Radiation Protection Dosimetry (2004) Vol. 112, No. 3, pp. 449–453
Advance Access publication 5 October 2004
doi:10.1093/rpd/nch407

SCIENTIFIC NOTE

ATMOSPHERIC RADON LEVELS IN BEIJING, CHINA

Liguo Zhang[1], Qiuju Guo[1,*] and Takao Iida[2]
[1]Department of Technical Physics, School of Physics, Peking University, Beijing 100871, China
[2]Department of Energy Engineering and Science, Graduate School of Engineering, Nagoya University, Furo-cho, Chikusa-ku, Nagoya 464-8603, Japan

Received June 24 2004, amended September 1 2004, accepted September 2 2004

The results of measurement of atmospheric radon concentration in Beijing, China, are reported. Continuous observation was performed hourly throughout 2003 to provide data on annual average radon concentration as well as the variation of radon concentration. An arithmetic annual mean value of 14.1 ± 5.5 Bq m^{-3} was obtained. The value was slightly higher than the world average and the national average. For the monthly average radon concentration, the maximum was 18.5 ± 5.0 Bq m^{-3} in November, while the minimum was 9.9 ± 4.1 Bq m^{-3} in May. Diurnal variation was also observed, and the average daily pattern of radon concentration consisted of a minimum in the late afternoon and a maximum in the early hours of the morning.

INTRODUCTION

Radon (^{222}Rn) is the gaseous radioactive decay products of the radium isotope ^{226}Ra, which is present in all terrestrial materials. Over the past few decades, there has been an increased scientific interest in the study of environmental radon. One of the main reasons is the health hazard associated with it, another is its widespread use as an environmental tracer(1,2). The atmospheric radon levels in China have been measured and reported previously(3,4), however, nearly all the results reported were obtained by grab sampling. Considering the variation in atmospheric radon concentrations, a continuous measurement was essential for the evaluation of outdoor radon levels.

A project named Measurements of Radon as a Tracer of Air Pollutants in East Asia was started several years ago, and the measurement of atmospheric radon concentrations at various locations in east Asia have been carried out. Being a member of the project, an Electrostatic Continuous ^{222}Rn Monitor (ERM) was installed in our laboratory, and a continuous measurement of atmospheric radon concentration was was carried out. All the data measured throughout 2003 in Beijing were analysed and reported in this paper. Both the seasonal as well as diurnal variation were discussed.

METHODS AND MATERIALS

Observation location

Atmospheric ^{222}Rn concentrations have been continuously observed in our laboratory which is located on the fourth floor (15 m from the ground) of the building (39.59°N, 116.19°E). Outdoor air was pumped continuously into the radon monitor. There were no closely located buildings in the vicinity. Unlike indoor ^{222}Rn concentrations, atmospheric ^{222}Rn levels are influenced by the radon flux rate from the ground and the meteorological conditions of the local area; therefore, it could be said that the atmospheric air that is characteristic of Beijing, a city in the northern part of China, was sampled.

Continuous radon measurement equipment

Atmospheric radon concentrations were sampled and measured with the Electrostatic Radon Monitor (ERM-B1) which is illustrated in Figure 1(2,5). Outdoor air was pumped continuously into the monitor and filtered with a cellulose nitrate membrane filter (pore size 0.8 μm) to remove aerosols and atmospheric radon decay products and then dried with P_2O_5 powder before being passed into a 16.8 l hemispheric vessel. Radon decays inside the vessel and positive ^{218}Po ions are collected electrostatically on the electrode of aluminised Mylar coated with a ZnS(Ag) scintillator. The scintillations due to alpha particles are detected by a photomultiplier tube. The scintillation pulse, which is amplified and processed, is then fed into a computer. Radon concentrations are calculated automatically every hour from the accumulated alpha counts.

