Photosynthesis Coursework
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I have been given the task of analysing and evaluating an experiment carried out by year 10 students to find the optimum distance for a lamp to be placed to enable aquatic plants to photosynthesise. Here is a table of results showing what five different groups recorded.

	Number of Bubbles Recorded in Five minutes					
Distance	Group 1	Group 2	Group 3	Group 4	Group 5	Average (1.d.p)
0cm	32	48	36	96	21	46.6
10cm	39	45	36	110	27	51.4
20cm	26	52	29	58	32	39.4
30cm	10	27	11	38	45	26.2
40cm	3	7	1	15	7	6.6
50cm	2	2	1	5	0	2
60cm	1	2	1	4	1	1.8

I have drawn a graph to illustrate the average values of these groups. As you can see, there are three clear sections to the graph, labelled A, B, and C. The shape of the graph shows a steady increase in the amount of bubbles given off through the experiment, showing a clear optimum distance for the light, and levelling out where the lamp is so far away it adds an almost negligible amount to the background light.

The optimum distance according to these results is 10cm, where the average amount of bubbles is 51.4. This can be seen as the peak on the graph. This is the maximum amount of bubbles that can be given off by the pondweed during photosynthesis, indicating the ideal amount of light that the pondweed needs to be most productive.

Section B on the graph, shows a steady increase in the amount of bubbles given off, and so indicates that the light was the only variable being changed. The more intense the light was, the faster the rate of photosynthesis, as the chlorophyll in the plants cells had more energy to create glucose and oxygen with. The equation for photosynthesis is:

$$\text{Carbon Dioxide} + \text{Water} \xrightarrow[\text{(Chlorophyll)}]{\text{(Light)}} \text{Glucose} + \text{Oxygen}$$

$$6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$$

As the pondweed was submerged in water, so its surface area had a constant supply of water (H_2O). This variable was controlled during the experiment, as the plant was constantly submerged in water. Carbon Dioxide also appears to have been in plentiful supply during B, as there is a steady rate of increase in the amount of bubbles given off. Temperature also affects photosynthesis, and this was obviously also constant during B, again due to a steady increase that is proportional along its length to the lamp being moved closer to the boiling tube.

In Section A of the graph, there is a noticeable decrease in the amount of bubbles given off. This coincides with the lamp being 0cm from the boiling tube. An obvious reason would be that the light had become too intense for the plant, and the chlorophyll in the plant could not function as well in so much light. I do not believe this is the case though, as plants in the wild draw their light from the sun, which has a far higher light intensity that the lamp. I believe that another factor, another independent variable, was introduced by moving the lamp so close, heat. All light bulbs give off heat as well as light, so, although light intensity was at its maximum, the rate of photosynthesis was hampered by the fact that the lamp was giving off heat, which would have denatured enzymes in the plant to making it harder for the plant to function and produce oxygen in photosynthesis.

Also, heat from the lamp may have started to kill cells on the surface of the pondweed, which would have decreased the rate of photosynthesis, as the plant would have fewer cells to photosynthesise with. Another reason for this decrease in the amount of bubbles given off is that, as the experiment was started with the lamp being at its farthest distance, and the last results recorded were those when the lamp was at 0cm, the supply of CO_2 in the boiling tube may have begun to be depleted. The method does not state that the groups conducting the experiment changed the water in the tubes for each measurement, and so by the end of the experiment the plant would not have had such a plentiful supply of CO_2 dissolved in the water around it as it did at the start. This means that the rate of photosynthesis would have been decreased anyway, no matter how close the lamp was. In the wild, pondweed does not have this problem, as organisms in the water around it replenish the supply of CO_2 as they respire.

In section C of the graph, the rate of photosynthesis levels out from the steady increase it saw in B. This is most likely to be because the lamp was so far away, that other light in the room would have been stronger, and thus would have caused photosynthesis in the plant to occur.

The predictions that were made were partly right. The first one states that they thought that the closer the lamp got to the pondweed, the greater the rate of photosynthesis. This can be seen as true in section B on the graph, as the closer the lamp got to the pondweed, the more bubbles were given off in proportion to it. The results show that this is not true though in sections A and C, but this is not because of the lamp, but of external factors, in A heat becomes a factor that affects the rate of photosynthesis, and in C, the lamp is so far away that backlight from the room affects the rate of photosynthesis more than the lamp. The second prediction was that the rate of photosynthesis would increase at a constant rate as the distance between the lamp and plant was reduced. This is also partly correct, as in section B, the rate of photosynthesis seems directly proportional to the distance of the lamp from the plant. But in A and C, again, this is not correct, as again other independent variables are introduced which affect the rate of photosynthesis. Both predictions would have been right, had the light from the lamp been the only factor being changed to affect the rate of photosynthesis, we would have seen a straight line on the graph. But because the experiment became susceptible to factors apart from the light from the lamp, the predictions were only partly right.

