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RADIONUCLIDE TRANSPORT FROM AN ARRAY OF WASTE PACKAGES IN A GEOLOGIC REPOSITORY

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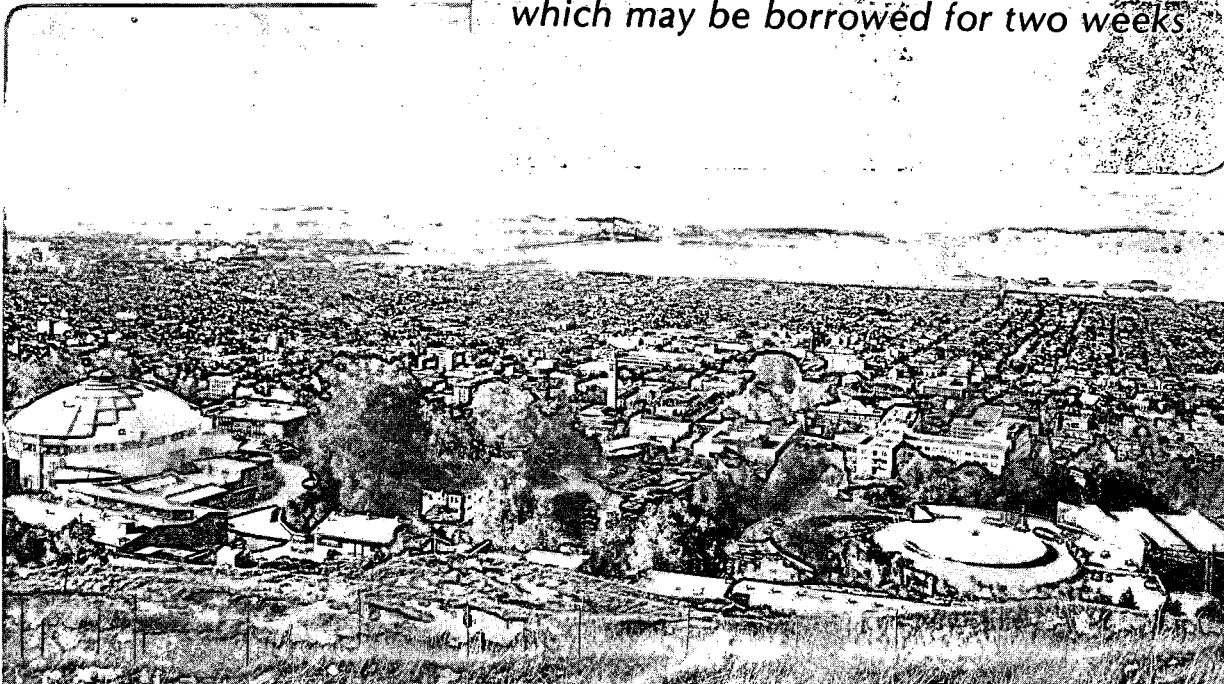
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C.L. Kim, P.L. Chambré, W.W.-L. Lee,  
and T.H. Pigford

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RADIONUCLIDE TRANSPORT FROM AN ARRAY OF WASTE PACKAGES  
IN A GEOLOGIC REPOSITORY

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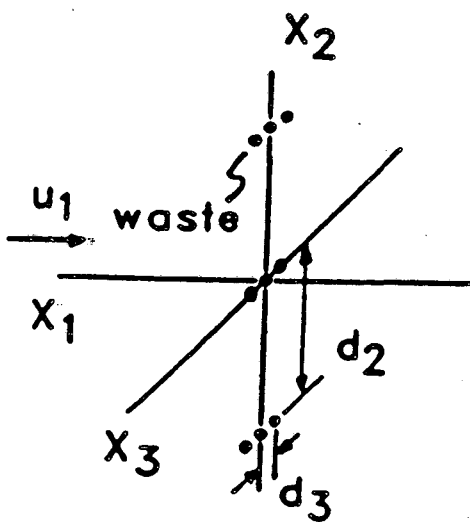
Nuclear waste in geologic repositories will be emplaced in thousands of individual containers. In evaluating radionuclide transport in performance assessments, will it be necessary to consider each individual waste packages in the array, or can the array be represented by an equivalent planar source? In this paper we consider the problem of space and time-dependent radionuclide concentration field resulting from an array of point sources in a water-saturated environment. First, we derive the diffusion-controlled, solubility-limited dissolution rate from a spherical-equivalent waste source and we then obtain the analytic solution for the concentration field from a single source. The analytic solution for the space-time-dependent concentration field from an array of point sources is obtained by superposition of single-source solutions. Our solutions are valid for advective transport in porous media with either isotropic or anisotropic dispersion. Numerical and graphical illustrations are provided.

