

STEM bulletin

supporting STEM for all Local Authorities through advice, ideas and inspiration

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SEFARI: Science education resources

The SSERC Biology Team have been collaborating with several scientists working within the new collective of Scottish Research Institutes, known as SEFARI (Scottish Environment Food and Agriculture Research Institutes) to help develop and promote their excellent educational resources available to support the delivery of the biology curriculum.

The world-renowned Research Institutes within SEFARI have helped to develop educational resources in collaboration with teachers and SSERC in a variety of areas including: animal behaviour and animal welfare, food security, immunology, parasitology, environment, conservation, crops and soils, classification, phylogeny, nutrition and diet.

Useful and up-to-date educational materials including video clips, animations, data sets, fact sheets, practical classroom activities, ideas for outdoor field work and projects along with support information for teachers have been developed. The new SEFARI national education project [1] is looking to create a resources catalogue covering early years, primary and secondary aspects of the curriculum to promote the resources more widely and enable easier access for teachers and schools across Scotland [2].



To help introduce the project and get valuable feedback from teachers, SSERC in collaboration with SEFARI researchers, and funded by Research Councils UK (RCUK), organised a CLPL event focussing on support for Higher Biology. The event was held at Moredun Research Institute, Edinburgh [3] on 16th Nov 2017 and teachers of biology from all over Scotland took part. The day comprised a mixture of short presentations and discussions on food security, soils, animal behaviour and tackling infectious diseases. The teachers also participated in laboratory sessions on parasitology and immunology.

The hands-on laboratory activities involved looking at techniques for extraction and identification of worm eggs from diagnostic samples and working out from

the data sets a treatment plan and whether drugs used to help treat livestock have been successful or not. These techniques are used to diagnose parasitic disease, the effect on livestock health and welfare, treatments for parasites and the extent of drug resistance in micro-organisms and how this can be managed to help reduce drug resistance and increase the life span and efficacy of antimicrobials and anthelmintics. There was discussion of the complicated lifecycles of parasites such as liver fluke, which involves small mud snails as intermediate hosts, and how the environment and climate, in particular, can have significant effects on the survival and transmission of these parasites.

The immunology practical focussed on antibody technology applied >>



to the ELISA diagnostic test which is used widely in medical and veterinary laboratories to help diagnose a range of different infectious diseases by identifying the quantities of specific antibodies in serum or blood samples. The teachers and researchers discussed how this practical could be used in the classroom with easy-to-obtain materials. The teachers then produced some disease outbreak scenarios that would help pupils engage with the activity.

The teachers' feedback indicates that they enjoyed the day and found it useful.

"All sessions were very useful giving information on current research and techniques and resources that can be used."

"I had very little prior knowledge of ELISA tests so it was brilliant to gain some insight into the technologies."

The SEFARI consortium comprises: The Moredun Institute, James Hutton Institute, Scottish Agriculture College, Royal Botanic Garden Edinburgh, Rowett Institute of Nutrition and Health, and Biomathematics and Statistics Scotland.



References

- [1] For further information on the SEFARI Education project please contact Professor Lee Innes, lee.innes@moredun.ac.uk, www.moredun.org.uk, <https://sefari.scot/>.
- [2] For further information on the SEFARI educational resources, please contact Professor Lee Innes, lee.innes@moredun.ac.uk.
- [3] The Moredun Institute at www.moredun.org.uk.

Recognition for SSERC



We are delighted to be able to report that, at a recent meeting of a GTCS Accreditation Panel, SSERC was formally awarded with the 'GTCS Quality Mark as a Professional Learning Organisation'.

General Teaching Council Scotland offers a suite of Professional Learning Awards [1] which celebrate, promote, and encourage teacher professionalism and professional learning at all stages of a teacher's

career. The Awards recognise and celebrate the impact of teacher professional learning along with the leadership of learning cultures in which teacher professionalism can thrive and bring about real impact.

