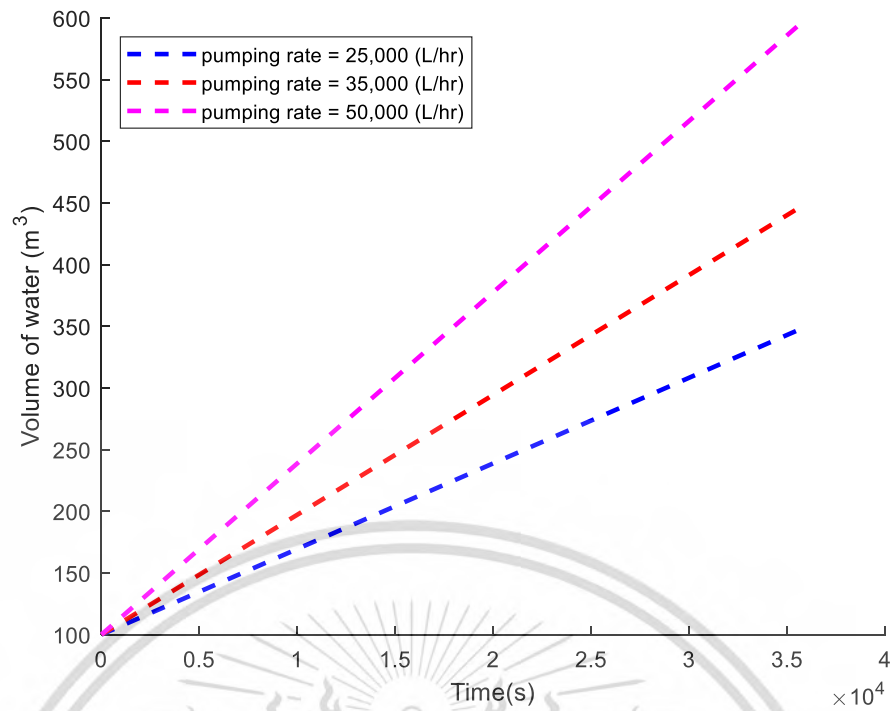


Figure 3.5: Graph of the volume of water in a well based on the rate of change in water level with multiple pumping rates.

From the graph above, it can be seen that the water level and water volume will increase. Depending on the pumping rate, the higher the pumping rate, the higher the water level and volume.

3.3 Water quality assessment model for one pond

The water quality in the shrimp ponds changed according to the amount of water in the ponds. We therefore, created a mathematical model to map the change in water quality depending on the amount of water in the pond and the time. We will determine the rate of change in water quality from the equation as follows:

$$v \frac{dc}{dt} = kc - Q, \quad 0 \leq k \leq 1 \quad (3.7)$$

where

- v (l/s) is the volume of water,
- c (mg/l) is the water quality,
- Q (mg/l) is the removal mechanism,
- t (second) is time,
- k is the reaction rate.

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3.4 Numerical simulation for water quality assessment model for one pond

We simulated events to use mathematical models to predict the rate of change in water quality with different volumes at different times under conditions:

Table 3.6: Different configurations used to calculate water quality.

The reaction rate	0.01
The removal mechanism	0.05 (mg/l)
The volume of water in the	3.2.

When we simulated events under the above conditions, we continued to predict the rate of change in water quality using mathematical modeling.

We will substitute the parameter into equation (3.7)

$$v \frac{dc}{dt} = 0.01c - 0.05 \quad (3.8)$$

Thus, we have

$$f(t_n, c_n) = \frac{0.01c - 0.05}{v(1000)} \quad (3.9)$$

When step size is $h = 1$ and the initial condition is $t = 0, c = 20, 0 \leq t \leq 36,000$.

We would like to estimate the solution of Equation (3.9) by the RK4 method.

Table 3.7: The water quality after recycling with volume change rate from pumping rate = 25,000 l/hr.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The water quality (mg/l)	20	19.9988	19.9978	19.9971	19.9964	...	19.9946

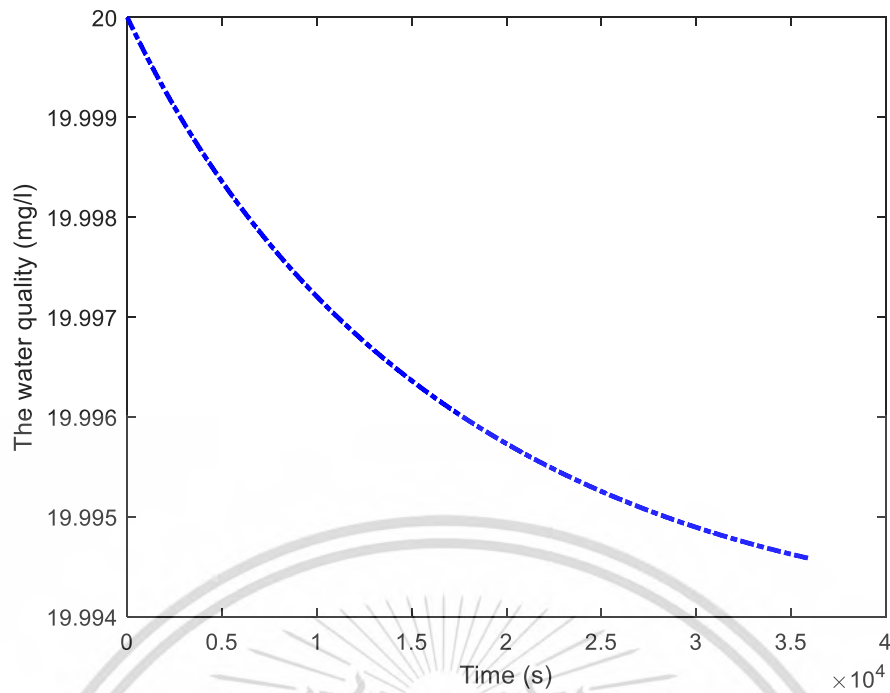


Figure 3.6: Graph of water quality in the well according to the rate of change in water level with pumping rate = 25,000 L/hr.

From the graph above, the trend is that the water quality or BOD is decreasing and will continue to decline over time. We therefore changed the removal mechanism Q to see a decrease in water quality or BOD.

Table 3.8: The water quality caused by change of the removal mechanism Q at 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
$Q = 0.05$ (mg/l)	20	19.9988	19.9978	19.9971	19.9964	...	19.9946
$Q = 0.1$ (mg/l)	20	19.9971	19.9949	19.9930	19.9915	...	19.9856
$Q = 0.5$ (mg/l)	20	19.9843	19.9715	19.9608	19.9515	...	19.9134

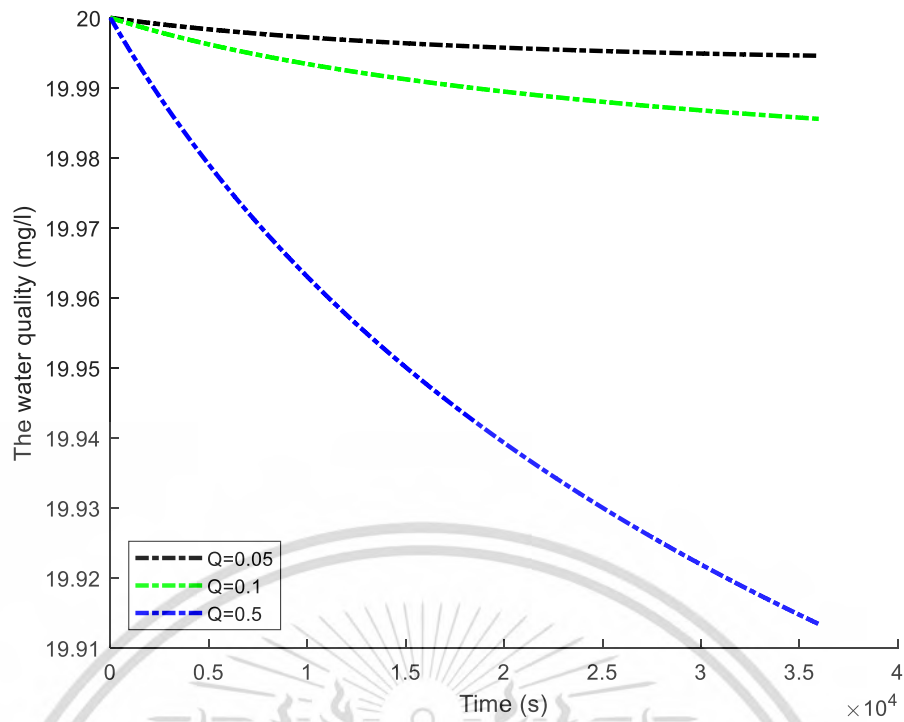


Figure 3.7: Graph of water quality in the well according to the rate of change in removal mechanism Q at 36,000 s.

