IMPORTANCE OF CLOSE-INTERVAL VERTICAL SAMPLING IN DELINEATING CHEMICAL AND MICROBIOLOGICAL GRADIENTS IN GROUND-WATER STUDIES

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A large degree of homogeneity is often ascribed to subsurface environments. Consequently, ground-water monitoring wells are frequently spaced with little attention to potential vertical gradients of either chemical or biological parameters. However, vertical gradients can exist in ground water and especially in contaminated aquifers. These gradients affect the geochemical nature of the aquifer and therefore the microbial processes in the aquifer. The purpose of this study was to determine detailed vertical gradients of chemical and microbiological properties within the contaminant plume at the Otis Air Force Base toxic waste study site (Cape Cod, Mass.). The steepness of the gradients within the contaminant plume dictates the sampling intervals necessary for future work at this site, particularly for microbiological studies.

The site chosen for sampling is located near the core of the contaminant plume (LeBlanc, Chapter B, this report, fig. B-1, site F347) about 250 m (meters) downgradient from the sewage-disposal sandbeds (about 1.5 years traveltime for ground water). Situated at this location are four observation wells (5-cm (centimeter) diameter polyvinyl chloride (PVC) pipe), each with a 0.6-m long slotted PVC screen. The screens are set 6 to 10 m apart vertically (fig. B-7). Chemical data collected previously from these wells demonstrated that the shallowest well was screened in a zone of uncontaminated ground water and the three deeper wells were screened in the contaminant plume. The interval between the upper two wells, which includes the gradient between uncontaminated and contaminated ground water, was the zone chosen for detailed sampling in this study.

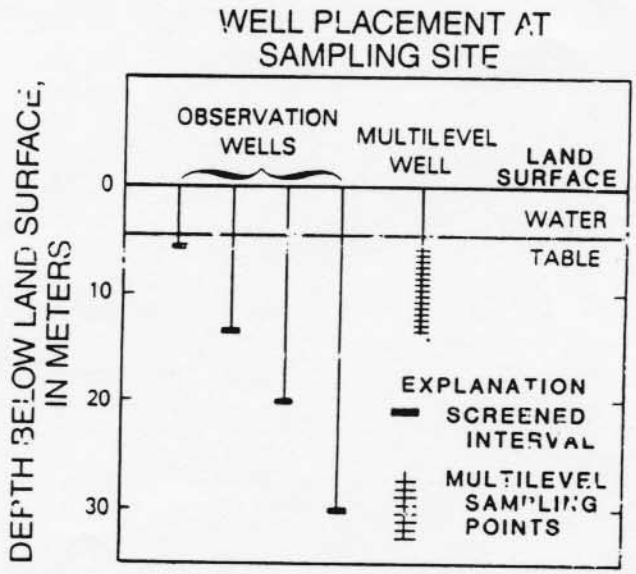

Figure B-7.—Well configuration at site F347.

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Detailed vertical sampling was done with a multilevel sampling device. This device has 15 ports spaced 0.6 m apart along an 8.5-m long section of 3.2-cm diameter PVC pipe. At each port, a 0.64-cm diameter polyethylene tube protrudes outside the PVC pipe through a hole and is capped with a nylon screen. Each tube extends to land surface inside the PVC pipe. Ground water was sampled from each port with a peristaltic pump. The placement of the multilevel sampler in the aquifer is shown in figure B-7.

Depth profiles of specific conductance (fig. B-8) and chloride (data not shown) exhibited steep vertical gradients. These constituents increased fourfold and ninefold, respectively, in the 2-m interval between 5.6 and 7.9 m beneath land surface. Below 10 m, the chloride concentration was constant with depth, while specific conductance decreased slightly. Nitrate concentrations also increased dramatically from 5.6 to 7.9 m (fig. B-9), but subsequently decreased with depth below 9 m. The entire nitrate-containing zone was undetected by the observation wells.

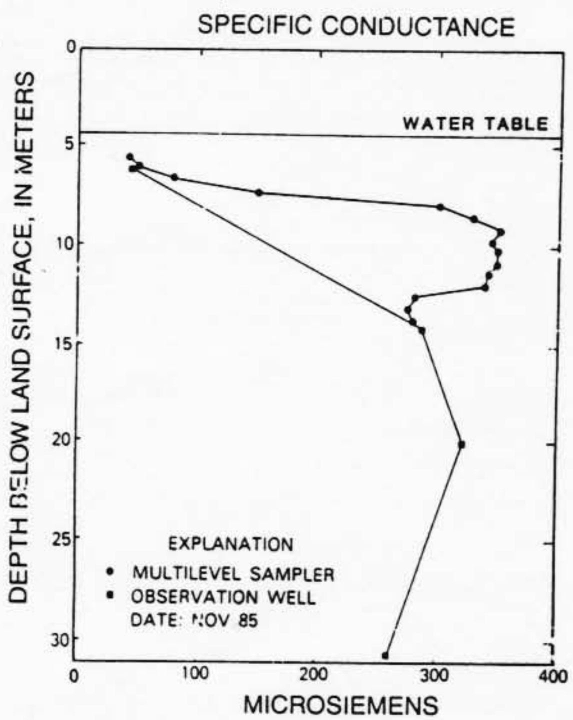

Figure B-8.—Depth profiles of specific conductance.

