Water Quality Problems of Irrigated Agriculture

J. D. Oster[1]

Introduction

My objective is to increase the awareness of water quality problems associated with crop production in general, with some extra emphasis on alfalfa. In the past, the focus would have been on leaching requirements to control salinity. Since alfalfa is moderately sensitive to salinity, controlling salt effects is important for irrigation waters with salinities exceeding 1 dS/m. Now the environmental fate of the salts contained in irrigation water and, in some cases, native salts in the soil must also be considered. The same is true for toxic trace elements, nitrogen, pesticides, and microorganisms.

Why are microorganisms on this list? In the future, agriculture will be given increasing opportunities to use municipal sludges and animal wastes as alternative sources of fertilizer and soil amendments. The annual production of human waste in California is about 1 million tons (dry weight) and that for animal waste (dairy, feeder and range cattle, swine, poultry, and horses) is about 3 million tons. These wastes contain microorganisms, salts, trace elements and nitrate which can adversely affect animal and human health.

History's Lessons

Selenium toxicosis among birds at the Kesterson Wildlife Refuge in the early 80s heralded the fragile nature of land and water resources. The long known fact that irrigation without adequate drainage creates unacceptable salinity levels was underlined. The surprise was, given the right soils and chemistry, irrigation drainage waters can contain trace elements that harm biota.

On the east side of the San Joaquin Valley, irrigated agriculture has been identified as a source of increased nitrate and pesticide levels in groundwaters. In the Turlock-Modesto area, municipalities are negotiating with irrigation districts to obtain surface water in exchange for groundwater to avoid treatment costs. The day may come when this is no longer possible. Case in point; past and current agricultural practices in and near Riverside in southern California.

In Riverside groundwater contamination with salts, nitrate, and DBCP occurred due to fertilizer and soil fumigant applications to orange orchards planted in the late 1800s. Houses have replaced these orchards, increasing the need for drinking water. Using a low interest loan of $15 million made available by the Water Conservation and Water Quality Bond Law of 1986, the Santa Ana Watershed Project Authority has built a reverse osmosis plant to remove salts, nitrate, and DBCP from contaminated groundwater. Seven million gallons per day are treated and a waste stream of one million gallons per day is discharged into the sea via the Santa Ana Regional Interceptor. Cleanup costs will be paid primarily by city residents, but other Californians are also paying some of the cost by providing the low interest funds.

Dairies in the Chino basin, about 15 miles west of Riverside, are a major contributor to nitrate and salt contamination of underlying groundwaters. Plans have

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1. J. D. Oster, Soil and Water Specialist, Department of Soil and Environmental Sciences, University of California 92521.

been made by SAWPA to construct another groundwater treatment plant similar to one in Riverside.

The underlying issues are clear: agriculture degrades water quality for later users, agriculture must minimize degradation, and ultimate disposal of agriculture's pollutants must be addressed. A National Research Council committee summarized the issues as follows: "...the practice of irrigation will require the ultimate sacrifice of some water quality and ecological values..." and "Management that fails to address ultimate disposal is simply moving the problem from one place to another, or from one generation to the next." Pollutants are like the baseball in a ball game: food production is impossible without pollutants; where they go can be good or bad depending on which team you support; and the audience wants minimum environmental impacts, it wants an exciting ball game.

In-Valley Disposal Issues

Westside

Disposal sites currently include the following: 1) soil and geologic strata beneath irrigated lands, 2) evaporation ponds, and 3) rivers which flow into the Delta. Only the first two options exist for the land-locked regions of the valley. But because of selenium toxicosis, there is a moratorium on building new ponds; the Central Valley Water Quality Control Board must establish acceptable waste discharge requirements to end the moratorium. Consequently, farmers in land-locked areas who have rising water tables in untilled fields face four options: 1) installing drains and reusing drainage water, 2) controlling water table depths by minimizing drainage volume through improved water management, 3) growing salt tolerant crops, or 4) removing the land from production.

Reusing drainage water requires skills to cope with increased soil salinity (crop growth), sodicity (water infiltration), boron (crop growth) levels, and drainage flow variability (highest in the early months of the year). Drainage water may be used directly, or blended with irrigation water, to grow moderately salt and boron sensitive crops (melons, tomatoes, alfalfa), or more salt and boron tolerant crops (sugar beets, cotton, barley, safflower, eucalyptus trees, and halophytic desert plants). Growing salt tolerant trees or desert plants will result in small, localized areas of high soil salinities, and disposal of highly saline drainage waters in small evaporation ponds and underlying soil strata.

