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Pesticides residues in environmental components of Nubia Lake, Sudan

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ABSTRACT

Field visits were carried out during January 2006 along the north part of Nubia Lake for collecting samples of fish; water and sediment to ensure the water quality safety before entering Egypt. The results indicated that residues of organochlorine and organophosphorus pesticides are present at low concentrations in the water and majority of common species. These residues have apparently originated from the areas of intensive pesticide application in the Gezera and along the White Nile in central Sudan. So, it is essential that continuous monitoring of residues in the environmental components of the whole lake should be conducted.

Key words: Pesticides, fish, water, sediment, Nubia Lake.

INTRODUCTION

Pesticides are divided into many classes, the most important of which are organochlorine and organophosphorus compounds. Organochlorine compounds, i.e hexachlorocyclohexanes (HCHs), DDT and its metabolites, endosulfan and endosulfan sulfate are ubiquitous, persistent, toxic and bioaccumulated in nature. The unique properties of such compounds make them environmentally persistent with a global distribution and they are thus exerting chronic toxic effects on wildlife and humans (Loganthan and Kannan, 1994). Organochlorine pesticides are still used in Sudan. Therefore, they are considered as an important component of the chemical pollutants found in all parts of the global marine environment. They are potentially hazardous to living systems because of their inclination to bioaccumulate in the lipid component of biological species and their resistance to degradation (GESAMP, 1989).

Organophosphorus pesticides, on the other hand, are known to be highly soluble in water and relatively short lived in the environment, due to their rapid degradation, depending on their formulation, method of application, climate and growing stage of plant. These types of pesticides generally may cause short term problems when present at high concentration.

Organic pesticides enter freshwater systems through a variety of sources, particularly via agricultural runoff. In the Great lakes, direct discharges or spills from manufacturing plants or other industries can also be serious sources. Other sources are domestic and municipal uses of organic pesticides

and their associated urban runoff. In the last decade, it has become increasingly clear that the atmosphere can be a major source of organic pesticides to the Great Lakes and thus for large lakes and reservoirs else where. The origin of atmospherically – deposited organic pesticides may be far distant from the point of deposition (Allan *et al.*, 1991a, 1991 b).

The agricultural sector in Sudan employs the majority of the work force, with about 65 % of its population making its living through crop growing or animal grazing. In 1995, a total of US $ 30 – 40 million was spent on pesticides in Sudan, mainly on cotton. Around 20% are used for mosquito and public health pest control. The remaining 80% are used for control of cotton pests and other related crops, besides considerable amounts used for the control of desert locust, birds and rodents and few are used for veterinary purposes. Organochlorine was banned in Sudan in 1981 with the exception of endosulfan. After that, pyrethroids were used to substitute DDT. Heptachlor, aldrin and dieldrin were used to control termites. Toxaphene, as well as a mixture of DDT and toxaphene was used extensively. (Annica valeij *et al.*, 2004).

Over 200 pesticides are registered in Sudan, either as single components or in combination, in about 700 different formulations of varying toxicity. There is no production, formulation and repacking of pesticides in Sudan at present. In 1963, shell chemicals established a formulation plant to produce organochlorides. No regular environmental monitoring for pesticides takes place in Sudan. However, during the period of late 1970 and early 1980, survey studies on pesticide residues in water, soil, biota, food as well as human samples were conducted. DDT and related derivatives were the most common residues encountered. Other substances including heptachlor, chlordane, endosulfan , aldrin , dieldrin and HCH (Hexachloro Hexane) were reported . (UNEP, 2002) & Annica waleij (2004).

Pesticide residues are often scavenged from the water through sorption on the suspended material that deposited on the bottom to become part of the bottom substrate. Consequently, bottom sediments often become reservoirs of pesticides in the environment (Khan, 1977). Miliadis (1994) stated that pesticide residues reach the aquatic environment through direct runoff, leaching, careless disposal of empty containers, equipment washings, etc.

The sediment component of aquatic ecosystems can be an ultimate sink of pesticides. Suspended particulate enter slower moving waters such as large water bodies settle out, and their associated pesticides are added to the sediment component (Chau and Afgan, 1982).

Pesticide residues in various aquatic ecosystems have been studied by several investigators such as Allen Gil *et al.* (1997), Pandit *et al.* (2001), Bhattacharya *et al.* (2003), Bakan and Ariman (2004), and Sankararamakrishnan *et al.* (2005), and in Egypt by Badawy *et al.* (1997), Abbassy (2000), Zidan *et al.* (2002), and Abassy *et al.* (2003).

