American Society of Agronomy
California Chapter

Co-sponsored by the California Plant Health Association

2011 CONFERENCE PROCEEDINGS

Agricultural Certification Programs- Opportunities and Challenges

February 1 & 2, 2011

Piccadilly Inn University
Fresno, California

Table of Contents

Groundwater Nitrate in the Tulare Lake Basin and Salinas Valley

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Introduction

Nitrate is the most frequently detected groundwater contaminant in California's groundwater. Fertilizer use, manure leaching from storage lagoons, manure applications to forage crops, septic tank leaching, and intentional recharge of municipal and industrial effluent contribute to groundwater nitrate contamination. Nitrate concentration exceeding the maximum contaminant level (MCL) for drinking water (45 mg/L as nitrate of 10 mg/L as nitrate-nitrogen) affects approximately 10% of California's public drinking water supply. In rural areas, many residents rely on domestic wells. Few data are available, but recent surveys have shown that typically 2 to 10% of domestic wells exceed nitrate standards. In intensively cultivated agricultural regions, a significantly higher number of domestic wells may be affected. In a recent survey of domestic wells in Tulare County, the State Water Resources Control Board (SWRCB), through its Groundwater Ambient Monitoring Program (GAMA), found over 40% of domestic wells to exceed the drinking water standard.

Already in the 1970s, high nitrate values were reported, e.g., in eastern Fresno County (Schmidt, 1971). More than a decade later, the state legislature ordered a report on the state of nitrate in groundwater and possible solutions (Anton et al., 1988). In the mid-1980s, 60% of domestic wells surveyed in a research study near Hilmar, Merced County, exceeded the nitrate MCL. In the Tulare Lake Basin area, high nitrates have been noted since the 1970s in a discontinuous belt along the eastside of the Valley from Fresno County to Kern County and including communities from Dinuba, Woodlake, Lindsay, Strathmore, Porterville, Exeter, down south to McFarland, Wasco, Bakersfield, Arvin, Edison, and Lamont. In the Salinas Valley, as much as 50% of monitored wells in the 1980s exceeded the nitrate drinking water standard. Providing a statewide, thorough summary of the extend of nitrate contamination, the 1989 Nitrate Working Group (Stephany et al., 1989) recommended that the California Department of Food and Agriculture (CDFA) implement the following actions:

- identify nitrate sensitive areas in California
- establish priority areas to implement nitrate control programs
- establish nitrate management progams in sensitive areas
- develop best management practices
- establish research and demonstration projects on nitrate control through irrigation, fertilizer, and manure management

The CDFA created the Fertilizer Research and Education Program (FREP) funded through a fertilizer tax. The program has focused primarily on the development of best management practices, but has failed at establishing clear linkages between nutrient management practices and groundwater quality. It is has also been questioned, whether the program has significantly affected fertilizer management practices (Franco, 1994). Over the past 25 years, perhaps the most significant change in agricultural practices, at least in some regions (Salinas Valley, Westside of the San Joaquin Valley/Tulare Lake Basin) has been a significant increase in irrigation efficiency and uniformity, which has led to significant reduction in water leaching to groundwater, and possibly to lower nitrogen loading rates. The latter effect is hypothesized and little research is available to date to test this hypothesis specifically for the Central Valley or Salinas Valley.

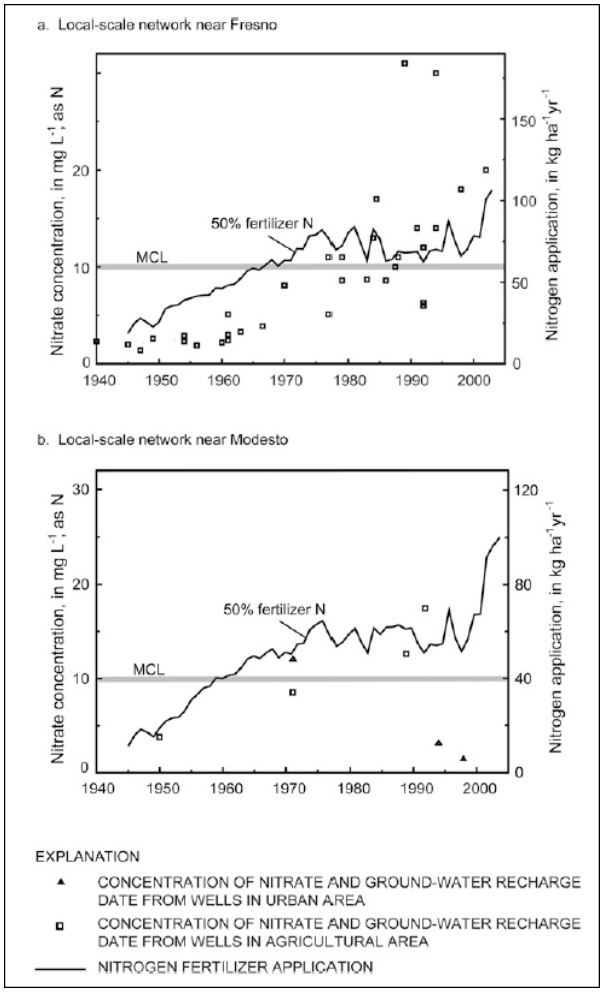

Figure 1: Estimated concentrations of nitrate in recharge and observed concentrations of nitrate in monitoring wells in (1) Fresno, California and (b) Modesto, California (*from*: Burow et al., J. of Environ. Qual., 2008).

