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The objective of BASELINE is to publish short communications for the concentration and distribution of elements and compounds in the marine environment. Only those papers which clearly identify the quality of the data will be considered for publication. Contributors to Baseline should refer to 'Baseline—A Record of Contamination Levels' (*Mar. Pollut. Bull.* **13**, 217–218).

Mercury Near a Caustic Soda Plant at Karwar, India

180 t of mercury are introduced into the Indian environment every year of which 166 t come from 38 caustic soda plants, including 23 units of mercury cell electrolysers of seawater (Choudhuri, 1980). Mercury levels in the Indian marine environment has been estimated by several workers and found to be within the safe limits except for certain identified 'hot spots' (Kureishy *et al.*, 1979; Zingde & Desai, 1981; Patel & Chandy, 1988; Sanzigiri *et al.*, 1988).

A caustic soda factory on the west coast of India, commissioned in 1975, is situated south of Karwar (Fig. 1). The effluents from the factory are discharged into Binage Bay which is well known for its mackerel fishery. Mass fish mortality was reported from this area in 1975 due to the high residual chlorine content of water (Annigeri, 1977).

Some studies involving periodic surveys have already been reported from this area (Kureishy *et al.*, 1987), but details of mercury levels in the seawater, sediment and biota near the plant have not been reported. High concentrations of mercury has been reported in seawater off Karwar (Sanzigiri *et al.*, 1988). The present study was initiated to understand the distribution of mercury and its impact on the marine ecosystem on the Karwar coast. This included monitoring of seawater, sediment, seaweeds, mussels and oysters in and around the impact area. In addition, varieties of pelagic fish and shell fish from commercial landings at Karwar were also monitored for mercury.

Water samples were collected from surface and bottom, from four stations near the discharge point in February 1989. Mercury was determined after a preconcentration step (Gardner & Riley, 1974). For sampling sediment and biota, time bulking method (Phillips & Segar, 1986) was used. Surface sediment samples were collected from 10 stations (Fig. 1) using a Peterson grab in September 1987–May 1988. The sediment samples were dried at 50°C and digested with H_2SO_4 and HNO_3 mixture.

Mussels (*Perna viridis*), oyster (*Crassostrea cucullata*) and seaweed (*Sargassum tenerimum*) were sampled from 12 stations along the Karwar coast in September

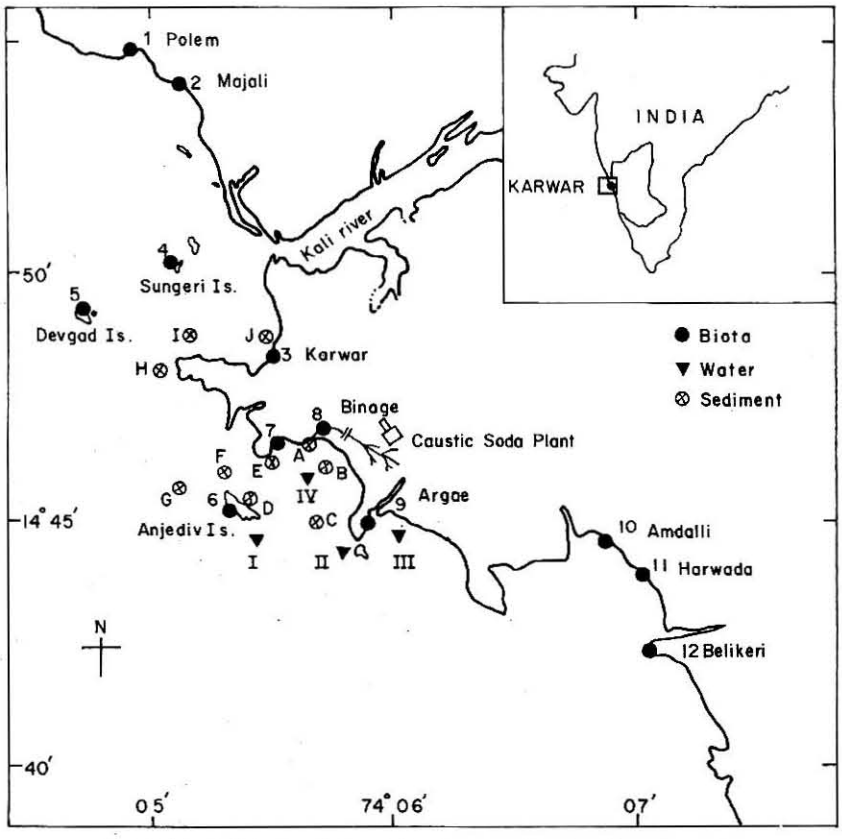

Fig. 1 Map of the study area showing sampling locations for water (samples 1–4), sediment (samples A–J) and biota (samples 1–12).

1987–February 1989 (Fig. 1) as determined by availability.

Fish, prawn, crab, and squid samples were collected from the commercial landings at Karwar. Soft tissues of mussels and oysters and the muscle of fish, prawn, crab and squid samples were analysed for mercury. Epiphytes of the seaweeds were removed and the entire green portion above the basal part was analysed for mercury. Biological samples were wet digested using HNO_3 and H_2O_2 mixture (Dalziel & Baker, 1983). All the digested samples were analysed for mercury by cold vapour atomic absorption technique using a mercury analyser, (ECIL).

The accuracy of the analytical procedure was checked using standard reference materials (lobster hepatopancreas) of the NRC Canada and found to be within ±10% of their specified concentrations. Repeated digestion and analysis of the same samples were carried out to estimate the precision of the analysis. Percentage recovery of mercury from the samples were estimated with added mercuric chloride (Table 1).

