SUPPORTING EVIDENCE FOR THE NITRATE GROUNDWATER POLLUTION HAZARD INDEX CONCEPT

A supporting document for the
UC Center for Water Resources (http://www.waterresources.ucr.edu)
Nitrate Groundwater Pollution Hazard Index

The USGS measured the occurrence of nitrate in ground water beneath three agricultural land-use settings in the Eastern San Joaquin Valley of California during the period 1993-1995 (Burow et al. 1998). Water samples were collected from 60 domestic wells in land-use settings of (1) vineyards, (2) almond trees, and (3) a crop grouping of corn, alfalfa, and vegetables.

The vineyards and almonds were located on similar coarse-grained, upper and middle parts of the alluvial fans with rather rapid water transmission properties and low potential for denitrification. The three-crop setting was on the lower part of the fan consisting of relatively fine-grained sediments that would have lower water transmission properties and a denitrification potential. We would rate the soil hazard index higher on the vineyard and almond lands than the three-crop lands. We give the vineyards a lower hazard index than the almonds because of the much lower N application to vineyards. The three-crop system includes alfalfa with the lowest hazard index and vegetables with the highest hazard index so the cumulative effect is unknown and is expected to be intermediate.

The NO_3 concentrations in the wells were highest in the almond area, intermediate in the three-crop area, and lowest in the vineyard area. We have emphasized that NO_3 concentration is not necessarily a reliable indicator of management, but in this case it is an appropriate criterion for some comparisons. The concentrations of chloride and NO_3 were correlated in the almond and vineyard settings indicating very little denitrification and that is consistent with the soil properties. We assume that the irrigation of the two crops provided similar leaching factions. Therefore, the higher concentration would be associated with the higher N application to almonds than for the vineyards. Furthermore, with similar amounts of deep percolation, the higher concentration would also mean higher N mass flow.

The soils for the three-crop system were expected to have lower hydraulic conductivity and also possible denitrification. The electrical conductivity (EC) and chloride concentration of the water were higher in the three-crop area than for the other two orchard crops, suggesting a lower leaching faction consistent with the soil properties. Also, the NO_3 and chloride concentrations were not correlated in the three-crop system, which indicates denitrification. The dissolved oxygen was also lower in the three-crop system than the others. Because of the diversity of crops in the three-crop system, it is not possible to draw other conclusions.

The USGS measured the NO_3 concentrations in ground water samples collected from 3 domestic wells in 1995 (Burow et al. 1998). The results were related to various physical and chemical factors in an attempt to understand the processes that control the occurrence and concentrations of nitrates. The results were also compared with results of the analyses of samples collected in 1986-87.

One major finding, which is consistent with numerous other studies, is that the NO_3 concentrations were not significantly correlated with the estimated amount of nitrogen fertilizer applied within a 0.25- and a 0.5-mile radial distance from the sampled well. The concentrations, therefore, were most likely affected by factors such as soil and sediment texture.

Nitrate concentration generally decreased with increasing depth below the water table. The deeper waters are older waters, which reflect lower historical application rates of nitrogen fertilizers.

The investigators did not find a relationship between NO_3 concentrations and soil permeability, hardpan percent, and clay percent. The lack of correlation may be explained by counterbalancing effects of these soil properties on NO_3 concentrations. Low soil permeability, hardpans, and clay would restrict the rate of water flow contributing to a low leaching faction, which could lead to higher NO_3 concentrations. Additionally, these soil properties are conducive to higher denitrification, which would reduce the NO_3 concentrations. Since there was no significant correlation between the soil properties and NO_3 concentration, neither mechanism predominated. Both mechanisms, however, contribute to lower NO_3 mass movement, but this was not measured.

Nitrate concentrations were positively correlated to dissolved oxygen concentrations. This result provides evidence that denitrification was a factor affecting the NO_3 concentrations. Nitrate concentrations were also positively correlated to specific conductance, which is related to salt concentration. This result provides evidence that increased concentration associated with lower leaching factions was a factor affecting NO_3 concentrations. This conclusion is further supported by the finding that the nitrate and specific conductance was more strongly correlated when the chemically reduced environmental samples were removed from the data set used in the statistical analyses.

Letey et al. (1977) reported the results of an extensive investigation of agricultural tile drain effluents in California. The annual total mass of the NO_3 collected in tile drainage water was inversely correlated to the highest percent of clay in the soil above the tile depth. This is consistent with the hypothesis that clay layers in the soil reduce the hazard index by restricting the rate of water flow and/or causing denitrification. Other studies in California have shown that textural changes in profiles can have significant effects on NO_3 loss below the root zone (Lund et al. 1974, Pratt et al. 1972).

References:

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