Exposure assessment and dose-response characterization are critical steps in the risk assessment of an environmental contaminant with potential human health effects. There are many established methods to conduct exposure assessments and to characterize the dose-response relationship between a contaminant of concern and a health outcome; however, many require extensive time and monetary resources that are becoming increasingly limited. Geostatistical methods are attractive approaches due to their cost-effective implementation and clear physical interpretations. Land use regression (LUR) is a type of geostatistical method that uses spatially-based explanatory variables to model outcomes using classical regression methods. Bayesian Maximum Entropy (BME) is a geostatistical framework for incorporating measurements as well as various knowledge bases in a logical and theoretically sound manner to produce estimates for variables of interest at unmonitored locations. This work advances these spatiotemporal geostatistical methods in the following three studies: 1) An exposure assessment of groundwater nitrate ($\text{NO}_3^-$), a biological nutrient with natural and anthropogenic sources that in excess has deleterious effects on human and ecological health; 2) An exposure assessment of groundwater radon ($^{222}\text{Rn}$), a naturally occurring gas with radioactively discharged alpha particles that are known human carcinogens; and 3) An epidemiological analysis of the association between groundwater $^{222}\text{Rn}$ exposure and lung and stomach cancer incidence.

First, we develop a nonlinear LUR model and then integrate the model into the BME framework to produce the first space/time exposure estimates of groundwater $\text{NO}_3^-$ concentrations across a large domain with a cross-validation $r^2$ of 0.74. Second, an exposure model for point-level groundwater $^{222}\text{Rn}$ is developed with anisotropic geological and uranium-based explanatory variables resulting in a cross-validation $r^2$ of 0.46. Lastly, we utilize the LUR-BME exposure model for $^{222}\text{Rn}$ to investigate associations with lung and stomach cancer at multiple spatial scales. It is the first epidemiological analysis of the association between groundwater $^{222}\text{Rn}$ exposure and lung cancer, moreover with a significant and positive association; and the first to find a positive association between groundwater $^{222}\text{Rn}$ and stomach cancer. This body of research provides advances in exposure assessment and dose-response methodology and practical real-world examples that can be used as resources for future cost-effective protection of public health.

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