The solutions are general, but for illustration we consider here a planar array of point sources perpendicular to the direction of ground-water flow, as shown in Figure 1. Figure 2 shows the concentration field around the planar array at local steady-state, after about 1,000 years, assuming a ground-water

pore velocity of 1 m/yr, a longitudinal dispersion coefficient of 50 m<sup>2</sup>/yr, a transverse dispersion coefficient of 5 m<sup>2</sup>/yr, and neglecting sorption and decay. The isopleths are for 0.01 g/m<sup>3</sup>. The plumes from all 9 point sources have merged, forming one large, irregularly-shaped plume.

In Figure 3, we consider the effect of larger arrays and whether an infinite-plane source approximation can adequately represent the array of individual point sources. The abscissa is the distance downstream from the array. The ordinate is the actual steady-state nuclide concentration along the X<sub>1</sub> axis of Figure 1, obtained by considering individual point sources normalized to the concentration predicted by an equivalent infinite-plane source, of the same areal dissolution rate. If this ratio is less than unity, the simpler infinite-plane source model overestimates and is conservative. Near the waste packages (X<sub>1</sub> < 1 m) the effect of individual sources is significant. For arrays containing as many as 31 x 31 packages or more, there exists a plateau, at a concentration ratio of unity, wherein the array solution is identical with that from an infinite plane source. The plateau region increases with array size. For finite arrays, and at increasing downstream distances, the centerline concentration falls below that of the infinite-plane source because of transverse dispersion. In this region the concentration field for the array can be adequately predicted by replacing the array with a finite equivalent plane source at the same total source strength as the array.

Similar analyses are being conducted for other point source orientations.



$d_2 = \text{pitch along } X_2 \text{ axis} = 36.6 \text{ m}$   
 $d_3 = \text{pitch along } X_3 \text{ axis} = 3.66 \text{ m}$

Figure 1. Point sources on a plane

\* Point source location  
3 x 3 Array  
Source strength = 0.45 gr/yr  
Ground water velocity = 1 m/yr  
No sorption  
Porosity = 0.05  
Longitudinal Dispersion =  $50 \text{ m}^2/\text{yr}$   
Transverse Dispersion =  $5 \text{ m}^2/\text{yr}$

