A PORTABLE APPARATUS FOR CONTINUOUSLY MEASURING Rn-222 EXHALATION FROM GROUND

Osamu Ariyada, Tatsuo Tanji, Michio Okino, and Sadamu Mochizuki

Muroran Institute of Technology, Muroran 050, Japan

INTRODUCTION

For the purpose of continuously measuring the rate of ^{222}Rn exhalation from the ground surface, an apparatus has been developed that consists of a radon collector, a 60-*l* cylindrical buffer tank, three kinds of filter and an ionization chamber of flow-through type.

The apparatus is capable of providing an evaluation of the ^{222}Rn exhalation rate that is sufficiently accurate for all practical purpose.

MEATHOD OF MEASUREMENT AND STRUCTURE OF APPARATUS

The means adopted for measuring the exhalation rate of ^{222}Rn, is an improved version of Wilkining's method.[1][2] The ^{222}Rn collector is of structure and dimensions as shown in Fig.1.

The measuring system is arranged as schematized in Fig.2. The ionization chamber(G in Fig.2) is cylindrical aspiration condenser with inner and outer cylinders measuring respectively 0.05 m and 0.2 m in diameter and 0.45 m in common length. The outer cylinder is maintained at a potential of -1 080 volts. The vibrating reed electrometer (I) is used to measure the ionization current.

The measurement proceeds with the respective components functioning in the following manner: The ^{222}Rn collector is placed on the ground to be measured: the sampling air is adjusted to flow at 6 *l*/min, which is a rate that will not let the radon exhaled from ground be forcibly entrained; this sam pling air contained ^{222}Rn and ^{220}Rn is then passed into the 60-*l* buffer tank(C) to eliminate ^{220}Rn, whose half-life is only 54.5 s and thus decays away during its stay in the buffer tank. Further downstream, before attaining the ionization chamber(G), the sampling airpasses through the silica gel desicator(D), the glass fiber filter(E) for eliminating the daughter nuclides of ^{222}Rn and ^{220}Rn, and the ion trap(F) for removing ions generated in the channels of the system by the radiations from ^{222}Rn and ^{220}Rn, as well from their daughter nuclides. The ionization current measured by the electrometer(I) is continuously recorded in analogical form, to be converted off-line into ^{222}Rn concentration byconsulting a calibration table, and the resulting data are then used for calculating the ^{222}Rn exhalation rate, asdescribed in the next section.

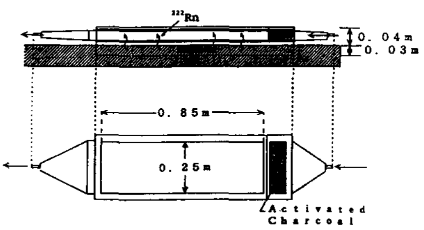
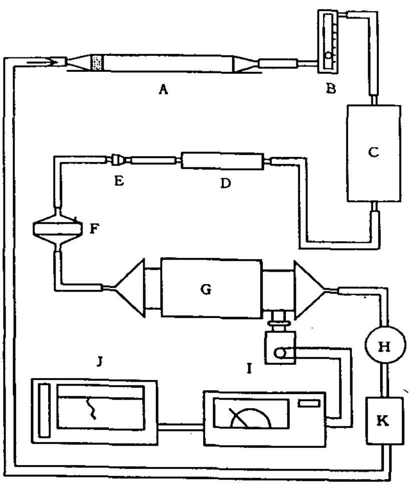


Fig. 1 Device for collecting ^{222}Rn exhalation



A: Radon collector, B: Flow meter, C: Buffer tank (60-*l* capacity), D: Silica gel desicator, E: Glass fiber filter, F: Ion trap, G: Ionization chamber, H: Pump, I: Electrometer, J: Recorder, K: Charcoal bed

Fig. 2 Arrangement of apparatus for measuring ionization current generated by ^{222}Rn exhalation from ground

DERIVING THE ^{222}Rn EXHALATION RATE FROM THE MEASURED IONIZATION CURRENT

For determining the relation between the measured ionization current and the concentration of entrained ^{222}Rn flowing through the ionization chamber, calibration measurements were made on radon gas exhaled from samples of sandy rock used for extracting titanium, containing in average 4 900 Bq/kg of ^{226}Ra.

Before proceeding on a calibration measurement, the initial zero point of ionization current was determined using Miranda's charcoal trap method.(3) Thereafter, the calibration proceeded as follows: Place a suitable quantity of the sandy rock sample in a spare 60-*l* tank; connect this tank and the ^{222}Rn collector(A in Fig.2) to the system; close off the system and leave it standing until establishment of radioactive equilibrium in the tank between radon and its daughter nuclides, with ^{220}Rn decay away; start up the pump(H) to circulate the sampling air through the system, and let system as a whole; adjust the pump speed to obtain a flow rate of 6 *l*/min; while continuing to circulate the sampling at this rate through the system, measure the ^{222}Rn concentration in the tank, applying Thomas' two-filter method;(4) plot the measured ^{222}Rn concentration against the corresponding reading of ionization current on the electrometer(I) to obtain a calibration plot; repeat this calibration measurement with the quantity of sandy rock parametrically varied, to gen-erate the calibration curve.

