Metal surveys in South African estuaries
X. Blind, Ihlanza, Nahoon and Quinera Rivers

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Abstract

Metal surveys to study the Blind, Ihlanza, Nahoon and Quinera Rivers near East London were undertaken. Samples were analysed for up to sixteen elements using atomic absorption spectroscopy. Inter-element relationships as well as absolute metal concentrations were examined before interpreting the data obtained.

The results indicate that the Blind, Ihlanza and Nahoon Rivers are subject to anthropogenic input of metals from a variety of sources while the Quinera is essentially unpolluted by metals.

Introduction

The source of the Blind River is in a municipal quarry approximately 3 km inland from the East London coastal zone (Fig. 1). The mouth of the river is blocked by a sand bar which is only breached during periods of high rainfall and flooding (Thornton, 1959). The catchment is entirely within a residential suburb of East London. A rubbish tip, to which there is unrestricted access, receives a wide variety of solid wastes from local, industrial and domestic sources.

The Ihlanza River is also short (approximately 2 km) and does not reach the sea. Its entire catchment is heavily populated. A pipeline, carrying raw sewage crosses the river near its mouth and overflow valves release material into the river during periods of high rainfall.

The Nahoon is the longest of the four study rivers, extending 90 km inland and draining a catchment area of 450 km^2 (Tow, 1981). The East London metropolitan area straddles the estuary but the rest of the river drains a pastural and unurbanized catchment. The Nahoon Dam is situated in the middle of the catchment and has a capacity of 22,1 x 10^6 m^3 (Tow, 1981). The estuarine area, which measures approximately 4 km in length with an average channel depth of 4 m, is used extensively for recreational activities.

The Quinera River is approximately 20 km long and drains an essentially unurbanized catchment of 500 km^2. The mouth of the river is blocked by a sand bar although seepage of salt water at high tide creates estuarine conditions for a distance of 2 km upstream.

The purpose of this study was to establish the current distribution of selected metals in the Blind, Ihlanza, Nahoon and Quinera rivers. This data would produce a baseline for future studies in the area and give an indication as to the present state of these rivers with respect to metal contamination.

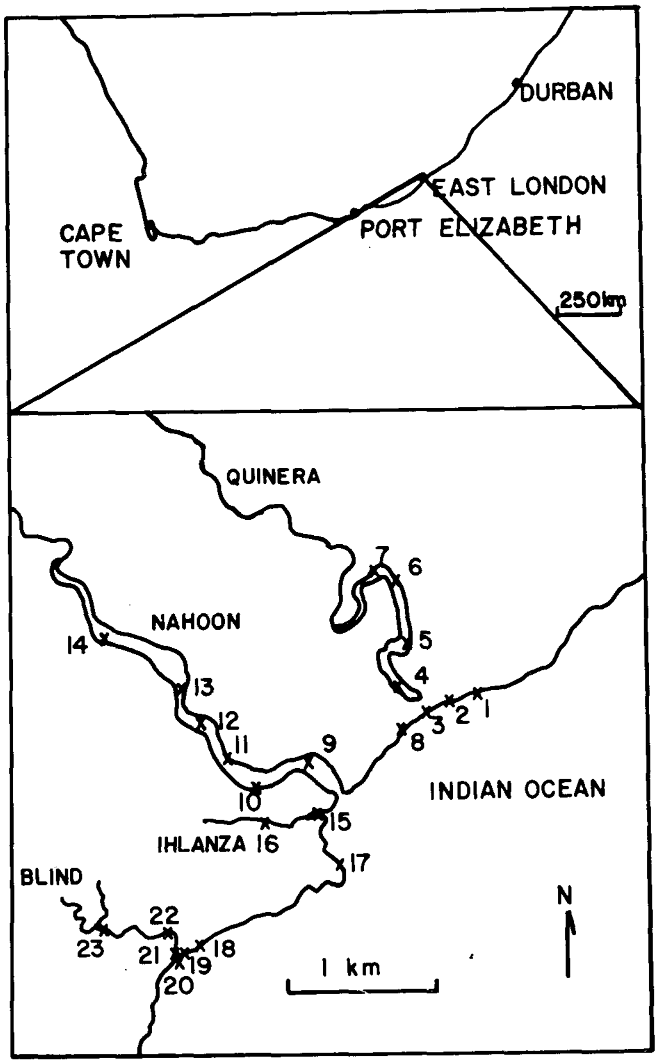

Figure 1
Distribution of sample sites in the Blind, Ihlanza, Nahoon and Quinera Rivers near East London