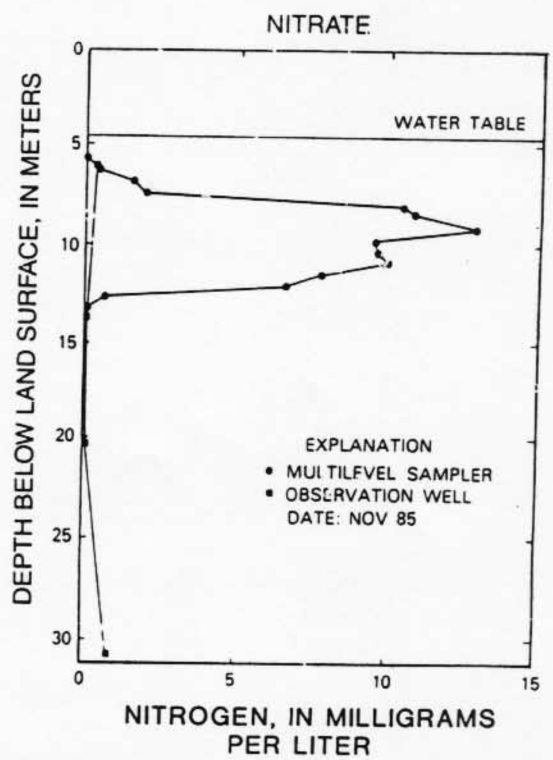

Figure B-9.—Depth profiles of nitrate.

Ground-water samples taken from the multilevel well also exhibited fine-scale variations in bacterial abundance and bacterial growth rates. Bacterial abundance increased 27-fold over background levels, reaching a maximum at 10.8 m below land surface (fig. B-10). Substantial changes in the bacterial community structure were evident across this gradient. The population changed from small, relatively uniform cells (average length 0.3 μm (micrometer)) to much larger, morphologically diverse organisms (average length 0.84 μm). Total cell biomass increased from 1.5 μg C/L (microgram of carbon per liter) at 6.1 m to 96 μg C/L at 14 m. Bacterial growth rates (frequency of dividing cells, fig. B-11) also increased over this depth interval, but not uniformly. Dividing frequency reached a maximum value at 12.6 m below land surface, which was twofold higher than the value for the observation well screened only 1.5 m below this depth.

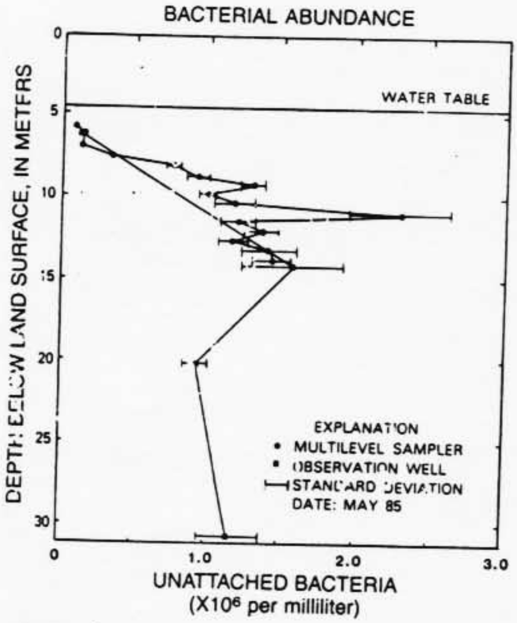

Figure B-10.—Depth profiles of bacterial abundance.

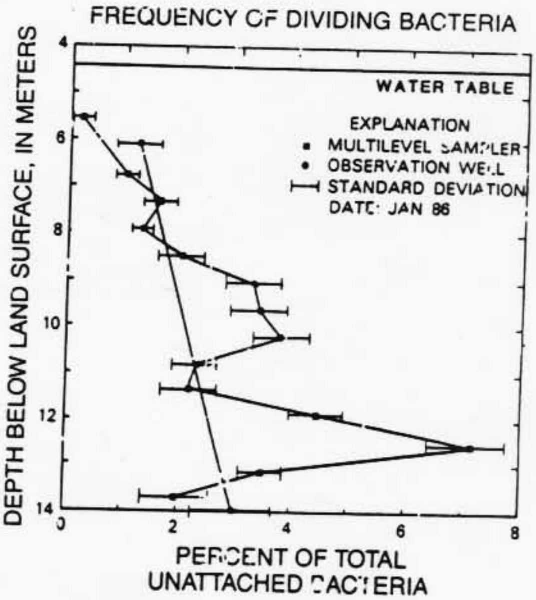

Figure B-11.—Depth profiles of bacterial growth rate (frequency of dividing cells).

The results of this study demonstrate that relatively steep gradients of chemical and microbiological properties occur in contaminated ground water. The detection of these gradients requires close-interval sampling. Otherwise, interpretation of data from only a few monitoring wells with screens set far apart vertically may yield incorrect conclusions about chemical and microbiological processes in the aquifer.

REFERENCE

LeBlanc, D. R., 1987, Fate and transport of contaminants in sewage-contaminated ground water on Cape Cod, Massachusetts: Introduction, *in* Franks, B. J., ed., U.S. Geological Survey Program on Toxic Waste—Ground-Water Contamination: Proceedings of the third technical meeting, Pensacola, Florida, March 23–27, 1987, Chapter B: U.S. Geological Survey Open-File Report 87–109, p. B-3–B-8.