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DISTRIBUTION OF CHLORIDES IN THE WATERS OF THE CATCHMENT OF MACINTYRE BROOK, SOUTHERN QUEENSLAND, AND THEIR EFFECT ON TOBACCO PRODUCTION

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SUMMARY

The main source of chloride in the system was identified as Treverton Creek and its tributaries, waters here containing in excess of 80 p.p.m. chloride.

A perched water table of inferior quality probably feeds into Macintyre Brook near the tobacco-growing area, increasing chloride content to an average of 55 p.p.m. Springs of low-quality water also affect the chloride content of the main stream in places.

The practical implications of a water supply containing more than 40 p.p.m. chloride for land use in the area are discussed.

I. INTRODUCTION

One of the main problems confronting tobacco-growers in the Inglewood district of southern Queensland is the frequent poor quality of the irrigation water available from Macintyre Brook. District tobacco-growers have received reasonable prices for their leaf in past years, but with the more recent increase in tobacco plantings in other areas of the State, buyers have rejected a good deal of Inglewood leaf because of high chloride content. This has caused some growers to leave the industry, usually under financial hardship.

The tobacco plant absorbs chlorides readily and these accumulate in the leaf and affect the carbohydrate metabolism. Starch builds up, and in severe cases the leaf becomes greatly thickened and exceedingly brittle, the margins curl upwards and the leaf surface becomes glabrous. There is also a marked reduction in fire-holding capacity of the cured leaf, and colour and aroma can deteriorate markedly. Recent work by Colbran and Green (1961) pointed to the importance of soil fumigants in halide uptake, but chloride added in

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the irrigation water is the main source of trouble in the Inglewood area. The problem is accentuated by periods of drought, when surface water supplies dwindle and the demand for water by the growing crop is most insistent.

While chlorides in excess of 3 per cent. in tobacco leaf adversely affect quality, beneficial effects are obtained with figures of less than 2 per cent. These beneficial effects include an increase in water content and turgor, which in turn produces a larger, smoother and thinner leaf. Cured leaf with this chloride content is also more hygroscopic and commonly has a lighter colour. The chloride also often functions effectively in preventing necrosis in the leaf due to drought. Unfortunately, the level of chloride in the waters of Macintyre Brook is such that the chloride content of the leaf resulting from irrigation with such waters is usually of the order of 3–4 per cent. and in extreme cases as high as 6–7 per cent. Under these circumstances, the beneficial effects of chlorides in the cured leaf are masked by the deleterious effects of the excessive quantity absorbed. A figure of 40 p.p.m. chloride has been adopted in Queensland as the arbitrary level above which water is unsuitable for tobacco production.

In view of the serious economic situation which had developed amongst tobacco-growers in the Inglewood area, it was decided to survey the incidence of salt in the surface and underground waters of the catchment and try to pinpoint the source of salt accession.

II. LITERATURE REVIEW

Reisenauer and Colwell (1950) found that the uptake of chloride and the concentration of this ion in the leaves of a tobacco plant increased in an almost linear manner with chloride application up to the level of toxicity. Chippendale (1954) published chloride figures for flue-cured tobacco grown in the various districts in Queensland. In every district except Mareeba, undesirably high chloride figures were obtained. Myhre, Attoe, and Ogden (1956) showed that the soluble chloride concentration of the soil and the amount taken up by the tobacco crop are correlated.

Peele, Webb, and Bullock (1960), studying the composition of irrigation water used for tobacco culture in South Carolina, found that the smoking quality of the leaf was lowered when the irrigation water contained 225 p.p.m. chloride ions but the commercial grade was not significantly affected. At first glance this figure would indicate that the Queensland figure of 40 p.p.m. as the critical chloride level is too low, but in this case the American crop received only 1·6 acre-inches of water during the growing season, so the American crop was mainly rain-grown. The salt load added was equivalent to 82 lb of found that more than 200 lb of chloride was added per ac using water containing 100 p.p.m. chloride and irrigating at the rate of 10 acre-inches of water during the growing season. In this case not only was smoking quality affected, but the commercial grades were lowered.

