EGU2020-7350
https://doi.org/10.5194/egusphere-egu2020-7350
EGU General Assembly 2020

Spatial Multicriteria Decision Analysis (SMCDA) for the construction of the European Geogenic Radon Migration map

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Radon generation, migration and exhalation into the atmosphere are natural processes that can lead to infiltration of radon into indoor environments, thus constituting a health risk. Analyses and models of these three processes can be used to create different maps depicting the potential of geological radon sources (GRS), geogenic radon migration (GRM), and radon exhalation (REX). The latter includes the first two processes, and be used to identify areas with increased radon levels in buildings (Radon Prone or Priority Areas, RPA). Here, we limit our analysis to the first two processes, and propose a spatial technique to map the contribution of some geological factors to the potential radon risk or geogenic radon potential (GRP) at European scale. The GRP can be understood as a measure of susceptibility of a location or of an area to increased indoor radon concentration for geogenic reasons.

The problem of estimating GRP has been examined over several years, using different multivariate statistical and spatial techniques. A number of direct and indirect models have been developed in order to create GRP maps (i.e., susceptibility maps) of a certain region by using both deterministic and probabilistic models. Direct models can be ascribed to multivariate regression of some predictors, but this was possible only at local scale where the response variables (i.e. soil gas radon and thoron) are available. The indirect mapping method integrates many factors and criteria and weighs the importance of the factors, based on subjective decision-making rules according to the experience of the geoscientists involved, or on multivariate statistical analysis.

In this work, we first propose to construct/create a GRP map at European level by using a GIS-based (spatial) multicriteria decision analysis (SMCDA) to quantify the geogenic contribution to indoor radon; and then, to create a European map of geogenic radon priority areas. SMCDA involves combining and handling of different criteria that determine the presence of a RPA, then uses the Analytical Hierarchy Process (AHP) to assess their importance and derives the relative weights for factors and criteria; finally it determines the overall final scores. The GRS map was derived by using a new lithological classification of the International Geological Map of Europe. Lithologies were ranked according to the mean content of uranium, thorium and potassium associated with each lithology. The GRS map was then coupled with maps of other parameters that serve as proxies for permeability, such as available water capacity and the fine fraction of the soil, the fault density and the map of the karst areas. All these maps were standardised by using the max score function and weighted by using AHP. A variance-based sensitivity analysis was conducted to define the uncertainty of the final map. In the absence of direct soil gas measurements, the final map was validated by using the indoor radon values collected by the JRC in the framework of the European Atlas of Natural Radiation. The work is conducted as a task within the framework of the European Metro RADON project (http://metroradon.eu/).