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Ecology of the Sundays River
Part I. Water Chemistry

by

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The Sundays River is unique in South Africa because of the high total dissolved solids (TDS) levels which prevail especially in the lower course. Other major South African studies, e.g. those of Harrison & Elsworth (1958), Oliff (1959) and Chutter (1963) have been limited to rivers where the TDS content above the estuary never consistently exceeds 400—500 mg/l.

The chemical nature of river water is greatly affected by the geological nature of the catchment area. Kemp (1963) has begun to correlate the chemical nature of some Natal rivers with the geology of the catchments. His studies have also been limited to rivers with a maximum TDS content of a few hundred parts per million.

In view of the high TDS levels of the Sundays River a study was initiated in January 1967. This paper attempts to correlate the chemical nature of the river with the geology of the catchment.

Main features of the catchment

The river course is shown in Figs. 1 and 2. The main topographical features are a large range of mountains, the Klein Winterhoekberge, the Klein Winterberge and the Suurberge, immediately below Lake Mentz. These mountains divide the river course into upper and lower sections and produce a rain shadow area over much of the upper catchment, most of which has an annual rainfall of only 150—250 mm as against 250—500 mm along the lower course.

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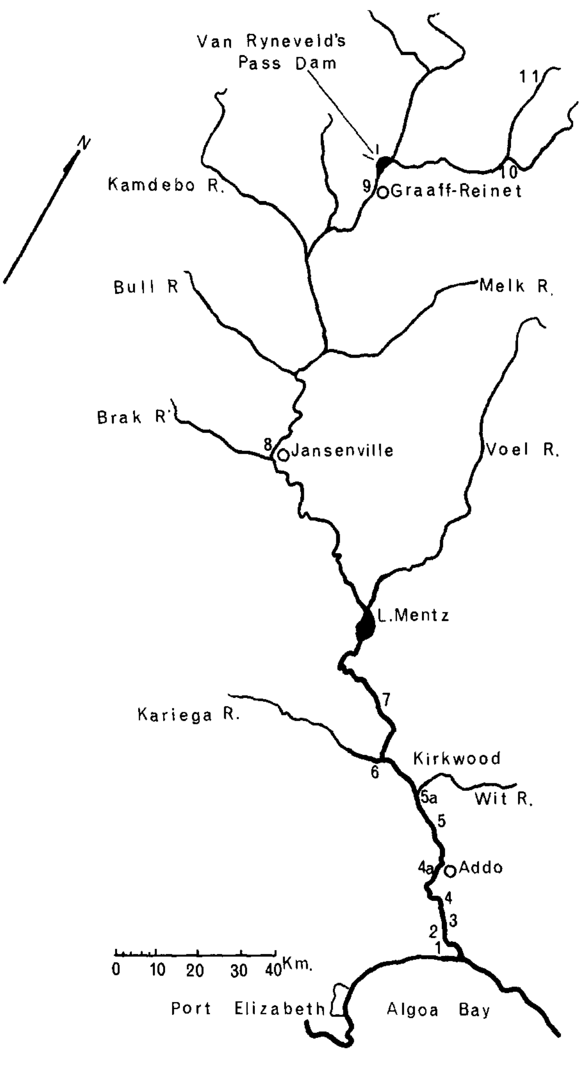

Fig. 1. The Sundays River and tributaries.
Sampling stations indicated by figures.
Scale 1 : 1,000,000

The flow in the upper course is largely dependent on thunder storms and the river is frequently dry for long periods. When the river does flow, water is collected by the van Ryneveld's Pass Dam and Lake Mentz. The latter reservoir supplies water for irrigation in the lower valley. Irrigation water is released into the river bed and flows through the mountains to a weir at Station 6 where the water is diverted into irrigation canals and this does not flow directly into

