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Residual Levels of Plasma Oxychlordane and Trans-Nonachlor in Pest Control Operators and Some Characteristics of These Accumulations

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According to surveys and monitorings (Kawano et al. 1984; El-Dib and Badawy 1985) concerning residues of chlordane in the environment, the aquatic ecosystems coupled with the environment has been contaminated on a worldwide scale by the insecticide, as well as other persistent organochlorine compounds such as DDT and PCBs.

Chlordane, as well as other organochlorine insecticides is neurotoxic compound for the central nervous system of man, as is shown in a few case studies (Kutz et al. 1983; Olanoff et al. 1983) regarding acute intoxication of the chemical. There are still some problems remaining to be solved about chronic low-level exposure to chlordane and its potential adverse effects on human health due to the exposure. Thus, residues of chlordane in the plasma of pest control operators (PCOs) were investigated in order to study possible illness associated with the use of chlordane in Japan. The present paper deals with chlordane exposure of PCOs, plasma levels of oxychlordane and trans-nonachlor, and effects of exposure periods upon these residual levels.

MATERIALS AND METHODS

Subjects were 17 occupationl spraymen engaged in pest control, whose ages ranged from 22 to 42 years. They belonged to three firms consisting of "I", "A", and "K". The number of subjects in each firm, i.e., firm I, firm A, and firm K was eight, six, and three persons, respectively. Their exposure periods to chlordane were less than 10 years except for five persons. Technical chlordane was diluted before use to 1% concentration in kerosene and/or 2% suspension in water, and applied with a power sprayer. The PCOs were protected from intake of the termiticide during spraying with rubber gloves for hands, clothes for head, neck, and face, goggles for eyes and respirator. The blood sample (ca. 10 ml) from each subject in the firms was collected during a period of January to March in 1985.

The procedure of Oki et al. (1982) was used to extract chlordane and related compounds from plasma. The Florisil column clean-up technique was modified to perform the time-consuming process of elution rapidly and precisely as follows; Short and narrow glass column (30 cm ×10 mm i.d. with 100 ml reservoir) was prepared and 5 g of Florisil, which was activated by heating at ca. 130° C overnight and cooled in a desiccator before use was poured little by little into the column containing ca. 10 cm n-hexane and followed by the addition of 2 g sodium sulfate. At first, pp'-DDE, trans-nonachlor and PCBs were eluted with 50 ml of hexane. Oxychlordane, heptachlor epoxide, β-BHC and dieldrin were fractionated by the next elution with 25 ml of 25% diethylether in hexane. Each fraction was concentrated to one or two ml by a K-D concentrator. Five to 10 μl aliquots of the concentrated solutions were analyzed using a Hitachi 063 gas chromatograph with ECD (^{63}Ni). Analytical glass column (2 m × 3 mm i.d.) was packed with 2% OV-17 and/or 2% DEGS + 0.5% H_3PO_4 on Chromosorb W (80/100 mesh).

RESULTS AND DISCUSSION

Oxychlordane and trans-nonachlor were selected as indicators of chlordane exposure in PCOs, since these two compounds were detected in their plasma as major chlordane related compounds. Figure 1 indicates the effect of exposure periods of time on total chlordane (trans-nonachlor plus oxychlordane) residues in the plasma of the spraymen. As for seven workers belonging to I firm, a statistically significant relationship at $p < 0.05$ is observed between the total chlordane residues and their periods of time engaged in the work, although the exposure periods give no effect on the residual values of five and/or three workers belonging to A and/or K firm, respectively. The annual amount of the termiticide employed by each firm was uncertain. However, it is estimated that these results may be due to smaller amount of the chemical applied by the PCOs in firm A, K and their shorter exposure time during a certain period of time as compared with the workers in firm I. Similarly, the relation between trans-nonachlor residues and exposure periods about the same subjects of I firm is also statistically significant at $p < 0.01$. In this case, correlation is more close than the case of total chlordane residue ($r = 0.881$). With regard to oxychlordane residues, however, the relation between these two factors is not significant ($r = 0.341$).

