Superfund Basic Research Program Annual Meeting
Dartmouth College
November 9-12, 2003

INTEGRATING SOIL pH AS A RISK FACTOR IN THE SPATIAL MAPPING OF ARSENIC DISTRIBUTIONS IN NEW ENGLAND GROUNDWATER

Seung-Jae Lee, Marc L. Serre, and George Christakos
Center for the Advanced Study of the Environment (CASE), Dept. of Environmental Science & Engineering, School of Public Health, Univ. of North Carolina-Chapel Hill, Chapel Hill, NC 27599

The spatial distribution of naturally occurring Arsenic (As) in the New England groundwater has become a considerable public health concern due to the relatively high As-levels observed recently at several private and certain public wells in New England. Our research plan is to employ the well-known Holistic Human Exposure Framework (HHEF) developed by our CASE group and successfully applied in various case studies during the last decade, including the population damage due to As in the Bangladesh drinking water and the assessment of North Carolina health effects due to PM10 exposure in space-time. HHEF is a systematic multidisciplinary/interdisciplinary human exposure framework that uses a stochastic environmental causal chain concept emphasizing functional relationships between contaminant exposure maps, physiology-based toxicokinetics, exposure-health effect relations, population dynamics, epidemiologic parameters and health risk assessment. In this presentation we focus on contaminant exposure mapping, which must take into account major sources of uncertainty introduced by the high natural variability of the geology in the area, the limited number of As-samples, the varying levels of measurement errors between samples etc.. The Bayesian Maximum Entropy (BME) technique of the HHEF is used to incorporate information available about soil pH in order to improve As-mapping across space. This information may take the form, e.g., of empirical laws between soil pH- and As-concentrations which are derived from pH- and As-databases at collocated locations in the area of interest or from regression relationships, whenever available. BME-base mapping generates accurate As-maps which provide estimates of As- concentrations at every unsampled location across space. Insight is gained by means of a synthetic case study involving simulated maps of pH- and As-values assuming a variety of possible pH-As laws. We found that our approach can lead to a substantial improvement of the mapping accuracy. We obtained, e.g., up to an 800 % increase in the RMSE drop as compared to a classical multivariate geostatistics approach. Furthermore, the synthetic study demonstrated the power of the proposed approach in a wide range of exposure applications involving contaminants for which relationships with covariate risk factors are available. We then applied the BME technique to construct spatial maps of naturally occurring As-concentrations in the New England groundwater using measurements at 1,359 wells and soil pH-data from 773 samples. Future investigations will focus on subsequent stages of the HHEF as described above, thus leading to a science-based health risk assessment of As-exposure in New England.