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Seawater Lamp: Utilization of Seawater as an Alternative Energy Source to Generate Electricity

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ABSTRACT

Fishermen are the main livelihood for coastal communities in West Sulawesi. In fishing activities, especially at night, fishermen use lights to attract fish for a greater chance of catching fish. However, fishermen need a supply of electricity to turn on their lights when at sea. Fishermen usually use batteries. This is a significant problem for fishermen because batteries require a relatively high operational level. Researchers found the idea by developing a battery replacement tool to reduce high operating costs. This study aims to utilize seawater as an alternative energy source to overcome the problem of high operational costs for fishermen. The tool developed in this study uses two electrodes (Zn and Cu) placed vertically in a container and then filled with seawater. The two electrodes are connected in series, producing a high output voltage to light an LED. After the initial measurement, the resulting output voltage is 5V and can turn on the LED with a bright enough light. In periodic measurements for 96 hours with data collection every 4 hours, the voltage, current, and power do not decrease significantly, so the seawater lamp is suitable for coastal communities and fishermen's use as lighting when going to sea at night. Series and parallel combinations must be developed to achieve higher voltage and power values and obtain brighter light. The results of this research can be an alternative and renewable energy source that can be widely used.

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I. Introduction

Electrical energy is a fundamental societal need and supports all aspects of life and national development [1]. As time goes by and technological developments, people's dependence on electrical energy increases [2]. Fuel oil (BBM) and gas fuel are non-renewable energy sources that people use daily [3]. The need for electrical energy continues to increase and demands the availability of alternative sources of electrical energy from renewable energy.

Generally, electrical energy is generated from diesel, water, and geothermal energy. However, in its development, there are still many obstacles. Therefore, another alternative is needed for developing renewable sources of electrical energy by utilizing available natural resources [4]. There are several ways to produce renewable electrical power, one of which is by using seawater. The utilization of seawater as a source of electrical energy has yet to be optimal.

The existence of electricity sourced from seawater is a potential and inexpensive solution for electricity needs around the coast and for fishermen. However, the electrical energy generated from renewable sources is always smaller than that from non-renewable sources. This problem must be addressed if renewable energy is expected to replace conventional energy [5].

Many countries have widely used seawater in this modern era as an alternative energy source and a material that can be used to make something useful. If used on a large scale, this seawater will have great potential to provide good sources of electrical energy in society to meet the needs of electrical power [6]. The energy crisis has become a protracted problem in Indonesia and other countries, including Malaysia, for people living in remote areas [7], [8]. Energy needs will continue to increase along with technological advances and population growth. Therefore, the use of seawater is beneficial for overcoming the electrical energy crisis that has hit various countries [9].

Marine energy is a "renewable" alternative energy that contains abiotic resources that have the potential to be developed. The sea is not only a food source but also has various energy sources, and its existence is becoming increasingly important as fossil fuel energy runs out. The potential of the sea is estimated to be four times the world's electricity demand, and it is not surprising that various developed countries are competing to utilize this energy [10].

Seawater can generate electrical energy by utilizing electrochemical processes [10]. Electrochemistry is a change in chemical energy into electrical power due to two electrodes and an electrolyte as a conductor of electrons [11]. The type of electrochemical cell used is a voltaic cell to produce electrical energy. The voltaic cell, an electrolyte of seawater, is given two metals as electrodes connected and has a potential difference that makes electrical power. Electrolytes are solutions that decompose into ions, then become electrical conductors [12]. Ions are charged atoms. Electrolytes can be water, acid-base, or other compounds. Electrolytes are generally acids, bases, or salts, and certain gases can act as electrolytes under certain conditions, such as high temperature and low pressure [13].