From the graph above tendency to measure water quality or BOD from various removal mechanisms Q found that the greater the Q value, the higher the water quality or BOD is getting better and better.

3.5 Simulation of a water quality assessment model for one pond in case of multiple inlet rates.

To compare the quality, we will try the real situation by taking samples of shrimp pond parameters to predict the rate of change in water quality from pumped inlet treatment with multiple pumping rates which will bring the amount of water from 3.2 to continue to calculate by specifying:

Table 3.9: Different configurations used to calculate the water quality of a multi-rate pump.

The reaction rate	0.4546
The removal mechanism	16.7515 (mg/l)
The volume of water in the	3.2.

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When we simulated events under the above conditions, we continued to predict the rate of change in water quality using mathematical modeling.

We will substitute the parameter into equation (3.7)

$$v \frac{dc}{dt} = 0.4546c - 167515 \quad (3.10)$$

Thus, we have

$$f(t_n, c_n) = \frac{0.4546c - 167515}{v(1000)} \quad (3.11)$$

When step size is $h = 1$ and the initial condition is $t = 0, c_0 = 22, 0 \leq t \leq 36,000$.

We would like to estimate the solution of Equation (3.11) by the RK4 method.

Table 3.10 The change in water quality from different pumping rates for treatment in 36,000 s.

The water quality (mg/l)	Time (s)						
	0	3,600	7,200	10,800	14,400	...	36,000
The pumping rate = 25,000 (l/hr)	22	21.4782	21.0547	20.6992	20.3935	...	19.1417
The pumping rate = 35,000 (l/hr)	22	21.4994	21.1185	20.8123	20.5570	...	19.5721
The pumping rate = 50,000 (l/hr)	22	21.5274	21.1968	20.9440	20.7404	...	20.0026

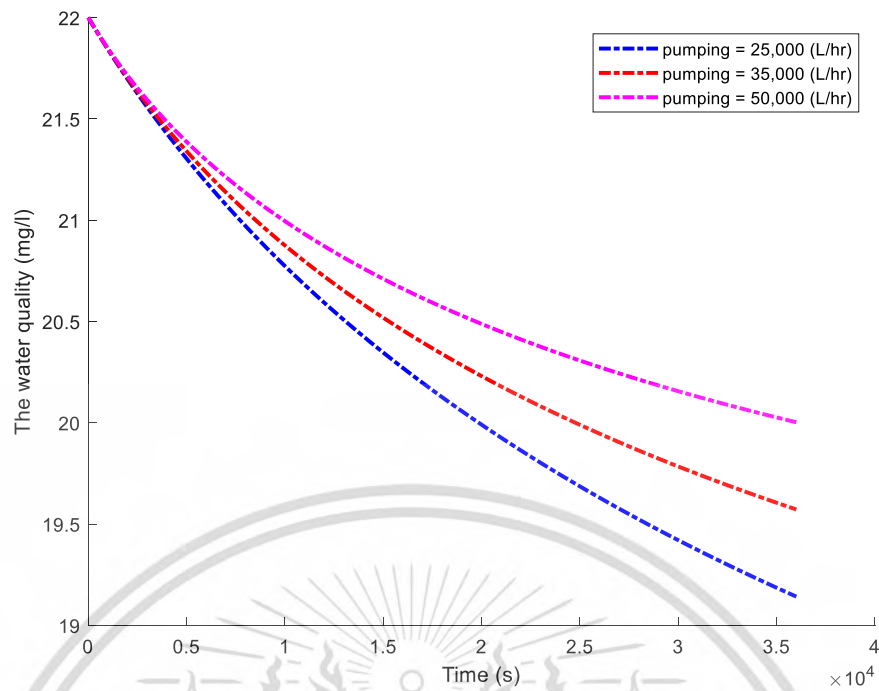


Figure 3.8: Graph of the change in water quality from different pumping rates over 36,000 s.

From the graph above, the trend of water quality measurement or BOD from various pumping rates has decreased with water level. It can be seen that the smaller the amount of water recycled, the more water can be recycled, the lower the water quality, the greater the amount of water. However, the quality of all recycled water is still good.

Chapter 4

Water quality assessment model for a couple ponds of shrimp farming

This chapter refers to the water quality assessment model which will be applied to 2 pond is the shrimp pond and the treatment pond 1. There will be a matter of decomposition of wastewater when pumping water to another well will cause water quality to be linked because the water that is pumped into the same water.

4.1 Water quality assessment model for a couple ponds

The change in water quality of shrimp ponds and water treatment pond 1 changed according to the water flow rate of the two ponds as show in Figure 4.1. We therefore created a mathematical model for assessing the water quality of the two ponds based on water volume and time.

4.1.1 The water quality assessment in the first pond

We will set the rate of change in water quality as follows:

$$v_1 \frac{dc_1}{dt} = k_1 c_1 - Q_1, \quad 0 \leq k_1 \leq 1 \quad (4.1)$$

where

v_1 (l/s) is the volume of water in the shrimp pond,

c_1 (mg/l) is the water quality of the shrimp pond,

Q_1 (mg/l) is the removal mechanism,

t (s) is time,

k_1 is the reaction rate of the shrimp pond.

4.1.2 The water quality assessment in the second pond

And there will be a case of pumping water that is pumped in from the shrimp pond to the treatment pond 1, the percentage of decomposition of wastewater into the treatment pond 1 is R_2 . The equation is

$$v_2 \frac{dc_2}{dt} = k_2 c_2 - Q_2 + R_2 c_1, \quad 0 \leq k_2 \leq 1 \text{ and } 0 \leq R_2 \leq 1 \quad (4.2)$$

where

v_2 (l/s) is the volume of water in the treatment pond 1,

c_1 (mg/l) is the water quality of the shrimp pond,

c_2 (mg/l) is the water quality of the treatment pond 1,

Q_2 (mg/l) is the removal mechanism of the treatment pond 1,

t (s) is time,

k_2 is the reaction rate of the treatment pond 1,

R_2 is percentage of decomposition of wastewater into the treatment pond 1.



Figure 4.1: Diagram showing the water quality of 2 ponds.

From Figure 3.8, the picture shows that water is pumped out of the shrimp pond for treatment in the treatment pond 1. The water quality of the treatment pond 1 is linked from the shrimp pond because water is pumped from the shrimp pond and from the water being pumped into the treatment pond 1 the waste water is decomposed during the process.

4.2 Numerical simulation for water quality assessment model for a couple ponds

We will simulate the event to use mathematical models to predict the rate of change in the water quality of the two ponds with different water flows. We will specify that the shrimp pond has a water level starting at 5 m and the water quality starting at 22 mg/l and the treatment pond 1. The water level starts at 2 m and the water quality starts at 10 mg/l. We define the water inlet and outlet rate = 25,000 l/hr and will define the water surface area width 10 m and length 10 m can be used to determine the quantity and quality of water as follows:



Figure 4.2: The diagram shows the water flow between the shrimp pond and the treatment pond 1 with the water pumping in and out while treating the water at the same time.

4.2.1 Water level and water volume of the shrimp pond

We will define the conditions for determining the level and volume of water in the shrimp pond as follows.

Table 4.1: Determination of pumping rates and surface area of shrimp farms.

The pumping rate	25,000 (l/hr)
The inflow rate	0 (m^3/s)
The outflow rate	$\frac{25,000 \times 10^{-3}}{60 \times 60}$ (m^3/s)
The water surface area	$10 \times 10 = 100$ (m^2)

When we simulated events under the above conditions, we next recalled the change in water level in the shrimp pond using mathematical modeling.

We substitute the parameters into Equation (3.2)

$$\frac{dy_1}{dt} = \frac{0 - \frac{25,000 \times 10^{-3}}{60 \times 60}}{100}, \quad (4.3)$$

$$= - \frac{2,5000 \times 10^{-3} \times 60^{-2}}{100}, \quad (4.4)$$

Thus, we have

$$f(t_n, y_{1n}) = - \frac{25,000 \times 10^{-3} \times 60^{-2}}{100} \quad (4.5)$$

When step size is $h = 1$ and the initial condition is $t = 0, y_1 = 5, 0 \leq t \leq 36,000$.

We would like to estimate the solution of Equation (4.5) by the RK4 method.