Since the 1988 Report to the Legislature, nitrate contamination in many communities has worsened, more wells have been affected by MCL exceedances, and the depth of nitrate contamination in the upper aquifer of the Central Valley aquifer system has deepened (Burow et

al., 1998, 2008). Research shows that today's groundwater nitrate contamination is the result of five decades of nitrate pollution and what is extracted for drinking water today may have been recharged thirty, forty, or fifty years ago (Tesoriero et al., 2007; Burow et al., 2008; VanderSchans et al., 2009).

Many of the communities affected by drinking water standards are in California's agricultural regions, which are economically disadvantaged ("disadvantaged communities" or DACs, defined as communities with a median household income less than 80% of the state's median income) or severely disadvantaged communities (defined as communities with a median household income less than 60% of the state's median household income). The communities struggle to finance, plan, and maintain public water supply systems that can provide clean drinking water. The problem of domestic well water pollution remains an altogether unaddressed drinking water problem.

The federal Clean Water Act has been largely ineffective at protecting the drinking water resources of these communities and rural households as it applies only to (navigable) surface waters, while over 90% of the drinking water supply in the Central Valley and Salinas Valley is from groundwater. In California, the 1968 Porter-Cologne Act goes above and beyond the provisions of the federal Clean Water Act in that it explicitly requires the protection of both surface water AND groundwater resources for beneficial uses. Until 2002, all major anthropogenic sources of groundwater nitrate were held to voluntary standards of groundwater protection. Since then, the State Water Resources Control Board (SWRCB) and its Regional Water Quality Control Boards (RBs) have embarked on regulating an increasing number of industries that potentially pollute groundwater through diffuse nonpoint source discharge. Among agricultural producers, Central Valley's dairy industry was the first to be regulated under new waste discharge waivers for groundwater protection; in 2011, all of irrigated agriculture will follow suit under a new Irrigated Lands Regulatory Program in the Central Valley and under the Agricultural Regulatory Program in the Salinas Valley/ Central Coast region. In addition, food processors, municipal wastewater treatment plants discharging to groundwater, and other groundwater dischargers of salts and nutrients will be regulated in the near future under the development of so-called salt and nutrient basin plan amendments in all nine regions of the SWRCB (see, for example, the Central Valley efforts at http://cv-salinity.org).

Not withstanding these efforts, the California Legislature, in 2008, requested the California Department of Public Health to authorize a comprehensive pilot study on groundwater nitrate, to be implemented by the SWRCB, which will issue a Report to the Legislature in May of 2012. In May of 2010, SWRCB contracted with the University of California to implement this pilot study, which will provide significant scientific, technical, and policy guidance to the various stakeholders involved in the ongoing regulatory programs on the nitrate source side (dairy regulatory program, irrigated lands regulatory program, salt and nutrient basin plan amendments) and also to the Department of Public Health and others involved in the protection of drinking water consumers, community development, and landuse planning. Beyond these programs, the pilot study will provide a significant baseline data compendium for the management of water resources at the regional level under the Integrated Regional Water Management Plans (IRWMPs) in the pilot basins and elsewhere.

Approach

Senate Bill 2X1 (SB 2X1), section 83002.5, requires the State Water Board, in consultation with other agencies, to develop pilot projects in the Tulare Lake Basin and the Salinas Valley that focus on nitrate contamination. The objectives of the work to be conducted within the pilot project basins by UCD are (http://www.waterboards.ca.gov/water_issues/programs/nitrate_project/index.shtml):

