Eutrophication - investigating the on the growth of

The broad theme of 'fertilisers and food security' in the new Scottish Curriculum was discussed in the previous edition of the SSERC bulletin. Activities about the effects of nutrient deficiency on plant growth and the use and design of fertilisers in food production were presented [1].

Learners need to understand that 'food security' is complex and there are no simple solutions to feeding the world's population in a sustainable way. The use of fertilisers is necessary to increase yield of food crops, but can also lead to a variety of environmental problems. A related theme, 'Human Impact on the Environment', also appears at various levels within the new science courses. 'Human Impact on the Environment' provides a context for learners to explore environmental issues relating to the use of fertilisers [2]. Coincidentally, the unusually balmy climatic conditions of summer 2013 highlighted a phenomenon associated with fertiliser use, making eutrophication very topical and relevant to learners!

Warm summers in Scotland are usually met with great delight and this year has been no exception. However the hot, dry weather also contributed to some unwanted effects in many of our fresh water lochs and ponds. Cyanobacteria and fresh water algae, which live in these ecosystems, increased in number sometimes causing blue-green, or green *blooms*. In some cases these blooms took the form of unpleasant looking scum, or floating mats of algae (Figures 1 and 2).

Algal blooms can occur when there is a combination of warm water (which is still or slow moving) and a high concentration of nutrients from sources like sewage or fertiliser run-off from local fields.
As well as looking and smelling unpleasant, algal blooms can cause health problems for those who come in direct contact with them. Cyanobacteria (blue-greens) in some blooms produce toxins which are dangerous to humans, dogs and many of the organisms which live in the water. At various locations throughout Scotland, notices such as that shown in Figure 3 were posted by local councils near to freshwater leisure facilities this summer.

This year algal blooms occurred in Strathclyde Loch resulting in it becoming unsafe for swimmers. Strathclyde Loch is the venue for the swimming stage of the triathlon event at the 2014 Commonwealth Games. There are, of course, concerns that we might have another warm dry summer next year and if an algal bloom occurred again it would pose problems for the Games organisers [3].

