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THE POTENTIAL OF LIQUID ELECTROLYTE FROM *Betta splendens* WASTE FOR BATTERY APPLICATION

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Abstract: This study focuses on the potential of liquid electrolyte from the wastewater of *Betta splendens* for battery application. In this analysis, two different parameters were manipulated, namely the time period and the electrical energy production from the different wastewater properties involving the use of *Terminalia catappa* leaves. The battery plays an important role in achieving universal access to clean, reliable, and affordable electricity services. The presence of ammonium (NH_4^+) in wastewater can produce renewable energy and help reduce environmental pollution. A voltage (V) unit is used in the measurement of energy potential by using a voltmeter. 25 *B. splendens* were cultured for five weeks in two aquariums, one without T. catappa leaves, and one with T. catappa leaves to get their weekly wastewater. Voltage output is measured against the number of weeks from the wastewater sample without *T. catappa* leaves and with *T. catappa* leaves. Observation shows that the highest voltage produced from the wastewater sample was from the first week for a motorcycle battery and the fifth week for the research battery. The results of the wastewater sample without T. catappa leaves and T. catappa leaves against the number of weeks on motorcycle battery is 4.210V and 5.129V respectively, while for the research battery is 0.5360V and 0.5380V respectively. The highest voltage values from a motorcycle battery and the research battery are taken to test their longevity for one month. The t-test analysis of this experiment shows an insignificant result for the motorcycle battery and a significant result for the research battery, thus proving that the concentration level of NH_4^+ has a significant effect on the amount of energy produced.

Keywords : Liquid electrolyte; ammonia; wastewater; battery application; *B. splendens*; *T. catappa.*

Introduction

Nowadays, several industries use fossil fuel-based energy. Some eighty-fifth percent of energy demand from fuel production is used as energy sources within the world (Kumar & Samadder, 2017). These dependable resources may become reduced over time. Another way to save these dependable resources is to seek out in our way to provide energy. To resolve these problems is to form smart energy from natural resources like chemicals, heat and waste into power. The latest world problems regarding waste to energy technologies are required for effective energy continuity and negatively impact surroundings in keeping with utterly different disposal techniques.

As an alternative source of energy, energy waste doubtless is an alternate way to give or act as a new manner of energy production, which might manage and stable the economy and running continuously as energy (Kumar & Samadder, 2017). The waste to energy technologies adopted in developing countries uses to look at challenges and barriers for successful edges of waste to energy technologies within the developing countries. Pleasant environmental quality with excellent advantages could lead to the declining of gas emission, and also the authorities take incentives by exploiting renewable energy sources through waste.

Hence, vital energy from animal wastes would be most well-liked (Lazaroiu *et al.,* 2017). It contributes to a few changes for uses of energy that may be reused within a developing country. The higher half that the global energy gathers, particularly for the facility sector area unit, promptly turning from renewable energy sources (Yu *et al.,* 2019). An altenate method is using animal waste to be applied is to use animals' waste to avoid the decline of fuel for electricity.

In concept, the transformation of waste energy with a decent storage method is reliable to be used once needed (Olabi, 2017). There should be an excellent and effective manner to store and provide the waste energy turning into voltage. Human dependence on fossil fuels should be reduced because they are considered one of the most important contributors to the world's problems since they were restricted and in high demand (Olabi, 2016). Moreover, the combustion of fuels will cause pollution that implements the indirect cause of global warming and has a negative impact on the health of many species.

The purpose of this study is to focus on converting wastewater to electricity. This can sustain the wastewater management by providing energy that can be reused once more and acts as catalysts for a sustainable economy, environment, and effective wastewater management for developed countries (Kumar & Samadder, 2017). This study has been designated as a liquid electrolyte that is made from ornamental fish waste. As stated by (SIWI et al., 2008), approximately 50% of the fish feeding products are used for growth and have been used while not advantages or lost when consumed by fish or other consumers (Papargyropoulou et al., 2014). This will become evidence that waste from humans and other organisms can give a benefit to the country.