The subjects were tentatively divided into two groups by their exposure period, i.e., one group consisted of six workers engaged in pest control for less than three years, and another of 11 workers for more than five years. Oxychlordane level, i.e., mean ± SD in the short

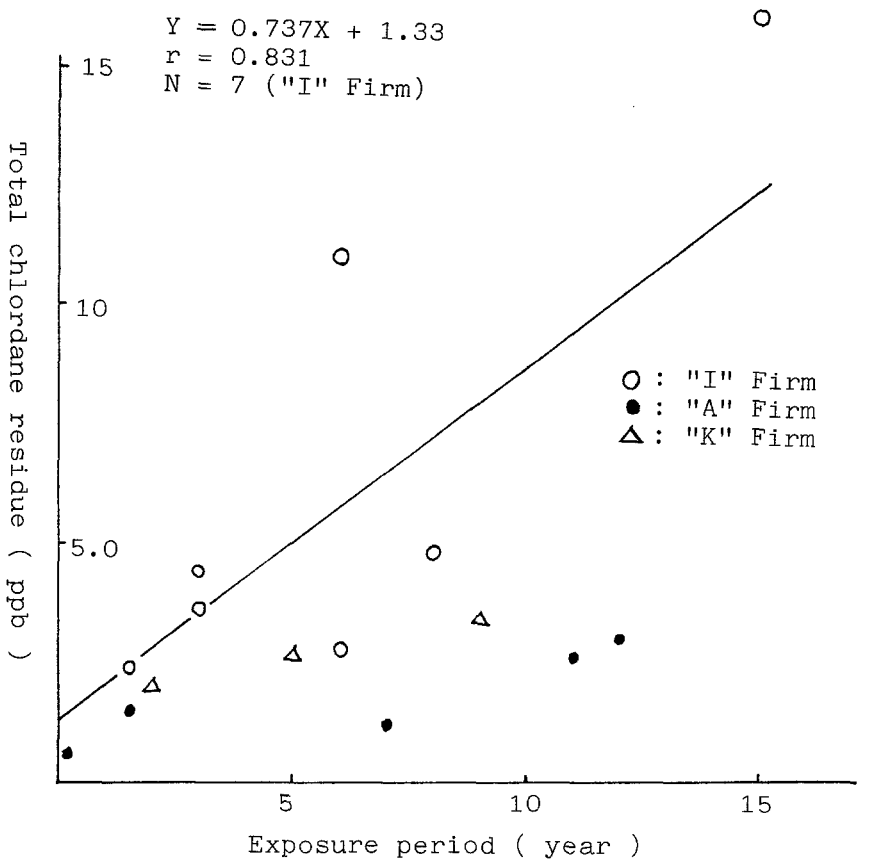

Figure 1. Relationship between total chlordane residue and exposure period

Table 1. Effects of exposure period on the levels of trans-nonachlor and oxychlordane

Exposure period	N	Residue in plasma(ppb, mean ± SD)	
		trans-Nonachlor	Oxychlordane
Less than 3 years	6*	0.98 ± 0.65	1.4 ± 0.98
More than 5 years	11**	3.7 ± 3.6	1.4 ± 0.99