Research on the use of seawater to generate electricity has been carried out by several previous researchers, such as that carried out by Sastromidjojo, by flowing 2 liters of Parangtritis seawater to the anode and cathode circuits in the form of graphite and zinc, which produce electrical energy with a voltage of 1.6 volts [14]. Raphael and Aisa Mijeno made a series of LED lights with a glass of water and two spoons of salt [14]. Many countries carry out research and development of new energy potential. Several studies have been conducted, including research on the analysis of the Utilization of Salt Water as an Alternative Energy Source Using Used Battery Carbon Electrodes; the potential of this research is very good for development [15]. Utilization of Seawater Electrolyte as a Source of Electrical Energy for Batteries with Copper–Aluminium Electrodes The seawater battery developed succeeded in turning on LED lamps and household lamps, with a generated voltage of 1.31 V and an electric current of 13.56 mA. 2-3 batteries arranged in series produced 2.55 V and 3,6 V [16]. In line with this research, the study entitled "Seawater Battery with Al-Cu, Zn-Cu, and Gal-Cu Electrodes for Fishing Lights" obtained a maximum power of zinc electrodes of 704.17 mW, not much different from galvalume's 726.41 mW. In comparison, the aluminum electrode produces 175.75 mW of power. This shows that the anode electrode material strongly influences the performance of the seawater battery. The best anodes to use are zinc or galvanium. Further development of seawater batteries with DC/DC converters and Dual in-line Package (DIP) LEDs suits innovations in effective and efficient fishing lights for lift net fishing [17].

However, from previous research, the resulting voltage is still minimal, ranging from 1.6 to 3.6 Volts. In this research, a seawater lamp will be developed, which fishermen can use when fishing at night with greater voltage, current and electric power. This research was carried out to produce a higher voltage by connecting several power sources in series. This study also used a series of LEDs with a size of 5×5 cm, input voltage of 3.7-5v, and 8 watts of power, with 16 LEDs connected in one circuit.

Natural resources, such as coal, oil, and gas, are abundant in Indonesia. However, it has yet to be utilized effectively and is still dependent on petroleum as the primary energy source [3]. Because of this, the government issued a renewable energy source policy stipulated in Law no. 33 of 2007 at 20 paragraph 4 concerning energy supply and meeting people's energy needs by seeking alternative energy sources to replace petroleum [18].

West Sulawesi is one of the provinces surrounded by an endless seawater supply. Most people work as fishermen who need electrical energy in their daily activities, including fishing at night. Some people use diesel generators and kerosene lamps, posing health risks and damaging coastal and marine ecosystems. This study generally aims to determine the potential for utilizing seawater batteries as an alternative source of lighting energy and a renewable energy source for fishermen. This study uses the electrolysis solution of two electrodes (Zn and Cu) with seawater. This seawater battery series is connected to LEDs arranged in parallel to produce bright light. The data measured are the electric power (W), voltage (V), and current (mA) generated by the seawater lamp to determine the durability of the seawater lamp before fishermen use it.

Water covers as much as 70% of the earth's surface, with 97.5% seawater. This makes it possible to develop seawater lighting products that can be renewable alternative energy sources. The result of this project is a saltwater-powered lighting product prototype to provide a stable supply of electricity, especially in rural areas enabling a better quality of life.

II. Theory

Sea water

Seawater is a mixture of 96.5% pure water and 3.5% salt, dissolved gases, organic matter, and insoluble particles. The salt content in seawater is influenced by mineral salts in rocks and soil, for example, sodium, potassium, calcium, and others. The salinity of seawater is 3.5%, meaning that 1 liter (1000 ml) of seawater contains

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35 grams of salt [19]. The physical properties of seawater, such as density, compressibility, freezing point, and temperature, are greatly influenced by the salt content in seawater. Two properties primarily determined by the sea's salt amount are electrical conductivity and osmotic pressure. The main salts contained in seawater are chloride (55%), sodium (31%), sulfate (8%), magnesium (4%), calcium (1%), potassium (1%), and the rest less than 1% consists of Bicarbonate, Bromide, Boric acid, Strontium, and Florida [19].

