# RESULTS OF A SOIL SALINITY SURVEY ON THE UMFOLOZI FLATS

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## Abstract

A survey was carried out to determine the extent of soil salinity problems on the Umfolozi Flats. Measurements were made on both soil and drainage water samples from widely distributed positions over the sugarcane areas. In spite of fairly extensive waterlogging, the area of land affected by soil salinity was found to be very small and confined largely to alluvial soils of relatively high clay content. A relationship was established between the electrical conductivity of the saturation extract ($EC_e$) and that of the equilibrium ground water ($EC_{gw}$.)

It was found that $EC_e = \frac{EC_{gw} - 40}{2{,}24}$.

## Introduction

It is well known that waterlogging, associated with a high water table, is a major problem on the very flat and poorly drained flood plain of the Umfolozi River, an area which is known as the Umfolozi Flats. Land under sugarcane in this region is some 9 500 hectares in extent. Sediments of Tertiary and Cretaceous origin underlie much of the area and protrude in the form of hillocks in various localities. Being of marine origin, these deposits are rich in sodium salts. Since the primary mechanism of soil salinisation in the South African sugar industry is the capillary rise of salty ground water from a high water table, the situation on the Flats clearly shows a potential for soil salinisation.

Soil samples received by the SASA Experiment Station from farms on the Umfolozi Flats in past years have indicated salt problems at a number of sites. Concern was therefore felt regarding the possible magnitude of the salinity problem on the Flats. It was consequently decided to survey the area in order to assess the extent of the salinity. Although it was anticipated that salinity would be associated with waterlogging, it was not intended to assess the magnitude of the drainage problem.

## Procedure

The approach adopted was to sample the soil at sites known to have been saline in the past, and also in many new areas where salinity was suspected, particularly in depressions in fields where sugarcane growth was obviously retarded. The sites sampled were distributed over the whole of the Umfolozi Flats and included, on the south-western wide, the Mavuye and Mokana catchments which have been virtually isolated by means of large dykes.

A portable electrical conductivity meter was used to measure the EC (electrical conductivity) of drainage waters. Since drains are so frequently encountered, this allowed an immediate indication of the salinity conditions in each locality inspected. Soil samples were taken at standard depths of 0-0,3, 0,3-0,6 and 0,6-0,9 m. The height of the water table was noted in each auger hole. Soil samples were taken from a total of 42 sites while salinity measurements were made on 47 drainage and ground water samples.

A survey was done between mid-September and mid-November, 1978.

### *Geology and Soils*

The soils of the Flats are derived almost entirely from alluvial material. In the lower (south-eastern) regions, soils are generally rather heavy and the predominant soil series that occur are the Phoenix, Katspruit and Glengazi. Where the clay content is high, soils of the Phoenix series and, to a much lesser extent, the Glengazi series generally occur. Katspruit series soils are usually represented where the clay content is somewhat lower and insufficient to produce marked cracking of the soil. It is in these areas where soils are rather heavy that salt problems have been identified in the past. In the upper (north-western) parts of the Flats, soils are generally sandy due to the deposit of sediment during fairly recent flooding of the Umfolozi River.

Associated with the alluvium are Cretaceous and Tertiary sediments which are exposed along the slopes which bound the Flats, and are also represented by rather prominent hillocks that protrude from the flood plain.

Organic soils of the Champagne series were encountered in the Mavuye catchment where old swamp lands have been reclaimed by drainage for sugarcane production.

## Results

Analytical data for selected soil and drainage water samples are given in Tables 1 and 2 respectively. The incidence of soil salinity was found to be very low and the only areas considered to be saline are described below.

The soils at points 38, 39 and 40 are shown in Table 1 to be moderately saline and sodic. The affected area of about four hectares was drained and ameliorated with gypsum some sixteen months prior to this survey. Before treatment some of the $EC_e$ (electrical conductivity of the saturation extract) levels at the soil surface were as high as 2 500 mS/m (or 25 mmho/cm). Although many of the drains installed are only about 0,7 m deep, salt levels clearly decreased and sugarcane now grows over the whole area, although growth is rather poor on the worst affected sites.

