Nitrate-nitrogen in the unsaturated zone below irrigated fields

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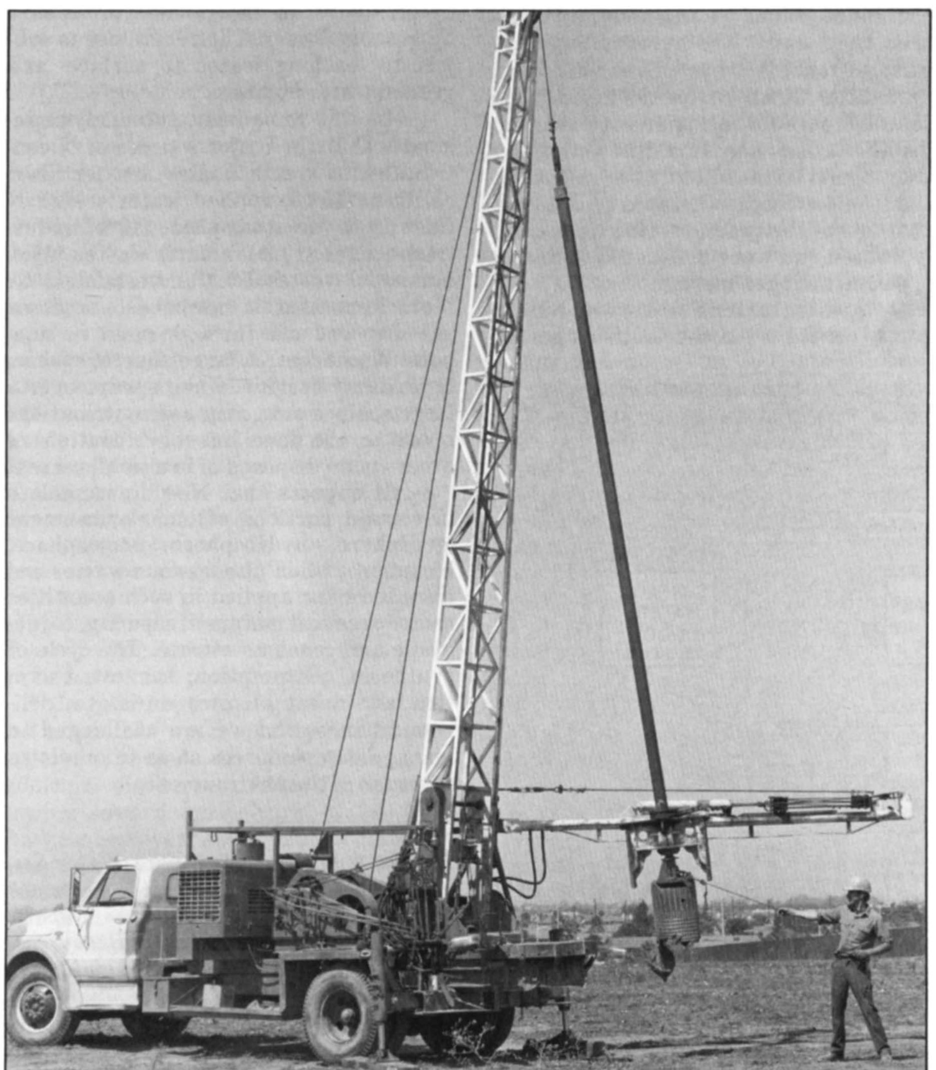
Today's concern for the quality of our environment has prompted investigations of the effects of irrigated agriculture on the underlying ground water. The work reported here is one phase of an intensive soil nitrate project being conducted by soil and water scientists of the U.C. Agricultural Experiment Station funded by the National Science Foundation's program on Research Applied to National Needs (RANN).

To collect information on concentrations of nitrate in the unsaturated zone and their relation to agricultural practices, soil samples were collected by mechanical auger to a depth of 50 feet at several irrigated farm locations in coastal southern and central California, and in the San Joaquin Valley. Sufficient data on previous fertilization, yields, and quantity and quality of irrigation were collected at 40 sites to enable the calculation of transit times and the amounts of NO_3-N that had moved past the root zone at those sites (see table).

