PESTICIDES IN ZIMBABWE

Toxicity and Health Implications

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8
Residues of Organochlorine Pesticides in Human Milk

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Summary
Levels of residues of chlorinated hydrocarbons p,p-DDT, p,p-DDE, p,p-TDE, x-, B-, y-hexachlorocyclohexane (HCH), heptachlor epoxide, dieldrin and polychlorinated biphenyls (PCBs) in the milk of 40 Zimbabwean mothers living in the Greater Harare area were analysed. Of all the milk samples analysed, relatively low residue levels of x-, B-, and y-HCH, peptochloroperoxide and dieldrin were detected in 58, 100, 63, 13 (not statistically significant) and 65 per cent respectively. Traces of the PCB congener 2,2,4,5,5′-pentachlobipheny (PCB 101) were found in 15 samples. One sample contained traces of 2,3′,4,4′,5-pentachlorobiphenyl (PCB 118). From this study, small though the sample was, it seems social status, educational background and living conditions are important demographic variables influencing the frequency distribution of residue levels of sum DDT in the mother's milk.

DDT, Dichlorodiphenyl trichloroethane, has been in use in Zimbabwe for four and half decades, from 1946 to 1982. DDT was registered in Zimbabwe for both public health and agricultural use such as the control of *Anopheles* mosquito and tsetse fly, vectors of malaria and sleeping sickness/Nagana respectively, agricultural pests such as maize stalkborer (*Busseola fusca*), cotton cutworm (*Agrotis spp*), and cotton bollworm (*Heliothis spp*). There is also evidence that DDT has been used as an insecticide to control pests of stored grain since 1982. DDT is registered by the Ministry of Health's Hazardous Substances Control Board as a "hazardous substance class 1", that is, a chemical that can endanger humans, domestic and wild animals and its procurement and use is restricted to cover tsetse and mosquito control only.

Environmental contamination by DDT in Zimbabwe is, therefore, related to its use as a vector control agent. DDT could find its way into the human body when inhaled as house dust, after the houses have been sprayed with DDT during the mosquito control exercise. However, the major source of DDT intake in the general population, accounting for over 90 per cent of individuals positive for DDT in blood or fat, is food.

Studies have been carried out in Zimbabwe to assess pesticide residue levels in serum (Mpofu, 1986). Since the first report of the presence of DDT in human milk in 1951 by Laugh *et al.*, a number of studies have been carried to assess the presence of DDT residues in human milk (Jensen, 1983). Bouwman *et al.* (1990) determined the concentrations of DDT and its metabolites DDE and DDD in the breast milk of KwaZulu (South Africa) mothers. It was found that DDT and DDE in breast milk increased after the application of DDT.

In Zimbabwe, Chikuni *et al.* (1991) published results of a survey and analysis of "Residues of organichlorine pesticides in human milk from mothers living in the Greater Harare city of Zimbabwe". This chapter is based on discussion and conclusions of the results from that study.

Mothers who had lived in four of the high or low density suburbs, around the capital for more than five years were randomly selected and enrolled into the study. The four high density suburbs selected are Mbare, Epworth, Mufakose-Kambuzuma and Dzivaresekwa and the low density suburbs are Milton Park, Queensdale, Avondale and Borrowdale. A total of 40 healthy breast-feeding mothers were interviewed using a pre-tested questionnaire and provided breast milk samples for analysis. The average age and parity of the mothers were 35 years and 1–3 respectively.

Milk samples were collected by means of manual expression. The samples (10 ml) were preserved with 50 ml of 33 per cent formalin, taking special care to avoid contamination. All samples were stored at -10°C until analysis. The milk samples were homogenized with an Ultrasonic homogeniser. Extraction, clean up and analysis of samples were carried out according to the modified method of Brevik (1978). PCBs were determined using gas chromatography against individual PCB isomers. The data obtained was evaluated for significance ($P < 0,05$) by the Wilcoxan's two-sample test (Hodges and Lehemann, 1970).

Milk-supplying mothers were classified into two groups according to socio-economic status, educational background and living conditions. Group 1 mothers (14) lived in the low density suburbs and had a relatively high socio-economic status and dietary habits, a good knowledge of pesticides and their use. Group 2 mothers (26) lived in the high density suburbs and had a relatively low socio-economic status, a basic educational background, poor dietary habits and had poor knowledge of pesticides and their use.

The statistical data is expressed on a fat weight basis as arithmetic mean together with range for the single determination of each of the samples. Median values are also given for sum DDT and DDT/DDE ratios (see Table 1).