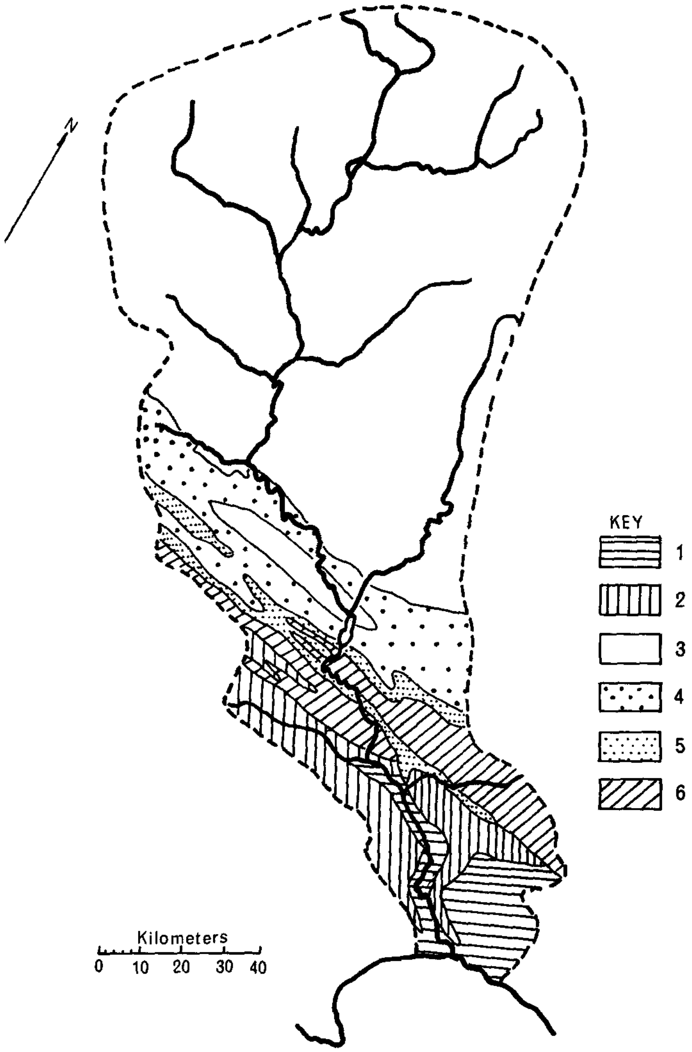

Fig. 2. Geology of the Sundays River catchment. Scale as in Fig. 1.

GEOLOGICAL LEGEND

Tertiary to Recent	Alexandria Beds	1
Cretaceous	Uitenhage Series	2
Karroo System	Beaufort Series	3
	Ecca Series	4
	Dwyka Series	5
	Witteberg Series	6

the lower course. This station roughly coincides with the transition between the predominantly freshwater strata of the Cape and Karroo systems and the marine Alexandria strata over which the lower course of the river flows. Although the flow was almost negligible at times, especially at Station 4 and at the Port Elizabeth Road Bridge across the Sundays River at Addo (4a), the lower course was never found to dry up completely.

Methods and results

On the basis of topography, geology, and accessibility, a series of sampling stations were selected (Fig. 1). The times of sampling at these stations are summarised in Table I. In February 1968 a severe drought prevailed and samples were only taken from the lower course and the Witrivier; the estuary and upper course were disregarded.

At the time of sampling the pH of the water was determined using a Beckman pH meter. 1—2 litres of water were brought back to the laboratory in glass bottles for analysis. The methods of analysis used were mostly those recommended by the American Public Health Association (1966) and Mackereth (1963). All results were first obtained in mg/l (ppm.) The accuracy of these analyses was checked by converting them to milli-equivalents and comparing

Table I

Comparison of cation and anion milli-equivalents. Dashes indicate that no samples were taken. "Discard" indicates that the discrepancy between anion and cation milli-equivalents was considered too great (> 20%).

Date	Feb. '67		July '67		Nov. '67		Feb. '68	
Stations	Anions	Cations	Anions	Cations	Anions	Cations	Anions	Cations
1	518.1	568.7	510.5	542.3	—	—	—	—
2	Discard		358.5	376.2	—	—	—	—
3	263.2	302.2	123.3	137.8	—	—	—	—
4	134.6	157.1	46.2	49.1	—	—	250.8	259.3
4a	—	—	—	—	78.7	80.7	151.8	167.1
4a (seepage)	—	—	—	—	377.6	411.9	493.3	495.6
5	69.8	75.0	Discard		—	—	79.1	79.3
5 (seepage)	—	—	112.7	136.6	—	—	96.7	103.2
5a	—	—	—	—	3.5	3.6	5.0	4.8
6	Discard		15.7	14.7	—	—	14.9	15.3
7	13.4	14.3	15.6	18.6	—	—	—	—
8	Discard		22.5	24.1	—	—	—	—
9	19.9	23.5	7.7	8.3				

the cations with the anions (Table I). The table shows that reasonable agreement was obtained in most cases; of the 25 results quoted, 20 differ by less than 10% and the remainder by between 10 and 20%. These differences were considered sufficiently small not to invalidate any conclusions that might be drawn.

Seepage water from the banks was also sampled at stations 4a and 5.

TABLE II

TDS range in mg/l, pH range and standardised analyses of water from the Sundays River.

