

part of the North Sea (10–25 ng Cd l⁻¹ and 20–35 ng Pb l⁻¹) (Kremling, 1985; Balls, 1985b; Brüggmann *et al.*, 1985; D. J. Harper, in prep.).

There are four areas in the Thames estuary where concentrations of cadmium and lead are elevated. Associated sources are the River Thames, the sewage-sludge dumping site in the Barrow Deep, the dredged-material dumping ground at South Falls and, possibly, the River Medway. In the outer estuary, elevated levels of cadmium are most marked at the dredged-spoil site and of lead at the sewage-sludge site. However, these increased trace-metal concentrations are essentially local in nature and return to double the background concentrations within ca. 5–10 nm of the centre of the affected area.

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Heavy Metals in Mindhola River Estuary, India

Mindhola River estuary, Gujarat State, India, receives 95×10^6 l day⁻¹ of wastewater channelled through Udhna Creek, from a variety of industries situated around Udhna town. Another group of industries located at Balesar also release their wastewater (33×10^6 l day⁻¹) into a weak tidal zone through a natural stormwater drain together with the wastewater from a sugar factory (1.2×10^6 l day⁻¹) which is released into the mid-estuarine region. These wastewaters transported 10, 12, 31, and 9 kg day⁻¹ of Ni, Cu, Zn, and Pb respectively to the estuary with over 85% of the total load entering via Udhna Creek (NIO, 1980).

Surface and bottom (1 m above the sediment level) water samples collected using a Niskin sampler were filtered through a 47 mm diameter 0.45 µm pore size Millipore membrane filter paper preweighed after acid cleaning and drying at 80°C. The filters were washed with deionized water, sealed in petri dishes and stored. Metals in the filtered sea water were preconcentrated using APDC–MIBK extraction procedure (Brewer *et al.*, 1969) and determined by flame (air-acetylene) atomic absorption on a Hilger Watts Atomspek Model H 1550 spectrophotometer. Five determinations of two

different samples gave the following precision: Cu=8%, Zn=9%, and Pb=10%. Sediment was sampled using a van Veen grab (0.1 m² area) and stored frozen in polythene bag until analysis. An aliquot was dried at 95–100°C for 24 h and then powdered. A portion of the dry sediment (1–2 g) was treated with concentrated HCl, HF, HNO₃, and HClO₄ (Bruland *et al.*, 1974). The metals were extracted with dilute HCl and appropriate dilutions were made for their determination using a Perkin–Elmer 5000 atomic absorption spectrophotometer. The observed concentrations, and the percentage recoveries using W₂ US Geological Survey (Centreville Diabasic) standard rock samples are given in Table 1. Heavy metals in the particulate

TABLE 1
Precision and percentage recovery using W₂ USGS standard rock (quadruplicate analysis).

Element	Reported concentration ppm, dry wt	Measured concentration ppm dry wt	Percent recovery
Mn	1300 ± 200	1340 ± 30	103
Ni	70	69 ± 4	98
Cu	84	80 ± 4	95
Zn	87 ± 21	79 ± 8	91

matter were also determined using a similar procedure. Organic matter in the sediment was estimated by the acid dichromate digestion and titration method (FAO, 1975). For the determination of P, the sediment was treated with concentrated HNO₃ and HClO₄. An acid

ammonium molybdate reagent was added to a suitable volume of the filtered digested solution and the intense blue colour developed by reduction with ascorbic acid of the resulting complex was measured colourimetrically (FAO, 1975).