Materials and methods

Surface water samples were collected in 250 ml high density polythene bottles, acidified with 1 ml concentrated redistilled nitric acid and stored for the determination of copper, lead, zinc, iron, manganese, cobalt, nickel, cadmium, sodium, potassium, calcium, magnesium, strontium and chromium. An additional 500 ml sample was collected for the determination of mercury. Concentrated nitric acid (10 ml) was added to this sample as a preservative.

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Copper, lead, zinc, iron, manganese, cobalt, nickel, cadmium and chromium were determined using a Varian Techtron AA875 with GTA95 graphite furnace. Mercury concentrations were determined using cold vapour atomic absorption. Samples were analysed for sodium, magnesium, potassium, calcium and strontium using standard flame conditions.

Methods used for the collection, preparation and analysis of surface sediments and sediment cores have already been detailed (Watling and Watling, 1982a).

Results and discussion

Metal concentrations in surface waters from selected sites in the study area (Fig. 1) are presented in Table 1.

The concentrations of copper, lead, zinc and nickel are elevated in surface water samples from the Blind and Ihlanza Rivers when compared with average levels in Eastern Cape rivers (Watling, 1982). However, the rubbish tip on the Blind River does not seem to contribute as high a soluble metal load as would be expected from the unrestricted use of the site. In the Ihlanza River, the two hydrophylic elements, copper and zinc, have elevated concentrations while lead possibly enters the water column as a particulate and ultimately settles near the mouth.

High concentrations of lead and nickel were present in surface waters from the Nahoon River. Levels of these elements increase to one thousand times higher than those found during a preliminary survey of the area in 1981 (Watling *et al.*, 1982). It is possible that these metals were introduced as a result of regatta activities in the area which finished two days prior to the start of the sampling programme. While such inputs would appear to be of short duration and their residence times strictly limited, they could have significant short term impact on the local biota. Excessively high levels of mercury were also present in all water samples from the Nahoon estuary, with concentrations ranging from 1 500 to 3 000 $\mu g/\ell$. These values are two orders of magnitude above those expected for uncontaminated Eastern Cape estuaries (Watling, 1982). The origin of this metal is as yet unknown, but the levels are too high to be entirely due to runoff of the regatta and there could be a significant natural input. The lack of elevated metal levels in water from the Quinera River indicates that this river is uncontaminated with respect to metals.

Metals in surface sediment

Metal concentrations in surface sediment samples taken from upstream of the rubbish tip on the Blind River (Table 2) are slightly elevated above average values for uncontaminated Eastern Cape rivers (Watling, 1982). Immediately downstream of the tip, elevated levels of copper, zinc and chromium testify to an anthropogenic source. In the mouth of the river, metal concentrations return to background. This implies that metals enter the river from this rubbish tip as particulates and are incorporated into the sediment within 100 m of the input source.

With the exception of lead at the head of the river and copper at the mouth, metal concentrations in Ihlanza River sediments indicate an unpolluted environment. The source of copper and lead in the river is unknown.

There is no legal discharge of effluent into the Nahoon River and consequently it must be suggested that the elevated levels of copper, lead, zinc, cobalt, nickel and chromium in middle reaches of the river could be the result of direct urban runoff. The sedimentology also changes in this region with an increase in clay facies minerals. However, the increased metal concentration cannot be accounted for by an increase in clay minerals and probably represents an anthropogenic input (Watling and Watling, 1982b).

Metal levels in sediments from the Quinera River are within the range of average concentrations in East Cape river sediments (Watling, 1982).

