An Improved Method for the Measurement of Atmospheric Radon

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We present an improved version of a radon meter based on the electrostatic precipitation of post-radon daughters. This equipment is capable of performing unattended real time measurements of ^{222}Rn and ^{220}Rn and can be used for environmental and atmospheric research, radioprotection, and geological prospecting,

INTRODUCTION

Radon and its decay products in the atmosphere are responsible for about 50% of the environmental radioactive dose at ground level. In certain closed environments such as in mines and residences its concentration can exceed the mean open-air environmental level of 8 Bq/m^3 by more than 2000 times. Since 1980, this fact have called the attention of the environmental agencies in the US and Europe, and has lead to intensive studies of the impact of radon on the incidence of lung cancer. On the other hand, the relatively long half-live of ^{222}Rn (3.82 days) have unveiled new perspectives to its use as a tracer in atmospheric science and geology. The track etch technique, for example, is widely employed in the uranium and rare-earth geological prospecting. The use of radon in atmospheric studies is also known for many decades, and has been employed more recently to calibrate global circulation models of the atmosphere (Jacob and Prather, 1990). In this work we present a new improved version of a device for measuring the two most important radon isotopes, ^{222}Rn and ^{220}Rn by the electrostatic precipitation principle (Pereira et al., 1989).

DESCRIPTION OF THE METHOD

The equipment performs real-time measurements of ^{222}Rn and ^{220}Rn by collecting the post-radon daughter products and trapping them onto alpha particle counters. The block diagram of the equipment is shown in Figure 1. It consists of a 39liter hemispherical precipitation chamber (F), with internal walls painted with conductive layer where a 20 kV DC voltage is applied. Polonium isotopes; ^{218}Po, ^{216}Po, ^{214}Po, and ^{212}Po, are present in the probed air as positive ion particles in equilibrium with the gaseous radon isotope parents. Inside the chamber their trajectories are field aligned which cause them to converge to the detector whose shield is grounded. The alpha particles emitted by these polonium isotopes within the active zone area of the detector are the key information to calculate the radon concentrations. Probing and measurements are performed in real time and the results are given directly in Bq/m^3.

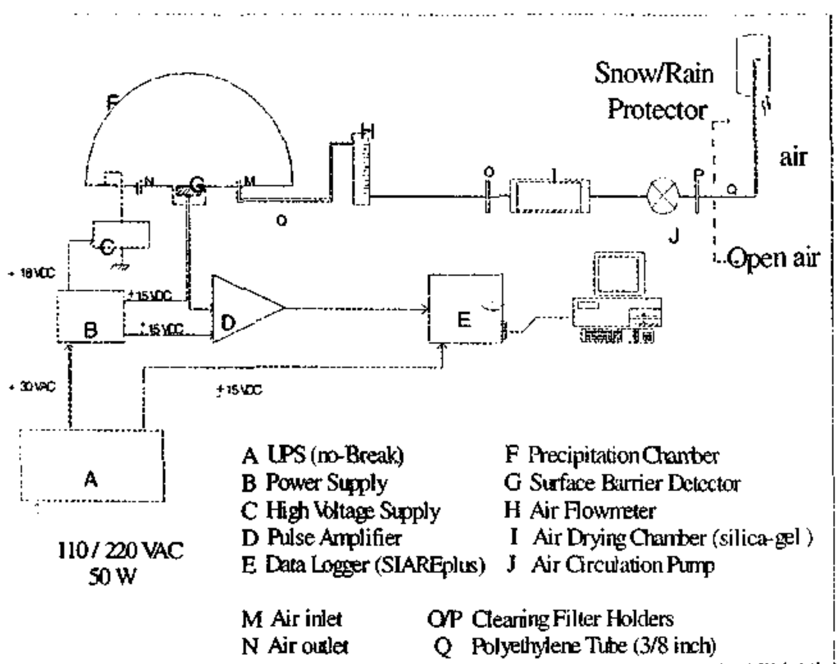

Figure 1. Block diagram of the instrument

A silicon barrier detector (G), model EPK 1700 - Eurisys Measurements) is used both as collecting electrode and as alpha particles counter/discrimination. It is located in the geometrical center of the hemisphere base with its active surface facing up to the interior of the chamber. This detector has a built in preamplifier. The pulse amplifier and pulse shaping electronics (D) feeds the spectrum analyzer system SIAREplus (E). The spectral data is internally stored by the SIAREplus memory and can be retrieved by any standard PC microcomputer through an RS232 serial interface (L). A dedicated software automatically performs all the required data collection and recording. The electric power for the equipment is provided by an uninterrupted power supply UPS (A).

