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SELECTION OF LOW-LEVEL RADIOACTIVE WASTE DISPOSAL SITES USING SCREENING MODELS VERSUS MORE COMPLEX METHODOLOGIES

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ABSTRACT--The task of choosing a waste-disposal site from a set of candidate sites requires an approach capable of objectively handling many environmental variables for each site. Several computer methodologies have been developed to assist in the process of choosing a site for the disposal of low-level radioactive waste; however, most of these models are costly to apply, in terms of computer resources and the time and effort required by professional modelers, geologists, and waste-disposal experts. We describe how the relatively simple DRASTIC methodology may be used for "pre-screening" of sites to determine which subset of candidate sites is worthy of more detailed screening. Results of site comparisons made with DRASTIC are compared with results obtained using the PRESTO-II methodology, which is representative of the more complex release-transport-human exposure methodologies.

This paper compares the results of evaluations of two radioactive waste disposal sites, one operating and the other proposed, obtained through two methodologies, DRASTIC (Aller et al., 1985) and PRESTO-II (Fields et al., 1986). These methodologies require greatly different amounts of time and computer resources to apply. We expect that the larger data base and more comprehensive methodology of PRESTO-II translates into a more extensive set of predictions, with smaller uncertainties in the results than those in the results obtained using DRASTIC. Nevertheless, DRASTIC is far cheaper to apply, and we expect that its results would quite adequately reflect major differences between sites, if such major differences exist. Our thesis is that, if comparative results can be obtained with the two quite different methodologies, a significant cost savings can be had by "pre-screening" sites with the simpler methodology. Only those sites that appear to be among the best choices would then be considered using the more complex methodology.

DRASTIC is a standardized system for evaluating groundwater pollution potential using hydrogeologic settings (Aller et al., 1985). This relative ranking scheme uses a combination of weights and ratings to produce a numerical value, called the DRASTIC index, which helps to evaluate areas with respect to groundwater contamination vulnerability. Water, principally from precipitation, is often the primary transport medium for radioactivity from low-level waste stored in shallow trenches. The DRASTIC system may be useful in assisting planners, managers, and administrators in the task of evaluating the relative vulnerability of areas to groundwater contamination from low-level waste disposal sites.

The present study compares the simulation results of PRESTO-II with those of the DRASTIC system. This study also tests the validity and applicability of DRASTIC system to identify areas appropriate for low-level waste disposal sites.

METHODS

DRASTIC System--The factors used in the DRASTIC system were the distance from the ground surface to the region below the ground level where all the pore spaces are filled with water (the water table), the net recharge of water per unit area of land which penetrates the ground surface and reaches the water table, the composition of the aquifer medium, the composition of the soil media, the slope and slope variability of the land surface, the physical properties of the zone above the water table which is unsaturated, and the hydraulic conductivity of the aquifer. The depth of the water table affects the quantity of radionuclides moving toward an aquifer. If the zone above the water table is comprised of clay, sorption will be moderately high, infiltration will be moderately low, retardation will be significant, and water-pollution potential will be low. The net recharge of water per unit area of land which penetrates the groundwater surface and reaches the water table is a very important parameter. It determines the dispersion and dilution of radionuclides. For example, the greater recharge means more rapid transport of radionuclides but a decrease in concentration. Topography and soil media also affect the net recharge.

PRESTO-II Methodology--PRESTO-II (Prediction of Radiation Effects from Shallow Trench Operations) is a computer code designed to evaluate possible doses and risks from shallow-land and waste-disposal trenches (Fields et al., 1986). PRESTO-II is intended to serve as a non-site-specific screening model for assessing radionuclide transport, ensuing exposure, and health impacts to a static local population for a 1,000-year period following the end of disposal operations. Human exposure scenarios include normal releases (including leaching and operational spillage), human intrusion, and limited site farming or reclamation. Pathways and processes of transit from the trench to an individual or population include groundwater transport, overland flow, erosion, surface-water dilution, suspension, atmospheric transport, deposition, inhalation, external exposure, and ingestion of contaminated beef, milk, crops, and water. The complex hydrologic and atmospheric pathways considered in the PRESTO-II model are shown in Fields et al. (1986). The PRESTO-II model performs a deterministic calculation based on conceptual models of physical processes that determine pollutant transport and human exposure. It permits a much

more complete description of the site than does the DRASTIC system, but with an attendant cost in data set preparation and model complexity.

