SPATIAL DISTRIBUTIONS OF ORGANOCHLORINE PESTICIDES IN COASTAL SEDIMENTS FROM BAY OF BENGAL, INDIA

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Abstract

Contamination of organochlorine pesticides has been carried from 23 sampling locations on five transects along the coast of West Bengal, India. The observed concentration of pesticide residues in sediments throughout the study stretch, ranged as lindane (0.8-35), dieldrin (0.6-22), aldrin (0.8-32), DDD (0.3-12), DDT (1.9-8.2) and DDE (0.1-12) $ng.gm^{-1}$.The observed average concentration of organochlorines in sediments was lindane (10) > aldrin (7.0) > dieldrin (6.4) > DDT (4.6) > DDD (4.1) > DDE (2.6) on $ng.gm^{-1}$. The observed pesticide concentrations are greater than interim sediments quality guidelines (ISQG) and probable effect levels (PEL).

Introduction

Pollutants that were carried to coastal waters by rivers, rainfall, and wind, eventually accumulate on the bottom sediments, which is the life support system for benthic biota and move up the food chain[1-2]. Organochlorine pesticides (OCPs) such as DDTs, lindane, cyclodienes such as aldrin, and dieldrin are of much concern in the environment because of their prolonged persistence, and tendency to accumulate in animal tissues[3]. For the past 4 decades, a serious concern has arisen due to presence of OCPs in the environment and their threat to the wildlife and humans. Studies have suggested that these compounds may effects the normal function of the endocrine system[4]. These OCPs have also been linked to human breast and liver cancers and to testicular tumors and lower sperm counts in humans[5]. During 1970s and 1980s use of some OCPs has been banned or restricted in developed and developing. However, OCPs are still in use for agricultural and public health purposes in some developing countries including India[2]. As reported elsewhere[6] the technical grade pesticides consumption during 1998-1999 in the Ganges River basin was 16,392 metric tones. Besides, India is a tropical country and the persistency of OCPs cannot comparable with those to temperate countries. As a result of these conditions the persistent OCPs behave differently in tropics as opposed to the temperate climates[7]. In the Bay of Bengal, the Hugli (Ganges) river system alone carry huge load of sediment[8]. When the Ganges reaches its mouth, it picked up 340 million tons of sediment every year and discharged into coast of West Bengal[9]. In 1990 Department of Ocean Development (DOD), Government of India, launched a nationwide programme 'Coastal Ocean Monitoring and Prediction System (COMAPS)' to study the coastal pollution up to 25 kilometer offshore, the territorial line of Indian coastal seas. Consequently the present study was aimed to analyze archived sediment samples which were covered the DOD's COMAPS's programme along the coast of West Bengal.

Materials and Methods

The study area is 200 km coastal stretch of West Bengal extending from Indo-Bangladesh border to interstate boundary of West Bengal and Orissa in the Bay of Bengal in India. It comprises the deltaic plains of Hugli-Matla river system. The geomorphology, hydrodynamics and ecology of this area are largely influenced by the sediments transported by the Hugli River. In the present study 23 sampling stations up to 22.5 km offshore were covered along an array of five selected transects. Transects were selected from east to west at the river

mouths of Matla (T-I), Saptamukhi (T-II), Hugli (T-III), Digha a tourist resort (T-IV) and a Subarnarekha (T-ŀV). The sampling stations at each transect were fixed geographical co-ordinates predetermined by GPS and designated as: 01 Inshore (-500 m before coast line), 02 Close to the shore (-2 km offshore or at 5 fathom depth), 03 At 5 km from the coast line, 04 At 10 km from the coast line and 05 At 22.5 km from the coast line, respectively. Sediment samples were collected from on-board CRV (Coastal Research Vessel) Sagar Poorvi, using Van-Veen Grab sampler. Samples were separately stored in labeled polyethylene bags and transported to the laboratory.

Air dried sediment (20 g) was taken in a 250-mL flask and mixed with 20 ml water then extracted 3 times with 100-mL of acetone in a mechanical shaker. The pools of acetone were transferred to a 1-L seperatory funnel containing 200-mL hexane. After manual shaking, aqueous layer was discarded and hexane layer was washed with hexane washed water then filtered through anhydrous sodium sulphate. The extract was concentrated to near 5-mL in a Rotavapour. The column cleanup allowed the separation of the contaminants of interest in fractions activated Florisil (10g) column equipped with a Teflon stopcock. The concentrated sample was added to the Florisil column followed by 100-mL pentane elution for aliphatic hydrocarbon removal and 200 mL of 1:9 diethylether:hexane elutions for OCPs. The eluted extract was concentrated to near 10-mL in rotary evaporator then concentrated to 1-mL using Kuderna-Danish concentrator. The concentrate with residue was cleaned up with 5% fuming sulfuric acid in concentrated sulfuric acid, treated with copper chips to remove sulfur and then washed with hexane washed water.

