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DISTRIBUTION OF CHLORINATED PESTICIDES IN SURFACE WATER AND FISH OF EL TEMSAH AND BITTER LAKES, SUEZ CANAL

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ABSTRACT

The potential effect of chlorinated pesticides pollutants carried by El Temsah and Bitter Lakes of the Suez Canal was investigated during four seasons of 2003. The results indicate the presence of total DDTs, total cyclodienes and total Hexachlorocyclohexane (HCHs) in surface water with ranges; 2.76-13.88 ng/l, 3.99-16.39 ng/l, and 0.39-1.25 ng/l, respectively. Total DDTs concentrations were ranged from 161-3100 ng/g (wet weight) with an average of 1087 ng/g (wet weight), while total HCHs concentrations were ranged from 30-1145 ng/g (wet weight) with an average of 316 ng/g (wet weight) recorded in three fish species; *Lutjanus sp., R. haffara* and *S. rivulatus* of the investigated area. Concentrations of chlorinated pesticides recorded in both of water and fish samples of the investigated area can be ranked in the order; total cyclodienes > total DDTs > total HCHs. Land based activities result from agricultural and municipal wastes are the main source of pollution by chlorinated pesticides in the area.

INTRODUCTION

Pesticides are mostly non-selective, widespread applied, possess toxic properties, and in some cases are very refractory. These features entitle pesticides to be one of the most fearful group substances, as far as biological communities and humans are concerned. They include insecticides, acaricides, herbicides, fungicides and algaecides, indeed any chemical which is used to control an unwanted organism (except bacteria), even rotenone which is used to kill unwanted fish. In the majority of cases, pesticides have the potential to cause damage to fish. The most prominent pesticides are organo-chlorides (e.g. DDT, Lindane, Aldrin and Dieldrin), ureatic derivatives (e.g. phenyl-ureatic derivatives, sulfonyl-ureatics and cyclic uracyl derivatives), triazines (e.g. Atrazine), carbamates and organo-phosphate compounds. Svobodova et al., (1993) stated that, organochlorine pesticides act as nerve poisons and are highly toxic to fish (48-hour LC_{50} <1.0 mg/L). In the New Zealand white rabbit, *Orcytolagus cuniculus,* residues of organochlorine pesticides have induced inactivation in the ATPase enzyme system of both brain and liver (Ahmed and Ismail, 1991). Because of their chemical structure and their persistence, their use is now strictly controlled or banned. Concentration of DDT's in the soft tissues of mussels (*Mylitus galloprovincialis*) from the North-Western Mediterranean coast were found to be 106.08 µg/g (dry weight) in 1973-1974 (Marchand *et al.,* 1976). The DDT concentrations in the samples were generally higher than its metabolite forms DDE and DDD. This may declares direct exposure from pesticides in the environment.

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Generally, chlorinated pesticides have caused extensive concerns for a long time due to their strong lipophilic properties, persistence in the environment and enrichment in food chain (Winter and Streit 1992; Marth *et al.,* 1997). These hydrophobic compounds are mainly stored in fat tissues and when fats are mobilized, the toxic substances re-enter the circulatory system disturbing the organism's normal body physiology (Svobodova *et al.,* 1993).

Ethyl benzene was identified by Grimalt *et al.,* (1984) as a marker of domestic wastes in the Mediterranean. Chloronation of ethyl benzene could easily give hexachlorocyclohexane (HCH). The discovery of DDT and other chlorinated hydrocarbons in parts of the world's Oceans, shows that the mechanisms of global dispersion of some of these pollutants had to be more rapid than was possible by Oceanic turbulence and current systems. The trans-Atlantic atmospheric transport of DDT by the northeastern trade wind system was first deduced from observations by Risebrough *et al.,* (1968). The presence of chlorinated compounds in the Sargasso Sea atmosphere and surface waters has been investigated more intensively by Bidleman and Olney (1974 and 1975). Beside atmospheric deposition, organochlorine compounds reach the marine environment through agricultural run-off, rivers and discharge of industrial and municipal wastes. Comparison of atmospheric and river input rates of organochlorine compounds to the world's Oceans was made recently by GESAMP (1993). They showed that pollution of the marine environment by these substances through the atmosphere is more important than river discharge.

