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Persistent Organochlorine Pollutants in the Aquatic Ecosystem of Lake Manzala, Egypt

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During the last few decades, widespread contamination and toxic effects of Persistent Organic Pollutants (POPs) such as organochlorine pesticides and polychlorinated biphenyls (PCBs) have become a serious environmental problem. Particular attention has long been given to the pollution by such compounds because of their accumulation in living organisms (Volder and Li 1995).

Many authors have been investigating the occurrence and distribution of POPs in the different aquatic ecosystems around the world. Some of the important publications in this field in the last decade are as follows: Allen Gil et al. (1997), Bernt et al. (1999), Valters et al. (1999), Bishop and Rouse (2000), Hobbs et al. (2001), Nhan et al. (2001) and Wainwright et al. (2001). In Egypt, Badawy and El-Dib (1984), Badawy et al. (1995) and Badawy and Wahaab (1997) investigated the occurrence and distribution of organochlorine compounds in water, sediment and fish samples of Lake Manzala and other Egyptian lakes.

The present study aimed to determine the levels of some organochlorine pesticides and PCBs in water, sediment and biota samples; representing an aquatic ecosystem of Lake Manzala. Moreover, attempt was made to compare residue levels detected in this study with those previously reported by Badawy and Wahaab (1997) on the contamination of Lake Manzala with POPs.

MATERIALS AND METHODS

Lake Manzala (Figure 1) is the largest of the Delta Lakes in Egypt, which is very important as a fish source. It is habitat for numerous aquatic plant species and many kinds of migratory and resident birds. But, with increasing discharge of industrial wastes, sewage and agricultural drainage into the lake, and decreasing its area due to the human activities leads to its decreasing of these resources, which in turn adversely effect on the lake ecosystem.

Water, surface sediment and biota samples were collected from different locations of Lake Manzala (except fish and bird samples were collected from random locations of the Lake region) during 1997-1998 at summer and winter seasons (figure 1). The biota samples collected are as follows: 1- aquatic plants

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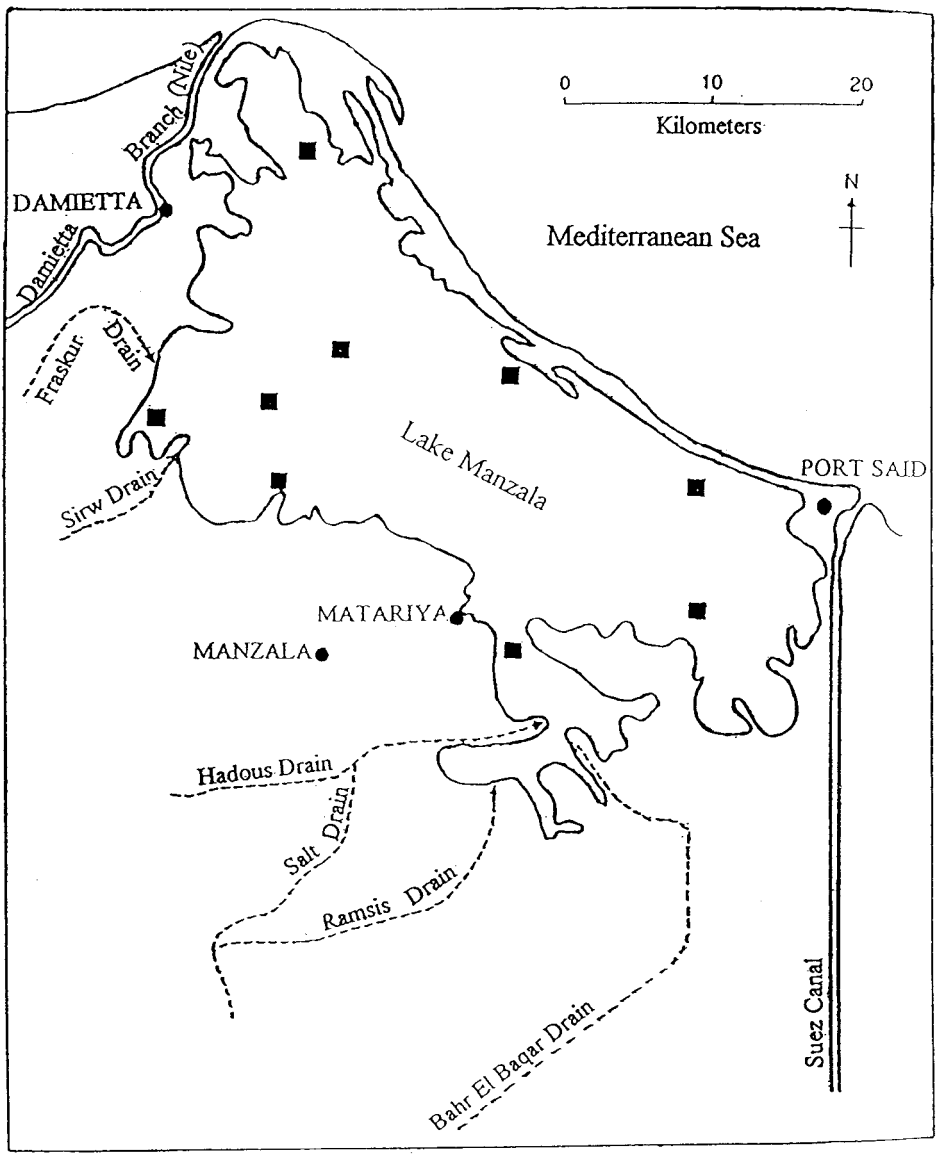