Data Summary by Site Averages and Ranges

Site	Number of sites	NO_3-N in soil water of unsaturated zone		NO_3-N percolating from root zone		Percolation volume		Transit time	
		Avg.	Range	Avg.	Range	Avg.	Range	Avg.	Range
		ppm		lb/acre/yr		acre-inches/yr		yr/50 ft	
Coastal sites									
Citrus	14	67	9-220	142	55-315	13	2-27	9	4-95
Field-vegetable	6	31	16-36	155	65-285	23	9-37	8	4-22
Inland sites									
Deciduous	7	18	10-44	53	25-105	15	6-23	9	7-21
Field-vegetable	13	29	9-51	74	25-170	12	5-22	12	7-30
All sites	40	40	9-220	106	25-315	14	2-37	10	4-95



Much variation was found in NO_3-N concentrations in the soil water of the unsaturated zone, not only among sites but also among samples taken from the same site. This has made it difficult to draw conclusions about effects of agricultural practices on ground-water quality. No significant correlation was found between the amount of nitrogen fertilizer applied and either (1) nitrate concentration in the unsaturated zone or (2) the amount of nitrate percolating. Thus, N-fertilization rates could not be used to predict nitrate concentrations below the root zone. This is hardly surprising in that this simple correlation overlooks the interaction of such processes as crop utilization, mineralization of soil organic matter, or denitrification, which affect the fate of nitrogen applied to the soil.

Statistical treatment of the soil nitrate concentrations revealed that the individual site data were so variable that seventeen 50-foot cores per site, instead of the four actually taken, would be required to give the desired reliability to only 75 percent of the site averages reported. The costs for such intensive sampling would be prohibitive. A low-cost yet more reliable method of investigating the unsaturated zone is needed.

The results presented in the table indicate that a wide range of NO_3-N concentrations exists in the soil water of the unsaturated zone beneath irrigated crops in California. The range in percolation volumes also contributes to the highly variable amounts of NO_3-N moving past the root zone annually. For convenience, the sampling sites were grouped by major cropping systems in each geographical area. Field and vegetable crop sites were combined, because at most of those sites both types of crops were part of the 10-year history of the site. The average values tabulated for the four groups do indicate differences based on both location and crop type. The inland deciduous tree crop group, for example, is markedly lower in average NO_3-N concentration and amount of NO_3-N percolating past the root zone than the coastal citrus group, where average amounts of applied nitrogen and irrigation water were higher. It was of interest to find that the average transit time (surface to 50-foot depth) for all sites was the same as the cropping history period chosen for the project — 10 years.

NO_3-N and agricultural practices

Relationships between agricultural practices and the movement of NO_3-N past the root zone obviously are a function of many complex variables. Even in non-agricultural locations sampled during this investigation, NO_3-N concentrations in the soil water of the unsaturated zone ranged from 4 to 53 ppm, with an average of 22 ppm. In fact, at three sites in western Fresno County (not included in the table), it was necessary to postulate the presence of geologic salt beds to account for the NO_3-N concentrations of over 2,000 ppm found in the unsaturated zones.

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Hydrobiological studies in the Sacramento-San Joaquin Delta

Clifford A. Siegfried ▪ Allen W. Knight

The Sacramento-San Joaquin Delta carries about 42 percent of the natural runoff of the state. It is high in biological productivity, receiving nutrient-laden waters from municipal and industrial activities and from intensively cultivated agricultural land surrounding the basin. The Delta supports important freshwater fisheries and serves both as a nursery ground for marine species and as an access route and habitat for young and adult anadromous species important in the state's sport fishery.

