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Development of Nitrate-Nitrogen Calibration Curve Using Laboratory Resistivity Method in Acidic pH Condition

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Abstract: A laboratory experiment was carried out to determine the resistivity value of various concentrations of nitrate-nitrogen in acidic solutions with pH values ranging from 2 to 6.2. The purpose of this study is to get the quantitative analysis of nitrate nitrogen calibration curve at acidic pH condition by performing resistivity method. In addition to find out how the ion flow with the concentration that use in this study. A series of nitrate-nitrogen covering three range namely low (2mg/L to 10mg/L), medium (20mg/L to 100mg/L), and high (200mg/L to 1000mg/L). Were prepared in acidic condition and was tested using resistivity meter box to obtain the associated resistance value. The resistivity value was calculated by multiplying the resistance reading obtained from resistivity meter box with multiplier factor of 10 at several acidic condition (pH 2 to 6.2). The results in this lab experiment show that the concentration of the nitrate-nitrogen is inversely proportional to the resistivity value. This is because the high number of ions will result in the high conductivity and low resistivity. The calibration curves that have been obtained including R2 value that showing its closer to 1.000. Thus, it can be referred that the calibration curve provided a great details and references as data collected was quite accurate.

Keywords: Nitrate-Nitrogen, Resistivity, Calibration Curve, Acidic

1. Introduction

The nitrate concentration is commonly expressed as NO3-. The term "nitrate-nitrogen" refers to the nitrogen that is present in the nitrate ion. This nomenclature is used to distinguish nitrate-nitrogen from ammonia nitrogen (ammonia nitrogen), nitrite nitrogen (nitrite nitrogen), and other forms of nitrogen. Typically, concentrations are expressed in milligrams per liter of nitrogen [1]. Nitrogen is a One of the most prevalent elements. Nitrogen makes up about 80% of the air we breathe [1]. When it comes to resistivity, a material's resistivity is low if it allows power to flow freely through it. However, because of the high resistivity, power is only directed through the material to a limited extent. Wires in overhead

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electrical cable and buildings are typically made of metals such as copper or aluminium [2].

A strong acidic solution will have high conductivity [3]. This happens due to high concentration of hydrogen ion in the acidic solution. High concentration of hydrogen ion will result in lower pH which also will bring in high conductivity and low resistivity in the acidic solution. The pH of a solution will significantly change when there is an addition of acid or base to pure water [4]. The flow of hydrogen electrons can be measured to determine the resistivity of fluid as well as to determine the concentration of ions in solution [4].

A soil box resistivity meter can be used to determine the electrical resistivity of liquid. Because the equipment required is highly sensitive in order to get precision, extra caution should be used when selecting a resistance meter [5]. Because there will be a source of voltage provided, electrical current can be generated in a solution. The quantity of ions in a solution can be used to calculate the resistivity value. Ions are known to transport electrons across a solution. As a result, the bigger the number of ions in an acidic solution, the lower the resistivity [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 nitrate-nitrogen concentrations at acidic pH range. Other than that, this study also determine the electrical resistivity value at nitrate-nitrogen concentrations and develop the calibration curve between nitrate-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 sodium nitrate 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 nitrate-nitrogen stock solution.[8] Decon 90 were used for cleaning the apparatus.[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 nitrate-nitrogen stock solution with various concentration:-

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

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 1: The concentrations of nitrate-nitrogen that conducted in this experiment

Concentration (mg/L)	2	4	6	8	10	20	40	60
Stock Solution Volume (mL)	2	4	6	8	10	20	40	60

Table 2: The concentrations of nitrate-nitrogen that conducted in this experiment

Concentration (mg/L)	80	100	200	400	600	800	1000
Stock Solution Volume (mL)	80	100	200	400	600	800	1000

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

This calibration curve was divided into three major ranges of Nitrate-Nitrogen solution as low range, medium range, high range concentration in acidic pH 2 to 6.2.

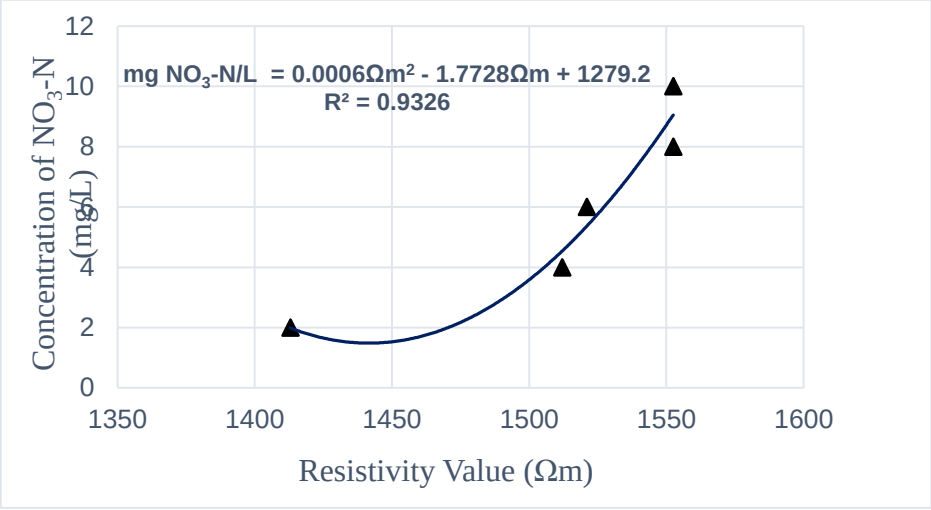

Figure 1: Calibration curve of nitrate-nitrogen concentration and resistivity at low range pH 3.0

Figure 1 shows the relationship between nitrate-nitrogen concentration with resistivity value at pH 3.0. According to the graph, when the concentration of nitrate-nitrogen increase, the resistivity value increase gradually. The relationship of nitrate-nitrogen with resistivity inside the of nitrate-nitrogen at pH 3 were $R^2 = 0.9326$.While the relationship of Nitrate-Nitrogen with resistivity inside the of Sodium Nitrate at pH 3 mg NO3-N/L = 0.0006Ωm2 - 1.7728Ωm + 1279.2 and $R^2 = 0.9326$.

