

Analysis of ^{222}Rn concentrations in surface water and groundwater samples



Radon-222 is a noble gas with half-life of 3.82 days that is frequently used in the study of hydrological and environmental problems. These include tracing groundwater input to streams (Cook et al. 2003) lakes (Tuccimei et al. 2004) and coastal zones, as well as rates of river water infiltration to banks (Hoehn and von Gunten, 1989) and sediment-water exchange.

Sampling and Submitting Samples

Because radon is a gas, great **CARE** must be taken, to ensure that the sample represents the concentration of this element in the groundwater. The sample should not be agitated when filling sample bottles or vials as some radon gas may be lost as a result.

Two methods (DIR and PET) are used for ^{222}Rn analysis at the CLW laboratory in Adelaide. Both methods involve measuring the α activity of the water using an ultra low background Quantulus LSC after concentrating the ^{222}Rn in a mineral oil/scintillant mixture in a 22 ml Teflon coated vial. The concentrating factor for the PET method is considerably greater than that for the DIR method. Further information on the testing of the PET method, and, to a lesser extent, the Direct method are given in Leaney and Herczeg, 2006.

Step-by-step instructions for both are included below.

The Direct Method

The DIR (direct) method is the simpler of the two methods to use. However, it is only useful when analysing groundwater samples because the level of detection is not sufficient to be of use for most studies involving surface water sampling. Furthermore, in general, the precision of analysis is less than that for the PET method. If you decide to sample using this method, a sampling kit will be sent to you with the following equipment and instructions.

The kit using the direct method

- * Preweighed , labelled vials containing 7 ml of scintillant.
- * 1 m silicon rubber tubing.
- * 20 ml syringe engraved to deliver 14 ml of sample
- * 2 needles

How to sample using the direct method

Radon is rapidly lost to the atmosphere when groundwater is pumped to the surface.

- 1 ENSURE that the pump is not cavitating i.e. partially pumping air.
- 2 REMOVE at least 3 stand-pipe volumes of water from the bore.
- 3 INSERT the tubing as far as possible into the by-pass tap on top of the pump (if present) OR at least 30 cm into the outlet pipe.
- 4 WATCH out for air bubbles that may be flowing down the sampling tube .Insert the tube further into the outlet pipe until there are no bubbles. FIX the tubing within the outlet and make sure there is no constriction.
- 5 ATTACH the needle to the syringe with CARE (SHARP).
- 6 INSERT the syringe through the wall of the tube into the water stream about 10cm from the OUTLET END of the silicon tube and collect/extract 20 ml of water then flush removing any trapped air in the syringe. Collect a second volume.

- 7 ADJUST the second volume of sample to the engraved 14ml mark.
- 8 INJECT the sample SLOWLY BELOW the scintillant in the vial without agitation.
- 9 RECAP the vial tightly and “tweak” using a pair of multigrips.
- 10 RECORD date and time of sampling.
- 12 POST vials to the CLW isotope laboratory using express post.
- 13 PLEASE arrange for samples to be collected AND posted in the shortest possible time. Ideally samples should be counted within a few days of collection. Post/courier to
Megan LeFournour
CSIRO Land and Water
Street Address: Gate 5, Waite Road, Urrbrae SA 5064
Postal Address: PMB #2, Glen Osmond 5064
Ph (08) 8303 8747

Note: the scintillant is a mineral oil, and is classified as non-flammable and non-toxic.

The PET Method

The PET (polyethylene terephthalate) method involves concentrating the ^{222}Rn from 1.25 L of water into mineral oil in a 22 ml vial. It derives its name from the type of plastic used in the process which is also the plastic used in most soft drink bottles. The method was originally developed for analysing surface water samples but can also be used for groundwater samples usually giving better precision than that when using the DIR method. If you decide to sample using this method, a sampling kit will be sent to you with the following equipment and instructions.

The kit using the pet method

- * Preweighed , labelled vials containing 21 ml of scintillant.
- * 60 ml syringe to remove 50 ml of water.
- *A nozzle that fits snugly into the soft drink bottle.

The nozzle, syringe and transport costs \$80+GST. There is no need to return the nozzle and syringe. Please keep them for future sampling.

How to sample Using the PET method

1. Collect water samples in 1.25L “soft drink” taking care not to agitate the water unnecessarily (which may lead to degassing and loss of radon). Place the cap on the bottles ensuring no air bubbles are present in the bottle. The method has been tested using 1.25 L soft drink bottles that contained the Coles Foodland brand soft drink (but any 1.25 L soft drink bottle is OK). Label the bottles with sample name and date and time of sampling.
2. The soft drink bottles can either be transported back to the laboratory without any further treatment or the radon extracted into mineral oil in low diffusion polyethylene vials (as follows) and the vials then sent back to the laboratory. There will be an additional charge for extraction if the extraction is carried out by laboratory staff.
3. Extraction of radon from water samples to the mineral oil can be done in the field or, after collecting several samples during the day, at night when back at the motel room. It is best to avoid extraction when the temperature is below 15 °C or above 35°C.
4. Firstly remove the lid of the bottle and syringe 50 ml of water from a full drink bottle Pour the entire contents of one of the scintillant vials into the bottle and screw the lid back onto the bottle. Discard the water from the syringe.
5. Mix water and scintillant by inverting every 2 seconds for a period of 4 minutes. This transfers most of the radon that was in the water into the scintillant. You can shake two samples at a time to reduce extraction time. Allow the bottle(s) to stand for at least one minute, during which time the

