Teaching Radon in the Living Environment

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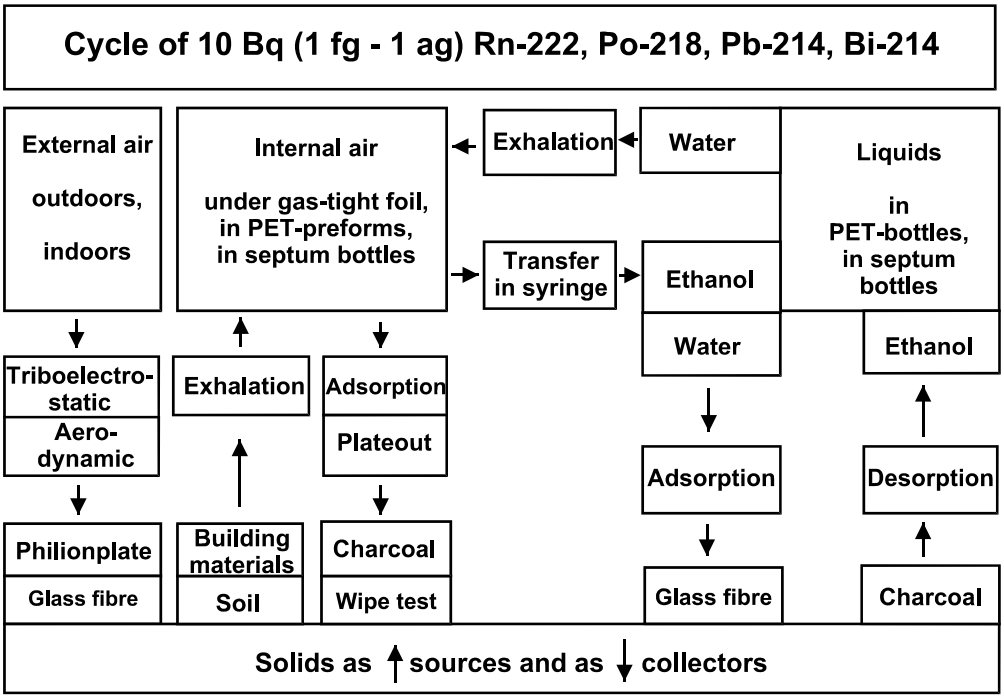
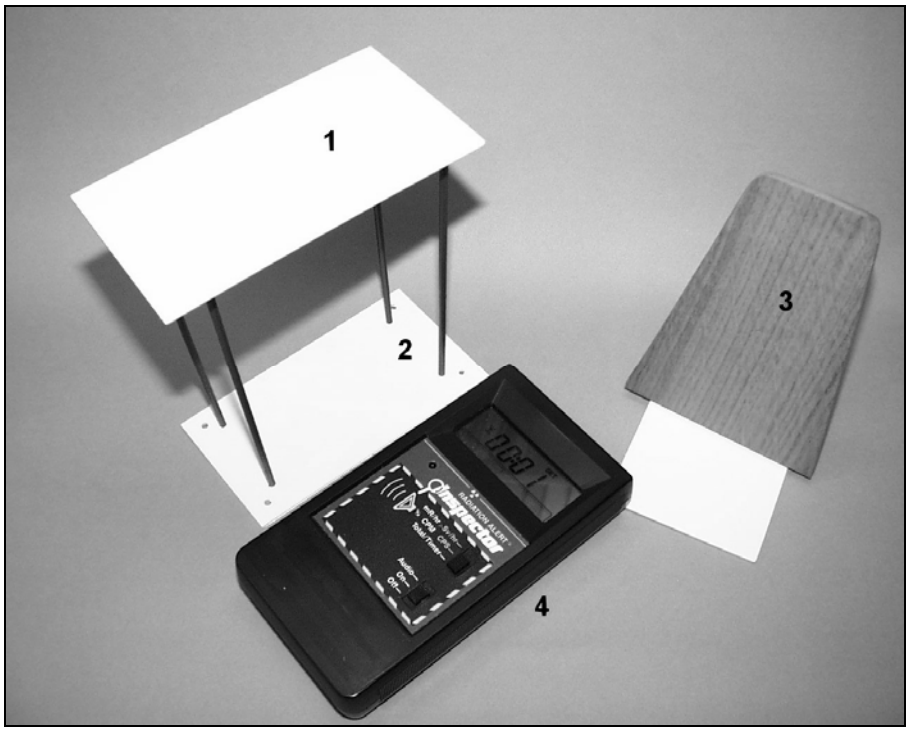
With so much research on radon in the living environment going on in universities and other public research institutions, there is an urgend need for both transfer of modern technology on radon to industry and for transfer of practical knowledge on radon to school, long neglected. Natural radioactivity is a phenomenon of fundamental importance in the development of modern sciences and hence should be brought over to pupils in schools.

