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Human Pollution by Chlordane and Life of Subjects

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Chlordane (USEPA 1988) had been used as a termiticide for more than twenty years until September 1986 in Japan. The characteristic features of chlordane are that it is stable in an environment such as sediment (Oloffs et al. 1978, Hirai and Tomokuni 1989, Smith et al. 1992) and that its bioaccumulation in some species of bacteria, invertebrate, and fish is large (WHO 1984). According to the evaluation by IARC, chlordane is possibly carcinogenic to humans (Group 2B) (1991).

Although the use of chlordane was prohibited in Japan, trace levels of chlordane are still detected on human skin and in human blood (Sasaki et al. 1991a,b, Hirai and Tomokuni 1993a). The level was higher in the subjects living in houses treated with a termiticide before September 1986. However trace levels of nonachlor, a major component of technical chlordane (Sovocool et al. 1977, Miyazaki et al. 1985), were also detected in the blood of almost all other subjects. The concentrations of some subjects were as high as the level of the subjects living in treated houses (Hirai and Tomokuni 1993b). Wide range in concentrations of blood nonachlor was one of common aspects of the pollution by chlordane of both of the subjects living in treated houses and of those living in non-treated houses. In this paper, we report the levels of chlordane, oxychlordane, and nonachlor on skin and in blood, and the results of the subjects' answers to questions about their life related to the compounds investigated as well as related to everyday life.

MATERIALS AND METHODS

The subjects were outpatients at Saga Medical School Hospital from May to September 1992. The purpose of the study and the procedures were explained to each subject, and informed concent was obtained to wipe skin surface of antebrachium and/or to use for analyzing the rest of blood utilized for hematological examination. We asked each subject about job (Saito et al. 1986), termiticide treatment (Wariishi and Nishiyama 1989), and habit of fish and shellfish intake (Wariishi et al. 1986) in relation to the compounds investigated. We also asked them about their efforts on general

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Table 1. Survey questions

In relation to the compounds investigated:	
Have you ever been engaged in a termiticide treatment before September 1986?	A
In case of yes, how long had you been engaged in it?	
Had your house been treated with a termiticide before September 1986?	B
In case of yes, when had it been treated?	
Are fish and shellfish your favorite foods and do you eat them almost everyday?	C
In relation to everyday life:	
Do you feel a sense of fulfillment in your life?	D
Do you give attention to ventilation, lighting, temperature, and humidity at your home?	E
Do you bear in mind to wear comfortable, safe, and clean clothes?	F
Do you bear in mind to have a meal regularly considering quality and quantity of it?	G
Are excretions such as urination and defecation smooth?	H
Do you keep yourself clean by taking a bath or in any other way?	I
Do you have a restful sleep?	J
Do you have a habit of physical exercise or sports?	K
Do you have a habit of smoking?	L
Do you have a habit of drinking?	M
Do you form any habit for health?	N
In case of yes, what kind of habit do you form?	

principles of health and sanitation to everyday life. Questions are summarized in Table 1. Chi-square test was used for statistical analysis of the answers.

The methods of sampling and pretreatment procedures for chemical analysis (Mitsutake et al. 1983, Saito et al. 1985, Hirai and Tomokuni 1987) were the same as those described in a previous paper (Hirai and Tomokuni 1993a). GC-MS were used to determine total amount of *cis*-chlordane and *trans*-chlordane($C_{10}H_6Cl_8$), oxychlordane ($C_{10}H_4Cl_8O$), and total amount of *cis*-nonachlor and *trans*-nonachlor ($C_{10}H_5Cl_9$). Blood data were adjusted by mean recoveries. Skin data were described as the amounts detected on 25 cm^2 of skin surface. Recoveries, coefficients of variation, and detection limits were described in a preceding paper (Hirai and Tomokuni 1993b).

