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Insecticide Residues in Wheat Grains and Straw Arising from their Storage in Premises Treated with BHC and DDT under Malaria Control Program

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Organochlorine insecticides, the use of which has been severely curtailed in the western countries, are still used extensively in several developing nations in agriculture as well as vector control programs. In India, current consumption of technical BHC (mixed stereoisomers of 1,2,3,4,5,6 hexachlorocyclohexane) and DDT is approximately 36 and 14 million kilograms per year, respectively. Out of this, about 16% of BHC and 85% of DDT use is for indoor spraying of rural dwellings for mosquito control at the rates of technical BHC equivalent to 0.2g γ isomer m^{-2} thrice a year or 1g DDT m^{-2} twice a year. However, the role of such intensive intradomicillary usage of these persistent compounds towards the contamination of stored food and feed is yet virtually unknown (Farvar 1979).

In India, Punjab state is the major producer and supplier of wheat in the country. Though BHC and DDT are not recommended for use on wheat crop or stored grains at any stage, monitoring studies conducted in this region have shown widespread occurrence of BHC and DDT residues in wheat grain and flour at levels generally less than 1 mg kg^{-1} (Joia et al. 1978; Kalra et al. 1986). Such levels of residues are too low to result from admixture of the insecticides with the grains to get protection against storage pests and could be arising from routes other than direct treatment. So this study was carried out to investigate the possible role of public health usage of insecticides towards the contamination of wheat grains and straw.

MATERIALS AND METHODS

Two adjoining districts of Punjab state of India viz. Sangrur which is sprayed with BHC under malaria control

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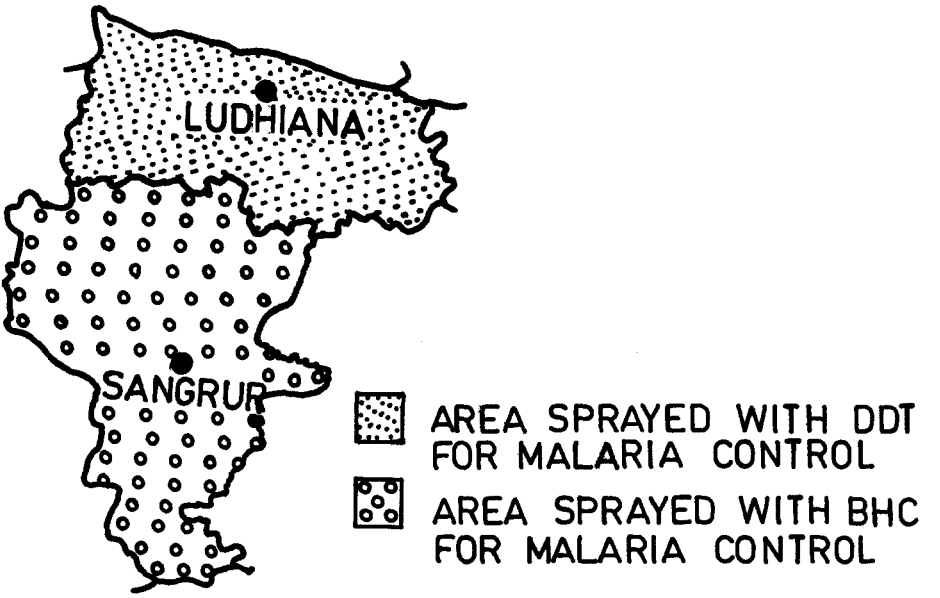

Figure 1. Location of the sampling sites.

program, and Ludhiana where DDT is used for this purpose, were chosen for this study (Figure 1). At three intervals, twenty wheat grain samples, having no history of direct insecticide use, were collected randomly from fields or houses of the villages belonging to each district (Table 1). At harvest time, samples were taken from fields while wheat crop was being harvested. During later samplings, wheat grains stored in houses for home consumption were obtained. The enquiries revealed that selected houses had been treated with insecticides under malaria control program in varying manners. While there had been complete coverage of some dwellings, others were partially or not treated with the insecticides during the sampling year. Similarly mode of storing wheat grains also ranged from stocking in metal bins to storage in gunny bags or even as uncovered heaps.