Crack and Chippendale (1961), working in the Burdekin Irrigation Area of Queensland, found high chloride content common in leaf irrigated by the furrow method. Soil chloride figures to a soil depth of 30 in. were low at the beginning of the season but built up as the season progressed. This accumulation was greatest in the top 6 in. of the hill on which the tobacco was grown between the furrows. The authors considered the high uptake was due to lateral and then upward movement of irrigation water beneath the plant. The water used in this case had a chloride content between 30 and 40 p.p.m.

III. METHODS

The survey was commenced in September 1961, when samples of water from each of the tributaries and from nearby wells were collected and analysed. A preliminary trial to assess the best sampling depth from the surface of the water showed no significant variation with depth. This was in direct contrast to findings of other workers (e.g. Hem 1959), but it was probably due to the fact that Macintyre Brook is, in the main, a shallow stream. Subsequent samples were taken at the surface in bottles rinsed first with the water being sampled. Care was taken to locate sampling points well below the junction of streams to allow for complete mixing of the two waters prior to sampling.

The samples were analysed for chloride content, using an electrometric titration method (Best 1929).

In September 1961, Macintyre Brook ceased to flow and became a chain of waterholes with water of high chloride content. The drought broke in November 1961. Minor flooding which occurred in January and again in March 1962 flushed out the high-chloride water. This made it possible to trace the subsequent chloride build-up in the water of the main stream and its tributaries. At peak flow the chloride content of Macintyre Brook waters was under 10 p.p.m. and any subsequent increase was from within the catchment area. There would be some increase due to evaporation, but in the season under survey this was regarded as insignificant. The stream continued to flow throughout the survey, which ended in September 1962, though at the time the flow was very small.

IV. RESULTS

The analyses of samples taken during the survey have been interpolated on Figure 1. It can be seen that the main source of chloride in the system is Treverton Creek and its tributaries. In one of these, Connors Gully, a peak concentration of 646 p.p.m. was recorded. The only tributaries of Treverton Creek which did not contribute high chlorides were Jack Wade Creek and an unnamed gully parallel to it. These are storm watercourses carrying water only immediately after rain. The remainder of the Treverton Creek system contributes water in excess of 80 p.p.m. chloride and often of the order of 120 p.p.m.