The present study has been conducted to evaluate the pesticide residues in fish, water and sediment along the north part of Nubia Lake.

MATERIAL AND METHODS

Sample collection

During January 2006, samples of water, sediments and fishes were collected from ten sites distributed as shown in Figure (1) along the north part of Nubia Lake, namely, El Daka – Okma – El Deweshat – Semina – Kagnarty – Morshed – Gomaye – Second cataract- Abd el kader – Doghaim and Dabarosa . Numbers of water and sediment samples were collected at studied Zone of Nubia Lake. A total of 50 individual adult fishes, representing 11 common species were obtained from local fishermen at Nubia Lake.

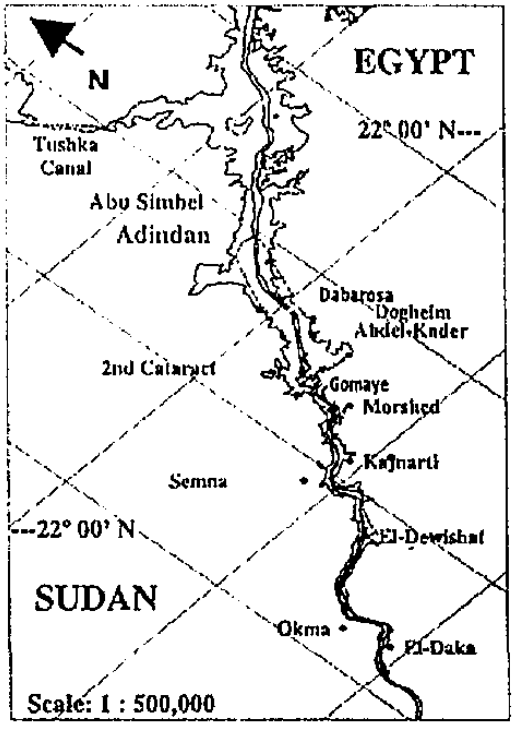

Figure (1): Location map of sites (•) surveyed in Nubia Lake

Analytical procedure

Water samples were filtered through whatman No. 1 filter paper to remove undissolved and colloid parts, then 1 liter was taken by measuring cylinder and transferred into a 2 liter separatory funnel. Partitioning was carried out three times as 100, 50 and 50 ml using dichloromethane (HPLC grade), then extract was dried through 50 g of anhydrous $Na_2 So_4$. The obtained organic phase was evaporated till dryness using rotary evaporator under vacuum at 40°C. (EPA, 1992).

Sediment samples

50 g of air dried sediment sample were weighed, and homogenized in mortar with 20 g of anhydrous sodium sulfate. The homogenized samples were

placed in conical flask then orbital shaker was used for shaking samples for 3 hours with 130 ml mixture of n-hexane and acetone (10: 3 volumes) as modification instead of n-hexane only to be suitable in sediment extraction then was dried through 50g of anhydrous $Na_2 SO_4$. The obtained organic phase was evaporated till dryness using rotary evaporator under vacuum at 40°C. (Leyva – cardoso *et al.*, 2003).

Fish samples

10 g of fish muscles were homogenized with 20 g of anhydrous sodium sulfate with tissue homogenizer till a fine homogenate was obtained. The homogenate was extracted with 50 ml of n-hexane: acetone (2:1) using HPLC grade. Extraction was carried out using orbital shaker for 2 hours, and then the extract was filtered through anhydrous sodium sulfate and evaporated till dryness, using rotary evaporator under vacuum at 40 °C.

Blank trials for water, sediment and fish samples were carried out to remove any interferring materials coming from solvents used. (Amaraneni and Pillala, 2001).

Cleaning up of sediment and fish samples

Cleaning up was carried out using 6g activated florisi (60-100 mesh) topped with 1 g anhydrous $Na_2 SO_4$ then column was wet using 30 ml n-hexane then elution of sample was done with 200 ml of the following mixture dichloromethane : n-hexane: acetonitrile (50:48. 5:1.5) (Mills *et al.*, 1972).

Quantitative determination

Organochlorine pesticide residues were determined by gas chromatograph (Hewlett Packard GC Model 6890) equipped with Ni_{63} electron capture detector (ECD).

