Bull. Environ. Contam. Toxicol. (1992) 48:295-301

Environmental Contamination and Toxicology

Biological Monitoring of Chlorinated Pesticides among Exposed Workers of Mango Orchards: A Case Study in Tropical Climate

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Organochlorine, organophosphorous and carbamate compounds are widely used pesticides in India for controlling disease carrying vectors and agricultural pests. Organochlorine compounds being persistent and lipophilic in nature, accumulate in the human body through food chain and environmental exposure (Siddiqui et al., 1981; Biddinger and Gloss, 1984). Accumulation of DDT, BHC and endosulfan has been implicated in the pathogenesis of cardiovascular disorders, hypertension and other health related problems (Morgan et al., 1980; Register and US Public Health Service, 1989). Earlier, we have observed respiratory impairment (36.5%) among workers engaged in spraying of organochlorine pesticides on mango trees at Malihabad (Rastogi et al., 1989). In the present investigation, the levels of chlorinated pesticides among exposed workers have been monitored to study the distribution pattern in blood and their excretion in urine of human subjects.

MATERIALS AND METHODS

Fifty two workers engaged in spraying of pesticides in mango orchards at Malihabad, approximately 10 Kms west of Lucknow city (India), were selected for serum and urinary pesticide measurement. Their ages and exposure duration were 17-50 (mean $\pm$ SD = 33.8 ± 9.8) and 4-25 years (mean $\pm$ SD = 10.1 ± 6.5), respectively. Twenty four unexposed workers were also selected for comparison with exposed workers. Incidence of smoking in both the groups (unexposed and exposed) were not different. The exposed workers were not using any protective respirator, gloves or coveralls. The pesticide levels at working atmosphere were also determined regularly for two consecutive years.

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The extraction of pesticides of blood samples and for air samples were done by standard methods described (Agarwal et al., 1976) and (Clesceri et al., 1984). Urine samples were analyzed as per standard method with the following modification. Measured volume of urine samples ca 200 mL was extracted with 30 mL of n-hexane (GLC grade) thrice. The extract was dried over anhydrous sodium sulphate. Cleaning of the dried extract (hexane fraction) was done by liquid-liquid partition with 25 mL of acetonitrile each time thrice. Acetonitrile fractions were collected in a 250 mL separatory funnel and hexane layer discarded. 100 mL of saturated sodium sulphate was added to the acetonitrile phase and extracted with 25 mL of hexane each time thrice. Acetonitrile fraction was discarded and hexane fraction was dried over anhydrous sodium sulphate, evaporated to 1 mL using three stage Snyder condenser followed by a Kuderna Danish condenser and final volume made up to 5 mL and refrigerated immediately. Residue measurement was done in ANTEK, GLC, Model 3000 with electron capture detector using a two meter column containing 1.5% OV-17 and 1.95% OV-210 in chrome WHP. Gas chromatographic condition used were N carrier gas, 60 psi; injector temperature, 250 C; detector temperature 250 C, column temperature 190 C; and running time 45 minutes. Pesticide residue standards were more than 99% pure. Recoveries of residue undergoing the analytical regime were greater than 90 per cent and relible sensitivity of detection was 1 ppb for pp'DDE and α-BHC and 2 ppb for β-BHC, Lindane, Aldrine, Endosulfan, op'DDT and pp'DDT. Data obtained for various pesticides in this investigation were corrected accordingly. All samples were run in duplicate. Levels of all compounds were well above the detection limits.

RESULTS AND DISCUSSION

Mean and range values of chlorinated pesticide in air samples collected during the last two years have been shown in Table 1. Total DDT, total BHC, endosulfan and aldrin levels ranged between 0.076-528.3, 14.0-2897.0, N.D.-216.2 and 1.0-240.4 ng/m^3 respectively which were significantly higher ($p < 0.05$) than the ambient air sample. Furthermore, the DDT level in the atmosphere of Malihabad is higher than the value reported for Gulf of Mexico (Bidleman et al., 1981) and Mississippi delta (Arthur et al., 1977) in between 0.034-33.0 and 7.5 ng/m^3 respectively, whereas total BHC level as reported by Baumann et al., (1980) at work place of pesticide industry ranged between 0.007 and 2.52 mg/m^3

The levels of different pesticides in the sera of exposed workers were significantly high ($p < 0.05$) in

Table 1. Chlorinated pesticides level in air samples at Malihabad (No. of samples = 45)

Pesticide	Mean (ng/m^3)	Range (ng/m^3)	±SD (ng/m^3)
α-BHC	163.0	10.01-780.0	256.8
γ-BHC	282.7	11.0-1583.8	540.0
β-BHC	67.2	2.33-595.8	123.6
Total BHC	511.8	14.0-2897.0	806.3
Aldrin	27.10	1.0-240.4	37.1
Endosulfan	7.74	ND-216.2	33.2
pp'DDE	12.95	ND-58.7	40.4
pp'DDD	0.53	ND-6.9	1.23
pp'DDT	0.001	ND-0.035	0.005
op'DDT	22.65	ND-528.3	96.57
Total DDT	31.16	0.076-528.3	99.95

