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The Effect of Meteorological Parameters on Radon Concentration in Soil Gas

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The production of ^{222}Rn depends on the activity concentrations of ^{226}Ra in the earth's crust, in soil, rock and water. Radon concentration levels are strongly affected by atmospheric influences such as rainfall, real humidity, temperature and barometric pressure, rather than by chemical processes, as it is an inert gas. In particular the exhalation of radon is positively correlated with moisture content, temperature and negatively with pressure, so that these factors must be considered in the determination of exhalation rates in environmental measurements. In this study, radon concentrations in soil gas were continuously monitored for nine months in ten minutes periods, using AlphaGUARD system and the fluctuations of radon concentration were compared with the regional meteorologic data, using time graphs.

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1. Introduction

Radon is a member of the natural decay series of uranium and it is the only gas among the elements of its radioactive chain. The concentration of ^{222}Rn depends on the activity concentrations of ^{226}Ra in the earth's crust, in soil, rock and water. Radon is emanated from solid grains and propagates through the soil pores, filled with air and water and then it is transported by diffusion and advection through this space and is exhaled into the atmosphere. Exhalation rates are highly affected by the permeability of the soil and by atmospheric parameters, such as rainfall, real humidity, temperature and barometric pressure.

Radon is being used for some scientific searches, such as location of uranium deposits and geothermal sources, medical applications etc. Radiometric surveys for mineral exploration or lithological mapping are routinely made from the air and on the ground [1]. The radioactivity of the soil is important since it disperses into water and air and also through the plants and other leaving beings [2]. Surveys of the radon concentration in soil gas can be used to: determine the radon index of the buildings and the effectiveness of preventive and remedial measures; identify contaminants and relative concentrations; identify sources; indicate extent of contamination [3]. Additionally, changes in soil radon are thought to be a possible precursor of earthquakes [4–7]. However, weather-related enhancement or depletion of soil-gas radon may cause misinterpretation of soil gas radon data. Long-term and continuous monitoring of radon in soil gas, together with meteorological and seismological data, is important for evaluating relationships with seismic activity [8].

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2. Materials and methods

2.1. Monitoring site

Measurements were carried out in Karahayıt-Turkey. Karahayıt district is accessed thorough Pamukkale, located 20 km in the north of Denizli. Thermal springs in Karahayıt are formed as a result of active geologic structure of Aegean region. Karahayıt spring deposits red travertine due to high iron concentrations in the fluid [9]. The climate conditions of Aegean, Central Anatolia and Mediterranean are seen clearly in Karahayıt. Summer season is sunny and dry, and winter season is warm and rainy.

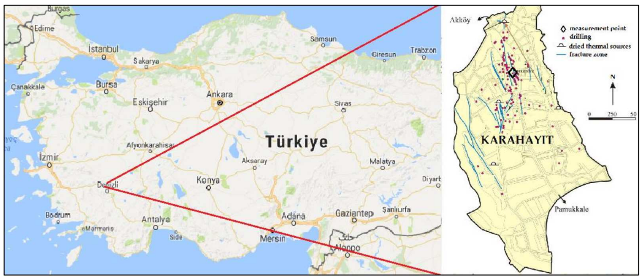

Fig. 1. The monitoring site.

2.2. The measuring equipment

Measurements have been performed by a portable device, AlphaGuard PQ 2000PRO, which is designed for long-term monitoring of radon gas concentration. AlphaGuard is an ionizing chamber which measures radon via alpha spectrometric techniques. In addition to the radon concentration in air, AlphaGUARD can measure and record simultaneously ambient temperature, relative humidity and atmospheric pressure using integrated sensors [10]. The AlphaGuard has several probes for different applications. The soil gas unit consists of a drilling rod with an exchangeable drilling tip with air-lock which is closed by a rivet and capillary probe (Fig. 2). For the measurement of soil-gas radon, a hole with a depth of 1 m was drilled using a drilling rod. With the pump and radon progeny filters connected in series, 0.3 l of soil gas were sucked out from the ground per minute and pressed into the ionization chamber of the monitor. In this measurement system, radon concentrations in soil air were continuously monitored for nine months in 10 minutes intervals.

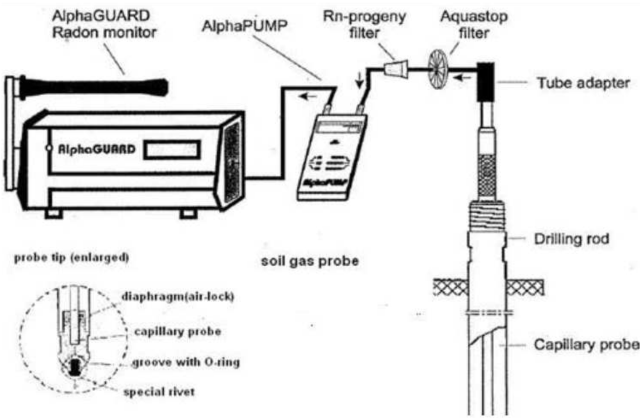

Fig. 2. Schematic view of experimental setup for radon measurement in soil gas.

