Hong Kong Student Science Project Competition 2023

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

Team Number: JBBC167

Project Title: Investigation of the effects of light pollution on the growth of plants

Project Type: Investigation

To our best knowledge, there <mark>***are***</mark> ***/ are no*** [*] ***similar works in the field; (if there are,) related research links are as below:***

1. Benes, K. (2018, January 4). Is light pollution changing how plants do – and don't – grow? Massive Science. https://massivesci.com/articles/light-pollution-plants-grow-rest/
2. Czaja, M., & Kołton, A. (2022b, October 1). How light pollution can affect spring development of urban trees and shrubs. Urban Forestry & Urban Greening; Elsevier BV. https://doi.org/10.1016/j.ufug.2022.127753
3. Taylor & Francis. (n.d.). Effect street light pollution on the photosynthetic efficiency of different plants. https://www.tandfonline.com/doi/abs/10.1080/09291016.2018.1518206

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

The above works provide us with information about the relationship between photosynthesis and plant growth, including the importance of darkness, which is mentioned in Source 2. Based on the information provided, we set our dependent variables as the concentration of different gases instead of substances (such as the amount of soluble sugar contents or photosystem II mentioned in Source 3). We also adjusted our setup to attempt to avoid errors of previous works done by others in Source 1.

*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

Light pollution, also known as photopollution, is caused by the excessive use of artificial lightning outdoors. It can potentially interfere with photoperiodism and cause photobleaching and lead to concerning impacts on public health and the ecological systems. Results of studies conducted by scientists show that the light pollution affected the photosynthesis parameters and the normal physiological processes of plants. To further investigate the effects on plants growth, we set up experiments on plants with different durations of light exposure, evaluating such impacts by measuring the concentration of oxygen and carbon dioxide produced by the plants and the height of the plant over a three-day period.

II.   Objectives

To investigate how light pollution affects the amount of oxygen produced and the amount of carbon dioxide absorbed by plants at different times in a day, and how it affects the growth of plants.

III.   Hypothesis

Under light pollution, the amount of oxygen produced by plants will decrease while the amount of carbon dioxide absorbed by plants will also decrease. Light pollution will lower the rate of photosynthesis and hinder the plants growth. Our hypothesis is drawn based on the potential occurrence of photobleaching, where light energy is excessive and creates too many oxygen molecules, shifting the quantum states with chlorophyll and react so strongly with each other that they are destroyed, causing the decrease in the amount of chlorophyll molecules. As photosynthesis is carried out by chlorophyll, we hypothesise that the photosynthetic efficiency of plants will decrease under the impact of light pollution.

IV.   Methodology

Fig. 1 shows the setup of the experiment. In brief, we will prepare two boxes, each of $73 \times 55 \times 46 cm^3$ in size. We will cut holes on both of the boxes to provide space for the connecting wires as shown in the diagram. In the boxes, the table lamp is connected to the socket (with a timer switching on at 6am and off at 6pm for control setup only). Meanwhile, Arduino sensors are connected to the computer which is also connected to the socket with the wire passing through the holes, then properly sealed with tape. For manual data, the O_2 sensor is plugged into the box properly and the CO2 sensor is stuck on a side of the box with the monitor facing outwards. The beans sprout plants and Epipremnum Aureum are provided with 40 cm^3 and 80 cm^3 of water respectively for both setups. We will first measure and record their height in the beginning and at the end of the experiment. We will also take readings of the oxygen and carbon dioxide concentration at 07:30, 10:00, 12:00, 14:30, 16:30 for 3 consecutive days.
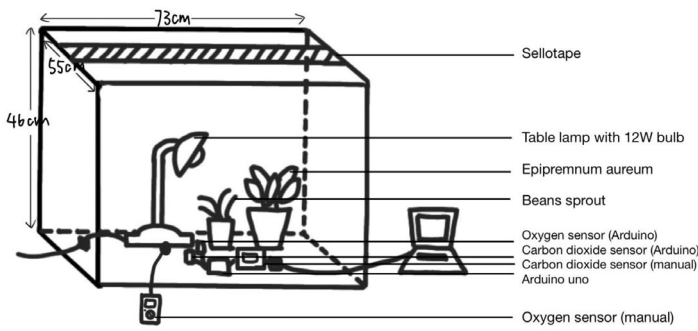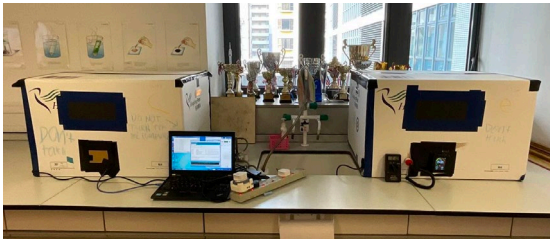
Fig. 1. (a)

Fig. 1. (b)   Fig. 1. (c)

Fig. 1. (a) An illustration of the control and experimental setups. Fig (b) and (c) The actual setup with the bean sprout and Epipremnum aureum. Timers were set to turn on and off the lamps of the control and experiment setups at 6 am and 6 pm everyday respectively. Another lamp was turned on and off at 6 pm and 6 am, respectively, in the experimental setup to mimic the light pollution effect.