Radon, though the rarest ubiquitous chemical element, has been made accessible experimentally by the authors through a number of recently discovered or improved effect with most simple means. What is needed are just pieces of polysterene and wood, glass fiber filters, a funnel, a heating stage, commercial adhesive foil, charcoal, an inexpensive Geiger counter preferably alpha sensitive an with an effective diameter of 45 mm, a cable connecting the Geiger counter with a computer and a computer program controlling the times of measurement. All materials, except the counter, the cable and the program, are contained in the Philion Experimental Case, a handsome metal box of 10 x 24 x 33 cm^3, which is available from the first author.

The modes of collecting, storing, transfering and measuring radon in and between air, liquids, and solids are shown in the synopsis ‘Cycle of Radon’.



The Philion (lover of ions) Plate [1, 2] is a piece of polystyrene, charged by rubbing with a piece of wood to -20 000 V. When exposed on four thin rods to ambient air for 5 - 10 minutes, the plate is a most efficient collector of positively charged, unattached radon decay products, namely Po-218, Pb-214 and Bi-214. An alpha-sensitive detector give a net count rate several times background.



1 Philion Plate

2 Stand

3 Wood for rubbing the Philion Plate

4 Inspector

The Philion Plate as Collector

Using a Philion Plate the transformation of elements can be shown. Proceeding on the assumption that there is only one kind of rays for each radioactive element the following measurement confirms the existence of two different kinds of rays and therefore the transformation of an element to another.

Exposition near an opened windows: 5 min
Time of measuremente: 1 min

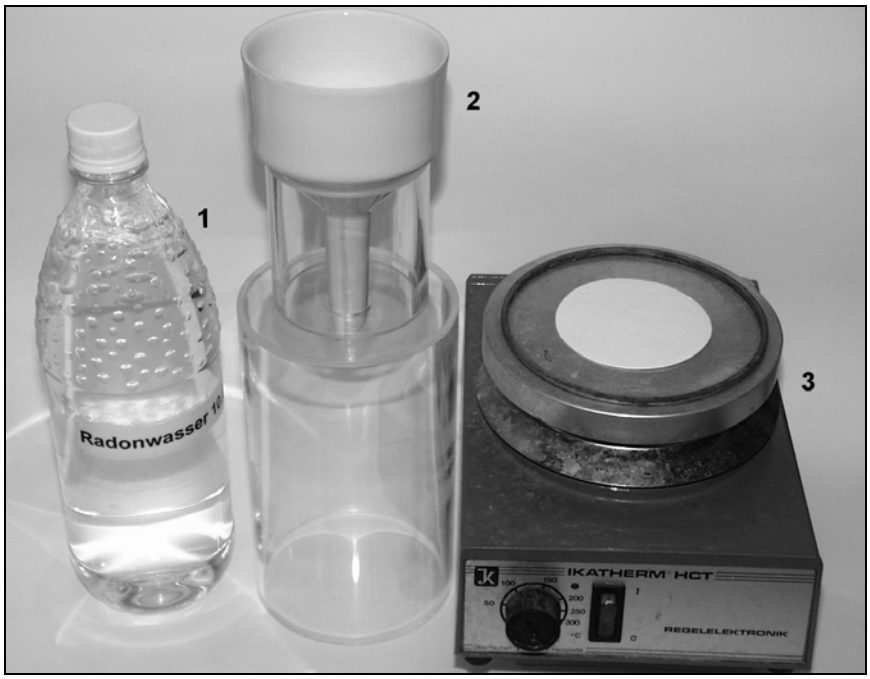
Measurements with and without paper between Philion Plate and Inspector
Cover of the Philion Plate with paper between the measurements

Background of the Philion Plate 28 ipm

Measurement after ... min	Gross amount impulses per min		Net amount impulses per min		Percentage concerning to the net rates	
	without paper	with paper	without paper	with paper	kind 1	kind 2
5	197	67	169	35	79 %	21 %
10	98	75	70	47	33 %	67 %
105	221	165	193	137	29 %	71 %

Glass fiber filters have been found [3] to be quantitative adsorbers of waterborne short-lived radon decay products with a sensitive of 1 - 2 Bq/L found in all non-suface waters.