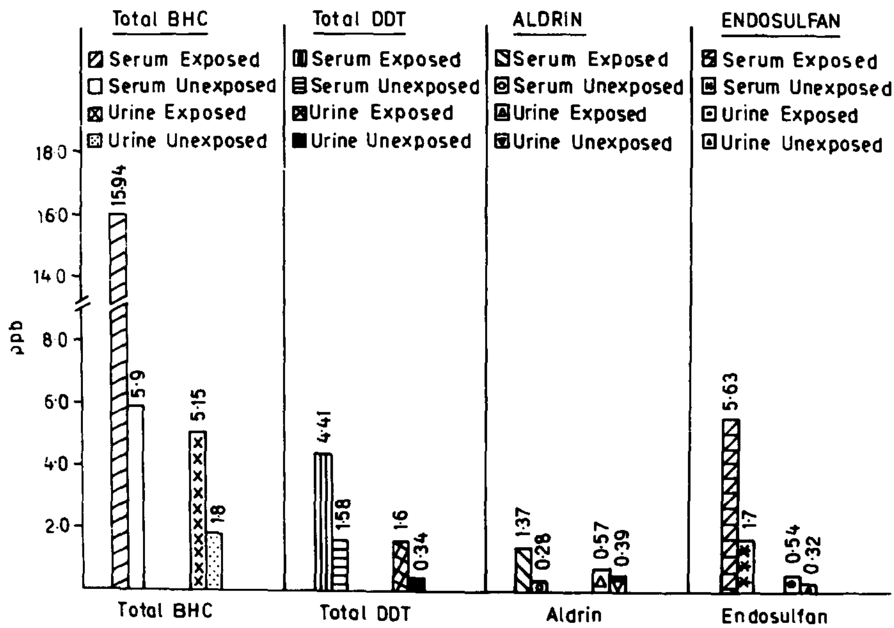

Figure 1. Showing the average values of organochlorine pesticides serum and urine of subjects.

comparison to that found in unexposed workers (Table 2 and Figure 1). Total sera BHC level as reported by Mossing et al., (1985) among the persons from Texas ranged between 0-16.5 ng/mL with a mean value of 2.5 ng/mL. Two other studies on total sera DDT level were to vary from 7.2 ng/mL found in Netherland workers to 20.2 ng/mL reported from workers in India (Siddiqui et al., 1981). The level of most of the pesticides in sera of exposed workers was found to be higher than

Table 2. Pesticides levels (ppb) in sera of exposed and unexposed workers

	Exposed Workers		Unexposed Workers	
Parameters	Mean	Range	Mean	Range
α-BHC	6.1217	0.00-18.8678	2.1591	0.112-6.9231
γ-BHC	2.1272	0.041-8.558	0.7600	0.00-1.9890
β-BHC	7.7806	0.00-37.512	3.0062	0.721-8.055
Total BHC	15.9374	2.6818-49.4834	5.9448	1.3799-14.169
Aldrin	1.3708	0.00-6.2345	0.2800	0.00-1.800
Endosulfan	5.6383	0.00-26.6635	1.7029	0.00-6.666
pp'DDE	3.7136	0.00-15.9155	1.4364	0.00-5.6805
pp'DDD	0.5827	0.00-6.695	0.2810	0.00-2.1005
pp'DDT	ND	ND	ND	ND
op'DDT	0.2712	0.00-4.850	ND	ND
Total DDT	4.4106	0.00-21.1341	1.5877	0.00-8.7805

those reported in the literature and the control values. Although the use of DDT has now been restricted, people are still using it probably because it is economical. May be for this reason higher levels of DDT in sera of exposed workers have been detected. The different pesticide levels in the serum of exposed workers at Malihabad was found in the order of BHC (10.94 ng/mL) < endosulfan (5.64 ng/mL) < DDT (4.4 ng/mL) < aldrin (1.37 ng/mL) (Table 2). Such high levels of BHC, are possibly because of extensive use of BHC on mango trees. Among the isomers of BHC (α,β, and γ), β-isomer was found more than α and γ-isomer possibly because of the higher stability of this isomer in comparison to α and γ. Bauman et al. (1980) showed that the air concentration of BHC (0.007-2.52 mg/m^3) was associated with the concurrent blood serum level in workers of 2.1 ug/L. Besides DDT, DDE one of its major metabolite was detected in appreciable amount (0.0-15.9 ug/L) in sera of the exposed workers of Malihabad. This observation is in agreement with other studies (Waston et al., 1970; Burns, 1974.; Register and US Public Health Service, 1989) and support the possible pathway of biotransformation of DDT in human body.