Recently GTCS has introduced the Professional Learning Award for Organisations. The award celebrates organisations which support and promote teacher professional learning and identifies those which aim through their work:

'to develop and enhance teachers' knowledge, expertise and skill; develop their professionalism,

and to impact positively on learning experiences and outcomes of children and young people'

Whilst we have always believed that the professional learning which we offer is of high quality, this formal recognition by GTCS is important as we seek to further enhance our reputation for quality.

Reference

- [1] <http://www.gtcs.org.uk/News/news/gtcs-professional-learning-awards.aspx> (accessed April 18th 2018).

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 to switch our allegiance to *Egeria najas*.



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

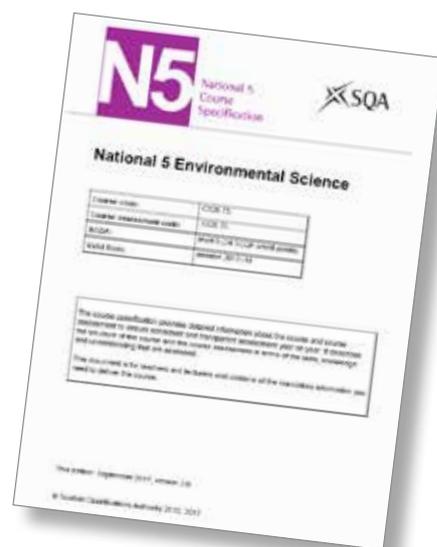
Until now we have not focussed on resources to support National 5 Environmental Science although a number of activities available through either chemistry or biology sections of the SSERC website could be utilised for such purposes. We present here a variant on the immobilised algae [2] and *Egeria najas* [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 cm³ 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 hydrocarbonate 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 cm³)
 - dissolve sodium hydrogencarbonate (0.85 g) in freshly boiled distilled water (200 cm³)
 - add the solution of cresol red and thymol to the distilled water and make to 1 dm³ 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.

Chrome dreams

For the last two years, the physics team at SSERC have investigated apps for Android and IOS that enable experimental work to be carried out with mobile devices. When we heard that a number of schools had chosen to issue Chromebooks to students, we took a virtual wander to the Chrome Web Store to see what was available there.

We were dismayed. There were plenty of apps, but they served to confirm our prejudices that devices were mostly being used in schools to do internet research or to create documents or presentations. It is not that these are bad things to do, more that our experience with Android and IOS suggests that portable devices have the potential to do so much more. It was good to see Pasco's Sparkvue, Vernier's Graphical Analysis and the Mu Python editor for the BBC micro:bit, but there was no suitable frequency spectrum analyser, video analysis app or indeed many other apps that might have inspired us to take a closer look. It all changed when we did a bit of research and found that an increasing number of Chromebooks are able to run Android apps. We bought two different models of Viglen Chromebook for evaluation purposes and looked at three ways of running apps:

- Using apps specially designed for the Chromebook from the Chrome Web Store;
- Using Android apps from Google Play Store;
- Using an online platform called Rollapp.

Figure 1 shows one of our Chromebooks running Pasco's Sparkvue app, which is available free from the Chrome Web Store. It is hooked up to a Pasco wireless temperature sensor. We also connected it wirelessly to a Pasco Smart Cart [1] and to a range of Pasco Passport sensors via USB.



Figure 1 - Chromebook running Sparkvue.

Eagle-eyed readers will notice a Bluetooth dongle plugged in at the right-hand side of the machine. This was needed, even though the Chromebook had onboard Bluetooth. Pasport sensors can also be connected wirelessly using an Airlink adaptor, but Pasco point out that their older Airlink 2 Pasport adaptor does not work with a Chromebook. We tried anyway and found that they were correct. If you have sensors that connect to Science Workshop interfaces, you can buy analogue and digital adapters to use these too.

