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Development of Phosphorus and Ammonium-Nitrogen Concentration Calibration Curve Using Laboratory Resistivity Method at Acidic pH Conditions

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Abstract: Phosphorus and nitrogen are important element to the living ecosystem, but the amountshould be in optimum level. The amount of concentration will bring effect towards thewater quality and the surrounding ecosystem. Water resistivity method can be applied in-situ to obtain the resistivity value of the water body. This study was proposed to develop the phosphorus and ammonium-nitrogen concentration calibration curve using laboratory resistivity method in acidic pH condition. A laboratory experiment was conducted to obtain the resistivity value of different concentration of phosphorusand ammonium-nitrogen in different pH value of acidic solution varies from 3.0 to 6.4 with 0.2 interval. The resistivity value was obtained using electrical resistivity box and analysed to develop the calibration curve. The calibration curves which reflect the relationship between phosphorus and ammonium-nitrogen concentration and resistivity value were developed. The highest determination coefficient for phosphorus was 0.6144 at pH 4.4 while for ammonium-nitrogen was 0.8352 at pH 3.0. The results from the calibration curves had shown the concentration of the phosphorus and ammonium-nitrogen are inversely proportional to the resistivity value. Regarding to pH value, the higher the pH value, the lower the resistivity value. The resistivity value decreases as the concentration of phosphorus and ammonium-nitrogen increases. The results show that the high number of ions will result in high conductivity and low resistivity. As conclusion, result for phosphorus concentration at pH 3.0 suited the best result while for ammonium-nitrogen concentration at pH 4.4 suited the best result.

Keywords: Phosphorus, Ammonium-Nitrogen, Calibration Curve, Acidic

1. Introduction

Nowadays, phosphorus is widely use throughout the world, especially in agriculture. Phosphorus is one of the key elements in modern agriculture. According to Wood [1], the largest amount of

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phosphorus used are found in fertilization of crops. The importance of phosphorus includes increase root growth, promote resistance to root rot diseases, provide resistance for plant against winter and so on [1]. Phosphorus brings benefit to our daily life, but it also impacts the environment and human health. Excessive amount of phosphorus will create a phenomenon which is eutrophication. Eutrophication is a phenomenon which excess discharge of nutrients in an aqueous system [2]. According to David Weaver [3], excessive use of phosphorus fertilisers already contributed to algal blooms in waterways and estuaries in Western Australia. These algae can cause a number of problems, such as making life unpleasant near waterways (nausal odors, aesthterics), causing skin irritations from contact with water, and the worst case is poisoning.

Ammonium-nitrogen ($NH4^{+}$-N) is known to be beneficial for chemistry in soil and inthe plant metabolism. Plant development and improvement of soil nitrogen retention together with an increase in the presence of phosphate will be benefits of maintaininga significant amount of concentration of ammonium nitrogen. However, nitrogen presents in wastewater, especially if the source is from blackwater which contributes immensely to the contamination of water quality [4]. Ammonium-nitrogen values in wastewater are measured in milligrams per litre and are used to specify water treatment systems and facilities. Sewage treatment plants, receiving lower values, typically remove 80 percent and more of the input ammonium and reach NH_3-N values of 250mg/L or less [5]. Ammonium toxicity happens because plant uptake too much ammonium from the rising medium. Usually, this is not an issue because the growing medium is warm as a nitrifying bacterium transforms ammonium to nitrate [6].

This study focus on the resistivity in different value of acidic pH range in a solution. Electrical resistivity can be measured by using the soil box and two electrodes connected to the soil box resistivity meter. The constant voltage of current will let to flow through the soil box fill with the fluid sample. The amount of ion contain will give effect to the result of resistivity. The lower the reading of the resistivity, the higher the concentrations of ion or salt dissolve in the sample.

The objectives of this study are to measure the electrical resistivity value of a solution mixture of phosphorus and ammonium nitrogen concentrations at acidic pH range. Other than that, this study also determine the electrical resistivity value at different phosphorus and ammonium-nitrogen concentrations and develop the calibration curve between ammonium nitrogen concentration and resistivity value.