- Identify sources, contributions, and reduction/prevention options for nitrate in groundwater
    - Identify sources, by category of discharger, of groundwater contamination due to nitrate in the Tulare Lake Basin and the Salinas Valley (pilot project basins).
    - Estimate proportionate contributions to groundwater contamination by source and category of discharger.
    - Identify and analyze options to reduce current nitrate levels and prevent continuing nitrate contamination of the pilot project basins and estimate the costs.
- Identify methods and costs associated with treatment or alternative water supply for nitrate contaminated groundwater
    - Identify methods and costs associated with the treatment of nitrate contaminated groundwater for use as drinking water.
    - Identify methods and costs to provide an alternative water supply to groundwater reliant communities in each pilot project basin.
- Identify all potential funding sources including, but not limited to, state bond funding, federal funds, water rates, and fees or fines on polluters
    - Identify funding sources to provide resources for the cleanup of nitrate in groundwater.
    - Identify funding sources to provide resources for the treatment of nitrate in groundwater.
    - Identify funding sources to provide resources for the provision of alternative drinking water supply of nitrate in groundwater.
- Develop recommendations for groundwater cleanup programs
    - Identify recommendations for developing a groundwater cleanup program for the Central Valley Water Quality Control Region based upon pilot project results.
    - Identify recommendations for developing a groundwater cleanup program for the Central Coast Water Quality Control Region based upon pilot project results.
- Participate in an interagency task force
    - The University of California Davis will participate in the Interagency task force that includes the; State Water Board, California Department of Public Health, Department of Toxic Substances Control, California Environmental Protection Agency, Department of Water Resources, Department of Food and Agriculture, Department of Pesticide Regulation, and local public health officials.

The project is implemented by an interdisciplinary team of researchers at the University of California Davis in collaboration with researchers from other universities and agencies, in collaboration with local and state agencies, and stakeholders. The principal components of the analysis are briefly outlined here.

The nitrogen loading assessment will be primarily conducted through a mass balance analysis at the landuse parcel level. Land parcels are assigned current (and historic) landuse categories (natural, urban, and agricultural, where each of these categories are further subdivided). Nitrogen inputs (fertilizer, manure, atmospheric deposition) and nitrogen removal (harvest, atmospheric losses) are considered to estimate groundwater losses of nitrogen by closure to a simple mass balance. For each category current nitrogen budgets are developed based on available data, recommended and/or documented practices associated with individual landuses, literature or agency reports of nitrogen applications, nitrogen discharges, (in the case of agricultural commodities:) harvest amounts (crop removal). Results are checked against field data of groundwater nitrogen losses, where available. The assessment will be done for the present time, but also for historic and future landuse conditions to better understand the effect of historic landuse on current and future groundwater nitrate levels.

Nitrogen loading reductions will be assessed by compiling and reviewing literature on agronomic, irrigation, and fertilization practices, through interviews of extension agents and agricultural consultants, and through implementation of expert panels. Economic costs of nitrogen source reduction measures are assessed through economic analyses of key alternatives to N loading reduction.

A thorough assessment of past, current, and future groundwater nitrate distribution is key to first, understand the contributions of historic landuses to current and future groundwater quality and second, to identify the affected population (current and future) that may need to treat drinking water or obtain alternative water resources (susceptible population) due to past and current groundwater pollution with nitrate. The groundwater assessment will be performed in two tracks: First, a comprehensive assessment of past and current groundwater nitrate data will be performed to establish a geographic information system (GIS) database that identifies not only nitrate levels, but also attempts to identify the depth from which groundwater is obtained. Private and public, local, regional, state, and federal resources and databases will be combined into a single comprehensive database, while protecting existing confidentiality and homeland security agreements. The database will be used to provide a comprehensive assessment of historic and current groundwater nitrate and trends in the pilot project areas. A second track will be to establish an explicit linkage between nitrogen loading and historic and current groundwater nitrate by implementing a groundwater modeling study that tracks nitrate loading from the source to the well and computes not only the travel path but also the travel time, potential nitrogen reaction, and nitrate dispersion/dilution in the aquifer and in the well intake screen. The groundwater nitrate model provides a tool to assess future groundwater nitrate conditions (time horizon: 1950-2050) under current and alternative landuse management scenarios.

Treatment options are compiled and treatment cost estimates developed through an extensive review of literature and industry sources, and through a survey of public water suppliers in the pilot basins. Treatment costs will take into account the effects of potential co-contaminants found in the study area.

The assessment of treatment and alternative water supply options relies on a better understanding of the current service areas of public water supply systems, particularly of the smaller and very small public water supply systems, and on a delineation of areas depending

entirely on domestic wells for their drinking water supply. An economic assessment of water supply alternatives will be implemented.

Rapid project progress depends heavily on already existing expertise within and outside the principal investigating team at UC Davis; and on a number of already ongoing studies that have direct links to this project including the California Nitrogen Assessment implemented by the Agricultural Sustainability Institute at UC Davis, collaborative work on water treatment between UC Davis and the California Department of Public Health, agricultural economic studies of nonpoint source pollution in the Central Valley for the Central Valley salinity program (http://cv-salinity.org), ongoing groundwater modeling studies in the Central Valley and Salinas Valley by various research groups and agencies, extensive groundwater quality assessment under the SWRCB GAMA program, and the USGS National Water Quality Assessment Program, and other ongoing work. A draft and final report will be submitted by the University of California team in September and December of this year, respectively.

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