

Metal Surveys in South African Estuaries VI Sundays River

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Abstract

Surveys to study the distribution of selected metals in the Sundays River were carried out in August 1979 and August 1981. Surface sediment and water samples and sediment cores were analysed for up to sixteen elements using atomic absorption spectroscopy. Interelement relationships as well as absolute metal concentrations were examined before interpreting the data obtained.

The combined results of both surveys of the river indicate that the input of metals by man is insignificant. There are strong indications of mineralization in the lower reaches of the estuary, particularly in the region of Colchester. This would lead to the introduction of metals mainly in the sulphide form, so that elements such as zinc, copper, lead and mercury would not be readily available to the biota and would therefore not be a threat to estuarine flora and fauna.

Introduction

The Sundays River enters Algoa Bay approximately 40 km east of Port Elizabeth. The river originates in the Karoo near Nieu Bethesda and flows over Karoo deposits (the Beaufort, the Ecce, the Table Mountain and the Witteberg geological groups). The river is dammed by the Mentz Dam near Jansenville from where a steady flow of fresh water is released. It drains the highly cultivated Sundays River valley but otherwise flows through undeveloped areas. Unlike the Swartkops River estuary, the Sundays River does not have any salt marshes or extensive mud flats.

The estuary is channel-like for its entire course with a narrow intertidal zone and because of this, flushing of the estuary is virtually complete during floods. The water is approximately 2,5 m deep near the mouth but this increases gradually to a maximum of 5 m on the first bend of the lower reaches. It then becomes gradually more shallow and is 2,5 m deep at the limit of tidal influence approximately 20 km from the mouth. The estuary is about 200 m wide at its widest point near the mouth, from where it becomes progressively narrower to about 20 m at the head of the estuary.

Forbes and Allanson (1970) studied the water chemistry of the Sundays River with the intention of relating the chemical characteristics of the water with the geological and geographical nature of the catchment. Otherwise, little research has been carried out on the ecology of this estuary and few data exist on the occurrence, abundance and distribution of its faunal communities. However, the Zoology Department of the University of Port Elizabeth has recently initiated a research programme on all aspects of the ecology of this estuary, including the physical and chemical characteristics and quantitative surveys of plankton, nekton, macro- and meiobenthos.

This estuary is virtually unpolluted with respect to industry but it flows through an extensive orange-farming area and pollutants from this source can be expected. It should be possible, therefore, to assess the impact of agricultural activities up river on the estuary. The aim of these preliminary surveys carried out in August 1979 and August 1981 was to determine the current metal levels in the sediments and water of the Sundays river. The data obtained will serve as a baseline for future monitoring surveys should urban development or industrialization be planned for this region of the South African coast.

Materials and Methods

Water Samples

Surface water samples were collected in 2,5 l high-density polythene bottles. Three subsamples were separated from each bulk and the preliminary sample preparation carried out on site as follows:

- a 100 ml sample acidified with 1 ml nitric acid for the determination of sodium, potassium, calcium and magnesium;
- a 500 ml sample acidified with 2 ml acid for the determination of mercury, and
- a 1000 ml sample for the determination of copper, lead, zinc, iron, manganese, cobalt, nickel, chromium and cadmium. The pH of this sample was measured and, where necessary, adjusted to pH7 with nitric acid or ammonia solution. Ten millilitres of a buffered solution of sodium diethyldithiocarbamate were then added and the sample shaken for 5 min.

A second 2,5 l sample was collected at each site, the bottle sealed and returned to the laboratory. About 1500 ml of this sample were filtered through a 0,45 µm pore size membrane filter. A 500 ml subsample was then acidified with 2 ml nitric acid, for the determination of mercury and the metals in a 1000 ml subsample were chelated as described for the unfiltered samples. The chelated metals in both the filtered and unfiltered 1000 ml samples were extracted into chloroform and the organic phase separated, acidified with 2 ml nitric acid and evaporated to dryness. This inorganic residue was dissolved in 10 ml 1 M nitric acid for atomic absorption analysis.

Ten millilitres 25% mass/v low-mercury potassium permanganate solution and 2 ml concentrated sulphuric acid were added to the 500 ml samples and the mixture allowed to stand for 24 h to oxidise all organically bound mercury to inorganic mercury.

