Simple Method for Determining Trace Pesticides in Air Using Extraction Disks

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A conventional method for the quantitative and simultaneous analysis of a large number of pesticides was proposed using a combination of commercial extraction disks and a quartz-fiber disk. Pesticides contained in air were collected on these disks at a flow rate of 10 l min^{-1} and extracted by acetone. The extracted solution was analyzed quantitatively with GC/MS. In order to evaluate the accuracy of this method, a recovery test was performed. Forty-five kinds of pesticides were spiked on the quartz-fiber disk at a concentration level of $0.2 \mu\text{g}$ by collecting 10 m^3 of clean air. The recovery efficiencies of almost 40 kinds of pesticides showed more than 80%, and the coefficients of variations were less than 20%. The method was applied to a practical environmental analysis of pesticides, and an appropriate result could be obtained.

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A large number of synthetic chemicals have been used as pesticides, insecticides, fungicides and herbicides in the late 20th century. It has been suspected that some pesticides, such as organochlorine insecticides, have disturbed the internal secretions of human and animals by their trace amounts. Those pesticides spread on plants were widely diffused in the environment.¹ They contaminated air, water, soils and animals. Therefore, it is important to monitor the concentrations of pesticides contained in the environment.

Since the concentrations of most kinds of pesticides contained in the environment are very small, a simultaneous and quantitative analysis of them is very difficult. Many workers have reported on sampling methods of pesticides in air using various adsorbents, such as polyurethane foam,^{2,3} polymer resins,^{4,5} activated carbon fiber filter,^{6,7} florisil and silica-gel.⁸

Recently, new commercial adsorbents have become available to collect pesticides in water^{9,10} or to collect polyaromatic hydrocarbons in air.¹¹ For example, solid-phase extraction disks comprising a Teflon fiber and silica gel coated with octadecylsilane (ODS) or styrene-divinylbenzene polymer resins are known to effectively adsorb organic substances.

In this study, solid-phase extraction disks were used as an adsorbent of 45 kinds of pesticides containing 7 organochlorine insecticides in ambient air. The efficiency for the adsorption of each pesticide in air and the stability of the adsorbates were studied.

Experimental

Materials

Two kinds of commercial extraction disks (ExD) with a diameter of 47 mm were used to collect pesticides. One was a disk comprising a Teflon fiber and silica gel bonded with octadecylsilane (C18, Octadecyl (Fast Flow), 3M Co. Ltd.). The other was a disk comprising of a Teflon fiber and styrene-divinylbenzene polymer resins (XD, SDB-XD, 3M Co. Ltd.). A

quartz fiber disk (QFF, 2500QAT-UP, Pullflex Products Co.) was also used in front of the extraction disk. The pesticides used in the experiment are listed in Table 1. These pesticides were purchased from commercial sources. Acetone (pesticide grade, Wako Pure Chemical Industries, Ltd.) and 9-bromoanthracene (analytical grade, Wako Pure Chemical Industries, Ltd.) were used without any purification.

Standard solution

An acetone solution containing $2 \mu\text{g ml}^{-1}$ each of 45 pesticides was prepared by mixing each pesticide solution. The solution is abbreviated as the mixed standard solution. An internal standard solution containing $50 \mu\text{g ml}^{-1}$ of 9-bromoanthracene was prepared by dissolving 5 mg of 9-bromoanthracene into 100 ml of acetone.

Procedure

The sampling apparatus is shown in Fig. 1. A QFF disk was attached near to the entrance of the air (1 in Fig. 1). Two stages

Fig. 1 Scheme of the sampling apparatus.