The gas chromatograph condition: DB-17 capillary column (30m length x 0.32 mm internal diameter (i.d.) x 0.25 um film thickness). Operating temperatures: column temperature was programmed: initial oven temperature, 160 °C for 2 min., raised at 3° C/ min to 220 ° C, then raised 15 °C to 270 °C and then held at 240 °C for 15 min . Injector temperature was 280 °C and detector temperature 320 °C with nitrogen carrier gas flow at 4 ml/min. All compounds were identified by their retention times compared to known standards.

The Organochlorine residues components were identified by comparing their retention times with those of the standards quantified by extrapolation of corresponding sample peak areas with those from standard curves prepared for each pesticide standard. Few variations were corrected by obtaining fresh chromatograms of the standard mixture after every nine injections. Standard solutions were prepared for each pesticide of concentrations, ranging from 0.01 to 0.04 ppm and then 1 µl was injected into the GC. Peak areas of standard solutions were plotted against their concentrations. A line of best fit was drawn through the points and the limits of detection were taken at five times the detector noise level.

Organophosphorus pesticide residues were determined by gas chromatograph, (Hewlett Packard GC. Model 6890) equipped with a flame photometric detector (FPD) with phosphorus filter. A fused silica capillary (DB-1701), column containing 14 % cyanopropilsyloxane as stationary phase (30 m length x 0.32 mm internal diameter (i.d.) x 0.25 µm film thickness) was used for the separation in the GC.

The operating conditions of GC instrument included injector and detector temperature were 250 °C, initial oven temperature 175°C for 2 min, raised at 6°C/min., and then held at 240 °C for 15 min, the carrier gas nitrogen at 4 ml/ min and hydrogen and air were used for the combustion at 75 °C and 10 ml/min., respectively.

RESULTS AND DISCUSSION

The distribution of organochlorine and organophosphorus pesticides among fish represented in Tables 1 & 4, water (Tables 2 & 5) and sediment (Table 3 & 6), the samples were collected from ten zones from north part of Nubia Lake.

Table (1): Residue levels of organochlorine pesticides in some Nubia Lake fish species, January 2006, ng/g.

Number	Fish type / pesticide	Permissible limits (ppb)	Bayuda	Concentration of pesticides (ng/g)										
1	α - BHC	200 (1)	ND	ND	ND	ND	ND	ND	ND	ND	ND	21.46	ND	ND
2	β - BHC	100 (2)	ND	74.66	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	γ - BHC	2000 (3)	ND	ND	ND	ND	ND	ND	87.86	ND	ND	ND	ND	ND
4	δ - BHC	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	Heptachlor	200 (4)	ND	206.6	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	Delta - BHC	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	Aldrin	200 (3)	109.3	ND	ND	ND	ND	ND	ND	99.33	ND	ND	ND	ND
8	Hept. Epoxide	200 (4)	ND	ND	930	ND	ND	ND	ND	ND	ND	ND	153	ND
9	γ - chlordane	50 (3)	ND	ND	ND	ND	ND	ND	ND	ND	340	ND	ND	ND
10	Dieldrin	200 (3)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	PP- DDE	-	40.13	ND	ND	ND	ND	293	ND	ND	ND	ND	ND	ND
12	Endrin	100 (3)	ND	124	ND	96.8 6	ND	ND	ND	ND	ND	ND	ND	246
13	PP. DDD	-	ND	6.53	ND	ND	ND	273	ND	ND	ND	ND	304	186
14	Op - DDT	5000 (3)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15	PP.DDT		ND	ND	ND	ND	90.07	ND	ND	ND	ND	ND	ND	ND

ND: not detectable

(1) FDA (1983)
(2) FDA (1994)
(3) Codex Alimentarius commission, (1999)
(4) Codex Alimentarius commission, (1986)

