

# **Storage of Organochlorine Insecticides in Adipose Tissue of Ugandans**

by M. WASSERMANN,\* L. TOMATIS,\*\* DORA WASSERMANN,\*  
N. E. DAY,\*\* and M. DJAVAHERIAN\*

*\*Department of Occupational Health  
Hebrew University—Hadassah Medical School  
Jerusalem, Israel*

*\*\*World Health Organization  
International Agency for Research on Cancer  
Lyon, France*

In the middle of the last decade, the trace amounts of organochlorine insecticides (OCI) stored in people living in various areas of the world appeared to us (3) of enough epidemiological significance to consider OCI as "current constituents of the human body". Field studies on humans reported the accumulation of OCI in the body of people of all ages and in the fetus, its crossing of the placental barrier and its presence in milk. Experimental studies in animals and findings in humans revealed that organochlorine insecticides are potent hepatic microsomal enzyme inducers, capable of quantitatively altering the response to some xenobiotics (drugs and toxic compounds) and to naturally occurring compounds in the animal body (e.g. steroid hormones) as well as influencing certain endocrine and immunological homeostatic processes.

At the same time, experimental evidence of the capacity of OCI to increase tumour incidence in laboratory animals was reported (1,2).

Such findings raised concern about potential hazards of OCI to human health. Among the steps considered necessary for control of this hazards was the assessment of the extent to which OCI are stored in various populations and the features of this process. In this regard, the World Health Organization - International Agency for Research on Cancer, Lyon - launched a program for assessing the storage of organochlorine insecticides in several areas of the world that would serve as an orientative baseline for prospective studies on this subject. This paper reports the findings obtained by investigating OCI storage in the general population of Uganda.

## **Materials and Methods**

A total of 75 samples of adipose tissue were collected during autopsy. All the specimens were sampled during 1969-70 from persons living in the Kampala area, who had no known occupational exposure to pesticides.

The distribution of samples according to age and sex is shown in Table 1. Samples of 1-2 gram adipose tissue were collected in jars containing 10% formalin. Specimens of 500 mg adipose tissue were extracted three times with a total of 20 ml petrol ether and cleaned on an Ottawa Sand-Florisil column. The extract was reduced to 0.5 ml and injected into a gas chromatograph equipped with dual electron capture detector and strip chart recorder.

TABLE 1

Distribution of Samples according to Age and Sex

Age in years	Males	Females	Total
0 - 4	14	6	20
5 - 24	10	6	16
25- 44	15	7	22
45+	10	7	17
Total	49	26	75

### Results and Discussion

In 75 samples of adipose tissue, from people of the Kampala area who had no known occupational exposure to insecticides, concentrations of DDT-derived material, the beta isomer of benzene hexachloride, dieldrin and heptachlor epoxide were determined (Tables 2-4).

#### Tables 2-4

In the 0-4 year age group, the mean total DDT was 2.3 ppm. DDE averaged 59.6% of the total DDT-derived material. The total p,p'-DDT averaged 2.2 ppm while the total o,p'-DDT constituted 0.06 ppm.

In the 5-24 year age group, the mean total DDT was 3.8 ppm. DDE averaged 50.2% of the total DDT-derived material. The mean total p,p'-DDT was 3.08 ppm and the mean of o,p'-DDT was 0.18 ppm. There was a significant difference in the storage of total DDT between the 0-4 year and 5-24 year age groups, respectively ( $p < 0.05$ ).

In the 25-44 year age group, total DDT averaged 2.9 ppm. DDE constituted 63.2% of total DDT-derived material. The mean total p,p'-DDT was 2.8 ppm and the mean of total o,p'-DDT was 0.14 ppm. There was no significant difference in the storage of total DDT between the 5-24 year and 25-44 year age groups.

TABLE 2  
Concentration of Organochlorine Insecticides  
in Adipose Tissue of Ugandans (ppm) Males.