V.   Results
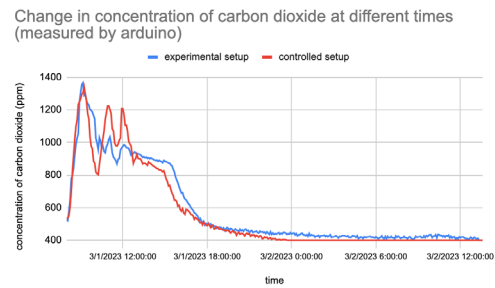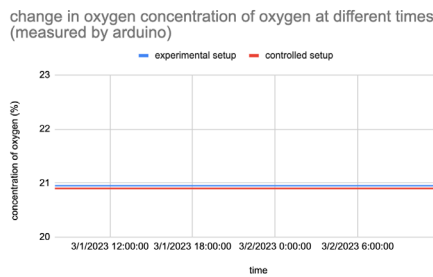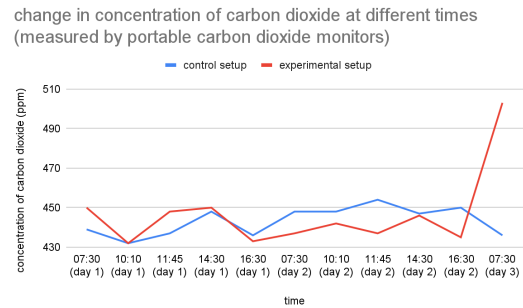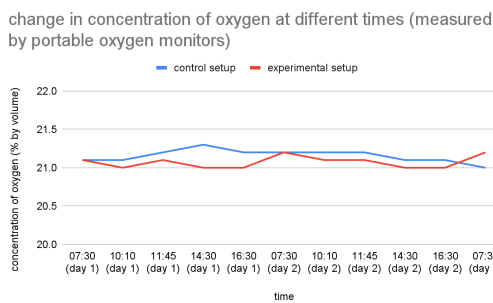
Change in the height of bean sprout plants before and after the experiment

		Height before experiment (cm)	Height after experiment (cm)
Controlled setup	Bean sprout	12	17
	Epipremnum aureum	17.5	27
Experimental setup	Bean sprout	11.5	17
	Epipremnum aureum	20	25

There are no significant changes for the concentration of both gases except for the CO_2 rise at last in level for the experimental setup. Also, the concentration of oxygen in both the experimental and control setups remained constant, meanwhile the

concentration of carbon dioxide does not have any significant difference. It takes longer for the experimental setup's carbon dioxide concentration to drop below 400 ppm, indicating that light pollution lowers the photosynthesis rate of plants.

For the height of the plants, the bean sprouts of the control and experimental setups have similar growth rate, whereas the Epipremnum aureum plant of control setup doubles the amount of height growth of that in experimental setup.

The above results show us that photosynthesis is heavily affected by light pollution, especially when we clearly see the more hindered growth of a plant with more chlorophyll than a plant with less.

In light of holding the investigation in a school laboratory, our apparatuses used are not able to bring out the most accurate results.

Here are some possible errors:

1. Although we have made our best effort to block holes on the boxes using tape, we are unable to ensure no holes are left out, lowering the accuracy of our setup as the levels of concentration of gases in the surroundings also affects the readings.
2. In our experiment, both the O_2 sensor and CO_2 sensor are placed at the very bottom of the carton boxes, which gives inaccurate data because CO_2 sinks, resulting in a higher CO_2 level and lower O_2 level recorded. To fix the error, we should place the sensors in the middle of the box to obtain a balanced reading accuracy.
3. Microorganisms in the soil respire and release CO_2. We should wrap the bottom of the plants with plastic to separate the gases released by plants and the microorganisms.

Despite the errors, we obtained somewhat accurate results that support our hypothesis. Light pollution decreases the photosynthetic rate which is a threatening environmental phenomenon to be improved. With this information in our minds, we'd be able to further develop our project.

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)*

n/a

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)*

n/a

VIII. Conclusion

As the graph shown above, there's no significant differences between the oxygen concentrations and carbon dioxide concentrations of both setups measured by portable monitors and oxygen concentrations measured by the Arduino system. However, according to Arduino system measurements, it takes longer for the carbon dioxide concentrations of the experimental setup to drop below 400 ppm than the controlled setup, indicating that photosynthetic rate is slower. As the table shown above, the growth rate of the experimental setup is slower than the controlled setup. Therefore, we can come to the conclusion that the photosynthetic rate and growth rate of the plant is affected by light pollution, simulated from the experimental setup.

☐ **Our project is developed based on previous project and the enhancement is below:**

n/a