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Organochlorine Compounds in Oysters and Sediments from Coastal Lagoons of the Gulf of Mexico

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In the last three decades, a large variety and quantity of chlorinated pesticides has been introduced into the developing countries coastal areas as a result of their use in agriculture, for protection and higher efficiency concerning harvests and desease vector control like malaria and paludism. While the application and production of those compounds has been restricted or totally banned in developed countries, they are commonly used in other regions like Central America, South America and Africa (Albert 1988; Chapin et al. 1981; Gutierrez-Galindo et al. 1988).

Mexico presents an annual chlorinated pesticides production consisting of 4000 tons DDT and 1800 tons of Lindane, Toxaphene, Dieldrin, Chlordane and Heptachlor, which are widely used in the national agriculture (Restrepo 1988) and are also exported mainly to Central America and Asia (Albert 1988).

Recent environmental studies show high agrochemical concentrations in food, fruits, vegetables and milk products (Alpuche 1991), maternal milk (Albert et al. 1981) and in organisms of coastal areas (Rosales et al. 1979; Rosales et al. 1985; Gutierrez-Galindo et al. 1988; Martin et al. 1989; Botello 1990).

Thus, the following study was carried out in order to obtain basic information about the concentration and distribution of selected chlorinated pesticides in three coastal lagoons in the southeast of the Gulf of Mexico, because their ecological importance as producers and harvest centers for oysters, clams and shrimps.

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MATERIALS AND METHODS

The study includes two important systems of coastal lagoons southeast of the Gulf of Mexico: the lagoon Carmen-Machona located in the littoral fringe of the state of Tabasco (93°35′ - 93°53′ W longitude and 18°14′ - 18°18′ N latitude) and the lagoon Alvarado in the state of Veracruz (95°34′ - 95°58′ W longitude and 18°42′ - 18°46′ N latitude), as show in figure 1.

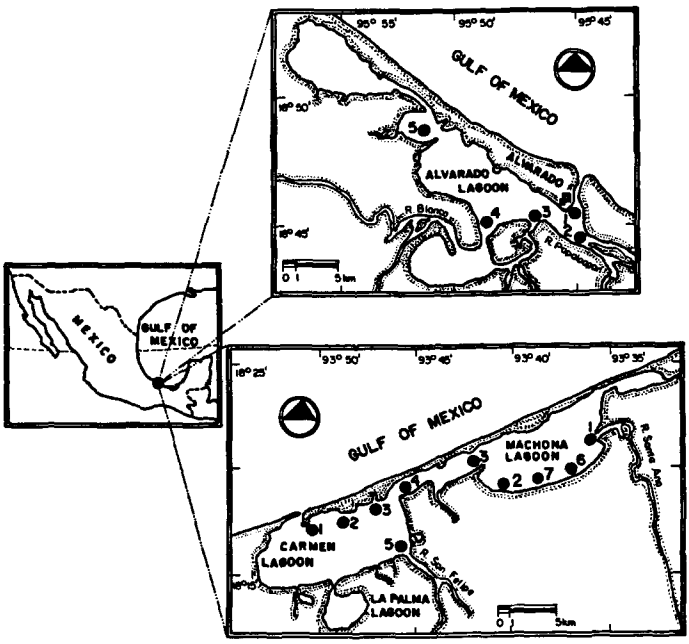

Fig. 1. Location of coastal lagoons (Alvarado and Carmen-Machona) showing sampling locations.

The sediments samples were obtained from 15 locations within the lagoon areas using a Van Veen dredge with a 5 kg capacity; the bivalve mollusks (*Crassostrea virginica*) were taken out manually from four different banks in both lagoons obtaining an approximate number of 50 organisms from each bank. The analytical methods used for the extraction, purification and quantification of the chlorinated hydrocarbons were those recommended by the UNEP (1982) for sediments and the UNEP (1986) for organisms. The sediments and organisms were extracted with 200 ml of bidistilled hexane for 8 hours in a soxhlet apparatus and the extract was reduced to 2 ml by rotoevaporation prior to fractionation using chromatographic columns (15 cm long., 3 cm ID) packed with 13 g of 1.25% deactived florisil and eluted with hexane and a mixture consisting of hexane-diethylether.

The volume was concentrated to 5 ml in order to be analysed by gas chromatography using a Hewlett Packard cromatograph model 5890, a 30 m x 0.25 mm ID x 0.25 um bonded 5%-phenilmethylsilicone, fused silica column was used. Nitrogen was the carrier gas with a flow 1 ml per minute, the oven temperature was programmed from 60°C to 300°C with an increase of 8°C per minute and the injector temperature was 260°C. A reference standard containing a mixture of 15 chlorinated pesticides was used (Cat. 4-8858 Supelco Inc.). Minimum detectable quantity $4x10^{-12}$ g for Lindane. In order to verify the analytical performance of this study, our laboratory participated in two Intercalibration Excercises for chlorinated hydrocarbons conducted by the IAEA being one of the seven laboratories with acceptable analytical quality (Villenueve and Mee, 1989a; Villenueve and Mee 1989b).

