CHAPTER 3

DETERMINATION OF PHOSPHORUS CONCENTRATION CALIBRATION CURVE USING LABORATORY RESISTIVITY METHOD AT ALKALINE pH CONDITION

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3.1 INTRODUCTION

Phosphorus (P) is an essential plant nutrient that accounts for approximately 0.2 % of plant dry weight [1][2]. Specifically, phosphorus in the environment is critical in supporting the growth of living organisms and developing a healthy ecosystem and they are necessary to all living systems. Phosphorus is a DNA and RNA component and indispensable for the energetic metabolism (ADP/ATP) of the living ecosystem [3]. In aquatic ecosystems low P concentrations benefit the biological productivity of freshwater lakes, reservoirs, and rivers [3]

Meanwhile, on the other aspect, phosphorus-containing wastewater is life threatening to humans and the environment, and must be treated before being discharged into rivers, lakes, seas, and land surfaces. Domestic and agro-industrial wastewater which undergoes mandatory anaerobic treatment, is still believed releases a huge amount of nutrients such as phosphorus into the wastewater. This situation can create natural nutrients pollution towards the water and is directly responsible for eutrophication; the situation associated with the abundant algae growth caused by excess nutrients in water bodies such as in in rivers, lakes, and oceans around the world [4][5][6][7].

An article by Corell [8] stated that concentrations as little as 0.02 mg P/L can be considered to cause eutrophication, having negative ecological effects to promote algal growth [9] and can cause hypoxia and negative effects from algal toxins [10][11]. Orthophosphate, metaphosphate and organically each compound were classified into three types of phosphorus form. Orthophosphate phosphorus refers to the total phosphorus fraction dissolved and available for chemical reactions via coulombic attraction to cations [12]. These phosphates can be divided into non-point sources and point sources.

Phosphate stimulates the growth of plankton and aquatic plants, which provide food for more significant organisms, including zooplankton, fish, humans and other mammals. Phosphate is the crucial element of the food chain. The aging process of the river basin or surface marine ecosystems will be accelerated because phosphate charge continues to build up in the river or surface water ecosystem. An in-situ analysis is used on the sample that has various concentrations. Water resistivity is the water capable of withstanding an electrical current. Water resistivity is dependent on the quantities of ionic material that is dissolved in the water. The method can be done without sending the sample to the lab for analysis and can save time to get resistivity value.

This study aims to determine the electrical resistivity value of phosphorus concentrations at alkaline pH range and high, medium and low phosphorus concentrations. After that, it is to develop the calibration curve between phosphorus concentration and resistivity value. This study focuses on developing a phosphorus concentration calibration curve using the laboratory resistivity method only in alkaline conditions. The value of resistivity in meter ohm by resistivity 4-pin method. This experiment is conducted in a laboratory in FKAAB of UTHM. The range of alkaline conditions covers from pH 7.6 to pH 12.0. The concentrations of phosphorus standard are divided into three major groups, which are high (101 to 1000 mg P/L), medium (11 - 100 mg P/L), and low (1 - 10 mg P/L).

This experiment was carried out to find the calibration curve for different phosphorus concentrations and obtain the value of moisture content. Doing this laboratory test can define the quality of water and the environment. This method prevents chemical reagent usage that is dangerous and affects the environmental quality. The sample can be done in-situ using the 4-pin method without bringing it to the lab and saving time. The pH value of different phosphorus concentrations can be obtained accurately by using a pH meter.

3.2 MATERIALS AND METHOD

Several apparatuses need to be prepared before the experiments, such as beaker, burette, pH meter, Duren and amber bottles, dropper and glass container. The chemical solution used for this study is potassium dihydrogen phosphate, KH2PO4. MILLER-400A resistivity meter and soil box were used to obtain the resistivity value of the solution. There are preliminary methods that need to be conducted: to prepare the phosphorus stock solution, reagent for washing which is 1M hydrochloric acid, and pH adjuster, which is sulfuric acid and sodium hydroxide (Table 3.1). PH adjuster is needed to observe the resistivity of the solution in different pH values.

The sample of phosphorus was prepared within the low, medium and high range of concentration. Eq. (3.1) is used for the preparation of stock solutions.

$$M_1V_1 = M_2V_2 \qquad (3.1)$$

M_1 = Phosphorus P concentration – stock solution; V_1 = volume of water taken from the phosphorus concentration; M_2 = Required phosphorus concentration; V_2 = volume of volumetric flask. For example, for the preparation of 20 mg/L phosphorus solution, 20 ml of 1000 mg/L phosphorus stock solution needed to be added in the 1000 ml volumetric flask and filled with ultra-pure water until the mark.