Seawater contains an electric current when it contains a high element of Sodium Chloride (NaCl) which breaks down into Na^+ and Cl^-. In the fact of these free-charged particles, an electric current arises. The emergence of an electric current by these charges can be used as a cheap and environmentally friendly source of electrical energy using the voltaic cell method [20].

Seawater Battery

A voltaic cell consists of two electrodes, namely the anode and cathode (see Figure 1). The Cu electrode serves as the cathode, and Zn is the anode. The cathode is the positive electrode, where the reduction reaction takes place. Meanwhile, the anode is the negative electrode where the oxidation reaction occurs [21]. In the reduction process, some ions or molecules on the positive electrons (cathode) receive reduction and electrons. Some ions and molecules give electrons on the negative electrons (anode), causing the oxidation process.

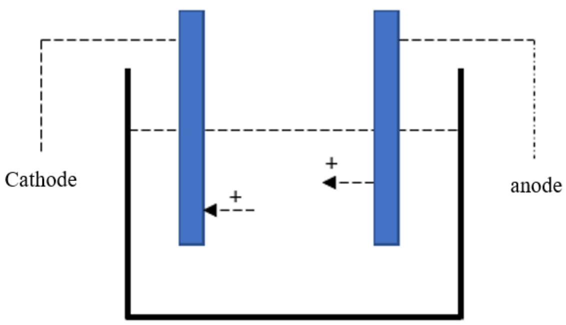

Figure 1. Seawater Battery electrochemical cell

Electrical Motion and Resistance in Batteries

In Figure 2, if the voltage is measured before being connected to the load resistance, "RL," then the voltage shows "E" volts. After the battery is connected to the load resistance and the voltage is measured, it will show "V" volts lower than the initial voltage.

In Figure 3, the voltmeter will show an open voltage of "E" volts before the "S" switch is connected, the ammeter will show that there is an electric current flowing across the load resistance, and the clamp voltage of the battery is shown by the voltmeter "V" volts after the switch is connected. The difference in electric voltage between V and E is caused by the electric current issued by the battery. The electric current must pass through the battery resistance before starting the load resistance. The battery resistance is called internal resistance, mainly found in the existing electrolyte material. The rest is on the plate and the end of the connection and marked "r"

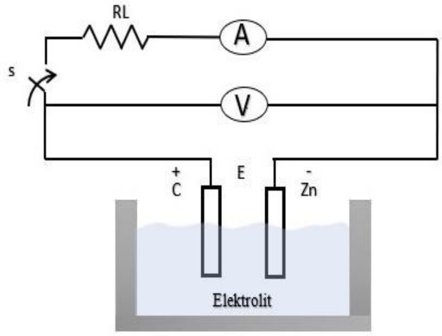

Figure 2. Measuring battery voltage and current [22].

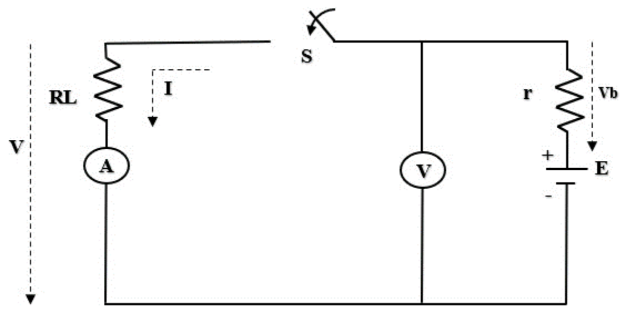

Figure 3. Flow chart for measuring battery voltage and current [22].

In the battery there is internal resistance caused by electrolyte materials and the plates and connections in the battery, so the voltage loss on the battery is Vb, as in equation 1.

$$V_b = E - V = I\,.r \text{ (Volts)} \tag{1}$$

Resistance in battery:

$$r = V_b.I = E - V.I \text{ (ohms)} \tag{2}$$

Voltage and Current Maximum in Battery

In Figure 3, when the "S" switch is connected, the overall system in the battery will work, in the circuit there is a load resistance "RL" and an internal resistance "r". the decrease in current in the circuit is influenced by the internal resistance of the battery.