El-Temsah and Bitter lakes are the most common lakes in the Suez Canal. El-Temsah lake lies at 76 Km from the northern part of the Suez Canal (Port- Said). It is affected by agriculture wastes results from land-based activities of Ismailia City. Great Bitter lakes lie between Devresoir at 97.5Km and Shandoura at 134.5 Km from the north. This area is considered as a transit area for ships passing through the Canal (Fig. 1). It is considered as semi-enclosed body affected mainly by municipal and/or agricultural wastes coming mainly from Ismailia city (connected to lake El Temsah) and from villages distributed along the Bitter Lakes. The pesticides can cause toxic symptoms similar to those caused by dioxin exposure, including developmental abnormalities and growth suppression, disruption of the endocrine system, impairment of immune function and cancer promotion (GESAMP, 1993). The knowledge of occurrence of chlorinated pesticides in the Suez Canal is limited. However, in this study, congener-specific concentrations of DDT and its metabolites (DDT's), hexachloro-cyclohexane isomers (HCHs) and cyclodienes were determined in water and fish tissues collected from the El-Temsah and Bitter lakes.

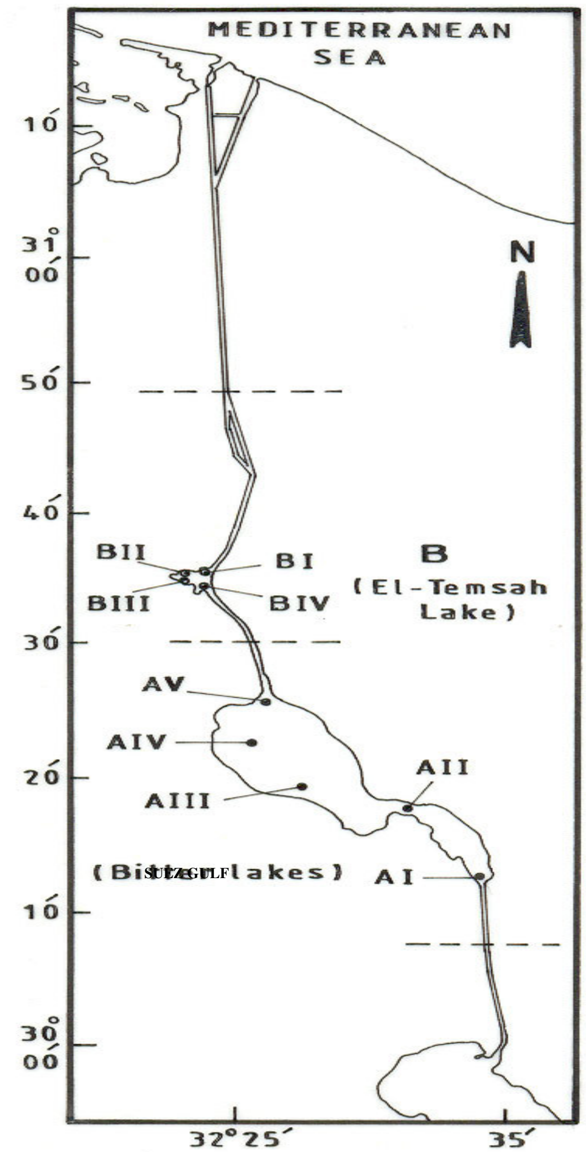

Fig. 1. Sampling stations of the investigated area along the Suez Canal during 2003: A= Great Bitter lakes (AI= Shandoura; AII= Kabrite, AIII= Fanara; AIV= Fayed and AV= Deversoir) and B= El-Temsah lake (BI-BIV).

MATERIALS AND METHODS

Thirty six of water samples were collected at 1m depth from nine stations distributed along the Suez Canal during the whole seasons of 2003 (Fig. 1) using Niskin bottle. Three types of fish (*Rhabdosargus haffara, Lutjanus sp.* and *Siganus rivulatus*) were caughted by fishermen from El-Temsah and Bitter lakes. These species are considered as the most common in the area of study. About ten fish of each species of similar weights (40-50 g) were collected, stored in cleaned aluminum containers and frozen at – 20 C until analysis. Ten gram aliquots were analyzed for pesticides following well-established techniques (UNEP/IOC/IAEA 1991).

