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Dynamics of soil gas radon concentration in a high permeable soil based on a long-term high-resolution measurement series

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One method of calculating Geogenic Radon Potential (GRP) is to estimate a continuous variable from the equilibrium concentration of ^{222}Rn in soil gas, in kBq/m^3 (C_∞) and the effective permeability of soil, in m^2 (k). These parameters can be determined during field work or can be estimated from other available parameters, such as ^{226}Ra concentration in dry soil (Bq/kg) or porosity, using transfer functions. Assuming short field measurement, temporal variation of soil gas ^{222}Rn concentration (c_{soilRn}) can cause difference of the measured value from C_∞ which should be considered during the evaluation. A long-term high-resolution observation can reveal various temporal features such as seasonality in c_{soilRn}. The main aim of this study was to determine the dynamics of c_{soilRn} in terms of trend, periodicity and transient event in a high permeable soil (1.5E-11 m^2) during a one year period.

We measured the c_{soilRn} in 15 minutes periods for one week in every month using RAD7 radon monitor coupled with soil probe (Durridge Company Inc.). The sampling depth was 80 cm. The measurement site was located in a Budapest urban area, Hungary. The underlying geological formation at the measurement site is Quaternary (upper Pleistocene) fluvial sediment, a Pleistocene diamicton (fluvial sand, gravel, clay). Robust statistical analysis and time series analysis were used for the characterization of radon dynamics in the studied high permeable soil.

Our results of statistical analyses showed seasonality in c_{soilRn}. We have observed statistically significant differences of c_{soilRn} between winter (from October to March) and summer measurements (from May to September). Medians of the c_{soilRn} data of summer weeks are lower than those of in winter. According to the Mann-Whitney (Wilcoxon) Test the medians of these two groups are significantly different at the 95% confidence level. The average of the median values for the winter season was 2.5 times higher (7.0 kBq m^{-3}) than for the summer season (2.8 kBq m^{-3}). The minimum and maximum values change together with the average value for each week as confirmed by correlation analysis. The calculated overall relative variability (MAD/median) was lower in the winter period (0.08) and almost two times higher in the summer period (0.16). Variability of c_{soilRn}, including the extreme values, also changes consistently with seasons between well-defined threshold values. Thus, the c_{soilRn} is predictable quite well from the observed data series. According to the natural breaks in the c_{soilRn} distributions of the measured periods, homogeneous groups were identified and their medians were compared using the resistant Mann-Whitney Test. Results showed that there is no a statistically significant difference between the medians of c_{soilRn} in May and August, May and June, October and January at the 95% confidence level, which clearly confirms the differences between the winter and summer periods.

These results show that in case of a GRP estimate from a single measurement on a high permeable soil the measured c_{soilRn} value has to be corrected to get the C_∞. The correction should be done according to the season considered.