Short communication

Boron content of South African surface waters : Preliminary assessment for irrigation

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Abstract

Boron, a naturally occurring constituent of surface and ground water, is an essential plant nutrient. However, at relatively low concentrations, boron becomes toxic to plant growth. In order to assess the boron status in South African surface waters, the Department of Water Affairs launched a long-term boron water quality assessment programme in 1985, encompassing the analysis of water samples taken at 91 sites throughout South Africa. Results to date indicate that the boron concentration in South African surface waters varies between 0,02 to 0,33 mg ℓ^{-1}. At these concentrations even the most boron sensitive crops can be grown without fear of boron toxicity.

Introduction

Boron can probably be considered a naturally occurring constituent of surface and ground water. Boron is furthermore an essential plant nutrient. However, at relatively low concentrations boron becomes toxic to plant growth and the dividing line between essential to plant growth and toxicity is often very narrow.

The assessment and interpretation of boron concentration in water used for irrigation, in terms of effect on plant growth, is a complex matter. Factors such as method of analysis, soil type, climate, leaching fraction, crop type, volume of irrigation water applied and soil acidity, *inter alia,* all influence the effect of boron on plant growth. Furthermore all currently available boron toxicity criteria used for evaluating irrigation water, can be traced back to sand culture studies carried out in 1935 and 1944 (Gupta *et al.,* 1985) There also exists an uncertainty in the extrapolation of sand culture results to field conditions.

One of the more commonly used guidelines (Scofield, 1936 as reported in Gupta *et al.,* 1985), of permissible limits of boron in irrigation water, is shown in Table 1.

The Department of Water Affairs launched a boron water quality assessment programme in 1985, encompassing the analysis of water samples taken at 91 sites throughout the Republic. This short communication presents the summarised results obtained thus far.

Method

The sites at which water samples were collected are shown in Fig. 1. In total water samples were collected from 78 dam sites and 13 river diversion weir sites.

For the purpose of this communication, data were grouped per major drainage region (Department of Water Affairs, 1984). Of the 21 major drainage regions in the Republic only two were not monitored, namely regions 600 (the north-west coastal region) and 1400 (a small catchment north of Port Elizabeth). Ciskeian and Transkeian rivers, representative of regions 1700 and 1800, were not included in this study. Samples were collected in 300 mℓ high density polyethylene bottles. Boron was determined by inductively coupled plasma emission spectrometry using the 249,68 nm boron analytical line (Kempster, 1986).

Data were subjected to basic statistical analysis that yielded, *inter alia,* mean, minimum, maximum, coefficient of variation and standard deviation. A 90% percentile value, indicating that 90% of all values were less than the value indicated, was also determined.

Results and discussion

Summarised results, of each drainage region, are shown in Table 2.

It is evident (Fig. 1) that not each and every source of surface irrigation water was monitored during the current survey. Furthermore no survey of the boron content of ground water, that could be, or is, used for irrigation, was done. Nevertheless the limited data currently available (Table 2) would suggest that even the most sensitive crops could, in all probability, be cultivated safely under irrigation anywhere in South Africa without major boron toxicity problems (Table 1). The only catchment where boron might cause toxicity problems to ultra-sensitive crops in the long term, is catchment 1100, more specifically the Groot River, downstream of Beervlei Dam. Within the area in question, however, none of the ultra-sensitive crops, such as citrus and avocado, are grown commercially, as lucerne, one of the most boron tolerant crops, is the major irrigated crop.

Boron toxicity problems appear, at this stage at least, to be of little consequence. This observation is based purely on the mean boron content of the water. The variation around the mean, evidenced by the rather high coefficient of variation (Table 2), would seemingly indicate that the use of mean boron concentration, as sole criterion, could be misleading. It is tentatively suggested that the 90% percentile boron concentration would, at this stage, be a more accurate criterion to use in assessment of suitability of water for irrigation. However, even use of this 90% value indicates that there should be no long-term deleterious boron toxicity/crop interaction. The above, however, does not preclude the possibility that one irrigation, with water containing an ex-