Points 54 and 55 are situated in the Mavuye catchment on organic soils which are derived from an old reed bed. These two samples represent a small area which is shown to be moderately saline but non-sodic. During dry periods in the past a visible salt crust has apparently appeared in these areas. At the time of sampling the young ratoon crop of variety NCo 310 looked very healthy. This is quite surprising as the $EC_e$ levels, particularly at point 55, exceeded 500 mS/m. Sugarcane growth is normally adversely affected where the $EC_e$ level exceeds 200 to 300 mS/m (von der Meden[4]; Mehrad[2]; Maas and Hoffman[1]). However, Valdivia[3] reported that the adverse effects of salinity were far less where a water table existed within reach of sugarcane roots than in a situation where the water table was very low. Where the water table was at a depth of 0,8 to 1,1 m below the soil surface, he found that sugarcane was only adversely affected by salinity where the $EC_e$ level exceeded about 800 mS/m. At points 54 and 55 in the survey the water table was 0,2 m below the soil surface. It is likely therefore that the ready supply of water to the roots allowed healthy sugarcane growth in spite of the relatively high $EC_e$ level in the soil.

Marginal salinity levels are shown at points 33 and 63 but sugarcane growth is unlikely to be affected.

No other sites sampled showed signs of salinity. The total area identified as being affected by salts and represented by the above sampling points amounted to less than eight hectares. It is possible, however, that other small saline areas exist but

**TABLE 1**
**Salinity status of soil samples**

| Sampling point | Depth (m) | Soil pH | Saturation extract | | 1N $NH_4OAc$ extract | | |
|---|---|---|---|---|---|---|---|
| | | | EC (mS/m) | SAR | Na (me%) | Ca (me%) | Mg (me%) |
| 6 | 0-0,3 | 7,2 | 60 | 2,5 | 1,4 | 15,3 | 13,3 |
| | 0,3-0,6 | 7,2 | 63 | 2,6 | 2,0 | 17,9 | 17,4 |
| | 0,6-0,9 | 7,3 | 77 | 2,7 | 1,8 | 17,1 | 17,4 |
| 14 | 0-0,3 | 5,9 | 33 | 2,1 | 0,8 | 11,4 | 11,5 |
| | 0,3-0,6 | 6,3 | 44 | 3,1 | 1,8 | 16,7 | 20,2 |
| | 0,6-0,9 | 6,7 | 60 | 3,9 | 2,4 | 16,1 | 18,8 |
| 25 | 0-0,3 | 5,9 | 80 | 2,2 | 1,1 | 12,3 | 12,3 |
| | 0,3-0,6 | 6,5 | 85 | 2,2 | 1,4 | 17,1 | 17,1 |
| | 0,6-0,9 | 6,9 | 146 | 3,4 | 2,1 | 18,3 | 17,7 |
| 33 | 0-0,3 | 7,7 | 267 | 9,3 | 4,3 | 13,3 | 9,9 |
| | 0,3-0,6 | 7,5 | 158 | 9,6 | 5,7 | 15,3 | 13,6 |
| | 0,6-0,9 | 7,4 | 200 | 8,5 | 5,9 | 17,7 | 16,4 |
| 38 | 0-0,3 | 7,0 | 163 | 9,4 | 11,9 | 15,2 | 18,7 |
| | 0,3-0,6 | 6,7 | 378 | 14,9 | 12,2 | 15,6 | 19,0 |
| | 0,6-0,9 | 6,6 | 484 | 13,3 | 13,2 | 14,5 | 19,6 |
| 39 | 0-0,3 | 6,4 | 407 | 9,6 | 8,8 | 15,4 | 16,9 |
| | 0,3-0,6 | 6,4 | 650 | 11,7 | 12,6 | 15,1 | 20,8 |
| | 0,6-0,9 | 6,5 | 642 | 13,4 | 14,9 | 14,6 | 21,8 |
| 40 | 0-0,3 | 6,6 | 433 | 10,1 | 8,6 | 16,5 | 18,3 |
| | 0,3-0,6 | 6,3 | 817 | 13,2 | 13,5 | 16,3 | 21,3 |
| | 0,6-0,9 | 6,5 | 726 | 16,3 | 15,5 | 15,5 | 21,7 |
| 54 | 0-0,3 | 5,1 | 224 | 2,6 | 1,9 | 17,8 | 11,4 |
| | 0,3-0,6 | 5,1 | 497 | 4,2 | 4,5 | 21,2 | 13,7 |
| | 0,6-0,9 | 5,4 | 616 | 4,5 | 7,4 | 27,0 | 22,5 |
| 55 | 0-0,3 | 5,2 | 545 | 3,6 | 3,4 | 22,4 | 14,2 |
| | 0,3-0,6 | 5,0 | 843 | 6,8 | 12,3 | 39,4 | 24,8 |
| | 0,6-0,9 | 5,4 | – | – | 14,9 | 33,9 | 35,1 |
| 63 | 0-0,3 | 6,0 | 121 | 5,2 | 1,0 | 4,3 | 1,9 |
| | 0,3-0,6 | 6,7 | 203 | 10,6 | 1,2 | 2,3 | 1,4 |
| | 0,6-0,9 | 6,0 | 339 | 6,9 | 0,9 | 2,5 | 1,2 |