scintillant/mineral oil should move to the top of the bottle. This can be helped by flicking the bubbles of mineral oil that stick to the side of the bottle. If there is algae in the water, the sample will need to stand for several minutes during which time other samples can be shaken.

6. Remove the lid from the bottle and insert the glass nozzle onto the top of the bottle by gently pushing it into the opening. Remove the lid from the empty scintillant vial under the glass nozzle and slowly squeeze the bottle. The pressure will push the scintillant out of the bottle into the vial (see photo below). Stop squeezing when the scintillant/water interface reaches the start of the capillary tubing at the start of the nozzle. It is better to leave a little scintillant behind than to get water in the vial. Hence, please do not be concerned if you only get 50 or 60% recovery. For some samples, even getting 50% may be a problem so, for these samples only, please extract the oil/water mixture into the vial.
7. Put the cap firmly back on the scintillant vial. Using a pair of multigrips, give the lid an extra “tweak” to make sure that it is tight. Be sure to record in field book or data sheet the **location and time of sampling**, and **the vial number and send the data to the lab**. Please do not put any labels or write on the sides or bottom of the vials.
8. Shake out any mineral oil left in the nozzle and then remove oil from the nozzle using a tissue.
9. Reusing PET bottles for other water samples will result in minimal sample to sample contamination providing bottles used for groundwater sampling are not subsequently used for surface water samples (and vice versa).

Within 2-3 days after sampling, courier bottles or vials to:

Megan LeFournour
CSIRO Land and Water
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Postal Address: PMB #2, Glen Osmond 5064
Ph (08) 8303 8747

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Figure 1 Extracting the oil/scintillant from the PET bottle after slowly shaking the water/oil mixture.

Analytical Precision and Level of Detection

The limit of detection, based on two standard deviations above background, for the PET and Direct methods are ~5 and 18 mBq/L respectively for the count time (200 minutes) usually employed at CLW. The analysis uncertainty (1 s.d.) as a function of ^{222}Rn concentration for 200 minutes counting time is given in the following figure.

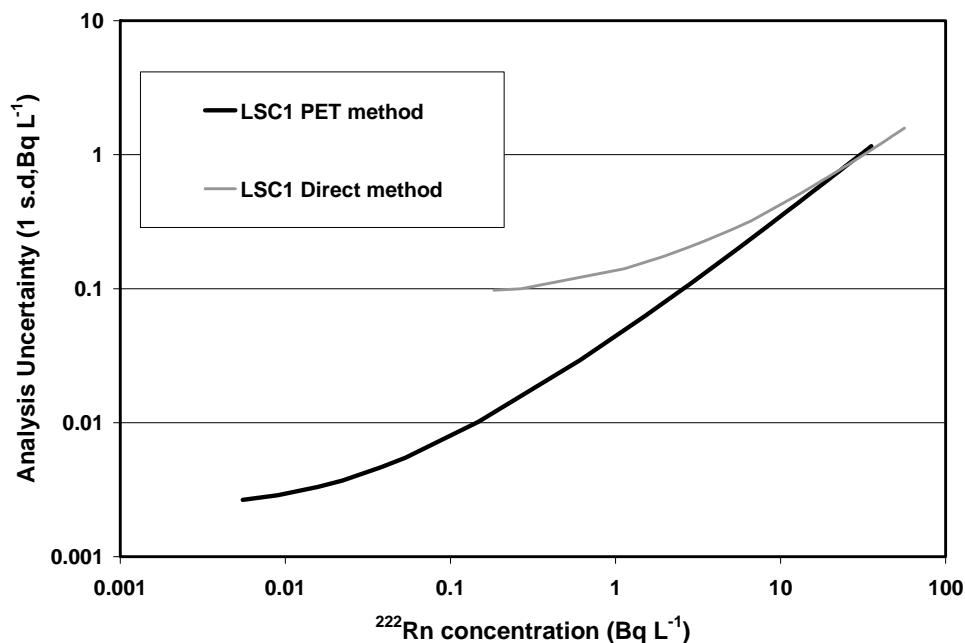


Figure 2 Analytical uncertainty in ^{222}Rn concentration as a function of ^{222}Rn concentration

References

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CSIRO Land and water

Contact Fred Leaney, Principal Research Scientist

Phone +61 8 8303 8728

Fax +61 8 8303 8750

Email Fred.Leaney@csiro.au