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Organochlorine Pesticide Residues in Fish from Lake Naivasha and Tana River, Kenya

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Organochlorine pesticides such as DDT, dieldrin and lindane are pesticides used in agriculture and public health. The chemicals persist in the environment and accumulate in fatty tissues of living organisms. Toxicity of organochlorines in non-target organisms is mainly due to chronic exposure to sublethal doses of the chemicals. Some of the documented detrimental effects of the pesticides in these organisms include liver microsomal enzyme induction (Oestreicher, 1971), tumor induction (IARC, 1974), egg-shell thinning in birds (Chang and Stockstad, 1975) and reduced egg hatchability in fish.

Organochlorine pesticides were widely used in Kenya between the mid 1940's and late 1970's in agriculture and aerial control of mosquitoes in the Lake Victoria region. However, only a few studies have been done to investigate the occurrence of the pesticide residues in Kenyan fish. The main objective of the present study was to identify and quantify organochlorine residues in fish from Lake Naivasha and Tana River so as to assess the extent of contamination of the fisheries by the pesticide residues and evaluate the toxicological significance of the findings.

MATERIALS AND METHODS

A total of 208 samples representing five species of fish were collected from Lake Naivasha and Tana River between October, 1988 and October, 1989. Samples from the Tana River were collected from Masinga Dam and the lower Tana River at Garsen and Tarasaa. The fish were caught by gillnets, line and hook or fishing baskets. Samples of the fillet, liver and eggs were obtained, wrapped separately in aluminium foil and labeled appropriately. Samples from each fish were packed in a labeled plastic paper bag. The samples were later transported to the laboratory in cool boxes packed with freezer packs and stored at -20°C until the time of analysis.

Extraction, clean-up and analysis of organochlorine pesticide residues was done as described by Bjerk and Sundby (1970) with some slight modifications. Briefly the procedure involved grinding of 3g of the sample with equal amounts (4.5g) of acid-washed sea sand and anhydrous sodium sulphate. The pesticides in 4g of the homogenate were extracted with diethylether and the extract cleaned with base (15% methanolic sodium hydroxide) and acid (concentrated sulphuric acid). The final pesticide extract was obtained in 1ml of hexane. Aliquotes (2-5ml) of the pesticide extracts and a chlorinated pesticide mixture (CPM) standard were injected into a gas liquid chromatograph (GLC) for analysis.

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A Packard gas liquid chromatograph, Model DX 12362, Series 428 fitted with a ^{63}Ni electron capture detector (ECD) was used for analysis. The GLC operating conditions were: Column, 2.0m x 4mm ID, all glass, packing GP 1.5% SP-2250/1.95% SP- 2401 on 100/120 Supelcoport. Temperature: column 210°C, detector 250°C, injector 230°C. Carrier gas: Nitrogen, flow rate 70ml/min. Attenuation 128; recorder chart speed, 10mm/min and recorder voltage, 10mV. The limit of pesticide residue quantitation was 0.001mg/kg calculated on wet weight basis.

Analysis of variance and Turkey's highest significant difference tests (Wayne, 1983) were used to determine if there was a significant difference in the means of residue levels in the various species of fish. A significant level of 5% was used.

RESULTS AND DISCUSSION

Residues of p,p' DDT, p,p' DDE, γ- hexachlorocyclohexane (γ- HCH or lindane) and α- HCH were detected in 14 fish samples from Masinga Dam. The other samples did not have detectable residue levels. The 14 samples composed 36.8% of the samples from Masinga Dam and 6.7% of all the samples analysed. Table 1 shows the mean and range of residue levels of the pesticides detected. The results for individual fish samples are shown in Tables 2 and 3.