Table 4.2: The water level of the shrimp pond when pumped out to the treatment pond 1 with a pumping rate of 25,000 V/hr in 0 to 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The water level (m)	5	4.7501	4.5001	4.2501	4.0001	...	2.5001

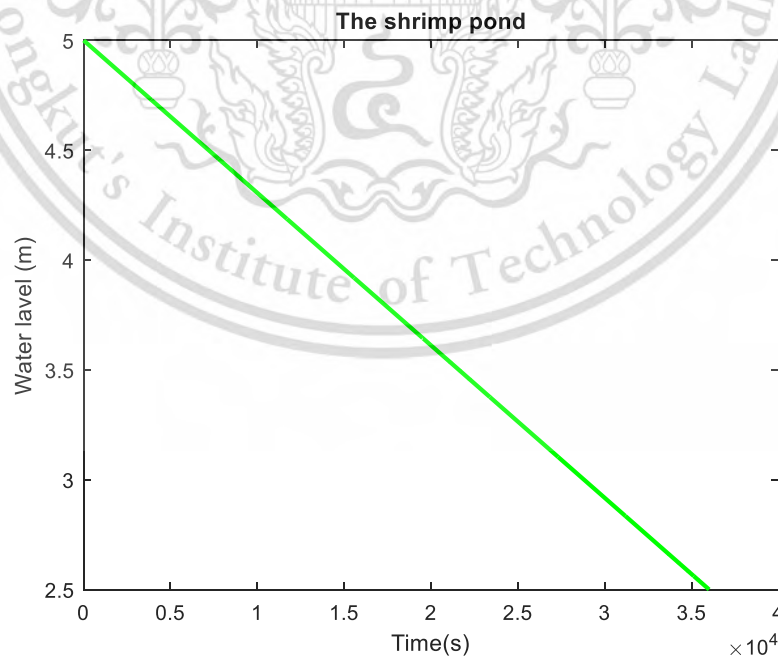


Figure 4.3: Graph of the change in water level in the shrimp pond when pumped out at the pump out rate = 25,000 V/hr for 0 to 36,000 s.

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Therefore, we get the volume of water from equation (3.3) as follows:

Table 4.3: The water content of the shrimp pond when pumped out to the treatment pond 1 with a pumping rate of 25,000 l/hr in 0 to 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The volume of water (m ³)	500	475.0069	450.0069	425.0069	400.0069	...	250.0069

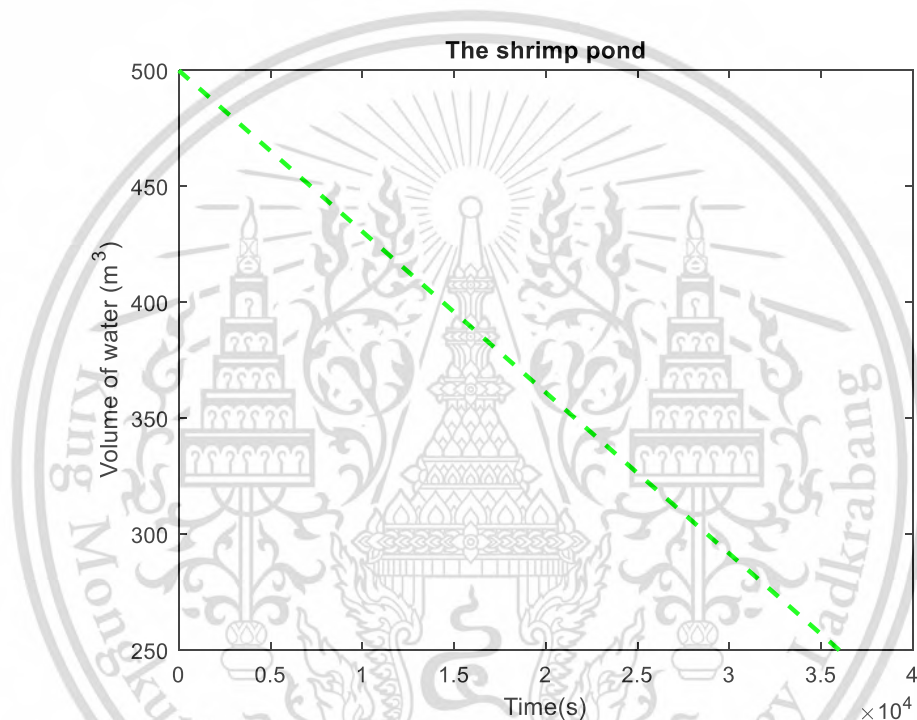


Figure 4.4: Graph of the change in water volume in the shrimp pond when pumped out at the pump out rate = 25,000 l/hr in 0 to 36,000 s.

4.2.2 Water level and water volume of the treatment pond 1

We will define the conditions for determining the level and volume of water in the shrimp pond as follows:

Table 4.4: Determination of pumping rates and surface area of the treatment pond 1.

The pumping rate	25,000 (L/hr)
The inflow rate	0 (m ³ /s)
The outflow rate	$\frac{25,000 \times 10^{-3}}{60 \times 60}$ (m ³ /s)
The water surface area	$10 \times 10 = 100$ (m ²)

When we simulated events under the above conditions, we next recalled the change in water level in the shrimp pond using mathematical modeling.

We substitute the parameters into Equation (3.2)

$$\frac{dy_2}{dt} = \frac{\frac{25,000 \times 10^{-3}}{60 \times 60} - 0}{100}, \quad (4.6)$$

$$= \frac{25,000 \times 10^{-3} \times 60^{-2}}{100}, \quad (4.7)$$

Thus, we have

$$f(t_n, y_{2n}) = \frac{25,000 \times 10^{-3} \times 60^{-2}}{100} \quad (4.8)$$

When step size is $h = 1$ and the initial condition is $t = 0, y_2 = 2, 0 \leq t \leq 36,000$.

We would like to estimate the solution of Equation (4.8) by the RK4 method,

Table 4.5: The water level of the treatment pond 1 when pumping incoming water from the shrimp pond with a pumping rate of 25,000 L/hr in 0 to 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The water level (m)	2	2.2499	2.4999	2.7499	2.9999	...	4.4999

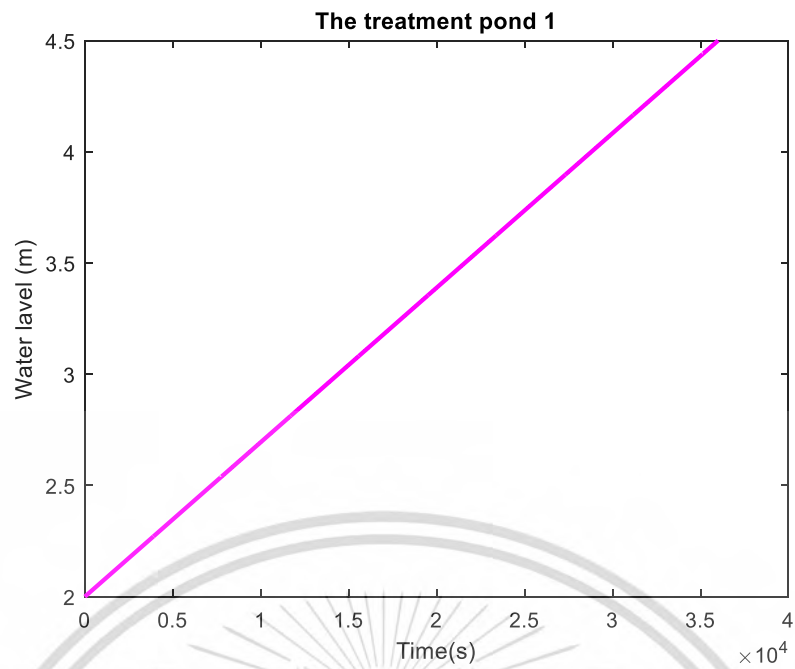


Figure 4.5: Graph of change in water level in the treatment pond 1 when water is pumped into the inlet rate = 25,000 L/hr for 0 to 36,000 s.