Learning to minimize drainage is likely the most profitable option over the short run because of the added costs to operate reuse systems. This option may also be the most profitable over the long run, particularly if drainage rates are less than the permeability of the Corcoran clay. Under current conditions from 0.3 to 0.5 ft/yr of water moves downward through this clay layer. This is more than adequate to control soil salinity levels in the root zone at acceptable levels. Irrigation with well water pumped from above and below the Corcoran clay helps maintain the downward movement of drainage water. But, this strategy results in degradation of groundwaters above and below the Corcoran clay layer.

Eastside

The land locked, irrigated areas along the eastside of the valley also have disposal problems similar to the westside. Here nitrates, particularly in the growing dairy area near Visalia and Tulare, and pesticides are the principal agricultural pollutants that degrade groundwaters. Improved on-farm management of water, fertilizers, and pesticides can reduce pollution where groundwaters are not degraded.

Where degradation has occurred and the groundwater is unacceptable for drinking, Eastside municipalities may be able to switch from groundwater to surface water as is occurring near Turlock and Modesto.

Municipal sludge

Application of municipal sludge to land requires consideration of potential adverse environmental or human health effects. The EPA expects to publish final regulations governing land application of sludge during 1992. The primary impacts on agricultural usage stem from nitrogen and microorganisms. Quoting from the proposed rules "...sewage sludge may not be applied at rates in excess of the nitrogen requirement of the crop and at rates that would cause the excess nitrogen in the sewage sludge to leach to the ground water. The objective of this requirement is to optimize the removal of the nitrogen from the sewage sludge for optimal plant growth and to minimize nitrate contamination of ground water."

Control of disease transmission by microorganisms involves rules about sludge treatment and cropping limitations. There are two classes of treated sludge: 1) composted, and 2) not composted. Heat generated during composting can kill parasites, bacteria, and viruses. Composting procedures will need to exceed those used to pass initial licensing requirements. No access or crop limitations will be proposed for land application of composted sludge.

Stringent rules will be proposed for land application of municipal sludges which are not composted. If the applied material is incorporated, there will be a 38-month waiting period before any root crop can be grown and sold for human or animal food. If it is not incorporated for four months, the waiting period is reduced to 20 months. For harvested crops which touch the ground and are sold for either animal or human consumption, the waiting period before the crop sold is 14 months. The objective of this regulation is to prevent soil contamination of the eatable portion of the crop. Application of this rule will require consideration of contamination caused by harvesting operations. Alfalfa would likely be considered a crop that touches the ground because of dust generated during harvest. The same may be true for silage corn. Fresh market roasting corn may be exempt because the eatable portion would remain covered by the corn husk during harvest operations in the field.

Runoff water from irrigated fields present another means to spread disease organisms. Riverside County regulations will not allow runoff water from irrigated fields to which municipal sludge has been applied. Maybe this restriction will not apply to composted sludge.

Animal waste

Dairy manure contains both nitrate and salt. The total salt excreted daily by a dairy cow is about 4 pounds. Nitrate is the largest component, 1.9 pounds per day. Nitrate volitization and chemical reactions in the soil reduce the amount of nitrogen and salt by about 50%. Management through controlled land application of manure, adjustment of nitrogen fertilization, and proper irrigation management will control the extent of groundwater contamination.

The possibly of disease transmission to humans is far less than with land application of municipal sludge. However, there are bacteria such as Salmonella and Shigella, and parasites such as round and tape worms, which provide a route for disease transmission. Feeding antibiotic supplements to animals can increase the resistance of these bacteria. Possible disease transmission, and the concern for nitrate contamination of groundwater, could result in regulation of land disposal of animal wastes. Prudent use of these wastes would be advisable, particularly on lands used to grow vegetables which contact the soil surface.

Conclusion

Management of agriculture's pollutants to minimize environmental impacts becomes more difficult with time as the pollutant list grows. The addition of disease organisms to the list comes at the same time as the need for land disposal of municipal and animal waste is becoming an issue. Source control of pollutants is an obvious means to reduce pollutant loads in surface and groundwaters. Uniform infiltration of only the water needed by the crop must also have a high priority. Excess infiltrated water, wherever it occurs within a field, transports pollutants downward. Runoff must be stopped from fields to which pesticides and untreated human and animal wastes have been applied.

Comprehensive source control--water, nitrate, pesticides, salts, microorganisms--must become the focus of agricultural practices to control agriculture's environmental impacts. And everyone needs to understand that even with very best agricultural source control practices, irrigation requires an ultimate sacrifice of some water quality and ecological vales. Agriculture, like municipalities, requires an acceptable repository for residual salts which, unlike nitrate and pesticides, are not removed by crop uptake, volitalization, or chemical reactions.