The samples were ground, extracted with acetonitrile: water (2:1, v/v), partitioned into n-hexane and cleaned up by treatment with concentrated sulphuric acid (Singh and Chawla 1982). The residues were estimated on Packard Becker GLC Model 417 fitted with tritium source electron capture detector and glass column (1m x 2mm i.d.) packed with 1.5% OV -

17+1.95% OV - 210 on Gas Chrom Q. The identities of residues were confirmed by micro-alkali derivatization (EPA 1980). The recoveries determined by fortifying low background samples with compounds of interest were greater than 80% and residue levels reported have not been corrected for recovery.

In addition 20 samples of wheat straw of crop harvested in April, 1985 were also collected from rural houses of each district during April, 1986. The residues were estimated by the method described as above for wheat grains.

RESULTS AND DISCUSSION

All the 120 samples of wheat grains collected from BHC as well as DDT sprayed districts contained residues of both these insecticides. The nature and amounts of various compounds comprising total BHC and total DDT are given in Table 1. At harvest time, wheat grains from BHC and DDT sprayed areas had similar low levels of these residues. As there had been no direct use of these chemicals in the wheat fields, this represents background contamination due to ubiquitousness of these compounds. Chalwa and Kalra (1983) have also observed that levels of 0.04 mg kg^{-1} BHC and 0.03 mg kg^{-1} DDT in wheat grains could result from environmental contamination.

At the time of second and third samplings made after 8 and 12 months of storage of wheat in rural houses, median BHC residues in grains from BHC sprayed district were 10 and 14 times higher than in the corresponding samples from DDT sprayed villages (Table 2). Similarly, median levels of DDT residues found in samples from DDT sprayed district were greater than those in samples from BHC sprayed area by factors of 2 and 16. During this time BHC levels in samples from DDT sprayed district and DDT levels in samples from BHC sprayed district remained similar to background levels observed at harvest time.

Therefore, this study reveals a relationship between intradomicillary use of BHC and DDT for malaria control and contamination of wheat grains stored in treated houses. As it has been reported that processing of wheat flour into chapatis (loaves) does not lead to lowering of BHC and DDT residue levels (Chawla et al. 1979), there is a possibility of substantial dietary intake of these insecticide residues by consumption of wheat contaminated at levels encountered in this study.

Table 1. Residues of BHC and DDT (mean±S.D., mg kg^{-1}) in wheat grain samples collected from rural areas sprayed with these insecticides for mosquito control.

Residue	April, 1985 (Harvest time)		December, 1985		April, 1986	
	BHC sprayed area	DDT sprayed area	BHC sprayed area	DDT sprayed area	BHC sprayed area	DDT sprayed area
α-BHC	0.01±0.01	0.01±0.01	3.27±8.81	0.03±0.03	1.19±4.35	0.02±0.03
β-BHC	Trace	Trace	0.51±1.38	Trace	0.25±0.84	0.01±0.02
γ-BHC	Trace	Trace	1.01±2.97	0.01±0.01	0.52±1.90	0.01±0.01
δ-BHC	Trace	Trace	0.39±1.16	Trace	0.18±0.68	Trace
TOTAL BHC :	0.01±0.01	0.01±0.01	5.18±14.31	0.04±0.04	2.14±7.77	0.04±0.05
o,p'-DDT	Trace	Trace	Trace	0.02±0.05	Trace	0.12±0.23
p,p'-DDE	Trace	Trace	Trace	0.01±0.02	Trace	0.02±0.03
p,p'-TDE	Trace	Trace	Trace	Trace	Trace	0.03±0.03
p,p'-DDT	0.02±0.02	0.02±0.01	0.04±0.05	0.10±0.18	0.01±0.01	0.31±0.45
TOTAL DDT :	0.02±0.02	0.02±0.01	0.04±0.05	0.14±0.25	0.01±0.01	0.51±0.78

Trace = less than 0.01 mg kg^{-1}

Table 2. Median and range of BHC and DDT residues (mg kg^{-1}) in wheat grain samples collected from rural areas sprayed with these insecticides for malaria control.