World international business supported by a gas economy needs the implementation of renewable gas in term of transportation and storage that build final processes safely and economically viable. An organic compound's benefits are not flammable, harmless, odorless, balance, and form like crystalline at normal temperature that offers appropriate ways to store and transfer by victimization parched containment (Olabi, 2017). So with this in mind, wastewater use has many benefits as well as energy supply. The prompt advantages from alternative gas carriers referred to as ammonia (NH_3) act as methyl-cyclohexane. This methyl-cyclohexane at the top product builds benzol as an outcome once its disintegration to atomic number 1. Applying this manner to provide a replacement energy production will cause the decreasing overuse of fossil fuels. It might maintain the continuity of the fossil fuels energy while not involving any price. The system ought to be applied to create a proactive way of realizing renewable sources and fossil fuels will be controlled and monitored. Therefore, the aim of this to create new energy from fish wastewater for battery applications.

Materials and Methods

Preparation for fish stocking

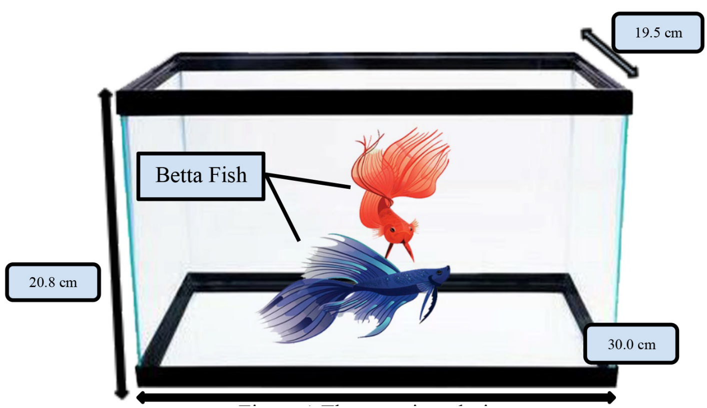

Figure 1: The aquarium design

Each Siamese fighting fish is weighed (g) using an electronic weighing machine to determine the appropriate density and feeding before it can be placed into the aquarium. Food Conversion Ratio (FCR) is used to fix the feeding rate of *B. splendens*, 10% from each fish weight (g). The feeding of *B. splendens* is fixed at twice a day. Figure 1 shows the preparation of two aquariums, one without the presence of *T. catappa* leaves and one with *T. catappa* leaves. The water that was put into the tank is about 9 liters. Twenty-five (25) individuals of *B. splendens* were placed in the first aquarium. The feeding of the betta was set at twice daily at 12 am and 12 pm. Throughout this study, the Siamese fighting fish were kept for five weeks, during which the wastewater from fish were taken weekly. Thus, five weeks equals five samples of wastewater without Indian-almond leaves. After the end of the betta culturing period, the total number of wastewater samples is ten. Five samples from wastewater without *T. catappa* leaves, and five more samples from wastewater with *T. catappa* leaves. Then, 300 ml of each wastewater samples were provided. Then, filter it by using filter paper and were collected to place it into the battery. After the finished sample is filtered, a beaker is placed to measure each wastewater samples' pH. The pH is measured by using a pH meter. The pH reading of five samples from wastewater without Indian-almond leaves and five samples from wastewater without Indian-almond leaves were recorded.