Figures 1 and 2 *- Algal bloom Biggar Pond, Summer 2013.*

effects of fertilisers an algal population

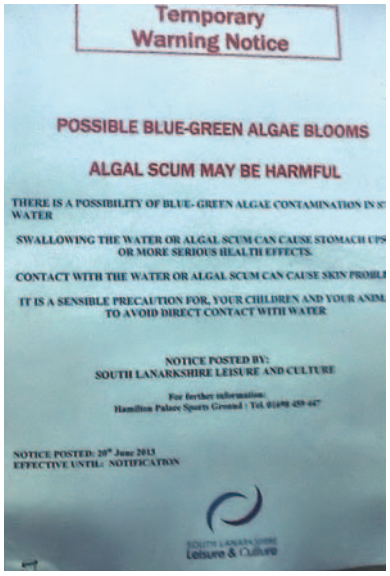

Figure 3 *- Notice posted at Biggar Pond, June 2013.*

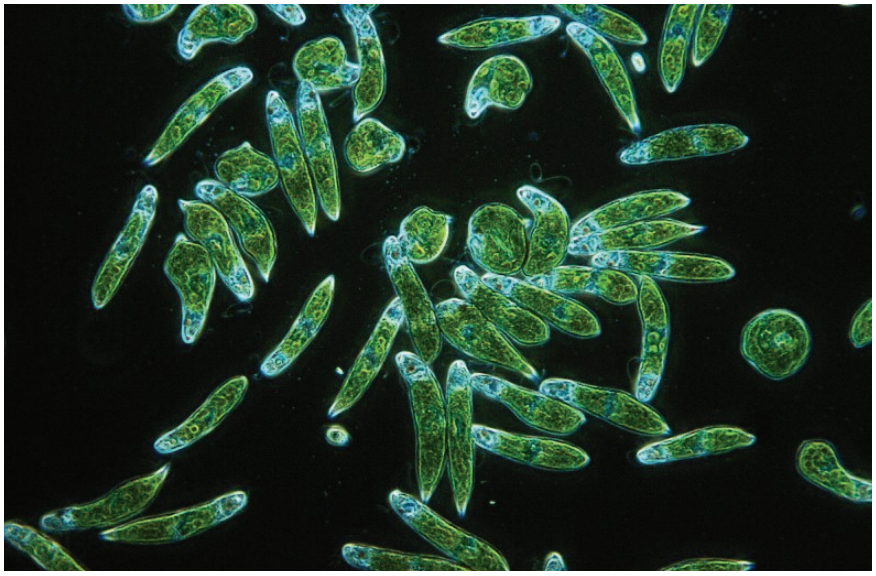

Figure 4 *- Image of Euglena gracilis (Wellcome images [5]).*

The increase in nutrient concentration that leads to algal blooms is known as *eutrophication*. Eutrophication is a process that happens naturally in some ecosystems. Eutrophication can also be increased by human activity when, for example, fertilisers from fields are washed into rivers, streams and ponds. Fertilisers are composed mainly of nitrogen, phosphorous and potassium and if these are washed by rain from fields into a waterway they will provide the additional nutrients which will lead to an increase in algal and plant populations. Warm weather exacerbates the problem by further promoting the growth of these populations leading to the kind of blooms we have seen this summer. Eutrophication can lead to a severe reduction in water quality. The organisms which make up algal blooms that form in high nutrient conditions live for only a short time resulting in large quantities of dead and decaying organic matter. The decay process involves rapid growth of bacterial populations which use up dissolved oxygen in the process of respiration. Levels of dissolved oxygen in the waterways are thus severely reduced and, being deprived of oxygen, fish and other organisms die.

The following practical activity investigates the effect of a plant fertiliser, *Baby Bio*™, on the growth of a population of algae. This classroom practical can serve as a model to represent algal blooms in a large body of water. The activity is adapted from a Society for General Microbiology protocol [4].
The alga used is *Euglena gracilis* (Figure 4) which is a common species of motile freshwater algae that can bloom due to the effects of fertilisers.

The effects of the plant fertiliser on the algal populations can be measured in two ways. By comparing the size of algal populations grown with and without fertiliser using a:

- colorimeter to compare absorbance of algal suspensions;
- light microscope to determine the concentration of algae.

Two populations of *Euglena gracilis* are set up. One population is grown in distilled water while the other is grown in a solution of plant fertiliser. The two populations are observed at regular intervals over a period of 3 - 4 weeks.

Materials

- Measuring cylinder
- 2 x conical flasks
- Distilled water
- Baby Bio™ (or other suitable liquid plant fertiliser)
- Colorimeter
- 2 x cuvettes
- 3 x plastic pipettes
- Access to a discard jar
- Culture of Euglena gracilis [6]
- Control cuvette 1 - containing distilled water. Control cuvette 2 containing fertiliser solution. (These should be retained and frozen after each colorimeter reading).

Method

Setting up the algal cultures

1) Label the conical flasks: Flask 1 - Distilled water; Flask 2 - Distilled water and fertiliser.
2) Put 250 cm^3 of distilled water into each flask.
3) Use a plastic pipette to put 3 drops of fertiliser into Flask 2.
4) Add 25 cm^3 of algal culture to each flask.