Therefore, we get the volume of water from equation (3.3) as follows:

Table 4.6: The water volume of the treatment pond 1 when pumped in from the shrimp pond at the inflow rate = 25,000 L/hr in 0 to 36000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The volume of water (m^3)	200	224.9931	249.9931	274.9931	299.9931	...	449.9931

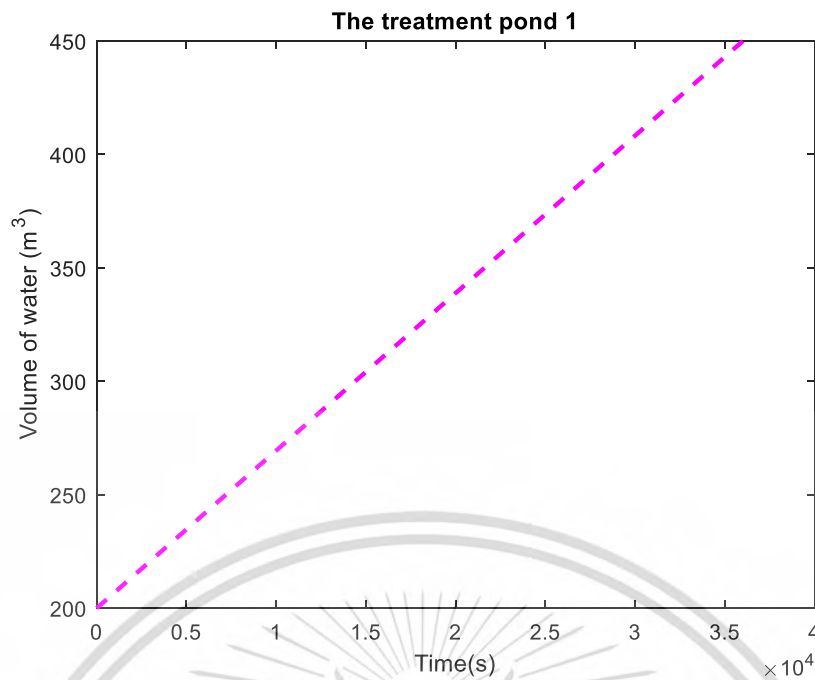


Figure 4.6: Graph of change in water volume in the treatment pond 1 when injected at pumping rate = 25,000 l/hr for 0 to 36,000 s.

4.2.3 Determination of water quality of shrimp ponds from changes in water level when water is pumped out of the pond

We will set various conditions to be used to calculate the water quality as follows:

Table 4.7: Various configurations used to calculate the water quality of shrimp farms.

The reaction rate	0.4546
The removal mechanism	16.7515 (mg/l)
The volume of water in the	4.2.1.

When we simulated events under the above conditions, we continued to predict the rate of change in water quality using mathematical modeling.

We will substitute the parameter into equation (4.1)

$$v_1 \frac{dc_1}{dt} = 0.4546c_1 - 16.7515 \quad (4.9)$$

Thus, we have

$$f(t_n, c_{1n}) = \frac{0.4546c_1 - 16.7515}{v_1(1000)} \quad (4.10)$$

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When step size is $h = 1$ and the initial condition is $t = 0, c_1 = 22, 0 \leq t \leq 36,000$.

We would like to estimate the solution of Equation (4.10) by the RK4 method,

Table 4.8: Water quality after it is pumped out to treatment pond 1 with a water output rate = 25,000 l/hr at 0 to 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The water quality (mg/l)	22	21.8927	21.7786	21.6571	21.5272	...	20.4917

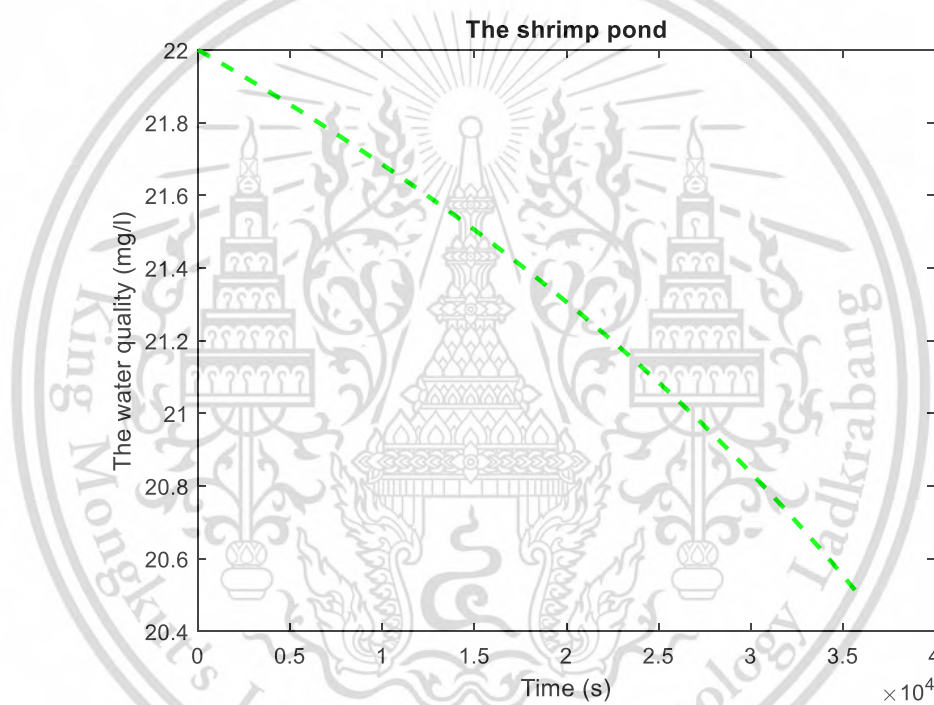


Figure 4.7: Graph of water quality after the change in water volume from pumping out to the treatment pond 1 at an outflow rate = 25,000 l/hr at 0 to 36,000 s.

4.2.4 Determination of the water quality of the treatment pond 1 from the change in water level when water is pumped into the shrimp pond

We will set various conditions to be used to calculate the water quality as follows:

Table 4.9: Various configurations used to calculate the water quality of the treatment pond 1.

The reaction rate	0.4546
The removal mechanism	16.7515 (mg/l)
The percentage of decomposition	0.01
The volume of water in the	4.2.2.

When we simulated events under the above conditions, we continued to predict the rate of change in water quality using mathematical modeling.

We will substitute the parameter into equation (4.2)

$$v_2 \frac{dc_2}{dt} = 0.4546c_2 - 16.7515 + 0.01c_1 \quad (4.11)$$

Thus, we have

$$f(t_n, c_{2n}) = \frac{0.4546c_2 - 16.7515 + 0.01c_1}{v_2(1000)} \quad (4.12)$$

When step size is $h = 1$ and the initial condition is $t = 0, c_2 = 10, 0 \leq t \leq 36,000$.

We would like to estimate the solution of Equation (4.12) by the RK4 method.

Table 4.10: Water quality after being pumped into the shrimp pond with an inflow rate of 25,000 L/hr at 0 to 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The water quality (mg/l)	10	9.7358	9.5011	9.2904	9.0994	...	8.2315

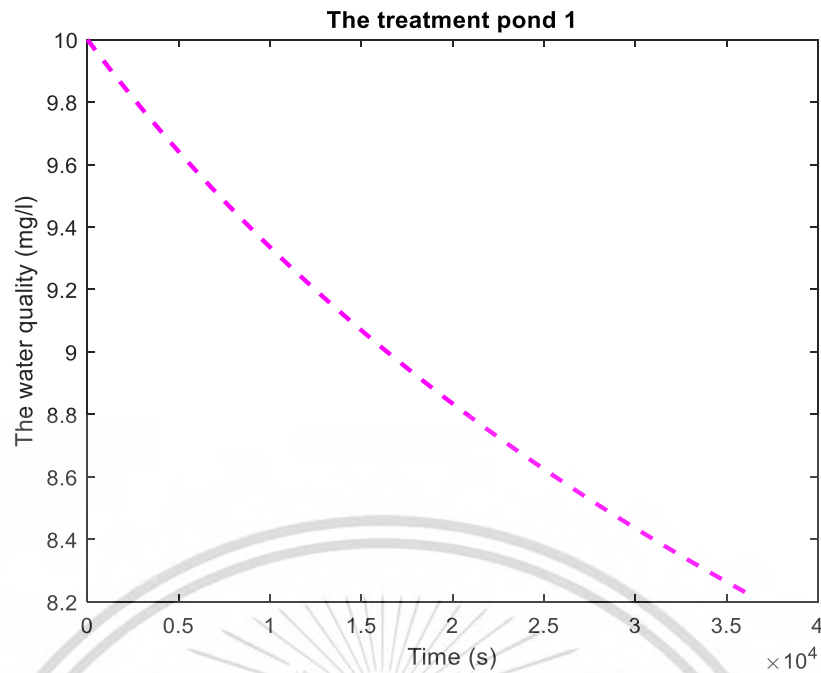


Figure 4.8: Graph of water quality after pumping from shrimp pond to the treatment pond 1 at an inflow rate = 25,000 L/hr at 0 to 36,000 s.