Water samples were transferred into a separating funnel (2L) and extracted with n-hexane (three times x 80 ml). The extract was treated with Hg metal to remove sulfur compounds. Clean-up of the extract were carried out according to UNEP (1988). The eluant volumes were rotary evaporated and concentrated to 1 ml using a gentle stream of clean dry nitrogen and analyzed by capillary gas chromatograph (GC/ECD).

Fish (10 g of wet weight) was placed in a blender and 30 gm of anhydrous sodium sulfate was added. Samples were blended at high speed until the mixture was well-homogenized (5 min). The mixture was transferred to a pre-cleaned extraction thimble and the dehydrated tissue was extracted with n-hexane-dichloromethane [(1:1), 200 ml] for 8 hours in a soxhlet apparatus cycling 5-6 times per hour. Anhydrous sodium sulfate (30 gm) was extracted in the same fashion as the sample and used as the blank. The extracted solvents were concentrated with a rotary evaporator down to about 15 ml (maximum temperature: 35 ^{o}C) then concentrated to 1 ml under a gentle stream of pure nitrogen gas. This was transferred to the top of a glass column packed with 1g anhydrous sodium sulphate, 10 g alumina and 10 g Florosil. Elution with 70 ml of hexane will give the PCBs congeners (F1), followed by elution with 50 ml mixture containing 70 % hexane and 30 % dichloromethane for pesticide fraction (F2). The pesticide fraction is concentrated to 1ml using nitrogen gas. Two µl of the final extract was injected into Hewlett Packard 5890 series II, high resolution gas chromatograph (Hewlett Packard, USA) equipped with a ^{63}Ni-electron capture detector (ECD). A fused silica capillary column (50m x 0.32mm x 0.52µm) coated with HP-5 (5% diphenyl and 95% dimethyl polysiloxane) was used for quantification. Organochlorine pesticides were quantified from individually resolved peak areas with the corresponding peak areas of the external standards (POC mixture provided by IAEA). To control the analytical reliability and assure recovery efficiency and accuracy of the results, four analyses were conducted on organochlorine compounds reference material SRM-2974 freez-dried mussel tissue (*Mytilus edulis*) provided by EIMP-IAEA. The laboratory results showed recovery efficiency ranged from 95-105% for pesticides reference material No. 2974 (provided by EIMP/IAEA) with coefficient of variation of 15-20% for all pesticide congeners. The limit of detection in the present study was estimated to be 0.3 ng/g for pesticide congeners based on the minimum quantity of sample required for a discernible peak appeared on the chromatogram.

Results And Discussion

The residual concentrations of chlorinated pesticides were determined in water of El-Temsah and bitter lakes during 2003 (Tables 1-5). A maximum annual average concentration of 0.873 ng/l of γ-HCH was recorded at Temsah II (Lake El-Temsah). HCH (hexachlorocyclohexane) is fully chlorinated alicyclic compound. The most common isomers are α, β and γ-HCH. The γ isomer known as Lindane is one normally used as an agricultural pesticide. HCH is a reasonably stable compound and only under alkaline condition decomposes to yield trichlorobenzene. It is considered as one of the less persistence organochlorine pesticide (UNEP 1990).

Heptachlor is the common name of 1, 4, 5, 6, 7, 8, 8-heptachloro-3a, 4, 7, 7a tetrahydro-4,7-methane-1H-indane. It is generally used as insecticide and also occurs technically as chlorodane. In the environment it is degrade or metabolized and it is more commonly found as its epoxide form; Heptachlorepoxide (UNEP, 1990). This illustrates the presence of a maximum average of 13.21 ng/l of heptachlorepoxide at Deversoir (Bitter lake) compared with a maximum average concentration of 2.09 ng/l of heptachlor compound recorded at the same Location.

Aldrin is an alicyclic chlorinated hydrocarbon and is therefore less resistant to oxidation than the aromatics. It is being rapidly converted to the epoxide form (dieldrin). The data show the presence of an average of 0.898 ng/l of aldrin, compared with an average concentration of 0.386 ng/l of dieldrin recorded at the investigated area. This clearly declares that there is a renewal source of aldrin with no sufficient oxygen available for oxidation process. In addition, this almost the same case in all sites.

