Photosynthesis using seaweed - opportunities for investigative work in Environmental Science?

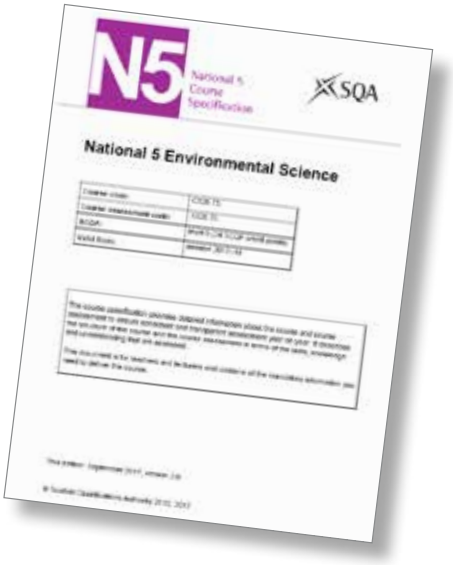
Background

Within SSERC we continue to explore the use of hydrogencarbonate indicator as a convenient experimental system for demonstrating both photosynthesis and respiration in plants [1] and we have recently extended our range of published protocols to include materials in support of the SQA assignment for revised National 5 Biology [2]. Without doubt *Cabomba* has, over the years, proved to be our plant of choice [3] although since it was placed on the 'banned list' [4] we have had had to switch our allegiance to *Egeria najas*.

Figure 1 - Ascophyllum nodosum - also known as Knotted wrack.

Until now we have not focussed on resources to support National 5 Environmental Science although a number of activities available through either chemistry or biology sections of the SSERC website could be utilised for such purposes. We present here a variant on the immobilised algae [2] and Egeria najas [4] activities.

Estimates of the proportion of photosynthesis that occurs in aqueous compared to land-based systems varies but the ratio 60:40 is often quoted and within aquatic systems clearly many different plant species are involved. In this article we explore whether commonly found seaweeds can be used in experiments suitable for school-based practical work.



Experimental protocol

This is similar, in principle, to that described in more detail in our support for National 5 Biology [2].

1) From a sheltered rocky beach obtain a sample of *Ascophyllum nodosum* (Knotted wrack, see Figure 1) from the high tide line. It is best to collect samples shortly after high tide in order to ensure that samples have not dried out. Knotted wrack is very common and dominant on rocky shores and so should be easy to find; it is also easy to distinguish with large air bladders and parasitic red algae.

2) We have found that if we rinse the Knotted wrack and leave it moist in a plastic bag that samples can be kept at room temperature for several days. Thus, collecting samples on 'days out at the weekend' is eminently possible!

3) Prepare hydrogencarbonate indicator solution (see [5] for details). Adjust the pH to be ca.7.2.

4) If samples have been left in the dark after collection and prior to this step it is advisable to leave them in daylight for an hour or so before proceeding. Take about 5 g of Knotted wrack into each of 2 Bijou bottles (or similar) and add 4 cm^3 of hydrogencarbonate indicator to each. Wrap one of the Bijou bottles with black paper to exclude light.

5) Place both Bijou bottles in front of a suitable light source (we have successfully used desk lamps and fluorescent tubes; sunlight also works well). >>

6) Leave the bottles in front of the lamp; after about 20-30 minutes you should start to see a colour change in the bottle which is not covered in black paper. As photosynthesis occurs the indicator will change from its starting orange/yellow to a red/purple colour. On the timescales used here, little colour change will be observed in the bottle covered in black paper.

7) Colour changes can be quantified using a colorimeter set to read at 580 nm or if using a colorimeter which has a diode as the light source use the green diode.

8) Once the basic protocol is established there are lots of opportunities for varying the experimental parameters e.g. the effect of light intensity on photosynthesis rate.

Figure 2 - Samples of Knotted wrack in hydrogencarbonate indicator after illumination. Samples were either covered with black paper (LHS) or exposed to light (RHS).

Different species of seaweed could be used - for example Bladder wrack (*Fucus vesiculosus*, Figure 3) although in our experience colour changes using this species are much slower.

Further information

The role of marine ecosystems in capturing organic carbon (so-called 'blue' carbon systems) is increasingly being recognised (see for example [6] which is based on a fuller article [7]) and we believe that the experimental system described here will allow students to do experimental work in a field which from a global perspective is both important and topical. <<

Figure 3 - Sample of Bladder wrack.

References

[1] Andrews, K., Beaumont, P.C. and Crawford, K. (2015), Measurement of limiting factors in photosynthesis. School Science Review, **96** (356) 31-35. (Copies of this manuscript are available from SSERC; enquiries@sserc.org.uk).

[2] National 5 Biology assignment packs, SSERC Bulletin, **261**, 10-12.

[3] Adams, A. Moore, G., Rutherford, A., Stewart, F., Crawford, K. and Beaumont, P.C. (2012), *Cabomba* - an exocharmic plant! *School Science Review*, 93, 9-12. (Copies of this manuscript are available from SSERC).

[4] Is it true that *Cabomba* has been banned from schools? SSERC Bulletin, **258** 4 6.

[5] We recommended that schools prepare their own indicator since those which are available commercially often vary in quality. To make a concentrated stock of indicator (10 times the concentration required for experiments with algae) use the following protocol:
- dissolve cresol red (0.1 g) and thymol blue (0.2 g) in ethanol (IDA, 20 cm^3)
- dissolve sodium hydrogencarbonate (0.85 g) in freshly boiled distilled water (200 cm^3)
- add the solution of cresol red and thymol to the distilled water and make to 1 dm^3 with freshly boiled distilled water.

For use in experiments:
- dilute the indicator (use 1 part indicator to 9 parts freshly boiled distilled water) prepared above
- adjust the pH to approximately 7.4
- aerate the solution prior to use

[6] University of Technology, Sydney (2015), Study backs seaweed's carbon capturing potential. Available at https://phys.org/news/2015-05-seaweed-carbon-capturing-potential.html (accessed 22nd March 2018).

[7] Trevathan-Tackett, S.M., Kelleway, J., Macreadie, P.I., Beardall, J., Ralph, P. and Bellgrove, A. (2015) Comparison of marine macrophytes for their contributions to blue carbon sequestration. Ecology, **96**, 3043-3057.