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ARTICLE

Bioelectric Batteries: Using Algae to Make the Battery Renewable

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Conventional batteries require relatively large amounts of energy to be sustained and need to be recharged consistently. When thrown away, the metals and solution within the battery may be toxic to the environment. There are 745 million batteries that are thrown out every year, contributing to the immense amount of waste in our environment [7]. Energy remains to be a massive contributor to climate change because it is the source that produces the greatest amount of greenhouse gases.

This led to the idea of creating sustainable batteries. Based on the research conducted by the University of Cambridge, algae could be used to make a biological photovoltaic battery (BPV), a battery that uses photosynthesis from microorganisms to remain charged [3]. The electrons produced from photosynthesis act as a catalyst for the battery.

This project chose to use algae as the microorganism since it would be beneficial in reducing harmful algal blooms by providing another purpose for the algae. It remains to be determined what type of algae and what colour wavelength placed around each jar can produce the greatest power. If this project is carried out, the amount of waste that goes into the energy factor will decrease because the length of battery usage can be improved.

PURPOSE

The purpose behind this project is to reduce amounts of battery waste while also creating batteries that can produce greater power and last longer than conventional ones.

HYPOTHESIS

It was predicted that the spirulina algae could create the highest mean power output compared to the copper and zinc battery without algae and nannochloropsis algae because it could best adapt to the saltwater with a high pH value which could allow for more effective photosynthesis. It is also inferred that the algae that absorbs blue light at wavelengths from 450 to 495 Hz would have a greater power than other batteries that absorb different wavelengths since most types of algae absorb blue light for photosynthesis.

MATERIALS AND METHODS

For this experiment, 16 biophotovoltaic batteries (BPV) were made using copper and zinc, saltwater, and each type of algae. The copper wire was measured and turned into equal sizes of spring to increase conductivity. Both metals were sandpapered before being put into the saltwater. Equal amounts of water and salt were also measured for the experiment. There were eight jars used for each type of algae: spirulina and nannochloropsis. One-fourth of a cup of each type of algae was put into every jar. Four jars had red plastic cut around them, another four had yellow, and another four with blue. The rest was a control BPV of every type of algae. Two of each type of colour contained either nannochloropsis or spirulina algae. There were two more batteries that acted as the control groups with no algae. For two days, a pH sensor, an ammeter, and a voltmeter were used to detect the pH, ampere, and voltage of every jar. LabQuest collected the data for every battery. For the statistical analysis, unpaired T-tests were used on a one-tailed hypothesis. The results are significant at $p < 0.05$.

RESULTS

Every spirulina algae battery had a greater average power output when compared to the nannochloropsis counterpart. The three-colour (red, yellow, blue wavelengths) jars produced greater power than the control battery. The first part of the hypothesis is supported because the spirulina algae did produce a higher overall power than the nannochloropsis algae, most likely because of its ability to adapt to saltwater, normally known to have a high pH. By finding the most effective algae, BPVs could be made more powerful than conventional batteries, proving to be a better alternative.

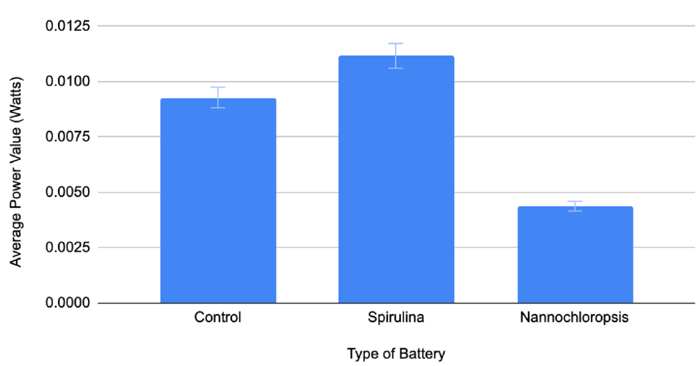

Figure 1. Average Power Value Comparison of Control, Spirulina, and Nannochloropsis Batteries. The p-value of this graph is 0.00001 ($p \leq 0.05$) and there was no overlap in my 95% confidence intervals, which is considered statistically significant and I can reject my null hypothesis.