RESULTS AND DISCUSSION

Atmospheric radon concentrations in Beijing were continuously observed throughout 2003, and average hourly radon concentrations were measured using the ERM-B1. The variability in the hourly radon concentrations for January is illustrated in

*Corresponding author: qjguo@pku.edu.cn

 © Oxford University Press 2004; all rights reserved

Downloaded from http://rpd.oxfordjournals.org/ at Peking University on March 20, 2014

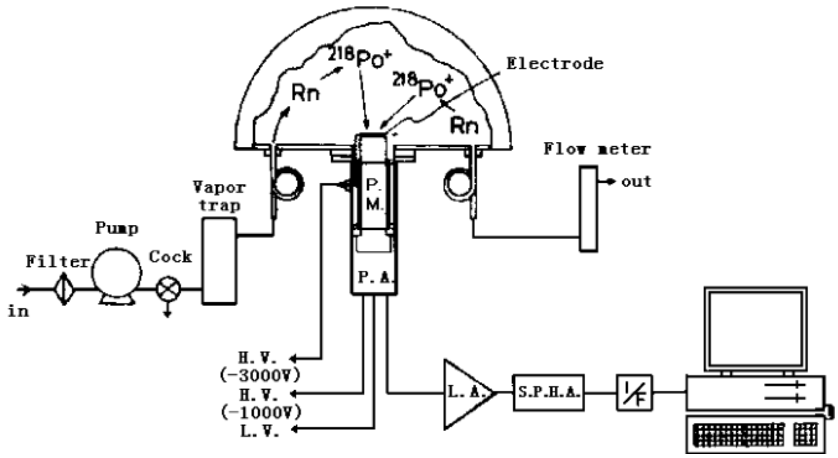

Figure 1. The electrostatic radon monitor (ERM).

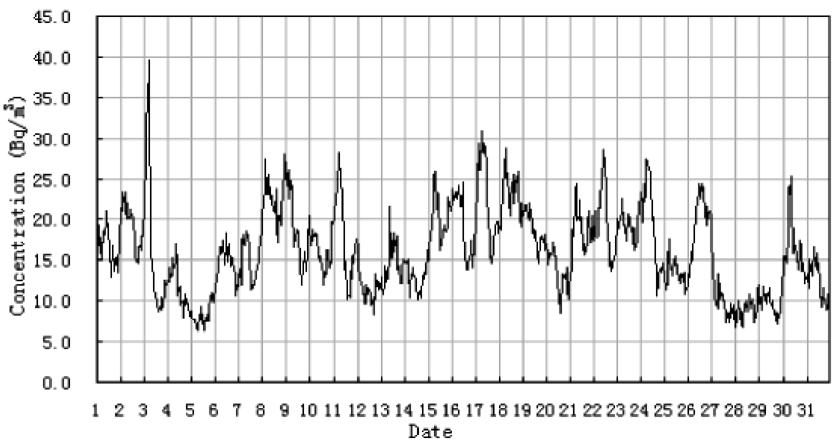

Figure 2. Hourly radon concentrations in January 2003.

Figure 2. It should be pointed out here that the measurement of data for August and September were not completed because of some hindrances; however, typical monthly data could be obtained and the annual variation tends were still clear.

Diurnal variation

The monthly average concentration at each time point was calculated to evaluate diurnal variation, so that 24 data, on an average day of each month was obtained to show the diurnal trends, and the result was shown in Figure 3 (except for August and September when the data was incomplete). The diurnal variation of radon concentrations for each month showed the same pattern: a minimum in the late afternoon (16:00 to 18:00) followed by a maximum in the early hours of the morning (6:00 to 8:00). The lowest concentration of the year was 2.7 Bq m^{-3} in May, while the highest was 40.4 Bq m^{-3} in October. Furthermore, the curve from 14:00 to 20:00 shows a moderate variation indicating a limited variation of radon concentrations.

On the other hand, annual variation was also shown in Figure 3. The curves for October and November were at the top of the figure, whereas the curves for April and May were at the bottom.

