PLUME-SCALE TESTING OF A SIMPLIFIED METHOD FOR DETECTING TRITIUM CONTAMINATION IN PLANTS AND SOIL

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Cost-effective methods are needed to detect contamination near radioactive-waste and other contaminated sites. Such methods should be capable of providing an early warning of contaminant releases and should be accurate and robust enough for assessing the long-term performance of waste-isolation facilities and remediation measures. Recently, a simplified method for detecting tritium contamination in plants and soil was developed (1). The method includes solar distillation of plant water from foliage, followed by filtration and adsorption of scintillation-interfering constituents on a graphite-based solid-phase-extraction column prior to direct-scintillation counting. The objectives of the in-progress study described here are to (i) test the simplified contamination-detection method for collection and analysis of plume-scale tritium data and (ii) gain insight into tritium migration pathways and processes.

Plume-scale testing is being done at the Amargosa Desert Research Site (2) under the auspices of the U.S. Geological Survey Toxic Substances Hydrology Program (3). Creosote bush (*Larrea tridentata*) samples were collected within a 63-ha area adjacent to a closed low-level radioactive waste facility (Figure 1). The data show elevated plant-water tritium concentrations up to 440 m from the waste facility. The maximum value is 4,890 Bq L^{-1}. Background values average 2.5 Bq L^{-1}. "Hot spots" identified by plant data have been verified by soil-water vapor measurements.

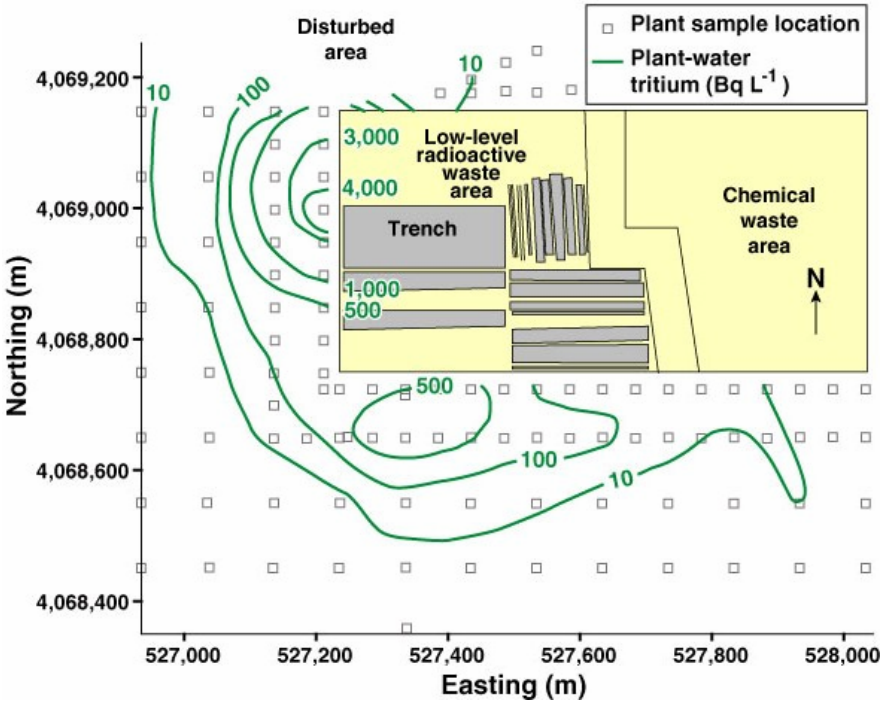

Figure 1. Plant sample locations and contours of plant-water tritium concentrations.

Geostatistical analyses (4) are being used to further evaluate the plant data and to generate a more complete map of estimated tritium concentrations. Semivariogram analysis indicates the plant-tritium concentrations are spatially correlated (effective range of about 380 m) and measurement error accounts for < 1% of the total variability in the data. Similar to the simple contour map (Figure 1), the plant-concentration map generated using ordinary kriging shows "hot spots" to the west and south of the waste facility (Figure 2a). The associated prediction errors are small (typically < 0.2 $\log_{10}$ Bq L^{-1}; Figure 2b).

