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Does shallow sub-surface seepage cause salting?

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Summary
Seepage, cut-off or interceptor drains, monitored on five sites near Pingelly in Western Australia for a period of six years, have failed to significantly change topsoil salinity levels or halt expansion of the salt-affected areas. The results indicate that deep groundwater, moving upwards through a foliated hardpan under considerable pressure and also by capillarity, is the main mechanism of salt encroachment operating at the sites studied.

The trial was not designed to exactly simulate the commercial interceptor banks which have been in use on some Western Australian farms for the last few years. Its purpose was to investigate the principle of cutting off sub-surface seepage on its way down a slope.

Introduction
The suggestion that interceptor drains could arrest and even reverse salt encroachment, has fired the imaginations of hundreds of Western Australian farmers. The result: thousands of kilometres of these drains stand out across the landscape throughout the wheatbelt and Great Southern.

Their purpose is to hold back and divert sub-surface shallow seepage on its way to valley floors. Valley floor waterlogging by surface runoff and shallow seepage often seems to be associated with salt on the soil surface. Against this, research by the Western Australian Department of Agriculture and the C.S.I.R.O. has indicated that wheatbelt salt encroachment is caused mainly by mobilisation of stored salts by water moving at a considerable depth. This occurs after clearing has removed the natural vegetation to make way for cereals and pastures. The deep-rooted perennial natural vegetation used the percolating water before it could contribute to the water-table, whereas the agricultural crops, being shallow-rooted annuals, use only a portion of this water. The unused portion causes the water-table to rise, mobilising the stored salt and eventually causing a saline area down-slope.

However it has been observed frequently that the land on and just upslope from saltland is often a relatively sandy topsoil overlying a sharp change to a clay subsoil. In wet periods during winter, a perched watertable occurs on this clay subsoil. A method used to drain sloping waterlogged land of this type is the across-slope contour interceptor drain (either open ditch or buried drainage pipe).

Increasing farmer interest in the early 1970s in the long-term effects of seepage interceptor drains on salt-affected land, prompted the experiments described here.

The hypothesis tested was that if the salts accumulating on the soil surface came mainly from shallow-moving groundwater, and if this seepage water can be intercepted and led off to a main creek, then the supply of further salts to the affected area would be cut off or greatly reduced. If this were successfully achieved, existing salt accumulations should thereafter be leached and removed, by rain falling on the salt-affected area lying below the interceptors. The net result should be a gradual reduction in the soil salinity.

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A cross-section of the type of interceptor used at the top of each slope.

Right: The interceptors were cut deeply into the underlying subsoil.

Far right: A salt-affected area near the sites.
Trial sites

In December 1971 a site was selected on “Rocky Valley” the property of Mr G. J. Ward, situated 16 km east of Pingelly. Interceptor drains were constructed in April 1972 above an area where rapid salt encroachment was occurring. A further three trial sites were established on this farm in August 1973, on newly cleared land, which had shown signs of salting for only five years.

Two sites also were selected for sampling in August 1973 on an area of old hillside saltland on Mr C. Pauley’s property, 8 km to the east of Pingelly.

Interceptor drains were constructed on a further three trial sites at Ward’s in March 1974 and on one of Pauley’s two sites in February 1976. At Pauley’s, Site 2 was used as a control (no interceptor drain) and both sites were monitored for 2½ years to find out the natural variation in salinity from season-to-season, before installing the interceptor drains on Site 1.

On all sites, the interceptor drains were located close to the uphill edge of the land showing visible signs of salt encroachment. Replacement of clover by barley grass was the main indicator used. The drains were graded from 0.6 to 0.8 per cent towards the creek disposal point. This grade was expected to result in slight scouring of channel bottoms, to prevent siltation which would reduce the efficiency of the interceptor drains.

The drains were constructed using a Cat 12 roadgrader. Using an eight run system the vee-shaped drains were excavated 60 cm deep.

As the depth to clay subsoil varied from 30-45 cm, the interceptor drain bottoms were cut 15-30 cm into tight clay. The drains were regraded every two years to remove any silt. This in conjunction with the steep channel grade ensured that seepage water did not escape from the channel and run through into the salt-affected area. A mid-winter photograph shows the interceptor drain on Pauley Site 1 running seepage water during winter 1977.

A roadgrader was used to construct the seepage interceptors at a cost of about $100 per km compared with an estimated $500 per km for bulldozer-built drains. Despite their small cross-sectional area, the grader-built drains were as deep as most dozer-built drains being constructed at that time (1972).