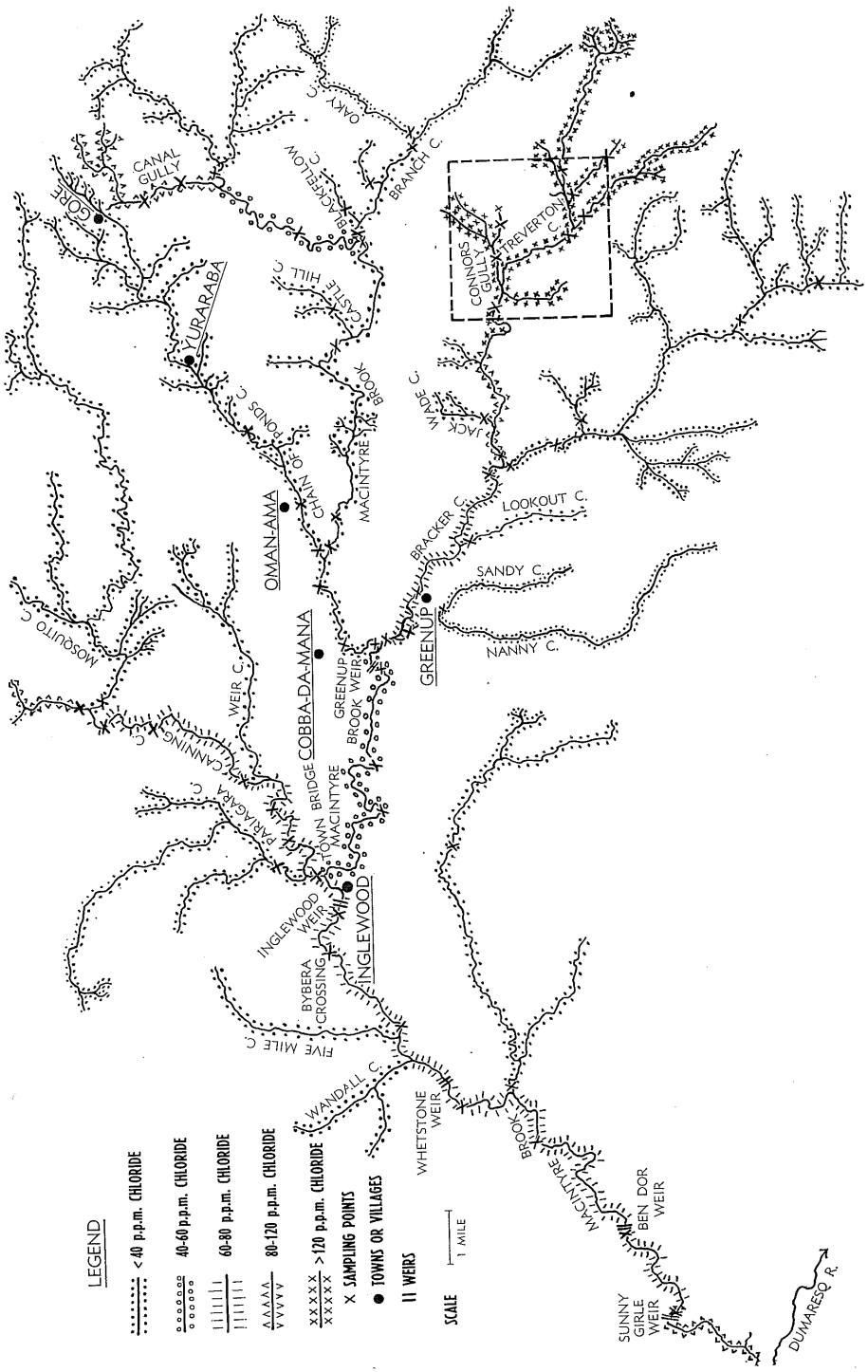

Fig. 1.—Map showing distribution of chlorides in Macintyre Brook and its tributaries.

There were, of course, variations in chloride concentrations in the gullies feeding Treverton Creek. Over the 12 months covering the survey, the chloride concentration in Connors Gully averaged 323 p.p.m. (range 181–646 p.p.m.). An unnamed gully leading into Treverton Creek from the southern side averaged 132 p.p.m. (range 81–270 p.p.m.) of chloride. The chloride content of Treverton Creek varied with site. The peak concentration was found immediately below the junction with Connors Gully (average 134 p.p.m., with a range 96–240 p.p.m.). At the mouth of Treverton Creek the figures were lower (average 107 p.p.m., with a range 74–151 p.p.m.).

The chloride concentration of the water carried by Bracker Creek before its junction with Treverton Creek averaged 37 p.p.m., indicating good-quality water, and although its surface water disappears, an underground flow continues to feed good-quality water into Macintyre Brook and this markedly dilutes the low-quality water from Treverton Creek. Bracker Creek after its junction with Treverton Creek is joined by three tributaries—Lookout, Sandy and Nanny—which only carry short-term run-off and do not affect the quality.

The upper reaches of Macintyre Brook above its junction with Bracker Creek carry waters generally below 40 p.p.m. chloride, but one tributary, Canal Gully, has low-quality water with an average of 95 p.p.m. (range 54–134 p.p.m.). Fortunately, this water is diluted by waters from Macintyre Brook and Branch Creek to an acceptable level. A number of streams in this complex carry only short-term water, e.g. Castle Hill Creek and Blackfellow Creek. Branch Creek and Chain of Ponds dry up but carry subterranean water.

Canning Creek introduces some chlorides to Macintyre Brook waters, but this creek and most of the tributaries flow only for a few weeks during the wet season, when the chloride content would be low by dilution.

The tobacco-growing areas are concentrated in a narrow strip bordering Macintyre Brook, below its junction with Bracker Creek. Four small weirs have been constructed to provide more water for irrigation. One of these, Greenup Weir, is situated about half a mile below this junction. It has a storage capacity of 320 acre-feet. There is a build-up in chloride concentration from this weir to the township of Inglewood some 12 river miles downstream, i.e. as Macintyre Brook moves away from its main source of chlorides. In this section there are a number of bores along the stream levee about 20 ft deep, with water at the level of that in Macintyre Brook. All of these bores contain water carrying in excess of 136 p.p.m. chloride, with a maximum of 246 p.p.m. This points to the existence of a perched water table of inferior quality, water which feeds into the main stream lifting the chloride content from 44 p.p.m. (range 20–70 p.p.m.) at Greenup Weir to an average figure of 55 p.p.m. (range 24–82 p.p.m.) at Inglewood.

