Hong Kong Student Science Project Competition 2023

Template of Extended Abstract (Investigation)
(Word Limit: 1,600 words, Pages: 3 pages only)

Team Number: SBBC108

Project Title: Power Plant in Plant_by Rhizodeposition 根際沉「電」

Project Type: Investigation

***To our best knowledge, there <u>are</u> similar works in the field*; (if there are,) related research links are as below:**

BP Statistical Review of World Energy 2016. Retrieved from: https://www.ls-energy.hk/chi/world-energy-consumption.html
Castresana, P. A., Martinez, S. M., Freeman, E., Eslava, S., & Di Lorenzo, M. (2019). Electricity generation from moss with light-driven microbial fuel cells. Electrochimica Acta, 298, 934-942. Retrieved form doi:10.1016/j.electacta.2018.12.108
EIA 2013 & WEC 2013. Retrieved from: https://www.hknuclear.com/nuclear/why/statistic/howlongwillreserveslast/pages/howlongwillreserveslast.aspx?lang=tc
Energy Information Administration. 2013. Retrieved from: https://www.hknuclear.com/Nuclear/Why/Statistic/Pages/WorldEnergyUsage_p2.aspx?lang=tc
Kabutey, F. T., Zhao, Q., Wei, L., Ding, J., Antwi, P., Quashie, F. K., & Wang, W. (2019). *An overview of plant microbial fuel cells (PMFCs): Configurations and applications. Renewable and Sustainable Energy Reviews, 110, 402–414.* Retrieved form doi:10.1016/j.rser.2019.05.016
Sawin, J. L., Martinot, E., Sonntag-O'Brien, V., McCrone, A., Roussell, J., Barnes, D., & Flavin, C. (2010). Renewables 2010 global status report.
Wichern, F., Eberhardt, E., Mayer, J., Joergensen, R. G., & Müller, T. (2008). Nitrogen rhizodeposition in agricultural crops: methods, estimates and future prospects. Soil Biology and Biochemistry, 40(1), 30-48. Retrieved from: https://doi.org/10.1016/j.soilbio.2007.08.010

The enhancement our project made / the difference with related research are:

The difference between the environmental factors of Hong Kong and foreign, including soil, temperature, light intensity and variety of plants, may lead to unexpected results.

Please delete if not applicable. The competition values the originality of works. Students must do enough literature research to ensure that their works are unique and list relevant reference materials before starting research or invention.

I. Background

Nowadays, the demand for electricity has been increasing and alarms that fossil fuels are being depleted. To solve the situation, we can only rely on renewable energies. However, the current renewable energies can't slow down the consumption of fossil fuels effectively due to various limits. We still rely on non-renewable energies. So using plants to generate electricity to slow down the rate of exhaustion of fossil fuels is considered. It may also help the greening of the environment, reduce greenhouse effect and protect the Earth.
Easier-to-find materials have been chosen to bring the technology to life. Previous studies have never been tried to generate electricity with the products of photosynthesis, and mostly used the respiration of microorganisms to generate electricity. So we thought that since respiration can generate electricity. Photosynthesis, which is similar to respiration, may also be able to do it.

II. Objectives

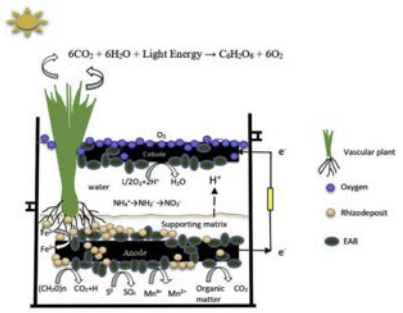
First, find out if plants in Hong Kong can generate electricity as some foreign papers say. Second, find out which kind in the prepared plants can generate the most electricity. Third, find out the factors that affect the power generation of plants, and the relationship between them.

III. Hypothesis

It was assumed that the products of the process of photosynthesis taken by plants could be used to produce energy carrying electrons by microorganisms, and hence used to generate electricity. The hypothesis was tested by finding whether there was voltage generated during photosynthesis of plants.