2. Method and Material

There were preparations of materials needed to be conducted before conducting experiment. The chemical solutions that are used for this study were potassium phosphate monobasic and ammonium sulphate solution. MILLER-400A resistivity meter and soil box were used to obtain the resistivity value of the solution. Other than that, sulphuric acid, H_2SO_4 and sodium hydroxide were used as the pH adjuster.[7] pH adjuster is needed in order to observe the resistivity of the solution in different pH value. There are preliminary methods that need to be conducted which is to prepare the phosphorus and ammonium-nitrogen stock solution.[7][8] Decon 90 and hydrochloric acid, HCL were used for cleaning the apparatus.[7][8] Cleaning the apparatus before conducting next experiment is to ensure the results are not affected by experiment before. The following equation is used in order to prepare the phosphorus and ammonium-nitrogen stock solution with various concentration:-

$$M_1V_1 = M_2V_2 \quad \text{Eq.1}$$

where M_1 = Concentration of stock solution (mg/L), V_1 = Volume taken from the stock solution (ml), M_2 = Required concentration (mg/L), V_2 = Volume of volumetric flask (ml)

For examples, a 1000 ml of volumetric flask will be filled with 20ml of 1000mg/L of phosphorus stock solution then filled with ultra pure water until reached the mark and the concentration of phosphorus stock solution will be 20mg/L.

Table 2: The concentrations of phosphorus and ammonium-nitrogen that conducted in this experiment

Concentration of phosphorus (mg/L)	2	4	6	8	10	20	40	60	80	100	200	400	600	800	1000
Concentration of ammonium-nitrogen (mg/L)	20	40	60	80	100	200	400	600	800	1000	1200	1400	1600	1800	2000

In this study, the measurement of resistivity by using the 4 soil pins electrodes which were parts of an electrolyte box are utilized. The electrolyte box is also known as the soil box. Electrical resistivity box used to determine the resistivity of a soil or liquid sample. In this experiment, we used Miller 400A type of resistivity box that applied 4 pin methods. This method used test leads and 4 electrodes and can use to determine the earth resistivity by driven the electrode in a straight lines and same distance from each other.[8] The geometric of the electrolyte box is one of the factors in measuring the resistivity and it can be calculate from the resistance value by using the MILLER-400 with the formula:

$$\rho = RA / L \qquad \text{Eq.2}$$

where ρ = Resistivity (ohm.cm), R = Resistance (ohms), A = Cross-sectional area of the current electrodes (cm), L = Separation between the potential electrodes (cm)

3. Results and Discussion

The calibration graph curve between phosphorus and ammonium-nitrogen concentration and the resistivity value at acidic condition starting at pH 3.0 to pH 6.4 are shown in Figure 1 to Figure 3.

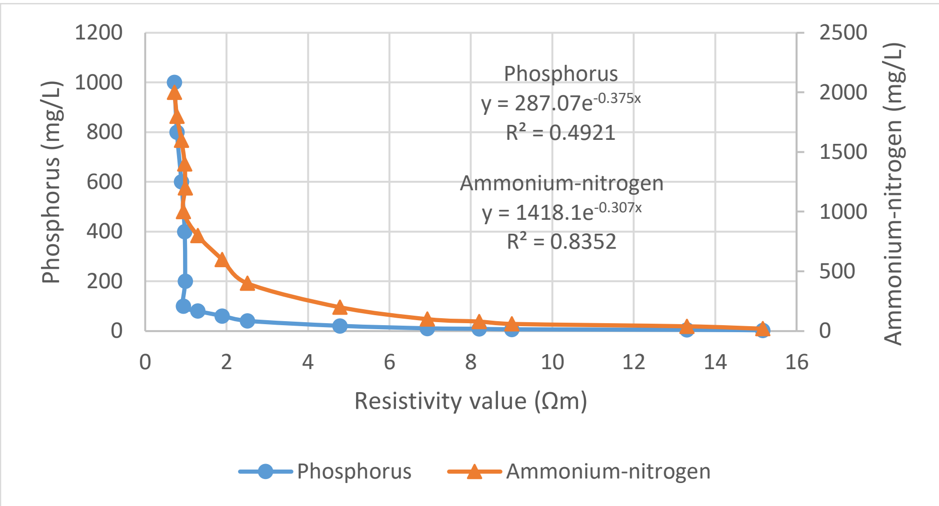

Figure 1: Calibration curve of phosphorus and ammonium-nitrogen concentration and resistivity at pH 3.0

Figure 1 shows the relationship between phosphorus and ammonium-nitrogen concentration with resistivity value at pH 3.0. According to the graph, when the concentration of phosphorus and ammonium-nitrogen increase, the resistivity value decreases gradually. The minimum value of resistivity value for phosphorus and ammonium-nitrogen are 0.73 Ω m at 1000 mg/L of phosphorus concentration and 2000 mg/L of ammonium-nitrogen concentration, whereas the maximum value of resistivity value is 15.17 Ω m at 2 mg/L of phosphorus concentration and 20 mg/L of ammonium-nitrogen concentration. For phosphorus, the equation is $[P^+] = 287.07e^{-0.375x}$ while the determination coefficient, R^2 is 0.4921. For ammonium-nitrogen, the equation is $[NH_4^+] = 1418.1e^{-0.307x}$ while the determination coefficient, R^2 is 0.8352.