4.3 Other simulations of numerical models for water quality assessment models for couple ponds

We will simulate the event to use mathematical models to predict the rate of change in the water quality of the two ponds with different water flows. We will set the shrimp pond to have a water level starting at 10 m and a water quality starting at 22 mg/l and a treatment pond to have a water level starts at 4 m and the water quality starts at 10 mg/l. We define the pumping rate in and out = 25,000 L/hr, 35,000 L/hr and 50,000 L/hr and will define the water surface area width 10 m and length 10 m to determine the quantity and quality of water under the following conditions:

Table 4.11: Defining the conditions of a model application example.

The shrimp pond	The treatment pond 1
$y_1(0) = 10$ m	$y_2(0) = 2$ m
$c_1(0) = 22$ mg/l	$c_2(0) = 10$ mg/l

when the following conditions are set $k_1 = k_2 = 0.4546$, $Q_1 = Q_2 = 16.7515$ mg/l, $R_2 = 0.01$ apply the conditions obtained to create an equation and find the water volume and water quality as follows:

Table 4.12: Changes in water level of shrimp ponds after drainage from shrimp ponds to treatment pond 1 with different drainage rates in 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The pumping rate = 25,000 (l/hr)	10	9.7501	9.5001	9.2501	9.0001	...	7.5001
The pumping rate = 35,000 (l/hr)	10	9.6501	9.3001	8.9501	8.6001	...	6.5001
The pumping rate = 50,000 (l/hr)	10	9.5001	9.0001	8.5001	8.0001	...	5.0001

Therefore, we get the volume of water from equation (3.3) as follows:

Table 4.13: Changes in volume of water of shrimp ponds after drainage from shrimp ponds to treatment pond 1 with different drainage rates in 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The pumping rate = 25,000 (l/hr)	1,000	975.0069	950.0069	925.0069	900.0069	...	750.0069
The pumping rate = 35,000 (l/hr)	1,000	965.0097	930.0097	895.0097	860.0097	...	650.0097
The pumping rate = 50,000 (l/hr)	1,000	950.0139	900.0139	850.0139	800.0139	...	500.0139

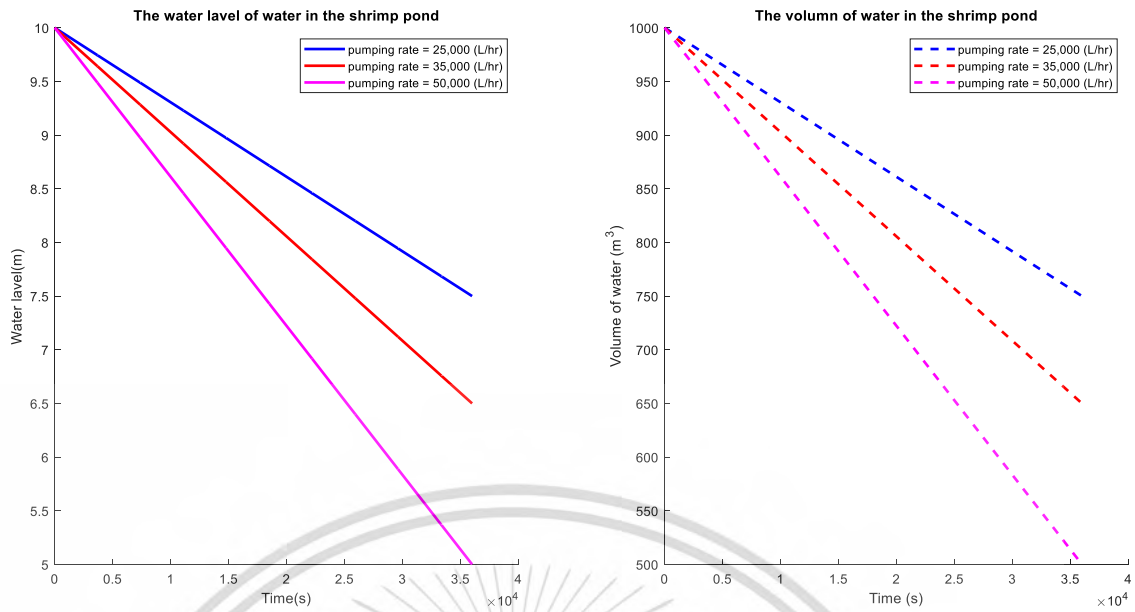


Figure 4.9: Graph of changes in water level and water volume of shrimp ponds.

The graph above shows that the higher the drainage rate, the lower the water level and volume and will get the water level and water volume of the treatment pond 1 as follows:

Table 4.14: Changes in water level in treatment pond 1 due to incoming water from the shrimp pond at different pumping rates in 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The pumping rate = 25,000 (L/hr)	2	2.2499	2.4999	2.7499	2.9999	...	4.4999
The pumping rate = 35,000 (L/hr)	2	2.3499	2.6999	3.0499	3.3999	...	5.4999
The pumping rate = 50,000 (L/hr)	2	2.4999	2.9999	3.4999	3.9999	...	6.9999

Therefore, we get the volume of water from equation (3.3) as follows:

Table 4.15: Changes in volume of water in treatment pond 1 due to incoming water from the shrimp pond at different pumping rates in 36,000 s.

Time (s)	0	3,600	7,200	10,800	14,400	...	36,000
The pumping rate = 25,000 (L/hr)	200	224.9931	249.9931	274.9931	299.9931	...	449.9931
The pumping rate = 35,000 (L/hr)	200	234.9903	269.9903	304.9903	339.9903	...	549.9903
The pumping rate = 50,000 (L/hr)	200	249.9861	299.9861	349.9861	399.9861	...	699.9861

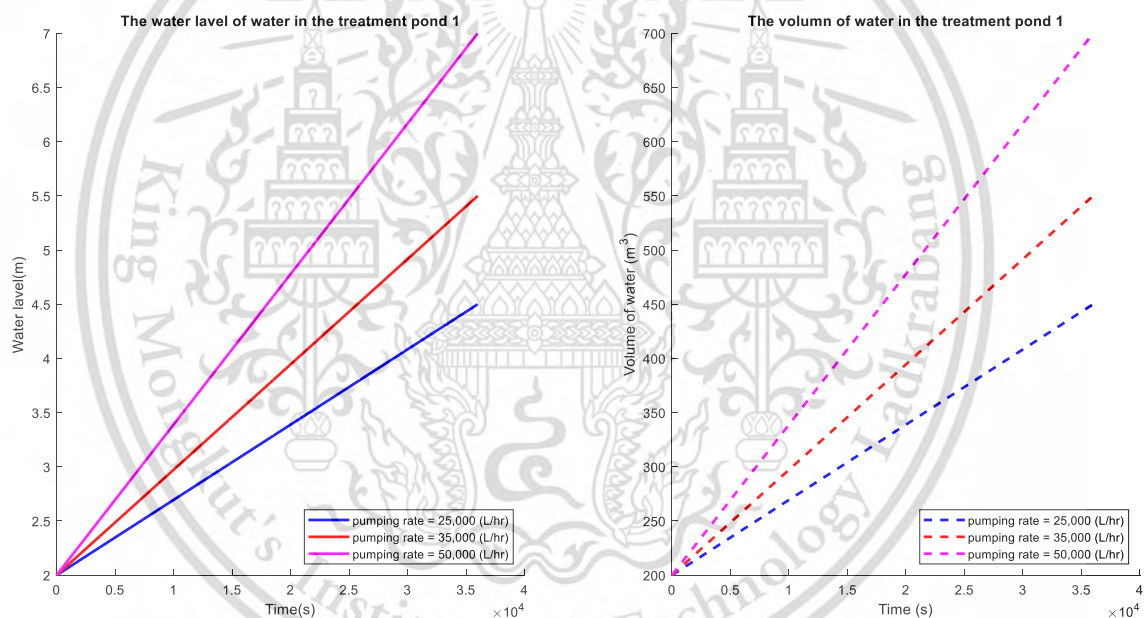


Figure 4.10: Graph of the change in water level and water volume of the treatment pond 1.

From the graph above, it can be seen that the amount of water in the treatment pond 1 increased with the pumping rate of water from the shrimp pond into the treatment pond 1. The higher the pumping rate the greater the water volume.

Next, the water content of the shrimp pond and the treatment pond 1 will be used. To calculate in equations (4.1) and (4.2), respectively, the water quality of both ponds will come out as follows.