First rain water after a dry week contains 100 Bq/L and more radon decay products. Filter samples of radon decay products have a sequence of half-lifes of 45, 33, 31, 29, 29 min.



1 Water containing radon (tap water, rain water, fountain water with high radon contents)

2 Funnel with glass fiber filter and vessel for collecting the water

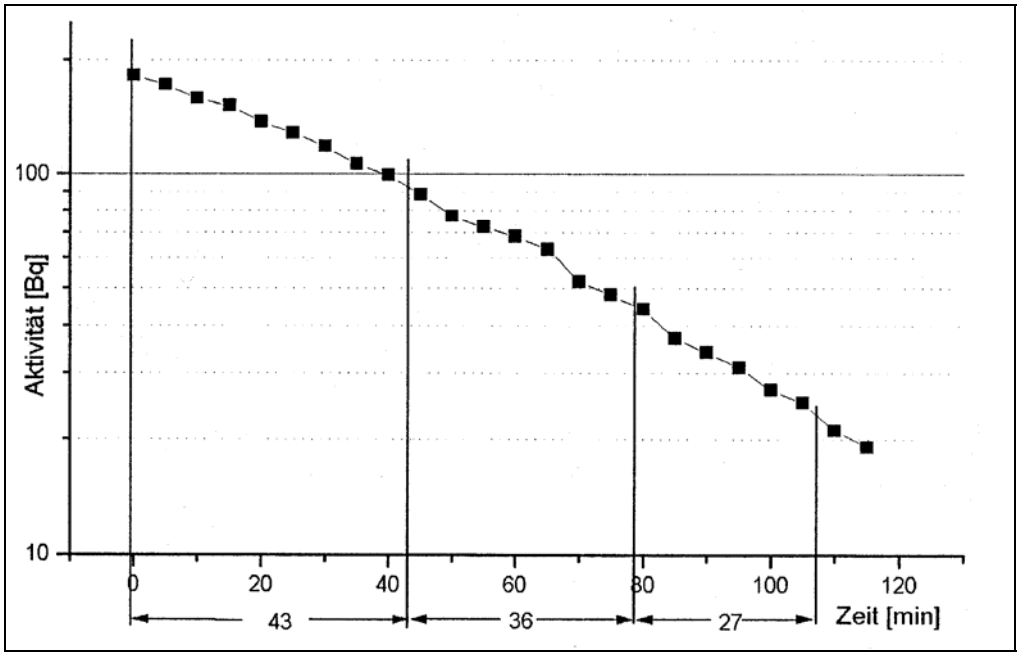
3 Heating stage with drying filter

Radon in Water

The glass fiber filter can be used for determination of half-lifes of radon decay products if water with high radon contents or radonol (see later) are used. Results are shown by the following measurement and the resulting diagram.