The electric power generated by the battery is the sum of the power lost in the battery and the power generated by the load resistance. The amount of electric power that the battery will completely release follows Equation 3.

$$P = P_b + P_L = E\,.I \text{ (watts)} \tag{3}$$

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If the battery is short-circuited, the load resistance becomes zero, and the amperage released is:

$$I = E_r \text{ (ampere)} \quad (4)$$

III. Method

This section describes the experimental procedure used for this research and the parameters to be studied, such as Voltage, Current, and electric power generated by seawater lamps. Details of the experimental procedure for each parameter to be studied will be explained in this section.

Materials and instruments

The research used seawater as an electrolysis solution and two Zn and Cu electrodes placed in an acrylic container with a size of (14×7.5×16) cm.

Characterization of Seawater Light

Overall the voltage and electric current are measured using a multimeter connected to a series of seawater lamps (Figure 4). Measurements were made using a multimeter connected to zinc and copper plates as the anode and cathode—voltage measurement.

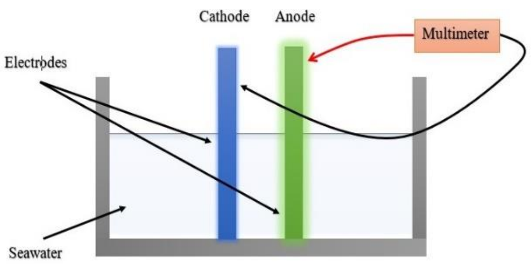

Figure 4. Electrolysis seawater experiment

Data collection, types, and sources

The research method used is a laboratory scale experiment. The test was carried out by assembling seawater battery units in series and giving a load of a series of LED light units. Experiments were carried out by measuring the voltage and current on the seawater battery and the rate of decrease in light intensity produced by the LED lights. The voltage generated by a seawater battery is affected by the type of electrode material used [23]. The data is used to estimate the durability of seawater battery components as a source of electrical energy.

Seawater Lamp Construction

This experiment used seawater as an electrolysis solution with a specific volume and put it into an acrylic container. One electrode of each metal with dimensions of 3×3 cm is inserted into the container at a distance of 4 cm from each other. The electrode area affects the battery capacity. Battery capacity is expressed by the number of active electrode materials that can produce electrical energy through electrochemical reactions. The wider the electrode, the greater the battery capacity. The wider the electrode used, the more active material that can accommodate electrons to produce more electrical energy. [24].

A copper wire is connected to each electrode at one end, and the other is connected to alligator clips. Two similar devices are made for current production and electrochemical characteristics.

Seawater Lamp Durability

The open circuit voltage is measured by connecting the positive and dangerous electrodes. A digital multimeter for four days (96 hours) measured current, volts, and electric power. This experiment aims to measure the electrode's durability in a seawater solution. To achieve this goal, voltage, current, and resistance changes are recorded every 4 hours. This corresponds to the ideal time used by fishermen when fishing at night.

IV. Results and Discussion

This seawater lamp voltage source circuit consists of two voltage source circuits connected in series to obtain a stable voltage gain.

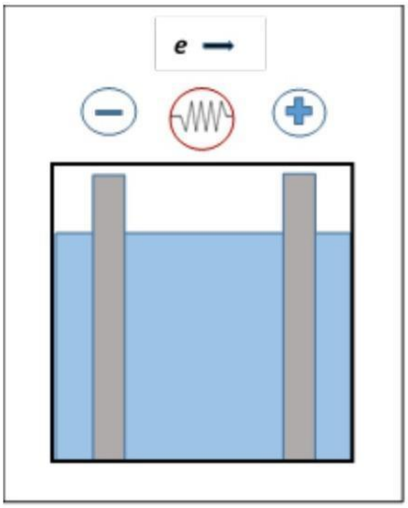

Figure 5. Seawater Lamp Voltage Measurement

The seawater lamp prototype that was successfully developed (Figure 5) uses Zn and Cu electrodes. Using 67 ml of seawater as the electrolysis solution. The zinc anode is an electrode with a higher Zn content than aluminum, resulting in a higher output voltage than aluminum [25], [17]. The high Zn content causes the oxide layer to react more quickly with chloride ions (Cl^-) in seawater.