The electrode pattern of the battery

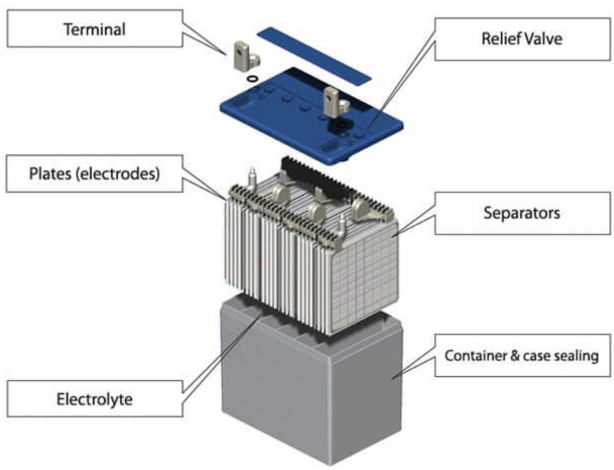

Figure 2: The components for cell fabrication of the motorcycle battery

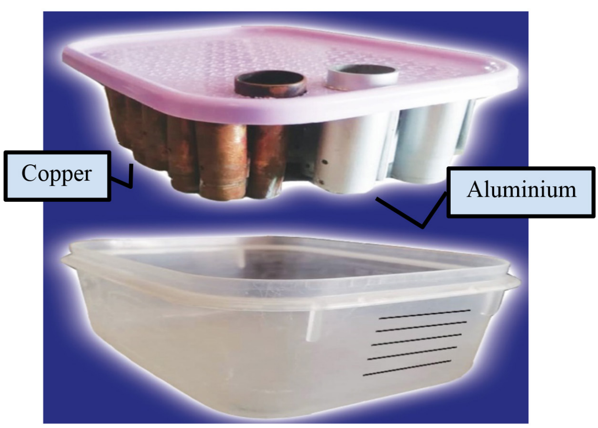

Figure 3: The components for cell fabrication of the research battery

Figure 2 shows the components for cell fabrication of motorcycle battery for the liquid battery. Carbon (C) and tin (Sn) were used as electrodes, where carbon carries a positive charge, and tin carries a negative charge. Then, the filtered wastewater was poured into the battery. Figure 3 shows the components for cell fabrication of an research battery for the liquid battery. Aluminum (Al) and copper (Cu) were used as electrodes, where aluminum carries a positive charge, and copper carries a negative charge. Then, the filtered wastewater was poured into the battery.

Energy output measurement

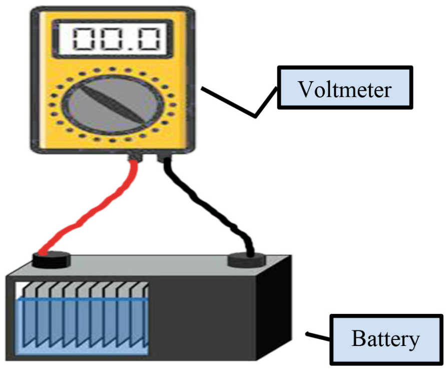

Figure 4: The voltage output measurement design

The voltage of wastewater samples through both liquid batteries was measured using a voltmeter, as shown in figure 4. The direct measure the output of liquid electricity (V) over a specified period of time: weeks 1, 2, 3, 4, and 5 from different wastewater properties, which is the five sample from the aquarium without *T. catappa* leaves and the five samples from the aquarium with *T. catappa* leaves were being recorded. The longevity of both batteries was also measured over a specified period of time: weeks 1, 2, 3, 4, and 5 from different water properties. Voltage readings are recorded once every two days in a month.

Statistical Analysis

The data need to be analyzed by the correlation between the period of time, water properties and readings of electrical energy output in voltage. Then, the data were analyzed using the Testing Tool (t-test). After that, the data were calculated to get its mean of voltage from the specified period of time and different water properties. The t-test is frequently used to observe and compare the significant difference between electrical energy output in voltage with a specified period of time and different water properties.

Results and Discussion

***The voltage produced from the wastewater samples without T. catappa* leaves**

Figure 5 shows that the electrical output of the wastewater samples without *Terminalia catappa* leaves against the number of weeks. From the figure, the mean of the motorcycle battery's voltage is 3.1664V with the regression value is 0.7091. For the research battery, there is 0.503V for the mean of voltage with the regression value 0.8445 respectively. The standard deviation (SD) for the motorcycle battery was 0.6061, and the research battery was 0.02632. The highest voltage reading of motorcycle battery from the wastewater sample without Indian-almond leaves was 4.210V during the first week, while the research battery was 0.5360V during the fifth week. The statistical analysis running on through t-test shows that the voltage output from wastewater samples without Indian-almond leaves versus the number of weeks was significant. The p-value is 0.00000487, which is less than $\alpha = 0.05$. The figure shows that the energy output produced was dependent on the number of weeks.

