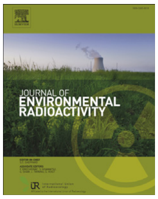
Journal of Environmental Radioactivity xxx (2016) 1–8

Contents lists available at ScienceDirect

Journal of Environmental Radioactivity

journal homepage: www.elsevier.com/locate/jenvrad



Indoor radon, geogenic radon surrogates and geology – Investigations on their correlation

H. Friedmann [a, *], A. Baumgartner [b], M. Bernreiter [c], J. Gräser [c], V. Gruber [c], F. Kabrt [b, e], H. Kaineder [d], F.J. Maringer [b, e], W. Ringer [c], C. Seidel [b], G. Wurm [c]

[a] University of Vienna, Faculty of Physics, Nuclear Physics, Währinger Strasse 17, A 1090 Vienna, Austria
[b] University of Natural Resources and Life Sciences, Vienna, LLC-Laboratory Arsenal, Faradaygasse 3, Arsenal 214, A 1030 Vienna, Austria
[c] AGES – Austrian Agency for Health and Food Safety, Radon and Radioecology, Wieningerstrasse 8, A 4020 Linz, Austria
[d] Federal Government of Upper Austria, Environment, Kärntnerstrasse 10-12, A 4020 Linz, Austria
[e] BEV – Federal Office of Metrology and Surveying, Arltgasse 35, A 1160 Vienna, Austria

ARTICLE INFO

Article history:
Received 17 November 2015
Received in revised form
20 April 2016
Accepted 20 April 2016
Available online xxx

Keywords:
Radon
Radon potential
Indoor radon
Geogenic radon surrogates
Radon correlated with environmental parameters

ABSTRACT

The indoor radon concentration was measured in most houses in a couple of municipalities in Austria. At the same time the activity concentration of radium in soil, the soil gas radon concentration, the permeability of the ground and the ambient dose equivalent rate were also measured and the geological situations (geological units) were recorded too. From the indoor radon concentration and different house and living parameters a radon potential (Austrian radon potential) was derived which should represent the radon concentration in a standard room. Another radon potential (Neznal radon potential) was calculated from the soil gas radon concentration and the permeability. The aim of the investigation was to correlate all the different variables and to test if the use of surrogate data (e.g. geological information, ambient dose equivalent rate, etc.) can be used to judge the radon risk for an area without performing numerous indoor measurements.

© 2016 Elsevier Ltd. All rights reserved.

1. Introduction

The identification of areas with enhanced radon risk is in most cases done by indoor radon measurements. The wide variation of the indoor radon concentrations demands a relatively dense measurement grid, in extreme, every house must be measured. To avoid such costly surveys it would be of main interest to find other indicators for areas with high risk for enhanced indoor radon concentrations. Indoor radon is, aside from construction properties, the result of a high radon concentration and a high permeability below the buildings. Radon (^{222}Rn) is a progeny of radium (^{226}Ra), uranium (^{238}U) resp. and therefore it seems to be obvious to correlate indoor radon with the soil gas radon concentration, the activity concentrations of uranium and/or radium in soil and the gamma dose rate from the ground. Moreover, it is common that certain rock types/geological units show a characteristic concentration in uranium, thorium, potassium and also grain size, permeability, porousness, hydraulic conductivity are sometimes well known. This raises the question if it is possible to use information from geology and perhaps from dose rate measurements as surrogates to determine the radon risk for areas. With this in mind, systematic investigations concerning the activity concentration of uranium and radium in soil, radon concentration in soil gas, permeability determination, ambient dose equivalent rate measurements and indoor radon concentration were performed in six municipalities in 2 regions in Austria (Upper Austria, Styria).

2. Methods

In three municipalities in Upper Austria the indoor radon concentration was measured in nearly all homes (~680 dwellings). The measurements were performed predominantly in living rooms and bed rooms by the use of SSNTD with an exposure time of 6 months (December/January until June/July). During spring and during

---

* Corresponding author.
E-mail addresses: harry.friedmann@univie.ac.at (H. Friedmann), a.baumgartner@boku.ac.at (A. Baumgartner), markus.bernreiter@ages.at (M. Bernreiter), valeria.gruber@ages.at (V. Gruber), franz.kabrt@bev.gv.at (F. Kabrt), heribert.kaineder@ooe.gv.at (H. Kaineder), franz-josef.maringer@boku.ac.at, franz-josef.maringer@bev.gv.at (F.J. Maringer), wolfgang.ringer@ages.at (W. Ringer), claudia.seidel@boku.ac.at (C. Seidel), gernot.wurm@ages.at (G. Wurm).

http://dx.doi.org/10.1016/j.jenvrad.2016.04.028
0265-931X/© 2016 Elsevier Ltd. All rights reserved.

Please cite this article in press as: Friedmann, H., et al., Indoor radon, geogenic radon surrogates and geology – Investigations on their correlation, Journal of Environmental Radioactivity (2016), http://dx.doi.org/10.1016/j.jenvrad.2016.04.028

autumn at 60 sites the soil-gas radon concentration, the permeability and the concentration of uranium (^{238}U), radium (^{226}Ra, ^{228}Ra), thorium (^{228}Th), lead (^{210}Pb) and potassium (^{40}K) were determined. Later on the ambient dose equivalent rate 1 m above ground was also measured. The sites could clearly be allocated to geological units. Because the selected municipalities showed a relatively uniform geological situation, next, three municipalities in Styria were selected which have a much more diverse geological background (Fig. 1). There the same types of investigations were made with in total 100 sites for soil analyses (40 during autumn, 60 during spring). Indoor radon concentrations were measured by SSNTD in 960 dwellings (~50% of all dwellings) with an exposure time in most cases of 6 months, half in winter- and half in summer-time. From the indoor data a radon potential (RP_A) was calculated as described in (Friedmann, 2005). This RP_A is the annual mean radon activity concentration in a standard room (living room at ground level, no basement, and several other standardized properties of the building and the social circumstances of the inhabitants). The RP_A should represent the geological radon risk for the site of the dwelling or by averaging over the dwellings within a certain area it should represent the (mean) geological radon risk for that area.