Figure 1. Lake Manzala sampling locations (■).

(*Ceratophylum demersum*, (Heckrish), *Lemna Spp.* (Adas) and *Potamogeton pictinatus* (Amshout)). 2- fish (*Tilapia nilotica* (Polti) and *Clarias lazera* (Catfish)). 3- birds (*Gallinula chloropus* (Moorhen), *Alceab athis* (Kingfisher) and *Egretta ibis* (Cattle egret)).

Extraction, clean up, fractionation and detection of organochlorine pesticides and total PCBs (as aroclors 1254 and 1260) were carried out according to the methods reported by US- EPA (1982), UNEP (1988) and Badawy and Wahaab (1997). Briefly, water samples were extracted with n-hexane using liquid/liquid extraction method. Soxhlet extraction for sediments and biota (sub-samples of plants, fillet of fish and bird muscles were blended with anhydrous sodium sulphate at a ratio 1:4 (wt/wt)) was carried out using 15% (v/v) dichloromethane in n-hexane. The clean up and fractionation procedure was carried out by passing the concentrated extract through deactivated florisil column. The first fraction eluted with n-hexane contained HCB, p, p′-DDE and PCBs. The second fraction eluted with 30% (v/v) dichloromethane in n-hexane contained lindane, p,p′-DDD and p,p′-DDT. Gas chromatograph HP-5890 Series II equipped with electron capture detector was utilized for the detection of the organochlorine compounds under the same conditions and column type as reported in the previous study of Abbassy (2000).

The recovery percentage of the tested organochlorine compounds (HCB, lindane, p, p′-DDE, p, p′-DDD, p, p′-DDT, aroclor 1254 and aroclor 1260) from the water, sediment and biota samples of Lake Manzala were ranged from 63 to 102%. Reported concentrations have not been adjusted on the basis of percent recoveries.

RESULTS AND DISCUSSION

The tested compounds were detected in water and sediment samples analyzed with frequency range between 44 and 100% (Table 1). In water, lindane was detected at higher levels with the mean concentration of 61.0 ng/l, while aroclor 1260 the lowest (5.0 ng/l). Similar compounds were also detected in most of the sediment samples. The higher level was observed for aroclor 1254 (237.9 ng/g dry wt, mean concentration) followed by p, p′-DDE (21.89 ng/g dry wt), while aroclor 1260 detected at lower level with the mean of 1.45 ng/g dry wt. The obtained results regarding the water–sediments distribution pattern of the detected compounds reflects the great capacity of the Lake sediments to adsorb and accumulate such compounds.