Table 4.16: Changes in water quality of shrimp ponds when draining water from shrimp ponds and pumping water into treatment pond 1 with different drainage rates in 36,000 s.

The water quality (mg/l)	Time (s)						
	0	3600	7200	10800	14400	...	36000
The pumping rate = 25,000 (L/hr)	22	21.9553	21.9090	21.8610	21.8113	...	21.4697
The pumping rate = 35,000 (L/hr)	22	21.9550	21.9077	21.8580	21.8056	...	21.4214
The pumping rate = 50,000 (L/hr)	22	21.9545	21.9057	21.8531	21.7963	...	21.3277

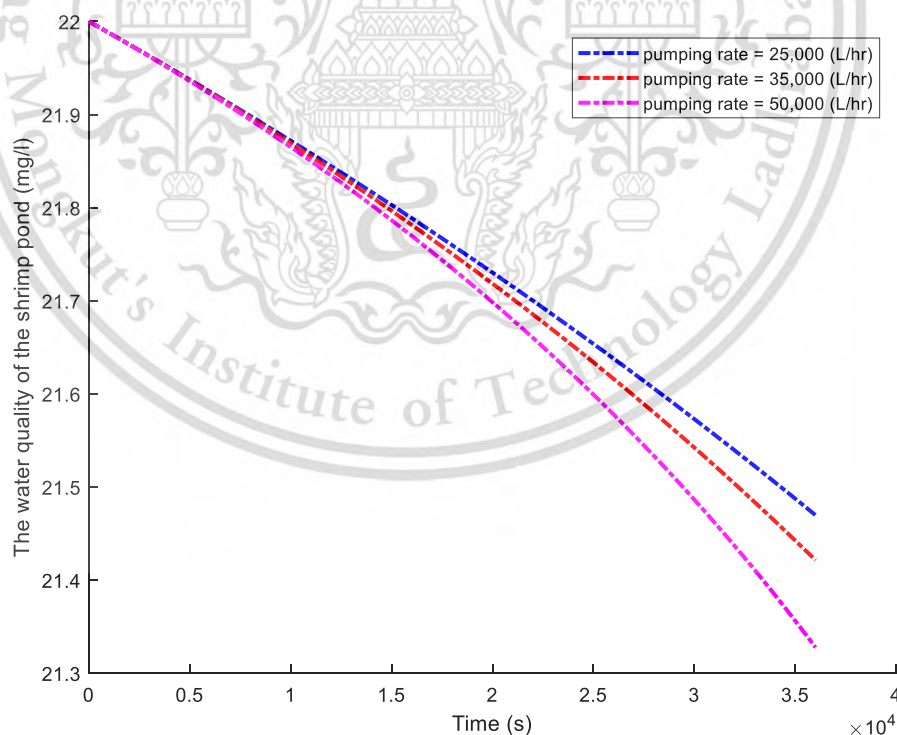


Figure 4.11: Graph of the change in water quality of shrimp ponds from drainage from shrimp pond to treatment pond 1 at 36,000 s.

The graph above shows that the value of the water quality decreases because the water is drained along with the treatment of the water itself, resulting in a noticeable improvement in the quality of the drained water. The more water is drained, the less water is treated, the better the water quality.

Table 4.17: Changes in water quality of treatment pond 1 when water is pumped from shrimp pond into treatment pond 1 with different drainage rates in 36,000 s.

The water quality (mg/l)	Time (s)					
	0	3,600	7,200	10,800	14,400	... 36,000
The pumping rate = 25,000 (L/hr)	10	9.7360	9.5014	9.2908	9.1000	... 8.2326
The pumping rate = 35,000 (L/hr)	10	9.7421	9.5223	9.3313	9.1629	... 8.4429
The pumping rate = 50,000 (L/hr)	10	9.7507	9.5500	9.3828	9.2401	... 8.6719

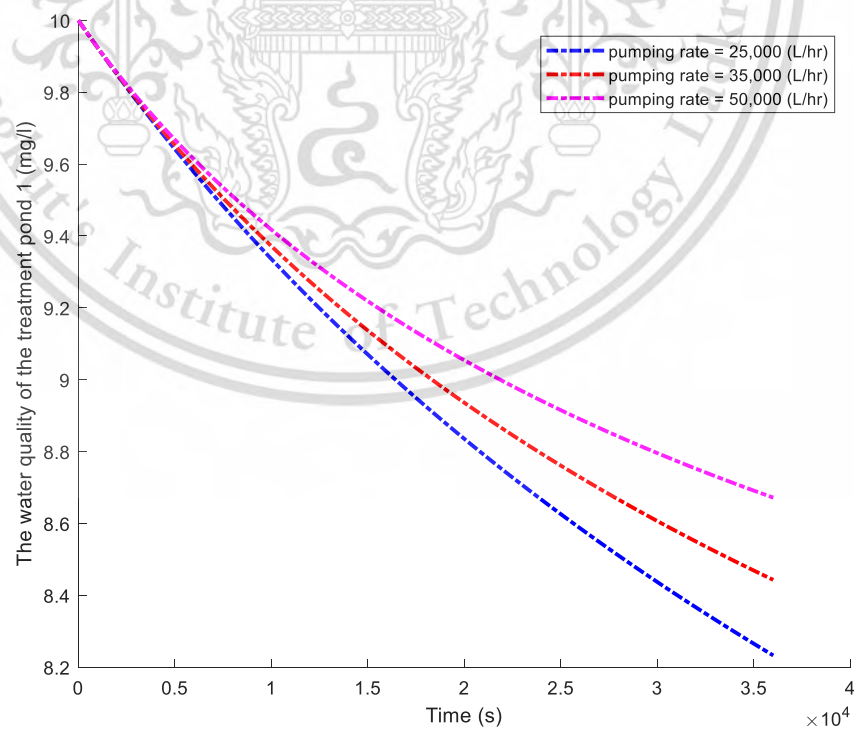


Figure 4.12: Graph of the change in water quality in treatment pond 1 from pumping incoming water from shrimp ponds for treatment in 36,000 s.

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From the graph, it can be seen that the water quality of the treatment pond 1 Improved water quality due to the fact that the water discharged and pumped out is continually treated, resulting in noticeably good water quality. Water with higher water content is better at treating water than with larger water content at the same time.



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Chapter 5

Discussion and Conclusion

In this chapter, we will discuss, discuss and summarize the results of a data collection simulation of a closed system shrimp farm using water level changes to predict water level and water volume in shrimp pond and treatment pond 1.

5.1 Discussion

From the simulations, it was found that the inlet and outlet pumping rates were different, resulting in the water volume changing according to the drainage and pumping rates. In the traditional method, the polluted water in the second pond is treated after the second pond becomes full. We found that with a small volume of water, the water treatment capacity was improved over a large volume of water over the same calculation time which can save energy and cost as well.

5.2 Conclusion

We studied a mathematical model of the water quality assessment. From the pumping of water from the shrimp pond to the treatment pond 1, it was found that the higher inlet rate affects the water volume in the treatment pond 1, resulting in a higher volume of water as well, resulting in higher water quality in the treatment pond. The first treatment pond was significantly reduced when treated with a small volume of water, making the water treatment capacity of water quality much better than the volume of water.

5.3 Suggestions

This research has developed a mathematical model to be useful for shrimp farmers. This research can be applied to other ponds in closed-system shrimp farms, such as the treatment pond 2, ready-to-use pond and sludge pond and to change the numerical method to suit the developed model situation may need to study other variables that affect the water quality in the pond as well.

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Appendix A



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Numerical Simulation of Water Quality in a Couple Pounds of Shrimp Farming *

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Abstract

Typical shrimp farming involves draining the wastewater from the shrimp ponds into the natural water source and pumping clean water into the shrimp ponds. The wastewater will be released into natural water sources. Impact on the environment, shrimp farming in a closed shrimp farm, is therefore used for circulating water for use in the farm by improving water quality without releasing wastewater into the environment. This research aims to present mathematical simulations to assess water quality in treatment systems and water level models of closed shrimp farms under the limitation of agricultural pumps in many actual cases. The numerical method was used to estimate the model's solution. The results of the simulations under various situations showed that the water treatment from the pumping pond to the sump had a satisfactory result. It can be concluded that if water quality is standardized and requires less water treatment time, should treat water from the start of pumping water from the pond to the reservoir which can save energy and cost as well.

Keywords: Water treatment, Water quality, Closed-system shrimp farms.