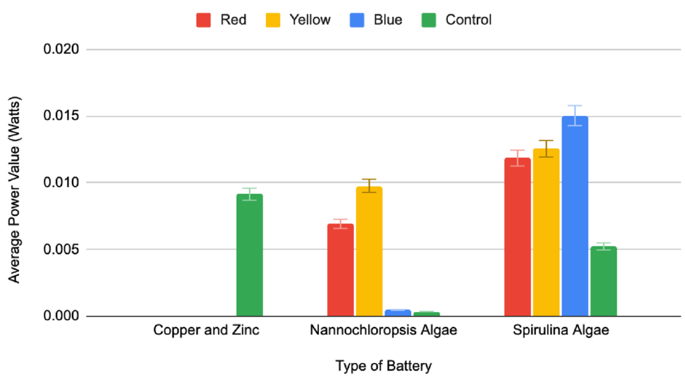

Figure 2. Average Power Value Comparison of Every Battery. The p-value of this graph is 0.00001 ($p \leq 0.05$) and there was no overlap in my 95% confidence intervals, which is considered statistically significant and I can reject my null hypothesis.

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The blue wavelength battery did not produce the average greatest power of both types of algae. The second part of the hypothesis was rejected because even though the blue wavelength battery did produce the most power for the spirulina algae battery, the yellow wavelength battery produced the greatest average power of both types of BPVs.

This may be the case because the wavelength of yellow light is between red light and blue light, two colours that are normally used for algae growth. By being in the middle of the two wavelengths, it could provide benefits for the algae that have previously not been recognized before. Through discovering what wavelength helps algae with photosynthesis the most, one can create batteries that allow specific wavelengths into the battery to increase the power output.

Figure 2. Average Power Value Comparison of Every Battery. The p-value of this graph is 0.00001 ($p \leq 0.05$) and there was no overlap in my 95% confidence intervals, which is considered statistically significant and I can reject my null hypothesis.

When comparing the potential, the control battery without the algae produces the greatest voltage. However, out of all the algae batteries, the yellow wavelength jar of both types of algae produced the greatest voltage. For the length of the battery life, the control group battery power decreased slightly, while it was inconsistent for the algae batteries. Some BPVs gained more watts and others lost power. A pattern that was discovered was that the lower the pH of the battery, the greater the voltage, although there were some outliers. The yellow wavelength jar of the nannochloropsis battery did not have a very low pH compared to the control nannochloropsis, but it still had a greater voltage than it. However, for the spirulina battery, the yellow wavelength jar had the lowest pH and highest voltage, other than the control battery. The error analyses that were used were T-tests and 95% confidence intervals.

DISCUSSION

Collectively, results suggest that algae may be used in batteries as they could last longer than conventional batteries and contain more power. Using yellow wavelengths to provide light for photosynthesis could be best for increasing the power in the battery. Previously, it has been discovered that "lily pad" shaped batteries that are coated with algae could be used to store the battery [4]. This method allows for one battery to be connected to another, which would improve the power of the batteries.

The study also showed that the batteries could yield power in the evening from the leftover electrons due to photosynthesis. It is also important to note that there were some variables that could not be controlled in the experiments conducted in this project. For example, the metals became oxidised and the metals could have contaminated the water which could have killed the algae. By keeping the jars indoors to not be affected by weather, the amount of sunlight could not be controlled either. The environment today is being impacted by immense amounts of algae, and this project provides a solution that can create energy using algae, which prevents sea communities from being harmed by algal blooms.

Findings from this study highlight the kind of batteries we could create in the future: longer-lasting and eco-friendly. With further studies conducted in this field, the power of biological photovoltaic batteries could certainly be harnessed in the future.

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Yu Han (Veronica) Guo is a Grade 10 student who is passionate about biochemistry and engineering. She is intrigued by the ways those two fields can be used to tackle environmental issues, such as energy efficiency. Since participating in CWSF for the past two years, she has also founded the Science Fair Club at her school where she encourages other students to pursue STEM interests as well. Outside of science projects, she also plays chess, basketball, and enjoys going on walks with her dog.