Table 2 shows that the organochlorine compounds investigated were detected in all samples of the aquatic plants analyzed, except aroclor 1260 detected in 66% only of the total samples of *Lemma Spp.* Also, lindane, p, p′-DDD, p, p′-DDT and aroclor 1260 were detected in 66, 83, 50 and 66% of the total samples of *Potamogeton pictinatus*, respectively. The same distribution pattern of the detected compounds as in sediments was also noticed in the plants analyzed. Aroclor 1254 was detected at higher levels with the mean of 32.68 ng/g wet wt, and aroclor 1260 was detected at lower level with the mean concentration of 0.12 ng/g wet wt.

Table 1. Levels of organochlorine compounds in water and sediment samples collected from Lake Manzala.

Detected Compounds	Levels in water; ng/l. (No. of samples= 18)				Levels in sediments; ng/g dry wt. (No. of samples= 18)			
	Mean	Minimum	Maximum	% of Frequency	Mean	Minimum	Maximum	% of Frequency
HCB	31.7	10.9	118.0	83	12.58	6.52	30.58	100
Lindane	61.0	11.1	96.0	88	5.81	0.34	35.14	66
p,p′-DDE	18.0	5.0	110.0	100	21.89	1.5	34.5	88
p,p′-DDD	6.18	1.5	24.5	55	2.19	0.12	3.16	44
p,p′-DDT	9.5	1.6	71.0	77	6.85	0.36	9.96	77
Aroclor 1254	28.0	6.0	120.0	94	237.9	19.96	615.6	100
Aroclor 1260	5.0	1.33	84.0	66	1.45	0.21	4.44	55

Table 2. Levels of organochlorine compounds (ng/g wet wt.) in three plant species collected from Lake Manzala.

Detected Compounds	HCB	Lindane	p,p′-DDE	p,p′-DDD	p,p′-DDT	Aroclor 1254	Aroclor 1260
Ceratophylum demerrsum. (No. of samples= 6)							
Mean	3.35	0.65	5.65	0.45	0.53	32.68	0.38
Minimum	2.18	0.32	4.11	0.31	0.26	17.12	0.11
Maximum	4.62	0.97	7.01	0.49	0.82	48.8	0.73
% of Frequency	100	100	100	100	100	100	100
Lemna Spp. (No. of samples= 6)							
Mean	7.08	0.14	5.09	0.46	0.55	8.92	0.12
Minimum	4.85	0.09	3.71	0.31	0.28	7.12	0.06
Maximum	9.14	0.24	6.43	0.57	0.86	10.12	0.22
% of Frequency	100	100	100	100	100	100	66
Potamogeton pictinatus. (No. of samples= 6)							
Mean	1.58	0.18	2.96	1.1	2.11	7.02	0.43
Minimum	1.06	0.07	2.45	0.95	2.04	4.84	0.36
Maximum	1.96	0.24	3.43	1.25	2.56	12.13	0.61
% of Frequency	100	66	100	83	50	100	66

It is known from many literatures that p, p′-DDE is the most stable degradation product of the parent compound; p, p′-DDT in the environment. Therefore, p, p′-DDE was detected, in general, at higher levels compared with the other tested organochlorine pesticides in the different types of the samples analyzed. It was detected by an average factor of 4 as a ratio of their levels in the sediments to submerged and floating aquatic plants. These findings have been expected because the plants were extracted as a total homogenates without any pretreatment processes such as washing or cleaning. Consequently, most of the p, p′-DDE detected in the plants analyzed might be referred to their quantities adsorbed on the surface of suspended colloidal matter which showed as a coating layer mainly on the submerged parts of these plants.

The detected levels of organochlorine pesticides and PCBs as aroclors 1254 and 1260 in fillet of the two fish species are shown in table 3. Aroclor 1254 was detected at higher mean levels of 53.67 and 86.2 ng/g wet wt in both *Tilapia nilotica* and *Clarias lazera*, while lindane detected at lower levels in both the species with the mean concentrations of 0.91 and 1.17 ng/g wet wt, respectively. The obtained data revealed noticeable bioaccumulation of organochlorine compounds especially aroclor 1254, p, p′-DDE and p, p′-DDT in fillet of the fish samples analyzed.