Compound	Age Group No of Cases	0 - 4				5 - 24				25 - 44				45 +			
		14				10				15				10			
p,p'-DDT	Range	0.0481	-	4.9235		0.0363	-	9.5000		0.0200	-	4.6135		0.0642	-	6.7278	
	Mean $\pm$ SD	0.7799	$\pm$	1.2554		1.4936	$\pm$	2.7362		0.9485	$\pm$	1.5103		0.9774	$\pm$	1.9365	
p,p'-DDD	Range	0.0070	-	0.5569		0.0084	-	1.1460		0.0053	-	1.3540		0.0064	-	1.2416	
	Mean $\pm$ SD	0.0772	$\pm$	0.1389		0.1951	$\pm$	0.3490		0.1232	$\pm$	0.3311		0.1575	$\pm$	0.3626	
p,p'-DDE	Range	0.0096	-	7.8824		0.0756	-	4.4230		0.1023	-	8.0159		0.1220	-	4.0888	
	Mean $\pm$ SD	1.2697	$\pm$	2.0785		1.6949	$\pm$	1.6670		2.0926	$\pm$	2.4998		1.0607	$\pm$	1.1882	
o,p'-DDT	Range	0.0005	-	0.2518		0.0322	-	1.6180		0.0091	-	1.2454		0.0170	-	0.1257	
	Mean $\pm$ SD	0.0541	$\pm$	0.0656		0.2348	$\pm$	0.4698		0.1520	$\pm$	0.3172		0.0433	$\pm$	0.0374	
o,p'-DDD	Range	< 0.0001				< 0.0001				0.0101	-	0.2686		0.0001	-	0.0054	
	Mean $\pm$ SD									0.0185	$\pm$	0.0671		0.0005	$\pm$	0.0001	
o,p'-DDE	Range	0.0007	-	0.0300		0.0035	-	0.1564		0.0041	-	0.0690		0.0035	-	0.0309	
	Mean $\pm$ SD	0.0090	$\pm$	0.0100		0.0231	$\pm$	0.0447		0.0147	$\pm$	0.0200		0.0132	$\pm$	0.0141	
Total p,p'-DDT	Range	0.0786	-	13.8507		0.1205	-	15.5303		0.1340	-	13.5844		0.2245	-	12.5243	
	Mean $\pm$ SD	2.2720	$\pm$	3.5988		3.5769	$\pm$	4.5487		3.4629	$\pm$	4.5123		2.3113	$\pm$	3.5426	
Total o,p'-DDT	Range	0.0013	-	0.2638		0.0361	-	1.6422		0.0060	-	1.2711		0.0235	-	0.1475	
	Mean $\pm$ SD	0.0639	$\pm$	0.0671		0.2605	$\pm$	0.4699		0.1870	$\pm$	0.3211		0.0537	$\pm$	0.0387	
Total DDT	Range	0.0799	-	13.9980		0.1205	-	17.1725		0.1400	-	14.2224		0.2467	-	12.6718	
	Mean $\pm$ SD	2.3367	$\pm$	3.6235		3.8374	$\pm$	4.9930		3.6500	$\pm$	4.5166		2.3651	$\pm$	3.5751	
$\beta$ -BHC	Range	0.0031	-	0.1036		< 0.0001	-	0.3554		0.0046	-	0.4648		0.0366	-	0.3371	
	Mean $\pm$ SD	0.0459	$\pm$	0.0283		0.0760	$\pm$	0.1020		0.0988	$\pm$	0.1166		0.0884	$\pm$	0.0854	
Dieldrin	Range	0.0042	-	0.2976		0.0189	-	0.0582		0.0048	-	0.5882		0.0050	-	0.0938	
	Mean $\pm$ SD	0.0309	$\pm$	0.0755		0.0308	$\pm$	0.0200		0.0502	$\pm$	0.1449		0.0304	$\pm$	0.0300	
H.Epoxyde	Range	<0.0001	-	0.7765		< 0.0001	-	0.3953		< 0.0001	-	0.5071		< 0.0001	-	0.4458	
	Mean $\pm$ SD	0.0918	$\pm$	0.1962		0.0968	$\pm$	0.1253		0.1478	$\pm$	0.1658		0.1104	$\pm$	0.1308	

TABLE 3  
Concentration of Organochlorine Insecticides  
in Adipose Tissue of Ugandans (ppm). Females.