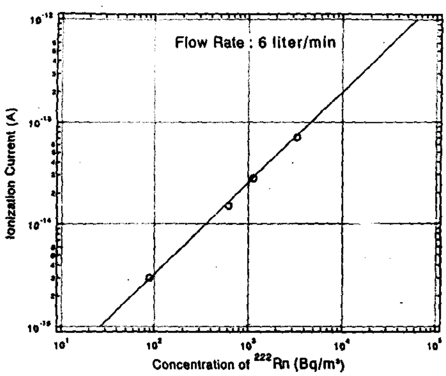


Fig. 3 Calibration plots relating measured ionization current to ^{222}Rn concentration

The calibration curve thus obtained is shown in Fig.3, relating the ionization current to the ^{222}Rn in the sampling air flowing through the ionization chamber at 6 *l*/min. Using the values of ^{222}Rn concentration determined by means of this calibration curve, the exhalation rate is calculated with the equation

$$E = C_{Rn} V_s / S$$

where E : Exhalation rate (Bq/m^{2}s)

C_{Rn}: Radon concentration (Bq/m^3)

V_s : Flow rate of sample air (m^3/s)

S : Covering area by collector (m^2).

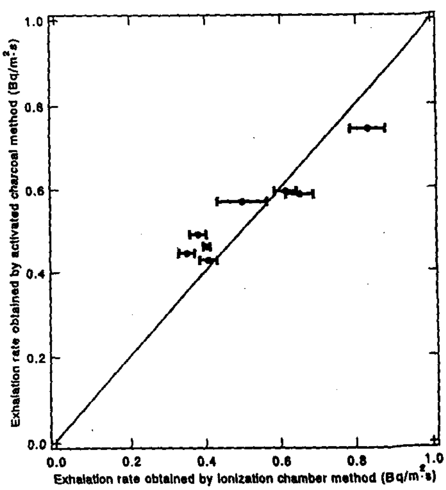


Fig. 4 Measured values of ^{222}Rn exhalation compared between present method and that using activated charcoal

COMPARISON BETWEEN VALUES OBTAINED WITH THE PRESENT AND WITH OTHER METHODS

The accuracy of measured values with the present method was evaluated through comparative measurements with corresponding values obtained using Megumi's activated charcoal method,(5) adopting as common sample parametrically varied quantities of river sand (for its uniformity of grain size) placed in a wooden box measuring 2 m x 2 m x 2 m. The measurements were performed inside a shed, to eliminate wind and other environmental effects.

The results obtained from the comparative measurements are plotted in Fig.4, from which a correlation coefficient of 0.91 has been derived. The plots of Fig.4 indicate a higher range of exhalation rate given by the ionization chamber compared with those by activated charcoal method.

OPERATING CHARACTERISTICS

The operating characteristics of this apparatus were determined from long-duration observations performed on the apparatus at different sites.

An example of the continuous record of exhalation rate is shown with atmospheric pressure and weather conditions in Fig.5. From the observations it was confirmed that the apparatus operates stably in a period of long-duration and even in stormy weather.

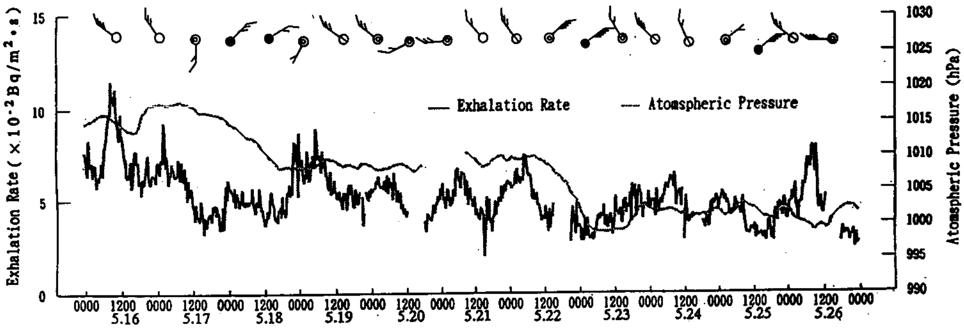


Fig. 5 An example of continuous record of exhalation rate.

CONCLUDING REMARKS

The basic experiments described above, substantiated by performance obtained in practical application in different sites, have yielded the following informations:

(1) The apparatus is capable of continuously recording measured data that provide an evaluation of ^{222}Rn exhalation rate with sufficient accuracy for all practical purposes.

(2) The apparatus operates stably even in stormy weather, and impairment of evaluation accuracy can be expected to be minimized, once a suitable formula -now being sought- is found for taking account of the difference between collector interior and ambient exterior brought by the storm in respect of such factors as the ground conditions, wind and air flow speed.

REFERENCES

1. M. H. Wilkining, and J,. E. Hand,*J. Geophys. Res.* 65, 3367 (1960).
2. J. E. Pearson, D. H. Rimbey, and G. E. Jones, *J. Appl. Meteorol.* 4, 349 (1965).
3. H. A. Miranda, *J. Atmos. Terr. Phys.* 11, 272 (1957).
4. J. W. Thomas, and P. C. Leclare, *Health Phys.* 18, 113 (1970).
5. K. Megumi, and T. Mamuro, *J. Geophys. Res.* 77, 3052 (1972).