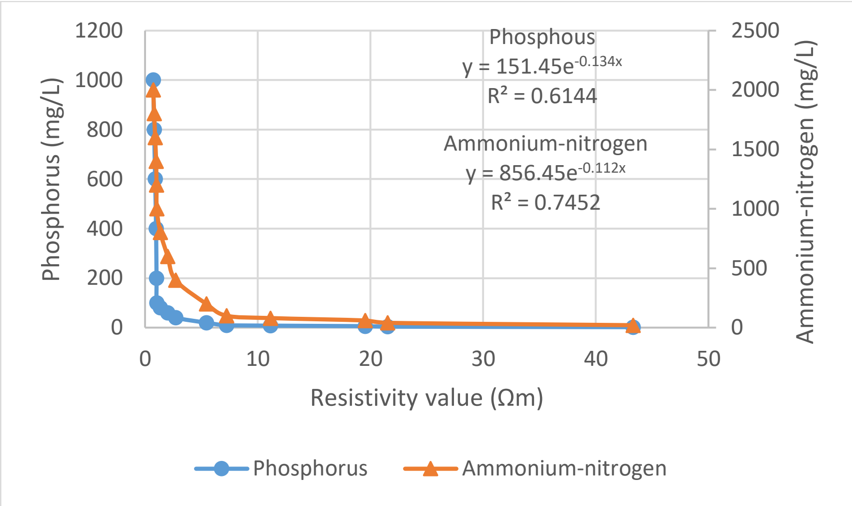

Figure 2: Calibration curve of phosphorus and ammonium-nitrogen concentration and resistivity at pH 4.4

Meanwhile, Figure 2 shows the relationship between phosphorus and ammonium-nitrogen concentration with resistivity value at pH 4.4. According to the graph, when the concentration of phosphorus and ammonium-nitrogen increase, the resistivity value decreases gradually. The minimum value of resistivity value for phosphorus and ammonium-nitrogen are 0.725 Ω m at 1000 mg/L of phosphorus concentration and 2000 mg/L of ammonium-nitrogen concentration, whereas the maximum value of resistivity value is 43.3 Ω m at 2mg/L of phosphorus concentration and 20 mg/L of ammonium-nitrogen concentration. For phosphorus, the equation is $[P^+] = 151.45e^{-0.134x}$ while the determination coefficient, R^2 is 0.6144. For ammonium-nitrogen, the equation is $[NH_4^+] = 856.45e^{-0.112x}$ while the determination coefficient, R^2 is 0.7452.

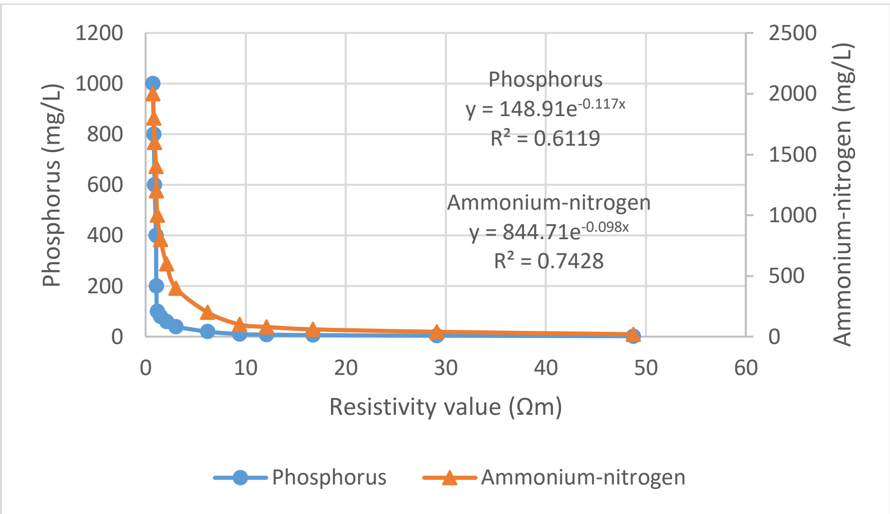

Figure 3: Calibration curve of phosphorus and ammonium-nitrogen concentration and resistivity at pH 6.4