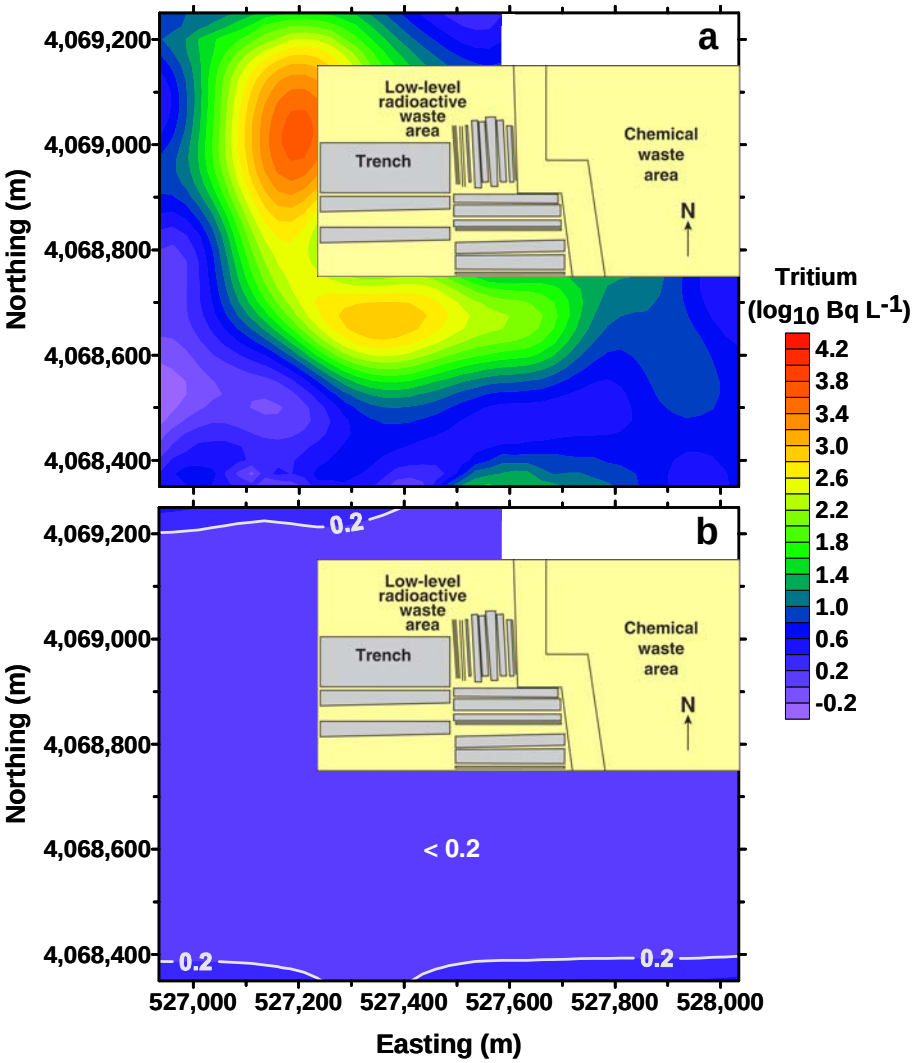

Figure 2. Maps of (a) kriged plant-water tritium concentrations and (b) associated kriging standard errors.

Regression analysis of measured tritium concentrations from several collocated plant- and soil-sampling sites indicates that empirical relations can be developed to predict subsurface concentrations from the more simply determined plant-water concentrations. For this study, samples collected from soil-gas tubes installed to depths of 0.5 and 1.5 m are used to develop regression equations for root-zone and sub-root-zone soil concentrations, respectively. The spatial distribution of subsurface tritium then is estimated by combining the kriged plant concentrations with the appropriate regression equation. Resultant maps of regressed soil-water vapor tritium in the root zone and sub-root zone are shown in Figures 3a and 3b, respectively.