TABLE 1
METAL CONCENTRATIONS IN SURFACE WATERS

Site	Cu ($\mu g/\ell$)	Pb	Zn	Fe	Mn	Co	Ni	Cd	Cr	Hg	Na ($\mu g/ml$)	K	Ca	Mg	Sr
1	0,3	2,6	2,0	61	7	0,2	0,8	<0,02	0,6	<0,01	11 800	370	480	1 460	12
2	0,4	2,0	1,9	66	8	0,1	0,7	<0,02	0,8	0,02	11 700	370	470	1 450	12
3	1,2	3,1	2,4	66	9	0,2	1,1	<0,02	1,4	0,01	10 400	330	440	1 400	11
4	2,5	12,2	8,0	231	69	<0,1	3,1	<0,02	0,3	<0,01	9 800	310	420	1 160	10
5	1,2	15,3	5,3	181	18	<0,1	3,8	<0,02	3,5	0,01	10 100	320	420	1 200	10
6	1,2	10,6	4,9	196	27	<0,1	3,0	<0,02	3,0	0,01	9 600	300	420	1 150	9
7	1,1	8,5	5,1	200	29	<0,1	3,7	<0,02	3,8	0,01	9 400	290	410	1 100	8
8	0,6	10,3	2,9	150	20	<0,1	3,6	<0,02	1,6	1,20	11 200	320	440	1 390	11
9	<0,1	228	3,3	16	4	0,3	14,6	<0,02	0,1	1,80	11 200	370	480	1 590	12
10	<0,1	75	1,3	16	1	0,2	2,0	0,06	0,1	2,70	11 800	380	470	1 470	12
11	1,4	70	5,7	150	19	0,6	61	0,16	0,6	2,80	12 000	370	480	1 520	12
12	0,1	100	0,8	81	19	0,4	4,2	0,06	0,6	1,50	11 800	370	470	1 170	11
13	0,1	23	1,2	100	19	0,2	4,0	0,05	0,2	2,30	11 700	370	470	1 190	12
14	0,1	15	11,8	193	48	0,2	6,1	0,17	<0,1	3,00	11 600	360	470	1 470	12
15	2,8	29	0,5	50	6	0,3	2,7	0,08	9,7	<0,01	6 700	240	290	860	7
16	10,2	10	68,0	21	9	0,6	4,6	0,16	8,4	0,01	6 700	240	280	780	16
17	0,6	5	1,7	20	5	0,4	2,5	<0,02	0,2	<0,01	13 100	400	510	1 650	12
18	0,9	4	1,2	15	5	0,2	2,0	<0,02	0,2	<0,01	13 000	410	500	1 500	12
19	1,0	4	1,4	4	3	0,2	1,6	<0,02	0,2	<0,01	12 300	430	520	1 590	12
20	1,0	3	2,2	12	13	0,2	0,6	<0,02	0,2	<0,01	12 000	390	440	1 800	12
21	2,0	14	1,7	72	<1	0,4	1,9	<0,02	1,8	<0,01	11 800	370	510	1 500	12
22	4,1	25	1,5	23	<1	0,4	0,9	0,28	1,3	0,10	187	57	102	1 630	2
23	2,8	12	0,3	18	8	0,2	3,7	0,49	1,2	0,10	193	57	102	1 610	2