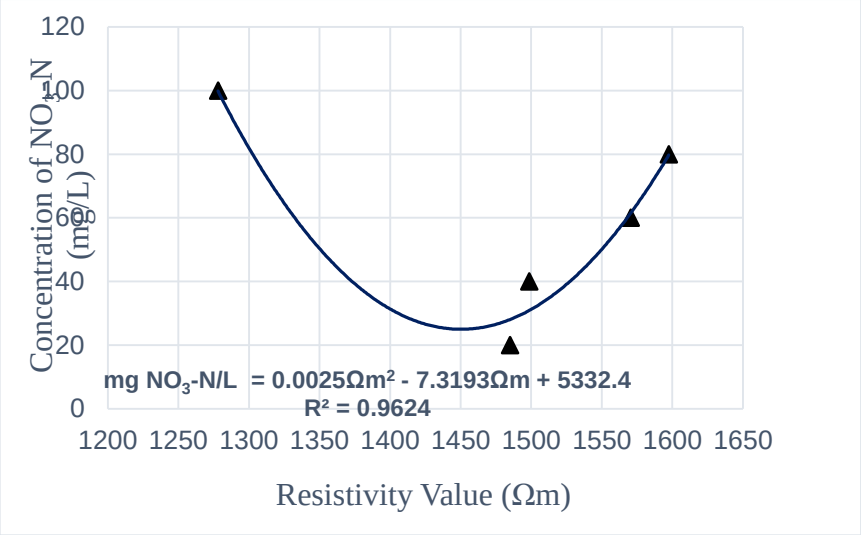

Figure 2: Calibration curve of nitrate-nitrogen concentration and resistivity at medium range pH 2.8

Meanwhile, Figure 2 shows the relationship between nitrate-nitrogen concentration with resistivity value at pH 2.8. According to the graph, when the concentration of nitrate-nitrogen increase, the resistivity value decreases gradually. The minimum value of resistivity value for nitarte-nitrogen are 1278 Ω m at 100 mg/L of sodium nitrate concentration, whereas the maximum value of resistivity value is 1597.5 Ω m at 80 mg/L of sodium nitrate concentration. While the relationship of nitrate-nitrogen with resistivity inside the of Sodium Nitrate at pH 2.8 mg NO3-N/L = 0.0025Ωm2 - 7.3193Ωm + 5332.4 and $R^2 = 0.9624$.

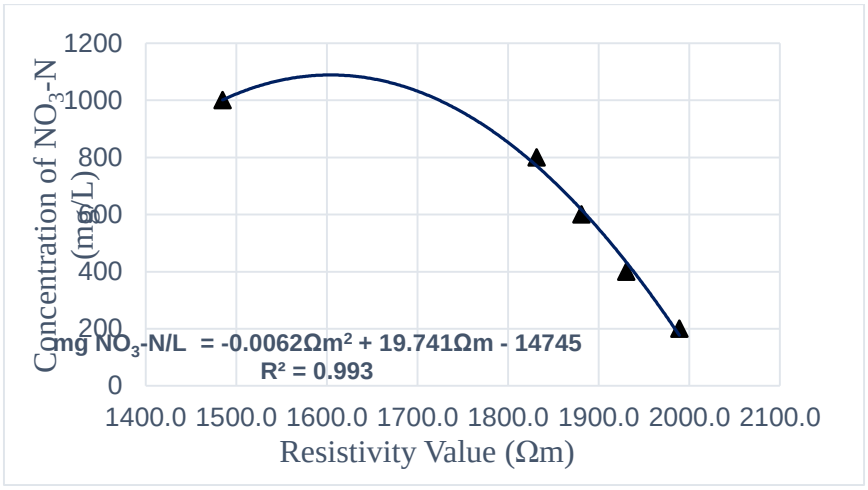

Figure 3: Calibration curve of nitrate-nitrogen concentration and resistivity at high range pH 5.2

Moreover, Figure 3 shows the relationship between nitrate-nitrogen concentration with resistivity value at pH 5.2. According to the graph, when the concentration of nitrate-nitrogen increase, the resistivity value decreases gradually. The minimum value of resistivity value for nitrate-nitrogen are 1485 Ω m at 1000 mg/L of sodium nitrate concentration, whereas the maximum value of resistivity value is 1989 Ω m at 200 mg/L of sodium nitrate concentration. While the relationship of Nitrate-Nitrogen with resistivity inside the of Sodium Nitrate at pH 5.2 mg NO3-N/L = -0.0062Ωm2 + 19.741Ωm - 14745 and $R^2 = 0.993$.

Based on the graphs, it was found that nitrate-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 2.0 to 6.2.

According to Zulklifi[7] and Khaleeda[8], when the resistivity value is low, the moisture content is high as a result. When solution is repeatedly combined with water until it becomes over-

saturated, this result occurs. As a result, the propagation of solution current is soothed and increased till the quantity of resistivity develops. Poor solution 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 nitrate-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. [9]

4. Conclusion

In conclusion, the laboratory experiment was conducted successfully. Nonetheless, the calibration curve were developed from the relationship between nitrate-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 low range was at pH 3.0 while for medium range was at pH 2.8 and for high range was at pH 5.2.

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