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DDT in *Mytilus edulis:* Spatio-Temporal Variations in the Punta Banda Estuary, Baja California, Mexico

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DDT is a synthetic organic compound used as a pesticide and with a high residual power. It was one of the first to be regulated because of its adverse effects on marine organisms (NOAA, 1979). The mussel *Mytilus* sp. has been widely used as a sentinel organism or biological indicator of organic pollutants in the marine environment (Goldberg *et al.*, 1978). In studies recently carried out in Baja California, Mexico, it was found that the spatial and temporal variations of DDT in samples of the mussel *Mytilus californianus* collected from the area exposed to the ocean do not follow a defined pattern and that the highest values of DDT are found at the border with the United States (Gutiérrez-Galindo *et al.*, 1983a; Gutiérrez-Galindo *et al.*, 1983b). Studies of organisms collected from coastal lagoons show higher levels of DDT than those reported in regions exposed to the open sea (Butler, 1973; Rosales *et al.*, 1976).

The Maneadero Valley in Baja California, Mexico, is an agricultural area where important volumes of pesticides are applied, part of which are transported to the Punta Banda Estuary where they remain for an undetermined period of time during which they are consumed and bioaccumulated by organisms. The main objective of the present work is to determine the levels and temporal variation of DDT in the mussel *Mytilus edulis* in the Punta Banda Estuary, Baja California. With the results, we will try to define the dynamics of this pollutant in the estuary.

MATERIALS AND METHODS

Samples of the mussel *M. edulis*, 50-65 mm in size, were collected in February, April, June and August 1984 from three sites in the Punta Banda Estuary (Fig. 1). Sixty mussels were collected at each station (three replicates of 20 organisms each) to be analysed according to the group analytical technique recomended by Flores-Baez and Galindo-Bect (1989). They were wrapped in aluminium foil and frozen at -20°C until further analysis in the laboratory.

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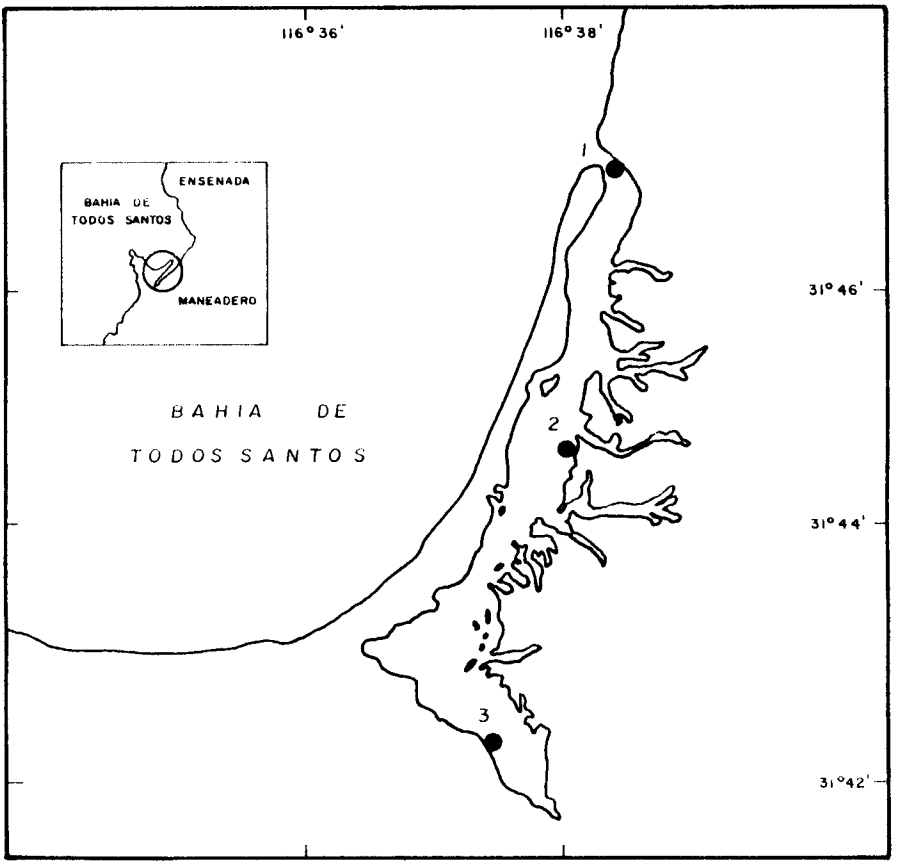

FIGURE 1. LOCATION OF THE SAMPLING STATIONS.