Table 3.1: The solution involved in the preliminary method and its purposes

Solution used	Concentration *M*	Purposes
Sulfuric acid	0.1, 1	pH adjuster
Sodium hydroxide	1, 2, 3, 5	pH adjuster
Hydrochloric acid	1	Washing reagent

Table 3.2: The range and value of concentrations of phosphorus conducted in this experiment

Range of concentration	Concentration of phosphorus (mg/L)				
Low	2	4	6	8	10
Medium	20	40	60	80	100
High	200	400	600	800	1000

The MILLER-400A was used to determine the resistivity of the sample of phosphorus concentration in the electrolyte box. The resistivity was obtained in ohm.meter using Eq. (3.2).

$$\rho = RA\,/L \qquad (3.2)$$

ρ = resistivity (ohm.cm); R = resistance (ohms); A = cross-sectional area of the current electrodes (cm); L = separation between the potential electrodes (cm).

3.3 RESULTS AND DISCUSSION

The resistivity value for the solution depends on phosphorus concentration and the pH value in the solution. This study was conducted to obtain the average value of the resistivity of the concentrated phosphorus solution from a low concentration of 2 mg/L to a high concentration of 1000 mg/L consisting of different pH from 7.6 to 11.0 with 0.2 intervals. This calibration curve was divided into three major phosphorus ranges: low, medium, and high range. The higher the concentration of the phosphorus means the higher the number of ions in the solution.

The calibration curve for the low range of phosphorus concentration was obtained from the lab experiment. Every graph is different based on the value of pH. With reference to Figure 3.1, the data for the 80 mg/L and 2 mg/L shows the lowest and highest resistivity among the low range of concentration for the phosphorus solution.

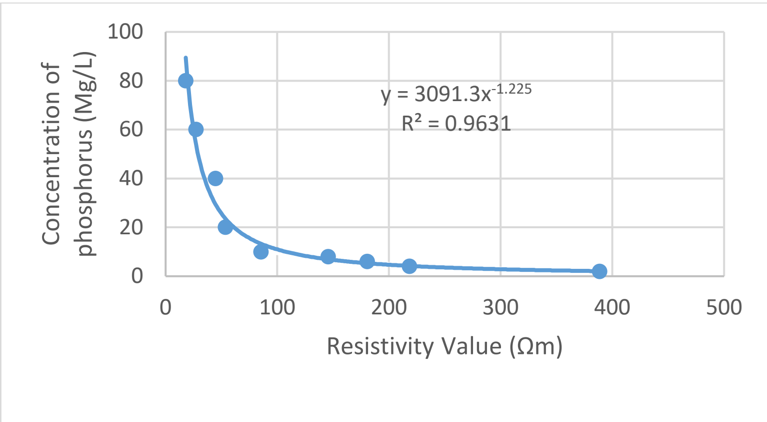

Figure 3.1: Calibration curve of phosphorus concentration and resistivity at pH 7.6

The calibration curve of the concentration of phosphorus was obtained. Every graph is different based on the value of pH. In Figure 3.2, the data for the 80 mg/L and 2 mg/L shows the lowest and highest resistivity among the low range of concentration for the phosphorus solution.

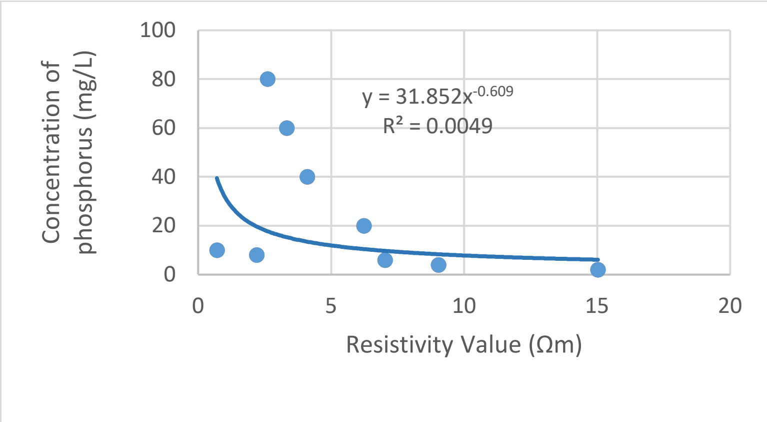

Figure 3.2: Calibration curve of phosphorus concentration and resistivity at pH 11

In general, this lab test shows the effects of the pH value on resistivity. The higher the pH value, the lower the value of resistivity of the phosphorus solution. Based on the graph, it shows the concentration of the phosphorus is inversely proportional to the resistivity value, which means the higher the concentration of the phosphorus will affect the reduction of the resistivity value. This is because of the increasing number of phosphorus ions in the solution.

3.4 CONCLUSION

From this study through the lab experiment, the highest phosphorus content in the water sample is the lowest c value that has been obtained. This can be seen as a result of the highest phosphorus concentration by 80 mg/L, resulting in the lowest resistivity value. The results also show that the water sample with a pH value of 11.0, high alkali, results in the lowest resistivity value. From the data obtained and calculated, two different phosphorus concentration calibration curves, which are low and medium, were developed within different pH values in alkaline conditions.

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