RESULTS AND DISCUSSION

In Mexico there is very little information dealing with the presence of chlorinated compounds in the tropical coastal areas inspite of their ecological importance and environmental impact.

According to the Official Catalog of Pesticides in Mexico (1991), the use the Heptachlor, Dieldrin, Aldrin and Endrin has been totally prohibited, while DDT, Lindane and HCH are severely rectricted; the results of this study, however, revealed the presence of the majority of the above mentioned chemicals indicating either their high persistence or recent applications.

Table 1 shows the sediment type, organic carbon percentage and the total concentration of chlorinated hydrocarbons in the sediments of the studied lagoons.

Table 2 shows the mean values and standard deviation for the individual chlorinated hydrocarbons. The pesticides with highest concentrations were Heptachlor, Aldrin, Dieldrin, Endrin, p,p'-DDT and Endosulfan sulphate. The presence of these compounds in the coastal areas sediments indicates that the environmental conditions may originate their transformation and degradation, specially concerning that of Aldrin to Dieldrin and Endosulphane into its correspondent Sulphate. In some cases these secondary metabolites are more toxic than their original component (McEwen and Stephensen 1979).

Table 1. Type of sediments, total organic carbon(%), and total concentration of chlorinated hydrocarbons (ng g^{-1} , dry wt) in sediments from Carmen, Machona and Alvarado Lagoons, Mexico.

Stations	Type of sediments	%TOC	Total concentration
Carmen Lagoon			
1	sand slime	1.26	10.00
2	sand slime	1.17	7.12
3	sand slime	1.37	20.82
4	sand slime	1.30	8.65
5	mud	1.29	12.46
Machona Lagoon			
1	slime sand	1.43	9.83
2	sandy mud	1.05	5.35
3	slime sand	0.88	5.57
6	mud	1.43	7.44
7	slime sand	1.27	14.53
Alvarado Lagoon			
1	sand	1.02	31.24
2	slime sand	0.66	4.12
3	slime sand	0.74	9.62
4	slime sand	2.05	28.10
5	slime sand	0.85	31.49

Table 2. Mean concentration and standard deviation of individual chlorinated hydrocarbons (ng g^{-1} , dry wt) in sediments from Carmen, Machona and Alvarado Lagoons, Mexico.

Compounds	Carmen	Machona	Alvarado
ALFA BHC	0.12 ± 0.08	0.09 ± 0.04	0.47 ± 0.29
GAMA BHC	0.24 ± 0.11	0.28 ± 0.16	0.85 ± 0.63
BETA BHC	0.50 ± 0.25	0.62 ± 0.34	1.86 ± 0.60
HEPTACHLOR	5.19 ± 4.33	2.30 ± 0.44	3.91 ± 2.21
ALDRIN	0.70 ± 0.53	1.15 ± 0.29	2.11 ± 1.66
HEPTACHLOR EPOXIDE	0.19 --	0.27 --	0.86 ± 0.45
ENDOSULPHAN I	0.45 ± 0.12	0.87 --	1.22 ± 0.74
p'p' -DDE	0.15 ± 0.07	0.26 ± 0.03	1.78 ± 1.77
DIELDRIN	6.84 ± 3.28	0.59 --	2.05 ± 1.08
ENDRIN	2.73 ± 2.59	4.91 ± 2.40	7.82 ± 4.77
p'p'-DDD	N.D. --	0.26 ± 0.08	0.89 --
ENDOSULPHAN II	0.06 --	N.D. --	0.67 --
p'p' -DDT	1.47 ± 0.82	0.88 --	2.24 ± 0.88
ALDEHIDE ENDRIN	0.88 ± 0.24	1.03 ± 0.27	1.77 --
ENDOSULPHAN SULPHATE	1.62 ± 0.52	0.79 --	1.40 --
TOTAL	21.14	14.30	29.90

The high persistence of those components is likewise well documented and recently Wade et al. (1988) informed about DDT found in the coastal areas sediments in the USA, although its application was prohibited 20 years ago. It is worth to mention that the concentration of chlorinated pesticides is two times higher in the Alvarado lagoon, which cross important industrial cities (Cordoba and Orizaba) and is also related to the watershed dynmics, type and composition of sediments, particles size and the rivers flora and fauna (Weber 1972).