The acetonitrile/hexane extraction method was used for the analysis of the chlorinated hydrocarbons, followed by a florisil clean-up (Young *et al.*, 1976). The samples were analysed in the laboratory of the Southern California Coastal Water Research Project (SCCWRP), Long Beach, U.S.A., with financial support from the Agency for International Development of the American Embassy. 1 μl of Mirex internal standard was added to each extract. It was then injected into a Varian Vista 44 gas chromatograph with a Varian 8000 Vista series autoanalyzer. This was equipped with a ^{63}Ni electron capture detector and a fused silica capillary column of 30 m and 0.25 i.d. The dry weight, obtained by evaporation, and the percentage of total lipids were determined (Blight and Dyer, 1959). The total DDT includes the ortho and para DDT, DDD and DDE isomers. The mean ($\bar{x}$), standard deviation (S) and 95% confidence interval (C.I.) were calculated (Table 1). The Wilcoxon and Kruskal-Wallis tests (Sokal and Rohlf, 1980) were applied to the results in order to determine the significant spatial and temporal differences.

Table 1. DDT concentrations in the mussel Mytilus edulis collected from the Punta Banda Estuary, Baja California, during 1984. Values in ppb (10 g^{-1}) given in wet weigth: 95% confidence interval. N.D.= No detected.

Station	Month	n		opDDE	ppDDE	opDDD	ppDDD	opDDT	ppDDT	Tot. DDT
1	Feb	3	$\bar{x}$	N.D	28.33	N.D	1.22	1.44	1.44	32.43
			S		1.67		0.39	0.51	0.39	0.77
			C.I.		24.2-32.5		0.7-2.2	0.2-2.7	0.5-2.4	30.6-34.3
1	Apr	3	$\bar{x}$	N.D	15.77	1.22	0.88	2.33	0.88	21.09
			S		1.71	0.19	0.51	0.34	0.19	1.54
			C.I.		11.5-20.0	0.8-1.7	0.1-2.4	1.5-3.2	0.4-1.4	15.3-22.9
1	Jun	3	$\bar{x}$	N.D	35.66	N.D	1.11	1.88	1.33	39.99
			S		2.53		0.19	0.19	0.34	2.85
			C.I.		29.4-41.9		0.6-1.6	1.4-2.4	0.5-2.2	32.9-47.1
1	Aug	3	$\bar{x}$	0.66	49.22	1.44	1.10	2.77	1.77	56.65
			S	0.58	18.40	0.69	0.38	0.96	0.69	21.62
			C.I.	0.8-2.1	3.5-94.9	0.3-3.2	0.2-2.1	0.4-5.2	0.1-3.5	3.3-110.7
2	Feb	3	$\bar{x}$	N.D	16.71	N.D	0.86	1.43	0.96	19.97
			S		0.96		0.19	0.51	0.0	1.58
			C.I.		14.4-19.2		0.4-1.4	0.19-2.7	1.0-1.0	16.2-24.0
2	Apr	4	$\bar{x}$	N.D	10.95	N.D	N.D	0.87	1.66	13.49
			S		5.27			0.63	1.16	4.64
			C.I.		2.6-19.4			0.1-1.9	0.2-3.5	6.1-20.9
2	Jun	3	$\bar{x}$	N.D	9.10	N.D	N.D	0.60	1.11	10.82
			S		1.26			0.10	0.19	1.30
			C.I.		6.0-12.3			0.4-0.9	0.6-1.6	7.6-14.1
2	Aug	3	$\bar{x}$	N.D	13.66	0.77		1.22	1.11	16.76
			S		1.34	0.19	N.D	0.39	1.17	1.92
			C.I.		10.4-17.0	0.3-1.3		0.3-2.2	1.8-4.0	12.0-21.6
3	Feb	3	$\bar{x}$	0.67	38.53	N.D	1.14	3.75	1.11	44.87
			S	0.39	5.05		0.19	0.69	0.51	6.33
			C.I.	0.2-1.7	26.0-51.1		0.6-1.6	2.1-5.5	0.1-2.4	29.6-61.1
3	Apr	5	$\bar{x}$	0.26	30.66	N.D	0.86	2.66	0.53	34.98
			S	0.28	6.02		0.30	0.53	0.19	7.10
			C.I.	0.1-0.6	23.9-38.8		0.5-1.2	2.0-3.3	0.3-0.8	26.9-44.5
3	Jun	3	$\bar{x}$	0.83	51.91	1.44	0.51	2.54	0.86	58.11
			S	0.19	15.22	1.26	0.51	1.26	0.38	17.91
			C.I.	0.4-1.4	14.1-89.7	1.7-4.6	0.7-1.8	0.6-5.7	0.0-1.8	13.7-102.1
3	Aug	3	$\bar{x}$	0.11	33.33	0.66	N.D	1.22	0.55	35.76
			S	0.19	8.97	0.34		0.19	0.51	9.47
			C.I.	0.4-0.6	11.0-55.6	0.2-1.5		0.8-1.7	0.7-1.8	12.2-59.3