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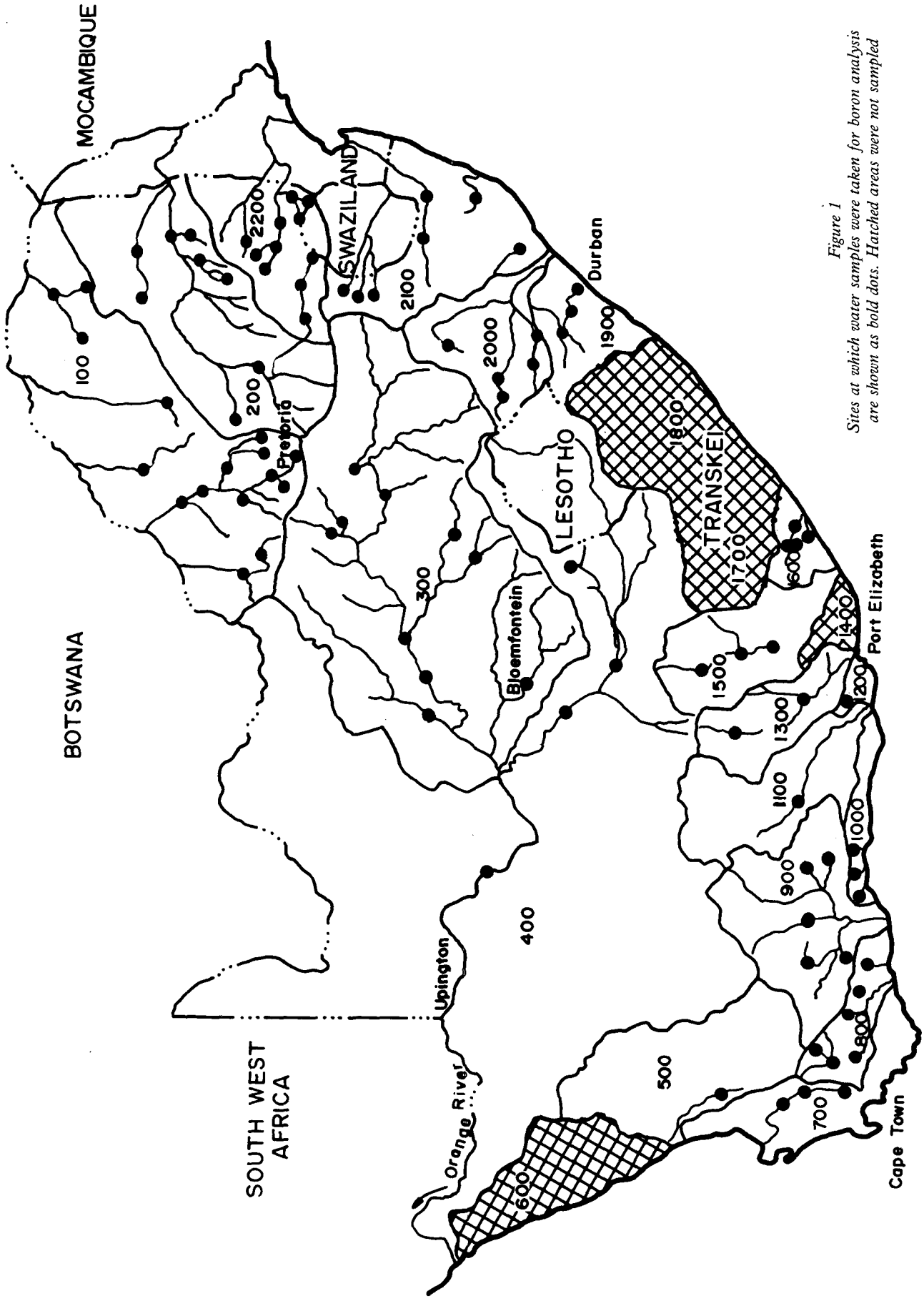

Figure 1
Sites at which water samples were taken for boron analysis are shown as bold dots. Hatched areas were not sampled

TABLE 1
PERMISSIBLE LIMITS OF BORON FOR SEVERAL CLASSES OF IRRIGATION WATERS* + +

	For irrigation of		
Boron class	**Sensitive crops**	**Semi-tolerant crops**	**Tolerant crops**
1	< 0,33	< 0,67	< 1,00
2	0,33 to 0,67	0,67 to 1,33	1,00 to 2,00
3	0,67 to 1,00	1,33 to 2,00	2,00 to 3,00
4	1,00 to 1,25	2,00 to 2,50	3,00 to 3,75
5	> 1,25	> 2,50	> 3,75

* Values as mg ℓ^{-1}
+ + According to Scofield, 1936 as reported in Gupta *et al.*, 1985.

TABLE 2
BORON CONCENTRATION OF SURFACE WATER IN VARIOUS DRAINAGE REGIONS IN SOUTH AFRICA.

Drainage region	Mean mg ℓ^{-1}	Min. mg ℓ^{-1}	Max. mg ℓ^{-1}	90% percentile	Coefficient of variation (%)
100	0,10	0,001	0,69	0,26	114
200	0,03	0,001	0,39	0,05	166
300	0,09	0,001	0,56	0,29	148
400	0,05	0,001	0,51	0,04	223
500	0,04	0,001	0,09	0,08	86
700	0,04	0,001	0,42	0,05	99
800	0,05	0,001	0,52	0,08	166
900	0,15	0,001	0,63	0,23	62
1 000	0,17	0,13	0,40	0,18	28
*1 100	0,33	0,03	0,62	-	-
1 200	0,04	0,01	0,08	0,07	50
1 300	0,26	0,001	0,59	0,43	50
1 500	0,18	0,01	0,99	0,45	98
1 600	0,08	0,02	0,51	0,08	113
1 900	0,03	0,001	0,33	0,04	189
2 000	0,02	0,001	0,28	0,02	226
2 100	0,07	0,001	0,26	0,18	107
2 200	0,04	0,001	0,26	0,09	83

*Insufficient data for statistical analysis.

cessive amount of boron, could be harmful to sensitive plants.

Summary

Results to date indicate that boron concentration, in South African surface waters, should not affect crop growth and yield. However, clearer insight to the presence of boron in irrigation waters will only be possible after many more years of data are available for analysis.

It should also be borne in mind that the current survey was by no means exhaustive and that localised areas of high surface water boron concentration can, and probably do, occur.

Acknowledgements

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