Also, the average concentrations of 10.41, 3.12 and 2.78 ng/l were recorded for p,p-DDE, o,p DDT and p,p-DDT respectively at the Shandoura station (Table 5). DDT [(2,2-bis (p-chlorophenyl) 1,1,1-trichloroethane] is the most common pesticide. It is generally used against a wide variety of agricultural and forest pests and against insect pests including vectors such as mosquito and tse-tse fly. In the environment, DDT can be degraded by solar radiation or metabolized in micro-organisms. Dehydrochlorination of DDT gives the metabolite DDE (WHO, 1989). This is confirmed by the presence of high concentration of 10.4 ng/L of p,p-DDE recorded at Shandoura compared with a lower one of 2.78 ng/l of p,p-DDT recorded at the same station. Table 5 indicates that the concentrations of chlorinated pesticides in water can be ranked in the order of; total cyclodiens (heptachlor and its epoxide derivative, aldrin and dieldrin) > DDTs > HCHs. In addition, the difference in concentrations during different seasons revealed the effect of temperature in the degradation processes of these compounds (Tables 1-4), as well as this explaining the presence of low levels of these compounds during summer compared with higher values recorded during winter (Tables 1-4). According to FAO/WHO (1985), the acceptable daily intake for DDT is 1.4 picogram/person everyday and for HCH is 1.8 mg/person everyday (EPA 1988). This indicates that the levels of DDTs recorded in the area of study were not safe in water (Table 5). Furthermore, higher vapour pressures of HCHs than for DDTs facilitate relatively rapid atmospheric dissipation in the tropics, leaving fewer residues in soil and water (Kannan et al., 1995). This proves the presence of lower concentrations of 1 ng/l HCHs in water samples of Shandoura (Table 5).

Table 1. Concentrations (ng/l) of pesticides in surface water collected from El-Temsah and Bitter lakes during winter, 2003

Chemical	Bitter Lakes					El-Temsah Lake			
Name	Shandoura (in)	Kabrite	Fanara	Fayed	Deversoir	Temsah I	Temsah II	Temsah III	Temsah IV
Alpha-HCH	0.153	0.029	0.191	0.063	0.037	0.091	0.125	0.053	0.117
Beta-HCH	1.104	0.082	0.672	0.186	0.330	0.239	0.331	0.138	0.269
Gamma-HCH	0.613	0.071	0.534	0.519	0.308	0.336	0.303	0.128	0.157
Heptachlor	3.762	0.327	1.281	1.029	1.223	0.730	1.591	0.755	1.259
Aldrin	2.740	0.238	1.995	0.188	0.719	0.691	0.474	0.296	0.705
HCP	16.741	0.408	9.010	0.456	0.670	1.665	1.812	1.290	0.970
Dieldrin	3.472	0.072	0.838	0.057	0.079	0.210	0.111	0.103	0.127
p,p'-DDE	26.492	0.441	8.303	0.185	0.178	0.872	0.613	0.366	0.418
o,p'-DDT	8.990	0.119	2.625	0.045	0.028	0.188	0.121	0.151	0.185
p,p'-DDT	5.542	1.728	2.503	2.579	2.525	3.244	1.074	2.594	4.955

Table 2. Concentrations (ng/l) of pesticides in surface water collected from El-Temsah and Bitter lakes during spring, 2003

Chemical	Bitter Lakes					El-Temsah Lake			
Name	Shandoura (in)	Kabrite	Fanara	Fayed	Deversoir	Temsah I	Temsah II	Temsah III	Temsah IV
Alpha-HCH	0.273	0.418	0.0505	0.063	0.222	0.14	0.234	0.095	0.208
Beta-HCH	0.563	0.52	0.1295	0.1435	0.434	0.232	0.495	0.238	0.276
Gamma-HCH	0.879	0.46	0.11	0.1215	0.621	0.209	0.452	0.204	0.253
Heptachlor	3.615	3.723	2.091	2.222	6.391	2.213	3.662	3.32	2.481
Aldrin	0.9755	1.142	0.728	0.7425	1.54	0.834	0.997	0.933	0.643
HCP	7.899	2.782	4.529	2.736	46.112	2.453	1.871	3.362	1.607
Dieldrin	0.7125	0.303	0.412	0.4	N.D	0.429	0.377	0.468	0.159
p,p'-DDE	4.4925	2.976	1.9105	1.9935	22.758	3.059	2.573	3.783	1.249
o,p'-DDT	1.361	0.153	0.501	0.618	3.709	1.765	1.801	1.163	0.782
p,p'-DDT	0.0095	N.D	0.0035	0.0045	0.251	0.006	0.008	0.004	0.003

