Advances in radon mapping and radiological protection in Ireland

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Abstract

Radon is a naturally occurring gas, classified as a Class 1 human carcinogen, being the second most significant cause of lung cancer after tobacco smoking. Although radon is an important health issue, exposure can be mitigated if appropriate measures are implemented. In this context the EU developed Council Directive 2013/59/EURATOM in which strategies to reduce exposure to ionising radiation are defined. In terms of radon exposure to the general public, the main objective of this EU Directive is to reduce the number of cancer cases. It stipulates that national policies should consider the distribution of radon in the natural and built environments, as well as defining appropriate methods to designate radon priority areas.

We present a new high spatial resolution radon risk map of Ireland and estimate the probability of having an indoor radon concentration above the national reference level of 200 Bq m^{-3}. This is accomplished using logistic regression modelling of indoor radon measurements (n=31,910) with relevant geological information (i.e. bedrock and Quaternary geology, soil permeability and aquifer type). Ireland may be divided into three main risk categories: High, Medium, and Low, with probabilities of exceeding the national indoor radon reference level of 19%, 8% and 3%; respectively. The current population affected by high indoor radon concentrations is estimated at ca. 460 k (about 10% of the total population).

Using geostatistical techniques, we also estimate an average indoor radon concentration by Electoral Division. An indoor radon map was used to calculate an effective dose by Electoral Division, then combined with available census data to model the incidence of radon-related lung cancer. Average indoor radon concentrations by Electoral Division range from 21 to 338 Bq m^{-3}, corresponding to an effective dose ranging from 0.8 to 13.3 mSv y^{-1} respectively. The radon-related lung cancer cases per million people therefore range from 15 to 239 depending on the Electoral Division, giving a modelled national incidence of approximately 290 cases per year.

Our combination of methodologies represents a novel approach in the field of radiological protection, helping to define radon priority areas based on (1) indoor radon concentration, (2) geogenic factors and (3) modelled radon-related lung cancer incidence. Our results provide a new high spatial resolution utility which permits customised radon awareness information to be targeted at specific geographic areas.

Keywords. Natural hazards, radon, indoor radon, radon mapping, geogenic factors, lung cancer