Generally, soil samples and soil gas samples could not be taken adjacent to the houses where indoor measurements were performed for different reasons (soil covered by anthropogenic work, permission for taking samples etc.). The selection of the sites was based on a broad variety of geological units in combination with accessibility and undisturbed soil structure.

Soil gas radon was measured with the system used in the Czech Republic (Neznal et al., 1991): A thin tube (diameter 12 mm) with a separate tip was hammered into the ground then slightly drawn back a few cm leaving the tip in the ground which opens the tube at the end. Firstly 200 ml gas were pumped out and discarded then a 100 ml gas sample was taken and the activity of the sample was measured either by an ‘Alpha Guard’ (Genitron Instruments) or by an ‘Atmos 12 DPX’ (Gammadata). Both instruments were calibrated with 100 ml samples of known ^{222}Rn activity because the soil gas samples did not fill the volume of the measurement instruments completely. At each site three measurements were performed at the corners of a triangle with a side length of approx. 1.5 m. A depth of 1.4 m was chosen for the soil gas samples to reduce meteorological influences on the soil gas radon concentration. In case it was not possible to get soil gas samples from a depth of 1.4 m then a correction was applied by assuming diffusion according to the Fick Law. The diffusion coefficient was taken as $D^* = 5\cdot10^{-2}$ cm^2 s^{-1} which in combination with the half-life of ^{222}Rn causes a diffusion length of 154 cm (Kemski et al., 1996). Values lower than the mean minus one standard deviation were eliminated for the risk of a dilution of the soil gas by atmospheric gas during the sample drawing. After the elimination of such outliers the mean value was used for further analysis (Kabrt et al., 2015).

From the same sample sources air was pumped out (about 1 L/min.) and the permeability could be computed according to (Damkjaer and Korsbech, 1992) from the measured flow rate, the pressure and the geometric parameters of the sampling probe (Seidel et al., 2011).

$$Q = F\cdot\left(\frac{k}{\mu}\right)\cdot\Delta p \qquad (1)$$

Q	flow rate (m^3/s)
k	permeability (m^2)
Δp	pressure difference (Pa)
μ	air viscosity ($1.75\cdot10^{-5}$ Pa s)
F	formfactor

$$F = \frac{2\pi l}{\ln\left(\frac{2l}{d}\sqrt{\frac{4D-l}{4D+l}}\right)} \qquad (2)$$

l	length of the sampling probe (m)
d	diameter of the sampling probe (m)
D	depth below surface (m)

Similar to the radon concentration in the soil gas the mean value for the permeability was used for the investigations.

From the soil gas radon concentration and the permeability another radon potential (RP_N) was calculated according to (Neznal et al., 2004; Neznal and Neznal, 2005) as

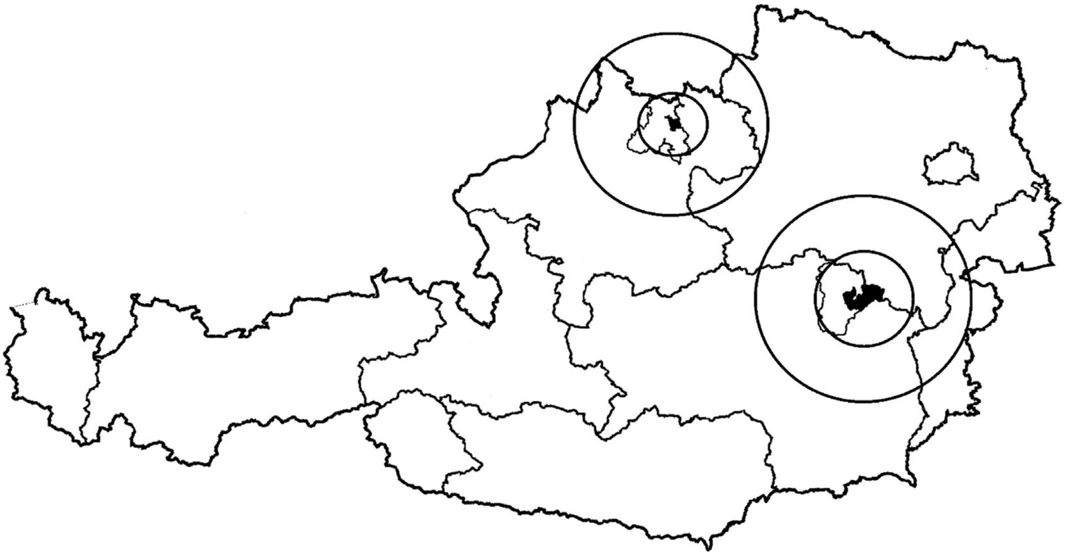


Fig. 1. Locations of the investigated areas in Austria.

Download English Version:

https://daneshyari.com/en/article/5477697

Download Persian Version:

https://daneshyari.com/article/5477697

Daneshyari.com