There is also an increase in chlorides from Inglewood Weir to the Tobacco Research Station, some 12 miles downstream, from an average figure of 60 p.p.m. to 66 p.p.m. There are some springs in the stream bank in this section feeding low-quality water into Macintyre Brook.

Downstream from the Tobacco Research Station is the Ben Dor Weir, with a capacity of 595 acre-feet. The chloride content of water here is similar to that at the Tobacco Research Station, but some four miles below Ben Dor Weir springs of extremely low quality water exist and lift the chloride content from 69 p.p.m. at Ben Dor Weir to 88 p.p.m. below the springs. In drought time the stream below this weir becomes a string of waterholes, and in one instance the chloride content in a waterhole rose to over 500 p.p.m. due to accession of low-quality water from a nearby spring, while waterholes in both sides had water of much lower chloride concentration.

V. DISCUSSION

The adoption in Queensland of an arbitrary upper limit of 400 p.p.m. chlorides in irrigation water above which water is unsuitable for tobacco is not universal. Some authorities do not advocate the use of water with a chloride content in excess of 25 p.p.m. The important thing is to ensure that the chloride content of the leaf is well below 2 per cent. This variation in the level of chlorides as advocated by various authorities is due to differing soils, cultural practices and irrigation techniques.

It is known that irrigation water with a chloride content in excess of 40 p.p.m. affects tobacco leaf quality in the Inglewood area and it is of interest to know where the chlorides originate.

Throughout south-eastern Queensland there are several localities where salting has taken place and affected land has been forced out of production. Around the Kalbar area, in the Reynolds Creek catchment, near Yangan beyond Warwick, at Mt. Alford and in the Sandy Creek catchment near Forest Hill, such outbreaks of salt water occur on the slopes and affect land immediately below the spring. The general explanation for a spring's appearance is that it represents water released by a rising water table resulting from ringbarking and killing the native forest.

The main source of the chlorides in the Macintyre Brook system is Treverton Creek, which drains a catchment area which for the most part has timber killed by ringbarking. Several springs occur in this catchment and all but one carry water with a chloride content in excess of 200 p.p.m. These springs feed the streams of the Treverton Creek complex with this low-quality water and this is the main source of the high chlorides in Macintyre Brook. The upper catchment of Canal Gully is also ringbarked.

The source of the chlorides in the spring waters is subject to conjecture. Lucas (1960) conducted a geological survey of the Terrica-Macintyre Brook area and produced a map of the geological sequences and their distribution. P. J. Skerman (unpublished data) has mapped the soils of "Terrica" holding and the occurrence of springs. The locations of the springs in relation to the distribution of geological strata as mapped by Lucas (1960) are shown in Figure 2. It

can be seen that the springs rise almost wholly in marine beds of the Beacon mudstones of the Lower Carboniferous period. Many of these rocks are unsorted sediments rich in a distinctive fine-grained matrix, the clays of which have been capable of trapping large quantities of water. Their homogeneous structure, as opposed to the usual bedding, foliation or flattening parallel to bedding, is consistent with this.

