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Summary Statement on the Manuscript

I conducted much research on nitrate (N) considering it to be both a plant nutrient and a potential water pollutant. I also served as a member of the Nutrient Technical Advisory Committee (TAC) appointed in 1994 by the State Water Resources Control Board. I have written a manuscript that, after peer review, has been accepted for publication by California Agriculture. Among other matters, I was critical of the Board "Recommendations Addressing Nitrates in Groundwater, Report to the Legislature" dated 20 Feb 2013.

The manuscript contains considerable technical new information on mineralization rates of organic materials and the effects of ignoring the temperature effect on mineralization. This information is not of great importance pp (7-12) to the present discussion. Other sections of the manuscript are more pertinent to my comments concerning the Board Recommendations. Most are to demonstrate the **short-comings of the "Track and Report" concept.**

The introduction acknowledges the great degradation of groundwater in California by N that was caused by agricultural activities. Nitrate is transported to groundwater by water that percolates through the soil as a result of precipitation and irrigation. Poor N fertilizer management is commonly stated as the major contributing cause to the degradation. Irrigation management is equally, if not of greater, importance. This statement is documented by scientific findings reported in the manuscript.

I was involved with extensive research conducted on 86 farmer fields throughout the state in the 1970s. The findings are summarized on pp3-4. The research was conducted in a manner to measure both the N concentration in the water and the water flow rate through soil. The product of these two gives the N load going to groundwater. The correlation coefficient between the amount of N leached and the drainage volume (associated with irrigation) was greater than the coefficient for the amount of N applied (associated with fertilization). This indicates that irrigation management is equally, or more important than N management. **Most importantly there was no significant correlation between the N concentration in the soil-water with either the drainage volume or the amount of N applied. The significance of this is that there is no value gained by measuring the N concentration in the soil-water. The concentration neither reflects the N load to groundwater nor the quality of the farm management. Indeed, as will be supported later, erroneous conclusions can be drawn from these data.**

A common assumption is that a reduction in N application will cause an equal reduction of N load to groundwater. This assumption is not always valid. Relationships between both the relative crop yield and the amount of leached N and the amount of applied N are illustrated in Figures 3,4,5,6, and 10. Note that reductions in N application can cause a reduction in both yield and the amount of N leached. However, the reduction in N leached is far less than the reduction in the amount applied. Indeed, in some cases, a reduction in N application does not cause any reduction in N leached. **Therefore, tracking N application *per se* does not provide a quantitative determination of the amount of N leached.** Tracking the crop uptake as well as the application still does not quantify the load because it ignores denitrification that can be substantial in some soils.

Measurement of denitification on one farmer field found that 51 kg/ha were denitrified over a 123-day span when 335 kg/ha were applied (15%) (Ryden et al. 1979). Denitrification losses on seven study sites at three fields cropped to vegetables resulted in a range from 95 to 223 kg N/ha/yr that represented 14 to 52% of the applied N (Ryden and Lund, 1979),

The rate of water flow and the N concentration at the bottom of the root zone are illustrated at different times of the year in Figures 7 and 8 for two irrigation water applications. Note that the N concentration remains fairly constant over the year, but the water flow rate varies drastically associated with irrigation events. The N concentration is higher for the lower water application than the higher water application. **If only the N concentration was tracked, one could conclude that the higher irrigation water application was better.** However, the cumulative amount of leached N over the course of a year is illustrated in Figure 9 for the concentrations and water fluxes reported in Figure 7. **The amount of N leached is far greater for the higher irrigation (low N concentration) than the lower irrigation (higher N concentration).** The amount of N leached is directly related to the water flux at the bottom of the root zone. **This flux cannot be practically measured (tracked) in the field, especially for the great variation with time and location. Tracking the N load migrating to groundwater, and not concentration, is the most important factor to track, and it is impossible to track.**

The present groundwater situation is the result of past activities, and nothing can be done about that. Our efforts today should be directed toward reducing the future N loads to groundwater. The load is dictated by farmer management; and therefore, the approach should be directed toward inducing good farm management, not merely tracking and reporting what is being done. This is particularly true when some of the costly tracking information is, at best, of useless value.

The 1994 TAC recognized management as being the key factor. The concept of having farmers develop best management practices (BMP) was the focus. The nitrogen hazard index (NHI) that approximates the relative risk of groundwater degradation on a given field was proposed as a resource in developing BMPs. NHI identifies whether the crop, soil, or irrigation system is creating the greater risk and management directed to that component. TAC also proposed that fields with a low index number that posed low threat to groundwater degradation be freed of some compliance restrictions so that resources could be directed to where they would more effectively reduce degradation. This recommendation was never implemented because index numbers for the soils and crops were not available. The numbers for several soils and crops are now available and others could potentially be indexed.

A micro-irrigation system and fertigation provide the absolutely best opportunity to have high crop yields and low water degradation. Both the water and N can be provided in the amounts and at the time that they are needed for uptake. Neither excess water to leach the N, nor excess N for crop requirement exists. However, this system requires investment. This system has an NHI equal to 20 or less, that is considered to pose low threat, under all conditions Therefore, if the farmer was freed from costly compliance requirements, they could use the money for upgrading their irrigation management.

The proposed recommendations to the Legislature entail very high costs to the farmers and to the state to mostly gather data, some of which is useless. There is no clear plan as to how these data will be used to induce farmers to improve management. Going the BMP route as proposed by TAC is superior to the tracking and reporting route recommended to the Legislature for funding.

References

Ryden, J.C., L.J. Lund, D.D. Focht, and J. Letey. 1979. Direct measurements of nitrous oxide and denitrification losses from a field soil. pp 71-124. In: P.F. Pratt (Principle Investigator) Final Report to the National Science Foundation for Grant nos. GI34733X, GI43664, AEN74-11136 A01, ENV76-10283 and PFR76-10283. Nitrate in Effluents from Irrigated Lands. University of California, May 1979.

Ryden J.C. and L.J. Lund . 1979. Nature and extent of directly measured denitrification losses. pp 355-416. In: P.F. Pratt (Principle Investigator) Final Report to the National Science Foundation for Grant nos. GI34733X, GI43664, AEN74-11136 A01, ENV76-10283 and PFR76-10283. Nitrate in Effluents from Irrigated Lands. University of California, May 1979.