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Poison in the Vadose Zone: An examination of the threats to the Snake River Plain aquifer from the Idaho National Engineering and Environmental Laboratory

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In order to determine the threat to the Snake River Plain aquifer from nuclear weapons production wastes at INEEL, we compiled and analyzed the available data on the current contamination in the vadose zone, which is the area between the ground surface and the water table, and the aquifer at INEEL. We found that the radionuclides and hazardous chemicals in the waste are polluting the Snake River Plain aquifer. The aquifer faces further contamination from the rapid migration of these contaminants in the wastes buried at the site.

Groundwater contamination can occur in plumes or in a more scattered and unpredictable fashion. The movement of contaminants depends on the pollutants in question, the methods of their discharge, and their interaction with the environment.

There are currently several contaminant plumes, or zones of polluted groundwater, in the Snake River Plain aquifer, including plumes of tritium, strontium-90, iodine-129, and trichloroethylene (TCE). Some areas of these plumes are contaminated above the maximum contaminant level (MCL) set by the U.S. Environmental Protection Agency under the Safe Drinking Water Act. This water is not currently being used for drinking. However, comparing the level of contamination to drinking water standards indicates the future usability of the water if site control is lost or if all or part of the site is used for civilian purposes, as is being done at several other DOE sites.

The two main point sources for these plumes are injection wells and percolation ponds. Until the mid-1980s, radioactive wastewater at INEEL was injected directly into the aquifer. When the injection wells were taken out of service, they were replaced with unlined percolation ponds. Wastewater discharged into these ponds migrates to the aquifer on the order of days to months. Water from percolation ponds can also mobilize other contaminants in the vadose zone to move more quickly to the aquifer.

Soil and groundwater measurements since 1972 show that plutonium and americium are also in the vadose zone and the aquifer, though no pattern or plume has been established. The main source of plutonium and americium is the large volume of transuranic waste that was dumped into shallow pits and trenches from 1952 until 1970.

It was assumed that a mechanism called ion-exchange in the soil would retard the migration of plutonium, preventing it from reaching aquifers for tens of thousands or even hundreds of thousands of years. The data show that transuranic waste is actually migrating to the aquifer on the order of tens of years - one thousand times faster than anticipated.

Radionuclides that are the longest lived, with half-lives of more than 100 years, present the most serious long-term risk in agricultural regions, such as Idaho. This is because they will not decay significantly relative to the speed of migration off the site. These radionuclides, including americium-241, plutonium-239, and iodine-129, have the potential to migrate well beyond the site boundaries before significant decay. For example, americium-241 has a half-life of 432 years. Water in the aquifer travels from under INEEL to the Magic Valley, southern Idaho's most productive agricultural region, in about half that time.

Some americium-241 has already migrated through the vadose zone into the aquifer. The highest concentration of americium-241 found in the groundwater was 1.97 picocuries per liter in 1997. The levels of americium-241 are still below the maximum contaminant level, which is 15 picocuries per liter. However, considering that the amount of time that has elapsed since the waste was buried is far shorter than a single half-life of americium-241, and that knowledge about transuranic radionuclide migration has many gaps, it is not possible to predict the fate of the americium-241 with confidence.

The evidence from groundwater sampling indicates that plutonium migrates far more slowly than americium. Nonetheless, plutonium migrates through the vadose zone to the aquifer orders of magnitude faster than those assumed by the policy of shallow-land dumping. The half-life of plutonium-239 - more than 24,000 years - is far longer than that of americium-241. Measurements of plutonium-239/240 as high as 24 picocuries per liter have been reported. The maximum contaminant level for plutonium-239/240 is 15 picocuries per liter. In addition, the buried waste contains more than a metric ton of plutonium-239/240, which is enough to make about 200 nuclear bombs. Therefore, the long-term risks of leaving plutonium in the buried wastes are substantial from both the environmental and the security points of view.

There is some controversy about whether the data on plutonium are valid. However, plutonium has also been detected deep in the vadose zone, which further verifies that plutonium is rapidly migrating. As early as 1976, plutonium-239/240 concentrations in sediments from wells were found to be as much as 100 picocuries per kilogram at depths of a hundred feet. High americium concentrations were also detected in some wells.

In conclusion, the total amounts of some individual long-lived radionuclides in the buried wastes are so large that each one by itself could pose a major threat to the Snake River Plain aquifer. The combined threat from the radioactive and hazardous chemicals in the buried wastes is enormous.