Moreover, Figure 3 shows the relationship between phosphorus and ammonium-nitrogen concentration with resistivity value at pH 6.4. According to the graph, when the concentration of phosphorus and ammonium-nitrogen increase, the resistivity value decreases gradually. The minimum value of resistivity value for phosphorus and ammonium-nitrogen are 0.732 Ω m at 1000 mg/L of phosphorus concentration and 2000 mg/L of ammonium-nitrogen concentration, whereas the maximum value of resistivity value is 48.77 Ω m at 2 mg/L of phosphorus concentration and 20 mg/L of ammonium-nitrogen concentration. For phosphorus, the equation is $[P^+] = 148.91e^{-0.117x}$ while the determination coefficient, R^2 is 0.6199. For ammonium-nitrogen, the equation is $[NH_4^+] = 844.71e^{-0.098x}$ while the determination coefficient, R^2 is 0.7428.Based on the graphs, it was found that phosphorus and ammonium-nitrogen concentration are inversely proportional to resistivity value. The higher the concentration, the lower the resistivity value. As for pH value, the resistivity value can be seen as the value increases from pH 3.0 to 6.4.

According to Zulklifi[7] and Khaleeda[8], when the soil resistivity value is low, the moisture content is high as a result. When dry soil is repeatedly combined with water until it becomes over-saturated, this result occurs. As a result, the propagation of soil current is soothed and increased till the quantity of resistivity develops. Poor soil moisture content impacts the difficulty of ions propagating in pore fluid, resulting in low soil conductivity as resistance increases. The presence of water is essential in order to measure resistivity using the soil box resistivity method since adding additional water causes the resistivity value to decrease.

In terms of the link between phosphorus and ammonium-nitrogen concentration and electrical resistivity, it follows the same pattern as the relationship between pH and moisture content and resistivity value. In this example, when the concentration rises, the resistivity value falls. The presence of ions from electrical current, which carry electrical charges in the form of ions, causes this. A small number of ions can be found in a little amount of concentration. As a result, the current has trouble transferring ions, which raises the electrical resistivity as a result. On the other hand, at larger concentrations, an abundance of ions can be discovered, which has the possibility of easily transporting ions and resulting in low electrical resistance.

4. Conclusion

In conclusion, it can be concluded that the laboratory experiment was conducted successfully. Nonetheless, the calibration curve were developed from the relationship between different phosphorus and ammonium-nitrogen concentrations and electrical resistivity values. The higher the concentration, the lower the resistivity value. The results show that the high number of ions will result in high conductivity and low resistivity. For the best fit of the result, for phosphorus was at pH 3.0 while for ammonium-nitrogen was at pH 4.4.

Acknowledgement

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References

[1] C. W. Wood, G.L. Mullins, and B.F. Hajek. (2019). Soil Quality Institute Technical Pamphlet. *Phosphorus in Agriculture*.

[2] Goel. R. (2013). Biological Phosphorus Removal. doi:10.13140/RG.2.1.4578.6728

[3] Weaver, D., Summers, R., Rogers, D., & Richards, P. (2020). The effect of soil pH on phosphorus content of clover pasture

[4] Purwono, A. R., Hibbaan, M., & Budihardjo, M. A. (2017). Ammonia-nitrogen (NH3-N) and ammonium-nitrogen (NH4+-N) equilibrium on the process of removing nitrogen by using tubular plastic media. *J Mater Environ Sci*, *8*, 4915-4922.

[5] Manios, T., Stentiford, E. I., & Millner, P. A. (2002). The removal of NH3-N from primary treated wastewater in subsurface reed beds using different substrates. *Journal of Environmental Science and Health, Part A*, *37*(3), 297-308.

[6] Silveira, M. L., Vendramini, J., & Sollenberger, L. E. (2010). Phosphorus management and water quality problems in grazingland ecosystems. *International Journal of Agronomy*, *2010*.

[7] Zulkifli, M. Z. B. (2020). Development of phosphorus concentration calibration curve using laboratory resistivity method at acidic pH condition.

[8] Kamarudin, K. B. (2020). Development of ammonium-nitrogen concentration calibration curve using laboratory resistivity method at acidic pH condition.