In addition, for a detailed analysis of diurnal variation, the frequency distribution of both the minimum and the maximum appearances at different time points were analysed statistically and the results are shown in Figure 4. The percentage of the minimum appearances in the period from 16:00 to 18:00

Downloaded from http://rpd.oxfordjournals.org/ at Peking University on March 20, 2014

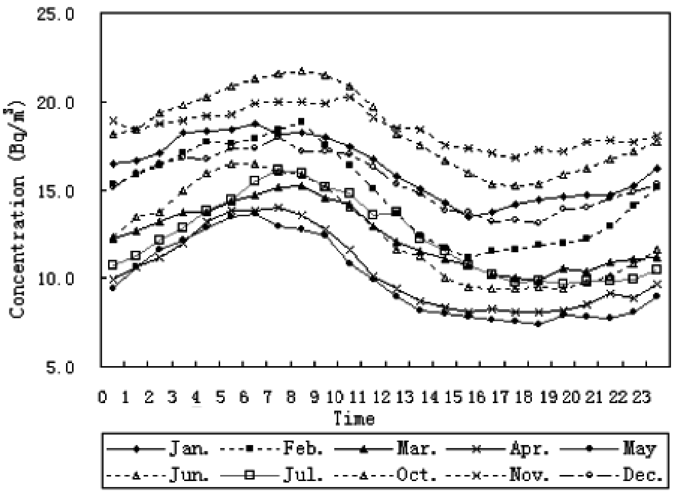

Figure 3. Diurnal variation based on an average day of each month (except for August and September).

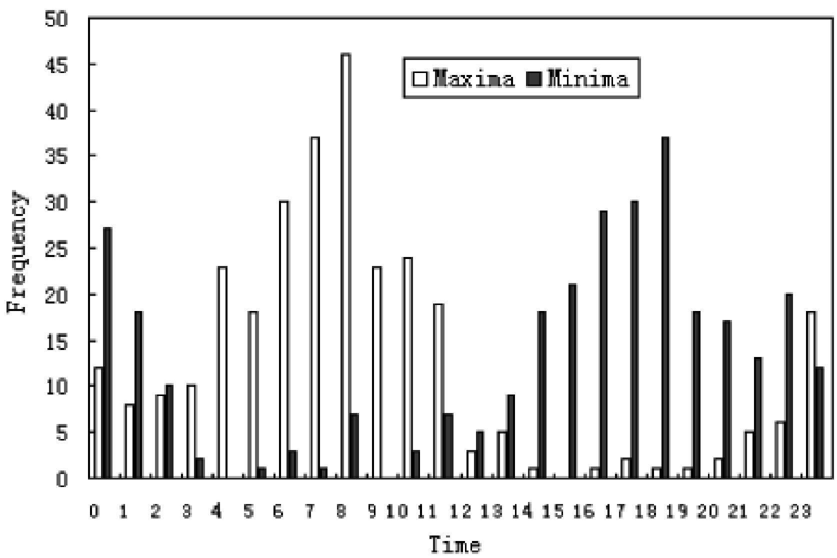

Figure 4. Frequency distribution of daily maximum and minimum appearances in 2003.

was 37.2%, whereas the percentage of the maximum appearances from 6:00 to 8:00 was 31.2%. It was noticed that both the minimum and the maximum appearances during the period between 23:00 and 24:00 also had a rather high frequency, ~13% and 10%, respectively.

Seasonal variation

From all the data measured in 2003 it was ascertained that average radon concentrations were higher in October and November but lower in April and May. The average radon concentrations for each month is shown in Figure 5. The average annual radon concentration was 14.1 ± 5.5 Bq m^{-3} (arithmetic mean), which was higher than the world average[6] and the reported national average[3,4] of 10 Bq m^{-3}. The maximum was $\sim 18.5 \pm 5.0$ Bq m^{-3} in November, while the minimum was $\sim 9.9 \pm 4.1$ Bq m^{-3} in May.

Figure 6 gives the frequency distribution at each radon concentration interval for monthly radon concentrations in 2003. The same results can be obtained for monthly radon concentration.

