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TIDAL FLUXES OF METALS THROUGH THE MERSEY ESTUARY, 1982–1984

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1. INTRODUCTION

The Mersey Metals Flux Surveys began in 1982 as an intensive pollution monitoring exercise, involving North West Water Authority and Water Research Centre teams. Earlier surveys have investigated the concentration of dissolved and particulate metals throughout the length of the estuary, but the lateral and vertical concentration gradients were not established. These new Flux Surveys concentrated on a single transect of the Mersey between Liverpool and Wallasey near the seaward end of the estuary where there is well-defined rocky bed. The width of this transect at mean high water is 1.5 kilometres and the maximum depth at high water is 26 metres.

The prime objective of the Flux Survey is: to determine the fluxes in suspension and solution of 8 trace elements (As, Cd, Cr, Cu, Hg, Ni, Pb, Zn) through the Mersey Narrows during selected tidal cycles and so derive the net transport of each element.

The importance of flux measurement from this particular estuary stems from a combination of factors. Sediment deposits in the inner estuary hold a reservoir of pollutants, derived from 150 years industrial activity in the Mersey Basin. Much has been done of recent years to prevent industrial and domestic sewage effluents from contaminating the Mersey catchment. Sewage sludges are tankered out to Liverpool Bay and deposited at dumping grounds 25 kilometres west of the estuary mouth in water 30 metres deep. It is therefore of particular concern to know whether there is a landwards net tidal transport of trace metals or whether the outwash of suspended matter from the inner estuary produces a net seawards transport

2. HYDROGRAPHIC AND WATER QUALITY MEASUREMENTS

Four tidal cycle surveys have been completed - two Neap tide surveys (June 1982 and August 1984) and two Spring tide surveys (September 1982 and September 1983). Each survey spanned a full thirteen hour tidal cycle, generally going from low water slack through the flood tide, high water slack and ebb tide to low water slack again. Normally 5 anchored boats (10 to 30 m in length) were used in each survey. To identify the precise position of the boats at all times (especially if anchor drag forced a boat off-station) they were continually surveyed-in from the shore, throughout each survey.

The anchored boats were spaced evenly across the transect and from them the tidal velocities were measured at half-hourly intervals, throughout the depth range, using conventional impeller-type meters. Water samples were pumped up to each anchored vessel, using nylon tubing attached to a paravane to hold it down against the tidal flow. The distance of the paravane from the estuary bed was accurately monitored using an echo sounding device. Pumping was achieved by peristaltic pump on deck and samples were taken from a range of depths every hour.

Each water sample comprised three litres in polyethylene screw cap bottles (one of two litres and one of one litre) which were transferred to shore at regular intervals for filtration and preservation in a specially equipped laboratory. Each survey generated some 250-300 samples.

All of the chromium and certain of the other metal analyses were carried out by the Department of Oceanography, Liverpool University; the remaining analytical work on metals was carried out at WRC laboratories at Medmenham and Stevenage. Considerable efforts have been made at analytical quality control in order to minimise bias and achieve adequate precision of analytical results.

3. FLUX CALCULATIONS

Because it took ~ 30 min to obtain water samples at five depths ranging from 1 m below the surface to 1 m above the bed, it was impossible to synchronize the current meter observations with them. Thus there has to be an interpolation in space and time, both of the current velocity and the metal concentration data. This was done from a weighting of the results from the four nearest locations and the two nearest times. By this means it was possible to derive elementary (concentration x discharge) products across the entire cross section of the estuary at 10 minute time intervals. Hence the cross-sectional distribution of flux could be plotted at selected time intervals, and these cross-sectional "snapshots" may be areally integrated to provide the tidal load of each constituent throughout the tidal cycle. A further time-wise integration provides the net tidal transport. Preliminary error analyses, using data on suspended solids only, suggest that net tidal transports in excess of 6%, as a percentage of flood tide transport, may be significant and that values over 10% are almost certainly so. Table 1 compares the dissolved and particulate chromium transport for the surveys completed in 1982 and 1983. Note that particulate Cr dwarfs the dissolved transport at all tidal ranges although the latter is far less variable than the particulate transport. Net tidal figures, as a percentage of the flood tide transport, reduce with increase in tidal range (see below).

Table 2 presents the net transport of metals and suspended solids for the September 1983 survey, which was a Spring tide of medium intensity and the event for which our data have been most fully evaluated. The % figures for particulate Cr and Hg and for dissolved Cr and As are extremely similar, in contrast to the other particulate determinands which are either insignificant or, in the case of nickel, strongly negative showing a landward net movement (see below).

4. FUTURE PLANS

Preparations are well ahead to install a permanently anchored vessel and an estuary bed platform which will be used to monitor current velocities, suspended solids and salinity on a continuing basis. This Mersey monitoring station, should allow the longer-term variations in suspended solids and dissolved fluxes to be inferred, in relation to a wide variety of sea, tide, weather and freshwater discharge conditions.

TABLE 1 Transport of Chromium through the Mersey Narrows

Date	Tidal Range (m)	DISSOLVED Cr					PARTICULATE Cr				
		Net * Tidal (Kg)	Flood (Kg)	Ebb (Kg)	Net/|Flood| (%)	Net/Ebb (%)	Net * Tidal (Kg)	Flood (Kg)	Ebb (Kg)	Net/|Flood| (%)	Net/Ebb (%)
16.6.82	5.3	+ 11	- 69	+ 80	+ 15.9	+ 13.8	+ 270	- 1112	+ 1382	+ 24.3	+ 19.5
21.9.83	7.1	+ 9	- 81	+ 90	+ 11.1	+ 10.0	+ 927	- 6925	+ 7853	+ 13.4	+ 11.8
16.9.82	8.0	- 9	-109	+100	- 9.1	- 9.0	+ 641	- 7037	+ 7678	+ 9.1	+ 8.4

TABLE 2 Transport of various metals through the Mersey Narrows: Spring tide of 21 September 1983

COMPONENT	DISSOLVED		PARTICULATE	
	Net Tidal (Kg)	Net/ |Flood| (%)	Net * Tidal (Kg)	Net/ |Flood| (%) ▲
Suspended Solids	...	...	-1010 x 10^3	(-2)
As	+ 130	+ 9	...	...
Cd	...	...	+ 1	(+2)
Cr	+ 9	+ 11	+927	+12
Cu	...	...	-316	- 6
Hg	...	...	+ 13	+ 9
Ni	...	...	-202	-11
Pb	...	...	+268	(+3)
Zn	...	...	+558	(+2)

* Positive value indicates seawards transport

▲ Non-significant values in parenthesis

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