Saline water enters the Delta from San Francisco Bay and the Pacific Ocean during periods when freshwater inflow is reduced. Releases from man-made reservoirs generally confine salinity intrusion to the area west of Rio Vista, preventing it from intruding into the interior of the Delta. Without summertime releases from these reservoirs, the waters of the Delta would, on occasion, probably became too saline for agricultural, industrial, and municipal users within the Delta and for diversion of irrigation waters to the San Joaquin Valley, and would harm the fisheries and wildlife resources of the Delta. Because of the importance of salinity intrusion to water quality in the Delta, much of our attention has been focused on the effects of salinity on the invertebrate fauna there.

The dominant invertebrate organisms of the Delta estuary include the opossum shrimp, *Neomysis mercedis*, the grass shrimp, *Crangon franciscorum*, and amphipods, *Corophium* spp. They are food organisms for such fish as the striped bass *(Morone saxatilis)*, the American shad *(Alosa sapidissima)*, the white sturgeon *(Acipenser transmontanus)*, and the white catfish *(Ictalurus catus)*. Any changes in water quality that affect *Neomysis*, *Crangon*, and *Corophium* populations also affect the fish that feed on them.

Neomysis has received considerable attention in prior work at our laboratory, and we are continuing to focus efforts on the physiology and population dynamics of this highly important component of the Delta community. Intensive studies on the metabolism of *Neomysis*, now completed, indicate that its metabolic rate is related to body size, temperature, salinity, sex, and season.

Results of bioassays suggest that *Neomysis* is relatively tolerant of a wide range of temperatures and salinities, with salinity tolerance affected by temperature. Juvenile *Neomysis* appear more tolerant of high temperatures than do mature ones. We have also evaluated the tolerance of *Crangon franciscorum* to variations in temperature and salinity and to the pesticide Kelthane.

One of the most important aspects of circulation in the western Delta is a two-layered flow generated by the intrusion of saline water, resulting in the establishment of an area in which circulation patterns create an "entrapment zone" where suspended materials are concentrated. Phytoplankton, zooplankton, *Neomysis*, and juvenile striped bass are also concentrated there in response to the concentration of food materials. The entrapment zone may be critical to the population dynamics of the fish and invertebrate fauna of the Delta estuary.

Cooperatively with the U.S. Bureau of Reclamation and the California Department of Fish and Game, we are currently engaged in a detailed determination of the distribution of *Neomysis*, *Crangon*, and *Corophium* in relation to the entrapment zone. Our studies will assist development of a preliminary model to describe the distribution and abundance of these organisms in the western Delta. Continued work on the basic estuarine dynamics of the Delta is designed to contribute to a more intelligent assessment of impacts resulting from man's manipulation (peripheral canal, industrial discharges, etc.) of the Delta water resources.

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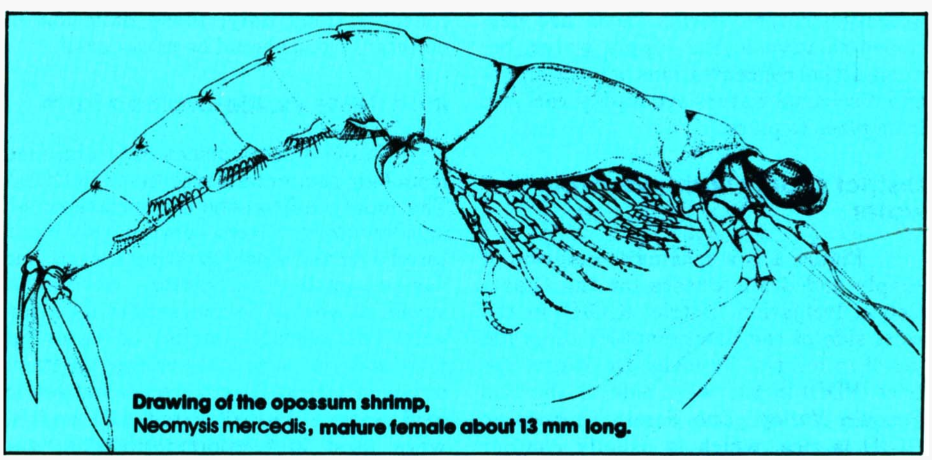

Drawing of the opossum shrimp,
Neomysis mercedis, mature female about 13 mm long.