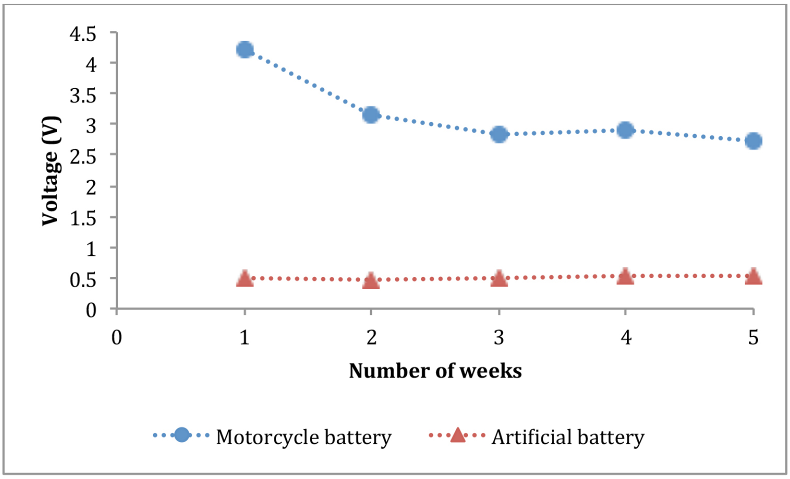

Figure 5: The voltage readings of wastewater samples without *T. catappa* leaves

The electrical output of the wastewater samples without Indian-almond leaves in the motorcycle battery was measured by differentiating the number of weeks. Voltage readings were recorded from five wastewater samples, namely week 1, 2, 3, 4 and 5. Based on figure 5, the voltage (V) readings decreased when the number of weeks increases. The motorcycle battery's voltage values decrease as the battery is discharged (Boehnstedt & Whear, 2009). The size of *B. splendens*, feeding rate, and period time during the culturing process had been fixed to get no significant result. The number of weeks has a linear relationship with the rising of fish waste that can produce more organic compounds such as ammonia. The rise in the amount of wastewater containing NH_3 and nitrite (NO_2^-) is produced (Turcios & Papenbrock, 2014). The amount of ammonia excreted by the fish varies with the amount of feed into the culture system, increase as feeding rates increase (Joseph & Mantrala, 2005). The higher voltage output reading on a motorcycle battery was 4.210V during the first week.

Generally, a battery uses an electrochemical reaction to convert chemical energy into electrical energy (Boehnstedt & Whear, 2009). First, it is necessary to activate all electrodes in the motorcycle battery using a high concentration of sulfuric acid. Simultaneously, sulfate (SO_4^{2-}) from the acid is coating the plates and reducing the surface area over which the chemical reaction can occur. The electrolyte of sulfuric acid contains more ions of sulfate and hydrogen (H) (Craig & Vinal, 1939). The SO_4^{2-} are negatively charged, and the hydrogen ions have a positive charge. The sulfate ions move to the negative plates and give up their negative charge. The excess electrons flow out the negative side of the battery and back to the battery's positive side. The ions moving around in the electrolyte are what create the current flow. Therefore, the wastewater samples without *T. catappa* leaves cannot activate or increase the energy output readings because the sulfate content in water is less concentrated than sulfuric acid. In that case, wastewater is capable of producing energy. The higher voltage reading on a motorcycle battery is 0.5360V during the fifth week. Increasing ammonia was the main focus of this study, known as natural resources applied to produce renewable energy (Dolomatov *et al.,* 2014). The problem was when increasing ammonia gives a threat to the environment, and this study was a way to solve the problem. The process that occurs in the research battery is synonymous with the motor battery because the energy output also resulting from the electrochemical reaction, which is reduction-oxidation takes place, which changes from chemical energy to electrical energy (Kumar & Samadder, 2017). The research battery is designed with negatively charged (cathode) electrodes made of copper (Cu), while positively charged (anode) electrodes are made of aluminum (Al). The use of electrodes is selected based on the reactivity series of the metal.