Voltage measurements are made by connecting a voltmeter to the seawater lamp output (Figure 6). The developed seawater lamp was tested by connecting it to an LED (Figure 7) and successfully lit it. Subsequent tests use three series of LEDs arranged in parallel to produce a bright enough LED flame (Figure 8).

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Figure 6. Seawater lamp connected to the LED

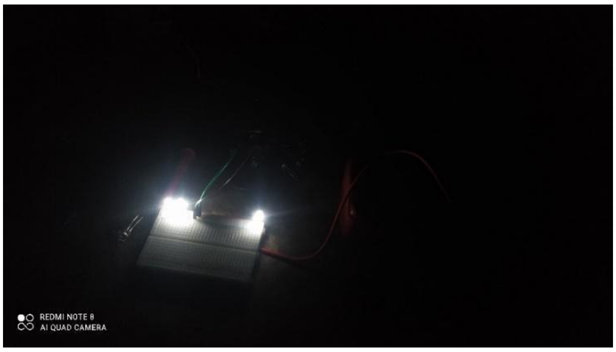

Figure 7. Seawater lights connected to 3 LED circuits

Figure 8. Seawater lights connected to 3 LED circuits

After measuring for 96 hours with a range of data collection every 4 hours under normal room conditions, the results are shown in Figure 9.

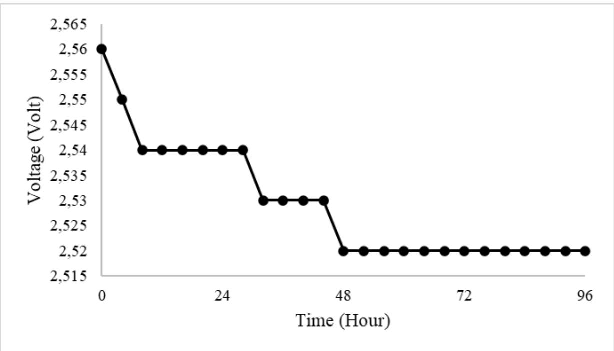

Figure 9. Voltage-Time Relationship Curve

Based on the obtained time-voltage relationship curve, the generated voltage decreased not significantly from the first to the second day, but from the third to the fourth day, the induced voltage did not change (Figure 9).

Based on the current-time relationship curve, the electric current generated in the seawater lamp series decreased significantly on the first day. On the second day, it decreased but not significantly, but from the third day to the fourth day, the generated voltage did not change (see Figure 10).

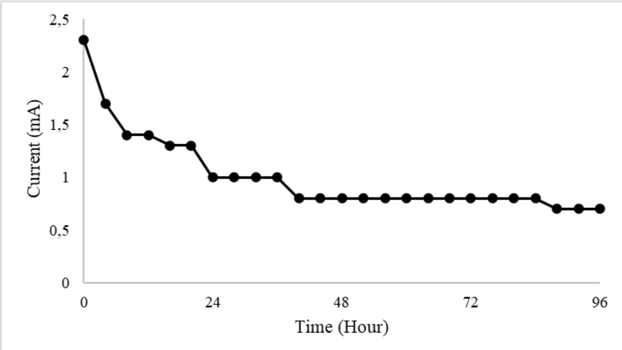

Figure 10. Current Time Relationship Curve

Based on the power-time relationship curve obtained, the generated electric power decreased drastically on the first day. On the second day, it decreased but not significantly, but on the third day, the generated power did not change, and on the fourth day, the electric power decreased, which was insignificant (see Figure 11).