3. Results and discussion

Daily fluctuations of radon concentration, together with temperature, humidity and air pressure of soil gas are shown in Fig. 3a. It is obvious that radon concentration and humidity of soil gas are correlated positively in contrast with temperature. The temperature of soil gas reaches maximum values between 06:00–08:00 PM; at the same time humidity and radon concentration get to the lowest values.

In Fig. 3b, radon concentrations in soil gas are presented together with the regional meteorological data. While the opposite pattern of humidity and temperature were continuing above ground, time differences were observed between radon concentration and humidity peaks. Phase differences of about 5 hours can be caused by slow heat transfer from atmosphere to soil.

Because of almost stable air pressure during the measurement period; the effect of air pressure on radon exhalation could not be evaluated. Kojima and Nagano have indicated that their experimental data show a poor correlation between the exhalation and atmospheric pressure, while an important role of the pressure has been emphasized by most authors [11].

Besides the daily fluctuations, seasonal fluctuations of radon concentration of soil gas were observed (Fig. 4). Radon concentrations are highest in the late winter and early spring, a period characterized by relatively wet, unstable weather, and are lowest in the fall, a season with typically dry, stable weather [12–14]. Correlation is seen clearly in comparison of monthly average radon concentration and temperature, humidity and pressure (Fig. 5).

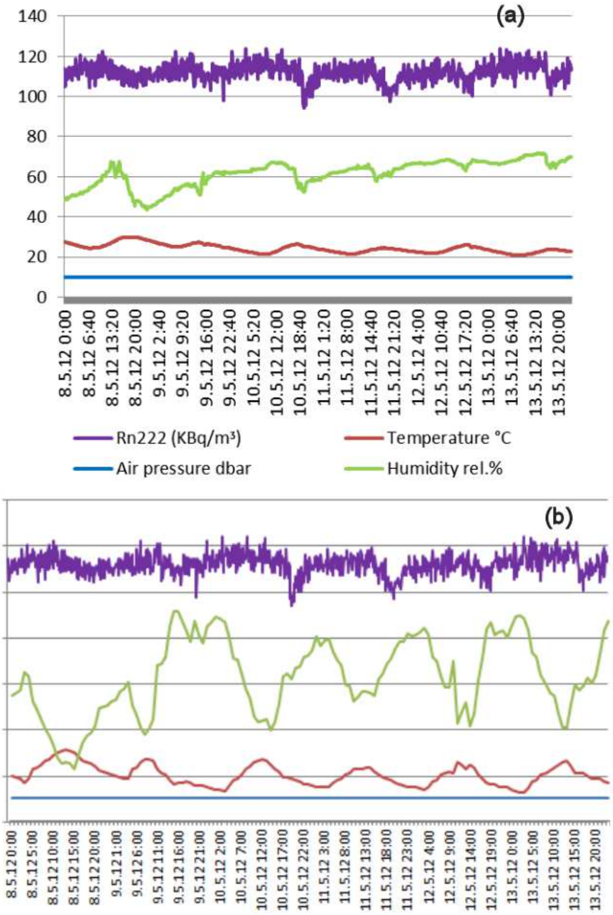

Fig. 3. Relationship between radon concentration and temperature, humidity and pressure: (a) soil parameters, (b) weather parameters.

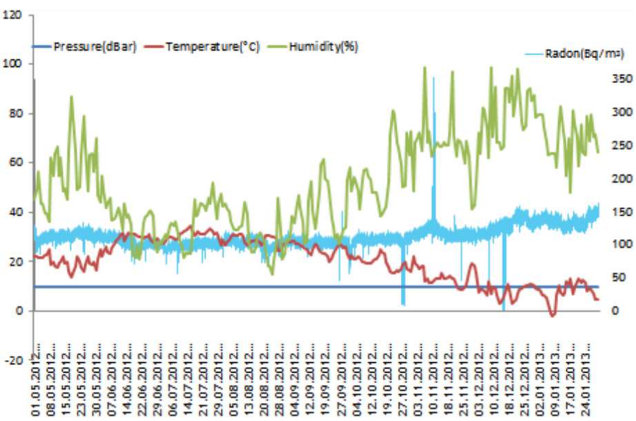

Fig. 4. Seasonal relationship between radon concentration and temperature, humidity and pressure.