IV. Methodology

Experiment 1: testing the power generation efficiency of different plants in flower pots



Theory of Power Plant in Plant (Kabutey et al, 2019)

Diagram of Power Plant in Plant

Use a multimeter to collect the index of voltage of the plants during photosynthesis after finishing the device. The experiment is repeated 9 times to ensure the credibility of the study.

Controlled device:

Controlled device 1:
the voltage is 0mV when there is no sunlight

Controlled device 2:
voltage is 0mV when there is no plant

Therefore, the voltage generated during the experiment can be inferred to be generated by photosynthesis reasonably.

Experiment 2: finding the factors affecting the power generation of plants

Although the increase of illuminance will increase the rate of photosynthesis, it can be seen from the first experiment that the illuminance does not seem to have much relationship with the power generation. So, it is believed that there are other factors that affect the power generation of plants.

It is estimated that the power generation of plants is related to the amount of water absorbed, since the amount of water affects photosynthesis of plants. It might affect the activity of microorganisms in the soil, and thus affect the power generation of plants.

Experiment 2 is designed to prove this hypothesis. There are two parts in experiment 2: finding the power generation of plants before and after watering; finding the effect of going without water for a long time on the power generation of plants.

Experiment 3: testing the feasibility of the application of Power Plant in Plant

6 kinds of plants, aloe vera, guiana chestnut, hedera helix, epipremnum aureum, mentha, dracaena sanderiana, were prepared and placed in a flower pot with a Power Plant in Plant device. A multimeter is used to collect the index of voltage of the plants during photosynthesis. So as to find out the voltage generated during the photosynthesis of plants.

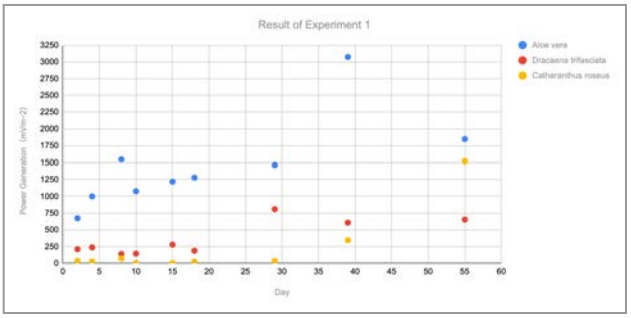
Experiment 4: finding setups that enhance the efficiency of Power Plant in Plant

In experiment 4, eight setups were tested, which contained four aspects: distance between layers of conductive materials, ratio of soil to electroconductive carbon fiber, shape of copper rope twisted and amount of hydrogel added. In experiment 4, eight setups were tested, which contained four aspects: distance between layers of conductive materials, ratio of soil to electroconductive carbon fiber, shape of copper rope twisted and amount of hydrogel added.

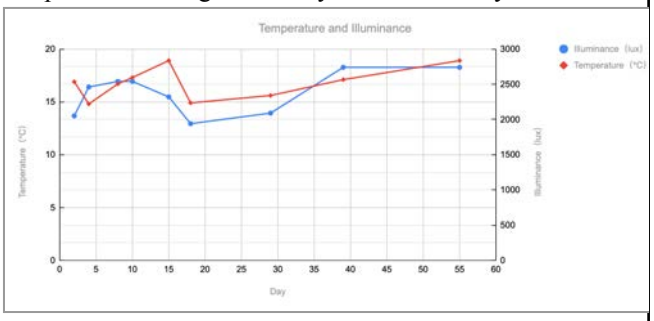
V. Results

Experiment 1 result:

Voltage produced per square meter of plants on different days



Temperature and light intensity on different days



It is found that plants do release electrons during photosynthesis, and these electrons can be collected and measured. It is believed that this is because some organic matter that is not consumed by plants will be discharged from the roots into the soil when plants perform photosynthesis during the day, and the microorganisms in the soil will decompose these organic

matter, so as long as the electrodes are placed on the roots of the plants and added to the soil the electricity generated by plants during photosynthesis can be collected.

Experiment 2 result:

Part 1: The generations of electricity of the two plants are much higher after watering than before watering. It is inferred from this that when the plants are watered, the rate of photosynthesis increases, so the microorganisms are more active, the rate of production of high-energy electrons increases. Therefore more electricity is produced.