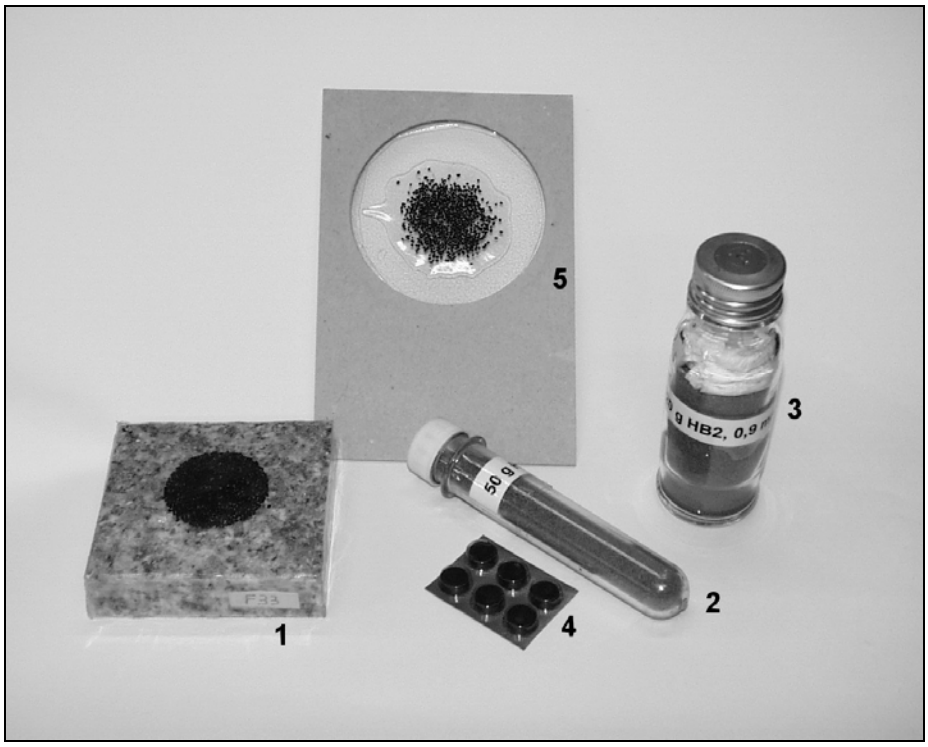
Measurement of a glass fiber filter contamined with radonol

Time of Measurement	1 min
Time between Measurements	5 min



The adsorption of radon on charcoal ist proportional to the activity per volume (concentration) and hence very large if the volume is made very small [4]. Small

volumes are achieved by wrapping granite in a type of commercial adhesive foil, found to be radon-gas-tight, or enclosing environmental soil with natural trace amounts of uranium and radium in prefoms for PET bottles, together with granular or compressed charcoal.



1 Granite plate wrapped in radon-gas-tight foil

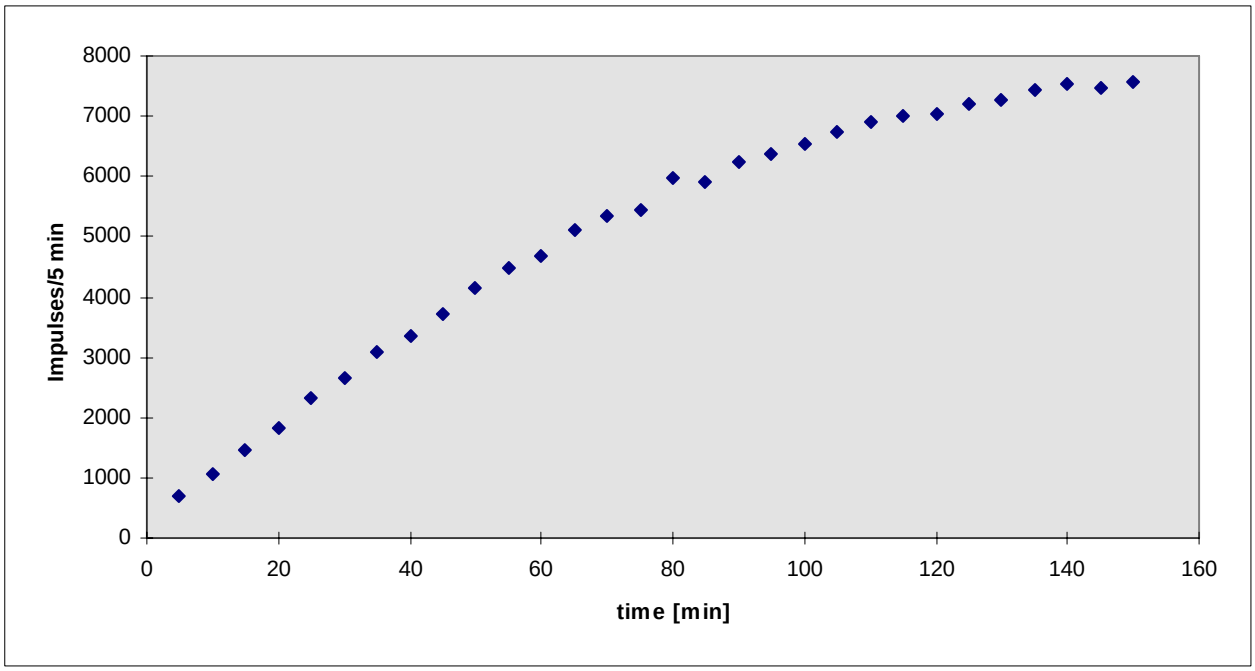
2 Radioactive soil in PET preforms for charging charcoal