Detailed descriptions of the further preparation of these water samples and the determination of their metal contents are explained elsewhere (Watling and Watling, 1982a).

Sediment Samples

Approximately 500 g of a composite surface sediment was collected using an aluminium scoop. These samples were air-dried between filter-paper sheets, disaggregated in a porcelain mortar and sieved through a 210 μm nylon screen. The fraction which passed through the screen was reserved for analysis.

Sediment cores were collected by hammering PVC tubes directly into the sediment. Good penetration with very little compaction of the sediment was achieved using this method. The tube was then sealed at the top using a rubber stopper and withdrawn from the sediment. Both ends of the tube containing the sediment core were sealed using polythene-covered corks and the whole sample frozen to -20°C . Frozen cores had to be stored for up to eight weeks but no deterioration of the sediment was observed during this period.

The further preparation and analysis of these sediment samples has been described (Watling and Watling, 1982a).

Results and Discussion

Samples were collected from seven sites in the Sundays River (Fig. 1).

Water Samples

The concentrations of major, minor and trace elements in water samples collected along the river are listed in Table 1.

The influence of the marine water is apparent as far as the McKay Bridge and possibly as far up river as site 7 (Fig. 1). The mouth of the river was open to the sea at the time of sampling and there was a significant freshwater input to the river so that hypersaline conditions were not observed anywhere in the estuary.

There are slight but distinct increases in the concentrations of copper, lead, zinc, chromium and mercury in samples collected near the river mouth which may be a reflection of the proximity of the town of Colchester. These levels are too low to affect the biota of the estuary adversely.

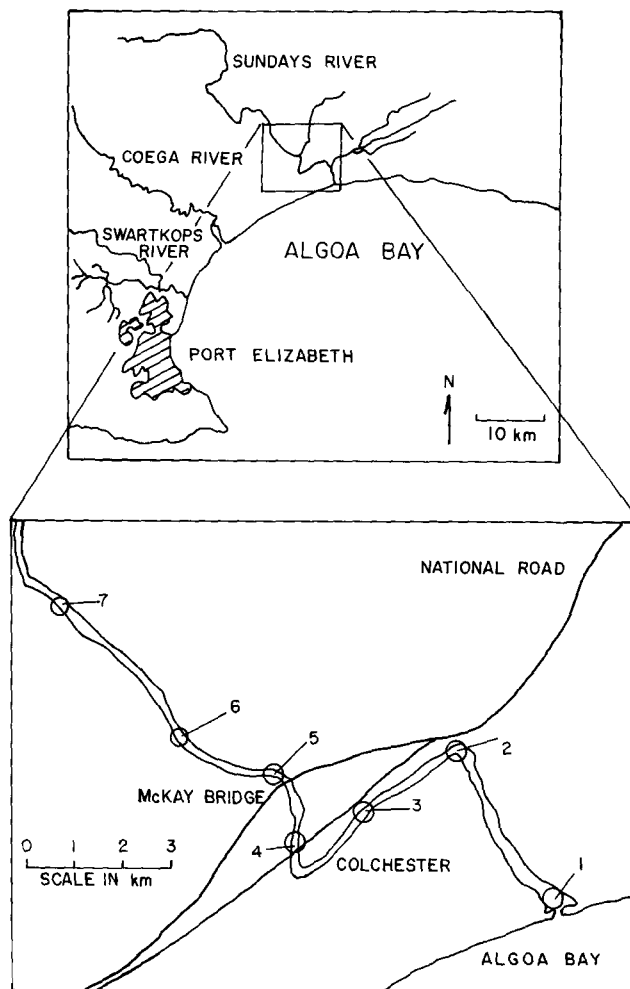


Figure 1
Study area and sampling sites.