	Upper Course (Stations 9, 8, 7)		Lower Course (Stations 6, 5, 4a, 4)		Estuary (Stations 3, 2, 1)	
TDS	Range: 574—1546		822—14,896		7539—34924	
pH	Range: 7.3—8.6 mean (8.3)		8.2—9.1 mean (8.76)		7.9—8.6 mean (8.3)	
	Mean	Range	Mean	Range	Mean	Range
CO_3	0.5	0— 1.6	0.9	0 — 2.6	0.2	0.04— 0.4
HCO_3	10.5	6.1—14.2	7.4	2.1 — 16.8	1.0	0.4 — 1.9
Ca	5.1	4.6— 7.4	1.9	0.3 — 6.0	1.1	0.8 — 1.4
Mg	5.3	4.0— 7.7	4.0	3.3 — 5.4	3.6	3.2 — 4.1
K	0.5	0.4— 1.2	0.7	0.1 — 1.6	0.6	0.4 — 1.0
Na	25.8	22.0—29.7	29.3	21.0 — 33.6	33.5	32.6 —34.1
SO_4	20.7	15.9—28.1	16.7	*8.9 — 33.0* (12.1)—(20.5)	7.4	6.8 — 9.1
Cl	31.6	20.2—37.7	39.1	*24.3 — 48.3 (32.9)— 48.3	52.6	49.4 —54.3

Results marked * indicate large variations found at Station 6; although they were tested and found accurate, they cannot be accounted for. Bracketed results immediately below indicate the range at the rest of the stations.

TABLE III

TDS range, pH and standardised analyses of water from the Witrivier tributary.

TDS Range	232—286 ppm	
pH Range	7.8—8.0	
	Mean	Range
CO_3	0	0
HCO_3	15.4	13.5—17.2
Ca	2.4	0.6—4.1
Mg	6.0	5.0— 7.1
K	1.5	1.0— 1.9
Na	25.0	24.4—25.5
SO_4	16.0	7.3—24.6
Cl	33.7	23.6—44.0

Water types are generally defined by their ionic proportions rather than their TDS levels. In this regard KEMP (1963 and pers. comm.) has developed a system of standardised analyses. In this method the concentration of each ion in mg/l is expressed as a percentage of the TDS content also in mg/l. This allows the relative proportion of each ion to be determined.

The results of this method of standardised analyses are summarised in Table II.

Results of analyses of water from the Witrivier tributary are given in Table III.

DISCUSSION

The upper course will be considered first. TDS levels in this section of the river were high in comparison with data from comparable sections of other rivers. Table II shows how the TDS levels rose from a few hundred to well over 1,000 ppm. HARRISON & ELSWORTH (1958) recorded a TDS content of 220 ppm in a comparable region of the Berg River while OLIFF (1959) states that TDS levels in the Tugela never rose above 202 ppm.

The catchment of the upper course lies on the Beaufort Series of the Karroo System. This is of interest as KEMP (loc. cit.) has established the typical ionic character of Natal rivers flowing over such a catchment. A comparison of his figures with those obtained from the upper Sundays River is shown in Table IV.

TABLE IV

Comparison of the standardised analyses of river water flowing over the Beaufort Series in Natal, and the upper Sundays River.

	CO_3 & HCO_3	Ca	Mg	K	Na	SO_4	Cl
Natal	53.4	11.3	5.5	2.6	10.4	7.8	9.0
Sundays River	11.0	5.1	5.3	0.5	25.8	20.7	31.6

One possible explanation of the differences is the aridity of the upper catchment of the Sundays River as compared to Natal. KEMP dealt with flowing rivers while the upper Sundays River is frequently dry or reduced to a series of pools. Greater evaporation rates coupled with differential precipitation in the upper Sundays could thus have affected the results obtained.

BOND (1946) in his review of South African underground water resources provides figures which indicate broad similarities between the upper Sundays River and the underground supplies in this area.

He reported chloride contents averaging 22.5% and sulphate contents averaging 10.8%. Differences are again apparent and it is possible that the use of irrigation water from van Ryneveld's Pass Dam may have affected the underground supplies.

Overall in the upper course there was little constancy in proportions of any ions and at the same time no apparent trend in the variation. The ephemeral nature of the river flow appeared to be the main feature of this section of the river.

In the lower course of the river from Station 6 to Station 4 (see Fig.1) the TDS levels rose rapidly especially during February 1967 and February 1968 under drought conditions. The TDS levels ranged from about 800—1,000 ppm at Station 6 to 2764 (July 1967) – 14986 ppm (February 1968) at Station 4.

From the detailed standardised analyses obtained for each station in both summer and winter the following features of the ionic nature of the water were noted (Summarised in Table II).