**TABLE 2**
**Salinity status of water samples**

| Sampling point | pH | EC mS/m | Ionic concentrations (me/ℓ) | | | | SAR |
|---|---|---|---|---|---|---|---|
| | | | Na + | Ca ++ | Mg ++ | $HCO_3$ − | |
| 8 | 7,2 | 164 | 9,7 | 4,7 | 5,1 | 10,4 | 4,4 |
| 10 | 7,2 | 231 | 12,2 | 7,1 | 7,7 | 8,6 | 4,5 |
| 66 | 7,2 | 176 | 9,4 | 3,5 | 5,8 | 13,6 | 4,4 |

these are unlikely to contradict the general findings of this survey.

Soil analyses given in Table 1 for points 6, 14 and 25 show the typical chemical status of soil which is unaffected by salt problems. The soils have a neutral to slightly acid reaction while $EC_e$ and $SAR_e$ (sodium adsorption ratio of the saturation extract) levels are low. Typical drainage water analyses are represented by samples 8, 10 and 66 in Table 2 where EC and SAR levels average about 200 mS/m and 4, respectively.

## Discussion

It is quite surprising that so few of the sites sampled showed excessive salinity levels. Most of the sites were poorly drained and showed clearly depressed cane growth. Salinity was often suspected as the cause, or at least the partial cause, of poor growth. In the event, it is evident that waterlogging was normally the reason.

In general, the water table at the time of the survey was very high. Seldom was the level found to be deeper than 0,6 m and generally it varied between 0,2 and 0,4 m. It should be pointed out that good spring rains had fallen prior to the survey (July 80 mm, August 90 mm, September 51 mm, October 181 mm). There were many instances of water ponding on the soil surface, where surface water was prevented from reaching existing open drains due to inadequate or improper land shaping.

Although salinity levels in the ground water are not high they are nevertheless sufficient to cause salinisation of the top soil under relatively dry conditions. It was thought that perhaps the good rains that had fallen before the survey could have produced an atypical picture of the normal salinity status of the soil. Therefore a number of sites were resampled about one year later in December 1979. Included in these were points 33, 54 and 55. Analyses showed salinity levels to be similar to those measured originally, thus confirming the validity of the survey results.