In the electrochemical process, the cathode is the site where reduction occurs. The anode is the site where oxidation occurs. The aluminum would be reduced at the cathode, while the copper would be oxidized at the anode (Rossmeisl *et al.,* 2007). A typical electrochemical process has an ionic solution called an electrolyte, wastewater samples without Indian-almond leaves. Generally, NH_3 is formed from one nitrogen atom bonded to three hydrogen atoms and results from excessive food and fish feces. Hydrogen ions are a significant source of energy. So the more H is contained in the water, the higher its ability to produce energy. The level of ammonium concentration in water depends on the level of fish nutrition and the results of fish extraction (Larsen *et al.,* 2015). The water samples did not change during culturing the betta until the fifth week and showed the research battery's highest electrical output values. This is why the voltage reading in the fifth week is much higher than in the previous weeks.

The voltage produced from the wastewater samples with T. catappa leaves

Figure 6 shows that the electrical output of the wastewater samples with *Terminalia catappa* leaves against the number of weeks. From the figure, the mean of the motorcycle battery's voltage is 4.1314V, with the regression value is 0.9723. For the research battery, there is 0.5292V for the mean voltage with the regression value of 0.7722. The standard deviation (SD) for the motorcycle battery was 0.6855, and the research battery was 0.010616. The highest voltage reading of motorcycle battery from the wastewater sample with Indian-almond leaves was 5.129V during the first week, while the research battery was 0.5380V during the fifth week. The statistical analysis running on through t-test shows that the voltage output from wastewater samples without Indian-almond leaves versus the number of weeks was significant. The p-value is 0.00000126, which is less than $\alpha = 0.05$. The figure shows that the energy output produced was dependent on the number of weeks.

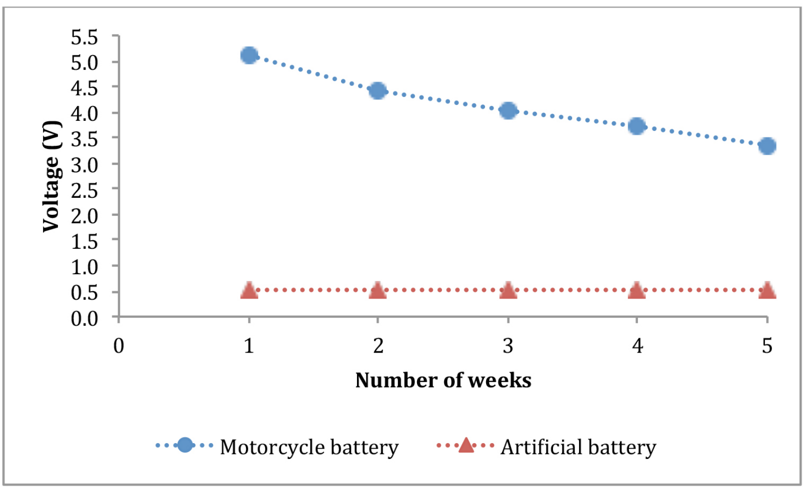

Figure 6: The voltage readings of wastewater samples with *T.catappa* leaves

The voltage output readings of the wastewater samples with *T. catappa* leaves within the motorcycle battery had been measured by differentiating the number of weeks. Voltage readings were recorded from five wastewater samples namely the first week, the second week, the third week, the fourth and fifth weeks. Based on figure 6, the electrical output decreased when the number of weeks increases. The size of the betta, feeding rate, presence of the Indian-almond leaves, and period time during the culturing process had been fixed to get no significant result. The discovery of *B. splendens* waste has a linear relationship with the increase of weeks. Most bony fish fishes could excrete NH_3 continuously if it got feeding, which provided good benefits by exchanging or converting urea to ammonia (Altinok & Grizzle, 2004). The upper voltage reading on a motorcycle battery is 5.129V during week one. A high voltage reading of wastewater with Indian-almond leaves can be concluded that the high ammonia content plays a role in increasing electricity energy. Liquid electrolytes with high-voltage batteries with improved performances and moderate environmental temperatures with safety features have the potential to promote large-scale applications in the future (Liu *et al.,* 2018). *T .catappa* plays the main role in water quality, which increases the ammonia level (Ikhwanuddin *et al.,* 2014).