Compound	Age Group No of Cases	0 - 4 6	5 - 24 6	25 - 44 7	45 + 7
p,p'-DDT	Range Mean $\pm$ SD	0.0409 - 1.8441 0.8185 $\pm$ 0.7755	0.0749 - 0.8059 0.2863 $\pm$ 0.2478	0.0378 - 0.9761 0.4611 $\pm$ 0.3582	0.1017 - 1.2169 0.6047 $\pm$ 0.3108
p,p'-DDD	Range Mean $\pm$ SD	0.0055 - 0.2076 0.0553 $\pm$ 0.0714	0.0079 - 0.0275 0.0217 $\pm$ 0.0054	0.0078 - 0.2000 0.0646 $\pm$ 0.0755	0.0069 - 0.2000 0.0680 $\pm$ 0.0632
p,p'-DDE	Range Mean $\pm$ SD	0.1207 - 2.8154 1.0404 $\pm$ 1.0232	0.1336 - 5.3153 1.7392 $\pm$ 1.9611	0.0972 - 1.5831 0.6458 $\pm$ 0.5382	0.1301 - 5.0607 1.2789 $\pm$ 1.5859
o,p'-DDT	Range Mean $\pm$ SD	0.0288 - 0.1063 0.0442 $\pm$ 0.0346	0.0042 - 0.0765 0.0322 $\pm$ 0.0223	0.0052 - 0.0868 0.0335 $\pm$ 0.0283	0.0103 - 2.3529 0.3932 $\pm$ 0.8012
o,p'-DDE	Range Mean $\pm$ SD	< 0.0001 0.0001	< 0.0001 0.0001	< 0.0001 - 0.0040 0.0006	< 0.0001 - 0.0040 0.0006
o,p'-DDE	Range Mean $\pm$ SD	0.0031 - 0.0077 0.0035 $\pm$ 0.0055	0.0030 - 0.0139 0.0078 $\pm$ 0.0031	0.0030 - 0.0332 0.0109 $\pm$ 0.0100	0.0033 - 0.0292 0.0171 $\pm$ 0.0100
Total p,p'-DDT	Range Mean $\pm$ SD	0.1808 - 4.3471 2.0329 $\pm$ 1.7421	0.2316 - 6.0838 0.2455 $\pm$ 2.2821	0.1659 - 2.8302 1.2490 $\pm$ 0.9965	0.2535 - 6.8549 2.0872 $\pm$ 2.0258
Total o,p'-DDT	Range Mean $\pm$ SD	0.0329 - 0.1063 0.0481 $\pm$ 0.0346	0.0122 - 0.0822 0.0408 $\pm$ 0.0200	0.0143 - 0.1068 0.0463 $\pm$ 0.0331	0.0212 - 2.3776 0.4129 $\pm$ 0.8046
Total DDT	Range Mean $\pm$ SD	0.2137 - 4.3471 2.0810 $\pm$ 1.7509	0.2776 - 6.1660 2.2863 $\pm$ 2.2898	0.1802 - 2.9049 1.2954 $\pm$ 1.0242	0.2993 - 9.2325 2.5001 $\pm$ 2.8123
-BHC	Range Mean $\pm$ SD	0.0046 - 7.5794 1.3036 $\pm$ 2.8070	0.0121 - 0.0928 0.0416 $\pm$ 0.0346	0.0218 - 0.0706 0.0444 $\pm$ 0.0141	0.0119 - 0.1038 0.0521 $\pm$ 0.0283
Dieldrin	Range Mean $\pm$ SD	0.0341 - 0.0735 0.0179 $\pm$ 0.0283	0.0028 - 0.0376 0.0095 $\pm$ 0.0104	0.0104 - 0.0354 0.0114 $\pm$ 0.0141	0.0024 - 0.0269 0.0087 $\pm$ 0.0100
H.Epoxide	Range Mean $\pm$ SD	0.0040 - 0.4218 0.1559 $\pm$ 0.1625	0.0032 - 0.6353 0.2247 $\pm$ 0.2740	< 0.0001 - 0.1109 0.0430 $\pm$ 0.0424	< 0.0001 - 0.0771 0.0216 $\pm$ 0.0332

TABLE 4

Concentration of Organochlorine Insecticides in  
Adipose Tissue of Ugandans (ppm) Both Sexes.

