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Human Pollution by Chlordane and Physical Condition 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).

We reported in the preceding paper 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 (Hirai and Tomokuni 1995). Inclinations of subjects' answers were evaluated by comparing the ratio of positive or negative answers of total subjects and that of subjects grouped based on termiticide treatment, skin levels, and blood levels. There were few significant data except the data in the item of termiticide treatment of subjects' houses before September 1986. We suppose that physical condition of subjects also affects the levels. 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 question about physical system related to disease.

MATERIALS AND METHODS

The subjects were outpatients at Saga Medical School Hospital from February to September 1993, and from January to August 1994. The purpose of the study and the procedures were explained to each of 245 of subjects, and informed concent was obtained from 222 subjects 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 physical system related to disease (Table 1). The subjects who were not clear about the physical system related to their diseases were classified into NA. The subjects who were not suffering from any disease in everyday life were

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Table 1. Survey questions

In relation to physical condition:	
Which of the physical systems is your disease mainly related to?	
Respiratory system (bronchium, lung, and so on)	A
Cardiovascular system (heart, artery, vein, and so on)	B
Gastrointestinal system (oral cavity, esophagus, stomach, liver, gallbladder, pancreas, intestine, anus, and so on)	C
Musculoskeletal system (bone, joint, muscle, and so on)	D
Kidney (production of urine, regulation of metabolism, and so on)	E
Urogenital system (urinary tract, bladder, testis, prostate, ovary, uterus, and so on)	F
Special sensory organs (eye, ear, nose, throat, and so on)	G
Skin and connective tissue (skin, fingernail, hair, and so on)	H
Immune system (defense against infection, immunoreaction, and so on)	I
Hematic system (bone marrow, spleen, red blood cell, white blood cell, blood platelet, and so on)	J
Metabolic and endocrinic system (metabolism of hydrocarbon, lipid, and protein, and regulation by hormone, and so on)	K
Nervous system (brain, spinal cord, and so on, and control by them, and so on)	L
Psychic system (relationship between mental state and physical state)	M

classified into NE. We also asked subjects about their life related to the compounds investigated as well as related to everyday life. Chi-square test with correlation for continuity 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 almost the same as described in a previous paper (Hirai and Tomokuni 1993a). LiChrolut SCX (Merck, FRG) was used in place of Adsorbex SCX 400 (Merck, FRG) on and after January 1994. GC-MS was 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 (n=4∿8) obtained every month. Mean recoveries for sixteen months were 0.59 for *cis*-chlordane, 0.43 for oxychlordane, and 0.64 for *trans*-nonachlor, respectively. Skin data were described as the amounts detected on 25 cm^2 of skin surface.

RESULTS AND DISCUSSION

Table 2 shows the levels of chlordane, oxychlordane, and nonachlor on skin and in blood and classified total percentages of subjects' answers to question in Table 1. The percentages were summarized for six groups, i.e., (1) total, (2) treatment no, (3) treatment yes, (4) skin chlordane 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