3 Radioactive soil in septum bottle for sampling radon gas

4 Compressed charcoal

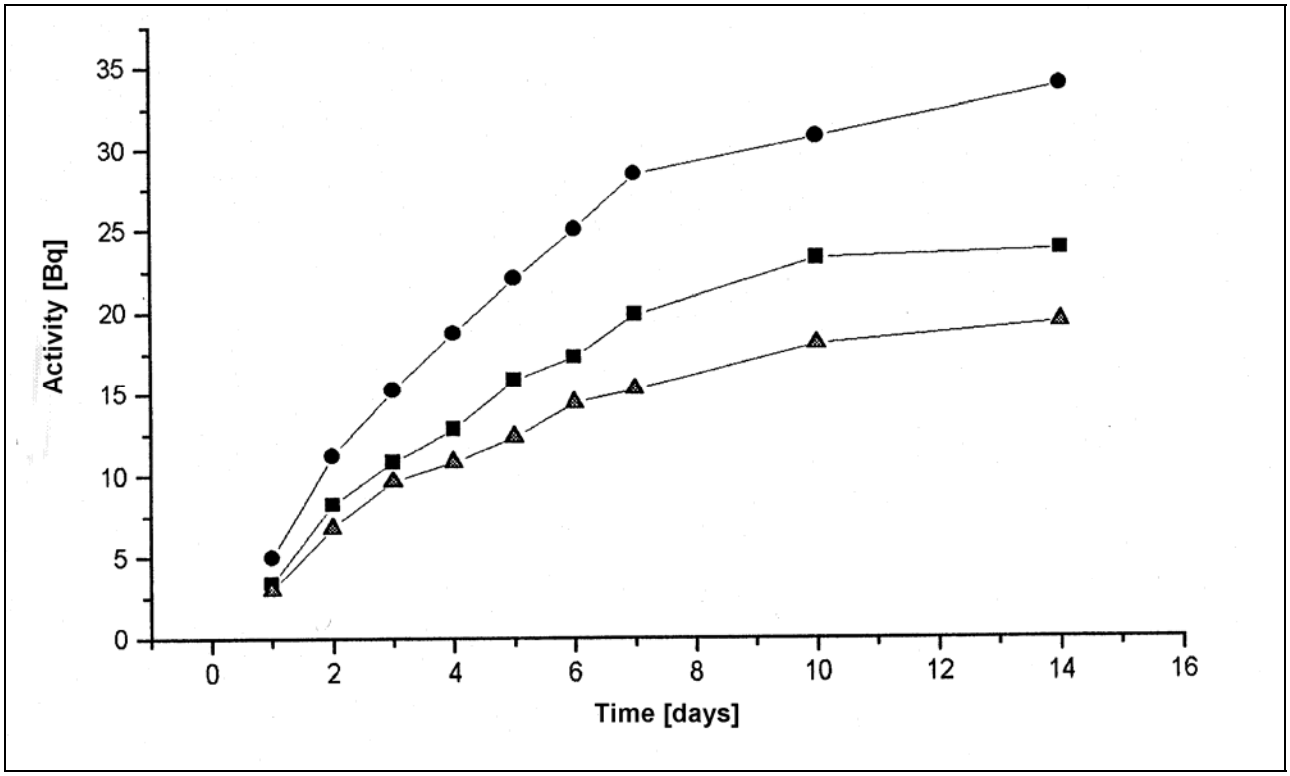
5 Charcoal loaded with radon and enclosed in gastight foil

If granular charcoal is loaded in a preform only for 10 - 15 minutes and then enclosed in a gastight foil the building up of the radon decay products can be measured until the balance between radon and its decay products is reached.

