

## Organochlorine pesticide residues in the northern Indian Ocean

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**Abstract** - The coastal waters of India receive about 4.4 Km<sup>3</sup> of domestic sewage and 0.44 Km<sup>3</sup> of industrial wastes, annually. A concerted effort is being made for about a decade now to assess the state of the Indian marine environment through periodic monitoring of the levels of the major pollutants. One on-going exercise has been to evaluate, qualitatively and quantitatively, the persistent organochlorine pesticide residues in the northern Indian Ocean. The baseline levels of some of these compounds have been established as: total-DDT (DDT plus its metabolites) 0.1 to 0.44 ppb in water, 50.0 to 1630.0 ppb in zooplankton, traces to 206.1 ppb in fish and 7.4 to 179.1 ppb in sediments from the Arabian Sea. In coastal Bay of Bengal the mean values are: 4.0 to 5.9 ppb in zooplankton; 0.3 to 8.6 ppb in fish and 0.02 to 720.0 ppb in sediments. Some of the other organochlorine pesticides detected in sediments from the Bay of Bengal are:  $\gamma$ -HCH (lindane) 0.01 to 0.21 ppb; aldrin 0.01 to 0.5 ppb and dieldrin 0 to 0.5 ppb.

[This paper discusses the results of studies on pesticide residues in water, biota and sediments of the seas around India in some detail.]

### INTRODUCTION

Anthropogenic influences have, in recent decades, led to a gradual but irrevocable modification of the global marine environment. Coastal waters, in particular, have undergone chemical changes of varying severity due to inputs from terrestrial drainage, atmospheric deposition and urban discharges. The major and more serious contaminants have been heavy metals such as mercury, lead and cadmium, chlorinated hydrocarbon compounds and petroleum hydrocarbons. This communication pertains to the residue levels of organochlorine pesticides in the Indian marine environment. Extensive agricultural development undertaken in the country entails large-scale use of agricultural chemicals, principally pesticides. It is estimated that approximately 55000 t of pesticides are used annually for agricultural purposes besides about 326000 t used for other purposes notably vector control in public health measures. It is believed that nearly 0.1% of the pesticides used on land so far has been carried to the sea mainly by atmospheric deposition and river outflow (QASIM and SEN GUPTA, 1987). A number of these synthetic organic compounds especially the organochlorine variety persist in the environment for long periods of time on account of their insolubility in water and non-biodegradable nature. Hence, in order to prevent pollution from these persistent compounds from becoming a common hazard in the Indian marine areas a systematic survey was undertaken to establish an environmental data base for the Indian waters. This paper analyses the data accumulated so far with regard to organochlorine pesticide residue levels in the coastal areas of the Arabian Sea and the Bay of Bengal.

### MATERIALS AND METHODS

Water, zooplankton, fish and sediment samples were collected during various cruises of RV *Gaveshani* and ORV *Sagar Kanya* between 1985 and September 1990. Water samples (about 145 litres) were concentrated on a column of Amberlite XAD-2 resin attached to a moored *in situ* water sampler (Sea Star). Some coastal varieties of fish were also obtained from the market within a few hours of landing. Zooplankton samples

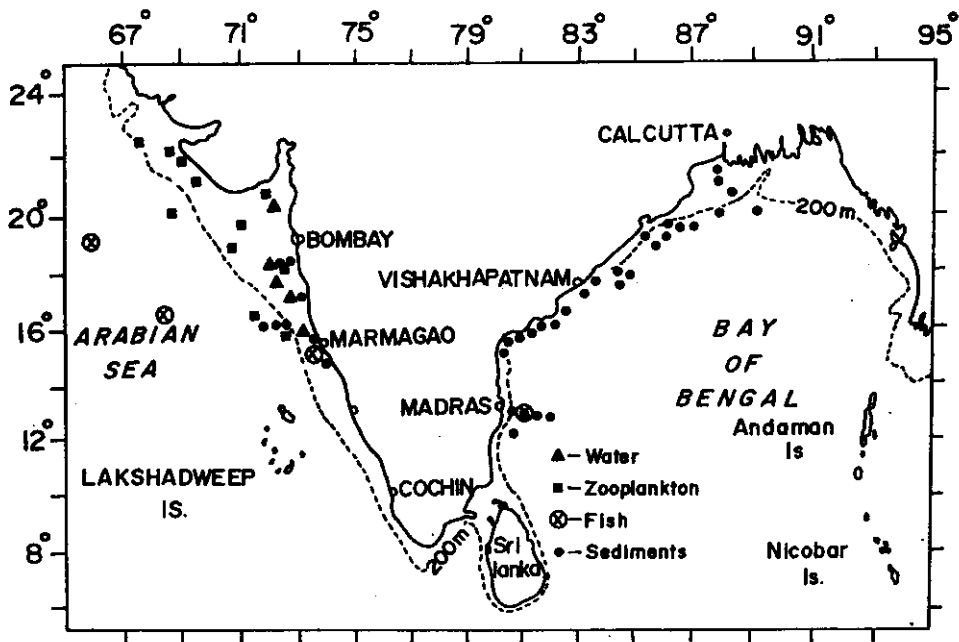


Fig.1. Sites sampled for organochlorine pesticide residues in the Arabian Sea and Bay of Bengal