2020 MSC: Primary 65L06; Secondary 92-10.

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1 Introduction

Problems encountered in open-system shrimp farming are often the result of wastewater in shrimp ponds due to biological substances generated in the ponds. Therefore, wastewater that is drained into natural water sources may affect the environment and various living things, causing pollution in water resources [1]. Farming methods for raising shrimp in a closed system and water recycling methods for circulating farm water [2] improve water quality by reducing the drainage from farms to natural water sources. Using water cost-effectively and getting the most benefit from it increases the efficiency of shrimp production and eliminates the risk of shrimp disease, enabling farmers to produce quality shrimp that are safe from the use of chemicals or antibiotics. This research presents the measurement of water quality [3] in enclosed drainage systems for shrimp farming and water flow that affects water quality using a mathematical model [4], [5], [6], [7], [8], [9]. The water quality was measured from the water circulation in the farm and the flow rate from the drainage of the wells by offering treatment and recycling methods [10] to improve water quality. The solution of the generative equation is estimated by a fourth order Runge-Kutta method (RK4) [11], [12], [13], which is convenient for calculating. It simulates a situation where water in a well is pumped at different flow rates while the wastewater treatment plant is running at different intervals to compare the water-quality obtained by considering Biological Oxygen Demand (BOD) [14] as an index for assessing water quality. Using simulations, the research will focus on 2 ponds [15], namely the shrimp pond and the treatment pond 1.

2 Closed System Shrimp Farm

A closed system shrimp farm uses a new shrimp farming method by using a water recycling system to circulate the water used in the farm without releasing water into the environment, promoting the most cost-effective and beneficial use of water by applying the sedimentation principle of tap water production together with technology to improve water quality to be suitable for shrimp farming. This reduces the amount of water taken from water sources. In addition, sediment is stored on farms and not released into water sources. Control the spread of disease from farms to the outside environment as well.



Fig 1: Water treatment diagram of a closed shrimp farm.

3 Mathematical Model for Assessing Water Quality

3.1 Water Circulation Model

The rate of change in water level when water is pumped into the pond depends on time consider the model

$$\left(\text{Change in the water level} \right) = \frac{(\text{inflow}) - (\text{outflow})}{A} \quad (1)$$

or

$$\frac{dy}{dt} = \frac{(\text{inflow}) - (\text{outflow})}{A} \quad (2)$$

when y (m) is the water level, inflow (m^3/s) is the inflow rate, outflow (m^3/s) is the outflow rate, A (m^2) is the water surface area and t (s) is time.

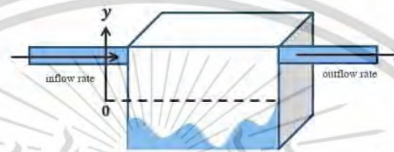


Fig 2: Diagram showing the flow rate of water.

We have the volume of water is

$$v = A \times y \quad (3)$$

where v (m^3) is the volume water, A (m^2) is the water surface area, y (m) is the water level.

3.2 Water Quality Assessment Model

The water quality in the pond changes with the amount of water. We therefore created a mathematical model to assess the quality of couple ponds from the following equations:

$$v_1 \frac{dc_1}{dt} = k_1 c_1 - Q_1, \quad 0 \leq k_1 \leq 1 \quad (4)$$

where v_1 (l/s) is the volume of water in the shrimp pond, c_1 (mg/l) is the water quality of the shrimp pond, Q_1 (mg/l) is the removal mechanism, t (s) is time and k_1 is the reaction rate of the shrimp pond.

And there will be a case of pumping water that is pumped in from the shrimp pond to the treatment pond 1, the percentage of decomposition of wastewater into the treatment pond 1 is R_2 . The equation is

$$v_2 \frac{dc_2}{dt} = k_2 c_2 - Q_2 + R_2 c_1, \quad 0 \leq k_2 \leq 1 \text{ and } 0 \leq R_2 \leq 1 \quad (5)$$

where v_2 (l/s) is the volume of water in the treatment pond 1, c_2 (mg/l) is the water quality of the treatment pond 1, Q_2 (mg/l) is the removal mechanism of the treatment pond 1, t (s) is time, k_2 is the reaction rate of the treatment pond 1 and R_2 is percentage of decomposition of wastewater into the treatment pond 1.

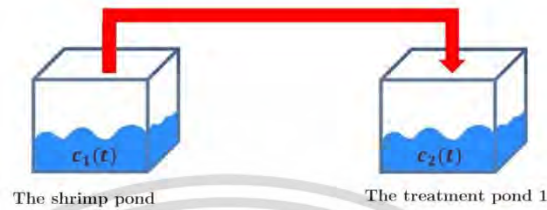


Fig 3: Diagram showing the water quality of 2 ponds.

From Fig 3, the picture shows that water is pumped out of the shrimp pond for treatment in the treatment pond 1. The water quality of the treatment pond 1 is linked from the shrimp pond because water is pumped from the shrimp pond and from the water being pumped into the treatment pond 1 the waste water is decomposed during the process.

4 Numerical Techniques for Solution of Water Circulation Model and Water Quality Qsessment Model

The Runge-Kuta 4th order method (RK4) is the most commonly used method for solving ordinary differential equations (ODEs) because of its high accuracy and precision. Let an initial value problem be specified as follows:

$$\frac{dy}{dt} = f(t, y), \quad y(t_0) = y_0 \quad (6)$$

now let's pick a step size $h > 0$ and define, for $t_{n+1} = t_n + h$ where $n = 0, 1, 2, 3, \dots$ we have

$$y_{n+1} = y_n + \frac{1}{6}h(x_1 + 2x_2 + 2x_3 + x_4), \quad t_{n+1} = t_n + h \quad (7)$$

where

$$\begin{aligned} x_1 &= f(t_n, y_n), \\ x_2 &= f\left(t_n + \frac{h}{2}, y_n + h \frac{x_1}{2}\right), \\ x_3 &= f\left(t_n + \frac{h}{2}, y_n + h \frac{x_2}{2}\right), \\ x_4 &= f(t_n + h, y_n + hx_3). \end{aligned}$$

5 Simulation Events to Use Mathematical Model

Consideration will be made to simulate the event to use mathematical models to predict the water level and water volume when the water flow rate is different at different time periods. It uses the rate of pumping water in and out that is commonly used in agriculture.

Example 1 Determine the initial water level of the shrimp pond = 10 m. The water will be pumped out to the treatment pond 1 at the pumping rate = 25,000 l/hr in 0 to 72,000 s and the treatment pond 1 has the initial water level = 2 m. Water is pumped in from the shrimp pond using the water inflow rate = 25,000 l/hr at 0 to 72,000 s and the initial water quality of the shrimp pond = 22 mg/l and treatment pond 1 = 10 mg/l by pumping water in and out of both ponds is treated all the time and the surface area of both = 100 m² is determined.

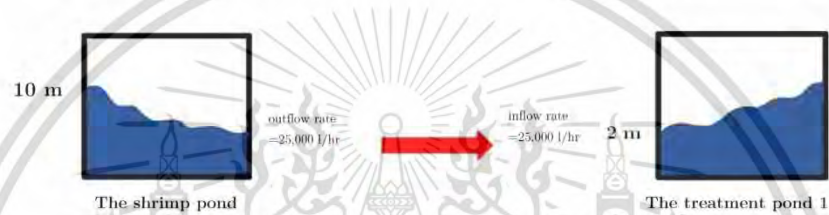


Fig 4: The diagram shows the simulation of the flow of water in two ponds at different times.

Table1: Defining the conditions of a model application example.

The shrimp pond	The treatment pond 1
$y_1(0) = 10 \text{ m}$	$y_2(0) = 2 \text{ m}$
inflow rate = 0 l/hr	inflow rate = 25,000 l/hr
outflow rate = 25,000 l/hr	outflow rate = 0 l/hr
$c_1(0) = 22 \text{ mg/l}$	$c_2(0) = 10 \text{ mg/l}$

when the following conditions are set $k_1 = k_2 = 0.4546$, $Q_1 = Q_2 = 16.7515 \text{ mg/l}$, $R_2 = 0.01$ apply the conditions obtained to create an equation and find the water volume and water quality as follows:

Numerical simulation for the water determination.

- The water volume of the shrimp pond:

set pumping rate = 25,000 l/hr.

The inflow rate is inflow = 0 (m³/s).

The outflow rate is outflow = $\frac{25,000 \times 10^{-3}}{60 \times 60}$ (m³/s).

The conditions can be substituted into equation (2) as follows:

$$\frac{dy_1}{dt} = \frac{0 - 25000 \times 10^{-3} \times 60^{-2}}{100} \quad (8)$$

when step size is $h=1$ and the initial condition is $t=0$, $y_1 = 10$, $0 \leq t \leq 72,000$.