Identification and quantification of residual pesticide isomers were carried out by subjecting samples to gas chromatography (GLC) equipped with ^{63}Ni electron capture detector (ECD), (Varian Star Series 3400, Australia). A capillary column (RTX-5) of 0.25 mm i.d. and 30 m with 0.5 µm of stationary phase (5% diphenyl-95% dimethyl polysiloxane) was used for all the analyte determinations. Nitrogen gas was used as carrier gas. Resolved peaks were integrated using Varian Star workstations software. Integrated individual peaks were quantified based on retention times from corresponding peak areas in standards. Certified standard were used to calibrate the gas chromatograph. Spiking of standard into samples was carried out for recovery of pesticides to assess the loss/contamination of analyte during processing of samples, the recoveries ranged from 86 $\pm$ 19 to 107 $\pm$ 17 % and the results were not corrected for recoveries.

Results and Discussion

Sediment characteristics were analyzed after International Society of Soil Science by Walkey and Black[10]. Mean concentrations of sand, silt and clay ranged 1-77, <1-67 and 8-50, respectively. Mean percentage organic carbon in five transects was 0.18-0.33. The textural characteristics were very much variable during the study period, but organic carbon contents were almost stable (ranged 0.1 to 0.3 %). Sand, silt, clay and organic carbon were higher in T-I, T-V, T-III and T-III, respectively and the results are vague.

The insecticides determined, were lindane, cyclodiene compounds such as aldrin and dieldrin and DDT and its breakdown products (o,p'-DDD, DDT and p,p'-DDE). The observed concentration range of lindane (γ-HCH), dieldrin, aldrin, DDD, DDT and DDE are presented in Table 1, while station-wise distributions of analytes are presented in Figure 1. Lindane was prevalent compound with average concentration of 10 and ranges between 0.8 (T-III, 05) to 35 (T-II, 02). The average concentration of dieldrin was 6.4 and ranged from not detected (T-III, 02) to 22 (T-I, 04). Average aldrin was 7.0 and its ranges were in between 0.78 (T-III, 05) - 32 (T-II, 02). The sum of DDT and its breakdown products in the study area were moderately distributed with mean and range concentrations of 11, 3.5 (T-III, 04) to 33 (T-IV, 04), respectively on ng.gm^{-1} dry weight basis.

The occurrence of pesticide residue significantly moved up to 10 km offshore (station 04) and decline offshore 22.5 km (station 05) (Table 1). Such distribution of pesticides may be due to the movement of surficial sediment with the tidal waters. Sand bars interfering the moment of sediments may ascertain the observed result

Table 1. Mean and range of pesticide concentration in sediments (ng gm^{-1} dry wt.) from Bay of Bengal.

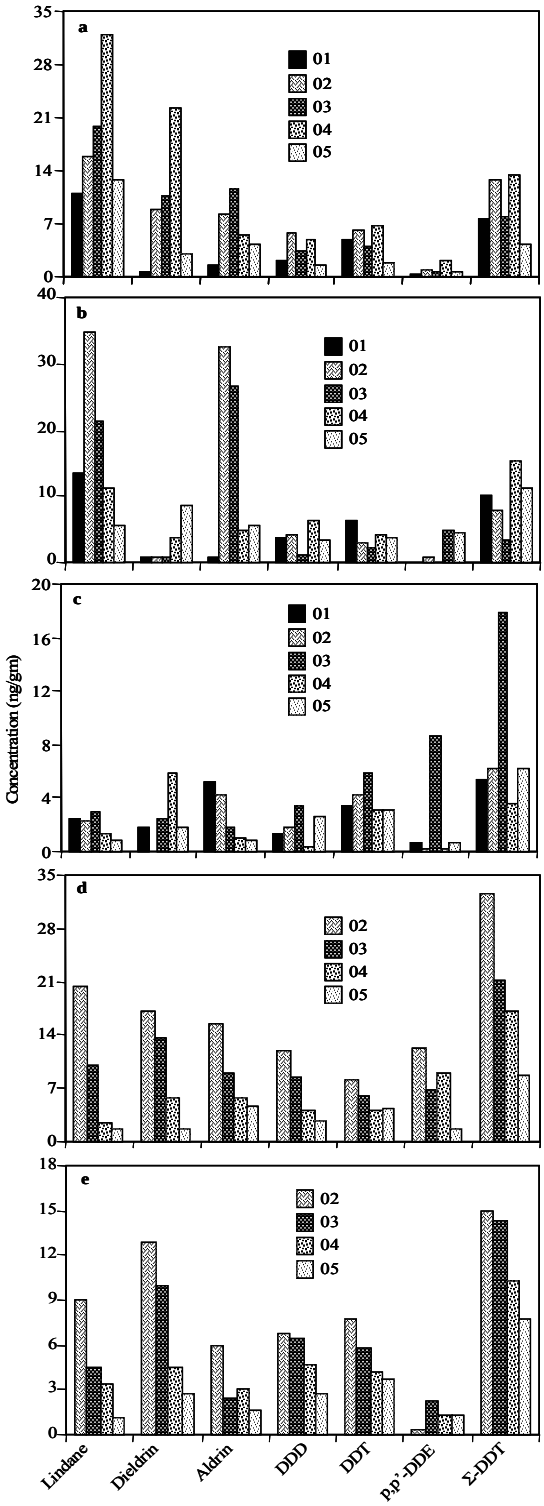
Compound	Transect Nos.				
	T-I	T-II	T-III	T-IV	T-V
Lindane	11-32 (18)	5.6-35 (17)	0.8-2.9 (2.0)	1.6-20 (8.6)	1.9-8.9 (4.5)
Dieldrin	0.67-22 (9.1)	0.6-8.8 (2.9)	1.8-5.8 (3.0)	1.6-17 (9.5)	2.8-13 (7.6)
Aldrin	1.4-11 (6.2)	0.9-32 (14)	0.8-5.2 (2.6)	2.6-16 (8.7)	1.6-6.0 (3.2)
DDD	1.6-5.8 (3.6)	1.0-6.4 (3.7)	0.3-3.4 (1.9)	1.9-12 (6.9)	2.8-6.7 (5.2)
DDT	1.9-6.8 (4.7)	2.2-6.3 (3.9)	3.1-5.9 (3.9)	3.9-8.2 (5.6)	3.7-7.8 (5.4)
p,p'-DDE	0.4-2.1 (1.0)	0.1-5.0 (2.0)	0.1-8.6 (2.0)	1.7-12 (7.4)	0.4-2.3 (1.3)
∑ DDT	4.2-14 (9.2)	3.4-15 (9.6)	3.5-18 (7.8)	7.8-33 (20)	7.7-15 (12)