Table 1 Target compounds list

No.	Compound	MW	Q ion	I ion	PTRI	DL/ pg	No.	Compound	MW	Q ion	I ion	PTRI	DL/ pg
1	Dichlorvos (DDVP)	221	109	185	1258	8	25	Methyldymron	268	107	106	2094	10
2	Fenobucarb (BPMC)	207	121	150	1621	4	26	Isofenphos	345	213	255	2097	17
3	Pencycuron	329	125	180	1700	20	27	Captan	301	79	149	2103	60
4	α -HCH	288	181	219	1724	40	28	Tetrachlorovinphos (CVMP)	366	329	331	2153	20
5	HCB	282	284	286	1739	20	29	Butamifos	332	200	286	2178	100
6	Simazine	202	201	186	1755	40	30	Napropamide	271	72	100	2183	20
7	β -HCH	288	181	219	1776	40	31	Flutolanil	323	173	145	2183	11
8	γ -HCH	288	181	219	1788	40	32	Isoprothiolane	290	290	189	2194	100
9	Propyzamide	256	173	145	1797	6	33	DDE	316	318	246	2208	20
10	Diazinon	304	179	137	1816	40	34	Buprofezin	305	305	172	2229	40
11	Chlorothalonil (TPN)	266	266	264	1844	20	35	Trichlopyr-2-butoxyethyl ester (TBE)	357	210	212	2234	60
12	Iprobenphos (IBP)	288	204	246	1859	10	36	Isoxathion	313	177	105	2247	200
13	Terbucarb (MBPMC)	277	205	220	1909	10	37	DDD	318	235	237	2297	17
14	Tolclofos methyl	301	265	267	1924	8	38	Mepronil	269	269	119	2323	17
15	Metalaxyl	279	306	354	1958	20	39	Chlornitrofen (CNP)	319	317	319	2348	160
16	Dithiopyr	401	286	237	1958	20	40	DDT	352	235	237	2378	10
17	Fenitrothion (MEP)	277	277	260	1970	80	41	Iprodione	330	314	187	2465	600
18	Malathion	330	173	125	1988	40	42	Pyridaphenthion	340	340	188	2478	100
19	Thiobencarb	258	125	101	1991	7	43	EPN	323	157	169	2493	100
20	Dimethylvinphos	332	295	297	2009	20	44	Ethofenprox	361	163	135	2880	40
21	Fenthion (MPP)	180	278	169	2009	60	45	Silafluofen	409	286	258	2903	60
22	Chlorpyrifos	351	197	199	2011	40							
23	Fthalide	272	272	243	2049	14							
24	Pendimethalin	281	252	162	2077	17							

MW: molecular weight; Q ion: mass number of quantitation ion; I ion: mass number of identification ion; PTRI: programmed temperature retention index; DL: detection limit.

of the extraction disks, such as C18 and XD, were fixed inside of the filter holder (2 and 3 in Fig. 1). Air was passed through the disks at a flow rate of 10 l min⁻¹ for a designated time at a designated temperature. After the disks were contacted with air, each disk was followed by the extraction procedure. The trapped pesticides in the disks were extracted ultrasonically with 10 ml acetone for 15 min, and then centrifuged so as to eliminate any solid-phase impurity at 3000 rpm for 15 min. Five milliliters of the supernatant was concentrated to 1 ml in a nitrogen stream, and to the concentrate was added 20 μ l of the internal standard solution. Further, 20 μ l of an acetone solution containing 0.5% of polyethylene glycol 200 and 300, respectively, was added to the sample solution to increase the accuracy in the GC/MS analysis.¹²

Quantitative analysis

The standard solutions diluted by plain acetone showed lower values in pesticides contents than that by the acetone solution containing impurities from an air sample. Therefore, standard solutions for a calibration curve were prepared by dilution of the mixed standard solution with acetone, which had been used for the extraction of a C18 disk passing through air at a flow rate of 10 l min⁻¹ for 16 h. Prior to the preparation, the air fed to the C18 disk was confirmed to contain no pesticides. The calibration curve was made by using the standard solutions in the concentration range from 0.025 to 0.4 μ g ml⁻¹ of each pesticide. The internal-standard solution and acetone solution of polyethylene glycol 200 and 300 were added to the standard solution in the same manner as the sample solution. The concentration of pesticides in air was calculated from the calibration curve using an internal-standard method.

GC/MS analysis

A mass spectrometer, Automass (II) 15 (JEOL Ltd.), equipped with a gas chromatograph, HP-6890 (Hewlett Packard Co.), was

used for a quantitative analysis. A fused-silica column HP-5 (Hewlett Packard Co.), 30 m long, 0.32 mm i.d., 0.25 μ m film thickness, was used. The GC/MS conditions were as follows: inlet temperature, 200°C; injection volume, 1 μ l; injection mode, splitless; carrier gas flow rate, 1.5 ml min⁻¹ at constant flow mode; column temperature, programmed from 50°C (held for 1 min) to 300°C (held for 4 min) at a rate of 10°C min⁻¹; ionization current, 350 μ A; ionization voltage, 70 V; scan mode measurement, ranged from m/z 46–450 at 0.3 s scan⁻¹ speed. The quantification ions (Q ion) and identification ions (I ion) of the pesticides are listed in Table 1, together with the molecular weight (MW) and the programmed temperature retention indexes (PTRI). The detection limits (DL, ng) calculated from the sensitivity of the standard peaks ($S/N=5$) are also listed in Table 1.

Results and Discussion

Extraction efficiencies

In order to examine the extraction efficiency of pesticides from each disk of QFF, C18 and XD, the disk was added with 200 μ l of the mixed standard solution; then, the acetone contained in the standard solution was evaporated from the disk at room temperature. The pesticides adsorbed on the disk were extracted ultrasonically with acetone and followed to the quantitative analysis. The results are shown in Table 2. The extraction efficiencies of the pesticides appeared in the range from 84% to 120%, except a few pesticides, as shown in Table 2. Errors of $\pm 20\%$ are inherent in the GC/MS method. Any errors above $\pm 20\%$ may be attributed to the unreproducibility on repeated runs according to their lower sensitivities for GC/MS.