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

Group Level(ng/g)	n	Classified total percentage (%) A	B	C	D	E	F	G	H	J	K	L	M	NA	NE
(1) Total nonachlor	222	13	13	30	9	3	5	10	5	4	5	7	1	15	17
≦0.06	26	15	4	19	0	4	8	15	8	0	0	4	4	23	15
0.06<<0.60	157	13	11	29	10	2	4	11	4	4	4	7	1	16	18
0.60≦ oxychlordane	26	12	38**	35	15	4	8	4	8	4	4	8	4	8	12
0.08≦ chlordane	39	15	26*	31	5	5	8	8	3	3	3	8	3	8	21
0.04≦	23	0	30*	22	0	4	4	9	9	9	0	4	0	4	22
(2) Treatment no nonachlor															
≦0.05	16	19	0	25	0	6	13	19	6	0	0	6	6	13	13
0.05<<0.43	90	12	8	29	8	2	2	10	2	8	2	10	1	18	25
0.43≦ oxychlordane	14	7	50**	29	14	0	0	7	0	0	7	7	0	7	7
0.08≦ chlordane	15	13	27	20	7	7	0	7	0	0	7	13	7	7	27
0.04≦	10	0	30	20	0	10	10	10	10	10	0	0	0	0	20
(3) Treatment yes nonachlor															
≦0.13	4	0	0	25	0	0	0	0	0	0	0	0	0	25	50
0.13<<0.90	39	28*	15	31	21*	3	11	18	11	3	8	5	3	11	11
0.90≦ oxychlordane	5	0	40	20	0	0	0	0	20	0	0	0	0	0	40
0.08≦ chlordane	13	23	31	23	8	0	8	8	8	8	0	8	0	8	15
0.04≦	8	0	50*	13	0	0	0	0	13	13	0	13	0	0	25
(4) Skin chlordane not detected nonachlor															
≦0.04	16	13	6	19	0	6	13	19	6	0	0	6	6	25	6
0.04<<0.47	87	9	8	25	8	1	2	10	1	3	3	9	1	21	24
0.47≦ oxychlordane	14	7	36*	36	36**	0	0	21	7	0	29**	14	0	7	0
0.08≦ chlordane	10	10	10	20	10	10	0	20	0	0	10	20	10	10	30
0.04≦	7	0	14	14	0	0	14	29	0	14	0	0	0	0	29
(5) Skin chlordane 0.04≦<0.10 ng/25 cm^2 nonachlor															
≦0.10	2	0	0	0	0	0	0	0	0	0	0	0	0	0	100*
0.10<<0.58	25	28	8	32	16	0	4	16	8	12	4	0	0	12	12
0.58≦ oxychlordane	4	0	75**	50	0	0	0	0	25	0	0	0	0	0	0
0.08≦ chlordane	8	25	38	13	13	0	13	0	0	0	0	0	0	0	25
0.04≦	5	0	40	20	0	0	0	0	0	0	0	0	0	20	20
(6) Skin chlordane 0.10 ng/25 cm^2≦ nonachlor															
≦0.11	6	33	0	33	17	0	0	0	0	0	0	0	0	0	33
0.11<<0.89	43	16	14	35	5	7	12	7	7	5	0	7	2	9	12
0.89≦ oxychlordane	4	0	25	25	0	0	0	0	25	0	0	0	0	0	50
0.08≦ chlordane	18	17	22	39	0	6	11	6	6	6	0	6	0	11	17
0.04≦	9	0	22	33	0	11	0	0	22	11	0	11	0	0	22

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

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≦). Fifteen subjects who lived in houses treated with a termiticide after September 1986 and five subjects who had lived in houses treated with a termiticide before September 1986 were not included in groups (2) and (3) of Table 2. Twenty one subjects who were not clear about the termiticide treatment of their houses were also not included in groups (2) and (3) of Table 2. Chi-square test with correlation for continuity was used to investigate the significance of difference between each percentage and the percentage of total subjects (n=222). 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_C^2.

A higher percentage of the subjects of respiratory system was observed in the subgroup of middle level of blood nonachlor in group (3). Higher percentages of the subjects of cardiovascular system were observed in the subgroups of higher level of blood nonachlor in groups (1), (2), (4), and (5). We suppose the disease of cardiovascular system may affect blood levels. Higher percentages of the subjects of musculoskeletal system were observed in the subgroup of middle level of blood nonachlor in group (3) and in the subgroup of higher level of blood nonachlor in group (4). There were no subjects of immune system. A higher percentage of the subjects of metabolic and endocrinic system was observed in the subgroup of higher level of blood nonachlor in group (4). A higher percentage of the subjects of NE was observed in the subgroup of lower level of blood nonachlor in group (5).

We assume that indirect exposures to chlordane through food chain are dominant for subjects in groups (2) and (4) (Taguchi et al. 1989), and that more direct exposures to chlordane by termiticide treatment are added for subjects in groups (3) and (6) (Asakawa et al. 1994, Konishi et al. 1990, Wariishi and Nishiyama 1989). 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.

Although there were a few significant data except the data in the item of cardiovascular system, some differences in tendencies of changes in percentages among items in Table 2 may be ascribed to modification of the factors affect blood levels, such as exposure, absorption, accumulation and metabolism, and excretion, by the disease of each physical system.

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

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