Evaluation

This experiment did collect results that supported the predictions made to some extent, and so it could be called a success. But because the results recorded indicated that other factors had affected the experiment apart from the light intensity from the lamp, this experiment failed to get accurate results that fully supported the predictions made.

Several anomalous results seem to have occurred. For one, the results from group four seem far higher in value than the other groups. This may have been because group four had a larger piece of pondweed than the other groups, or that it had a larger surface area (the amount of pondweed to be used is not specified). This would have caused a larger amount of bubbles than a smaller piece as the

more of the plant there was, the more photosynthesis could be carried out. Although group four's results were much higher than the other groups, their results still keep within the same general trend as the other groups results, and so they did not dramatically change the shape of the graph. The other set of anomalous results were those of group five, who recorded no bubbles at 50cm, but recorded one at 60cm. This may have been because at 50cm, the light intensity from the lamp was no longer strong enough for photosynthesis to happen, but at 60cm, a last bubble of oxygen from when the plant was photosynthesising was released. It may have been caught under a leaf, or perhaps at 60cm, another light was switched on in the room that caused the plant to start photosynthesising again. The rate of photosynthesis may have also been so slow at this point that it took the 10 minutes from the 40cm test to the 60cm test for a single bubble to form. Remember that year 10 students and not professional scientists carried out this experiment. It is most likely that the groups were doing their experiments at the same time, and so one group may have moved their light away from their pondweed, but closer to group 5's during the time in which group 5 where recording their results for 60cm, causing their pondweed to pick up the light that it was giving off and beginning to photosynthesise. This also adds to the theory that when the line on graph levels out is because at 60cm, other group's lamp's light intensity may have been stronger than the lamp which the group was using.

I think that there are enough results to support the predictions that were made, as during section B on the graph there are no other factors affecting the rate of photosynthesis, and the constant increase during this time can be seen as evidence that the predictions were correct. The anomalies that occurred in sections A and C of the graph, preventing the graph from being a constant straight line, can be accounted for by other factors affecting the rate of photosynthesis that can be blamed on errors in the method of the experiment which allow these independent variables (heat and background light) to affect the results.

Limitations in the experiment can be found, for instance, the size, mass, and surface area of the pondweed cannot be accurately reproduced for each group without using complex equipment that they did not have at their disposal. Each pondweed is different, and so cutting a piece that is near to exactly the same as the other groups would be impossible. A way to improve this part of the experiment would have been to clone pondweed plant using cuttings, and then

take a specific part of the clones produced for the experiment, which would increase the fairness of the experiment, as each group would have identical pieces of pondweed. Also, the actual intensity of the light was not measured, as intensity may have varied from lamp to lamp. This experiment could have been improved by the use of light sensors, which could have been used to make sure each piece of pondweed got the same amount of light. Heat from the lamp could have affected the rate of photosynthesis, to prevent this happening, a protective screen made of glass could have been put in between the lamp and pondweed to prevent heat from the lamp getting to it. The amount of CO_2 in the water would have been depleted at the end of the experiment, decreasing the rate of photosynthesis. To avoid this, the water in the boiling tubes could have been replaced for each separate light intensity, so preventing the CO_2 from becoming an unwanted variable. The way in which bubbles were counted was not specified, they could have been counted as they formed on the plant, or as they reached the surface of the water, etc. Without a specific way of counting the bubbles, we cannot assume that all bubbles were counted accurately; some may have been counted twice if they were counted both when on the plant, and as they left it. To prevent this, bubbles should only be counted when they leave the plant's surface.

Future experiments could include investigating the other factors affecting the rate of photosynthesis, such as temperature, CO_2, or mineral concentration. The effect of temperature could be measured by heating the tube in which the pondweed is, and seeing how that affects the rate of photosynthesis by again counting bubbles. Distilled water could be used compared with tap water to see how CO_2 and mineral concentration affect the rate of photosynthesis by counting how many bubbles were produced for each.