Table 3. Concentrations (ng/l) of pesticides in surface water collected from El-Temsah and Bitter lakes during summer, 2003

Chemical name	Bitter Lakes					El-Temsah Lake			
	Shandoura	**Kabrite**	**Fanara**	**Fayed**	**Deversoir**	**Temsah I**	**Temsah II**	**Temsah III**	**Temsah IV**
Alpha-HCH	**0.301**	0.294	0.235	0.221	0.235	0.065	0.081	0.068	0.102
Beta-HCH	**0.576**	0.796	0.450	0.374	0.309	0.067	0.107	0.100	0.109
Gamma-HCH	**0.403**	0.371	0.370	0.425	0.225	0.077	0.066	0.112	0.105
Heptachlor	**0.975**	0.584	0.473	0.313	0.309	0.077	0.114	0.116	0.300
Aldrin	**1.838**	1.703	1.477	1.375	1.505	0.390	0.550	0.503	0.630
HCP	**2.205**	4.657	6.806	8.953	5.413	2.358	1.942	2.115	2.453
Dieldrin	**0.335**	N.D	0.719	2.130	0.352	0.017	N.D	0.004	N.D
p,p'-DDE	**N.D**	2.976	2.661	0.465	N.D	0.213	0.025	0.166	0.267
o,p'-DDT	**2.019**	0.153	0.825	0.314	0.476	0.026	0.011	0.030	0.060
p,p'-DDT	**0.018**	N.D	0.051	0.136	0.046	N.D	0.023	N.D	0.007

Table 4. Concentrations (ng/l) of pesticides in surface water collected from El-Temsah and Bitter lakes during autumn, 2003

Chemical name	Bitter Lakes					El-Temsah Lake			
	Shandoura	**Kabrite**	**Fanara**	**Fayed**	**Deversoir**	**Temsah I**	**Temsah II**	**Temsah III**	**Temsah IV**
Alpha-HCH	0.034	0.072	0.055	0.089	0.067	0.089	0.330	0.080	0.107
Beta-HCH	0.047	0.127	0.081	0.106	0.061	0.134	0.641	0.120	0.212
Gamma-HCH	0.070	0.815	0.271	0.360	0.238	0.358	2.671	0.215	0.536
Heptachlor	0.270	0.436	0.517	0.402	0.425	0.390	1.168	0.744	1.177
Aldrin	0.150	0.323	0.229	0.374	0.149	0.629	1.479	0.339	0.993
HCP	0.390	0.818	0.325	5.318	0.623	9.771	5.319	1.498	4.007
Dieldrin	0.047	0.067	0.054	0.177	0.041	0.311	0.267	0.118	0.269
p,p'-DDE	0.249	0.765	0.411	3.226	0.676	4.822	4.926	1.204	2.659
o,p'-DDT	0.101	0.098	0.141	0.787	0.149	1.300	0.221	0.359	0.891
p,p'-DDT	3.340	4.978	2.924	1.075	2.780	1.464	2.354	3.784	3.013

Table 5. Annual average concentrations (ng/l) of pesticides in surface water samples collected from El-Temsah and Bitter lakes during, 2003

Chemical name	Bitter lakes					El-Temsah Lake			
	Shandoura	Kabrite	Fanara	Fayed	Deversoir	Temsah I	Temsah II	Temsah III	Temsah IV
Alpha-HCH	0.190	0.203	0.139	0.114	0.140	0.096	0.193	0.074	0.134
Beta-HCH	0.572	0.381	0.333	0.202	0.284	0.168	0.394	0.149	0.217
Gamma-HCH	0.491	0.429	0.321	0.359	0.348	0.245	0.873	0.165	0.263
Total HCHs	1.254	1.014	0.780	0.603	0.772	0.509	1.459	0.388	0.613
Heptachlor	2.155	1.268	1.090	0.991	2.087	0.853	1.634	1.234	1.304
Aldrin	1.426	0.852	1.270	0.786	0.978	0.636	0.875	0.518	0.743
HCP	6.809	2.166	5.168	4.366	13.205	4.062	2.736	2.066	2.259
Dieldrin	1.142	0.147	0.484	0.691	0.157	0.242	0.252	0.173	0.185
TC	11.531	4.396	7.752	6.717	16.388	5.792	5.434	3.991	4.445
p,p'-DDE	10.411	1.790	3.321	1.551	7.871	2.242	2.034	1.380	1.148
o,p'-DDT	3.118	0.131	1.243	0.447	1.091	0.820	0.539	0.426	0.480
p,p'-DDT	2.780	3.353	1.370	0.949	1.401	1.571	0.865	2.127	1.995
Total DDTs	13.882	3.597	5.697	2.759	8.394	4.240	3.438	3.401	3.622
TP	26.666	9.006	14.229	10.080	25.554	10.541	10.330	7.780	8.680
A	50.945	39.936	39.796	27.279	32.849	40.222	33.277	43.716	41.731
B	4.610	11.256	5.538	5.983	3.020	4.831	14.124	4.984	7.059
C	44.445	48.808	54.666	66.739	64.131	54.947	52.599	51.300	51.210