Vernier also have a free app that allows their sensors to be used with Chromebooks. It is called Graphical

Analysis. Vernier's USB Go!Link and wireless GoDirect systems worked with this app. Figure 2 shows a wireless radiation monitor. Figure 3 is a screenshot from Graphical Analysis showing background count over time. >>



Figure 2 - Vernier Radiation Monitor.

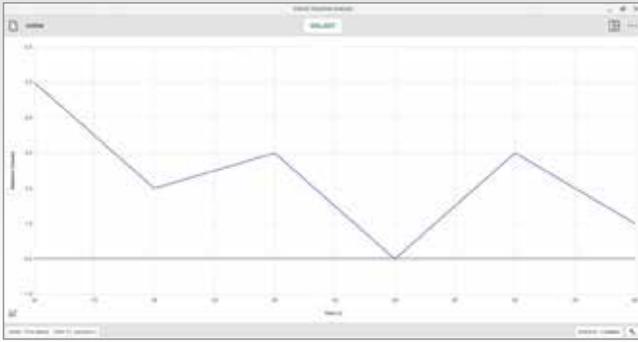


Figure 3 - Some readings of background count shown on Graphical Analysis.

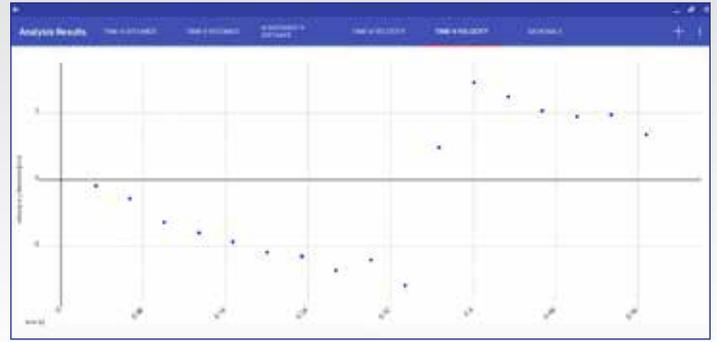


Figure 4 - Y-velocity of a bouncing ball.

In the last two years, Android apps have become available to some Chromebooks, usually following a system update. This facility has to be activated by the user or, for a managed device in a school, by the administrator. Apps may have to be approved or “whitelisted” before you can use them. Some will not work if the device does not have certain features, for example a camera or touch screen.

When we first started investigating apps, we looked for one that would do motion analysis through video. For Android, we discovered Vidanalysis and Trackit! Vidanalysis is free if you accept an advertisement-supported version. It is probably better suited to a Chromebook than tablet provided that you already have a video to analyse, taken using another device. It is easier to mark points with a trackpad than with chunky fingers on a touchscreen. Trackit! Is a similar app. It allows you to change the angle of the axis, a feature missing from Vidanalysis, but we have not worked out how to do this with a trackpad.

Figure 4 is a screenshot from Vidanalysis, showing the behaviour of the Y-velocity of a bouncing ball with time. The graph is generated when the user marks the position of a moving object from frame to frame in a video. Contact SSERC for comprehensive instructions on how to use apps like this.

Over the last decade, the piece of physics freeware that has impressed us more than any other is Tracker. This PC/Mac/Linux package can be used for motion analysis and much more. Tracker (Figure 5) is not available on Android or Chrome but it can run on a Chromebook via an online platform called Rollapp [2]. Rollapp is free unless you want to be able to save files. It requires users to register or to log in via social media or Google. Tracker runs in a browser and, once you have got used to the slightly fiddly way of uploading video files, behaves exactly as we described in Bulletin 225, ten years ago.

According to the Rollapp site, Audacity, another SSERC Physics favourite, is coming to the platform soon.

In Bulletin 226 we tested a Linux-based netbook computer called the Asus EEE which we used with Vernier sensors. We remarked: ‘There are now a number of inexpensive portable computers on the market that bring the age of “one laptop per child” tantalisingly close. A machine that does word processing, spreadsheets, presentations, internet access and interfacing is a useful beast.’ The Asus never really caught on, despite being a useful beast. Perhaps the Chromebook, already established in many schools for other uses, will be the device that brings apps and interfacing to the masses. <<

References

- [1] See SSERC Bulletin 258.
- [2] www.rollapp.com/app/tracker.