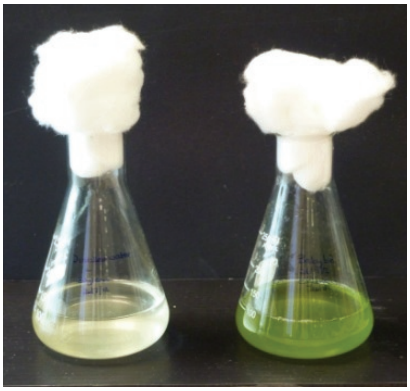

Figure 5 *- Euglena growing in distilled water (left) and in Baby Bio (right).*

Comparing the algal populations using a colorimeter

1) Use control cuvette 1 to calibrate the colorimeter for Flask 1 (665 nm). Retain the control cuvette to be frozen for use with subsequent colorimeter readings.
2) Gently swirl Flask 1 to mix the contents and, using a clean pipette, put 3 cm^3 algal suspension into a clean cuvette. Place the pipette in the discard jar.
3) Place the cuvette in the colorimeter, read and record the absorbance. Empty the cuvette back into Flask 1.
4) Repeat steps 1 - 3 using control cuvette 2 and Flask 2.

This process is repeated once per week for the next 3 - 4 weeks and the absorbance is used as an indication of the size of each of the algal populations. The greater the absorbance, the greater the number of *Euglena* present in the suspension. Changes in colour of the suspensions could also be photographed (Figure 5).

Comparing algal populations by observing hanging drops of the two cultures

In this activity a hanging drop of each culture is made and the *Euglena* are observed using a microscope (see Preparing a Hanging Drop Help Card SSERC website [7]). This method might also be used to compare the two populations each week for about 3 - 4 weeks (Figure 6 and 7).

Figure 6 *- Euglena grown in distilled water.*

Figure 7 *- Euglena grown in Baby Bio™.*

Figure 8 *- Algal bloom on Loch Leven.*

Figure 9 *- Algal bloom on Loch Leven.*

Eutrophication in Loch Leven - a case study

Loch Leven is the largest shallow eutrophic lake in lowland Scotland. From the 1800s, industries increased their demand for a more stable water supply from the loch. Surrounding landowners reclaimed land around the shores of the loch for agriculture. Over the years these activities caused algal blooms and reduced water clarity and biodiversity (Figures 8 and 9). With permission from the Centre of Ecology and Hydrology a case study, relating to the history of the ecology of the loch, has been adapted *(SSERC website link [8])*. In this case study learners are asked questions about the reasons why eutrophication occurred and how it has been managed and controlled. A copy of the original article is also available for teachers and for students, who might use this material as the basis for an assignment or project.

References

[1] SSERC 2013, *SSERC Bulletin 244*, Autumn 2013.
[2] SQA (2012). Course Unit Support Notes for new National Qualifications are available on the SQA website at http://www.sqa.org.uk/sqa/41328.html (accessed 21st September, 2013).
[3] *The Herald*, Saturday 24th August, 2013. Available at http://www.heraldscotland.com/news/home-news/toxic-algae-outbreak-raises-fears-for-2014-games-event.21956567.
[4] The Society for General Microbiology, 2012, *Algae: a practical resource for secondary schools.*
[5] Image available from Wellcome Images. Available at http://wellcomeimages.org/ (accessed 21st September, 2013).
[6] *Euglena gracilis* available from: *Sciento Organisms for Biological Sciences*. Available at http://www.sciento.co.uk/.
[7] The SSERC website is available at www.sserc.org.uk. Please note that to access all resources on the website you will need to register and be provided with a log-on ID and password. Available at http://www.sserc.org.uk/index.php/biology-2/biology-resources/biology-national-4149/n4-life-on-earth/3394-fertiliser-design-and-environmental-impact-of-fertilisers.
[8] The SSERC website is available at www.sserc.org.uk. Please note that to access all resources on the website you will need to register and be provided with a log-on ID and password. Available at http://www.sserc.org.uk/images/Biology/Life_on_Earth_Nat4/Eutrophication/Loch%20Leven%20for%20pupils.docx.

Curriculum links

National 4, Unit 3 Life on Earth

[4] Fertiliser design and environmental impact of fertilisers. Investigate the effects of fertilisers e.g. algal blooms.

National 5, Unit 3 Life on Earth

[5] Human Impact on the Environment
b. Fertilisers can leach into fresh water, increasing algal blooms. This leads to a reduction in oxygen levels.