TABLE 1
MAJOR, MINOR AND TRACE ELEMENT CONCENTRATIONS IN WATER SAMPLES

Site (refer Fig. 1)	Cu	Pb	Zn	Fe	Mn	Co	Ni	Cd	Cr	Hg	Na	K	Ca	Mg	Sr
Unfiltered Samples															
1	8,6	1,3	5,6	470	17	0,1	1,2	0,03	1,6	0,067	14 200	380	510	69	17
2	2,2	0,8	2,0	321	17	0,2	1,0	0,04	1,5	0,039	7 900	270	400	52	13
3	2,5	0,3	1,3	237	14	0,2	0,8	0,04	1,0	0,037	6 200	170	290	39	12
4	5,7	0,9	3,0	488	22	0,1	1,2	0,08	1,7	0,036	3 100	100	160	30	9
5	2,6	0,6	2,1	253	12	0,3	0,9	0,02	1,1	0,035	1 620	70	110	21	6
6	2,9	0,8	3,4	372	23	0,3	1,1	0,03	1,1	0,017	500	25	90	6	3
7	3,3	2,3	2,7	503	34	0,5	1,3	0,03	1,5	0,036	400	10	27	6	2
Filtered Samples															
1	6,2	1,3	5,6	5	6	0,2	0,7	0,02	0,3	0,006					
2	3,1	0,4	5,0	6	9	0,2	1,1	0,05	0,4	0,033					
3	2,3	0,4	5,3	5	6	0,2	1,6	0,02	0,4	0,099					
4	5,9	0,5	3,5	7	2	<0,1	2,5	0,04	0,5	0,012					
5	2,8	0,6	1,9	6	2	<0,1	0,8	0,01	0,4	0,035					
6	2,8	0,9	2,8	5	5	0,5	1,1	0,01	0,4	0,057					
7	3,6	0,6	3,0	9	2	0,5	1,2	0,03	1,6	0,037					

The main differences in the results for filtered and unfiltered samples are observed for iron, manganese and chromium, all of which are relatively high in the unfiltered samples. This implies that these elements are present mainly in association with the particulate phase, probably being absorbed onto iron and manganese hydroxides or suspended clay minerals. The concentrations of copper, lead and zinc remain relatively high in the filtered samples, indicating that these elements are present mainly in solution.

It will also be noted that the concentrations of some elements in some of the samples are higher in the filtered than in the unfiltered sample. Many, but not all, of these differences are within the precision of the analytical method. All possible precautions to prevent contamination were taken throughout the analytical programme from sample collection to final analysis. Filter pads were acid leached and filtration apparatus thoroughly cleaned between filtrations. However, it is obvious that a minor amount of contamination of samples has occurred during the filtration stage and this is why general trends in trace metal content of waters are discussed rather than absolute metal levels.

Surface Sediments

Metal concentrations in surface sediments are listed in Table 2. The levels of copper, lead, zinc, cobalt, nickel and chromium are elevated in surface sediments collected from all sites except in the river mouth. These elements are probably derived from leaching and weathering of the mineralized Uitenhage beds in which the river is entrenched.

The potassium-aluminium ratios indicate that these sediments are rich in clay, the carbonate facies only attaining significance at the mouth of the estuary. The iron-aluminium ratios indicate the presence of hydrated iron minerals as a discrete phase in the surface sediments.

When the sediment metal concentrations in this estuary are compared with those in sediments from the upper reaches of the Swartkops River (Watling and Watling, 1982a) where the Uitenhage beds are again encountered, some similarity between element assemblages is observed. Copper, lead and zinc levels are elevated in the Swartkops River but these sediments have a much greater clay component. Nickel, cobalt and chromium levels are elevated in the Sundays River but the clay component of the sediment is an order of magnitude lower. This implies that the Sundays River catchment has greater mineral potential than that of the Swartkops River and the possible presence of mineralization in the Sundays River catchment will be investigated further.

Sediment Cores

Only sites 1-5 were sampled during the initial survey of the Sundays River and the data from these cores were analysed in full as described by Watling and Watling (1982a). The remaining two cores (sites 6 and 7) were collected during the later survey. Samples from these cores were analysed for ten elements only and no correlation matrices were described. The combined data for both the surveys are detailed elsewhere (Watling and Watling, 1982b). The geometric means for the concentrations of each element in these cores have been calculated and are listed in Table

