Category III - Water Quality

The Effect of Soil Water Content on Organic Chemical Sorption During Transport Through Unsaturated Soil

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Executive Summary:

Significant parts of California and other parts of the country used for farming are comprised of coarse-textured soils that commonly remain at relatively low water content in the subsurface, even when subjected to irrigation management. In the past, it has often been assumed that chemical sorption is insignificant in coarse-textured subsurface regimes, because these zones are generally low in organic carbon. This proposal challenges that assumption, on the grounds that simple partitioning models of the type used in virtually all transport models predict that soils low in water content can produce significant attenuation of dissolved organic chemicals. For example, in the proposal it is shown that assuming zero sorption in a sandy soil profile from the Central Valley of California underestimates the travel time to ground water by nearly a factor of three under typical irrigation management. Clearly, it is important to determine the degree to which sorption can slow down the migration of dissolved chemicals in soils of low water content and carbon. However, virtually no experimental tests of this hypothesis have been carried out in the past.

Organic chemical pollutants are not expected to be strongly sorbed by sandy soils as the soils is coarse in texture and low in organic carbon. Results of preliminary experiments demonstrated that the transport of organic solute in sandy soils was significantly retarded in comparison to that of the water flow when the soil moisture content of soils decreased. As the cropland soils are frequently under relatively low water contents, this finding may have significant implications on the pesticide transport in vadose zone.

Work performed during the first year of this project has focused on construction of our experimental system, and execution of the first set of transport experiments. Cylindrical columns containing repacked sandy soil from agricultural areas in Fresno, CA were connected to pressure control devices so that the columns could be maintained at a constant unsaturated water content during flow experiments. Two chemicals, the bromide, a tracer for water and bromacil, a mobile pesticide were added as pulse inputs to the inlet end of the column and monitored continuously at the outlet end until all of the chemicals had moved through the column. The concentration profile from the bromide was used to measure the water velocity and the degree of chemical dispersion in the system, while the bromacil concentration record was used to determine to what extent the sorption process operated in unsaturated the sandy soil containing only small amounts of organic carbon. Our preliminary results show that the sorption process does operate as predicted from sorption equations. As the water content of soil decreases, the extent to which the chemical transport is retarded in comparison to that of the water flow increases. As a result, serious errors can be made in predicting travel times to ground water if this mechanism is neglected. Our data also suggests that the process is rate-limited at higher water velocities, so that kinetic equations are necessary to accurately describe the shape of the concentration pulse as it exits the columns. However, it is not necessary to use kinetic equations to estimate the mean travel time of the pesticide through the column. The overall effect of sorption is to make the travel time of a sorbing compound relatively insensitive to variations in water content so that simple model predictions based on mean water content will result in reasonable estimates of travel time from the root zone to ground water. These estimates will be of great value to pesticide regulators seeking to determine whether a given compound may be used without harm to underground water supplies.