Investigating the effect of different light intensities on water weed [Online Simulation]

PE: Not much sign of personal engagement.

Research question

Is there a change (decrease / increase) in oxygen (O_2) production (number of bubbles) of water weed with changing light intensities?

Ex: The research question should refer to the fact that a simulation is being used.

Variables

Independent variable – the light intensity (varying from a scale of 1 – 10, unknown units)

Dependent variable - The number of bubbles produced over a known period of time (O_2 production)

Control variables **How is it being controlled?**

Ex: Identifies variables

Ex: Method considers control.

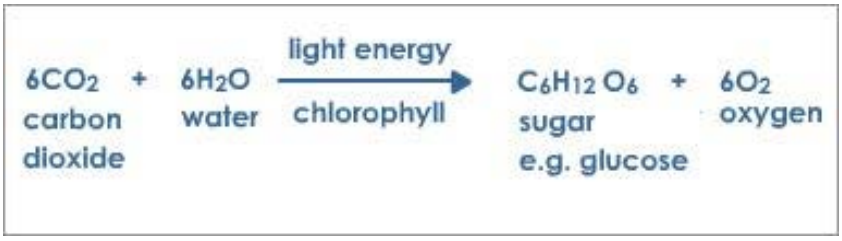
Type and age of water weed	The water weed used in this experiment was unknown. It could not be controlled and it was assumed that it was healthy and would give consistent results.
Weight (amount) of pond weed	This could not be controlled. It was assumed that the experiment provided the optimum amount for best results.
Temperature of the CO2 solution	This was unknown and could not be controlled. It was assumed that the temperature remained constant and was at an optimum level.
Time of bubble collection	This should always be the same and of a reasonable length to provide stat data, A time of 30 seconds was pre-programmed into the simulation. The speed could be at normal time or x 5 so the faster simulation speed was used to quicken data collection. It was assumed that this did not influence the results given. The results could be doubled up to 1 minute (see evaluation)
External light intensities	These could not be controlled and no data was provided. It was assumed that the simulation was

	carried out in dark conditions to provide optimum results.
Sodium carbonate concentration	This could be controlled using an arbitary scale of 1 – 10. The simulation gave no indication of the solution composition or Molarity so it was assumed that CO2 was in excess. The level used in this experiment was 10 to ensure that the CO^2 was in excess and would not influence the results.
Temperature of the room	This was unknown and could not be controlled. It was assumed that it was optimum for the experiment.
Size of bubbles	From observations during the simulation these appeared to be of a regular size and were released from the plant at regular intervals.

Aquatic plants can be used to demonstrate oxygen evolution in the process of photosynthesis. In theory, when an aquatic plant is placed in a solution containing a source of carbon dioxide [$CO^{2)}$], in the presence of light of appropriate intensity, the plant will photosynthesise and produce bubbles of oxygen-containing gas. These bubbles can be counted and the rate of bubbling can serve as an indication of the rate of photosynthesis. When the light intensity is increased, the rate of bubble production should increase. Decrease the light intensity and the rate of bubbling should decrease. Remove the light source altogether, or move in to a distance beyond which the energy levels are to small for photosynthesis, and the bubbling should cease.

Ex: Prediction made

The equation for photosynthesis is



Light is essential for photosynthesis. Green plant cells that are placed in the dark will not photosynthesis. An increase in light intensity will produce an increase in the rate of photosynthesis until a level of light intensity is reached [normally 38% -(1)] above which the rate does not increase because the light saturation point has been reached and another factor (CO2 concentration or temperature) is limiting.

Ex: Relevant scientific context used

In this experiment, the light intensity is changed, by decreasing the light intensity. The rate of photosynthesis should decrease and therefore the amount of oxygen bubbles should decrease.

Hypothesis

I think that if the light intensity is very low, then the number of bubbles of oxygen produced will also be very low, because the plant obtains light energy from photons being absorbed by pigments in photosystems, and this energy is what drives the photosynthetic process. At low light intensity, water will not undergo photolysis and therefore will not produce O2 as a byproduct. As the light intensity increases, more electrons are energised in the reaction centre of the Photosystem, and so more photolysis occurs to replace the high energy electron, thus releasing more oxygen which can be detected as more bubbles.

At the highest light intensities it is possible that the number of bubbles will plateau, as photosynthesis can be limited by several factors: light intensity, temperature, and carbon dioxide concentration. The rate of photosynthesis is unlikely to continue increasing even with high light intensities because e.g. carbon dioxide concentrations may not be optimal.