Site Description--The Barnwell low-level radioactive disposal facility is located 8 km west of the town of Barnwell, South Carolina. The climate near Barnwell is relatively mild. The monthly temperatures range from 9 to 27°C for January and July, respectively (United States Nuclear Regulatory Commission, 1982). Most of the annual precipitation occurs in the summer with a mean total of 1.13 m. The atmosphere around the site is considered to be relatively stable (Pasquill-Gifford classes D and E). Topsoil of the region is generally loamy sand, while the subsurface region is generally clayey, fine to coarse sand.

The Koteyli, Balikesir, site is in the southern Marmara region of Turkey. Precipitation, as snowfall, occurs mostly in the winter with a total mean of 0.723 m/year (Devlet Su Isleri Genel Mudurlugu, 1984; Uslu et al., 1988). The annual average temperature is 14.5°C, and maximum annual temperature is 43.7°C with an annual average relative humidity of 68%. The depth of the water table is 17.1 m. Topsoil of the region is generally sandy, and below the surface is generally limestone.

Calculations--A numerical ranking system to assess groundwater pollution in hydrogeologic settings has been devised using the DRASTIC factors. The system for determining a rating for a given site contains three significant parts: weights (W_i), ranges (R_i), and hydrogeologic feature ratings (F). The ratings are calculated using equations of the form $F = \Sigma_i W_i R_i$. In this equation, i is an index identifying each hydrogeologic feature, and individual feature ratings are summed to determine a site rating. After identifying the region in which the area is located and the hydrogeologic setting that most closely approximates the conditions of the area, ranges and ratings for the area are found. The approach presented by Aller et al. (1985) has been used to evaluate available area information for each DRASTIC parameter.

Results and Discussion

The evaluation results from DRASTIC for the two sites examined are given in Table 1. The DRASTIC index was calculated as 71 for the Barnwell site and 89 for the Koteyli site. The higher the DRASTIC index is, the greater the groundwater pollution potential is. DRASTIC yields a relative numerical value which can be compared to a value obtained for another setting either in the same region or in a different region. Thus, the groundwater pollution potential is higher in the Koteyli site relative to the Barnwell site.

Similar relative water pollution potentials were obtained using the PRESTO-II computer code, and simulation results of annual intake by ingestion for both sites are given in Fig. 1. Using the same radionuclide data, annual intake from ingestion at the Koteyli site is higher than that at the Barnwell site; however, values are approximately equal in the case of annual intake by inhalation. Results of the simulations suggest that there would be, in comparison to background health risks, little health impact associated with burying these wastes in a low-level waste disposal area at either site.

To date, there are >108 groundwater transport models available (Science Applications, Inc., 1980), and these span a wide range of complexity and application expense. Site selection by using complex computer codes is expensive due to processing time required to simulate the model; furthermore, the data for every proposed site are sometimes not available. During site selection, there are various considerations regarding disposal. The main purpose of this study was to consider if one might reduce the number of site alternatives using the DRASTIC system and then use the PRESTO-II computer code for precise site-selection analysis of selected disposal sites. It would be useful to investigate the distribution of DRASTIC scores for different sites versus the range of doses and health risks predicted using PRESTO-II. Such a study would more rigorously evaluate the applicability of DRASTIC.

Acknowledgments

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TABLE 1. Ranges and ratings for Barnwell site, South Carolina (B), and Koteyli, Balikesar, site, Turkey (K).

Feature	Range		Weight	Rating		Number[1]	
	B	K		B	K	B	K
Depth of water	30-50	50-75	5	5	4	25	20
Net recharge	0-2	0-2	4	1	1	4	4
Aquifer media	Sandstone, limestone	Massive shale	3	4	3	12	9
Soil media	Sandy loam	Sandy	2	6	9	12	18
Topography	2-7	6-10	1	5	5	5	5
Impact on vadose zone	Silt and clay	Bedded limestone	5	2	6	10	30
Hydraulic conductivity	1-100	1-100	3	1	1	3	3

[1]DRASTIC index = 71 for Barnwell site and 89 for Koteyli site.

