Radon grab sampling in water by means of radon transfer in activated charcoal collectors (*)(**)

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Summary. — The proposed portable device is suitable for radon surveys in water-bearing strata. It allows a complete tranfer in activated charcoal canisters of radon dissolved in water collected with a 0.6 l bottle. The detection is performed in laboratory with a low background γ-ray spectrometer utilizing a $3'' \times 3''$ NaI(Tl) scintillator only after about ten hours. This time is necessary to let radon be uniformly distributed within the activated charcoal.

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1. – Introduction

The concentration of ^{222}Rn in water can be determined by detection of radiation α emitted by ^{218}Po and ^{214}Po or γ emitted by ^{214}Pb and ^{214}Bi, ^{222}Rn short-lived daughters.

The method proposed in this work stems from the widespread use of activated collectors in the measure of ^{222}Rn concentration in air [1]. Collectors are generally metal boxes cylindrical in shape which contain activated charcoal. A collector of 6 cm in diameter set up by the authors [2] is shown in fig. 1.

The activity of ^{222}Rn adsorbed during exposure is determined with γ spectrometry, usually with a NaI(Tl) detector [3]. The main γ lines investigated are those emitted in β decays of ^{214}Pb (242, 295 and 352 keV) and ^{214}Bi (609 keV). For calculations it is necessary to have a calibrating collector which contains a known activity of ^{226}Ra in equilibrium with ^{222}Rn.

As a consequence, laboratories equipped for measurements of ^{222}Rn concentration in air find it useful and economical, from a point of view either monetary or operational, to assess the ^{222}Rn concentration in water with the same technique of activated charcoals.

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(**) The authors of this paper have agreed to not receive the proofs for correction.

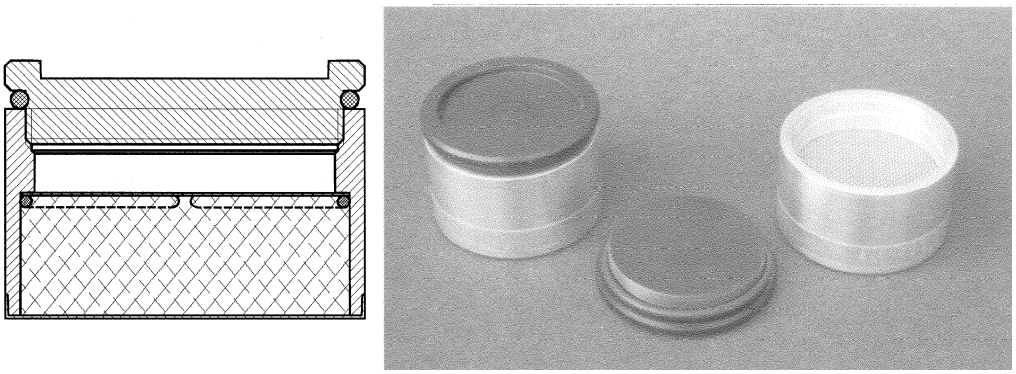

Fig. 1. – Activated charcoal collector of 6 cm in diameter. Vertical section and photograph.

2. – Method

The water sample to be analysed is taken with a bottle having a large neck ISO 45 type of a nominal volume of 500 ml. The filling pipe is inserted deep in the bottle and the water is kept flowing until the complete renewal of contained fluid. The bottle, full to the brim (real volume of 600 ml), is closed with a watertight cap provided with an expansion chamber A (fig. 2) in order to let the air bubble. Furthermore, that cap is

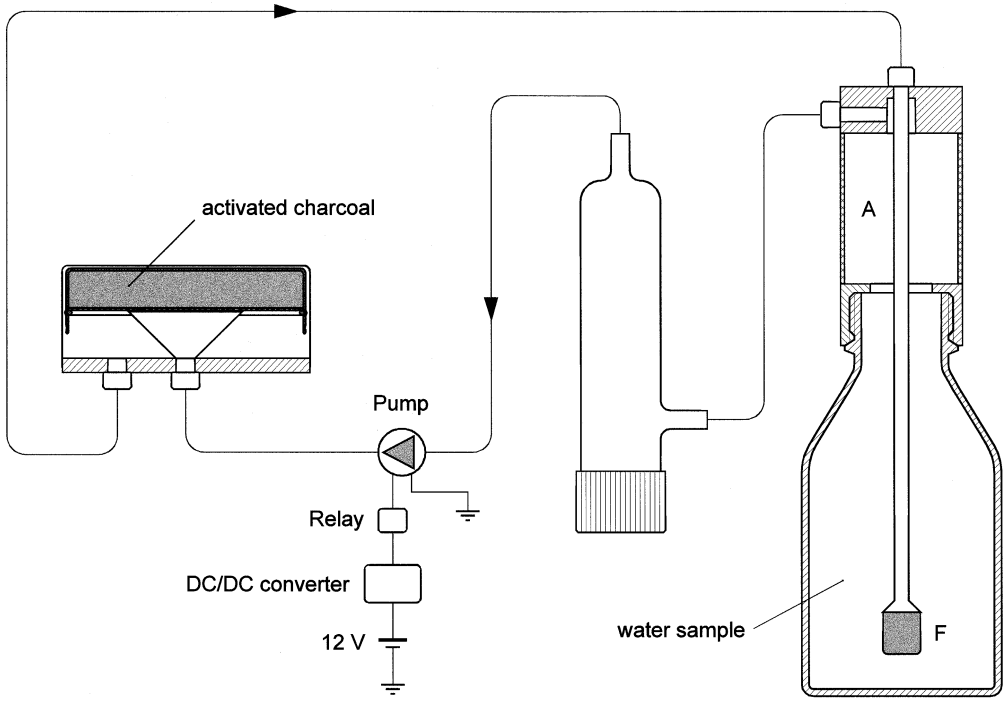

Fig. 2. – Scheme of the degassing portable system.