A = % of total DDTs to total pesticides (TP); B = % of total HCHs to total pesticides; C = % of total cyclodienes (TC) to total pesticides; HCP =Heptachlorepoxide; N.D = not detected

The accumulation of concentrations of chlorinated pesticides in three fish species of the most commercial and economic fishes in the investigated area are given in Table 6. It is obvious that the total pesticides concentrations (TP) was higher in *Lutjanus sp.* than that recorded in *R. haffara* and *S. ruivulatus* with 754.6 and 9697.9 ng/g (wet weight) for both Bitter and El Temsah lakes, respectively. The average concentrations of total cyclodienes were ranged from 232 ng/g to 6583 ng/g with an average of 1930 ng/g (wet weight). The concentrations of heptachlorepoxide were 3 times more than that for heptachlor at most stations. The same trend was observed for aldrin which is 5 times more than that of dieldrin, while total HCHs showed lower values than that of total cyclodiens in all fish samples. Total HCHs were ranged from 30 to 1145 ng/g (wet weight) in *Lutjanus sp., R. haffara* and *S. rivulatus* at the study area (Table 6). According to the results of GESAMP (1993), the use of HCHs in agriculture is greater than cyclodiens and DDTs. The relatively low concentrations of HCHs in fish tissues of the present study reflect their lower potential for bioaccumulation than other congeners pesticides. However, concentrations of DDTs in the same species were ranged from 161 ng/g to 3100 ng/g with an average of 1088 ng/g (wet weight). The concentrations of DDD (metabolite form of DDT) represent the major part of all recorded DDTs, suggesting that metabolic transformation of DDT under oxidative conditions will lead to p,p-DDD which is detected in large percentage (93 %) of all DDTs values.

A comparison between the average concentrations of chlorinated pesticides in surface water of the investigated area with other relevant environmental compartments is presented in Table (7). It is apparent that the investigated area have concentrations of chlorinated pesticides lower than that recorded in other areas of the Mediterranean. EL Sebae and Abo EL Amayem (1979) studied the potential effect of pesticide pollutants carried by the Nile River and its associated canals. Their results indicated the presence of some chlorinated pesticides in concentrations ranged from 340-950 ng/l in Mahmoudieh canal water and from 190-920 ngl^{-1} in slaughter waste water. According to Table (7), the results of the present study are lower than that given by EL Sebae and Abo EL Amayem (1979). The detectable levels of concentrations may reflect the flowing of agricultural and industrial wastes into El-Temsah and Bitter lakes from towns and villages distributed in the area via land based activities.

The persistence half-life; $T_{1/2}$= 5 years for DDT in marine systems as given by Carvalho *et al.* (1994) and recent work on the dechlorination of DDE to DDT in anaerobic sediments; $T_{1/2}$= 6 years are similar (Quensen *et al.,* 1998). Assuming that after 1974, there have been no further releases of DDT, these half-life values would allow for an estimated reduction of DDT in the coastal environment. Nevertheless, despite the ban of DDT there are still continuous inputs into the coastal environment, mainly by atmospheric deposition of these compounds (Villeneuve and Cattini 1986) and DDT leaching from agricultural soils followed by discharges into estuarine areas (Claisse 1989). These inputs would help maintain DDT presence in the coastal environment. Results of the other pesticides indicate either a rapid disappearance from the coastal environment than DDT (ILMR 1975 and Villeneuve *et al.,* 1999) or low usage than DDT.