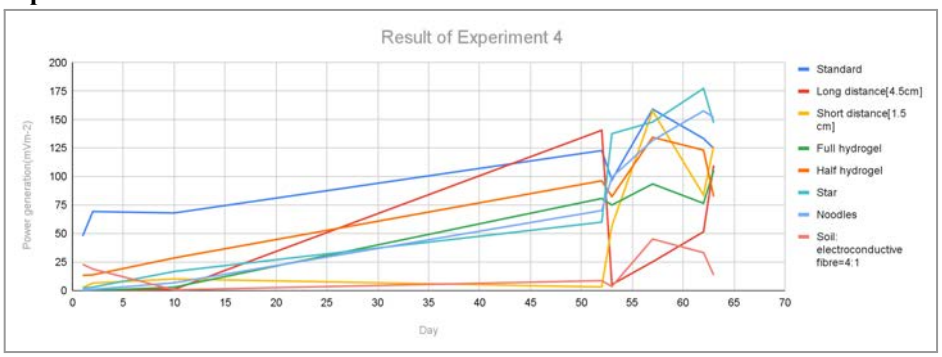
Part 2: Compared with watering everyday, the generation of energy of the plants decreased significantly. It is inferred that this is because long-term non-watering will reduce the rate of photosynthesis of plants, the rate of microorganisms producing high-energy electrons, and thus the power generation of plants. The longer the plant is not watered, the lower the rate of photosynthesis and the lower the power generation of the plant.

Conclution: First, the amount of water absorbed has the greatest impact on the power generation of plants. Second, the power generation of plants after watering is higher than that before watering. Third, the longer the plant is not watered, the lower the power generation.

Experiment 3 result:

It is proved that large-scale plant power generation still has its efficiency and voltage output. So, the potential of plant power generation still remains. It is hoped that this technology can be used in different greenbelts, such as laying the circuit under the plants in parks and adding USB plugs on the benches, so that people can charge their mobile phones, chargers, etc. while resting. It is also hoped that this technology can be widespread and make people interested in planting, and plant at home as environmentally friendly chargers. Also, if it can be applied in large-scale farming, it is believed that the technology will bring a huge amount of electricity for farmers to use or sell out, and thus solve the energy problem.

Experiment 4 result:



VI. If your team will compete the Sustainable Development Award, please indicate the specific sustainable development goal the project is related to, and provide justification for competing for this award. *(Word limit: 300 words)*

The depletion of fossil fuels is imperative. Discovering high-efficient renewable energy sources which can be extensively utilized is unquestionably an alternative to relieve the situation from deterioration. Plants, one of the universal mediums, can be affordable and clean energy and meanwhile protect life on land, subsequently establish sustainable cities and communities in response to the climate action. The cost of developing this technology is low such that even less developed countries, where there is a lack of financial resources and education of citizens, could afford the extensive utility. Moreover, deforestation has been a concern for years, while the effectiveness of the technology depends on the amount of plants and hence, heaps of plants, especially precious species in rainforests, could be preserved through the application of the technology, maintaining biodiversity and protecting life on land. Furthermore, the technology could coordinate urban greening, developing sustainable cities and communities and contributing to lessen global carbon emissions, in response to climate action.

VII. If your team will compete the Social Innovation Award, please list the target group or social issue the project focuses on, and provide justification for competing for this award. *(Word limit: 300 words)*

The severity of global warming is alarming. To lessen carbon emissions, the idea of environmental afforestation is advocated by the globe as a superordinate goal. The orientation of Power Plant in Plant is to be in line with the strategies of environmental afforestation and to mitigate the energy crisis by supplying electricity efficiently, effectively and stably. Power Plant in Plant is a fire-new domain in Hong Kong, while the most niche outline which suits the environmental factors of Hong Kong the most is proposed to meet the demands of the society. Thus, the efficiency of the technology could be maximized.

VIII. Conclusion

The products of photosynthesis in plants could be used to produce energy carrying electrons by microorganisms, and hence generate electricity. However, the power generation of plants is not yet efficient. How the power generation rate could be uplifted still requires the study of scientists.