Table 1. Mean, Standard deviation (SD) and range of pesticide residue levels in fish from Masinga Dam

		Pesticide residues (mg/kg)				
		pp'DDE	pp'DDT	Lindane	α-HCH	Sum DDT
Species/sex/ organ	No. of samples	Mean±SD Range	Mean±SD Range	Mean±SD Range	Mean±SD Range	Mean ± SD Range
Common carps						
Fillet	19	0.03±0.021 0.015-0.054 (3)	0.223± 0.34 0.085-1.125 (9)	0.14±0.093 0.033-0.295 (8)	-	0.234±0.358 0.085-1.185
Catfish						
Liver	8	0.138±0.081 0.059-0.22 (3)	0.052 (1)	0.01±0.001 0.009-0.011 (3)	0.009 (1)	0.163±0.054 0.117-0.222
Fillet	11	0.102 (1)	0.052 (1)	0.009±0.006 0.004-0.013 (2)	0.013 (1)	0.113
Tilapia						
Fillet	8	-	-	0.011 (1)	-	-
Eggs	1	0.068 (1)	-	0.009 (1)	0.021 (1)	0.075

Figures in parenthesis represent the number of positive samples for each residue
Residue levels are given on wet weight basis
Mean was calculated for the positive samples
(-) Below the detectable limit

Table 2. Pesticide residue levels in fillet of common carps from Masinga Dam

Sample No.	Pesticide residues (mg/kg)				
	pp'DDE	pp'DDT	Lindane	α-HCH	Sum DDT
F15	0.054	1.125	-	-	1.185
F18	-	0.085	0.033	-	0.085
F19	-	0.085	0.233*	-	0.085
F20	-	0.102	0.295*	-	0.102
F21	-	0.205	0.075	-	0.205
F22	-	0.102	0.195	-	0.102
F23	0.015	0.096	0.10	-	0.113
F24	-	0.096	0.134	-	0.096
F25	0.022	0.112	0.151	-	0.136

Residue levels are given on wet weight basis
* Above the NFA maximum residue limit
(-) Below the detectable limit

Table 3. Pesticide residue levels in liver and fillet of catfish from Masinga Dam

Sample No.		Pesticide residues (mg/kg)				
		pp'DDE	pp'DDT	Lindane	α-HCH	Sum DDT
L1	27.7	0.059	0.052	0.011	0.009	0.117
L2	27.13	0.135	-	0.009	-	0.150
L3	27.2	0.220	-	0.009*	-	0.333
*F3	27.1	-	-	0.013	-	-
*F1	27.6	0.102	-	0.004	0.013	0.113

Residue levels are given on wet weight basis
(-) Below the detectable limit
* Fillet sample

p,p' DDT occurred in ten samples and was mainly detected in the fillet of common carps. The mean p,p' DDT residue levels for the three species of fish from Masinga Dam ranged from 0.052 to 0.223mg/kg. The highest p,p' DDT residue level was 1.125mg/kg detected in the fillet of a common carp. Residues of p,p' DDE were detected in low levels in seven samples. The highest residue level recorded was 0.22mg/kg. Common carps had significantly higher sum DDT levels than catfish ($p<0.05$). The highest sum DDT level was 1.185mg/kgdetected in a fillet sample from a common carp.

Lindane was detected in 13 of the samples analysed and the levels ranged from 0.003 to 0.295mg/kg. Common carps had significantly higher residue levels than catfish ($p<0.05$). Two samples had lindane levels exceeding the maximum residue limit of 0.2mg/kg set by the National Food Administration (NFA) of Sweden in fish for human consumption. The NFA is a collaborating centre for the Joint FAO/WHO Food and Animal Feed Contamination Monitoring Programme. Low levels of α- HCH ranging from 0.009 to 0.02mg/kg were detected in a liver and fillet sample from one catfish and the only available egg sample from tilapia.

The residue levels found in this study compare well with those reported in studies in other areas in Kenya (Koeman et al., 1972; Greichus et al., 1978; Lincer et al., 1981; Kanja, 1989; Mitema and Gitau, 1990). The presence of lindane residues in levels above the maximum residue limits set by the NFA indicate that the Dam could be acting as a sink for pesticides used in the catchment of the Tana River and a recently established irrigation scheme in the dam's environs. This indicates that with time people could consume fish with harzardous levels of the pesticides. Periodic monitoring of organochlorine pesticide residues in fish in the dam should be done to determine the trend of the chemicals in the reservoir.

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