Recovery test

Recovery tests were carried out by the following

Table 2 Extraction efficiencies from QFF, C18 and XD by acetone

No.	Compound	Extraction efficiency ^a , %			No.	Compound	Extraction efficiency ^a , %		
		QFF	C18	XD			QFF	C18	XD
1	DDVP	89	87	91	24	Pendimethalin	84	114	83
2	BPMC	98	95	96	25	Methyldymron	104	106	104
3	Pencycuron	114	97	111	26	Isofenphos	87	97	86
4	α -HCH	103	96	95	27	Captan	111	109	99
5	HCB	93	86	85	28	CVMP	110	115	112
6	Simazine	108	106	113	29	Butamifos	98	105	99
7	β -HCH	114	108	105	30	Napropamide	98	96	96
8	γ -HCH	107	94	101	31	Flutolanil	120	116	116
9	Propyzamide	113	105	97	32	Isoprothiolane	91	93	95
10	Diazinon	100	91	89	33	DDE	105	97	98
11	TPN	113	124	111	34	Buprofezin	106	100	108
12	IBP	93	96	97	35	TBE	96	101	104
13	MBPMC	110	101	100	36	Isoxathion	96	106	109
14	Tolclofos methyl	103	100	99	37	DDD	111	107	108
15	Metalaxyl	108	109	116	38	Mepronil	109	109	119
16	Dithiopyr	106	101	109	39	CNP	89	100	106
17	MEP	85	92	99	40	DDT	105	102	101
18	Malathion	114	120	116	41	Iprodione	71	104	104
19	Thiobencarb	101	103	107	42	Pyridaphenthion	118	132	136
20	Dimethylvinphos	102	106	109	43	EPN	115	112	113
21	MPP	101	97	101	44	Ethofenprox	106	144	143
22	Chlorpyrifos	120	128	108	45	Silafluofen	106	109	113
23	Fthalide	113	120	107					

a. Average of duplicates. QFF: quartz fiber filter; C18: extraction disk C18 fast flow; XD: extraction disk SDB-XD.

procedure.^{13,14} After 200 μ l of the mixed standard solution had been added to QFF and the acetone contained in the solution had been evaporated, QFF was set at the entrance of the filter base, as shown in Fig. 1. Two C18 disks without any treatment were set in series behind QFF to check the retention ability. C18-1 and C18-2 represent the first and second C18 disks, respectively. Ten cubic meters of clean air was passed through the three disks at a flow rate of 10 l min⁻¹ at different temperatures. The contents of the pesticides on each disk were determined by a GC/MS analysis. The results are given in Table 3. Most of the pesticides remained on the QFF, or moved to C18-1; however, no pesticide was detected on C18-2 by the air feed at 20°C. The values of the total recovery for the pesticides distributed in the range from 0% to 151% at 20°C and from 0 to 128% at 32°C. Pencycuron (No.3) was observed on QFF, but not detected on both C18-1 and C18-2 at both experimental temperatures. Very small values in recovery were observed in Isofenphos (No.26), Captan (No.27) and Butamifos (No.29). Their recoveries decreased in a run at 32°C. The results suggest that Pencycuron (No.3) is strongly adsorbed on QFF and that Isofenphos (No.26), Captan (No.27) and Butamifos (No.29) are easily decomposed by air feed.

Although almost all pesticides were not detected on C18-2 at both 20°C and 32°C, only HCB (No.5) was detected on C18-2 in large quantities; further, the total recovery of HCB decreased at 32°C. This result indicates that the breakthrough volume of HCB for C18 is very small and sensitive to the temperature. A decline of the total recovery at 32°C may be attributed to the lower retention ability of HCB for C18 at higher temperature.

The total recoveries of MPP (No.21) were small at both experimental temperatures of 20°C and 32°C. Especially, the run at 32°C showed a very small value in the total recovery of MPP. This was because of the high reactivity of MPP in the air feed.

To compare the retention ability of C18 and XD disks, experiments were carried out using two different combinations

of disks: QFF+XD and QFF+C18. Ten cubic meters of the clean air was passed through the disks at 20°C. Almost all pesticides were wholly or partially shifted from QFF to XD or C18, as shown in Table 4. The recovery efficiency for various pesticides showed only small differences between the runs on QFF+XD and QFF+C18.

The run on QFF+C18 was repeated four times in order to calculate the coefficient of variations (CV%). Most of the CV% was less than 22%. Isofenphos (No.26) and Butamifos (No.29) showed extremely high values in CV%. The recoveries of these pesticides were very small due to their higher reactivities in the air feed. Subsequently, the recoveries should vary widely in every run. Their large CV% values may result from two reasons. One is an analytical error caused by a small quantity of pesticides; the other is a difference in the reactivity in the air feed during every run. Taking account of the recovery and CV%, at least 40 species of tested pesticides can be collected quantitatively by this method.