RESULTS AND DISCUSSION

Positive answers were fewer for questions A, B, C, K, L, M, and N, and negative answers were fewer for questions D, E, F, G, H, I, and J in Table 1. There were no subjects who had been engaged in treating termiticide before September 1986 (question A in Table 1). We have already reported the levels of chlordane, oxychlordane, and nonachlor on skin and in blood of the subjects in a preceding paper (Hirai and Tomokuni 1993b). Table 2 shows the levels and classified total percentages of the subjects' answers to questions in Table 1. The percentages were summarized for six groups, i.e., (1) total, (2) treatment no, (3) treatment yes, (4) skin chlordane

Table 2. Levels of chlordane, oxychlordane, and nonachlor on skin and in blood and classified total percentages of subjects' answers to questions in Table 1

Group Level(ng/g)	n	Classified total percentages (%) B yes	C yes	D no	E no	F no	G no	H no	I no	J no	K yes	L yes	M yes	N yes
(1) Total nonachlor	186	29	25	18	12	3	30	25	1	24	30	34	29	35
≦0.11	25	12	28	28	20	4	52*	32	0	24	44	28	16	32
0.11<<0.57	120	26	20	15	12	2	31	23	1	25	31	35	33	37
0.57≦ oxychlordane	21	71**	33	10	14	0	19	10	0	19	10*	38	24	29
0.08≦ chlordane	56	45*	27	11	16	0	27	18	2	27	20	39	38	34
0.04≦	25	64**	20	12	16	0	16	12	0	20	32	28	20	48
(2) Treatment no nonachlor														
≦0.10	14	0*	21	29	29	7	50	29	0	21	43	21	14	29
0.10<<0.44	75	0**	20	21	11	3	35	27	1	25	36	39	28	37
0.44≦ oxychlordane	16	0**	31	6	19	0	25	13	0	13	31	44	44	25
0.08≦ chlordane	29	0**	31	10	14	0	28	21	3*	21	17	45	38	21
0.04≦	8	0	13	25	13	0	13	25	0	38	38	25	13	38
(3) Treatment yes nonachlor														
≦0.19	7	100**	14	14	0	0	71	14	0	29	14	29	57	0
0.19<<0.92	30	100**	23	13	17	0	23	23	0	27	27	37	30	43
0.92≦ oxychlordane	10	100**	30	0	20	0	20	10	0	10	10	20	30	40
0.08≦ chlordane	25	100**	20	12	20	0	28	16	0	32	20	36	36	48
0.04≦	16	100**	25	6	19	0	19	6	0	13	31	31	25	56
(4) Skin chlordane not detected nonachlor														
≦0.09	8	0	38	13	13	13	50	25	0	25	50	25	13	38
0.09<<0.39	41	7**	20	17	15	2	39	22	0	20	29	34	24	32
0.39≦ oxychlordane	11	9	36	18	9	0	27	18	0	18	36	55	55	27
0.08≦ chlordane	14	7*	43	14	7	0	29	21	0	14	14	71**	50	7*
0.04≦	3	0	0	33	33	0	0	33	0	33	67	33	33	33
(5) Skin chlordane 0.04≦<0.10 ng/25 cm^2 nonachlor														
≦0.12	5	0	20	40	0	0	40	40	0	20	80*	20	20	40
0.12<<0.49	28	11*	14	14	18	4	25	25	0	36	39	46	32	43
0.49≦ oxychlordane	4	0	50	25	0	0	25	25	0	25	0	25	25	25
0.08≦ chlordane	11	9	18	9	18	0	18	18	0	45	27	36	45	45
0.04≦	2	0	50	50	0	0	0	50	0	100*	0	50	0	0
(6) Skin chlordane 0.10 ng/25 cm^2 ≦ nonachlor														
≦0.15	8	38	25	13	13	0	38	25	0	0	25	38	13	25
0.15<<0.81	44	57**	20	16	11	0	27	23	2	25	23	27	36	39
0.81≦ oxychlordane	11	100**	36	0	18	0	18	9	0	9	9	27	27	36
0.08≦ chlordane	29	76**	24	10	21	0	28	17	3*	24	21	28	31	45
0.04≦	20	80**	20	5	15	0	20	5*	0	10	30	25	20	55

*, $p<0.05$; **, $p<0.01$

level of not detected, (5) skin chlordane level of between 0.04 and 0.10 ng/25 cm^2, and (6) skin chlordane level of higher than 0.10 ng/25 cm^2. For each group, the percentages were listed for five subgroups based on blood levels, i.e., nonachlor level of less than geometric mean (g.m.) minus geometric standard deviation (g.SD), nonachlor level of between g.m. minus g.SD and g.m. plus g.SD, nonachlor level of higher than g.m. plus g.SD, oxychlordane detected (0.08 ng/g≦),and chlordane detected (0.04 ng/g≦). Chi-square test was applied to investigate the significance of difference between each percentage and the percentage of total subjects. Observed numbers of answers and expected numbers of answers from the percentage of total subjects were used for the calculation of the values of χ^2.