The organic carbon content would also be considerd as another factor responsible for the different concentration; correlation tests were therefore carried out revealing the following values; r=0.83 in the Carmen lagoon, r=0.51 in the Machona lagoon and r=0.50 in the Alvarado lagoon. The regression curves indicate very good correlation in the case of the Carmen lagoon, while being less significant for Machona and Alvarado lagoons.

Table 3 shows the average concentration of chlorinated hydrocarbons determined in the tissue of the american oyster (*Crassostrea virginica*).
The accumulation and persistence of pesticides in coastal areas depend on environmental factors, type and composition, particle size and the organic carbon concentration in the sediments (Weber 1972), as well as on the content of lipids, age, sex, and nutritional habits of the organisms (Mearns et al. 1988).
The concentrations in the oysters were two times higher compared to the sediments; also the Alvarado lagoon shows high average values (50 ng g^{-1} dry wt), compared with those obtained for Carmen-Machona lagoon.

Recent data by Mearns et al. (1988), Nadjek and Bazulic (1988) indicate that the oysters found on the american coasts concentrate pesticides up to two times more intensively compared to the sediments due to their progressive concentration mechanisms for certain pesticides.

Also, Marcus and Renfrow (1990) determined average concentrations of chlorinated pesticides of 5.18 ng g in the american oyster (*Crassostrea virginica*) from the estuary of South Carolina. However, these values are lower in comparison with the values herein reported.

Previuos studies carried out by Rosales and Alvarez, (1979) showed low concentrations of chlorinated hydrocarbons in oysters from Carmen and Machona lagoons

in a range of 0.2 to 17 ng g^{-1} and 1.2 to 9 ng g^{-1} for bivalves in the Alvarado lagoon. Thus, comparing both studies, a clear increasing tendency of pesticide concentration can be observed with the passing years.

Table 3. Mean concentrations and standard deviation of individual chlorinated hydrocarbons (ng g^{-1}, dry wt) in *Crassostrea virginica* from Carmen, Machona and Alvarado Lagoons, Mexico.

Compounds	Carmen	Machona	Alvarado
ALFA BHC	1.94 --	0.31 --	2.61 ± 2.19
GAMA BHC	1.75 --	1.53 ± 0.46	2.73 ± 0.23
BETA BHC	0.62 ± 0.45	0.97 ± 0.69	2.08 ± 1.94
HEPTACHLOR	2.10 ± 1.86	1.77 ± 1.50	2.91 ± 1.63
ALDRIN	2.56 ± 1.95	1.61 ± 0.46	6.61 ± 4.80
HEPTACHLOR EPOXIDE	2.49 ± 0.94	3.24 ± 2.71	2.17 ± 1.62
ENDOSULPHAN I	0.83 ± 0.38	N.D. --	1.22 ± 0.76
p'p' -DDE	4.17 ± 1.30	N.D. --	N.D. --
DIELDRIN	N.D. --	N.D. --	N.D. --
ENDRIN	1.5 ± 0.78	10.61 ± 6.76	7.95 ± 4.70
p'p'-DDD	2.11 ± 0.86	N.D. --	N.D. --
ENDOSULPHAN II	14.93 ± 6.26	8.78 ± 4.52	17.65 ± 7.76
p'p' -DDT	N.D. --	5.6 ± 2.34	1.64 --
ALDEHIDE ENDRIN	3.96 ± 1.84	N.D. --	1.92 ± 0.21
ENDOSULPHAN SULPHATE	N.D. --	N.D. --	N.D. --
TOTAL	38.96	34.42	49.91

The unsual ratios p'p'DDT:p'p'DDE for oysters in this study seems to be influenced by bacterial activity, specially in the interphase water-sediment where the oysters are in close relation with high bacterial populations. McEwen and Stephenson (1979) reported the different ability of estuarine organisms to degrade DDT within the same ecosystem.

Also, the concentration levels of chlorinated pesticides in the Alvarado lagoon are higher compared to other coastal lagoons located in the Gulf of Mexico (Botello 1989), but lower in comparison with those reported by Nadjek and Bazulic (1988) in the Bay of New York and by Mearns et al. (1988) for the american coasts.

Botello (1990) determined the presence of other pollutants as PAH's, heavy metals and pathogenic bacteria that togheter with the reported concentration of pesticides may cause sublethal or lethal effects to

the biota living in the examined lagoons.

Thus, pesticides concentrations reported in this study exceed significantly those previously described by other authors harming the organisms inhabiting the estuaries; chlorinated pesticides of high toxicity and persistence also appear in the environment as a result of their inmoderate use (Restrepo 1988).

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