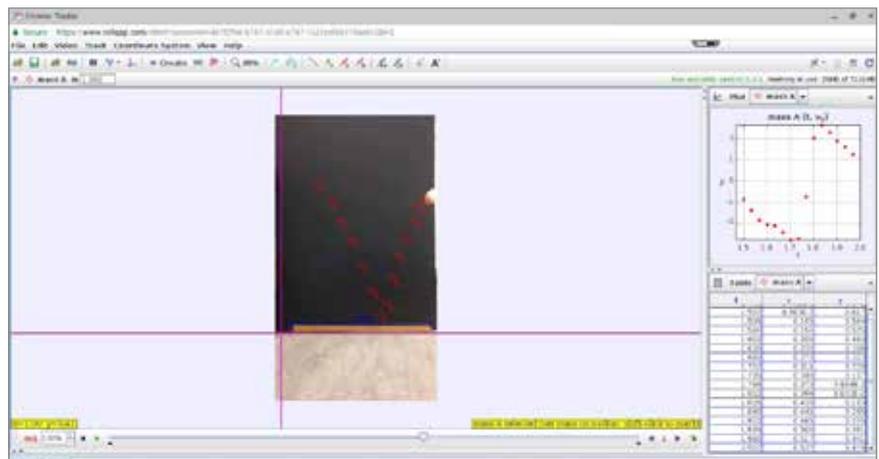


Figure 5 - Tracker on a Chromebook.

It's a gas, gas, gas

There is much excellent chemistry that can be done in class using gases but unfortunately, less is done than might be the case due to the difficulty of getting a supply of gases to experiment with.

Some gases are commonly obtained in cylinders: hydrogen, oxygen, carbon dioxide and occasionally nitrogen. These cylinders are bulky and, of growing difficulty these days, relatively expensive.

Other gases can be produced by technicians and stored for short periods in gas jars. The problem here is that relatively large quantities are produced, there is always the risk of spillage and each jar is 'single use' only.

An alternative is at hand.

Here I should cite the work of Bruce Mattson of the Department of Chemistry at Creighton University, Omaha, Nebraska, USA who has

pioneered the method that follows and generously made it available to chemists everywhere .

The principle is simple. You simply need the appropriate chemicals (See Table 1) and a syringe and tablet 'blister' (see Figure 1).

Gases are generated within a syringe. A 60 cm³ plastic Luer Lock syringe is ideal as the screw-cap means that the gas can be produced and stored within the same syringe if required. In most cases a small amount of a solid reagent is cleverly placed in a container in the bottom of the syringe. A 'blister' from tablets works well. The plunger is then pushed as far down as possible.

Then a small volume of the liquid reagent is drawn up into the barrel of the syringe and the lid is put on. The syringe is then shaken. The reaction produces gas and, with a little assistance, this pushes the barrel upwards, filling it with the required gas.

The photographs in the following section are of the process to produce oxygen. The method is the same for all, just the reagents are different.



Figure 1 - Syringe and tablet.

Step 1 - Remove the plunger, and the cap if it is fitted to the syringe.

Step 2 - Take a single 'blister' from a pack of tablets (indigestion tablets are ideal) and weigh out the correct mass of your solid reagent.

Step 3 - Put your finger over the end of the syringe and fill the barrel right to the brim with water. >>



Figure 2 - Place the reagent on top.

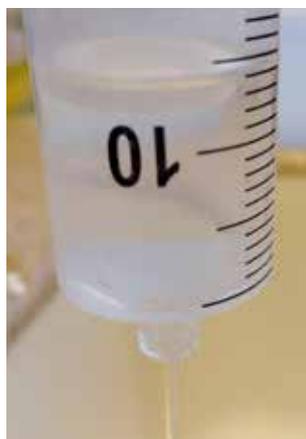


Figure 3 - The 'blister' is gently lowered.