The top bank at each site has been modified to prevent flood damage to the system, by moving the spoil to the uphill side. Thus these channels handle sub-surface seepage only.

Soil sampling and analysis

The effect of the interceptor drains on the salting problem was monitored by estimating the percentage of common salt from specific resistance measurements in the surface soils lying downslope of the interceptor. The sampling was carried out in mid-February each year on a 10 m grid. At each of the thirty sampling points below each drain, four samples of 0-5 cm topsoil were taken with a 5 cm diameter auger.

Results

A trend to slightly increasing topsoil salinity levels at Wards occurred during the period February 1974 to February 1980. The temporary reduction in salinity in February 1975 probably reflects an increased leaching of salts from the topsoil during the preceding wet winter in 1974. The results at Pauley Site 1 (with interceptor) and Site 2 (no interceptor) indicate that during the six year period of the trial little overall change in topsoil salinity is evident, apart from the sharp reduction in February 1975 and the even steeper increase by February 1976. High downward leaching during the wet winter of 1974, followed by increased upward ground water pressures and salt transport to the surface in 1975 would account for these fluctuations (see graph).

Statistical analysis of the results for the six year period confirmed that the interceptors had no significant effect on soil salinity.

Deep drilling

Three 7.5 cm diameter test wells were drilled below and two above the interceptor drain on Ward Sites 2 and 3. One of these was sealed to isolate the deep pressure water from shallow seepage flows. A single test well was drilled on Ward Site 1.
The interceptors succeeded in collecting and diverting the subsurface water.

This drilling confirmed that the two trial sites in question are underlain by saturated pallid zone clay—the white pipe clay well known to dam sinkers. The water in the pallid zone is under considerable upward pressure but is overlain by a confining layer of foliated siliceous hardpan. This hardpan lies about 60 cm below ground level and has both horizontal and vertical cracks and old root channels capable of transmitting water. Once the hardpan was penetrated, the groundwater was able to rise in the bore casing to over 60 cm above ground level.

Groundwater salinity
Water samples from natural seepages, interceptor drain flows and deep bores were collected and analysed for total soluble salts in 1977/78. The water from the deep bore on Ward Site 2 varied from 2,260 to 2,914 milligrams per litre (mg/l). Surface water running from a strong seepage near this deep bore contained 2,780 mg/l. Water from a flowing interceptor at Ward Site 2 in June 1978 contained 1,749 mg/l. This is fresher than the deep bore water and suggests that some dilution of the deep groundwater by shallow seepage has occurred.

Indicator plants
At Ward's, the interceptor was installed up-slope of the barley grass on the seepage area in soil carrying clover pasture. Seven years later the barley grass boundary was 20 m further up-slope indicating an increase in salting despite the interceptor.

Some 3 x 3 m plots of various salt-sensitive and salt-tolerant crop and pasture species were sown below the interceptor drain on Ward Site 2 in winter 1977. In the same year Mr Ward cropped the remainder of the salt-affected area on Sites 2 and 3 to oats. Although it was not possible to assess these plots by harvesting grain or seed we observed that the salt-sensitive species Unicrop lupins, Geraldton subclover and Gaminya wheat germinated poorly, were stunted and showed leaf burn consistent with salt damage. Cereal rye and Merredin Early Ryegrass, which are recognised as reasonably salt-tolerant developed more normally.

Conclusions
- Seepage interceptor drains excavated well into the subsoil clay, immediately above five hillside salt areas at East Pingelly, collected and diverted shallow-moving seepage water.
- The interceptor drains did not significantly change topsoil salinity levels at any of the five trial sites over a six year period. Indicator cropping on one of these sites reinforced the conclusion that the soil salinity problem was still present at that site after four years. Barley grass is still dominant after eight years (1981), suggesting little change from the 1977 situation.
- The interceptor on Ward Site 2 has not prevented the upslope encroachment of salinity into previously unaffected clover pasture land. The saltland boundary is now 20 m further upslope than it was when the interceptor was installed in 1974.
- Deep drilling confirmed the presence of a saline groundwater under considerable upward pressure on Ward Sites 1, 2 and 3. The presence of strong year-round seepage 'eyes', flows from which were not halted by construction of the interceptor drains, suggests that a major source of the topsoil salt is the deep groundwater.

Further reading