* : Not significant (trans-nonachlor vs oxychlordane)
**: $p < 0.01$

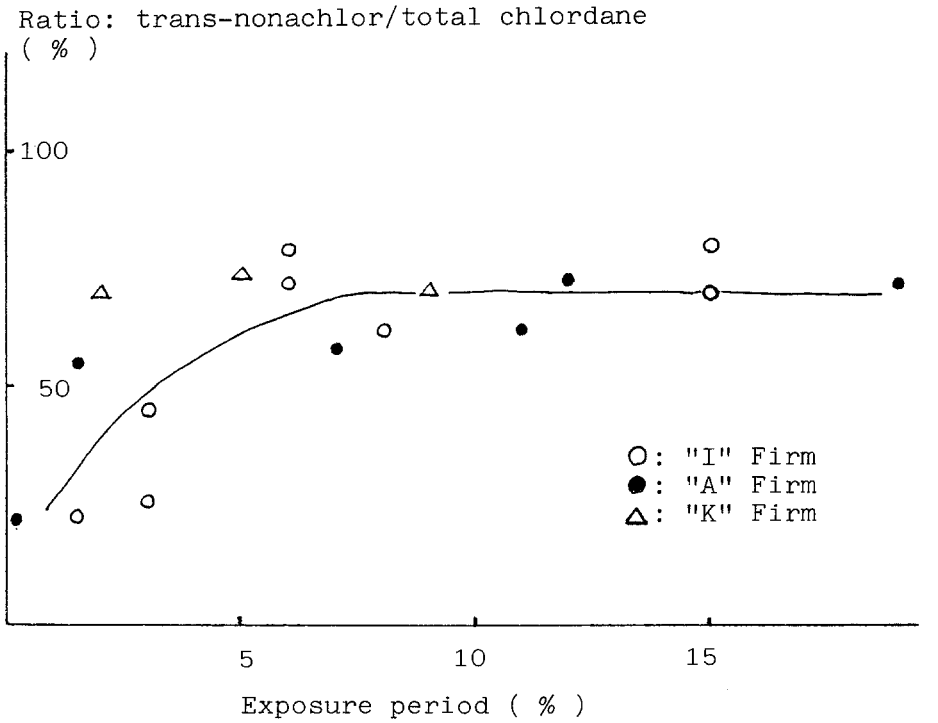

Figure 2. Time course of residue ratio of trans-nonachlor per total chlordane

period group was 1.4 ± 0.98 ppb, and this level agrees with that in the long period group, as is shown in Table 1. On the contrary, mean value of trans-nonachlor in the long period group was 3.7 ppb and this level is about four times higher than that in the short period group. With respect to the workers in the long period group, the association between values of oxychlordane and trans-nonachlor is statistically significant at p 0.01 ($r = 0.922$), although that in the other group is not significant ($r = 0.410$). This suggests that oxychlordane accumulates in humans in the same manner as trans-nonachlor.

Figure 2 shows fluctuations and time course of residual ratio of trans-nonachlor per total chlordane being accompanied with their exposure periods. The ratio steadily increased with the period of time and its curve reached a plateau, which level ranged from 60 to 80 per cent. Thus, trans-nonachlor occupied a large part of total chlordane residue about the PCOs in the long period group.

Investigation concerning the protective apparel of the PCOs suggests that they were exposed to the airbone

chemical primarily by a route of inhalation because of their dermal intakes of the chemical being almost completely protected. In addition, Kawano and Tatsukawa (1982) who performed similar study concerning chlordane residues of PCOs, indicated that the amount of their absorbed chemical resulting from exposure might be markedly influenced by the use of a respirator and its function. In this case, the constituent of the toxicant absorbed into the body is considered almost the same as that in technical chlordane.

Trans-nonachlor is relatively minor constituent in technical chlordane, i.e., its weight ratio is less than 10 % (Sovocool et al. 1977). On the other hand, major compounds in the insecticide are cis and trans-chlordane. Sum of both isomers occupy about one half of the chemical agent. These two compounds are estimated to be likewise easily metabolized to oxychlordane in humans from the experiment in vitro about human liver tissue (Tashiro and Matsumura 1978). In fact, both isomers were not detected in the plasma of the PCOs at the detectable level of ca. 0.2 ppb.

According to Wariishi et al. (1986), residual level of oxychlordane in the blood of the general population was higher than that of trans-nonachlor and, those of cis and trans-chlordane were comparable to trans-nonachlor level. Meanwhile, in the case of human milk, residual level of trans-nonachlor was highest among the chlordane related compounds detected, and those of cis and trans-chlordane were scarcely in the range of the detection limit (Miyazaki et al. 1985). It is estimated that these results may be due to relatively high affinity of cis and trans-chlordane for blood corpuscle.

Based on these data and estimation, it is suggested that these chlordane related two compounds accumulate similarly in the human body and that trans-nonachlor contained in technical chlordane does far more than oxychlordane, which is synthesized in vivo. Consequently, biological half life of trans-nonachlor will be far longer than that of oxychlordane.

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