In comparison with the effect of other meteorological parameters, it is seen that there is a significant correlation in relation of the exhalation rate with the precipitation (Fig. 6). It is found that the exhalation rates are

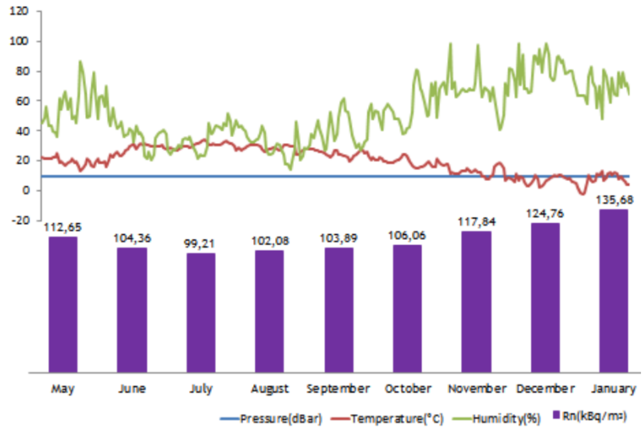

Fig. 5. Relationship between monthly average of radon concentration and temperature, humidity and pressure.

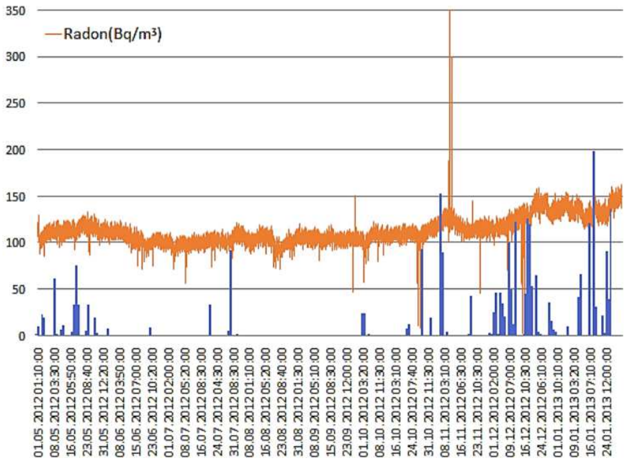

Fig. 6. Relationship between radon concentration and precipitation.

extremely reduced by a heavy rainfall, because the water fills the empty pores and reduces the diffusion of radon. After rainfall the exhalations are rapidly recovered and increased.

4. Conclusions

The measured values of radon concentration in soil gas were between 0.1 kBq/m^3 and 160 kBq/m^3. The lowest values were recorded after heavy rainfalls, when water may have caused the reduction of air permeability in soil. Also the highest values were observed at high humidity and low temperature values in winter. Radon is easily soluble in water but the solubility of radon decreases with temperature. Winter provides appropriate conditions for high solubility and radon dissolved in subsurface fluids may migrate over long distances. During the seasons of the high levels of radon, high indoor radon concentrations can be expected.

Acknowledgments

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References

[1] N.A. Uyanik, Z. Öncü, O. Uyanik, İ. Akkurt, *Acta Phys. Pol. A* **128**, B-441 (2015).

[2] N. Zaim, A.B. Tugrul, H. Atlas, B. Buyuk, E. Demir, N. Baydogan, N. Altınsoy, *Acta Phys. Pol. A* **130**, 64 (2016).

[3] B. Kunovska, K. Ivanova, Z. Stojanovska, D. Vuchkov, N. Zaneva, *Romanian J. Phys.* **58**, 172 (2013).

[4] E. Hauksson, *J. Geophys. Res.* **86**, 9397 (1981).

[5] C. King, *J. Geophys. Res.* **91**, 12269 (1986).

[6] H. Woith, *Eur. Phys. J. Special Topics* **224**, 611 (2015).

[7] T. Tsvetkova, I. Nevinsky, B. Suyatin, I. Akkurt, F. Kulali, *J. Radioanal. Nucl. Chem.* **307**, 169 (2016).

[8] R. Fujiyoshi, K. Sakamoto, T. Imanishi, T. Sumiyoshi, S. Sawamura, J. Vaupotic, I. Kobal, *Sci. Total Environ.* **370**, 224 (2006).

[9] F. Kulalı, I. Akkurt, N. Özgür, *Acta Phys. Pol. A* **130**, 496 (2016).

[10] F. Kulalı, İ. Akkurt, *Acta Phys. Pol. A* **128**, B-445 (2015).

[11] H. Kojima, K. Nagano, in *Proc. Radon in the Living Environment*, 19–23 April, 1999, Athens-Greece, p. 627.

[12] F. Ertuğral, H. Yakut, E. Tabar, R. Akkaya, N. Demirci, Z. Zenginerler, *Acta Phys. Pol. A* **128**, B-251 (2015).

[13] Z. Zenginerler, F. Ertugral, H. Yakut, E. Tabar, N. Demirci, K. Gunermelikoglu, *Acta Phys. Pol. A* **130**, 450 (2016).

[14] R.R. Schumann, D.E. Owen, S. Asher-Bolinder, *Factors affecting soil-gas radon concentrations at a single site in the semiarid western U.S.*, in: *Proc. 1988 E.P.A. Symposium on Radon and Radon Reduction Technology 2*, 1988.