We would like to estimate the solution of equation (8) by the RK4 method and apply the resulting water level to the volume of water in equation (3).

Table2: The volume of water of the shrimp pond.

Time (s)	0	18000	36000	54000	...	72000
The volume of water (m ³)	1000	875.0069	750.0069	625.0069	...	500.0069



Fig 5: Graph of shrimp pond water volume after pumping out at 0 to 72,000 s.

- The water volume of the treatment pond 1:

set pumping rate = 25,000 (L/hr)

The inflow rate is inflow = $\frac{25,000 \times 10^{-3}}{60 \times 60}$ (m³/s).

The outflow rate is outflow = 0 (m³/s).

The conditions can be substituted into equation (2) as follows:

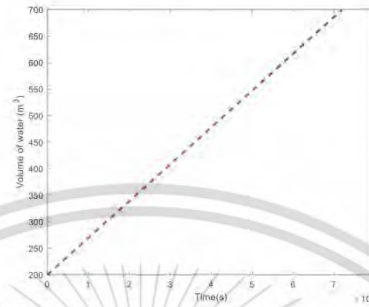
$$\frac{dy_2}{dt} = \frac{25000 \times 10^{-3} \times 60^{-2} - 0}{100} \quad (9)$$

when step size is $h=1$ and the initial condition is $t=0$, $y_2 = 2$, $0 \leq t \leq 72,000$

We would like to estimate the solution of equation (9) by the RK4 method and apply the resulting water level to the volume of water in equation (3).

Table 3: The volume of water of the treatment pond 1.

Time (s)	0	18000	36000	54000	...	72000
The volume of water (m ³)	200	324.9931	449.9931	574.9931	...	699.9931

**Fig 6:** Graph of treatment pond 1 water volume after pumping in 0-72,000 s.**Numerical simulation for water quality assessment model.**

- The volume of water obtained in the shrimp pond was used to determine the water quality with the following conditions:

- 1) The reaction rate $k_1 = 0.4546$.
- 2) The removal mechanism $Q_1 = 16.7515$.

The conditions given in equation (4) can be substituted as follows:

$$V_1 \frac{dc_1}{dt} = 0.4546c_1 - 16.7515 \quad (10)$$

thus, we have

$$\frac{dc_1}{dt} = \frac{0.4546c_1 - 16.7515}{V_1:1000} \quad (11)$$

when step size is $h=1$ and the initial condition is $t=0$, $c_1 = 22$, $0 \leq t \leq 72,000$.

We would like to estimate the solution of equation (11) by the RK4 method.

Table 4: The water quality of the shrimp pond after the treatment was completed.

Time (s)	0	18000	36000	54000	...	72000
The water quality (mg/l)	22	21.7597	21.4697	21.1118	...	20.6553

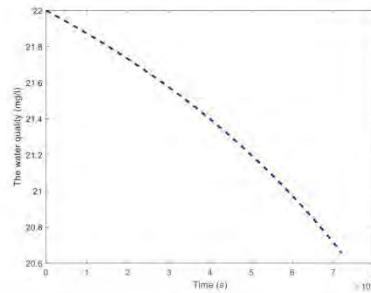


Fig 7: Graph of the water quality from water volume in the shrimp pond.

- Bring the volume of water obtained in the treatment pond 1 to find the water quality with the following conditions:

- 1) The reaction rate $k_2 = 0.4546$.
- 2) The removal mechanism $Q_2 = 16.7515$.
- 3) The percentage of decomposition of wastewater into the treatment pond 1 $R_2 = 0.01$.

The conditions given in equation (5) can be substituted as follows:

$$v_2 \cdot \frac{dc_2}{dt} = 0.4546c_2 - 16.7515 + 0.01c_1 \quad (12)$$

thus, we have

$$\frac{dc_2}{dt} = \frac{0.4546c_2 - 16.7515 + 0.01c_1}{v_2 \cdot 1000} \quad (13)$$

when step size is $h=1$ and the initial condition is $t=0, c_2=10, 0 \leq t \leq 72,000$.

We would like to estimate the solution of equation (13) by the RK4 method.

Table 5: The water quality of the treatment pond 1 after the treatment was completed.

Time (s)	0	18000	36000	54000	...	72000
The water quality (mg/l)	10	8.9251	8.2316	7.7295	...	7.3426

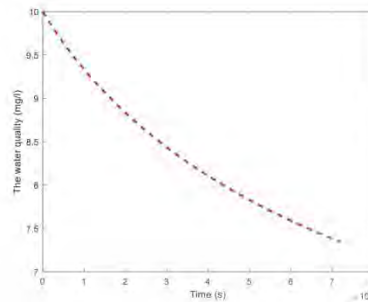


Fig 8: Graph of the water quality from water volume in the treatment pond 1.

Example 2 Scheduling of pumping in and out at the same time as in the example 1 and change the initial water level to less than the first sample to see how the difference between the amount of water in the initial shrimp pond is greater and the less water quality is different with the following conditions:

Table 6: Defining the conditions of a model application example.

The shrimp pond	The treatment pond 1
$y_1(0) = 6 \text{ m}$	$y_2(0) = 2 \text{ m}$
inflow rate = 0 l/hr	inflow rate = 25,000 l/hr
outflow rate = 25,000 l/hr	outflow rate = 0 l/hr
$c_1(0) = 22 \text{ mg/l}$	$c_2(0) = 10 \text{ mg/l}$

when the following conditions are set $k_1 = k_2 = 0.4546$, $Q_1 = Q_2 = 16,7515 \text{ mg/l}$, $R_3 = 0.01$ apply the conditions obtained to create an equation and find the water volume and water quality as follows:

Table 7: The volume of water.

The volume of water (m ³)	Time (s)					
	0	18000	36000	54000	...	72000
The shrimp pond	600	475.0069	350.0069	225.0069	...	100.0069
The treatment pond 1	200	324.9931	449.9931	574.9931	...	699.9931

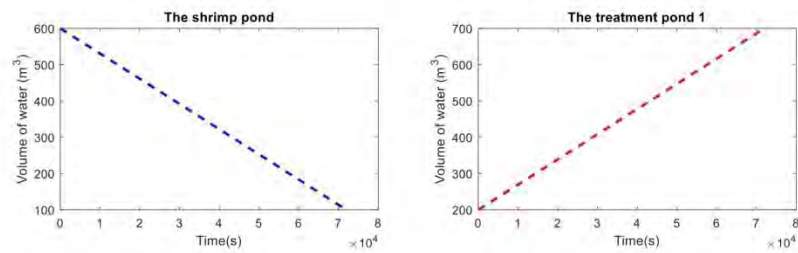


Fig 9: Graph of the volume water of the shrimp pond and the treatment pond 1.

Table 8: The water quality.

The water quality (mg/l)	Time (s)					
	0	18000	36000	54000	...	72000
The shrimp pond	22	21.5183	20.8635	19.8796	...	18.0054
The treatment pond 1	10	8.9233	8.2286	7.7254	...	7.3378

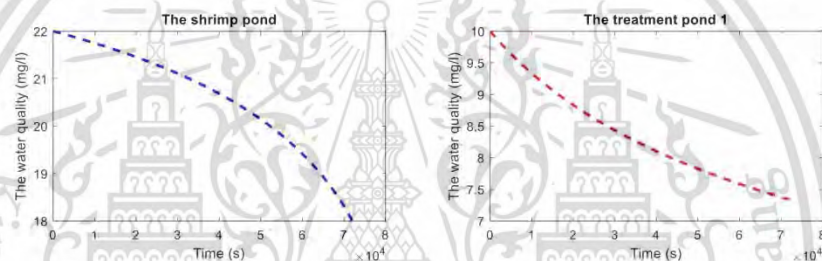


Fig 10: Graph of the water quality the shrimp pond and the treatment pond 1.

6 Discussion and Conclusion

From the simulations, it was found that graphs 5, 6 and 9 showed that the water inlet and outlet flow rates were different for each time period, resulting in the change in water volume according to the pumping rate and the water inlet treatment out with causing the concentration of pollution in the water to continuously decrease. From the simulations showing the difference in the initial water volume of the two shrimp ponds, it was found that the water treatment when the amount of water was lower would increase the treatment capacity better than the water treatment when the volume was large. See Graph 7, 8 compare to graph 10. It can be seen that the graph 10 has more deterioration in water quality. If water quality is standardized and requires less treatment time, water treatment should be started from the start of pumping into the well until the water is full and when the desired water quality is achieved, the water treatment will be stopped.

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