DDD and DDT are sum of o,p' and p,p' isomers., In parenthesis mean value

Of higher concentration at Saptamukhi River and Matla river sediments (Figure 1a,b). The dredging of the surface sediment from Hugli River (Figure 1c; a navigational channel to the Haldia and Kolkata ports) has carried out regularly. The dredged sediments dumped on both sides of the river which influenced the sediment quality of Saptamukhi River and Digha where the level of pesticide residues were higher than the other transects in the study area. The Matla River and Saptamukhi Rivers are also influenced by eastern part of Kolkata and adjoining areas where pesticides are used in agriculture and public health practices[11]. These reasons may attribute to high deposition of lindane (32), dieldrin (22) and aldrin (32) in the sediments on $ng.gm^{-1}$. The catchments area of Subarnarekha River in Figure 5e is covered by agricultural lands so that the moderate residual pesticide distributions were observed.

Basically lindane was major pollutants followed by total DDTs, dieldrin, aldrin and p,p'-DDE. The volatile nature of lindane can able to disperse these chemicals even with high temperature and atmospheric pressure[1]. It should be indicated that highest concentration of aldrin was noticed in T-II with 32 $ng.gm^{-1}$ which is almost similar to lindane (35 $ng.gm^{-1}$) in same transect. These results reveals that specific contamination source were available in this sector. Further it can be explained that sand bars interfering sediment movement, dredged sediment dumped in river bed (T-II) and greater usage of pesticides in eastern part of Kolkata[12] played a major role for specific contamination in this river sediment. Maximum concentration of DDTs in Digha sediment is of concern and these results again reveal that high deposition of dredged sediment on the river bed could be plausible explanation. The observed results of pesticides were statistically processed and Pearson's moment correlation relationships with the sediment characteristics (data not shown). In the study area, OCPs do not show any significant correlation (r^2= >0.5) with the sediment texture and organic carbon. This indicate that tidal water currents influence surface sediment, but further accumulation of pesticide residues in sediments cannot be ruled out where tidal fluxes found to low.

The observed DDTs concentrations were much lower than values reported by other Indian studies[12-14]. DDTs from China and Kenya showed elevated concentrations than our study. However, the observed concentrations in this study are much higher than temperate countries. Overall, from the observations it is revealed that all pesticide concentrations are greater than interim sediments quality guidelines (ISQG) and probable effect levels



(PEL)[15]. Particularly Digha is greatly contaminated when compare to the other Rivers. Therefore, negative implications to the aquatic animals can be expected due to elevated lindane, dieldrin, DDT and DDE.

Figure 1. Station wise (a: Matla River, b: Saptamukhi River, c: Hugli River, d: Digha River & e: Subrnarekha River) distribution of pesticide concentrations.

Acknowledgement

Authors thank Department of Ocean Development (DOD), Government of India for financial support. We are also very much thankful to chairman Central Pollution Control Board for his constant encouragement in conducting this research.

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