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Landform, natural drainage and salinity

By Eric Bettenay, CSIRO

An understanding of salt movement in streams and groundwater may lead to better methods of control and prevention of salinity.

Most of Western Australia forms a part of what may be described as the oldest part of an old continent. For perhaps the last 100 million years the landscape has been eroded to a generally low relief, undisturbed by mountain building periods or by glaciations. The soils and landforms are thus markedly different from those of many other continental land masses.

In south Western Australia the divide which separates drainage to the Southern and Indian Oceans from drainage to the Nullabor is a broad upland at less than 600 m. This divide passes through dry areas, with high potential evaporation, which produce no permanent rivers inland. Valleys therefore are often choked with debris such as sand, silt and gypsum which the streams cannot remove. Salinity is higher in headwaters of rivers and becomes increasingly less as they approach the higher rainfall areas near the coast.

Landscape stability has allowed the development of lateritic weathering resulting in deep chemically-weathered zones, together with the surface accumulation of iron and aluminium minerals frequently referred to as ironstone.

Later erosion has resulted in the accumulation of extensive surface deposits of sand and gravel. The upper sandy and gravelly zones are normally leached and low in salts, but large quantities of salt, particularly common salt (NaCl), are often stored in the deeper weathered zones.

Landforms of Western Australia

An understanding of the landforms of Western Australia, particularly types of valleys (Fig. 1) does much to explain salinity.

Inland, the major valleys are only shallow with some 60 m from valley floor to divide. They are of low gradient and often have shallow groundwater which contain salts accumulated over many thousands of years. Generally these valleys are marked by strings of salt lakes often with gypsum dunes, and saline deposits along their downwind edges.

The lakes and major drainage lines are naturally saline and were present before agricultural development. Frequently however the main tributary valleys develop extensive salinity after clearing. Even in higher rainfall zones, as in the Darling Range, the upper reaches of the rivers and streams have broad flats which become salty after agricultural development.

Downstream of a point known as the “Meckering line” the broad-floored valleys give way to steeper U-shaped valleys. These are not associated with salt lakes, but, after clearing, salinity develops on the narrower alluvial terraces associated with the streams. Dissection here has removed much of the weathered mantle so that groundwaters may outcrop as saline seeps, seldom bigger than a few hectares in extent, on the valley sides.

Further downstream again, valleys are steeper and most soils are shallow and freely drained. Salinity here is thus largely restricted to near the streams and to minor hillside seeps.

Thus broad regions may be recognised where characteristic salinity patterns may be expected. At a more detailed scale, local variations in topography and geology are important in determining the location and size of saline seeps.

Hydrology

Although some soil salinity is associated with local movement in the profile, major redistribution of salts results from a change in surface and groundwaters after clearing. Such changes are due to reduced water usage, since the introduced crops “pump” much less water than the deeper rooted native vegetation. Studies of water movement can therefore help explain how salts are leached from one part of the landscape and accumulated in other parts.

A study in the Belka valley (Fig. 2) indicates that three relatively separate water bodies occur:

- Soil water. Much water is stored in the soil profile but in soils with low permeability little leaching takes place and salt concentrates in the root zone.
- Surface water. After periods of heavy rain much water may be shed, particularly from those soils where permeability is low. Such waters are generally fresh and may be stored in dams for farm water supplies. Also included are near surface flows in coarse sandplain soils where ironstone restricts the downward movement of water. In extensive sandplain areas, as at North Meckering, fresh water soaks and lakes may develop as a result of clearing.
- Groundwater. At variable depths throughout the Belka Valley, and in the wheatbelt generally, there is a zone of saturated fine-textured materials constituting an aquifer. Large granite domes are

Fig. 1.—Long section of the Avon-Salt Lake drainage illustrating changes in valley type from inland to the coast

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thought to be the intakes to the aquifer since water salinity here is low, and there is a regular increase in salt concentration as the valley floors are approached.

The aquifer is confined below by basement rock, and above by heavy clays and ironstone so that much of it is under pressure.

Discharge is affected by both leakage through the confining surface layer, and directly into the salt lakes which intersect the aquifers. Clearing increases surface water in the valleys thus leading to higher soil water content and greater time, and area, over which the zone above the aquifer is moist. This in turn results in greater upward movement of water and an accumulation of salts at the surface in areas which were previously salt-free.

Current work in the higher rainfall Darling Range area indicates a similar situation. Under native vegetation seasonal streams yield high quality water during wet winters. After clearing however they become discharge areas for the saline groundwaters and extensive salinity results. A difference is that rock outcrops are often not extensive and recharge appears to be through upland areas which are gravelly, or in which the ironstone is broken into blocks which allow water to penetrate.

In the more westerly parts of the Darling Range streams are fed by permanent flow of variable, but generally acceptable, salinity. It appears that higher rainfall with steeper gradients of the watertable, and well-incised streams, has led to removal of stored salts, or to reduced storage of salt.

Such studies, both at a regional and a local scale should lead to a better understanding of salt movement, and therefore to better methods of control, and prevention of salt encroachment.

Fig. 2. — Hydrology in the Belka Valley. Groundwater salinity shown in ppm.