Organic waste that can produce electrical energy include several biodegradable substrates such as waste from fruits, meats, papers, and yards (Pavi *et al.,* 2017). However, energy output readings dimmish with the number of weeks increase due to the motorcycle battery is in the discharged phase (Boehnstedt & Whear, 2009). The fully electrochemical reaction generated in the motorcycle battery must first activate all electrodes using a high concentration of sulfuric acid before it works. The electrolyte of sulfuric acid has many ions of sulfate SO_4^{2-} and H (Craig & Vinal, 1939). The sulfate ions are charged, and therefore the hydrogen ions have an electric charge. The sulfate ions move to the negative plates and provide up their electric charge. The ions travelling within the electrolyte are what create a flow. Therefore, the wastewater samples with Indian-almond leaves cannot activate or increase the voltage values because the SO_4^{2-} content in water is a smaller amount concentrated than sulfuric acid. In therein case, wastewater samples from the Catappa leaves are capable of manufacturing power. The difference from the voltage output reading on the research battery increases from week to week. The upper voltage value on a motorcycle battery is 0.5380V during week five.

Organic waste could be processed to produce electrical energy using the anaerobic and aerobic biological treatment for biological reactivity reduction. The time of feeding and total weight are affected by rising waste (Edeghe & Ajah, 2018). This factor plays a big role in increasing NH_3 and to make sure the results were accurate in this study. The electrochemical reaction also occurs in the research battery, which is reduction-oxidation. The research battery is designed with Cu as negatively charged (cathode) while the Al as positively charged (anode). The cathode is the site where reduction and the anode are the oxidation site during the electrochemical process. The aluminium would be reduced at the cathode, while the copper would be oxidized at the anode (Rossmeisl *et al.,* 2007). A typical electrochemical process has an ionic solution called an electrolyte, a wastewater samples with T. catappa leaves. The graph shows the energy output produced was dependent on the number of the week. The electrical conductivity of a liquid depends upon the number of ions per unit volume and its drift velocity. Generally, ammonia is formed from one N atom bonded to three H atoms and results from excessive feed and fish feces. H^+ is a major source of energy. NH_3 is produced by excessive feed and fish feces, but it will result in decay, which produces ammonia in a dying plant. Ammonia turns into nitrite in an aquarium, and both compounds are toxic to aquarium organisms. The high concentration of the Catappa leaves can affect water quality, which resulted in an increased ammonia level (Ikhwanuddin *et al.,* 2014). The water samples did not change during culturing the betta until the fifth week is also given the highest voltage reading on the research battery. These are the two main factors of rising electrical output per week.

Comparison of voltage output between the motorcycle battery and research battery

Figures 5 and 6 show the comparison of electrical output readings from a motorcycle and research battery based on the wastewater samples. The result shows that the motorcycle battery's voltage values are insignificant while the research battery is significant against the number of weeks. The most noticeable difference between the two batteries is that the voltage output readings on the motorcycle battery decrease per week while the electrical output readings on the research battery increases as the week increases. The process that occurs in both batteries is an electrochemical reaction called reduction-oxidation, which changes from chemical energy to electrical energy (Kumar & Samadder, 2017). Although there are similarities to the motorcycle battery, there are also differences in the discharged phase. The research battery has no discharged phase. The energy flow from the research battery is spontaneous. This is because the electrodes selected and electrode arrangement in the motorcycle battery are already fixed by determining the voltage capacity using sulfuric acid to activate (Boehnstedt & Whear, 2009). But the research battery only needs ammonia to accomplish a reduction-oxidation reaction to produce electrical energy (Rossmeisl *et al.,* 2007). Increasing ammonia when increasing the number of weeks was the main focus of this study that can be applied to create renewable energy (Dolomatov *et al.,* 2014). This is obviously in the readings of the voltage output by the research battery as the number of weeks increases, and so does the energy output. But, diminishing energy production as the number of weeks increase due to the motorcycle battery is in the discharged phase (Boehnstedt & Whear, 2009).