The percentages of the subjects of treatment yes (positive answer to question B in Table 1) were significantly higher in the subgroups of higher level of blood nonachlor in groups (1) and (6). Significantly higher percentages were also observed in the subgroups of chlordane detected and oxychlordane detected. These facts indicate direct exposure to chlordane by the termiticide treatment (Noguchi 1985, Jitsunari et al. 1987, Wariishi and Nishiyama 1989).

Higher percentages of positive answer to question C were observed in the subgroups of both lower and higher level of blood nonachlor except in group (3). Median level of blood nonachlor of the subjects was 0.33 ng/g (n=38) which was higher than the median level of total subjects (0.23 ng/g n=166).

Higher percentages of negative answer to question D were observed in the subgroups of lower level of blood nonachlor in groups (1), (2), and (3). A reversed tendency was observed in group (4).

We expected that higher percentages of negative answer to question E would be observed in the subgroups of higher level of blood nonachlor. However the tendency was slightly observed only in group (3). The negatively answered subjects in the subgroups of lower level of blood nonachlor might not give attention because their houses were built considering ventilation, lighting, temperature, and humidity, or they were built in environments where such an attention was not necessary.

There were a few subjects who answered negatively to question F. Their levels of blood nonachlor were lower.

Significantly higher percentage of negative answer to question G was observed in the subgroup of lower level of blood nonachlor in group (1). Similar tendencies were observed in all other groups. We suppose that efforts concerning the question also give chances to increase the intake of chlordane.

Higher percentages of negative answer to question H were observed in the subgroups of lower level of blood nonachlor except group(3). Significantly lower percentage was observed in the subgroup of

chlordane detected in group (6).

There was one subject who answered negatively to question I. The levels of skin chlordane, blood oxychlordane, and blood nonachlor were higher than the median levels of total subjects.

The percentages of the subjects who answered negatively to question J were not higher in the subgroups of higher level of blood nonachlor. Significantly higher percentage was observed in the subgroup of chlordane detected in group (5).

The percentage of the subjects of positive answer to question K was significantly lower in the subgroup of higher level of blood nonachlor in group (1). The percentage was significantly higher in the subgroup of lower level of blood nonachlor in group (5).

Slight increases in percentage of positive answer to question L were accompanied by increases in the level of blood nonachlor in groups (1), (2), and (4). The percentage was significantly higher in the subgroup of oxychlordane detected in group (4).

Higher percentages of positive answer to question M were observed in the subgroups of higher level of blood nonachlor in groups (2) and (4). A reversed tendency was observed in group (3). Somewhat increases in percentages were observed in the subgroups of oxychlordane detected.

One third of subjects answered that they formed habits for health. Fifty percent of them related to physical exercise or sports, and twenty percent related to give attention to their meals. No increases in percentages of positive answer to question N were observed in the subgroups of lower level of blood nonachlor. The percentage was significantly lower in the subgroup of oxychlordane detected in group (4).

We assume that indirest exposures to chlordane through food chain are dominant for subjects in groups (2) and (4), and that more direct exposures to chlordane by termiticide treatment are added for subjects in groups (3) and (6). Some differences in tendencies of changes in percentages among groups in Table 2 may be ascribed to the difference in routes and levels of exposures to chlordane.

Nonachlor is slowly metabolized to chlordane, whereas chlordane is more rapidly metabolized to oxychlordane in human (Tashiro and Matsumura 1978, Nomeir and Hajjar 1987). Consequently, levels of these compounds are in the ascending order of chlordane, oxychlordane, and nonachlor in human blood (Hirai and Tomokuni 1991a) as well as in human adipose tissues where median concentrations were 9.5, 23, 110 ng/g (n=24) for chlordane, oxychlordane, and nonachlor, respectively (Hirai and Tomokuni 1991b). However there were wide ranges in concentrations and in their ratios among the compounds in human blood. For example, concentrations of chlordane, oxychlordane, and nonachlor in the blood of two subjects were 0.32, not detected, and 0.47 ng/g, and

0.05, 0.45, and 2.50 ng/g. We assume that there were much differences in factors such as exposure, absorption, accumulation and metabolism, and excretion in individuals.

Although there was a few significant data except the data in the item of termiticide treatment (question B in Table 1), some differences in tendencies of changes in percentages among items in Table 2 may be ascribed to modification of some factors described above by each item.

Further investigations are in progress to elucidate the levels of chlordane, oxychlordane, and nonachlor in human.

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