One of the major route of excretion of chlorinated pesticides is through feces (Gold and Brunk, 1982, 1983 & 1984; Fawcett et al., 1987). However, we have not analysed the pesticide level in feces. In this study we have found considerable amount of chlorinated pesticides in the urine (Table 3 and Figure 1), thereby suggesting other route of excreation could be through urine which is in agreement with other studies (Register and US Public Health Service, 1989).

Table 3. Pesticides levels (ppb) in urine of exposed and unexposed workers

Parameters	Exposed Workers		Unexposed Workers	
	Mean	Range	Mean	Range
α-BHC	0.8347	0.022-6.4728	0.1152	0.006-0.395
γ-BHC	0.9721	0.0015-9.410	0.6798	0.003-2.3895
β-BHC	3.3475	0.00-52.8757	1.0126	0.003-4.525
Total BHC	5.1544	0.001-59.7847	1.8078	0.0367-5.2191
Aldrin	0.5733	0.00-4.589	0.3921	0.00-1.095
Endosulfan	0.5441	0.00-2.8590	0.3276	0.00-2.005
pp'DDE	0.9730	0.00-12.2218	0.1894	0.00-1.008
pp'DDD	0.0597	0.00-0.3849	ND	ND
pp'DDT	0.5304	0.00-13.4796	ND	ND
op'DDT	0.1095	0.00-1.005	0.1593	0.00-0.9852
Total DDT	0.1095	0.00-13.5180	0.3488	0.00-1.084

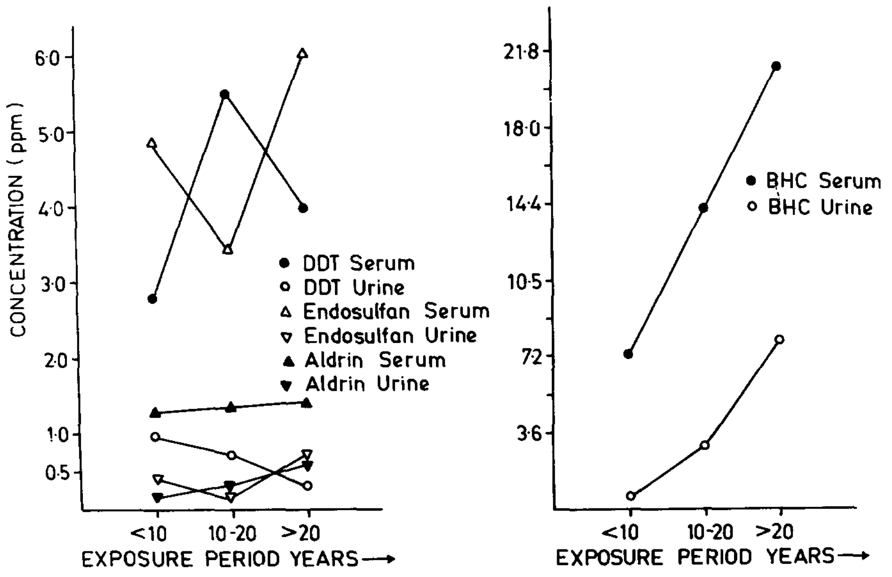

Figure 2. Variation of chlorinated pesticides in serum and urine with respect to exposure period.

Total BHC level in the urine of exposed worker was significantly higher ($p < 0.05$) than the unexposed workers. Similarly, total mean DDT level in exposed worker was 1.63 ng/mL which in comparison to unexposed workers was high (0.35 ng/mL). The excretion of aldrin and endosulfan through urine was more or less similar to unexposed values (Figure 1). Rate of excretion of these pesticide, increasd with the increase of exposure of pesticides. Metabolites composition of chlorinated pesticides in urine and sera of exposed workers suggest the possible metabolic pathway of chlorinated pesticides in human.

Total BHC level in sera of exposed workers showed a gradual increasing trend with exposure period. Furthermore, the rate of accumulation of DDT in workers, exposed for twenty or more years, was found equal to the rate of elimination of DDT through urine; whereas workers exposed for less than 20 years (0-20 group) showed higher accumulation of DDT in sera of exposed workers (Figure 2). Therefore, the present study indicates that the body has a capacity to accommodate pesticide, beyond which it tries to remove through major route of excretion mechanisms like urine (Register and U.S. Public Health Services, 1989). Thus, the findings indicate that low excretion of pesticides occur through the urine in comparison to high accumulation in the serum of the exposed subjects which may, possibly, be the reason for health related problems (Rastogi et al., 1989).

Acknowledgments. The authors are grateful to Dr. P.K. Ray, Director of our centre for his valuable guidance and support in the study. Thanks are due to Mr. G.S. Tandon for technical assistance and Mr. Umesh Prasad for computer assistance.

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Received September 3, 1991; accepted September 28, 1991.