The results are expressed as means. The ranges are listed in parentheses. There were no significant differences between corresponding results from the two groups, when $p > 0,05$. Group II mothers showed high mean levels of sum DDT compared to that of Group I mothers. The highest individual sum DDT in Group II was six times higher than that of Group I. The ratio DDT/DDE was higher in Group II mothers. The main organochlorine contaminants found in all the 40 samples were p,p'-DDT and the more persistent metabolites, p,p'-TDE and o,p'-DDT.

Table 1: Residues (ppm, mg per kg fat weight) of sum DDT and the ratio DDT/DDE in Zimbabwe human milk.

Group	Sum of DDT		DDT/DDE	
	Mean	Median	Mean	Median
Group I & II	6,00 (0,59–55,50)	3,22 (0,59–55,53)	0,74 (0,06–6,40)	0,36 (0,00–6,44)
Group I	3,44 (0,63–8,31)	3,10 (0,63–8,31)	0,37 (0,00–1,05)	0,21 (0,00 1,05)
Group II	7,39 (0,59 55,50)	3,97 (0,59–55,53)	0,93 (0,11–6,44)	0,45 (0,11–6,44)

Table 2: Residues (ppm, mg per kg fat weight of (p, p´-TDE, o, p´-DDT and p,p'-DDE in human milk

GROUP	FAT	TDE	o,p´-DDT	p,p´-DDT	p,p´-DDE
II & II	3,0 (0,3–7,7) 40/40	0,43 (0,00–10,67) 24/40	0,34s (0,00–3,83) 39/40	2,39 (0,00–38,16) 40/40	2,53 (0,40 –9,01) 40/40
I	2,6 (0,74–4,20) 14/14	0,04 (0,00–0,15) 5/14	0,11 (0,00–0,41) 13/14	0,90 (0,00–3,98) 13/14	2,18 0,52–5,00) 14/14
II	3,3 (0,3–7,7) 26/26	0,64 (0,00–1,67) 19/26	0,47 0,00–3,83) 25/26	3,19 0,12–38,16) 26/26	2,71 0,40–9,01) 26/26

Residues of the most persistent metabolite, p,p´DDE were observed in all the samples and group II mothers had the highest level of contamination of this metabolite.

Table 3 below shows mean residue level (in ppm, mg per kg of fat weight) of other organochlorine pesticides such as α-, β-, γ-hexachlorocyclohexane (HCH), heptachlorepoxide and dieldrin observed in the two groups. The table shows that the mean levels of the organochlorine pesticides was generally very low compared to that of the other contaminates, that is, DDT and its metabolites analysed. The highest mean level of the pesticide observed in this table was β-HCH in Group I mothers. In general, a great variation among individual samples of the level of contamination was observed.

Table 3: Residues (ppm, mg per kg fat weight) of x-HCH, B-HCH (lindane) heptachlor epoxide and dieldrin

Group	x-HCH	B-HCH	y-HCH	Heptachorepoxide	Dieldrin
I & II	0,03	0,84	0,04	0,01	0,05
	(0,00–0,16)	(0,00–2,63)	(0,00–0,49)	(0,00–0.07)	(0,00–0,82)
	23/40	40/40	25/40	5/40	26/40
I	0,04	1,23	0,05	0,00	0,04
	(0,00–0,16)	0,34–2,58)	(0,00–0,49)	–	(0,00–0,24)
	10/14	14/14	8/14	0/14	7/14
II	0,02	0,62	0,03	0,01	0,06
	(0,00–0,08)	(0,00–2,63)	(0,00–0,26)	(0,00–0,07)	(0,00–0,82)
	12/26	25/26	16/26	5/26	18/26

Table 4 shows that Zimbabwe has one of the highest DDT/DDE ratios compared to all the other countries. More than two times higher mean sum DDT levels and 2,6 times higher mean DDT/DDE ratio were found in samples from Group II. However, the differences were not statistically significant. Some traces of polychlorinated biphenyls (PCBs) were found in 15 out of the 40 samples. The isomer identified in all 15 samples was 2,2,4,5, 5′, pentachlorobiphenyl (PCB 101).

The relatively high levels of sum DDT and high DDT/DDE ratio together with the presence of the metabolites p,p′-DDT found in the study analysed (Hodges and Lehamann, 1970) reflect a continuing use of DDT as an insecticide in agriculture and malaria-control programme in Zimbabwe.