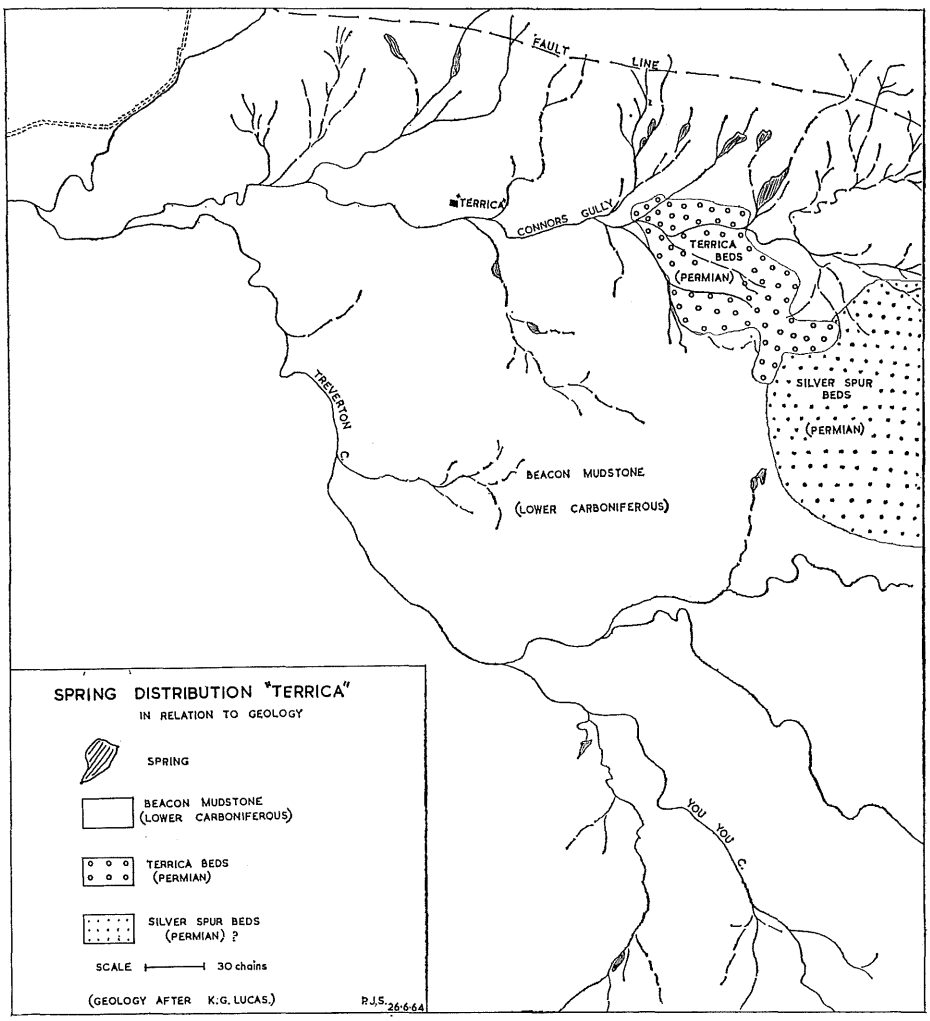

Fig. 2.—Spring distribution on "Terrica" Station in relation to geology.

Remedial measures against damage to tobacco by irrigation waters high in chloride have been considered. Inglewood district growers have adopted a new planting technique which helps to reduce the chloride hazard. Under furrow

irrigation, the chloride concentrates in the "hill" between the furrows. This is usually where the tobacco seedling is planted, and being a shallow-rooted plant, its roots are in an ideal position for chloride uptake. The new technique is to plant the seedlings on the side of the hill. Water is withheld from the plants for 5–6 weeks to allow the root system to develop. In this way some reduction of chloride uptake has resulted.

The reafforestation of the catchment area could be expected to lower the water table of the groundwater below dangerous levels. This could no doubt be done in strategic places but it would throw very good wool-growing land out of wool production. Reafforestation above the springs may dry them up, but many of the spring-fed slopes grow very good salt-tolerant herbage which is invaluable for sheep in dry times.

A dam could be constructed on Treverton Creek to hold back the low-quality waters until heavy run-off from the general catchment would allow its release, without danger to tobacco production because of its heavy dilution with fresh water. Quite frequently, however, summer rains are not received in sufficient volume to carry this low-quality water past tobacco areas.

A practical solution would be to establish permanent pastures with the inclusion of lucerne as a dewatering plant. Lucerne fits into the scheme admirably because of its extensive root system and its comparative salt tolerance. On the heavy black clay soils of the Darling Downs, W. E. Fox (private communication) has shown that lucerne can dehydrate these soils to a depth of 10 ft in 3–4 years Lucerne has recently been introduced into the Treverton Creek catchment area on "Terrica" and there are forward plans to increase the area sown to this legume. Unfortunately, a good deal of the catchment area is both steep and stony, but a chisel plough has been effectively used on this "traprock" country to establish lucerne pasture.

It may be sound practice to vacate the field of tobacco culture in the Inglewood area in favour of crops such as cotton, lucerne, pasture seed, stone fruit and grapes, which are not so adversely affected by the levels of chloride at present found in the streams of Macintyre Brook catchment area. The Inglewood tobacco industry developed as a result of a shortage of Australian-grown tobacco leaf, but with recent expansion of the industry, quality is now of prime importance. A change-over from tobacco to some other farming enterprise would demand consolidation of existing tobacco farms and resubdivision for other crops.

VI. ACKNOWLEDGEMENTS

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