Table 4 shows the detected levels of organochlorine compounds in the muscles of three bird species collected from Lake Manzala region. All the tested compounds were detected in most samples analyzed of the bird muscles, except p, p′-DDD and p, p′-DDT were below the minimum detection limits in all the samples of *Alceab athis* and *Egretta ibis*, respectively. The highest level of the detected compounds was observed for p, p′-DDE in the muscles of *Egretta ibis* with the mean of 442.5 ng/g wet wt, while the lowest level was observed for aroclor 1260 with the mean of 1.11 ng/g wet wt, in the muscles of *Alceab athis.*

The obtained results indicate that, in general, the distribution and bioaccumulation of organochlorine compounds in the bird muscles has the same pattern as in sediment, fish and plant samples analyzed. Aroclor 1254 and p, p′-DDE were detected at higher levels, while aroclor 1260 and lindane detected at lower levels.

The observation of the present study regarding occurrence and accumulation of the investigated organochlorine compounds in sediments and fish is more or less similar to the previous study on Lake Manzala (Badawy and Wahaab 1997). This clearly shows that the degree of contamination at the Lake with these compounds remains unchanged. Moreover, the same compounds were also recorded in water of the Nile river (Abbassy et al. 1999) and water drained from Edku and Mariut lakes (Abbassy 2000); revealing the local and non-local sources of the Egyptian lakes contamination with persistent organic pollutants.

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Table 3. Levels of organochlorine compounds (ng/g wet wt.) in the fillet of *Tilapia nilotica* and *Clarias lazera* samples collected from Lake Manzala.

Detected Compounds	HCB	Lindane	p,p´-DDE	p,p´-DDD	p,p´-DDT	Aroclor 1254	Aroclor 1260
Tilapia nilotica (No. of samples= 18)							
Mean	2.62	0.91	20.2	1.42	10.68	53.67	1.37
Minimum	0.84	0.68	1.56	0.12	2.12	1.35	0.15
Maximum	8.92	1.50	37.1	4.02	18.57	125.9	1.8
% of Frequency	100	100	100	66	77	100	83
Clarias lazera (No. of samples= 18)							
Mean	1.52	1.17	6.24	1.4	13.9	86.2	1.6
Minimum	0.43	0.23	1.32	1.11	3.16	64.25	0.23
Maximum	4.35	2.34	30.4	2.56	50.14	121.3	2.4
% of Frequency	88	100	100	66	100	100	86

Table 4. Levels of organochlorine compounds (ng/g wet wt.) in the muscles of three bird species collected from Lake Manzala.

Detected Compounds	HCB	Lindane	p,p´-DDE	p,p´-DDD	p,p´-DDT	Aroclor 1254	Aroclor 1260
Gallinula chloropus (No. of samples= 8)							
Mean	3.27	1.66	210.9	4.53	2.48	79.87	2.58
Minimum	1.97	0.53	65.4	2.62	2.14	19.86	1.12
Maximum	4.25	2.79	291.7	6.57	2.72	165.27	3.6
% of Frequency	100	77	100	66	66	100	100
Alceab athis (No. of samples= 8)							
Mean	2.49	1.58	14.57	N.D	1.38	23.79	1.11
Minimum	2.15	0.18	6.51	N.D	0.97	13.67	0.19
Maximum	4.72	3.53	24.52	N.D	2.75	30.06	2.18
% of Frequency	100	100	100	0	100	100	75
Egretta ibis (No. of samples= 8)							
Mean	2.26	1.16	442.5	1.17	N.D	15.87	1.93
Minimum	1.02	0.16	163.8	0.86	N.D	8.06	0.86
Maximum	2.83	3.28	721.3	3.46	N.D	31.41	3.04
% of Frequency	75	75	100	75	0	100	62

N.D = Not detected. The instrument (GC-ECD) minimum detection limit for p,p´-DDD and p,p´-DDT is approximately 2.0 pg.

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