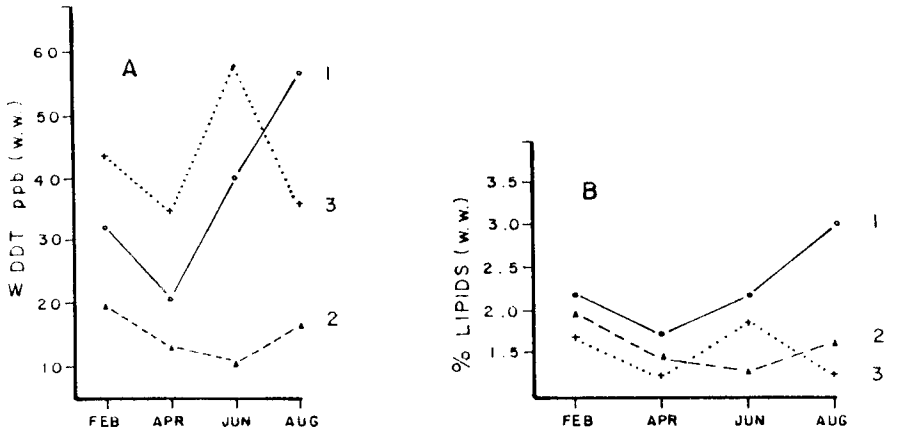

FIGURE 2. ≤ DDT IN ppb (WET WEIGHT) (A) AND PORCENTAGE OF LIPIDS (B)(%) OF THE MUSSEL Mytilus edulis FROM THE PUNTA BANDA ESTUARY B.C., DURING 1984.

RESULTS AND DISCUSSION

The results are shown in Table 1 and 2. Apart from DDT and its metabolites, other chlorinated compounds (hexachlorobenzene (HCB), Lindane, Aroclor 1242 and 1254) were occasionally detected but were not analysed because of their inconsistency. The presence of DDT and its metabolites was detected every month sampled, though more than 85% corresponded to DDE (Table 1 and 2). The highest values of total DDT were always found at the head of the estuary (station 3, Fig. 2A) except in August when it was found at the mouth of the estuary (station 1, Fig. 1). The maximum value of total DDT found throughout the period under study was 58.11 ppb at station 3 (Fig. 1). The minimum value was 10.82 ppb at station 2 (Fig. 1).

A relationship exists between total DDT and the percentage of lipids (Fig. 2B). In all cases we can observe that a decrease in the lipidic content corresponds to a decrease in total DDT and vice versa. The distribution of lipids in the organisms studied indicates that the highest lipidic content occurred at station 1 (Fig. 2B, Table 2). Phillips (1980) mentions that the organochlorines exhibit high solubility in the fatty tissues and that they are accumulated and stored in the organisms. This could explain the differences in concentrations between sites and between months.

According to the Kruskal-Wallis non-parametric test, it was determined that significant spatial and temporal differences exist in DDT concentrations for all the sites.

Table 2. Percent humidity, lipids and ratio ppDDE vs.total DDT in the mussel *Mytilus edulis* collected from the Punta Banda Estuary, Baja California, during 1984.

Station	Month	% $\frac{PPDDE}{\sum DDT}$	% Lipids	% Water
1	February	87.3	2.23	84.18
1	April	82.6	1.41	87.52
1	June	89.2	2.22	83.61
1	August	86.3	3.07	81.8
2	February	83.4	2.00	86.46
2	April	81.2	1.46	88.34
2	June	84.11	1.33	86.34
2	August	81.5	1.68	87.58
3	February	85.0	1.72	87.22
3	April	87.8	1.34	88.28
3	June	89.1	1.93	86.79
3	August	93.2	1.34	90.3

It should be noted that the organisms sampled are subject to completely different environmental conditions with regard to biological availability of the pollutant in the studied sites. The organisms at station 1 (Fig. 1) are subject to changes of water between the bay and the estuary because of the ebb and flow, with normal dry periods according to the tide. At station 2, the organisms are exposed to a longer dry period since the area is often obstructed/clogged with sediments from the San Carlos stream. There is a greater availability of the pollutant only during spring tides. At station 3, the organisms are permanently submerged and therefore have a greater filtration rate. The presence of DDE at the sites indicates that DDT is not of recent application, since DDE is the latest degradation product of this pesticide (Turk and Wittes, 1973). The concentrations of DDT measured in *M. edulis* in the Punta Banda Estuary, were two orders of magnitude below the tolerance limit for human consumption (5 ppm wet weight, established by FNI, 1969).

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