Downloaded from http://rpd.oxfordjournals.org/ at Peking University on March 20, 2014

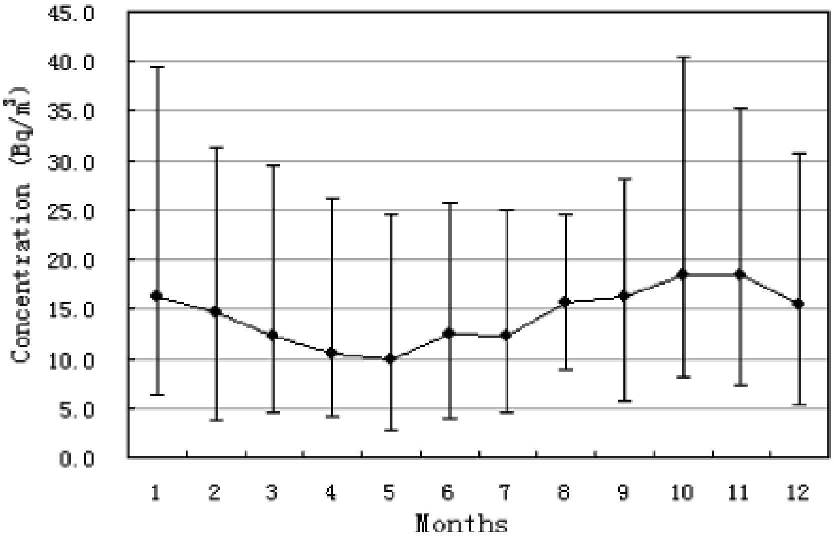

Figure 5. Monthly average radon concentrations in 2003.

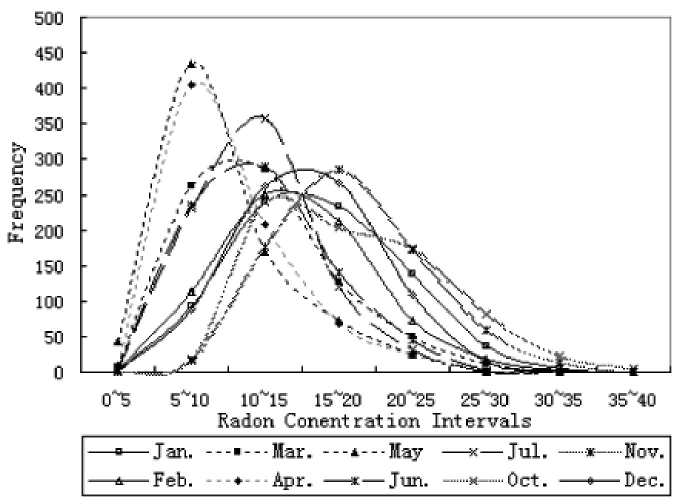

Figure 6. Frequency distribution of radon concentrations for each month in 2003 (except August and September).

Downloaded from http://rpd.oxfordjournals.org/ at Peking University on March 20, 2014

CONCLUSIONS

From the continuous measurement data in 2003, average annual atmospheric radon concentration in Beijing was found to be 14.1 ± 5.5 Bq m^{-3} (arithmetic mean), while monthly concentrations varied between a maximum in November and a minimum in May. Although diurnal variation patterns also varied according to the prevailing meteorological conditions, hourly radon concentrations tended to be at a maximum in the early morning and at a minimum in the late afternoon.

The process of continuous measurement is still being carried out and presently the effect of meteorological conditions on atmospheric radon concentrations is being studied.

REFERENCES

1. Taguchi, S., Iida, T. and Moriizumi, J. *Evaluation of the atmospheric transport model NIRE-CTM-96 by using measured radon-222 concentrations*. Tellus **54B**, 250–268 (2002).

2. Iida, T. *et al*. *Continuous measurements of outdoor radon concentrations at various locations in East Asia*. Environ. Int. **22**, 641–647 (1996).
3. Pan, Z. *et al*. *Estimation of natural radiation background level and population dose in China*. Radiat. Prot. **12**, 251–259 (1992) (in Chinese).
4. Cheng, J., Guo, Q. and Ren, T. *Radon levels in China*. J. Nucl. Sci. Technol. **39**, 695–699 (2002).
5. Iida, T., Ikebe, Y. and Toji, K. *An electrostatic radon monitor for measurements of environmental radon*. Res. Lett. Atomos. Electr. **11**, 55–59 (1991).
6. UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation). *Sources and effects of ionizing radiation*. (New York: United Nations) (2002).

Downloaded from http://rpd.oxfordjournals.org/ at Peking University on March 20, 2014