The fully electrochemical reaction generated in the motorcycle battery must first activate all electrodes using a high sulfuric acid concentration before it works. The electrolyte of sulfuric acid has many sulfate ions and hydrogen as a catalyst for the battery to work (Craig & Vinal, 1939). However, the cell voltage is dependent on several factors, such as electrode chemistry, temperature, and concentration ion contain in an electrolyte (Berera, 1958). It can also be found that wastewater samples with Indian-almond leaves are more effective in making some energy than wastewater samples without Indian-almond leaves. The solid waste that comes from fish wastes have the potential capacity to produce biofuels, bioenergy, and biobased materials (Greggio et al., 2018). Waste would be the most beneficial source of clean and important energy, and it could be contributed to declining the primary energy sources consumption (Kropáč et al., 2011).

The longevity of both batteries from wastewater samples without T. catappa leaves

The wastewater samples with the highest electrical output readings were used to measure the longevity of both batteries. The voltage output was used for the motorcycle battery is 4.210V or the first-week voltage value while the research battery is 0.536V or the fifth-week of the voltage value. Figure 7 shows that electrical output readings of both batteries' longevity from wastewater samples without *Terminalia catappa* leaves against the number of days. From the figure, the mean of the voltage on the motorcycle battery is 11.074V with the regression value is 0.9365 meanwhile the research battery, there is 0.5517V for the mean of voltage with the regression value is 0.015 respectively. The standard deviation (SD) for the motorcycle battery was 0.3408, and the research battery was 0.00861. The statistical analysis running on through t-test shows that the voltage output of longevity from wastewater samples without Indian-almond leaves versus the number of weeks was significant. The p-value was 8.96E-40, which is less than $\alpha = 0.05$. The figure shows that the energy output produced was dependent on the number of days.

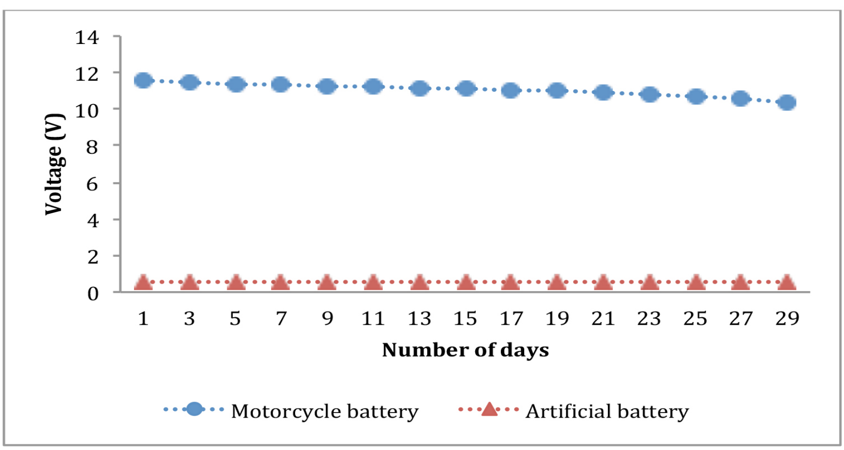

Figure 7: The longevity of both batteries from wastewater samples without *T. catappa* leaves

The longevity of both batteries from wastewater samples with T. catappa leaves

The wastewater samples with the highest electrical output readings were used to measure the longevity of both batteries. The voltage output was used for the motorcycle battery is 5.129V or the first-week voltage value, while the research battery is 0.538V or the fifth-week voltage value. Figure 8 shows that the electrical output readings of both batteries' longevity from wastewater samples with *T. catappa* leaves against the number of days. Voltage readings were recorded once every two days in a month. The motorcycle battery's mean voltage was 11.0807V with the regression value 0.9133, while the research battery was 0.56413V means of voltage with the regression value 0.3503, respectively. The standard deviation (SD) for the motorcycle battery was 0.3348, and the research battery was 0.02067. The statistical analysis running on through t-test shows that the voltage output of longevity from wastewater samples with Indian-almond leaves based on the number of weeks was significant with the p-value was 5.76E-40 less than $\alpha = 0.05$. The figure shows that the energy output produced was dependent on the number of days.