a- Organochlorine pesticides

The obtained results revealed that the average levels of the detected organochlorine pesticide residues in the examined freshwater fish muscle samples were 109.3 and 40.13 ng/g for aldrin and pp.DDE in Boweza (*Moryrus casschive*); 74.66, 206.6, 124 and 6.53 ng/g for β-BHC Heptachlor, Endrin and pp. DDD in Raya (*Alestes dentex*); 930 ng/g for Hep. Epoxide in kalb el samak (*Hydrocynus forskalii*); 76.66 ng/g for endrin in lebeis Nili (*Labeo niloticus*); 90.07 ng/g for pp. DDT in Benni (*Barbus bynni*); 293 and 273 ng/g for pp.DDE and pp. DDD in schilba (*Schilbe (Eutropius) niloticus*) 87.86 ng/g for γ-BHC in Bayad (*Bagrus bajad*); 99.33 ng/g for Aldrin in Docmac (*Bagrus docmac*); 340 ng/g for γchlordane in Schall (*Synodontis schall*); 21.46 ng/g for α- BHC in Bolti Nili (*Oreochromis niloticus*); 75.2 and 204 ng/g for Hep. Epoxide and pp.DDD in Samous (*Lates niloticus*) and 246 and 186 ng/g for endrin and pp.DDD in Fahaka (*Tetraodon linneateus*).

El-Zorgani (1980) recorded DDT content of samples of seven fish species taken at Wadi Halfa on Nubia Lake at the border between Sudan and Egypt. The levels of DDT in all fish were significantly higher than the maximum permissible levels. Such high pollution with DDT was attributed to the continued use of DDT on cotton fields in the Gezera project in central Sudan to control agricultural pests and vectors of malaria, typhus, yellow fever and sleeping sickness.

Data in Table (2) indicate the detection of few pesticides in low levels in water samples collected from Nubia Lake. Aldrin , Hep. Eposide, γ- Chlordane, pp.DDE, Endrin, pp.DDD, and pp.DDT were detected in the ten locations.

All of the detected pesticides in water samples (Table 2) were at low concentrations, except those collected from Dabarosa section (143 ng/l).

Table (2): Residue levels of organochlorine pesticides in Nubia Lake water, January 2006, ng/l.

Number	Location / pesticide	El Daka	Okma	El Dewishat	Semna Kagnarti	Morshed	Gomaye	2nd Cataract	Abdel kader	Doghein	Dabarosa
		Concentration pf pesticides (ng/g)									
1	α- BHC	49.2	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	β- BHC	130	ND	ND	ND	ND	ND	355	ND	ND	ND
3	γ- BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	δ - BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	Heptachlor	209	215	ND	ND	147	ND	ND	ND	366	ND
6	Delta – BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	Aldrin	ND	20.55	ND	ND	13	ND	ND	25	17.5	ND
8	Hep. Epoxide	ND	35.45	ND	ND	107	ND	ND	299	152	ND
9	γ - chlordane	145	ND	ND	ND	52	65.75	ND	110	30.95	ND
10	Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	PP-DDE	277	19.5	ND	33	ND	ND	277	20.3	ND	ND
12	Endrin	ND	32.6	ND	ND	ND	ND	ND	ND	ND	15.6
13	PP.DDD	ND	ND	ND	ND	23.35	94.5	13.25	75.1	ND	ND
14	O.P - DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15	PP - DDT	ND	ND	330	315	545	509	313	730	ND	511

ND: not detectable

All of the detected pesticides in water samples (Table 2) were at low concentrations, except those collected from Dabarosa section (143 ng/l).

Among the analyzed organochlorine residues in sediment samples, α BHC, β-BHC, Heptechlor, Aldrin, Hep. Eposide, γ- Chlordane, pp-DDE Endrin, pp.DDD, and PP-DDT were detected at levels ranging from ND to 4[illegible] g/g for α -BHC, 130 to 355 ng/g for β-BHC, 147 to 366 ng/g for Heptachlo[illegible] to 25 ng/g for Aldrin, 35.45 to 299 ng/g for Heptachlor, 13 to 25 ng/g [illegible]ldrin, 35.45 to 299 ng/g for Hep.Epoxide, 30.95 to 145 ng/g for γ-chlord[illegible].5 to 277 ng/g for pp. DDE, 15.6 to 32.6 ng/g for Endrin, 13.25 to 94.5 [illegible]r pp. DDD and 313 to 730 ng/g for pp. DDT. The highest concentration w[illegible]rved for pp-DDT for several locations in Abdel kader section (730 ng/[illegible] shed (545ng/g), Dabaosa (511 ng/g) and Gomaye (509 ng/g).

On the contrary, lower levels of organochlorine residues we[illegible]ined for Aldrin in Morshed section (13 ng/g) and pp-DDE in Okma se[illegible]19.5 ng/g). Although there is a lack in data concerning Nubia lake sedi[illegible]t, the obtained results agree with findings obtained by Sallam *et al.* (2006) in sediments of River Nile.