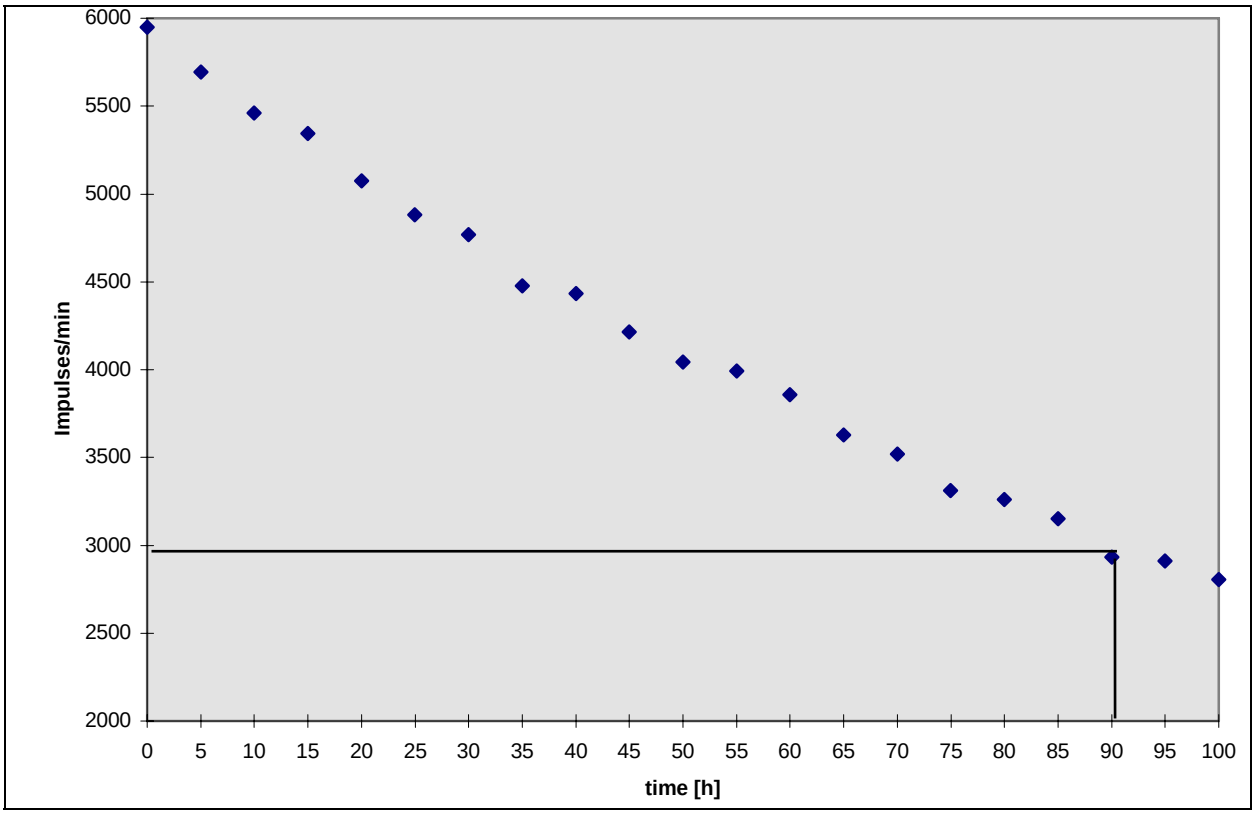


The same results are produced by granite plates wrapped in gastight foils together with granular charcoal. By this method it is possible to measure the difference in exhalation of