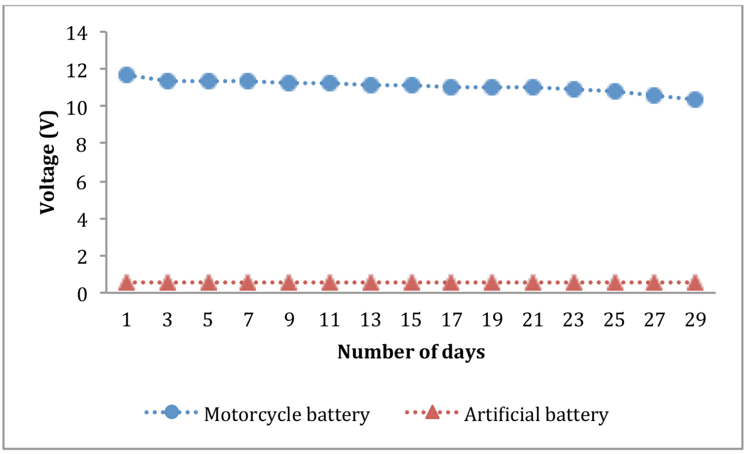

Figure 8: The longevity of both batteries from wastewater samples with *T.catappa* leaves

Figures 7 and 8 show the comparable longevity of electrical output readings from a motorcycle and research battery based on the wastewater samples. The result shows that the motorcycle battery's voltage value is insignificant while the research battery is significant against the number of weeks. The decrease in voltage readings of both batteries from the sample is uniform. One of the reasons for voltage output changes during testing is due to battery chemistry, application of battery, and temperature (Berera, 1958). The battery life is mainly determined by the use cycles of the battery. The chemical composition of batteries also has the ability to store and deliver power over time. It is clear from this evidence that the voltage reading continuously decreases against the number of days. The battery can only store a limited amount of electricity (Choong-koo Chang, 2019). Temperature plays an important role in battery performance. The chemical reaction inside the battery is very effective when at ambient temperatures. The performance of a battery is measured in capacity. Therefore, the capacity of a battery is lower when the ambient temperature is too low.

In higher temperatures, the cyclic battery life would significantly reduce. It can be concluded that a warmer temperature is great for the battery's performance, whereas a cooler temperature is great for battery life. From the figure, it can also be found both wastewater samples have the potential to produce a lot of energy. Increasing waste needs to be prevented and recycle to achieve the global goal of waste management (Brunner & Rechberger, 2015). Human activities lastly would result in producing a lot of wastes. The higher the material turnover and the more the materials produced, the more challenging it is for waste management to reach a sustainable country (Brunner & Rechberger, 2015). Positive effects of using liquid electrolytes raise awareness and protect the environment (Earis et al., 2009).

Conclusion

In conclusion, the electrical output from the *Betta splendens* produced different results according to the different tests between the number of weeks (N=1,2,3,4,5) and different wastewater properties. It tested using two batteries, namely, a motorcycle and an research battery. The highest voltage on motorcycle battery from the wastewater sample without *T. catappa* leaves is 0.4210V during the first week, while the research battery is 0.5360V during the fifth week. The highest voltage on motorcycle battery from the wastewater sample with *T.catappa* is 0.5129V during the first week while the research battery is 0.5380V during the fifth week. Thus, it can be concluded that energy output depends on ammonium (NH_4^+) and sulfate (SO_4^{2-}) that contain in the wastewater.

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