Figure 4 - Holding the syringe vertically.



Figure 5 - You will notice the plunger start to move upwards.



Figure 6 - A syringe full of gass to use in experiments.



Figure 7 - Connecting two syringes using a piece of tubing.

Step 4 - now float the 'blister' with your reagent on top (see Figure 2) of the water.

Step 5 - Remove your finger from the end. The water flows steadily out of the syringe and the 'blister' is gently lowered to the bottom of the barrel of the syringe (Figure 3).

Step 5 - insert the plunger (being careful not to shake it too much and displace your carefully lowered solid) and push down as far as you can.

Step 6 - Put some of your other (liquid) reagent into a small beaker or cup (wide enough for the syringe to fit in).

Step 7 - Draw up the required amount of this liquid into the barrel of the syringe.

Step 8 - Still holding the syringe vertically, carefully screw the cap in place (Figure 4).

Step 9 - give the syringe a good shake to mix the reagents. You will notice the plunger start to move upwards. Pulling gently on it will help the process (Figure 5).

Step 10 - before it gets to the top, go to the sink. Hold the syringe with the nozzle upwards and unscrew the cap (you may here a slight hiss as pressure is released).

Step 11 - Invert the syringe over the sink. Some liquid might be pushed out by the gas pressure. Gently push on the syringe a little to expel the rest of the liquid. A bit of shaking will help to dislodge liquid from the blister.

Step 12 - Replace the cap. You now have a syringe full of gas to use in experiments.

Step 13 (optional) - If you want, you can now transfer the gas to a clean, dry syringe for storage/use. You can do this by simply connecting two syringes with a piece of tubing (Figure 7) and push/pull on the two plungers in tandem. If required, you can insert a tube with some drying agent in (e.g. calcium chloride) to get dry samples of your gases.

The advantage of using your gases in these syringes is that you can use the plunger to simple expel the volume you need and then stop and put the cap back on - that way one syringe of gas can also be used for several tests.

The quantities in the Table 1 (below) will produce about 50-60 cm³ in 15-60 seconds. More details of the individual methods will be appearing on the SSERC website in the coming weeks.



Gas	Solid reagent	Liquid reagent	Comments
Carbon Dioxide	0.2 g sodium hydrogen carbonate	5 cm ³ vinegar	Other dilute acids can be used.
Hydrogen	0.05 g magnesium turnings	3-5 cm ³ 1 mol l ⁻¹ hydrochloric acid	(ribbon or powder can be used if wanted)
Oxygen	0.05 g potassium iodide	3-5 cm ³ 6% (20 vol) hydrogen peroxide	Watch out for staining from iodine when you empty out the reaction mixture.
Nitrogen	0.14 g sulphamic acid	5 cm ³ 0.5 mol l ⁻¹ sodium nitrate III (nitrite)	
Nitric oxide	0.25 g sodium nitrate III (nitrite)	3-5 cm ³ acidified iron II sulphate solution*	*See SSERC website (Uses of Iron compounds) for recipe.
Sulphur dioxide	0.35 g solid sodium hydrogen sulphite (NaHSO ³)	3 cm ³ 6 mol l ⁻¹ hydrochloric acid	In a hot water bath
Ammonia		5 cm ³ concentrated ammonia (0.880)	
Chlorine	0.22 g calcium hypochlorite	5 cm ³ 2 mol l ⁻¹ hydrochloric acid	(or 1 cm ³ 6 mol l ⁻¹ HCl and 3 cm ³ bleach)
Ethyne	0.2 g calcium carbide	3 cm ³ water	(if your carbide is old, you may need more)

Table 1

SSERC professional development courses



Our professional development courses range from twilight events, day-courses through to residential meetings lasting up to 6 days in total. Our curriculum coverage spans both primary and secondary sectors and we offer events for teachers as part of their career long professional learning, newly qualified teachers and technicians. Many of our events receive funding from the ENTHUSE awards scheme or the Scottish Government.