The mercury concentrations in water collected from four stations are shown in Table 2. Mercury concentration was found to be higher in the vicinity of the discharge point (0.91–2.62 μg l^{-1}). The average value of mercury in the Arabian Sea is 0.061 μg l^{-1} (Sanzigiri *et al.*, 1988). Mercury concentration was found to be higher in the surface water than in the bottom samples (Table 2). Similar observations were reported by earlier workers (Kureishy *et al.*, 1987).

Mercury concentrations in the sediment samples collected from 10 stations are given in the Table 3. Near the discharge point, concentrations were comparatively high. High mercury levels were also reported in the sediment samples collected from the vicinity of industrial discharge zones from Bombay coast and Western Bay of Bengal (Patel & Chandy, 1988; Sasamal *et al.*, 1987).

Mercury concentrations in fish, prawn, crab and squid samples (Table 4) are comparable with the values reported for these species from the Indian coast (Sanzigiri *et al.*, 1988). The mackerel *Rastrelliger kanagurta*

TABLE 1
Precision (coefficient of variation) and percentage recovery of mercury analysis.

Sample	Precision	Percentage recovery
Seawater	4%	99
Sediment	10%	91
Biological tissue	6%	95

TABLE 2
Total mercury in the seawater* collected from the vicinity of discharge point of the Caustic Soda factory, Karwar ($\bar{x} \pm SD$, N = 3).

Station No.	Depth m	Total mercury μg l^{-1}
1	0	1.49 ± 0.22
	18	1.06 ± 0.07
2	0	2.62 ± 0.20
	10	0.91 ± 0.12
3	0	1.43 ± 0.15
	9	1.05 ± 0.20
4	0	0.99 ± 0.14
	10	0.94 ± 0.09

*Total = dissolved + particulate.

had higher mercury concentration than sardine, prawns, crab and squid, probably due to its carnivorous food habit and the linkage in the food chain.

Mercury concentration in oysters, mussels and seaweeds sampled from the Karwar coast is shown in Fig. 2. In bivalves and seaweeds collected from the vicinity of discharge point (stations 5–8) mercury levels were found to be comparatively high (0.06–0.314 μg g^{-1}). Stations 1 and 2 were found to be comparatively unpolluted areas. The sequence of mercury levels observed in the biota studied is as follows:

sardine < squid < crab < prawn < mackerel < seaweed < mussel < oyster

The green mussel *P. viridis* has been proposed as a biomonitor of heavy metals in tropical waters (Phillips, 1985). The present study shows that *C. cucullata* and *P. viridis* can be used as suitable bio-indicators of mercury contamination in the coastal environment (Fig. 2).

Before the construction of the present submarine effluent pipeline, the discharge went directly into a stream which originates from the factory site and flows into the sea (Annigeri, 1977). The oysters collected from this stream (Stn 8) showed a very high concentration of mercury. Earlier workers also reported high mercury levels in the water and sediment collected from the stream (Kureishy *et al.*, 1987). The results of the present study show the same trend indicating that mercury may still be continuing to reach the stream (Fig. 2).

Mercury concentrations observed in the biota in the present study are well within the safe limit of 0.5 μg g^{-1} wet wt (Nauen, 1983).

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TABLE 3
Total mercury concentration in the sediment samples collected from the coastal water of Karwar ($\bar{x} \pm SD$, N = 3).

Station	Description of sediment	Total mercury μg g^{-1} dry wt
A	Sand	0.10 ± 0.01
B	Mud	1.14 ± 0.04
C	Mud	1.30 ± 0.01
D	Sand	0.01 ± 0.005
E	Mud	0.007 ± 0.001
F	Mud	0.023 ± 0.007
G	Mud	0.053 ± 0.01
H	Mud	0.018 ± 0.008
I	Mud	0.122 ± 0.005
J	Sand	0.002 ± 0.001

TABLE 4
Mercury concentration in fish and shellfish sampled from the commercial landing at Karwar ($\bar{x} \pm SD$, N = 5).

Species	Total mercury μg g^{-1} wet wt.
Fish	
Sardinella longiceps	0.003 ± 0.001
Rastrelliger kanagurta	0.03 ± 0.004
Crab	
Portunas pelagicus	0.01 ± 0.001
Prawn	
Penaeus merguensis	0.01 ± 0.001
Parapenacopsis stylifera	0.01 ± 0.001
Squid	
Loligo duvaucelli	0.006 ± 0.001

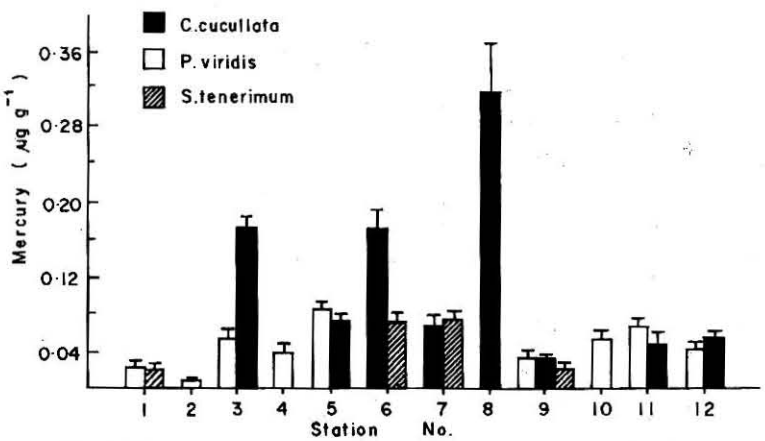

Fig. 2 Mercury concentration (μg g^{-1} wet wt ($\bar{x} \pm SD$, N = 5) in *Crassostrea cucullata. Perna viridis* and *Sargassum tenerimum* collected from the coastal waters of Karwar.

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