Compound	Age Group No of Cases	0 - 4 20	5 - 24 16	25 - 44 22	45 + 17
p,p'-DDT	Range Mean $\pm$ SD	0.0409 - 4.9235 0.7915 $\pm$ 1.1332	0.0363 - 9.5000 1.0409 $\pm$ 2.2450	0.0200 - 4.6135 0.7935 $\pm$ 1.2833	0.0642 - 6.7278 0.8239 $\pm$ 1.5097
p,p'-DDD	Range Mean $\pm$ SD	0.0055 - 0.5569 0.0706 $\pm$ 0.1229	0.0079 - 1.1460 0.1301 $\pm$ 0.2884	0.0053 - 1.3540 0.1043 $\pm$ 0.2780	0.0064 - 1.2416 0.1206 $\pm$ 0.2846
p,p'-DDE	Range Mean $\pm$ SD	0.0096 - 7.8824 1.2009 $\pm$ 1.8303	0.0756 - 5.3153 1.7115 $\pm$ 1.7833	0.0972 - 8.0159 1.6323 $\pm$ 2.1923	0.1220 - 5.0607 1.1505 $\pm$ 1.3701
o,p'-DDT	Range Mean $\pm$ SD	0.0005 - 0.2518 0.0511 $\pm$ 0.0574	0.0042 - 1.6180 0.1586 $\pm$ 0.3843	0.0052 - 1.2454 0.1143 $\pm$ 0.2661	0.0103 - 2.3529 0.1873 $\pm$ 0.5431
o,p'-DDE	Range Mean $\pm$ SD	$\leq$ 0.0001	$\leq$ 0.0001	0.0040 - 0.2686 0.0128 $\pm$ 0.0449	0.0040 - 0.0054 0.0006 $\pm$ 0.0017
o,p'-DDE	Range Mean $\pm$ SD	0.0007 - 0.0300 0.0073 $\pm$ 0.0071	0.0030 - 0.1564 0.0173 $\pm$ 0.0360	0.0030 - 0.0690 0.0135 $\pm$ 0.0449	0.0033 - 0.0309 0.0148 $\pm$ 0.0100
Total p,p'-DDT	Range Mean $\pm$ SD	0.0786 - 13.8507 2.2003 $\pm$ 3.1605	0.1205 - 15.5303 3.0776 $\pm$ 1.2385	0.1340 - 13.5844 2.7585 $\pm$ 3.9063	0.2245 - 12.5243 2.2190 $\pm$ 3.0141
Total o,p'-DDT	Range Mean $\pm$ SD	0.0013 - 0.2638 0.0592 $\pm$ 0.0600	0.0122 - 1.6422 0.1781 $\pm$ 0.3866	0.0060 - 1.2711 0.1423 $\pm$ 0.2737	0.0212 - 2.3776 0.2016 $\pm$ 0.5462
Total DDT	Range Mean $\pm$ SD	0.0799 - 13.9980 2.2600 $\pm$ 3.1811	0.1205 - 17.1725 3.8374 $\pm$ 4.9930	0.1400 - 14.2224 2.9008 $\pm$ 3.9294	0.2467 - 12.6718 2.4207 $\pm$ 3.2834
-BHC	Range Mean $\pm$ SD	0.0031 - 7.5794 0.4232 $\pm$ 1.6419	$\leq$ 0.0001 - 0.3554 0.0631 $\pm$ 0.0843	0.0046 - 0.4648 0.0815 $\pm$ 0.1000	0.0119 - 0.3371 0.0734 $\pm$ 0.0700
Diieldrin	Range Mean $\pm$ SD	0.0042 - 0.2376 0.0270 $\pm$ 0.0648	0.0028 - 0.0582 0.0228 $\pm$ 0.0200	0.0048 - 0.5882 0.0379 $\pm$ 0.1212	0.0024 - 0.0938 0.0214 $\pm$ 0.0245
H.Epoxyde	Range Mean $\pm$ SD	$\leq$ 0.0001 - 0.7765 0.1110 $\pm$ 0.2921	$\leq$ 0.0001 - 0.6353 0.1447 $\pm$ 0.2044	$\leq$ 0.0001 - 0.5071 0.1144 $\pm$ 0.1469	$\leq$ 0.0001 - 0.4458 0.0738 $\pm$ 0.1114

In the group aged 45 years and over, the mean total DDT-derived material was 2.4 ppm. DDE averaged 53.6% of total DDT-derived material. The mean total p,p'-DDT was 2.2 ppm and the mean total o,p'-DDT was 0.2 ppm.

