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Relationships between geogenic radon potential and gamma ray maps with indoor radon levels at Caprarola municipality (central Italy)

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Exposures to relatively high indoor radon (222Rn) levels represents a serious public health risk because Rn is associated with lung cancer (Darby et al., 2001; WHO, 2009; Oh et al., 2016; Sheen et al., 2016). The risk is high because radon, and its short-lived decay products in the atmosphere, contributes for about 60% of the total annual effective dose (UNSCEAR, 2000; WHO, 2009). Cancer risk is increased by smoking being almost 9 times higher than the risk to non-smokers exposed to similar levels (EPA, 2009). Due to these reasons, it is very important to assess the indoor exposure of public to radon and their daughters. Rn is a natural ubiquitous gas and its abundance is mainly controlled by the geology, and in particular by the soil and rock content of its parent nuclide (238U). Furthermore, bedrock characteristics (i.e. permeability and porosity) and also fault activity can affect the amount of Rn released in the ground (Ciotoli et al., 2007; Barnet et al., 2018). As such, in conditions of permeable and/or fractured bedrock and high uranium content, high indoor radon concentrations are expected (Bossew and Lettner, 2007; Gruber et al., 2013; Cinelli et al., 2015; Ielsch et al., 2017; Ciotoli et al., 2017). A non-natural contribution that controls the indoor Rn levels is home construction type and building materials (Vauptic et al., 2002; Appleton, 2007). Additionally, meteorological factors, such as wind, temperature and humidity, can affect the rate of Rn entry into the buildings (Porstendörfer et al., 1994; Miles et al., 2005; Schubert et al., 2018).
In this work, we propose a new geospatial technique to construct the geogenic radon potential (GRP) map of the Caprarola municipality (northern Lazio, central Italy) characterized by recent (about 100 Kyr) volcanic deposits with high content in radon parent nuclides (Ciotoli et al., 2017). GRP map has been obtained by using Empirical Bayesian Kriging Regression (EBKR) technique with soil gas radon, as the response variable, and a number of proxy variables (i.e. content of the radiogenic parent nuclides, the emanation coefficient of the outcropping rocks, the diffusive 222Rn flux from the soil, the soil-gas CO_2 concentration, the Digital Terrain Model (DTM), the permeability of the outcropping rocks and the gamma dose radiation of the shallow lithology. Furthermore, possible relationships between predicted soil radon values (i.e. GRP) and gamma radiation distribution with the indoor concentrations measured in private and public buildings has been investigated, respectively. The obtained results confirm that GRP maps provide the local administration of a useful tool for land use planning and that, the mapping of gamma emission, allows to a fast and effective evaluation of indoor radon hazard because it is mainly influenced by the building materials rather than other anthropic controls.