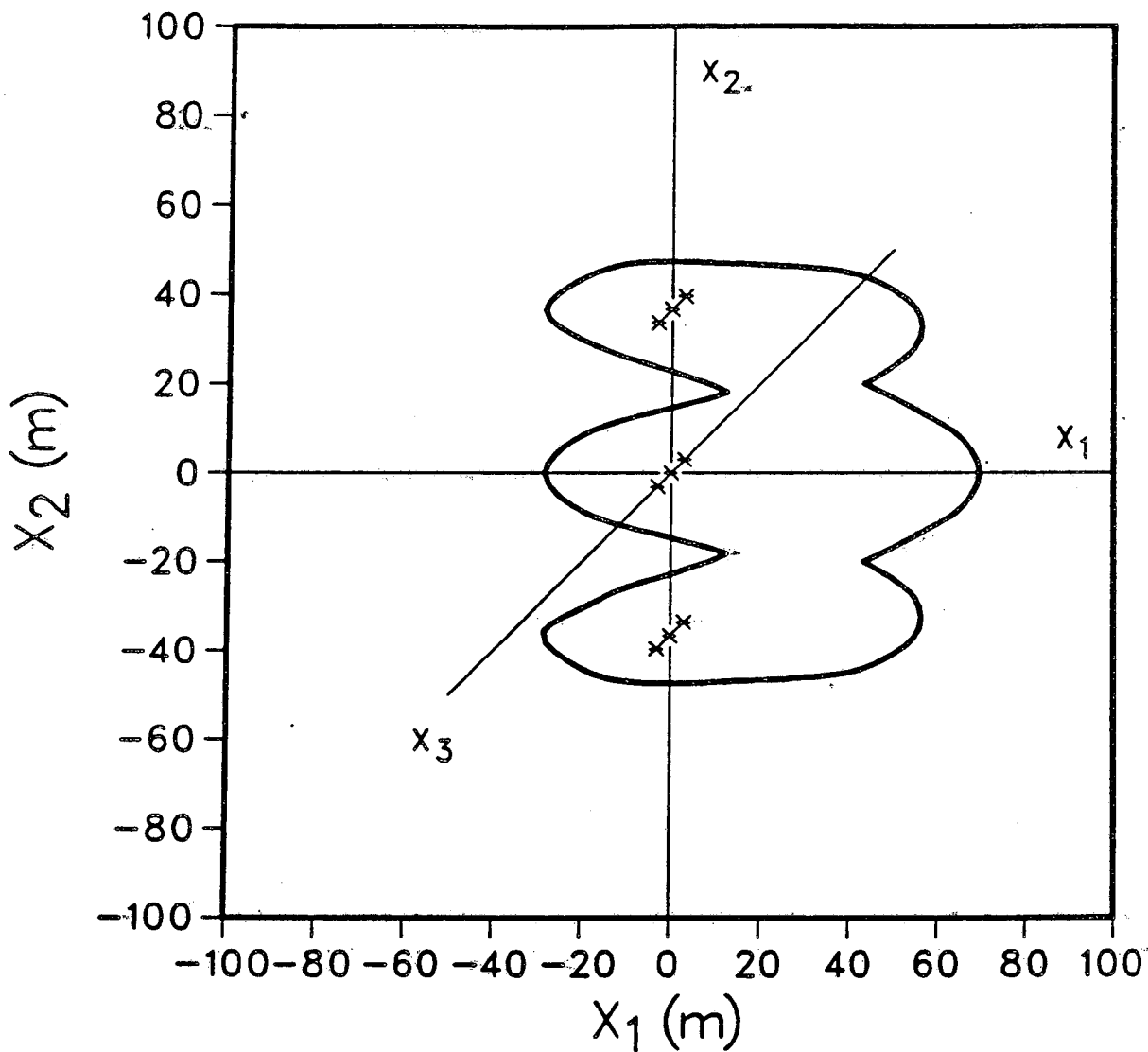


Figure 2. Isopleths of stable species at  $0.01 \text{ g/m}^3$ ,  
at local steady-state



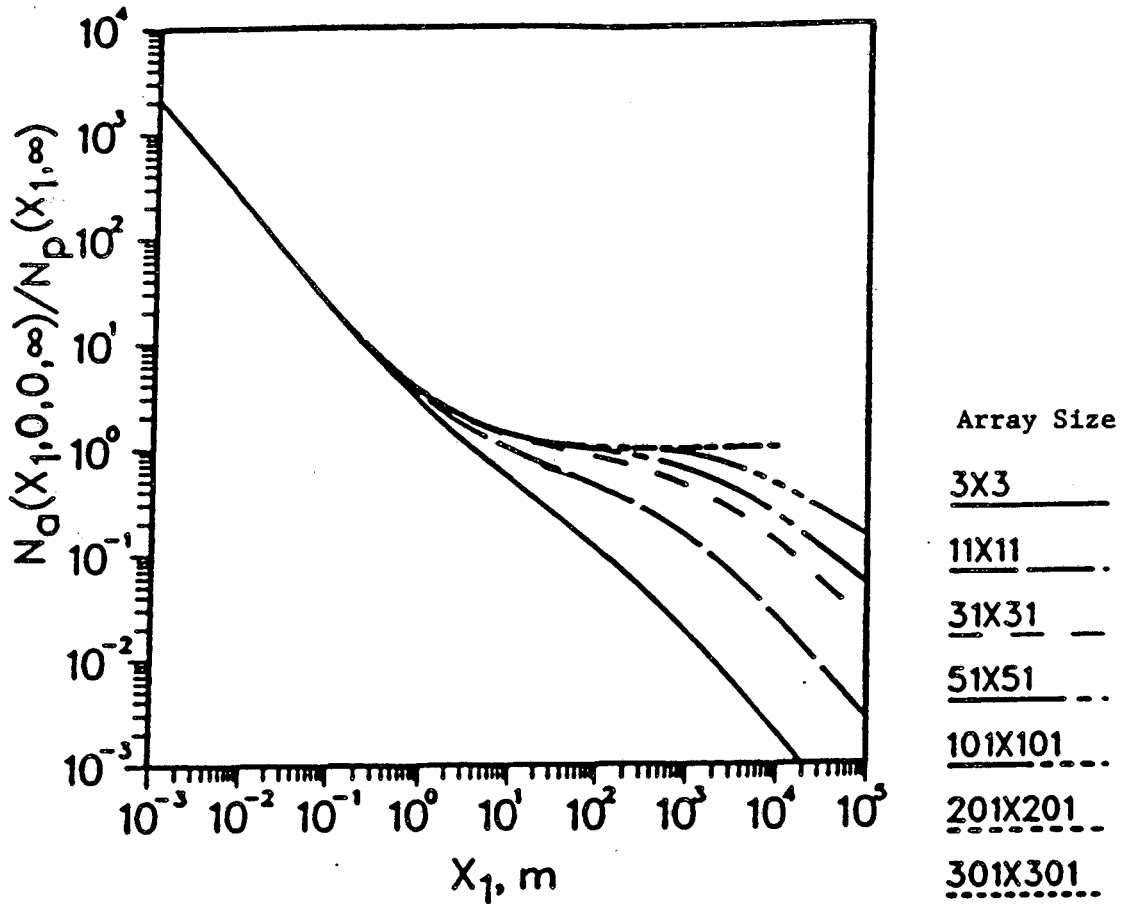


Figure 3. Comparison of concentration from array model with concentrations from an infinite-plane model. Conditions are the same as in Figure 2.

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