Table 1. Mean concentrations ( $\text{ng g}^{-1}$  wet weight) and ranges of organochlorine pesticides in samples from the Arabian Sea

Sample	t-DDT <sup>§</sup>	Aldrin	Dieldrin	HCH	Others
Water	115.2* (15.8-444.0)	3.7* (N.D.-9.80)	10.4* (2.1-51.0)	2.7* (0.3-9.4)	--
Zooplankton	825.0 (50.0-1630.0)	N.D.	N.D.	$\gamma^{**}$	--
Fish					
(a) Estuarine (8 sps.)	344.7 (17.0-577.1)	N.D.	N.D.	$\alpha$ & $\gamma^{**}$	--
(b) Coastal					
Free swimming (10 sps.)	170.4 (N.D.-618.3)	N.D.	N.D.	$\alpha$ & $\gamma^{**}$ Hexachlorobenzene, 1-Hydroxy chlordene	--
Sessile (2 sps.)	165.5 (125.0-206.1)	N.D.	N.D.	$\alpha$ & $\gamma^{**}$	--
(c) Open ocean (3 sps.)	25.4 (3.0-41.4)	N.D.	N.D.	N.D.	--
Sediment	43.3 (7.4-179.1)	8.7 (0.9-35.7)	0.1 (N.D.-0.88)	5.0 (N.D.-17.9)	--

<sup>§</sup> t-DDT : DDT plus its metabolites, \* expressed as  $\text{ng l}^{-1}$ , \*\* Traces, N.D. Not detected

were collected with a neuston net. Sufficient precautions were taken to ensure contamination-free sampling. The various samples were extracted and analysed following standard EPA methods. The organochlorine pesticide residues were identified and quantitated by gas chromatography with reference to standard compounds obtained from EPA and Supelco.

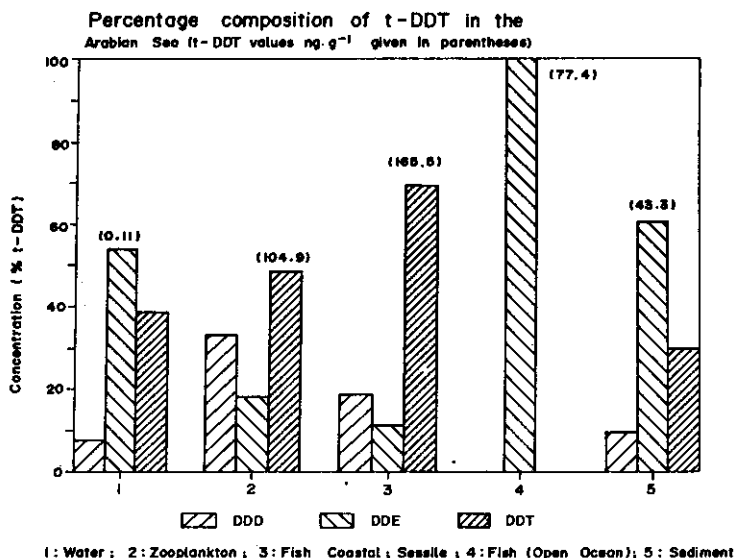


Fig.2. Percentage composition of t-DDT in the Arabian Sea

Table 2. Mean concentrations (ngg<sup>-1</sup>) of organochlorine pesticide residues in the Bay of Bengal (12°N 00 80°N 56 E)

Sample	t-DDT	Aldrin
Zooplankton	5.2	0.60
Fish		
(a) Adult (Decapterus sp.)	0.3	0.05
(b) Immature (Carangoides sp.)	8.6	0.80
Sediment	720.0	0.53

## RESULTS

Fig.1 shows the sites of sampling in the northern Indian Ocean. The mean values of the different chlorinated hydrocarbon pesticides detected in water, zooplankton, fish and sediments of the Arabian Sea are given in Table 1. Among the four marine segments analysed, zooplankton had the highest concentration of total DDT (t-DDT; DDT plus metabolites) corresponding to a value of 825 ng g<sup>-1</sup> while water had the lowest (115.2ng l<sup>-1</sup>). Fig.2 shows the percentage composition of the various components of t-DDT. While DDD was the major component in zooplankton, concentration of DDE was the highest in all the others tested.

