Bull. Environ. Contam. Toxicol. (1992) 48:302–307

Environmental Contamination and Toxicology

Levels of Organochlorine Insecticides in Human Blood from Ahmedabad (Rural), India

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Assessment of human exposure to persistent organochlorine insecticides (OCI) through biological monitoring offers a profound criteria to evaluate the magnitude of potential health risk, if any, due to use of these chemicals. Residues of these chemicals especially DDT and HCH have been identified and reviewed in man and his environment from different parts of the world (Hayes 1982; Jensen 1983), however, by comparison very high levels of DDT and its metabolites have been reported in human body fat, blood and milk samples in India (Kaphalia and Seth 1983; Ramachandran et al. 1984; Zaidi et al. 1989). Since there is a definite relationship between the amount of DDT and its residues in blood and those present in human fat depot, blood can be easily be used for assessing the total body burden of persistent OCI in various populations (Brown and Chow 1975). In view of fragmentary reports on the levels of DDT and HCH in human blood samples from India which categorically pertain to the general population of urban areas like Delhi (Agarwal et al. 1976; Ramachandran et al. 1984) and Lucknow (Kaphalia and Seth 1983), we attempted to provide a database on residues of DDT and HCH including other cyclodiene compounds, e.g. heptachlor, heptachlor epoxide, aldrin, oxychlordane, HCB and dieldrin in blood samples collected from general population of Ahmedabad (rural) area.

MATERIALS AND METHODS

DDT and its metabolites (pp'-DDT, op'-DDT, pp'-DDE, pp'-DDD), HCH (α-HCH, β-HCH, γ-HCH), heptachlor, heptachlor epoxide, aldrin, oxychlordane, HCB and dieldrin were obtained as gift from U.S.E.P.A., Analytical Chemistry Branch, Research Triangle Park, N.C. 27711, U.S.A. All solvents of analytical grade were predistilled and checked for any pesticide contamination. Glasswares used in the study were free from residue contamination.

Blood samples (4-6 mL) from 31 male healthy subjects of Ahmedabad (rural) area during 1989-90 were collected by

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venipuncture and the serum was separated. Serum samples were stored at 4°C until analysis. These subjects aged between 18-57 yr (mean 28.38 yr), were not occupationally exposed to organochlorine insecticides. Blood serum (0.5 mL) was extracted with 6 mL hexane in round bottom tube for 2 hr on slow speed rotating machine according to the procedure as described by Dale et al. (1966). 5 mL aliquot of hexane layer was quantitatively transferred to an evaporative concentrator tube to which was affixed modified micro-snyder column. The extract was concentrated in a waterbath and the final volume was adjusted to correspond to the expected concentration of the pesticide residue.

A suitable aliquot was injected into Gas Chromatograph (GC, Perkin Elmer 8700) equipped with ^{63}Ni electron capture detector. The assay conditions were: Perkin Elmer, VIT silica capillary column containing 25 QCZ/OV 1701, length-25m, id-0.2mm; carrier gas, argon/methane (90/10) at 15 PSIG; injection port temp 220°C; detector temp 275°C; column temp 215°C; chart speed, 2 cm/min. Quantitative analysis of these chemicals were effected by comparing the peak height/area of unknown concentration to that of external standards of known concentration (Gaul 1966). The minimum detection limits for HCB, α-HCH, γ-HCH, heptachlor, aldrin, β-HCH, oxychlordane, heptachlor epoxide, pp'-DDE, dieldrin, op'-DDT, pp'-DDD and pp'-DDT according to respective retention time were 0.5, 1.25, 1.75, 2.0, 1.8, 10.0, 2.8, 3.0, 5.0, 6.8, 16.0, 8.0 and 60.0 pg/uL respectively.

RESULTS AND DISCUSSION

Standard chromatogram with major peaks of different OCI as per their retention time is shown in Figure 1. Thirtyone serum samples were analysed by GC for OCI and the results are shown in Table 1. Serum level of pp'-DDE, op'-DDT, pp'-DDD and pp'-DDT ranged from 8.642-137.263, 0-3.254, 0-3.134 and 0-27.84 µg/L with a mean of 37.25, 0.335, 1.33 and 8.828 µg/L respectively. However, the total DDT (equivalent sum of pp'-DDE, op'-DDT, pp'-DDD and pp'-DDT) content in serum samples had a mean of 47.745 µg/L in range of 10.348-164.209 µg/L. pp'-DDE was the major metabolite and it alone contributed about 78% of total DDT. All serum samples were contaminated by HCH (equivalent sum of α-HCH, γ-HCH, β-HCH) with an average of 147.935 µg/L which ranged from 34.664-231.474 µg/L. The data on total DDT and HCH is lower than earlier reports from Delhi's population (Agarwal et al. 1976; Ramachandran et al. 1984) but comparable to the data on Lucknow's population (Kaphalia and Seth 1983) and other countries (Hayes 1975). This could be explained either as a descending trend in the bio-accumulation of DDT and HCH in the body or might be a regional variation.

