8 TREATMENT FOR RADON AND URANIUM

8.1 Radon removal

8.1.1 Introduction

There are three main treatment methods for radon removal – decay storage, GAC (Granular Activated Carbon) and aeration. Due to the large size of the radon atom, it can also be removed by reverse osmosis and nanofiltration techniques. With all the removal systems, location is a key issue, both for hydraulic reasons and radiation exposure. Some systems may require an additional pump to be installed, or a bypass system. This increases the complexity of the system. Where a system results in the build-up of radioactive substances, it may not be appropriate to keep it under the sink. On the other hand, if the radiation risk means that there is a need to build an extra outbuilding to house a unit, the cost may be prohibitively expensive. For radon removal, point of use systems fitted to the drinking water tap (as opposed to point of entry systems, which treat the entire supply) are not acceptable as radon is released wherever water is used in the house and it can then be inhaled. Table 8.1 summarises the features of the principal methods for radon removal.

8.1.2 Decay storage

As radon (^{222}Rn) has a half-life of 3.82 days (i.e. its radioactivity halves every 3.82 days), it is possible (provided that mixing and short-circuiting are avoided) to store it to achieve an adequate reduction in radioactivity. The amount of time required will depend on the level of activity. An eight-fold reduction would take two weeks to achieve. For household consumption, this would typically require two 10 m^3 tanks, used alternately – impracticably large for most locations. With a lower activity level, requirements would be less and this option may be feasible.

8.1.3 Granular activated carbon

GAC was first used in the US in 1981 for radon removal. The method has been found to be very effective and is generally quoted as achieving about 95% radon removal. GAC is commonly used for removing taste, colour, odour and synthetic organic chemicals. It works by adsorption and the extremely high internal surface area within the porous structure is responsible for its effectiveness. GAC filters are described in Section 8.8.1.

The main drawback of GAC is that as the radon is trapped in the filter, the radioactivity of the filter increases. Although radon decays rapidly, there is a continuously increasing radioactivity due to other radionuclides being trapped and the build up of longer-lived radionuclides further down the radon decay chain (notably ^{210}Pb). As such, it is important to either shield the filters or place them in a separate shed outdoors or in an unused basement. There are also disposal problems with these levels – the filters have to be handled with care.

Table 8.1 Radon removal techniques

Treatment option	Efficiency	Availability	Disposal issues	Approximate cost per household	Other issues
Decay storage	Up to 100%	Storage tanks readily available.	Good ventilation system required (or very large tanks).	Variable, depending on size of tank and ventilation system.	Low maintenance. Would need to be designed for each site. Would require further testing and monitoring. Cannot handle higher levels easily.
GAC specifically designed for radon removal	Variable. Up to >99.9%	Common technology. Many carbon suppliers and suitable apparatus.	Carbon becomes radioactive and high radiation doses reported around filter as well – needs careful placement/shielding. Used filter may need specialist disposal.	£500 - £1,000, assuming no pre-treatment and no new building required. Possible annual filter replacement and high disposal costs.	Widely used in USA. Computer program available for home users (free download from EPA) to assess radiation risks and removal rates. Waste disposal and maintenance are key concerns. A number of available carbons have been specifically tested for radon removal. Not as effective or ‘safe’ as aeration.
GAC – standard water treatment package	Unknown. May be up to 99.9%	Yes – domestic water treatment companies.	As GAC above.	About £2,500.	Provides a complete water treatment system. From initial observations, size of GAC filter too small for effective radon removal. No specific units have quoted radon removal rates. Expensive, and complex waste/maintenance issues.
Aeration	Up to >99.9%	Widely used technology but not for this application at this scale – companies are able to design and test systems. A few ready-tested ones available.	Adequate ventilation required.	£1,000 upward. Running costs about £20 p/a.	Can operate without pre-treatment, unless water is very hard and needs softening. Some very good package systems available. Low maintenance – one annual clean recommended. With less disposal issues, no radiation build up and reasonable costs, aeration appears to be the best solution.

8.1.3 Granular activated carbon (continued)

With local authority permission, substances up to a radioactivity of 15 Bq/g can be disposed of to landfill with other household waste. The time before the filter reaches this level will depend on activity levels of radon in the raw water and on the retention time in the GAC. Once a GAC filter is taken out of service its radioactivity will fall as the adsorbed radon and other radionuclides decay – it has been shown that after three to four weeks out of service the activity of a GAC unit can be close to background levels.[1]

In order to avoid clogging of the filter and to extend its life, it may well be necessary to pre-treat the water.

8.1.4 Aeration

Aeration is the preferred treatment for radon removal. In the natural environment this process ensures that most waters coming from springs in radon emitting rocks quickly lose their radon to the atmosphere. The main reason why problems occur with radon in many private supplies is because the water is either abstracted from the rock directly or very soon after. There are many different aeration methods (Section 5.6). With aeration, radon can be easily vented to the outside air. This prevents build up of radiation levels and means there are no disposal issues. As such, the system will, typically, require less maintenance. Depending on the system, there may be a need for a pressure tank or an additional pump.

[1] Lowry, J.D. and Brandow, J.E. (1985). Removal of radon from water supplies. *Journal of Environmental Engineering* 111(4), 511-527.