Date of Sampling	Total BHC		Total DDT	
	BHC sprayed area	DDT sprayed area	BHC sprayed area	DDT sprayed area
April, 1985	0.01	0.01	0.02	0.02
(Harvest Time)	0.01-0.03	Trace-0.03	Trace-0.05	0.01-0.05
December, 1985	0.21	0.02	0.03	0.07
	0.02-60.21	0.01-0.24	Trace-0.24	0.01-1.10
April, 1986	0.28	0.02	0.01	0.16
	0.11-35.06	Trace-0.19	Trace-0.01	0.06-2.40

Trace = less than 0.01 mg kg^{-1}

Table 3. Residues of BHC and DDT (mg kg^{-1}) in samples of wheat straw stored in premises treated with these insecticides for mosquito control.

Insecticide residue	BHC sprayed area		DDT sprayed area	
	Mean±S.D. (Range)	Median	Mean±S.D. (Range)	Median
α-BHC	0.11±0.22 (0.01-1.00)	0.05	0.02±0.02 (0.01-0.09)	0.01
β-BHC	0.07±0.08 (Trace-0.31)	0.06	0.01±0.01 (Trace-0.05)	Trace
γ-BHC	0.05±0.08 (0.01-0.33)	0.03	0.01±0.01 (Trace-0.04)	0.01
δ-BHC	0.01±0.02 (Trace-0.06)	0.01	0.01±0.01 (Trace-0.05)	0.01
Total BHC	0.24±0.35 (0.02±1.49)	0.13	0.05±0.04 (0.02-0.18)	0.03
o,p'-DDT	0.01±0.02 (Trace-0.08)	Trace	0.20±0.41 (ND-1.80)	0.10
p,p'-DDE	0.01±0.02 (Trace-0.07)	0.01	0.07±0.15 (ND-0.67)	0.03
p,p'-TDE	Trace (ND-0.02)	ND	0.09±0.14 (ND-0.42)	0.04
p,p'-DDT	0.04±0.04 (Trace-0.13)	0.03	0.99±1.94 (0.05-8.05)	0.26
Total DDT	0.06±0.07 (Trace-0.28)	0.03	1.35±2.58 (0.05-10.94)	0.46

ND = Not Detected (less than 0.005 mg kg^{-1}); Trace = between 0.005 and 0.009 mg kg^{-1}.

The analysis of 40 wheat straw samples also showed the presence of BHC and DDT residues in all the samples (Table 3). The straw from BHC sprayed area had about 4 times higher BHC residues (median value 0.13 mg kg^{-1}) as compared to samples from DDT sprayed area (median value 0.03 mg kg^{-1}). In contrast, DDT residues in straw from DDT sprayed area were 15 times higher than those in samples from BHC sprayed area. The mean environmental contamination levels of freshly harvested wheat straw in the region of this study have been reported to be 0.060 mg kg^{-1} BHC and 0.048 mg kg^{-1} DDT

(Chawla and Kalra 1983), which are similar to residue levels observed in this study for straw samples from areas treated with contrary insecticides for mosquito control (Table 3). Thus the higher level of residues of an insecticide in straw samples from the area where that insecticide had been used for malaria control indicates the role of public health usage of insecticides towards the contamination of wheat straw. As this commodity is used as cattle feed, insecticide residues in straw are likely to get bioconcentrated and therefore might be contributing to the high levels of BHC and DDT residues observed in milk and milk products of this region (Kalra et al 1983).

Mosquito control programs are generally evaluated in terms of malaria control and public health. As the present study reveals that BHC and DDT use in houses for vector control can lead to considerable intake of their residues via contamination of the stored wheat and straw, it seems imperative that the assessment of malaria control programs should also be made in terms of their insecticide residue implications. Moreover, there is also a need for investigations to define precisely the mechanism of contamination of food and feed stored in premises sprayed with insecticides.

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