II. Perspectives

The geologic origins of California, its arid climate, imported water, evaporation, plant transpiration — all contribute to the accumulation of salts in the soil. Even relatively "pure" water adds 300,000 tons of salt to the Central Valley each year.

Transport of salts by water

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The huge trough known as the Central Valley of California is enclosed on the east by the gently rising slopes of the tilted igneous Sierra Nevada and on the west by the strongly folded and faulted Coast Range of more recent sedimentary formations. At one time, the trough was an arm of the sea and marine sediments dominated the deposits. In these sediments is contained a body of unsuitable saline entrapped water.

With time, the proportions of nonmarine sediments increased as erosional debris from the Sierra Nevada and Coast Range filled the trough. These sediments contain fresh water of 800 mg/L total dissolved solids, and during one period of formation, a lake or river basin (lacustrine) deposit of slowly permeable diatomaceous Corcoran clay was laid down over a large area of the valley floor. Additional unconsolidated alluvium laid down on this clay barrier is a principal source of groundwater in the San Joaquin Valley with total dissolved solids of some 1,500 mg/L.

Extensive alluvial fans on the eastern side of the Valley, deposited by the several rivers of low salt content (characterized as sodium bicarbonate waters), are derived from the more weather-resistant igneous rocks, shale, and sandstone of the Sierra Nevada. Soils of the eastern side reflect this type of parent material; they are more permeable with fewer water table problems.

By contrast, the alluvial fans on the west side, although fertile, are limited in productivity by the availability of water and its quality. Water in deposits from the Coast Range contains relatively high concentrations of sulfate, calcium and magnesium. Many of the basin soils along the rim are saline, sodic, or both. Their imperfect to poor drainage, coupled with the arid climate of only a few inches of rainfall, high salt content in the parent material, and high water

Even high-quality irrigation water can add thousands of tons of salt to farmland.

Garn Stanworth

table, produces conditions for accumulation of salts. Extensive borings along the west side reveal large concentrations of soluble salt and gypsum in some areas, as reported by L. D. Doneen and K. K. Tanji, of the Department of Land, Air, and Water Resources, UC Davis.

Although groundwater is widely used for crop production, surface water has been introduced from the Sacramento Valley through the Delta Mendota Canal, the California Aqueduct, and the East Side Canal. The salinity of this water is quite low — on the order of 230 mg/L — but the total salt imported is greater than 300,000 tons per year.

The system is gradually moving into a more critical stage, because conditions for additional deterioration are present. There are extensive areas where both excessively and slightly soluble salts are present and soils are slowly permeable. Importation of water brings in additional salt, releases immobilized salts in surface soils, increases the area affected by shallow water tables, and intensifies the hazards of salinity. Disposition of salts, water quality requirements, and the effect of salts on soils and plants are therefore of primary concern.

Disposition of salts

Problems and solutions of water and salt flow are site-specific. Evaluating the relative contributions of sources of salt to the root zone, to irrigation return flows, and to deep percolation and subsurface drainage is sometimes accomplished by salt and water balance methods. Salt balance methods are applied to both small-scale farm-size and large-scale river basin systems.

Irrigated areas develop problems when more salt enters the soil solution than is removed. Both concentration and type of salt are important. Soils and plants react differently to different salts.

Control of salt through removal by crops is not significant, since plants absorb only small quantities of salt. Although rainfall may be an important source of salt deposition in coastal areas, the real significance of rainfall in irrigated regions may often be associated with displacement of salt from the root zone and replenishment of the soil water. Rainfall may be as much as 30 percent more efficient for leaching salt than many irrigation methods, as shown by Miller, Biggar, and Nielsen, at UC Davis.

If irrigation is practiced in a particular area, it is implied that either rainfall is insufficient or water use does not coincide with the supply. This mismatch in use and supply may occur with respect to time as well as location. The importation of water into such a region inevitably leads to the development of shallow water tables and accumulation of excess salt. Irrigation water then becomes an important source of salt to the plant root zone, and the larger the concentration and volume of water applied, the greater the probability that problems will develop. Even after the initial reduction in native salinity found in soils of the west side of the Valley, water importation enhances the tendency toward increased area of perched water tables and accumulation of salt. In addition, problems of saline drainage water disposal and degradation of supply water become more critical.

Deposition of salt in the soil profile is partly a consequence of the differential removal of water by plant transpiration, leaving the salt in the soil. An irrigation water containing 100 mg/L total dissolved solids will deposit 0.136 ton of salt in the soil for each acre-foot per acre of water applied. Some cropping programs require 3 acre-feet of water annually; if the water contains 1,000 mg/L, a concentration common to many sources of water, 4.1 tons of salt will be applied to the soil in one season.

A shallow water table may inhibit plant growth because of excess salinity and water. Natural salinization of soils can result from shallow water tables and upward movement of water and salt due to evaporation and drying at the soil surface, conditions that exist in irrigated regions. Crops that derive part of their water requirements from shallow water tables are more salt-tolerant than others, but, depending on the saline content of the shallow water, even they will produce lower yields than under more favorable conditions.

Not all salt in the root zone comes from irrigation water or water tables. Some soils in their natural state contain varying quantities of slightly soluble solid forms of some salts, which continue to dissolve as water moves through the soil. In some places, these dissolving minerals, such as calcium sulfate, contribute more salinity to the soil solution and drainage water than is applied in the irrigation water. Areas on the west side of the San Joaquin Valley are noted for this effect.

Soil salinity control

A major process for salinity control depends on leaching water through the root zone to remove excess salt and limit the dissolved salt content to the tolerance limits of the crop to be grown. Movement of water through the profile is necessary to remove excess soluble salt from the root zone of crops but is undesirable when it dissolves precipitated salts, since excess water and salt increase drainage requirements and the salt degrades groundwaters.

It is prudent to minimize the flow of water through the soil profile to reduce dissolution of soil minerals and promote precipitation of slightly soluble carbonates and sulfate minerals in the profile. Since precipitated minerals have little effect on plant growth or soil properties, the reduction in salt load should be beneficial to groundwater and surface flows. Unfortunately, neither of the mentioned processes can prevent a soil from eventually becoming salinized. Some means of collecting saline drainage waters is essential to balance salt inflow and outflow and maintain a favorable salt environment in the root zone of a crop. In some cases, crop selection may be dictated by the achievable salt balance, but the higher the concentration of soluble salts in the root zone, the narrower the choice of crops and the smaller the economic returns.

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Effect of salt on soils

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When water is applied, particles of soils with high smectite (montmorillonite) clay content may swell considerably due to hydration of expandable soil minerals. Such swelling reduces the cross-sectional area of soil pores. The process of swelling is more pronounced in the presence of high sodium or low salt concentrations, or both, in the soil water.

Dispersion of fine soil particles is controlled by a similar mechanism. Dispersion is directly influenced by ions adsorbed on particle surfaces, particularly clay minerals. The presence of high sodium, especially at low salt concentration in the soil water, causes dispersion and movement of fine particles within the pores. The particles may then become lodged in smaller pores, blocking water or air.

Swelling and dispersion are both in-