As shown in Table (3), the concentration of BHCs was lower than DDTs. This may be due to their differences in physicochemical and biological properties with BHCs , which have higher water solubility, vapor pressure, biodegradability, lower lipophilicity and particle affinity compared to DDTs.

Table (3): Residue levels of organochlorine pesticides in sediment from Nubia Lake, January 2006, ng/g.

Number	Location / pesticide	Drinking water guidelines in Australia (µg/l)	El Daka	Okma	El Dewishat	Semna Nagnardi	Morshed	Gomaye	2nd Cataract	Abdel kader	Dogheim	areas
			Concentration of pesticides (ng/l)									
1	α- BHC	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	β- BHC	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	γ- BHC	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	δ - BHC	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	Heptachlor	0.05	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
6	Delta - BHC	-	ND	ND	ND	ND	ND	ND	[illegible]	ND	ND	ND
7	Aldrin	0.01	ND	[illegible]	ND	ND	[illegible]	ND	ND	ND	[illegible]	ND
8	Hep. Epoxide	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	[illegible]
9	γ - chlordane	0.01	ND	ND	ND	[illegible]	ND	ND	ND	ND	ND	ND
10	Dieldrin	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	PP-DDE	-	[illegible]	ND	ND	ND	ND	ND	ND	ND	ND	ND
12	Endrin	-	[illegible]	ND	ND	ND	ND	ND	ND	ND	ND	ND
13	PP.DDD	-	ND	[illegible]	ND	ND	ND	ND	[illegible]	ND	ND	ND
14	O,P - DDT	0.06	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
15	PP - DDT		ND	ND	[illegible]	ND	ND	ND	ND	ND	ND	ND

ND: not detectable

b- Organophosphorus pesticide

Concentrations of organophosphorus pesticides in Nubia Lake are shown in Tables (4), (5), and (6). Compounds identified included ethoprophos, diazinon, Chlorpyriphos methyl, chlorpyriphos, malathion, fenitrothion, fenthion, fenthioate, and profenophos.

In fish, bioconcentration from water via the gills, skin, and food is a possible route for organophosphorus (OP) pesticide to accumulate in tissue: the route depends mainly on their feeding preference, general behavior, and trophic level (Fisher, 1995). The present study indicated that Samous species (*Lates niloticus*) has a higher tendency to bioaccmulate OP than others, which can be attributed to its specific feeding habits.

Table (4): Residue levels of organophosphorus pesticides in some Nubia Lake fish species, January 2006, ng/g.

Number	Fish type / pesticide	Permissible limits (ppb)	Bowere	Rayah	Kalb el samak	Lebes Nili	Benni	Schilba	Bayad	Doemak	Schall	Bolti Nili	Samous	Fahaka
			Concentration of pesticides (ng/g)											
1	ethoprophos	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	cadusaphos	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	phorate	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	diazinon	700 (1)	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	Chlorpyriphos methyl	50 (1)	83.28	159.15	ND	ND	ND	ND	ND	ND	ND	ND	ND	103
6	chlorpyriphos	200 (1)	ND	ND	ND	ND	ND	73.78	ND	41.5	83.12	ND	ND	ND
7	malathion	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	300	ND
8	fenitrothion	50 (1)	ND	100.8	ND	ND	212	ND	ND	ND	ND	ND	ND	ND
9	fenthion	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	126	182
10	Fenthioate	-	ND	ND	109.6	ND	ND	ND	ND	ND	ND	45.2	ND	ND
11	Profenophos	50 (1)	ND	ND	ND	98.93	ND	ND	91.1	ND	ND	ND	360	ND
12	fenamiphos	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND: not detectable

(1) Codex Alimentarius commission, (1999)

Tables (5) and (6) illustrate OP concentration in water and sediments samples for ten sampling sites. The level of concentrations were 20.8 and 37.06 ng/l for fenthion and profenophes in El-Daka section , 40.76 ng/l for profenophos in Semna and Kagnarti section, 44.9 and 17.6 ng/l for chlorpyriphos methly and fenthion in Gomaye section; 23.85 ng/l for fenthioate in Abdel kader section and 99.82 ng/l for dazinon in Dabarosa section.

Table (5): Residue levels of organophosphorus pesticides in Nubia Lake water, January 2006, ng/l.