TABLE 2
METAL CONCENTRATIONS IN SURFACE SEDIMENTS

Site	Cu	Pb	Zn	Mn	($\mu g/g$) Co	Ni	Cd	Cr	Sr	Na	K	(mg/g) Ca	Mg	Al	Fe
1	2,9	16,2	2,9	30	0,15	0,55	0,10	5,5	1 325	1,7	0,2	125	2,6	1,6	1,62
2	3,1	12,3	3,0	25	0,12	0,40	0,06	7,3	1 340	1,9	0,2	133	2,7	1,7	1,42
3	16,5	2,0	4,1	20	0,25	0,50	0,05	4,6	800	1,1	0,2	95	1,5	1,7	1,35
4	5,1	7,7	9,6	60	3,75	9,50	0,02	39,5	60	1,7	1,7	9	1,4	9,8	8,15
5	7,0	14,5	27,5	125	8,95	10,2	0,09	48,5	25	6,0	2,2	4	3,1	23,5	13,20
6	6,0	21,5	13,0	125	5,85	8,60	0,01	40,5	15	3,9	1,6	1	1,5	11,5	9,35
7	17,0	13,5	24,0	120	5,85	11,8	0,07	45,5	25	2,9	3,9	2	2,2	20,0	12,50
8	2,7	12,4	3,1	36	0,11	0,23	0,11	6,7	1 410	1,4	0,1	132	2,7	1,7	1,49
9	3,0	0,4	6,2	50	0,32	25,5	0,26	7,3	1 150	3,0	0,3	15	3,9	2,0	2,75
10	24,0	5,5	68	205	4,78	12,5	0,21	25,1	35	3,9	2,0	4	2,7	15,8	18,10
11	11,2	4.3	34	125	6,03	36,0	0,27	37,4	18	5,3	2,2	1	3,3	25,0	17,50
12	30,0	31,1	98	355	6,12	14,2	0,36	59,0	39	2,5	10,2	2	11,1	8,5	18,50
13	3,7	14,6	8,3	360	0,17	0,86	0,16	6,7	1 080	1,4	0,3	98	2,1	1,4	19,50
14	3,0	8,7	6,3	32	0,15	0,30	0,70	5,2	1 070	1,5	0,2	102	2,2	1,5	1,25
15	27,2	3,2	3,4	30	0,16	0,62	0,08	6,3	1 100	1,6	0,1	161	2,7	0,5	1,20
16	1,6	45,4	6,3	40	0,81	1,32	0,07	7,5	965	1,1	0,2	86	2,1	2,0	2,54
17	2,7	3,4	4,8	56	0,32	0,80	0,10	9,4	830	1,5	0,2	116	2,5	1,5	2,10
18	2,9	5,2	4,1	200	0,16	2,10	0,05	8,3	390	5,0	0,3	70	2,2	1,8	2,36
19	2,6	4,1	4,1	190	0,10	0,31	0,02	8,0	350	6,0	0,3	52	2,0	1,7	2,10
20	3,0	4,1	6,3	210	0,07	0,14	0,04	7,3	300	5,1	0,3	51	2,1	1,7	2,20
21	3,1	7,4	8,6	48	0,12	0,86	0,06	8,4	820	1,7	0,2	112	2,6	1,6	2,25
22	72	6,1	315	29	6,04	15,1	0,36	53,2	315	7,0	3,7	38	4,2	17,0	12,30
23	10,4	27,6	47,2	960	4,13	4,11	0,26	23,8	26	0,2	0,6	2	1,0	7,0	11,40
Average E. Cape	6,4	9,0	22,0	140	4,6	8,4	0,09	20	3 080	4,13	2,20	44,5	3,9	11,9	12,00