Males stored larger amounts of DDT-derived material than females, in all the age groups up to 45 years.

In all the age groups, dieldrin was stored at levels below 0.1 ppm and heptachlor epoxide below levels of 0.2 ppm. The beta isomer of hexachloride was stored at levels below 0.1 ppm in all the age groups, except for females aged 0-4 years, where a mean level of 1.3 ppm was found.

The findings reported in this paper indicated that in the group aged 25-44 years, the mean DDT storage level was higher than in the group aged 0-4 and 45 years and over, and statistically not different from the 5-24 year age group.

On the whole, a relatively low storage level of DDT-derived material was observed in people from Uganda (Table 5), when compared to findings in other countries.

TABLE 5

Storage of DDT-derived Material in the Adipose Tissue of  
25-44 year age group (ppm).

Country	Total DDT			References
	M + F	Males	Females	
Nigeria	6.5	7.4	5.98	Wassermann et al (5)
Brazil	7.8	9.6	6.3	Wassermann et al (6)
Israel	14.4	15.9	12.6	Wassermann et al (9)
South Africa				Wassermann et al (4)
White	8.5	10.5	6.6	
Bantu	6.5	8.6	4.4	
Thailand	13.0	15.5	10.2	Wassermann et al (7)
Kenya	4.5	4.6	4.2	Wassermann et al (8)
Uganda	2.9	3.6	1.2	This paper

In studies carried out in about the same period, on people from Kenya, Nigeria, South Africa, Thailand, Brazil, and Israel (Table 5), we found that DDT-derived material tends to be stored at a higher level in the adipose tissue of people of both sexes, aged 25-44 years, when compared to lower age groups. In the 45 and over age groups, the level of DDT-derived material varies from country to country, being higher or lower than in the 25-44 year age group. These features of the storage of DDT-derived material in the general population of several countries, led us to the conclusion that the 25-44 year age group is a useful indicator of the OCI storage level of a community and may be used for comparison with similar groups in other countries.

### Summary

In the framework of a WHO - International Agency Program for Research on Cancer, people from five African, three Asian, and two South American countries were studied for the storage level of organochlorine insecticide storage in the adipose tissue of Ugandans.

Specimens of adipose tissue (75) collected during autopsy from Ugandans living in the Kampala area, who had no occupational exposure to organochlorine insecticides were analyzed by the gas chromatographic method for organochlorine insecticides (DDT-derived material, the beta isomer of BHC, dieldrin and heptachlor epoxide).

In the 0-4 year age group, DDT-derived material averaged 2.3 ppm; DDT constituted 59.6% of total DDT. In the 5-24 year age group, total DDT averaged 3.84 ppm. DDE constituted 50.2% of total DDT. In the 25-44 year age group, total DDT averaged 2.9 ppm DDE constituted 63.2% of total DDT. In the 45 and over age group, total DDT averaged 2.4 ppm and DDE constituted 53.6% of total DDT.

Dieldrin and the beta isomer of BHC were stored at levels below 0.1 ppm and heptachlor epoxide below levels of 0.2 ppm.

Males generally stored more OCI than females.

Lower storage levels of total DDT were observed in the group aged 45 years and over, when compared to the 5-24 and 25-44 year age groups.

In comparison to other populations in Africa, Asia, and South America, people from Uganda stored the lowest amount of OCI.

It is proposed that the 25-44 year age group may characterise the OCI storage level of a community since in this age group DDT-derived material tends to be stored at higher concentrations in the adipose tissue of people in several countries, when compared to lower age groups. (In the over 45 year age groups the level of DDT-derived material varies from country to country being higher or lower than in the 25-44 year age group.)

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