*Note on relationship between $EC_e$ and EC of equilibrium ground water*

Since a water table existed over virtually the whole area surveyed, the situation lent itself to an investigation of the relationship between EC ground water (or $EC_{gw}$) and $EC_e$ of soil with which the water is in contact. It was thought that this relationship might be useful in any subsequent surveys as a means of obtaining a rapid indication in the field of the likelihood of soil salinity. A portable electrical conductivity meter is extremely simple to operate and making this measurement on a water sample eliminates the inconvenience of preparing a soil paste. The measurements would most conveniently be made on drainage water which, in effect, is groundwater.

In establishing this relationship, it was often difficult to know the depth of soil to which the groundwater sample should be related. However, where the water table existed below a depth of 0,6 m, the EC of sample taken from the 0,6-0,9 m depth was used. Where the level of the water table was above 0,6 m, a mean $EC_e$ of the samples taken from the 0,3-0,6 and 0,6-0,9 m depths was used. It is apparent that the manner in which this relationship was derived was somewhat imprecise and a close correlation could hardly be expected.

Figure 1 shows that the $EC_{gw}$ is considerably higher than the equivalent $EC_e$. This is presumably due to the dilution that occurs when water is added to the soil during preparation of a saturated paste. It was found that an $EC_e$ of 200 mS/m was equivalent to an $EC_{gw}$ of about 490 mS/m. Where the $EC_{gw}$ exceeded 490 mS/m a soil salinity problem could reasonably

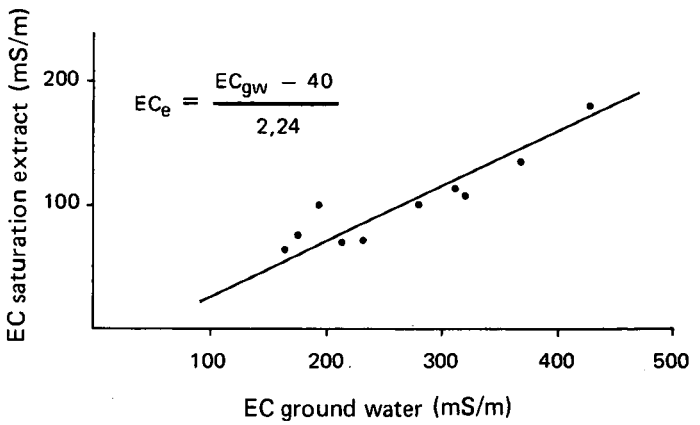


**FIGURE 1** Relationship between EC saturation extract ($EC_e$) and EC of ground water ($EC_{gw}$) in contact with soil.

be suspected since sugarcane growth is adversely affected by $EC_e$ levels higher than 200 mS/m (von der Meden[4]). This relationship should, however, be used with caution as the salinity level of the topsoil could be high even though $EC_{gw}$ is lower than 490 mS/m. Nonetheless, for the sites studied in this survey there was a clear relationship between $EC_{gw}$ and the general salinity status of the soil.

## Summary and Conclusions

There is an apparent potential for soil salinisation to occur on the Umfolozi Flats where the water table is often high and salt-rich sediments are present in the environment. Despite the possibility of salinisation, the survey showed soil salinity to be a very minor problem. High rainfall in the area is believed to be the main reason for the maintenance of a favourable salt balance, as this greatly enhances the removal of salts from a soil.

Soils in the lower regions of the Umfolozi Flats are generally fine textured and the major soil series represented are the Phoenix, Katspruit and Glengazi. However, in the upper regions recent deposits of sand are found. Organic soils of the Champagne series occur in isolated areas where old swamps have been drained. The small areas of salinity that were identified occurred in the heavy alluvial and the organic soils mentioned above.

At the time of the survey the level of the water table was invariably found to be 0,2 to 0,4 m below the soil surface.

The relationship between $EC_{gw}$ and $EC_e$ of soil from which the water had drained was studied. It was found that $EC_e$ was less than one half of the value of $EC_{gw}$. More precisely,

$$EC_e = \frac{EC_{gw} - 40}{2{,}24}.$$

## Acknowledgements

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