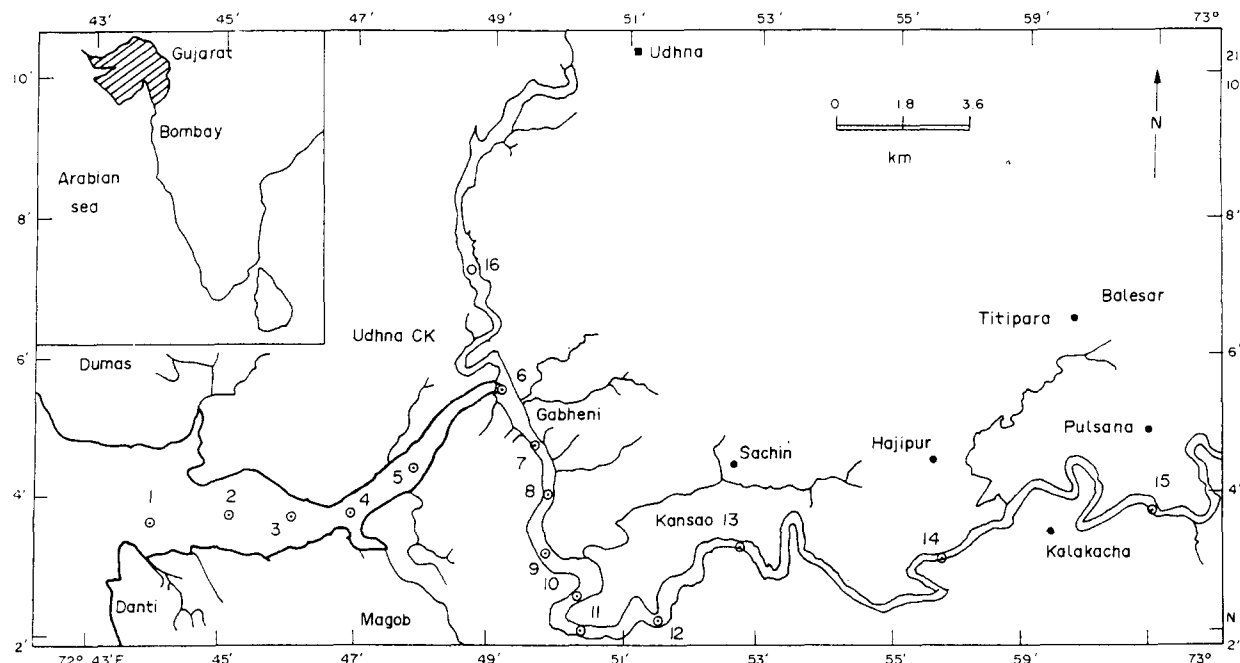


Fig. 1 Sampling locations.

TABLE 2
Particulate (ppm dry wt) and dissolved heavy metals (µg l⁻¹) in Mindhola River estuary

Stn	Salinity (‰)	Dissolved oxygen (mg l ⁻¹)	Particulate matter (mg l ⁻¹)	Particulate metals					Dissolved metals		
				Mn	Ni	Cu	Zn	Pb	Cu	Zn	Pb
1	33.8	6.5	283	1020	87	98	171	17	7.8	13	-
	17.3	5.8	209	1165	92	107	159	8	5.2	10	3.5
	8.4	6.0	428	992	78	107	142	21	6.0	9	2.3
	6.3	4.3	162	905	105	118	180	19	7.5	12	3.2
3	33.5	6.7	192	1250	94	87	102	9	2.7	8	-
	21.2	6.5	269	1119	86	112	110	22	3.8	10	2.5
	12.7	5.5	128	1198	100	126	160	17	3.5	8	4.3
	4.3	4.0	260	1311	115	113	153	30	8.2	12	4.8
5	25.9	5.6	328	1275	78	108	115	16	4.6	10	5.7
	21.1	5.8	221	990	80	132	132	19	4.3	3	3.7
	2.8	4.5	306	1076	54	117	128	27	6.5	14	4.9
	0.9	2.0	319	1132	110	149	176	20	6.7	17	3.2
6	15.6	5.6	296	1170	115	119	186	17	5.9	16	6.6
	9.2	5.1	305	1067	103	137	201	45	12.2	28	6.8
	0.3	1.9	662	1129	123	213	332	27	15.9	48	4.7
	0.3	2.0	259	980	131	182	256	62	12.0	11	5.3
8	12.3	4.8	108	1258	80	110	147	15	2.7	8	2.5
	4.9	5.5	213	1126	76	147	122	9	4.1	12	-
	0.7	4.0	341	1004	94	139	186	13	3.2	4	-
	0.1	2.5	167	1191	90	135	189	14	5.5	11	3.1
11	4.3	5.2	255	1087	102	121	109	7	4.8	3	-
	1.2	5.2	251	1198	113	115	137	8	5.2	9	-
	0.5	3.3	108	1250	92	117	128	21	2.6	6	2.8
12	6.1	5.1	177	1362	85	139	183	5	8.8	9	-
	0.8	5.3	317	1320	97	120	127	22	9.4	7	-
	0.1	4.1	255	1255	78	112	198	20	6.9	12	5.7
14	0.08	7.2	169	1306	121	128	209	12	9.5	12	6.1
	0.06	7.8	106	1359	107	123	132	6	4.9	6	-
15	0.08	7.9	67	1189	117	105	125	19	4.9	7	-
	0.05	8.2	153	1078	104	123	117	3	3.1	10	2.7