Photosynthesis also requires CO^2 to be present and the simulation provides this as a solution of CO^2 of changeable concentration with arbitary units 1-10.

Comm: Incorrect format.

Photosynthesis is dependent on the CO^2 concentration but this is in excess and will not influence the results. Decreasing CO2 concentrations could be explored in this simulation.

Ex: But it was not actually done

Light is absorbed by chlorophyll during photosynthesis, in the blue/green spectrum. Normal light provides these wavelengths, so using a normal light bulb (white light) without filters is sufficient. The use of coloured light could be explored using this simulation.

Ex: As this was not carried out the comment is irrelevant here

The Simulation program: Water weed

This simulation permits the experimenter to modify light intensity, carbon dioxide levels and the colour of the light.
The screen shot below shows the virtual set up.

Ex: Screen shot useful

http://www.saddleworth.oldham.sch.uk/science/simulations/waterweed.htm

Method

The parameters were set on the simulation as follows:

- CO2 level =10
- Light filter white
- Speed x5

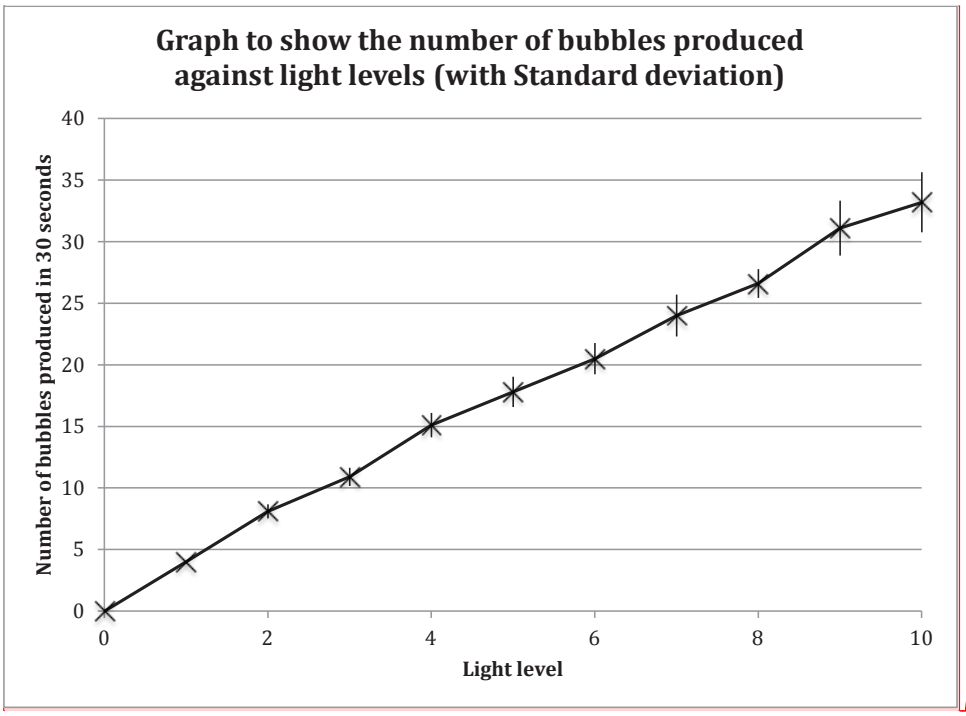
Data was collected from light levels 1 -10. 5 repeats were carried out at each light level.

The raw data collected is shown in tables in the appendix

An: Raw data presented. No qualitative observations but they are not relevant in this investigation

Light Level (AU)	Number of bubbles produced in 30 seconds (+/-0.05 seconds)												
	Rpt 1	Rpt 2	Rpt 3	Rpt 4	Rpt 5	Rpt 6	Rpt 7	Rpt 8	Rpt 9	Rpt 10	Mean	St Dev	95%
0	0	0	0	0	0	0	0	0	0	0	0.0	0.00	
1	4	4	4	4	4	4	4	4	4	4	4.0	0.00	0
2	8	8	9	9	8	7	8	8	8	8	8.1	0.57	0.35
3	11	11	12	10	11	10	12	10	11	11	10.9	0.74	0.46
4	17	15	14	14	16	15	14	16	15	15	15.1	0.99	0.61
5	17	20	17	17	17	18	17	17	18	20	17.8	1.23	0.76
6	19	19	22	21	20	19	20	22	21	22	20.5	1.27	0.79
7	22	26	26	22	24	23	26	24	25	22	24.0	1.70	1.05
8	26	27	28	28	27	26	25	28	26	25	26.6	1.17	0.78
9	33	32	29	32	32	32	33	28	27	33	31.1	2.23	1.38
10	35	30	31	31	36	36	34	32	36	31	33.2	2.44	1.51

An: Processing ap propriate and accurate. Could be converted to the rate of bubbling per min.