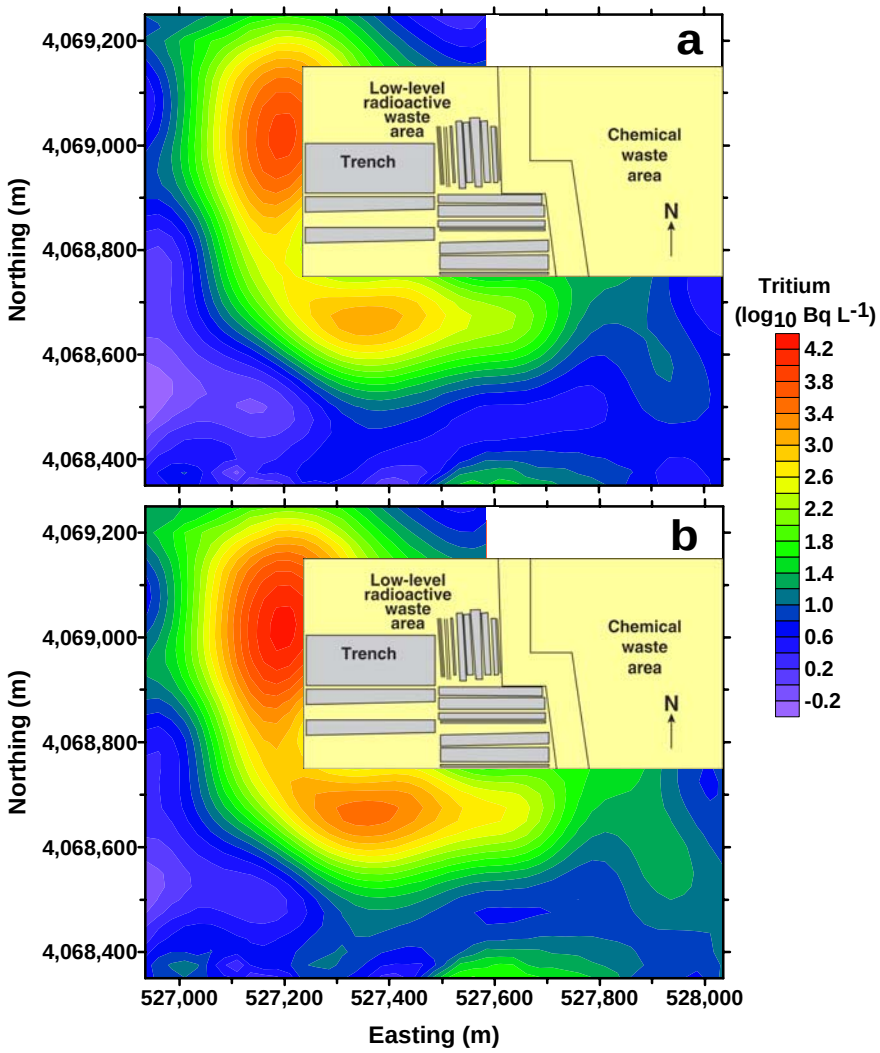

Figure 3. Maps of regressed soil-water-vapor tritium concentrations in the (a) root zone (about 0- to l-m depth) and (b) sub-root zone (about 1- to 2-m depth).

A comparison of tritium concentrations in Figures 2a, 3a, and 3b indicates that, for any given location within the contaminant plume, the greatest concentration occurs in the sub-root-zone soil layer (gravelly sand). These results are in agreement with field measurements. Mapped and measured results indicate preferential movement of tritium away from the waste source occurs in the coarse textured layer beneath the root zone, from which it moves upward and is subsequently released to the surface environment. Numerical models have been unable to replicate the lateral extent of tritium migration observed at the site; model predictions underestimate the observed transport by about one order of magnitude or more (5, 6). The discrepancy between observed and predicted transport remains an intriguing scientific problem. Understanding the relevant processes is critical to effective containment and long-term monitoring of contaminated sites.

In summary, results of this in-progress study indicate the simplified contamination-detection method can facilitate collection and analysis of plume-scale tritium data. The method provides a volume-integrating (versus point) sample approach, and it reduces equipment costs and time. Collection and preparation of plant samples for tritium analysis requires one-fifth the time of

soil-gas samples. The method also is proving useful in improving understanding of contaminant migration pathways away from the waste facility. The greatest source of uncertainty in the plume-scale application of the method is the use of empirical relations to extrapolate from plant- to subsurface-contamination. Other, relatively minor sources of uncertainty are those associated with the solid-phase extraction and solar-distillation of plant water (1). Creosote bush was selected for use in this study because it is the dominant plant in North American warm deserts. However, the simplified contamination-detection approach reported here may be transferable to additional species and environments. To evaluate transferability, site-specific testing is needed to choose the appropriate solid-phase-extraction column for the plant water of interest, and to develop and evaluate the accuracy of predictive relations between plant and subsurface tritium concentrations. Depending on the objectives and results of such testing, the end-user may have options to use the method as a general indicator or a quantitative predictor of subsurface contamination.

References

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