Distribution of t-DDT in sediment samples from coastal Bay of Bengal is depicted in Fig.3. The highest value (720ng g<sup>-1</sup>) was noted in the area of 12°00 N 80°56 E where,

incidentally, the aldrin concentration was also the highest. Samples of zooplankton and fish taken from the same area in the Bay of Bengal had t-DDT concentrations of 5.2 and 0.3 ng g<sup>-1</sup>, respectively (Table 2).

## DISCUSSION

Data collected from the northern Indian Ocean show that zooplankton from the Arabian Sea have the highest t-DDT residue concentrations. However, these were not reflected in the fish perhaps because a major metabolic product of DDT in zooplankton is DDD (Fig.2; also, SHAILAJA and SEN GUPTA, 1990) which, in fish, can be converted readily to DDA, which is a water-soluble and hence excretable compound (RISEBROUGH *et al.*, 1970). Of the 23 species of fish analysed from the Arabian Sea (Table 1), the estuarine variety had the highest t-DDT residue burden (344.7ppb) followed by the coastal variety. t-DDT values in the Arabian Sea sediments were not significantly high (Table 1; also, SARKAR and SEN GUPTA, 1987) but the Bay of Bengal sediments accounted for very high t-DDT concentrations (Table 2; also, SARKAR and SEN GUPTA, 1988). The reason for this is that a major part of the agricultural area of the country is drained by rivers flowing in to the Bay of Bengal. Pesticide residues carried by the river waters are presumably transported rapidly to the seabed on account of the higher load of suspended particulate matter in the waters of the Bay of Bengal (mean value 8.08mg l<sup>-1</sup>) as compared to 4.6mg l<sup>-1</sup> the maximum value noted in the north-west shelf of India. This is also evident from the low t-DDT residue concentrations observed in zooplankton from the Bay of Bengal as compared to that from the Arabian Sea.

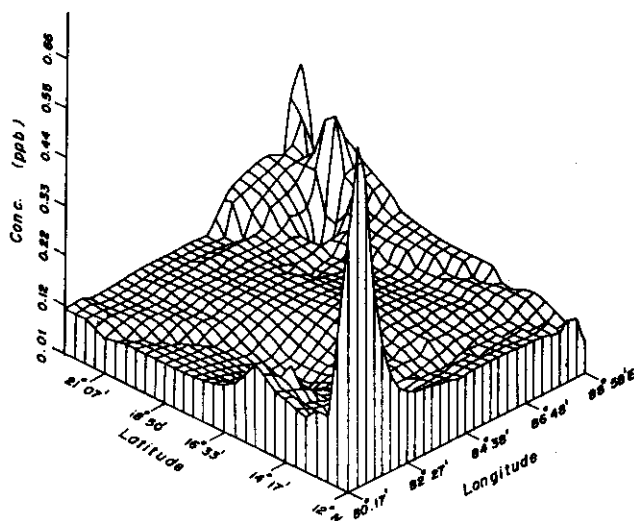


Fig.3. Distribution of t-DDT residue in sediments of the east coast of India

The rate and manner of mobilization of DDT residues in the sediments are not fully understood yet. However, reports indicate that bioturbation and bioconcentration by oligochaete worms play an important role in the mobilization of contaminants from bottom sediments (OLIVER, 1987). Additionally, in the sediment, microbial degradation has been found to lead to the formation of DDD (PATIL *et al.*, 1972) while physico-chemical degradation has been envisaged to produce DDE (SARKAR, unpublished).

In conclusion, the data collected so far indicate that organochlorine pesticide residues, notably t-DDT, are widely present in the Indian marine environment albeit

within hazardous limits. The mean t-DDT values observed in fish from the coastal Arabian Sea was 168ppb as compared to the values observed in other areas of the Indian Ocean such as 7.1ppb in the Arabian Gulf (DOUABUL *et al.*,1987) and 110ppb in the Wilderness Lakes System of South Africa (DE KOCK and BOSHOFF,1987).

The presence of a higher proportion of DDE noted in relation to the total DDT burden in most of our samples indicates that this environment is not threatened by new inputs of DDT (BUHLER *et al.*, 1975; ADDISON *et al.*,1984). However, some sessile animals from inshore areas had high DDT concentrations unlike the coastal fish although the total residue burden in the two were similar. Similarly, as seen in Table 2, adult fish had a lower residue burden than immature ones which is to be expected because of the larger surface area of the latter.

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