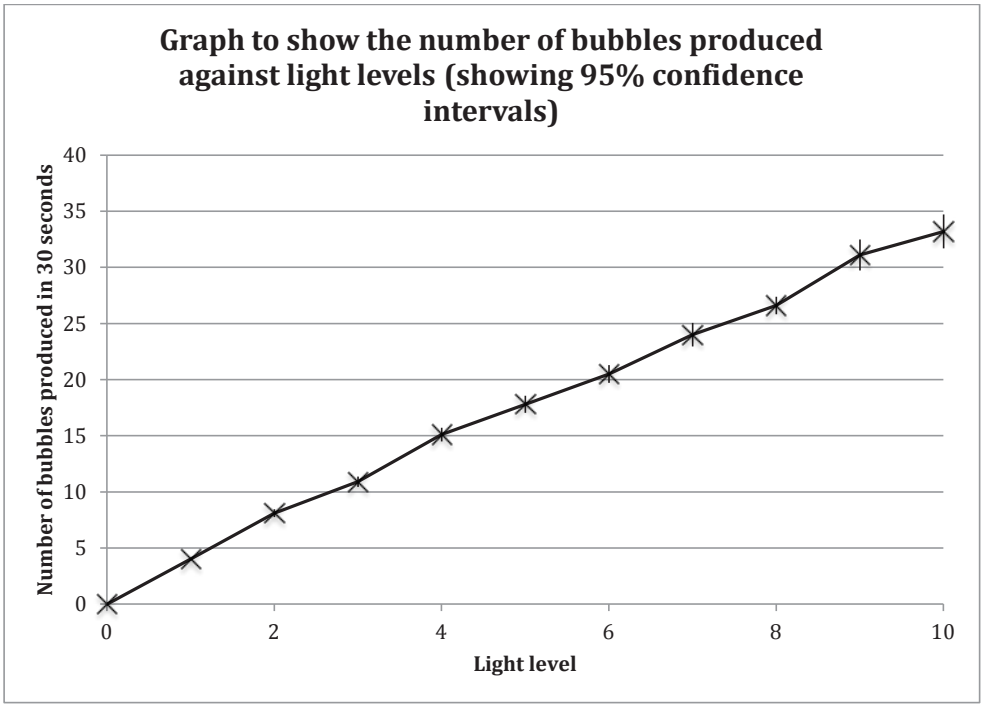


An: The title should state that this is a mean number of bubbles.

An: Trend line would be appropriate.

Comm: Error bars identified

Comm: Uncertainties given are error bars



Conclusion

As the light levels are increased there is an increase in oxygen (bubble) production from photosynthesis of the plant. This result suggests that my hypothesis was correct.

An: Interpretation of data correct.

Light levels at unit 10 were approximately twice those at light level 5. This corresponded to levels of photosynthesis at light level 10 being twice that of light level 5. This can also be seen e.g. with the number of bubbles at a light intensity of 4 units being double that seen with a light intensity of 2 units, indicating that there is a direct, positive correlation between light intensity and the number of bubbles produced.

An: The data is interpreted

Standard deviation was calculated to determine the reliability of the experiment. Standard deviation shows the spread of the data about the mean, and so the lower the standard deviation, the more reliable the results. It can be seen on the graph that the higher the light level, the greater the standard deviation and 95% confidence limits become, showing that the data becomes less reliable as the light intensity increases. However, at all light intensities the standard deviation was relatively small in comparison with the mean, being at the most less than 8% of the mean value (for light level 2).

An: Uncertainties considered.

An: Interpretation of uncertainties is carried out

The results of this experiment demonstrate the theory that, at low light levels photolysis is not happening much because there are only a small number of photons striking the Photosystem, and therefore not many electrons being excited to a higher energy level. Photolysis is not occurring, water is not being split and therefore no, or few oxygen bubbles are being released by the plant.

Ev: Conclusion supported by data.

As the light increases in intensity, more photons are being absorbed by the pigments and more electrons need replacing in the primary reaction centre of the photosystem, resulting in a higher rate of photolysis and more oxygen bubbles (2).

Ev: Conclusion set in a scientific context.

My hypothesis was only partially correct, as I predicted that at a certain light intensity the number of bubbles would reach a plateau because another factor would be limiting. This did not happen, but this is possibly due to the light saturation point not having been reached in this experiment.

Ev: An explanation as to why the light saturation point might not have been reached would be useful here.