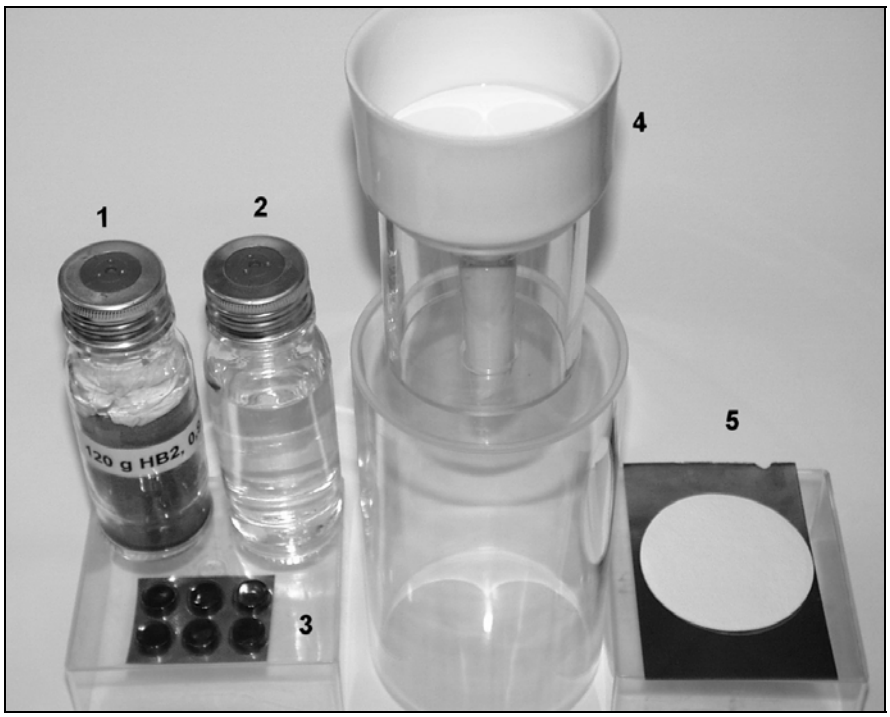
radon from various samples both from the same quarry and from differents. Samples of the same quarry vary in factors of 2, samples of different quarries in factors up to 30.



Samples of charcoal loaded with radon gas and enclosed in gastight foil have a half-life of 92 h.



Transfer of radon from air to liquid and from liquid to solid is achieved by radonal, radon in ethanol [5]. For that compressed charcoal is loaded in a PET preform or in a septum bottle with radioactive soil for 8 - 15 days and put into a septum bottle with ethanol.



1 Septum bottle with radioactive soil

2 Septum bottle with ethanol

3 Compressed charcoal

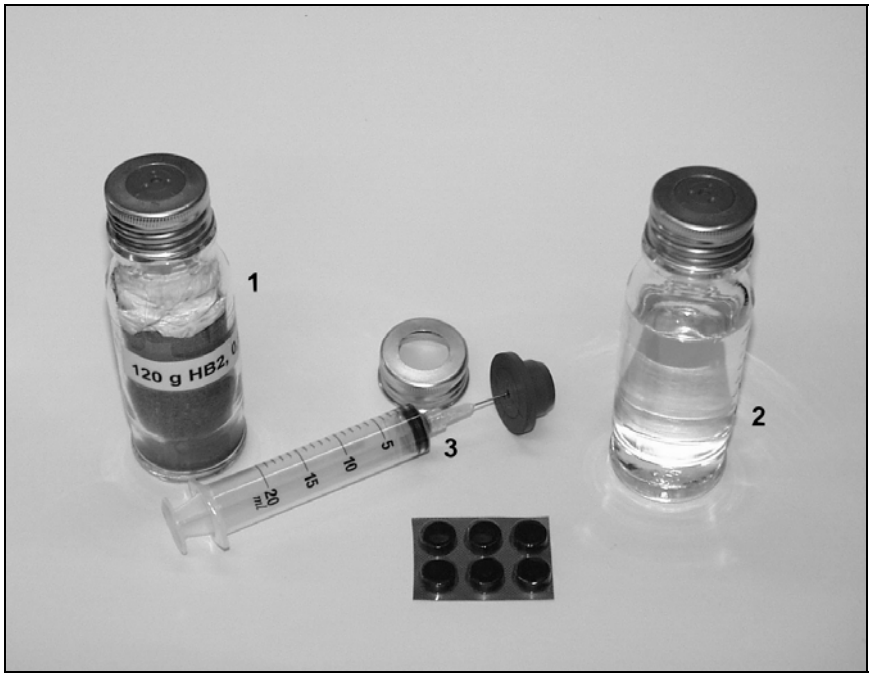
4 Funnel with glass fiber filter

5 Glass fiber filter on a sheet of lead or tungsten for reflection of beta rays

Production of Radonol

Radonol can be used for efficient adsorption of radon decay products on glass fiber filters by filtration. With such filters, dried an measured without and with an underlying sheet of tungsten or lead, back reflection of electrons is easily demonstrated by an increasing count rate.

