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The Electrical Behaviour Study on Saltwater Batteries in Various Electrolyte Concentrations and Cross-Sectional Areas

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Abstract
A study has been conducted to analyze the effect of various electrolyte concentrations and cross-sectional areas on voltage and current in batteries using the galvanic cell method (voltaic cells). This study aims to determine the electrolyte concentration and electrode cross-sectional area that provide optimal effects on voltage, current, and power in batteries. Variations in NaCl electrolyte concentration of 1 M; 3 M; 5 M; 7 M; and 9 M as electrolytes and variations in the cross-sectional area of Cu-Al 5 cm^2, 10 cm^2, 15 cm^2, 20 cm^2, 25 cm^2 as electrodes. From these tests, the optimal voltage value was obtained at a concentration of 7 M and a cross-sectional area of 25 cm2 with a value of 0.73 V, the optimal current value at a concentration of 7 M and a cross-sectional area of 25 cm2 with a value of 19.99 mA, and the optimal power value at a concentration of 7 M and a cross-sectional area of 25 cm2 with a value of 14.593 mwatts. The larger the cross-sectional area of the electrode, the greater the electrical energy produced. The optimum concentration of electrolyte greatly influences the value of the electrical power produced.

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INTRODUCTION

Battery technology is improved continuously(Waseem et al., 2025). In motor vehicles, hybrid vehicles also use batteries as energy storage technology(Jacobs et al., 2024; Pavlovic et al., 2024). Various methods are widely used in making batteries (Ali et al., 2024; Huang et al., 2022; Lippke et al., 2024). However, most studies use expensive materials, so they cost a lot of money. In addition, the long method is considered quite time-consuming and costly. In this study, batteries were made using natural materials (Anisa & Zainuri, 2020; Zhang et al., 2024). Salt is easy to get, here the researcher uses saltwater as the main component of electrolyte (Guy et al., 2025). In addition, the manufacturing technique uses a simple method so it saves more time and money.

A series of voltaic cells consisting of copper (Cu) and aluminum (Al) electrodes has been carried out by using sea saltwater as an electrolyte . The results of the study analyzed the voltage, current, and power values on the Cu-Al electrode pair with a series of one battery cell, two battery cells, and three battery cells in series circuit. In this study, it can be concluded that the magnitude of the voltage and current produced varies(Anisa & Erwanto, 2024). This is due to several influencing factors, namely, the conductor wire used, the type of electrolyte and the amount used, and the cross-sectional area of the electrode.

Based on research conducted by (Anisa & Setyaningrum, 2022), the power produced is quite small due to its small cross-sectional area and the absence of variations in electrolyte concentration (Neigum & Wang, 2024). So the author wants to continue by analyzing the effect of variations in electrolyte concentration and cross-sectional area on the voltage and current in the battery using the galvanic cell method (voltaic cell) (Singh et al., 2024). With variations in NaCl concentration of 1 M; 3 M; 5 M; 7 M; 9 M as electrolyte and variation of cross-sectional area of Cu-Al 5 cm^2, 10 cm^2, 15 cm^2, 20 cm^2, 25 cm^2 as electrode. It is expected that with variation of concentration and cross-sectional area can be known which gives optimal influence on voltage and current, so that the power produced is perfect. So through this research, it is expected to know how the electrolyte concentration affects the current and voltage produced. From this research, it is hoped to understand how far the electrode cross-sectional area affects the electrical power produced.

METHOD

Tools and Materiaks

The tools used in this study include glassware, analytical scales, petri dishes, hot plates, magnetic stirrers, alligator clips, vessel containers, scissors, rulers, and digital multimeters.

The materials used in this study include salt, distilled water, aluminum (Al) plates, copper (Cu) plates (Flores-Lasluisa et al., 2022).

Working Procedures

The stages in conducting this research are grouped into 3 that is preparation, testing, and data collection stage.

Preparation Stage

Making Electrochemical Cell Design

Prepare the design of an experimental device (experiment kit) in the form of a 250 liter beaker glass containing NaCl solution. Then a pair of electrode rod clamps are placed on top of the vessel, which can be shifted or adjusted to vary the distance between the two electrodes and the position of the electrode rod can be raised and lowered to adjust the variation of the electrode cross-sectional area (Gopi & Ramesh, 2024).

Electrode Preparation

Place the Cu (Copper) and Al (Aluminum) electrodes on the clamp with variations: 5 cm^2, 10 cm^2, 15 cm^2, 20 cm^2, 25 cm^2 (Liu et al., 2024).

Electrolyte Preparation

Make NaCl solution with concentration variations: 1 M; 3 M; 5 M; 7 M; 9 M.

