Moving from protecting health to protecting the environment

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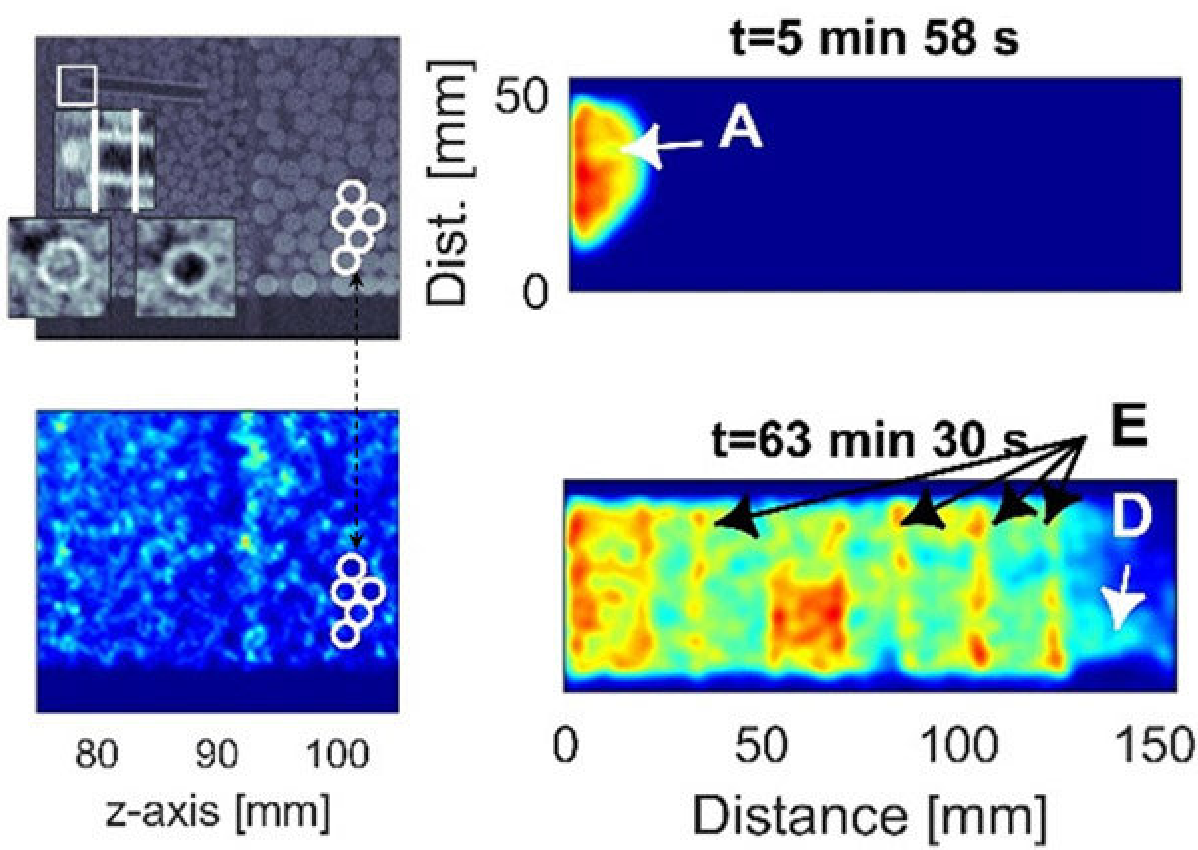

To understand how radioisotopes move through soils, scientists used the same imaging techniques used to track the isotopes during medical tests, focusing on transport across interfaces. The research used different types of CAT scans of interfaces in a column containing different size beads (in the picture on the top left, white circles are 2-millimeter beads) to understand the flow and accumulation of radioactive species. Areas of higher radioactivity are indicated by the blue regions in the lower left picture. In the time-lapse images on the right, local (A) and global (D) non-uniform flow phenomena are observed (mm=millimeters, t=time). In the lower right image, the "E" indicates the location of filter papers in the column. Credit: US Department of Energy

Disposing of nuclear weapons production waste is important to national security. Knowing how technetium and other isotopes behave at subsurface storage sites is vital. Previous studies of radionuclide mobility have been limited to after-the-fact destructive sampling of the soil. This study adapted two well-known medical imaging techniques to perform non-destructive analysis. SPECT (single-photon emission computed tomography) imaging revealed non-uniform transport. X-ray computer tomography correlated pores and other structural features.

This study showed that combining these common medical imaging techniques offers sufficient resolution for non-invasive imaging of transport processes in soil and rock. It also provides insights to preferential flow paths and reactive transport. This work could lead to better large-scale predictions of the release and transport of radioactive isotopes. Understanding how isotopes move is vital for risk analysis of subsurface waste disposal.

Existing techniques for understanding radionuclide transport in the environment do not fully capture the 3-D complexity of transport in soil and waste forms. To understand the influence of coupled processes on transport in the environment, a team led by researchers from Clemson University combined medical imaging techniques to monitor dynamic radionuclide experiments in mixtures of soil and glass beads. They used soil and glass beads as a model to investigate the viability of these imaging techniques for studying the potential environmental transport if waste forms failed or were breached. They combined commonly used

SPECT (single-photon emission computed tomography) with well-established X-ray computer tomography (CT). The time-lapsed SPECT images illustrated both local and global non-uniform transport phenomena, and the high-resolution CT data allowed for correlations of non-uniformity with structural features within the materials, such as macropores.

This combined data can be efficiently used to detect fractures, macropores, and permeability variations as well as non-uniform flow paths. Direct imaging of concentration changes during transport can allow for testing and refinement of models describing how radionuclides interact with geologic and human-made materials. These insights could further our fundamental understanding of biogeochemical processes in porous media, which is important in large-scale environmental risk analyses.

More information: Mine Dogan et al. High-Resolution 4D Preclinical Single-Photon Emission Computed Tomography/X-ray Computed Tomography Imaging of Technetium Transport within a Heterogeneous Porous Media, *Environmental Science & Technology* (2017). DOI: 10.1021/acs.est.6b04172

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