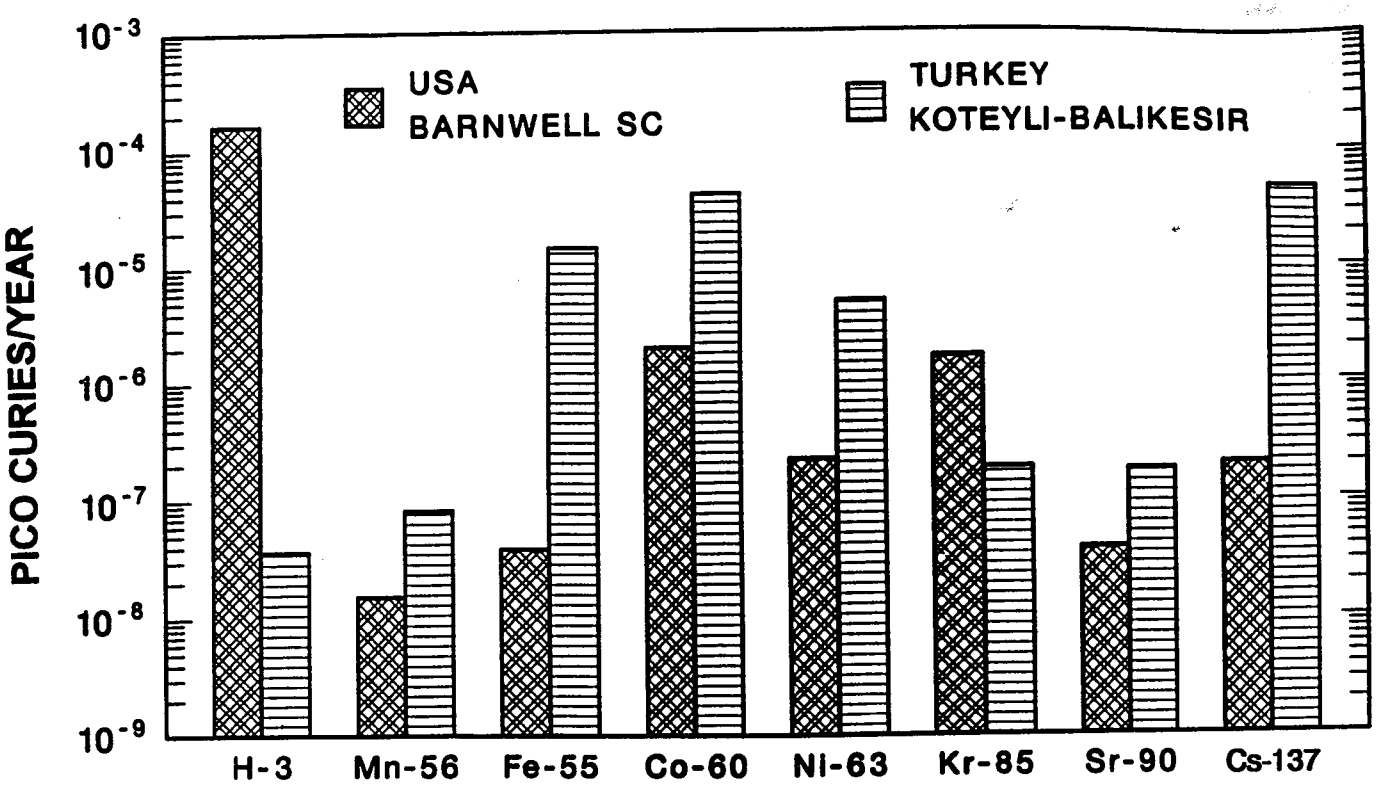

FIG. 1. Yearly radionuclide ingestion as estimated using PRESTO-II methodology.

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