TABLE 3
Concentrations of heavy metals, carbon and phosphorous in surface sediments of Mindhola River estuary
(values are in ppm dry wt, except for C: in %)

Station	Texture	C	P	Mn	Ni	Cu	Zn	Pb
1	Silty sand	1.3	743	1109	92	113	157	19
2	Clayey silt	1.7	540	930	102	97	128	12
3	Clayey silt	1.5	425	871	117	105	108	6
4	Sandy silt	1.0	560	1071	97	87	120	14
5	Sandy silt	1.1	710	1065	103	110	139	19
6	Sandy silt	2.6	982	1114	120	137	279	32
7	Sandy	1.0	270	741	86	93	119	4
8	Sandy	0.8	236	612	76	73	96	4
9	Sandy	0.3	243	435	89	76	78	9
10	Sandy	0.5	277	624	92	87	63	12
11	Sandy	0.8	312	728	101	89	75	13
12	Clayey silt	2.7	871	927	108	130	157	21
13	Clayey silt	1.7	687	1005	119	116	121	7
14	Clayey silt	1.7	792	1253	115	108	192	17
15	Clayey silt	2.0	581	1167	113	121	127	14
16	Clayey silt	6.4	1283	1184	162	213	369	67

The tidal range of the estuary for springs at the mouth of 5.5 m decreases to 1.9 m at 32 km inland. High sea water influx, strong currents and small low tide volume rendered the estuary well mixed vertically with high suspended load (Table 2). The maximum intrusion of sea water up to 35 km inland was during spring tides (in April)—the lean period of river runoff. The high BOD (16,000 kg day⁻¹) entering the estuary (NIO, 1980) decreases dissolved oxygen in the segment between stations 5 and 11 (Fig. 1) during low tide (Table 2).

Dissolved Cu, Zn, and Pb varied considerably throughout the estuary and the concentrations were higher at station 6 which is closest to the major source of pollution. There was a general tendency for the concentrations to increase with a decrease in salinity (Table 2) because of greater impact of the wastewater during low tides when the estuary volume decreased at least by 75% of the high tide volume (NIO, 1980). Marked increase in the levels of particulate Ni, Cu, Zn, and Pb was also evident at station 6, particularly at low salinities. Enhancement in the concentrations of C, P, Ni, Cu, Zn, and Pb in the sediment at station 6 was also evident (Table 3). At station 16 (Udhna Creek) the concentra-

tions in the sediment were distinctly higher. The levels were markedly lower in the estuarine zone between stations 7 and 11 perhaps because of the sandy nature of the sediment.

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ICES REPORTS

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Health of the Irish Sea

A report on *The Status of Current Knowledge on Anthropogenic Influences in the Irish Sea*, edited by R. R. Dickson of the Ministry of Agriculture, Fisheries and Food, England, and R. G. V. Boelens of the Irish Science and Technology Agency, Ireland, has recently been published by the International Council for the Exploration of the Sea (ICES) in its Cooperative

Research Report Series.

The report is based on two separate national reports prepared by groups in Ireland and England, but in keeping with present ICES activity in promoting regional assessments in sea areas within its geographical area of interest, it includes contributions from a number of ICES Working Groups and was reviewed and endorsed both by these Working Groups and by the ICES Advisory Committee on Marine Pollution prior to its publication.

The terms of reference for the report excluded the subject of radioactive contamination which is to be the subject of a second report with different authorship.