equipped with two quick connectors for air inlet and outlet. When the water sample has been taken, the bottle is inserted in a closed circuit where a diaphragm pump aspirates air from the bottle and pushes it toward the surface of the charcoal layer in the collector, which is enclosed in a small airtight chamber. Air comes out from the activated charcoal, reaches a fritted disk F placed at the end of a small brass pipe and finally bubbles through the water. Between the pump and the bottle there is a phial so as to prevent any micro-drop from getting to the pump. ^{222}Rn taken out of the water [4] is adsorbed onto activated charcoal. The minimum flowing time necessary for a complete ^{222}Rn transfer from water to activated charcoal is about two minutes with a nominal pump delivery capacity of 4 l/min. The increase in weight due to the water adsorbed in activated charcoal is less than 0.2 g.

At the end of the ^{222}Rn transfer the collector is closed with an airtight cap. At first ^{222}Rn is adsorbed within a narrow charcoal layer close to the center of the surface invested from the incoming air flow. Afterwards ^{222}Rn diffuses inside the charcoal layer [5] mainly axially [6].

The diffusion process makes time requested for the achievement of maximum count larger than that needed for the establishment of radioactive equilibrium between ^{222}Rn and its short-lived daughters; this is shown in fig. 3 where the count rate is plotted *vs.* time from ^{222}Rn transfer to collectors. Counts in the ordinate, which refer to a counting time of 15 min and have been obtained by integration over the whole ^{222}Rn spectrum from the γ line at 242 keV, are corrected in order to compensate for ^{222}Rn decay (T = 3.82 d) and normalized to the equilibrium value. The count rise at the beginning is due to the growth of short-lived daughters of ^{222}Rn; after about four hours ^{222}Rn and its daughters reach radioactive equilibrium, nevertheless the curve has not reached a plateau since ^{222}Rn is not uniformly distributed yet. Counts keep rising till a maximum; after that there is a slow decrease to the equilibrium value, reached after

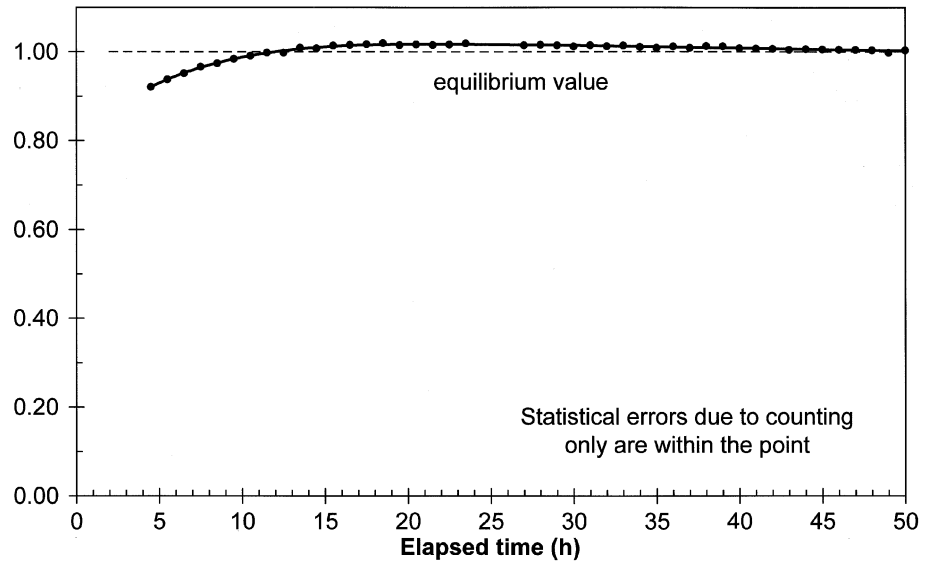

Fig. 3. – Normalized plot of count rate *vs.* time elapsed from degassing.

Fig. 4. – Photograph of the degassing portable system.

some tens of hours approximately and due to the radial diffusion of ^{222}Rn which causes a decrease in geometrical efficiency of the detector.

In the degassing portable system we have realized, which makes use of collectors of 6 cm in diameter, the maximum count value overshoots the equilibrium value for less than 2%, as displayed in fig. 3, and therefore it can be practically believed to have reached the equilibrium value after about 10 hours. However a specific table lets us correct values with correspondence to time from degassing.

The degassing portable system realized from IAT S.r.l. for the Department of Nuclear Engineering and Conversion of Energies of the University of Rome "La Sapienza" is shown in fig. 4. It is battery supplied (12 V) and equipped with 20 collectors for outdoor surveys.

Six water samples have been taken at a spring near Rome: in each sample a Marinelli beaker and a bottle for ^{222}Rn transfer to the collector have been filled in parallel. Mean concentration values from Marinelli beakers and collectors of 270 ± 2 Bq/l and 273 ± 4 Bq/l, respectively, have been measured [7].

3. – Conclusions

The prototype we have realized will be employed by the National Institute of Geophysics of Rome for surveys near Rome (Castelli Romani) and other places however distant from the analysis laboratory. As a matter of fact distance is not a serious problem since the collectors can arrive at the laboratory within 24-48 hours from the sampling via a fast carrier without detriment for the measure, stated the good tightness of collectors and the fairly high half-time of ^{222}Rn (3.82 d).

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