Carbonate was very low and varied erratically although it tended to decrease downstream; bicarbonate was higher and showed a marked decrease downstream. Calcium showed a similar decrease. Sodium was the major cation and was fairly constant in proportion at all stations at all times. Magnesium was far less important than sodium but equally constant in proportion. Potassium was very low at all stations. Sulphate and chloride were the main anions. Unaccountable variations occurred at Station 6, but downstream the proportions remained fairly constant although chlorides did increase slightly in proportion.

Table II indicates that there was relatively little change in ionic proportions along the lower course above the estuary. Bicarbonate, chloride and calcium were possible exceptions. pH levels were always high. Thus the changes in TDS levels were mainly concentration and dilution effects. The possible biological significance of this will be discussed in subsequent papers. Water collected in the upper catchment is funnelled into Lake Mentz and subsequently diverted into irrigation canals at Station 6. The upper course thus makes little direct contribution to water flow in the lower course, which obtains water from local rainfall and from seepage of irrigation water applied to the citrus orchards in the lower valley. Before this water reaches the lower course it flows through or over the Alexandria marine deposits.

This would be expected to affect the chemical nature of both these sources of water. The results of analysis of this seepage water collected at Stations 4a and 5 are shown in Table V.

TABLE V

Mean standardised analyses of seepage water from Stations 5 and 4a. (Variation less than 1% from mean in all cases).

Stations	TDS mg/l	CO_3	HCO_3	Ca	Mg	K	Na	SO_4	Cl
5	5851 & 7585 (July '67) (Feb. '68)	0	8.1	1.9	2.6	0.3	33.6	19.3	34.2
4a	25910 & 28406 (Nov. '67) (Feb. '68)	0.1	0.8	1.7	5.1	0.2	29.6	11.1	51.5

Table V clearly shows that the TDS levels of the seepage water were remarkably high. At Station 4a the seepage water formed pools on the bank before entering the river and the higher of the two figures recorded was probably partly an evaporation effect. However, the lower figure was obtained when the seepage flow was rapid enough to make evaporation effects negligible. At Station 5 there were no standing pools and the water ran for a short distance over muddy banks and through long grass before entering the river. TDS levels of this seepage water were not as high as at Station 4a although they are still considerable.

The raised TDS levels of the seepage water at both stations are obviously geological effects. The standardised analyses as well as the TDS levels from the two stations differ markedly. The water from Station 4a has a much lower bicarbonate content while the sulphate-chloride proportions are virtually those of sea-water.

Despite the differences one factor indicates that these seepages have a common source. Analyses of the seepage water indicated nitrate enrichments, 18 ppm at Station 4a and 45 ppm at Station 5 as against a maximum river level in the lower course of 2.1 ppm recorded at Station 5. The nitrates probably originated in fertilizers applied to the orchards which were dissolved and eventually carried to the river.

This seepage water must contribute considerably to the high TDS levels found in the river. In an attempt to ascertain the extent of this contribution some measurements were made of the flow rates of the river and seepage water at both stations in April 1968. These indicated that the contribution at the time at Station 4a was about 4% of the total river flow, while at Station 5 it amounted to about 12%.

Comparison of the standardised analyses of river and seepage water at Station 5 were very similar. The effect of the seepage water would thus be to raise the TDS level of the river water. However, at Station 4a the seepage water differed from the river water and was more comparable with sea-water. Therefore it is possible that ionic changes might occur, the seepage tending to raise the chloride and lower the bicarbonate content of the water in the river.

In contrast to the seepage water the Witrivier tributary represents a source of water with a low TDS value. However, there was no flow in February 1968 and even during rains the contribution to the main river flow did not appear significant.

In the estuary, seawater was the main factor affecting the ionic proportions of the water (see Table II). Although the TDS content dropped to 7,539 ppm at Station 3 in July 1967 due to inflow of water from the lower course, analysis showed that the ionic proportions were typical of seawater. Table II also shows the marked change that occurred between the lower course and the upper estuary, viz. the marked decrease in the proportions of bicarbonate and sulphate and the increase in chloride. The possible biological effects of this transition will be discussed in Paper 2.

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Summary

Water analyses were done on samples taken at a series of points along the Sundays River in the Eastern Cape, South Africa. The chemical characteristics of the water were then correlated with the geological and geographical nature of the catchment.

Zusammenfassung

Wasserproben von einer Reihe von Stellen des Sundays Rivers in der Östlichen Kapprovinz, Süd Afrika, sind analysiert. Die chemischen Eigenschaften sind bezogen auf der geologischen und geographischen Natur des Sammelgebietes.

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