Thirty serum samples were contaminated by heptachlor which ranged from 0-1.936 µg/L with an average of 0.819 µg/L. Heptachlor is readily absorbed via all routes of exposure and

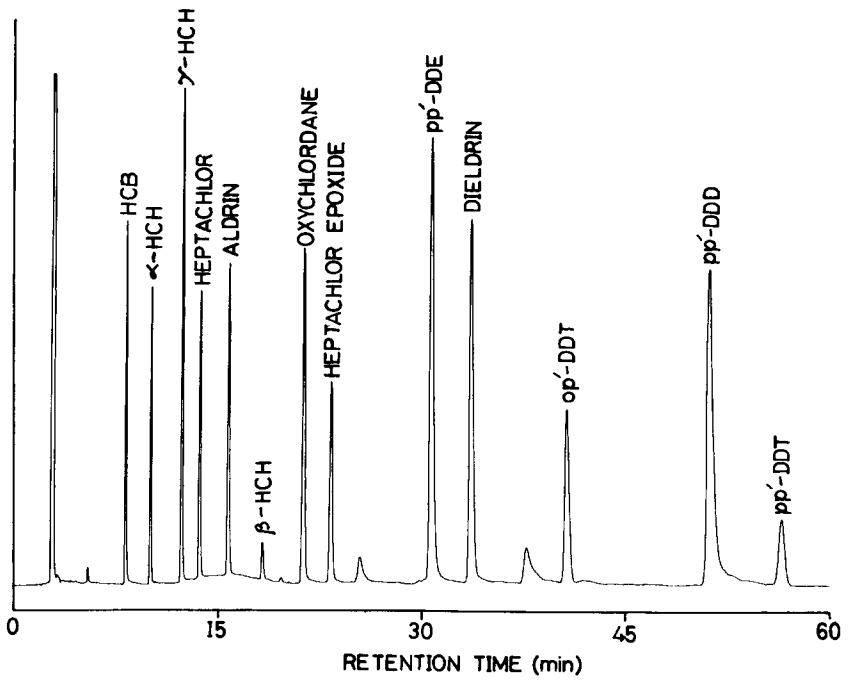

Figure 1. Standard chromatogram with major peaks of different OCI as per their retention time. Perkin Elmer VIT silica capillary column containing 25 QCZ/OV 1701, length-25 m, id-0.2 mm; carrier gas, argon/methane (90/10) at 15 PSIG; injection port temp, 220°C; detector temp, 275°C; column temp, 215°C; chart speed, 2 cm/min.

is metabolized to heptachlor epoxide by mammals (Hayes 1982). Heptachlor epoxide was not detected in these samples. Furthermore, there is limited information available on blood levels of heptachlor epoxide, but it has been confirmed that levels in blood are several orders of magnitude lower than those found in adipose tissues (WHO 1984a).

Oxychlordane was detected in all serum samples ranging from 0.672-2.52 µg/L with a mean of 1.465 µg/L. It is the common metabolite derived from both α- and γ-chlordane via the intermediate 1,2-dichlorochlordene (WHO 1984b). Occurrence of this compound in blood samples may reflect previous exposure to chlordane and/or oxychlordane. HCB was not detected in these samples.

Aldrin was identified in 16 serum samples in range of 0-0.813 µg/L having an average of 0.2 µg/L. Twentynine serum samples

Table 1. Organochlorine insecticides in human serum samples (μg/L)

Compounds	No*	Range	Median	Mean±SE
pp'-DDE	31	8.642-137.263	29.404	37.250±4.553
op'-DDT	5	0-3.254	0	0.335±0.157
pp'-DDD	30	0-3.134	1.149	1.330±0.118
pp'-DDT	27	0-27.840	6.720	8.828±1.341
Total DDT	31	10.348-164.209	38.875	47.745±5.541
HCH	31	34.664-231.474	149.366	147.935±7.898
Heptachlor	30	0-1.936	0.735	0.819±0.072
Heptachlor-epoxide	ND@			
Oxychlor-dane	31	0.672-2.520	1.406	1.465±0.088
HCB	ND@			
Aldrin	16	0-0.813	0.145	0.200±0.045
Dieldrin	29	0-3.730	2.176	2.152±0.165
Total OCI	31	58.348-321.429	206.380	200.318±10.215

* Number of positive samples; ND@ - Not detected.

showed a mean of 2.152 μg/L of dieldrin (range 0-3.73 μg/L). Aldrin is readily metabolised to dieldrin in plants and animals therefore less serum samples showed aldrin (WHO 1989). There are scanty reports on aldrin being present in human blood, placenta, adipose tissue and other tissues (Fernicola and Azevedo 1982; Mossing et al. 1985). Our findings on dieldrin level are slightly higher than other reports from U.S.A. in which mean serum concentration of dieldrin ranged from 0.5-1.46 μg/L (WHO 1989).