TABLE 3
MEDIAN METAL CONCENTRATIONS FOR SEDIMENT CORES

Site	Cu	Pb	Zn	Mn	$\mu g/g$ Co	Ni	Cd	Cr	Sr	Na	K	mg/g Ca	Mg	Al	Fe
1	1,6	12,8	4,0	47	0,37	1,64	0,08	7,8	1 070	1,4	0,2	99	21	2,1	1,8
3	19,4	1,1	3,6	32	0,22	0,96	0,04	4,4	934	1,4	0,2	101	23	2,0	1,7
4	5,4	6,5	16,1	136	5,53	9,63	0,03	37,9	133	2,3	2,7	149	24	14,6	11,8
5	9,0	10,8	25,0	133	7,30	9,21	0,02	35,5	23	3,5	3,8	4	27	23,5	11,1
6	25,1	12,3	25,8	310	9,84	13,4	0,03	54,8	16	2,8	2,0	3	26	20,5	15,3
7	8,5	12,0	20,1	69	4,45	10,7	0,05	41,0	32	2,9	3,4	1	28	21,2	12,3
8	19,8	0,5	3,2	52	0,27	0,62	0,06	6,4	1 260	1,4	0,1	135	23	1,5	1,7
9	1,2	1,2	3,0	52	0,43	2,01	0,04	6,9	402	2,6	0,3	80	31	2,0	2,6
11	7,4	7,2	23,3	100	5,79	9,30	0,08	30,8	42	3,0	3,1	2	24	18,4	14,6
12	7,9	7,6	29,0	117	5,28	11,3	0,01	17,2	44	3,3	2,5	2	30	22,0	19,2
13	6,1	7,3	20,6	72	5,16	7,12	0,04	21,1	50	2,5	2,4	2	22	14,7	12,8
15	1,8	8,6	5,9	40	0,52	0,90	0,25	6,8	140	1,5	0,3	111	29	2,3	2,0
16	1,4	17,2	6,0	34	0,58	0,95	0,20	7,9	952	1,1	0,2	86	22	2,0	2,2
18	3,0	0,6	3,9	51	0,39	0,58	0,05	7,4	858	1,7	0,2	124	26	1,5	2,2

Metals in sediment cores

Sediment cores were collected in the Nahoon, Ihlanza and Quinera Rivers. Unfortunately the bed of the Blind River was too rocky to permit penetration of the coret. However, it was possible to take one core sample in the sand bar at the mouth.

The substrate at site 16 on the Ihlanza River consisted of a mixture of medium to fine grained sand. Reducing conditions are found at approximately 100 mm below the surface. Lead concentrations (Table 3) are elevated throughout the top 400 mm of the core. The lack of significant correlation between lead and any other element indicates a probable anthropogenic input for this metal. Anoxic conditions began at a similar depth in core 15 at the mouth of the river.

Cores from the Nahoon and Quinera Rivers indicate the presence of similar sedimentary environments. Reducing conditions start at approximately 100 mm in all cores but totally anoxic conditions were not encountered. Metal concentrations and interelement relationships in the study cores indicate that the major input of metals is via weathering of catchment rocks. No cores show evidence of a systematic build up of metals throughout time although elevated metal concentrations are present in the surface region of cores from all areas.

The strong inter-element relationship between magnesium and aluminium found in the sediments of the Buffalo River (Watling *et al.*, 1983) was also evident in the study rivers. This indicates the distinct transition from the potassium-rich clays of the East Cape to the magnesium-rich clays of the Border area. This change is associated with an equivalent change in the bedrock of the area from quartz-rich acidic rocks to more basic dolerites and shales.

The concentrations of copper in core 6 from the Quinera

River are consistently four to five times greater than mean levels expected in equivalent core material from the East Cape (Watling, 1982). This copper is probably associated with the natural weathering of catchment rocks and does not represent anthropogenic input.

Conclusions

The Blind, Ihlanza and Nahoon Rivers are subject to anthropogenic input of heavy metals from a variety of sources. Copper, lead, zinc and nickel are elevated in surface waters of the Blind and Ihlanza Rivers while high concentrations of lead and nickel are present in surface waters from the Nahoon River. The extremely high levels of mercury in surface water from the Nahoon River are a cause of considerable concern. At this stage, however, it has not been possible to establish the source of this mercury or whether it is a long term or transient phenomenon. Metal concentrations can vary considerably with time and it is possible that elevated levels in the Nahoon River may be a direct result of water sport activities. If this is the case, these high concentrations would be of short duration. Further investigations are being undertaken to clarify the situation.

Unrestricted use of the rubbish tip on the banks of the Blind River has caused an increase in metal levels in the sediment column downstream of the site. It is probable, however, that metals enter the river as particulates and as such their bioavailability is limited.

There is no evidence of a systematic buildup of metals in core material from the study area, although elevated metal levels are found in the surface sediments of all cores. Natural inputs of metals, for example copper in the Quinera River, are apparent, but are at concentrations which cannot be considered harmful to local biota.

In general, despite anthropogenic input of metals, concentrations of the study toxic elements are only slightly elevated above average East Cape values and as such do not represent a long term pollution threat to the environment.

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