Courses available for online booking include:

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Safe Use of Fixed Workshop Machinery (June)	No	12-13 June 2018	29 May 2018	Secondary
Safe Use of Fixed Workshop Machinery (Refresher: June)	No	15 June 2018	1 June 2018	Secondary
Maintenance of Fixed Workshop Machinery (May)	No	20-22 June 2018	25 May 2018	Secondary
Super Summer Science (Primary)	Yes	21-23 June 2018	25 May 2018	Primary
Biology Summer School	Yes	26-28 June 2018	25 May 2018	Secondary
STEM CLPL for Early Level	No	24 August 2018	18 June 2018	Primary
Biomedical Engineering (to be held at the University of Edinburgh)	No	28 August 2018	22 June 2018	Secondary
STEM CLPL for Early Level	No	29 August 2018	18 June 2018	Primary
Maintenance of Fixed Workshop Machinery (September)	No	5-7 September 2018	29 June 2018	Secondary

We are in the process of putting the final touches to our full programme of CLPL for the new academic session and details will be made available through a range of channels. Please check our website page www.sserc.scot for the most up-to-date details.

Leak testing - myth versus actuality

“I’m never going to use electricity in my department because there’s a legal requirement that portable appliances need to be tested.” If you had a pound for every time you heard somebody say that, you would not have any extra money at all. Nobody thinks that way, at least where electricity is concerned.



Figure 1 - ZP1481 (foreground) and Frederiksen GM tubes.

However, we know that a number of people are put off from working with radioactive materials because some sources need an annual leak test to ensure that radioactive material is not escaping into the environment. A strange mythology has grown around the leak test. *It is complex. It is onerous. A lot of paperwork is involved.* We hope to show you that none of this is true.

What has to be tested?

- All sealed sources except radium;
- Protactinium generators;
- Eluting half-life sources.

No leak tests are required for gas mantles, mineral sets or thoriated TIG welding rods. Radium sources, very rare in Scottish schools, require a different test. Contact rpa@sserc.scot if you have one.

How often do I leak test?

The law says every two years. However, the sealed sources used in schools tend to be kept for much longer than

their recommended working lives. Extensive experience has shown us that this is not at all unsafe. However, if your sealed source is more than 10 years old, or 5 if it is cobalt, switch to annual testing. Note that a protactinium generator will require specialist disposal at the end of its 8 year recommended working life. If any source is dropped on the ground, leak test it as soon as possible.

What do I need?

- Geiger-Müller tube and counter.
- Timer (if the counter cannot be set to count for a fixed time of 100 seconds).
- Ethanol (few ml).
- Dropper.
- Clamp stand.
- Filter paper.
- Cotton buds (certain sources only).
- Paper and pen.
- Computer with a copy of SSERC leak test analysis spreadsheet. >>



Figure 2 - Wiping the grill on a "standard" source.

The widely-used Centronics/Mullard ZP1481 tube is suitable, as is the Frederiksen model (Figure 1), which is often rebadged by datalogger manufacturers such as Alba and Pasco. You can download the leak test analysis spreadsheet from www.tinyurl.com/radproSSERC.

Getting started

Remove the end cap, if fitted, from the GM tube. Clamp the tube vertically, a few mm above a piece of filter paper. With any sources at least 4 metres away, take and record two readings of background count, each over 100 seconds. Expect a count of between 20 and 40 per 100 seconds, though it may be a little more or a little less depending on your location.

Wiping

For old-style "standard sources", the eluting source and the protactinium generator, cut a piece of filter paper about 1 cm x 2 cm. As it is important to know which side of the paper was used for wiping the source, you might wish to put a dot on one surface. Moisten it with ethanol. When wiping sources, work over a tray placed on a bench so that if the source drops it will not roll on to the floor. Hold the wipe with tweezers.

