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Utilizing multiple approaches for the definition of radon priority areas

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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. However, although radon is an important health issue it can be mitigated if appropriate measures are implemented. In this context, for example, the EU developed Council Directive 2013/59/EURATOM, in which strategies to reduce exposure to ionising radiation are defined. The main objective of a National Radon Action Plan is to reduce the number of cancer cases due to radon exposure, and it is based on the distribution of radon in the built environment and the definition of radon priority areas. Radon mapping will therefore help to detect radon-priority areas, and define a cost-effective and spatially targeted Radon Action Plan.

Due to the high number of dwellings tested in Ireland (31,910 geo-referenced indoor radon measurements were sampled in Ireland between 1992 and 2013 by the Environmental Protection Agency of Ireland), we have used Ireland as a case study for radon mapping producing three main maps; (1) a probabilistic map, (2) an average indoor radon map by Electoral Division (ED), and (3) a map showing the expected number of radon-related lung cancer cases. Collectively, these are used to define radon-priority areas.

The probabilistic map shows the percentage of homes having an indoor radon concentration higher than the national domestic reference level (200 Bq/m3), and was developed applying logistic regression models taking into account geological information (i.e. bedrock geology, Quaternary geology, subsoil permeability, and aquifer type). The average indoor radon concentration by ED (3,409 EDs, with individual population range from 66 to 38,900; ED areas range from 0.04 km2 to 162 km2) was estimated using geostatistical techniques. The average indoor radon map was used to calculate an effective dose by ED, then combined with available census data to model the incidence of radon-related lung cancer.

The methodology presented in this study therefore represents a novel approach in the field of radiological protection, helping to define radon priority areas based on a combination of (1) indoor radon concentration, (2) geogenic factors and (3) modelled radon-related lung cancer incidence. In this regard all three maps are distinct but complimentary. Results show that multiple methodologies can be effectively used in conjunction with each other in order to take account a variety of variables in the natural and built environment and with respect to human population systematics in order to define a cost-effective national Radon Action Plan.