Testing Stage

The testing stages carried out are as follows: NaCl which has become an electrolyte solution, each poured into a container with concentration variations of 1 M; 3 M; 5 M; 7 M; 9 M. Furthermore, the Cu-Al electrode pair with cross-sectional area variations of 5 cm^2, 10 cm^2, 15 cm^2, 20 cm^2, 25 cm^2 is dipped into the sample and then clamped. Then the voltage and electric current of the entire cell are measured with a multimeter for each variation of the electrode cross-sectional area. If the voltage and current values are known, the magnitude of the power value produced can be calculated.

Data Collection

Data collection is carried out through 2 main stages which are data collection techniques and data analysis techniques

Data collection techniques

The data collection technique uses the observation method of the experiments carried out. So that the data obtained and used in this study are primary. Data collection was obtained from the results of observations of the treatments given by recording the results of the potential differences generated by using solutions with different NaCl concentration variations and variations in the cross-sectional area of the Cu (Copper) and Al (Aluminum) electrodes (Singh et al., 2024).

Data analysis techniques

The data analysis techniques used in this study were carried out qualitatively by interpreting the observation data and quantitatively by using the One-way ANOVA test to test the differences between different groups or treatments. The One-way ANOVA test was used in this test because there was only one independent variable and one dependent variable.

RESULTS AND DISCUSSION

Based on the research that has been conducted, the results of measurements of the treatment of variations in the concentration of table salt solution (NaCl) 1 M; 3 M; 5 M; 7 M; 9 M and variations in the cross-sectional area of the Cu-Al electrode (Lobato-Peralta et al., 2024), including 5 cm^2, 10 cm^2, 15 cm^2, 20 cm^2, 25 cm^2. The results of these measurements are in the form of electrical voltage, electrical current, and electrical power.

The Effect of Electrolyte Concentration and Electrode Cross-sectional Area on Battery Voltage

Table 1 Results of Battery Voltage Measurement

Concentration	Cross-Secsional Area				
	5 cm^2	10 cm^2	15 cm^2	20 cm^2	25 cm^2
1 M	0,58	0,60	0,63	0,64	0,66
3 M	0,61	0,62	0,65	0,65	0,69
5 M	0,63	0,64	0,67	0,68	0,71
7 M	0,65	0,68	0,70	0,72	0,73
9 M	0,51	0,54	0,54	0,59	0,59

*Volt

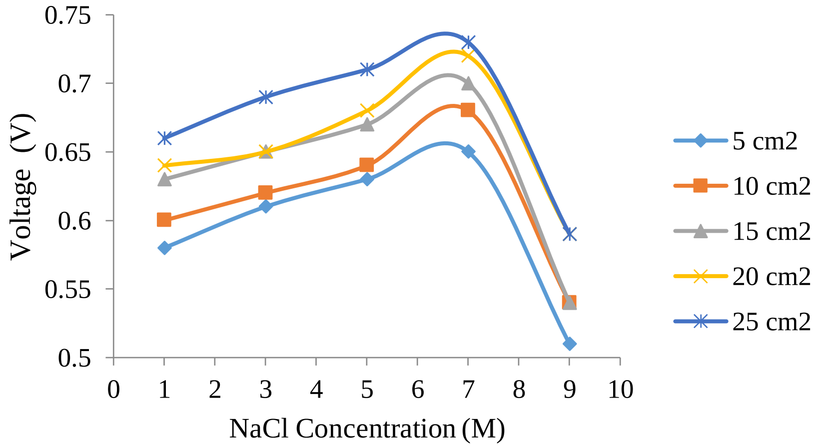

Figure 1. Graph of Battery Voltage Measurement Results

The results of measuring the voltage of table salt (NaCl) solution with concentration variations of 1 M; 3 M; 5 M; 7 M; 9 M and variations in the cross-sectional area of the Cu-Al electrode

(Slavova et al., 2025) of 5 cm^2, 10 cm^2, 15 cm^2, 20 cm^2, 25 cm^2 are presented in Table 1 and Figure 1. The graph in Figure 4.1 shows that the concentration of NaCl electrolyte has a linear relationship with the voltage value where the greater the concentration of the NaCl electrolyte solution used, the higher the voltage generated (Lobato-Peralta et al., 2024).

The Effect of Electrolyte Concentration and Electrode Cross-sectional Area on Battery Current

Table 2. Battery Current Measurement Results

Concentration	Cross-sectional Area				
	5 cm^2	10 cm^2	15 cm^2	20 cm^2	25 cm^2
1 M	5,94	7,52	8,18	9,38	10,77
3 M	7,96	9,76	11,44	13,75	15,67
5 M	9,15	13,84	14,83	18,05	18,92
7 M	10,72	16,42	17,99	19,96	19,99
9 M	5,33	6,07	6,68	8,43	9,72