For sealed sources: Holding the source with a handling tool, wipe the protective grill. Put the source back in its pot (Figure 2).

For the eluting source, wearing gloves, hold the source. Remove the cap from the end where the liquid emerges. Wipe this end (Figure 3).

For the protactinium generator, place it in a tray with the sealed cap uppermost. Wipe around the cap (Figure 4).



Figure 3 - Wiping an eluting source.

More modern Hi-Tech type sources do not have a protective grill. Using an ethanol-moistened cotton bud, you can either wipe the inner end of the source, being very careful not to touch the foil, or you can wipe the storage pot. We recommend the latter (Figure 5).

Place the wipe or bud on the filter paper. Make sure the side you used to wipe the source is facing upwards. Place all sources at least 4 metres away. Do not let the wipe or bud touch the end of the GM tube.

Further readings

Take four readings, each over 100 seconds, with the wipe in place. Remove the wipe from under the GM tube but do not discard it. Take a further two background readings, again each over 100 seconds. >>



Figure 4 - Arrow shows where to wipe the protactinium generator.

Processing results

The easiest way to process results is to enter them into the downloadable SSERC spreadsheet (Figure 6). This processes the data and displays whether or not the wipe has passed or failed. Enter the background counts in the green column, overwriting any existing values. Wipe counts go in the yellow column. Be careful not to enter data in other cells as you may overwrite a formula.

If you prefer to process results manually, do the following:

- Take the mean of the four background readings. Call this N_b .
- Take the mean of the four wipe readings. Call this N_w .
- Find the difference $N_w - N_b$.
- The spreadsheet checks to see whether the difference in the means is greater than two standard deviations in the difference. It can be shown that this is approximately equal to $\sqrt{(N_w + N_b)}$.
- Statistics theory tells us that if two means differ by more than two standard deviations, the difference has a 95% chance of being significant.
- In other words, if $N_w - N_b > \sqrt{(N_w + N_b)}$, there is a 95% chance that the wipe is contaminated.

We use this statistics-based test because of the random nature of radioactive decay. A more detailed explanation can be found in our document *Working with Radioactive Materials in Schools*.

If the source passes

If the source passes, put the wipe in the bin. File your results, making sure the test date and the source are clearly identified. One way of doing this is to save and print the spreadsheet, having entered the source and date in an empty cell.

If the source fails

Using the same wipe, repeat the readings, i.e. two background, four wipe and another two background readings, each over 100 seconds. Put the wipe in a sealed plastic bag. Put the source in storage. Send your results to rpa@sserc.scot. There is a "Set of 8" tab on the spreadsheet into which you can enter all 16 values. Do not use the source again until we have discussed your results with you.

Tips

If you have more than one source, use the last two background counts for source A as the first two for source B and so on.

Beware sudden air changes which can affect radon gas levels in the testing room. It is best to keep the door shut and to place a 'Do Not Enter' sign on the door.

Watch out for sudden very high readings. Occasionally, a cosmic ray burst will cause this to happen.

Safe working summary

- Wear a lab coat.
- Point sources away from the body.
- Work over a lined tray.
- Handle standard sources using tongs or bespoke handling tools or holders.
- Wear disposable gloves when handling the eluting source.
- Wear eye protection and disposable gloves when handling the protactinium generator.
- Place a wipe that is suspected to be contaminated in a sealed bag, before disposal.



Figure 5 - Wipe the pot, not the source.

	A	B	C	D	E
	Background count	Wipe count	Difference in mean values	Twice SD of difference	Leak test result
1					
2	$(100\text{ s})^{-1}$	$(100\text{ s})^{-1}$			
3	29	25			
4	28	31			
5	25	23			
6	23	27			
7	105	106			
8	26.25	26.5	0.25	7.26	Pass

Figure 6 - Downloadable spreadsheet.