TABLE 2
METAL CONCENTRATIONS ($\mu\text{g/g}$) IN SURFACE SEDIMENT SAMPLES FROM THE SUNDAYS RIVER

Site (refer Fig. 1)	Cu	Pb	Zn	Fe	Mn	Co	Ni	Cd	Na	K	Ca	Mg	Sr	Al	Cr
1	0,8	0,7	6,1	7 600	100	3,2	5,8	0,045	4 100	2 740	132 000	4 730	849	10 000	17,2
2	6,2	10,3	36,1	16 300	240	6,2	11,9	0,041	3 690	2 620	25 900	4 150	163	12 500	22,3
3	12,4	14,1	43,2	18 300	240	8,3	15,1	0,081	4 430	3 660	18 500	4 710	109	14 100	29,6
4	20,3	24,6	72,6	35 800	460	14,6	25,4	0,019	6 390	5 640	3 760	8 090	23	31 400	44,7
5	20,4	21,3	78,6	33 200	298	12,3	26,8	0,060	6 310	5 080	3 650	9 000	37	35 000	29,4
6	18,4	17,6	56,3	12 500	563	8,4	17,0	0,093	6 410	5 160	3 920	8 100	30	36 000	64,7
7	8,4	16,8	39,3	13 600	621	12,7	26,4	0,069	5 920	5 010	4 000	8 640	33	37 100	60,6

TABLE 3
GEOMETRIC MEANS FOR METAL CONCENTRATIONS IN CORES FROM THE SUNDAYS RIVER

Site	Concentration ($\mu\text{g/g}$)															
	Cu	Pb	Zn	Fe	Mn	Co	Ni	Cd	Na	K	Ca	Mg	Sr	Al	Cr	Hg
1	1,4	1,1	5,7	2 950	39	0,5	0,8	0,05	3 000	429	133 000	3 260	983	2 520	8,1	0,006
2	6,6	10,9	37,2	17 100	243	6,3	12,5	0,04	3 860	2 840	25 300	4 350	156	13 900	23,3	0,023
3	12,0	13,8	43,4	18 300	243	8,0	15,1	0,08	4 430	3 660	18 500	4 710	109	14 100	28,8	0,018
4	20,4	23,7	72,3	35 800	459	14,8	25,4	0,01	6 390	5 640	3 760	8 090	23	31 400	43,8	0,028
5	20,0	21,5	78,2	33 200	298	12,3	26,8	0,06	6 310	5 080	3 650	9 010	37	35 000	29,3	0,012
6	9,6	12,3	58,2	3 600	159	3,8	15,8	0,33							5,6	0,029
7	11,6	13,7	68,3	7 800	460	8,3	20,3	0,38							28,4	0,051

3. While this is not an ideal way to display core data, it does serve as an easy method for identifying anomalous areas.

It is apparent from these data that levels of certain metals in the sediment column are elevated at and upstream from site 2, notably the elements copper, lead, zinc, cobalt, nickel and chromium. In the samples from core 3 these elements are inter-related consistently with iron which suggests that they are derived from the weathering of locally mineralized catchment rocks. Further upstream absolute metal concentrations remain high but the interelement relationships within the cores break down. This suggests that variable amounts of slumped river-bank material have been incorporated in the sediment column with only partial sorting and separation of the heavier minerals.

The role played by hydrated iron oxides in coprecipitating the transition metals decreases upstream of site 5, so that at sites 6 and 7 it is assumed that the metals are associated primarily with clay minerals.

In general, the core data for the Sundays River indicates that there is little if any input of metals as the result of human activities. The transportation of metals out of the area is minimal and considerable sedimentation occurs in the area between site 3 and the mouth; clearly this situation could be reversed during periods of flooding at which time it is possible that considerable amounts of metal-rich sediment could be introduced into the nearshore coastal zone. This input of metals may well have a significant effect on the coastal biota but would probably be less damaging than the increased turbidity and decreased salinity of the water.

Summary

The results of these surveys indicate that the input of metals by man is insignificant. The increased levels of metals in the sediment column are probably derived from catchment weathering of mineralized zones and metals are likely to be present in the stable sulphide form making them relatively unavailable to the biota.

The Sundays River is at present unpolluted with respect to metals and unless further urban, agricultural or industrial developments take place it should not be necessary to monitor the area.

Acknowledgement

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References

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