The air is probed and circulates inside the chamber by continually pumping (J) through a hole (M) in the chamber. A silica gel bottle (I) located on the circulation line is used to eliminate the humidity of the air. The membrane filters (O and P), also located on the circulation line, are used to remove particles from the sampled air. The flow meter (H) indicates the sample flow rate.

BASIC PERFORMANCE RESULTS

Calibration was provided by a liquid standard radium source (NBS, SRM No.4967). One interesting and important feature of this equipment is that the concentration results do not depend on the flow rate although the response time is flow rate dependent. The background level was 0.0019 Bq/m^3 for 72 hours of uninterrupted measurement of a radon-free air sample. The minimum detection level depends on the integration time and on the accepted confidence level. As a role, the larger the integration time the lower is the detection level for a given confidence level. Thus, if we assume a typical 30-minute integration time, and accept a relative error of 20%, the detection limit will be of 0.96 Bq/m^3. This is far below the mean ground level, open-air radon concentration of 8 Bq/m^3.

Probing flask	*Start/End sampling Time (h)*	*Flask results (Bq/m^3)*	*EML (Bq/m^3)*	*This equipment (Bq/m^3)*
4	11:19 -11:39	6.5 ± 0.4	11.16 ± 2.45	5.49 ± 0.42
10		6.3 ± 0.4		
5	13:20 - 13:40	1.7 ± 0.3	9.40 ± 2.25	3.25 ± 0.33
9		2.9 ± 0.4		

Table 1. Performance results when compared to absolute results from proportional counter chamber and with two-filter scintillation technique. Probing were made at the same inlet manifold for the three techniques.

An inter-comparison was performed with another real-time radon measuring equipment from the Environmental Measurements Laboratory - EML of the US Department of Energy (two-filter type scintillation counter). The inter-comparison results are summarized in Table 1. Results from these two equipments were checked against absolute activity measurements given by the EML proportional chamber. We can see that the EML equipment yielded biased results when compared to the absolute results of the proportional chamber and of this equipment. The second set of probing flasks (#5 and # 9) yielded discrepant results due to an operator's error when opening the vacuum valve in flask #5.

This equipment have been successful employed in several missions for atmospheric studies in remote environments. Simultaneous measurements of atmospheric radon are being made for several years at the Brazilian Antarctic station Ferraz, in the city of Punta-Arenas, Chile (Pereira. 1990), and at the Italian Antarctic station in the Terra Nova Bay. This technique is appropriate for environmental monitoring purposes (Pereira. 1992). The equipment was also airborne operated in the Amazon region to determine the flux balances of trace gases in the troposphere (Pereira et al. 1991).

CONCLUSIONS

The electrostatic precipitation technique described here is well suited for continuous unattended monitoring of radon in the atmosphere. It finds its applications in the study of the atmosphere related to atmospheric dynamics, trace gases studies, and global atmospheric circulation. It can also be used in environmental studies and radiation protection dosimetry of radon. Another possible application is in the uranium and rare earth geological prospecting.

Potential clients for this new technique are among the environmental protection agencies, atmospheric research centers and universities, and the geological survey companies.

REFERENCES

JACOB, D. and PRATHER, M.J., Radon-222 as a test of convective transport in a general circulation model. *Tellus*, 42B(1):118-134, 1990.

KRITZ, M. A. and ROSNER, S.W., Radon Measurements in the lower tropical stratosphere: evidence of rapid vertical transport and dehydratation

of troposphere air, *J.Geophys. Res.*, 98(D5):8725-8736, 1993.
PEREIRA. E.B., and DA SILVA. H.E., Atmospheric radon measurements by electrostatic precipitation, *Nuclear Instruments and Methods*, A280:503-505, 1989.
PEREIRA. E.B., Radon-222 time series measurements in the Antarctic Peninsula (1986-1987), *Tellus*, 42(B):39-45, 1990.
PEREIRA. E.B.; DIAS. P.L.S. e NORDEMANN. D.J.R., Radon concentrations profiles over the Brazilian Amazon basin during wet season, *Revista Brasileira de Geofísica*, 9(1):61-68, 1991.
PEREIRA. E.B., A Radioatividade Atmosférica Natural, *Ciência Hoje*, 14(81):42-50, 1992.

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