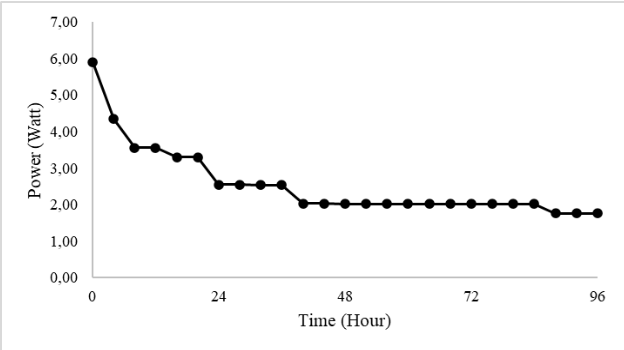

Figure 11. The Curve of the Relationship of Electric Power Against Time

The decrease in voltage and current generated by the battery is also caused by the reduced concentration of NaCl in the seawater used. The high NaCl element by H_2O is broken down into Na^+ and Cl^-; an electric current appears from this process. NaCl has an ionization degree of 1, or close to 1, and NaCl is a robust electrolyte solution and can be completely ionized in water [26]. The dimensions of the electrodes and the electron solution (salt) significantly affect the magnitude of the current and voltage generated by an electrochemical cell. This means that to restore the voltage and current of a seawater battery, one of the conditions is to replace the electrolyte solution [27].

After testing the durability of seawater lamps and obtaining excellent and durable results, fishermen can use seawater lamps when fishing at night. After researching seawater lamps, the results of this tool were that it could become a very efficient source of renewable energy if used by coastal communities and fishermen. After the trial results were obtained, this seawater lamp could last up to 96 hours. Besides that, seawater can be a solution to replace fuel oil or diesel fuel because of the free particle charge of NaCl salts contained in seawater [12].

Fe and Al can produce electric potentials up to 1.2 V, while Zn, Al, and Fe and Zn produce electric potentials below 1.2 V [14]. This shows that Cu and Zn can make better prospects than other electrode pairs. Another study used Cu and Zn electrodes, adding 1000 ml of water and 100 grams of salt to produce a potential of 0.52-0.53 volts [28]. Redox reaction resulting in increased electron flow. The ability of seawater batteries to generate electrical energy is also influenced by the effective surface area of the electrodes used, the rate of electron transfer, and external resistance [29]. The potential for electrical energy is higher at lower salt concentrations, and this is due to a large amount of free space for moving ions and the lower corrosion rate in water with low salt content [30].

Developing this seawater lamp device is easy and can be reproduced using simple equipment. For future applications, this prototype can be used by fishermen to assist in fishing activities at night. These unit cells can be connected in series combinations to achieve higher circuit voltages.

V. Conclusion

Seawater lamp can last for more than 96 hours non-stop and produces an initial output voltage of 4.23 V with an initial power output of 6 watts, using 67 ml of seawater. After connecting with LED lights and measuring using a multimeter, the highest voltage on the LED is 2.56 V, and the voltage drop is only 0.04 V. Meanwhile, the highest current test on the LED is 2.4 mA and only decreases. Recent is about 1.8 mA. And in the power test, it was obtained that the highest power on the LED was 6 Watts, and it experienced a decrease in intensity of 4 Watts.

This seawater lamp is suitable for coastal communities and fishermen's use as lighting when going to sea at night. The combination of series and parallel needs to be developed to achieve higher voltage and power values and obtain brighter lights. This research has significantly contributed as a source of renewable energy and alternative electrical energy for fishermen. However, empirical testing has not been carried out. Therefore, further research needs to examine the further development of seawater lamps by considering the corrosion rate of the electrodes used and studying the most effective electrodes for use.

VI. Acknowledgment

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Declarations

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