Number	Location / pesticide	Drinking water guidelines in Australia (μg/l)	El Daka	Okma	El Dewishat	Semna Kagnarti	Morshed	Gomaye	2nd Cataract	Abdel kader	Doghelm	Dabarosa
			Concentration pf pesticides (ng/l)									
1	Ethoprophos	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
2	Cadusaphos	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	Phorate	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	Diazinon	1	ND	ND	ND	ND	ND	ND	ND	ND	ND	99.82
5	Chlorpyriphos methyl	-	ND	ND	ND	ND	ND	44.9	ND	ND	ND	ND
6	Chlorpyriphos	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	Malathion	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	Fenitrothion	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
9	Fenthion	-	20.8	ND	ND	ND	ND	17.6	ND	ND	ND	ND
10	Fenthioate	-	ND	ND	ND	ND	ND	ND	ND	23.85	ND	ND
11	Profenophos	0.3	37.06	ND	ND	40.76	ND	ND	ND	ND	ND	ND
12	Fenamiphos	-	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND: not detectable

Residues of OP in sediments are given in Table (6). It is evident that the concentrations of studied compounds were subject to considerable variation with respect to sites. The concentration values were 106.6 and 36.3 ng/g for fenitrothion and fenthioate in El-Daka section, 58.6 ng.g for chlorpyriphos methyl in El-Dewishat section, 153 ng/g for chlorpyriphos methyl in 2nd cataract and 13.59 ng/g for Ethoprophos in Dabarosa section. Our findings are in harmony with that obtained by Sallam (2006).

Table (6): Residue levels of organophosphorus pesticides in sediment from Nubia Lake, 2006, ng/g.

Number	Location / pesticide	El Daka	Oloma	El Dewishat	Semna Kagnarti	Morshed	Gomaye	2nd Cataract	Abdel kader	[illegible]	[illegible]
		Concentration pf pesticides (ng/g)									
1	Ethoprophos	ND	ND	ND	ND	ND	ND	ND	ND	ND	13.59
2	Cadusaphos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
3	Phorate	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
4	Diazinon	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
5	Chlorpyriphos methyl	ND	ND	58.6	ND	ND	ND	153	ND	ND	ND
6	Chlorpyriphos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
7	Malathion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
8	Fenitrothion	106.6	ND	ND	ND	ND	ND	ND	ND	ND	ND
9	Fenthion	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
10	Fenthioate	36.3	ND	ND	ND	ND	ND	ND	ND	ND	ND
11	Profenophos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
12	Fenamiphos	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND

ND: not detectable

The presence of chlorpyrifos methyl, fenitrothion and fenthioate, in sediments samples collected from Nubia Lake could be attributed to the intense agricultural activity in the area. On the other hand, the absence of most organophosphorus pesticides in water and sediment may be attributed to its rapid degradation, depending on their formulation, rate of application, method of application and climatic factors. These compounds are highly soluble in water and relatively short-lived in the environment

From the results, Nubia Lake shows that the residues of organochlorine and organophosphorus pesticides exist in low concentrations in water and majority of common species. These residues have apparently originated from the areas of intensive pesticide application in the Gezera and along the White Nile in central Sudan. The natural processes of weathering are likely to result in the transfer of pesticide residues to the main course of the Nile, especially during the rainy season and hence their transport downstream. Nubia Lake is the site of deposition for most of the Nile-borne silt and other suspended matter. Under these circumstances, it is expected that an appreciable build-up of residues with time will take place around the agriculture zone in central Sudan. Increased contamination with residues is certain to adversely affect the fish population (El Zorgani, 1979) and hence endanger the plants for the development of the fisheries industry in this vital area. In order to keep the situation under control, it is essential that a system for the continuous monitoring of residues as key environmental components in the whole lake should be established.

Conclusion and Recommendations

The following can be concluded from this research:

1- Some pesticides with negative carcinogenic effects are still used in Sudan.
2- The collected fish samples from Nubia Lake are contaminated with low levels of pesticides.
3- Levels of organochlorine and organophosphorus insecticides in water are still within safety margins, compared to the permissible limits for drinking waters.
4- Continuous monitoring of pesticide residues in freshwater fish is recommended to detect any probable addition of organochlorine pesticide along Nile Basin countries in order to keep the water away from the sources of pollution.

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