Remarkably the total OCI content in all serum samples showed an average of 200.318 μg/L with a range of 58.348-321.329 μg/L. Amongst these chemicals, HCH and DDT were the chief contaminants and their order of persistency was HCH DDT dieldrin oxychlordane heptachlor aldrin. The concentration in serum samples ranged from a low of 0.2 μg/L for aldrin to a high of 147.935 μg/L for HCH. In fact, we could not observe any age-dependent trend on the accumulation of these chemicals, however, the factors that may influence the storage and bio-accumulation of these chemicals are compound intensity, efficiency of absorption, species, sex, nutritional status and integrity of organs (Hayes 1982).

The mean level of each contaminant in our study is approximately equal to their respective median which implies that the data follows a normal distribution. The frequency distribution of total OCI ($\leqslant$100, 101-150, 151-200, 201-250, 251-300 and $>$300

μg/L are 2, 3, 9, 11, 5 and 1 respectively) appears to be bell shaped which also supports the normality.

The toxicological implications on the present level of these contaminants during this study could not be assessed very precisely as the sample size is small and the calculation of percentile values of each contaminant cannot be applicable for general population which requires a large sample size, however, it serves a profound standpoint of diagnostic values for epidemiological work in this area. Food chain is the main source of OCI residues in the human body. Their levels in various food commodities and dietry intake from different parts of India have well been reviewed (Dikshith, 1978; Kaphalia et al. 1985). However, the judicious use of these chemicals is warranted and preventive measures should be adopted to reduce the existing body burden.

Acknowledgments. Author's thanks to Mr.Ashok Patel and Mr.S.N. Yadav for technical assistance. Thanks are also due to Mr.P.A. Thomas for secretarial assistance.

REFERENCES

Agarwal HC, Pillai MKK, Yadav DV, Menon KB, Gupta RK (1976) Residues of DDT and its metabolites in human blood samples in Delhi, India. Bull WHO 54: 349-351

Brown JR, Chow LY (1975) Comparative study of DDT and its derivatives in human blood samples in Norfolk County and Holland Marsh, Ontario. Bull Environ Contam Toxicol 13: 483-488

Dale WE, Curley A, Cueto C Jr (1966) Hexane extractable chlorinated pesticides in human blood. Life Sci 5:47-54

Dikshith TSS (1978) DDT - The problems of residues and hazards. J Sci Ind Res 37:316-328

Fernicola NAGG, Azevedo FA (1982) Serum levels of organochlorine insecticides in humans in Sao Paulo, Brazil. Vet Hum Toxicol 24(2):91-93

Gaul JA (1966) Quantitative calculation of gas chromatographic peaks in pesticide residue analysis. J Assoc Off Agr Chem 49:389-99

Hayes WJ Jr (1975) Toxicology of pesticides. Williams & Wilkins, Baltimore

Hayes WJ Jr (1982) Pesticides studied in man. Williams & Wilkins, Baltimore

Jensen AA (1983) Chemical contaminants in human milk. Res Rev 89:1-128

Kaphalia BS, Seth TD (1983) Chlorinated pesticide residues in blood plasma and adipose tissue of normal and exposed human population. Indian J Med Res 77:245-247

Kaphalia BS, Siddiqui FS, Seth TD (1985) Contamination levels in different food items & dietry intake of organochlorine pesticide residues in India. Indian J Med Res 81:71-78

Mossing ML, Redetzke KA, Applegate HG (1985) Organochlorine pesticides in blood of persons from El Paso, Texas. J

Environ Hlth 47(6):312-313
Ramachandran M, Banerjee BD, Gulati M, Grover Anjana, Zaidi SSA, Hussain QZ (1984) DDT & HCH residues in the body fat & blood samples from some Delhi hospitals. Indian J Med Res 80:590-593
Zaidi SSA, Bhatnagar VK, Banerjee BD, Balkrishnan G, Shah MP (1989) DDT residues in human milk samples from Delhi, India. Bull Environ Contam Toxicol 42:427-430
WHO (1984a) Environmental Health Criteria 38 Heptachlor. Geneva
WHO (1984b) Environmental Health Criteria 34 Chlordane. Geneva
WHO (1989) Environmental Health Criteria 91 Aldrin and Dieldrin. Geneva

Received March 1, 1991; accepted August 15, 1991.