Evaluation

Weaknesses	**Improvements**
No intermediate values could be assessed	The simulation does not allow assessment of any values outside the pre-programmed values. This is an area that could be explored in the laboratory. It would be useful if this could be changed.
Maximum light level of simulation did not reach light saturation point, therefore other limiting factors could not be determined.	Unlike a related practical carried out in the laboratory this simulation did not have maximum or minimum light levels that influenced photosynthesis. This could not be controlled and would add more to results if it could be explored.
Units of light and CO2 concentration were in units of 1 -10. There was no indication of how this is related to a laboratory situation and what the solutions and the light levels actually were. These variables cannot be controlled and may not provide sufficient data to comment fully or provide the variation in an experiment that would normally be carried out. No trial runs can be carried out.	Provide more detail about light units, solutions etc. Allow fine adjustments of variables. Provide more information.

Ev: Why is this necessary? There are sufficient intervals and data points to establish a clear relationship.

Ev: More runs at different levels of the other variables (CO_2, temperature, light colour) could be tried.

Ev: Why not?

References

(1) www.proprofs.com

(2) 'Steps in Photosynthesis ' Clegg, Biology for the Diploma, 2007, Hodder Education

Appendix Raw Data Produced on 31/1/12 11.16am- 11.33 am

An: Raw data presented.

Run	CO2	Light	Filter	Count
1	10	0	White	0
2	10	0	White	0
3	10	0	White	0
4	10	0	White	0
5	10	0	White	0
6	10	0	White	0
7	10	0	White	0
8	10	0	White	0
9	10	0	White	0
10	10	0	White	0

Run	CO2	Light	Filter	Count
1	10	1	White	4
2	10	1	White	4
3	10	1	White	4
4	10	1	White	4
5	10	1	White	4
6	10	1	White	4
7	10	1	White	4
8	10	1	White	4
9	10	1	White	4
10	10	1	White	4

Run	CO2	Light	Filter	Count
1	10	2	White	8
2	10	2	White	8
3	10	2	White	8
4	10	2	White	9
5	10	2	White	9
6	10	2	White	8
7	10	2	White	7
8	10	2	White	8
9	10	2	White	8
10	10	2	White	8

Run	CO2	Light	Filter	Count
1	10	3	White	11
2	10	3	White	11
3	10	3	White	12
4	10	3	White	10
5	10	3	White	11
6	10	3	White	10
7	10	3	White	12
8	10	3	White	10
9	10	3	White	11
10	10	3	White	11

Run	CO2	Light	Filter	Count
1	10	4	White	17
2	10	4	White	15
3	10	4	White	14
4	10	4	White	14
5	10	4	White	16
6	10	4	White	15
7	10	4	White	14
8	10	4	White	16
9	10	4	White	15
10	10	4	White	15

Run	CO2	Light	Filter	Count
1	10	5	White	17
2	10	5	White	20
3	10	5	White	17
4	10	5	White	17
5	10	5	White	17
6	10	5	White	18
7	10	5	White	17
8	10	5	White	17
9	10	5	White	18
10	10	5	White	20

Run	CO2	Light	Filter	Count
1	10	6	White	19
2	10	6	White	19
3	10	6	White	22
4	10	6	White	21
5	10	6	White	20
6	10	6	White	19
7	10	6	White	20
8	10	6	White	22
9	10	6	White	21
10	10	6	White	22

Run	CO2	Light	Filter	Count
1	10	7	White	26
2	10	7	White	26
3	10	7	White	22
4	10	7	White	24
5	10	7	White	23
6	10	7	White	26
7	10	7	White	24
8	10	7	White	25
9	10	7	White	22
10	10	7	White	22

Run	CO2	Light	Filter	Count
1	10	8	White	26
2	10	8	White	27
3	10	8	White	28
4	10	8	White	28
5	10	8	White	27
6	10	8	White	26
7	10	8	White	25
8	10	8	White	28
9	10	8	White	26
10	10	8	White	25

Run	CO2	Light	Filter	Count
1	10	9	White	33
2	10	9	White	32
3	10	9	White	29
4	10	9	White	32
5	10	9	White	32
6	10	9	White	32
7	10	9	White	33
8	10	9	White	28
9	10	9	White	27
10	10	9	White	33

Run	CO2	Light	Filter	Count
1	10	10	White	35
2	10	10	White	30
3	10	10	White	31
4	10	10	White	31
5	10	10	White	36
6	10	10	White	36
7	10	10	White	34
8	10	10	White	32
9	10	10	White	36
10	10	10	White	31