The results of this pilot study suggest that there is a possibility of sustained exposure to DDT in the Greater Harare area, particularly in the lower income group. Similar results have been found in Kenya (Kanja *et al.*, 1986). This has serious implications, warranting a country-wide investigation of the real situation. This would help shed light onto whether enough is known about pesticide hazard by child-bearing women where pesticides are in general use.

The very low sum DDT levels in the Norwegian study are due to the fact that use of DDT is banned in Norway (Jensen, 1987). DDT is still used in India and China, hence the high levels that have been reported (Slorach and Vaz, 1983; Warmex *et al.*, 1983; Skaare *et al.*, 1988 and Clench-Ass *et al.*, 1988). The results also show that the y-isomers were found in 58 per cent of the milk samples. The different isomers have quite different biological properties, the B-isomer being the most persistent with the highest accumulation potential (Heechen, 1980; Szokalay *et al.*, 1977). The x- and y-isomers may also isomerise into the B-isomer in living organisms (Chikuni *et al.*, 1991). The ratio between the different HCH isomer residues, therefore, may change from the start of food

Table 4: Residues of organochlorine pesticides in human milk A comparison of mean sum DDT residues (ppm, mg per kg fat weight) and DDT/DDE ratio in human milk from Zimbabwe and some other countries.

Country	Number of mothers studied	Fat (%)	Sum DDT	DDT/DDE	Reference
Zimbabwe, 1989	40	3,1	5,91	0,8	5
Kenya, 1983–85	302	3,2–5,1	1,69–18,73	0,7–5,7	10
China, 1982	100	4,4	6,71	0,4	9
India, 1983	50	4,8	6,55	0,3	9
Immigrants To Norway From Pakistan 1981–82	7	3,00	5,98	–	–
Rwanda, 1983	75	3,3	4,16	0,7	17
Nigeria, 1987	44	2,8	3,83	0,6	8
Norway, 1981–82	36	2,6	0,91	–	13
Norway, 1986	28	3,7	0,58	–	7

chains until excretion in human milk fat, resulting in the more persistent isomer being the predominant in human milk as shown in the results (Szokalay *et al.*, 1977; FAO/WHO, 1978).

The extent of aldrin and dieldrin use in Zimbabwe is probably much less than the use of DDT, since only low levels of dieldrin were found in a smaller number of samples analysed. Low levels of heptachlor epoxide were found in only five samples in the present study as compared to what has been reported from other countries (Jensen, 1987). Heptachlor, heptachlor epoxide and chlordane are closely related chlorinated insecticides. Heptachlor epoxide and oxychloradane are very persistent epoxy metabolites of heptachlor and chloradane. Traces of polychlorinated biphenyls, which are major contaminants in industrialised countries were found in some breast-milk samples.

The implications of all this to clinical paediatric toxicology is somewhat difficult to interpret. If the acceptable daily intake (ADI) for adults estimated by the FAO/WHO to be 5 kg per day for sum DDT (Atuma and Okor, 1987) is applied, the average infant body weight set at 5 kg, the mean intake of milk set at 800 g per day, and the milk assumed to contain 3 per cent w/w fat, a "tolerable" concentration of sum DDT in human milk would be 1 mg per kg.

The study by Chikuni *et al.* (1991) indicated that the intake of sum DDT is exceeded by several folds by most children. However, there is no evidence so far that this has a deleterious effect on the health of the infant. Consequently, because of the well-established advantages of breast feeding, this practice should still be encouraged. However, a country-wide and more extensive study of pesticide residues still needs to be carried out.

List of abbreviations and meanings of compounds mentioned in the text

p,p´-DDT	=	L,1,1-trichoro-2,2-bis (p-chloro-phenyl) ethane or Dichloro-diphenyl trichloroethane.
DDD	=	Dichloro-diphenyl dichloroethane
p,p´-DDE	=	1,1 Dichloro-2,2-bis diphenyl ethylene
p,p´-TDE	=	Trichloro-diphenyl ethylene
HCH	=	x-, B-, y-hexachlorocyclohexane
B-HCH	=	Beta benzene hexachloride or gamma-HCH: or
		1x, 2x, 3B, 4x, 5x, 6B - hexachlorocyclohexane
PCBs	=	Polychlorinated biphenyls
PCB 101	=	2,2,4,5,5´-pentachlorobiphenyl.
PCB 118	=	2,3´,4,4´,5-pentachlorobiphenyl

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