Measurement of a glass fiber filter without underlaying sheet ..... ipm
Measurement of a glass fiber filter with an underlaying sheet of lead ..... ipm



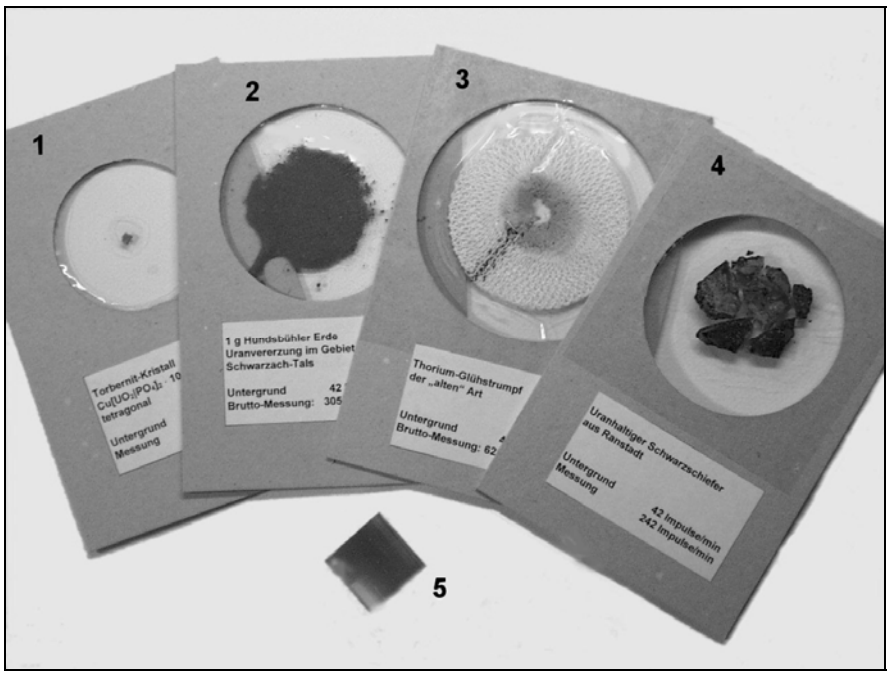
1 Septum bottle with radioactive soil

2 Septum bottle with ethanol

3 Syringe

Transfer of radon

Radon gas is transferred [6] between two septum bottles with soil and with ethanol by means of a syringe or by the formerly described desorption from charcoal and subsequent adsorption radon decay products on glass fiber filter during filtration of radonol.



1 Small crystal of torbernite

2 Uraniferous soil from Hundsbühl/Bavaria

3 Thoriated gas mantle

4 Uraniferous black shale from Sweden

5 Uraniferous glass

Natural and technical samples

In addition the Philion Experimental Case [7] contains natural and technical samples: KCl, uraniferous soil, dried grass with Cs-137, uraniferous glass and glazed ceramic, torbernite and zircon crystals, thoriated gas mantle, heavy mineral sand, black shale etc. These samples can be used for back reflection of beta rays (heavy mineral sand), for shield from rays by paper, aluminium or lead, for the medium range of alpha rays in air, for autoradiographies and many other experiments.

[1] H. von Philipsborn: Offenlegungsschrift DE 195 03 173 A1 vom 1. 2. 1995

[2] H. von Philipsborn, Chr. Hoffmann: Messung von Radonfolgeprodukten. Strahlenschutzpraxis 4/95, 56 - 58.

[3] H. von Philipsborn: Efficient adsorption of waterborne short-lived radon decay products by glass fiber filters. Health Physics 72, 277 - 281, 1997.

[4] G. Just, H. von Philipsborn: Radonexhalation aus Bau- und Rohstoffen. Strahlenschutzpraxis 4/96, 78 - 82.

[5] I. Winter, H. von Philipsborn: Ethanol als Radonspeicher - Anwendungen in der Meßtechnik. Strahlenschutzpraxis 4/97, 68 - 70.

[6] H. von Philipsborn, unpublished 1998.

[7] H. von Philipsborn, R. Geipel: Experimente mit dem Philion Experimentier-Koffer. 1. Ausgabe. 1999