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How saltland can be reclaimed

By A.J. Peck, CSIRO

Some possibilities for reclamation of saltland

As a result of current farm practices, areas of non-irrigated land in southern Australia have become saline. This article presents a logical approach to saltland reclamation based on the physical principles of salt and water movement in the landscape.

Identification of saline soils

Usually saline soil is obvious from its depressed yield of the crop or pasture, changes in the numbers and species of plants in a mixed pasture, or the existence of salt crystals on the soil surface. However, the standard expressions of soil salinity are the electrical conductivity of water extracted from a soil sample, or the weight of sodium chloride per unit dry weight of the soil.

Methods for measurement of the salinity of undisturbed soil in the field are improving rapidly. They hold great promise for identification of salt-prone areas before there is any observable effect on plant growth.

Origin of salt

There is abundant evidence that small quantities of oceanic salts are dissolved in the rain which falls in south-western W.A. But this input of salt, which decreases from about 200 kg/ha each year in the Darling Range to about 20 kg/ha each year in the eastern wheatbelt, is much smaller than the output which has been measured in streams draining farmland.

The excess of salt is released from the enormous amounts stored in soils and subsoils. This amounts to about 1,000 tonnes/ha in an area with an average annual rainfall of 600 mm and generally more in drier areas of the south-west.

Salt movement

The movement of salt in soils has been studied extensively. In essentially all situations of practical interest, salt movement results from the flow of water containing dissolved salts. Because of this, the key to reclamation of saltland is improved water management.

Water movement

Water movement in the field can take several forms: flow over the ground surface; in water-saturated soils and subsoils (aquifers); and in unsaturated soil. In each case flow takes place as a result of differences in hydraulic head (the sum of pressure and elevation effects). Given the same difference of head between two points, the flow is usually most rapid over the surface and least rapid through unsaturated soil. However, the total quantity of water moved also depends on the cross-sectional area through which the flow takes place.

Often more than one form of water movement will be found in a particular area. For example, soil which is flooded by runoff after rainfall may also receive water by unsaturated flow from a shallow aquifer. Because of the variation which normally exists from place to place, the first step toward reclamation of a particular area of saltland should be to determine the relative importance of the different forms of water movement which transport salt into the area.

A flow chart for saltland reclamation

The technical steps required for saltland reclamation can be linked together in a logical order and illustrated in the form of a flow chart such as that shown in the Figure. The first step is to identify salt-affected land as early as possible using methods mentioned above. The following paragraphs discuss identification of the forms of water movement in the area, and treatments which are known to reduce or redirect these flows.

Surface water and salinity

Surface water flow is obvious when it occurs. However, surface water alone will rarely cause a salinity problem unless it has accumulated a substantial concentration of dissolved salts from some other area, and evaporation is essentially the only mechanism of water loss. Very often, areas which are occasionally flooded are also affected by a shallow aquifer that receives some recharge from the flooded surface. Moreover, water may lie on the surface in an area because a shallow water table reduces the rate at which water can infiltrate into the soil.

Any accumulation of surface water on saline soils should be avoided until subsurface drainage can be improved. Surface water can be controlled by well-established methods such as the construction of small banks and ditches, cultivation on the contour, and vegetation management to reduce run-off from the upslope.

Aquifers and salinity

An area of soil which has become saline as a result of salt-water movement from an aquifer may be called a salt seep. Areas of "hillside seepage" and "valley salting", both terms which have been used in Western Australia are examples of salt seeps. The new term is preferable because it focuses attention on the mechanism causing salinity rather than the position of the affected area in the landscape. When water rises in an observation hole to the same level that water-saturated soil was first encountered during drilling, the aquifer is said to be unconfined. But often groundwater is under pressure so it comes to rest at a higher level in the observation hole, and the aquifer is then said to be confined or semi-confined.

As a general rule, when saline water flows into an observation hole about 2 m deep, a salt seep will develop during rainless periods by upward capillary flow of water to replace that lost by evaporation from the soil surface. The rate of leakage towards the soil surface depends on the permeability of the confining layer. Sometimes old root channels or cracks conduct most of the water through a confining layer, and several dry observation holes may have to be dug before one of these channels is encountered to reveal the presence of a confined aquifer.
A confined aquifer can leak both water and salt into an unconfined aquifer in more permeable soil near the ground surface. Special observation holes are needed to identify the presence and importance of confined and unconfined aquifers when both occur in the same area.

To reclaim a salt seep, the intake of water to the aquifer or aquifers should be reduced, the seep area should be drained, or both of these treatments may be applied together. Salts should then be leached from the soil surface.

Economical methods for locating the area of intake of water to an aquifer are not yet well established. In Western Australia, it is believed that most water gets into aquifers in areas of deep gravel and sandplain soils under crop or pasture, and in areas receiving runoff from rock outcrops.

Generally, an unconfined aquifer is most affected by intake (rainfall or leakage from a deeper confined aquifer) close to the seep, but the intake to a confined aquifer may take place at a great distance from the area where the seep develops (the discharge area).

Much is known about what affects the rate of intake of water to an aquifer. This intake can be reduced by diversion of any surface run-on, and by the maintenance of a dense, healthy cover of deep-rooted vegetation to maximise evapo-transpiration from the area. When the area of intake is very extensive, it may be possible to achieve adequate control by the management of special vegetation in strips, or otherwise dispersed, but covering only part of the total area.

The principles of subsurface drainage to reclaim salt seeps are very well established. However, it is not always possible to apply these techniques because of cost or the lack of a suitable place for disposal of saline effluent from the drains. An alternative which may be effective in some cases is to grow deep-rooted vegetation in and near the seep to lower the water table by evapo-transpiration. A limitation of this method is that salt accumulation in the root zone will reduce the rate of evapo-transpiration, and may finally kill the plants.

**Residual salinity**

The term residual salinity refers to saline soils which are neither flooded nor affected by an aquifer. In Western Australia these have sometimes been referred to as areas of "dryland salt". Residual salinity naturally occurs in soils such as "morrel" soils which are poorly leached due to inadequate rainfall and impermeable subsoils. Also, after treatment to prevent flooding and lower the water table in any salt-affected area, residual salts will remain near the surface until they are leached into subsoils or drains. As a general rule it has been found that to leach 80 per cent of the salts out of a given depth of soil requires the passage of about the same depth of water through the soil. For example, most of the salt in soil to a depth of 1 metre would be leached after 1 metre of water had moved into the subsoil. In our agricultural areas it may take several years for this amount of water to accumulate from rainfall after losses by evapo-transpiration. However, crop or pasture can be grown sooner, when a much smaller depth of soil near the surface has been adequately leached.

Salts move freely in the water flowing through unsaturated soil except at very low moisture contents. The upward movement of saline water allows residual salts to move to the soil surface where they may then be deposited by evaporation in dry weather. The depths from which salts can rise without a shallow water table will usually be less than 1 metre.

A healthy plant cover favours reclamation of saltland; plants shade the soil surface, and their roots are distributed through a depth of soil. These effects reduce evaporation from the soil which otherwise results in very high concentrations of salt at the soil surface. However, to remove salts from the root zone, they must be leached to subsoils or to artificial drains in an excess of water as discussed above.

On heavy soils, leaching of residual salt may sometimes be limited. Improvement may be then possible by deep ripping or by applying gypsum to increase permeability. When rainfall is limiting, run-off water from upslope may be diverted to the area, with careful control to avoid the development of a shallow water table. Alternatively, infiltration may be increased and evaporation reduced by mulching the area with sand or plant litter.