*mAmpere

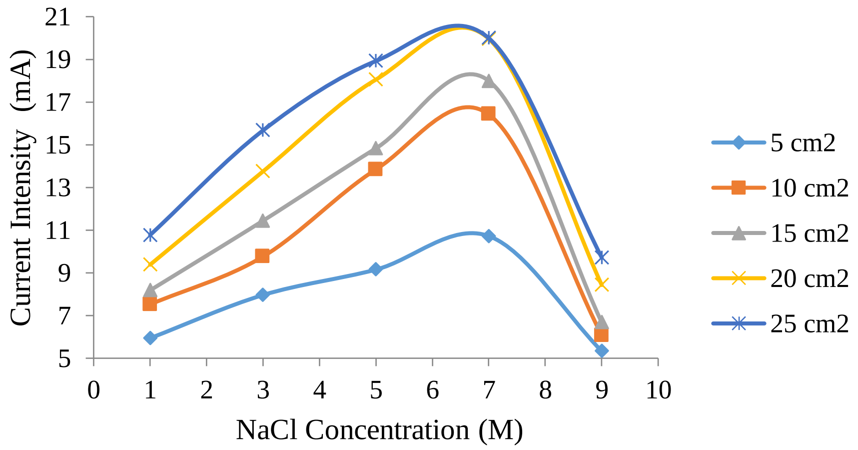

Figure 2 Graph of Battery Current Intensity Measurement Results

The results of current measurements on treatments with variations in the concentration of table salt (NaCl) solution 1 M; 3 M; 5 M; 7 M; 9 M and variations in the cross-sectional area of the Cu-Al electrode (Grube et al., 2024), including 5 cm^2, 10 cm^2, 15 cm^2, 20 cm^2, 25 cm^2 can be seen in Table 2 and Figure 2. The graph in Figure 2 shows that the concentration of NaCl electrolyte has a linear relationship with the current value; the greater the NaCl electrolyte solution concentration, the higher the current produced means higher electrical energy (Meng et al., 2017).

The Effect of Electrolyte Concentration and Electrode Cross-sectional Area on Battery Power

Table 3. Results of Battery Power Measurement

Concentration	Cross-sectional Area				
	5 cm^2	10 cm^2	15 cm^2	20 cm^2	25 cm^2
1 M	3,445	4,512	5,153	6,003	7,108
3 M	4,856	6,051	7,436	8,937	10,812
5 M	5,764	8,858	9,936	12,274	13,433
7 M	6,968	11,166	12,593	14,371	14,593
9 M	2,718	3,278	3,607	4,974	5,735

*mWatt

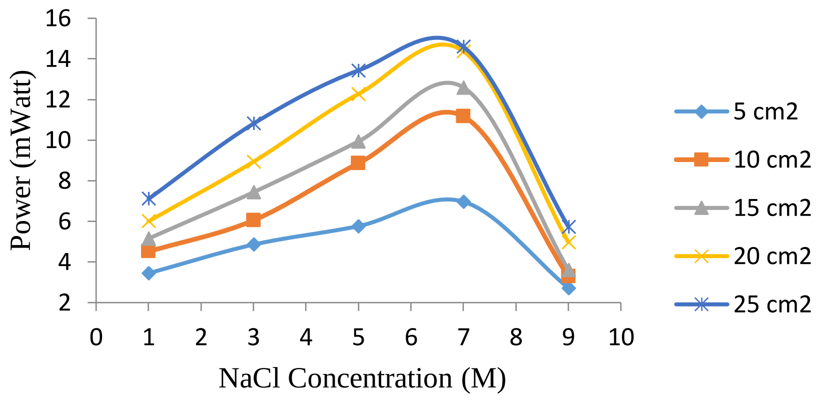

Figure 3. Graph of Electric Power Measurement Results

Power is the amount of energy absorbed in a circuit (Prakoso et al., 2020), power is generated from the difference in voltage and current (Li et al., 2018). Table 3 and Figure 3 show a comparison of electrolyte concentration variations with the increase in power from each cross-sectional area. Although there is a decrease in some data from each electrolyte due to a decrease in voltage and current values(Yang et al., 2022). These results indicate that the cross-sectional area that produces better power in each electrolyte concentration is at a Cu-Al cross-sectional area of 25 cm^2.

CONCLUSION

Based on the results of the research that has been carried out, it can be concluded as follows: The electrolyte concentration and cross-sectional area that provide an optimal effect on the voltage value are at a concentration of 7 M and a cross-sectional area of 25 cm^2 with a value of 0.73 V. The electrolyte concentration and cross-sectional area that provide an optimal effect on the current value are at a concentration of 7 M and a cross-sectional area of 25 cm^2 with a value of 19.99 mA. The electrolyte concentration and cross-sectional area that provide the optimal influence on the power value is at a concentration of 7 M and a cross-sectional area of 25 cm^2 with a value of 14.593 mWatt. The maximum electrolyte value does not always produce maximum electrical energy, but the optimum electrolyte concentration will produce maximum electrical energy. Unlike the electrode cross-sectional area, the wider the electrode cross-section used, the greater the electrical power output.

RECOMMENDATION

For each concentration and cross-sectional area variable, it is advisable to conduct more sampling for each variation and with more test repetitions

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