The variation between concentrations of different stations in the investigated areas depends on their distance from the input source of pollution. Also, the higher percentage of total HCHs in some stations is represented by discharging of municipal wastes into the Suez Canal environment.

The maximum permissible level of toxic DDTs and cyclodienes recommended by the National Academy of Sciences and National Academy of Engineering (NAS-

NAE 1972), for the protection of aquatic biota is 100 ng/g for cyclodienes (as weight concentration in whole-body tissue). In Sweden, the recommendations are 5000 ng/g for DDTs and 200 ng/g for HCHs (Swedish Food Regulation 1983). Comparing the results of current study (Table 6) with the above permissible levels, it is clear that the concentrations of total HCHs and total cyclodienes (1145 and 6583 ng/g, respectively) recorded at lake El-Temsah much exceeded the above levels. The same is true for *R. haffara* at the same area, while for *S. rivulatus* the concentrations were safe. This reflect the difference in physiological ability of fishes for uptake and release of pollutants even at the same location. However, these levels were safe in all fishes collected from Bitter lake. Thus there is an optimum need for monitoring of chlorinated pesticides in El Temsah Lake to ensure the protection of fishery wealth in the area.

Table 6. Concentration (ng/g) of pesticides in fish samples collected from El-Temsah and Bitter lakes during winter, 2003

Chem. Name	Shandoura (Bitter lake)			El Temsah lake		
	Lutjanus sp.	R. haffara	S. rivulatus	Lutjanus sp.	R. haffara	S. rivulatus
Alpha-HCH	5.345	6.743	8.021	153.108	105.774	13.997
Beta-HCH	13.798	21.32	22.762	310.538	203.82	36.254
Gamma-HCH	10.910	15.36	40.576	682.078	211.32	37.694
Total HCHs	30.053	43.423	71.359	1145.724	520.914	87.945
Heptachlor	36.253	46.072	47.815	994.273	233.453	115.872
Aldrin	54.605	72.897	27.841	1559.415	1273.06	148.33
HCP	229.48	99.519	181.653	3757.065	1340.816	1020.854
Dieldrin	35.863	14.098	18.742	272.253	N.D	N.D
TC	356.201	232.586	276.051	6583.006	2847.329	1285.056
p,p'-DDD	345.556	347.516	145.95	1695.265	2909.27	500.203
p,p'-DDE	21.637	21.98	13.515	250.153	163.838	57.31
p,p'-DDT	1.217	3.238	1.585	23.758	27.64	4.27
Total DDTs	368.41	372.734	161.05	1969.176	3100.748	561.783
TP	754.664	648.743	508.46	9697.906	6468.991	1934.784
A	48.818	57.455	31.674	20.305	47.932	29.036
B	3.982	6.693	14.034	11.814	8.052	4.545
C	47.200	35.852	54.292	67.881	44.015	66.419

A = % of total DDTs to total pesticides (TP); B = % of total HCHs to total pestiides;
C = % of total cyclodienes (TC) to total pesticides; HCP = Heptachlorepoxide; N.D = not detected

Number of composed fish samples in each station = ten

Table 7. Comparison between the average concentrations (µg/l) of chlorinated pesticides in surface water of the investigated area and other areas in the Mediterranean Sea and Gulf of Suez.

Station	total DDT		total HCHS		Reference
	average	range	average	range	
El Temsah Lake (Suez Canal)	0.004	0.0034-0.0084	0.001	0.0004-0.0015	present study
Bitter Lake (Suez Canal)	7.083	2.13-18.04	0.882	0.557-1.617	present study
Itlay, Medit. Sea	0.012	0.01-0.02	0.006	0.006-0.007	Leoni and D·Arca (1976)
Yogouslavia, Medit. Sea	0.005	N.D-0.1	0.800	N.D-0.007	Picer and Picer (1982)
Greece, Medit. Sea	0.010	N.D-0.002	0.050	0.01-0.12	Fytianos *et al.,* 1985
El Max, Medit. Sea, Egypt	0.153	0.01-0.45	0.019	0.014-0.042	Abdallah, 1994
Suez Bay, gulf of Suez	0.154	0.003-0.01	0.071	0.05-0.10	Said and Hamed, 2001

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