Storage stability test

The stabilities of the target pesticides on the disks were examined as follows. Two hundred microliters of the mixed standard solution were added to QFF and C18, respectively, and the solvent contained in the mixed standard solution was evaporated. These disks were stored under two conditions: (a) The disk was kept in the atmosphere (abbreviated as "open condition").

(b) The disk was sealed in a vessel without access to air (abbreviated as "closed condition").

Both disks were placed for designated times in a dark place at room temperature. The pesticides contained in each disk were extracted and analyzed in a same manner as described in the previous section. The results are shown in Figs. 2 and 3, respectively. Supposing that the pesticides exist on the disks with a stable state, their recoveries range from 80 to 120% based on a quantitative analysis, because the precision of

Table 3 Recovery test with 2 stage of C18 disks after 16 h

No.	Compound	Recovery, %							
		20°C				32°C			
		QFF	C18-1	C18-2	Total	QFF	C18-1	C18-2	Total
1	DDVP	nd	114	nd	114	nd	100	nd	100
2	BPMC	33	84	nd	117	nd	100	nd	100
3	Pencycuron	98	nd	nd	98	128	nd	nd	128
4	α -HCH	nd	120	9	130	nd	95	5	100
5	HCB	nd	89	6	95	nd	23	53	76
6	Simazine	71	26	nd	97	73	14	nd	87
7	β -HCH	nd	83	nd	83	nd	99	nd	99
8	γ -HCH	nd	77	nd	77	nd	104	nd	104
9	Propyzamide	43	64	nd	107	11	82	8	101
10	Diazinon	49	22	nd	71	67	12	nd	79
11	TPN	nd	103	nd	103	7	98	7	113
12	IBP	85	18	nd	103	94	7	nd	102
13	MBPMC	81	15	nd	96	77	17	nd	94
14	Tolclofos methyl	nd	89	nd	89	nd	91	nd	91
15	Metalaxyl	52	62	nd	113	9	87	nd	96
16	Dithiopyr	50	65	nd	115	12	84	nd	96
17	MEP	17	98	nd	115	11	100	9	120
18	Malathion	60	27	nd	87	72	12	nd	83
19	Thiobencarb	48	51	nd	99	15	78	nd	93
20	Dimethylvinphos	80	18	nd	98	69	8	nd	77
21	MPP	15	38	nd	53	6	12	7	25
22	Chlorpyrifos	8	82	nd	90	nd	85	nd	85
23	Fthalide	7	99	5	112	nd	98	nd	98
24	Pendimethalin	10	74	nd	84	8	88	19	114
25	Methyldymron	71	10	nd	81	96	nd	nd	96
26	Isofenphos	nd	nd	nd	0	nd	nd	nd	0
27	Captan	nd	9	10	19	nd	6	6	12
28	CVMP	97	19	nd	116	90	nd	nd	90
29	Butamifos	9	nd	nd	9	20	17	7	44
30	Napropamide	53	28	nd	81	37	29	nd	66
31	Flutolanil	97	8	nd	105	87	5	nd	92
32	Isoprothiolane	70	11	nd	81	76	nd	nd	76
33	DDE	nd	89	nd	89	5	87	6	98
34	Buprofezin	98	13	nd	111	85	5	nd	91
35	TBE	86	20	nd	105	87	nd	nd	87
36	Isoxathion	57	30	6	93	55	17	nd	72
37	DDD	9	89	nd	98	nd	91	nd	91
38	Mepronil	94	11	nd	105	83	nd	nd	83
39	CNP	29	89	nd	118	9	86	9	104
40	DDT	10	75	nd	85	nd	88	nd	88
41	Iprodione	151	nd	nd	151	52	nd	nd	52
42	Pyridaphenthion	88	nd	nd	88	82	7	6	95
43	EPN	45	18	nd	63	56	26	7	88
44	Ethofenprox	92	5	nd	97	70	nd	nd	70
45	Silafluofen	87	5	nd	92	72	7	nd	78

The pesticides (0.2 ng each) were spiked on the QFF disk. C18-1: first C18 disk; C18-2: second C18 disk; nd: not detected.

GC/MS is $\pm 20\%$ in this method. When QFF spiked with pesticides was stored for 24 h in the atmosphere, as shown in Fig. 2, the recoveries of 33 species ranged from 80 to 120%. A very high recovery value of Iprodione (No.41) indicates that Iprodione is stable on QFF. The recoveries of α -HCH (No.4), HCB (No.5) and Captan (No.27) were nearly equal to zero on the QFF. β -HCH (No.7), γ -HCH (No.8), TPN (No.11), MPP (No.21), Isofenphos (No.26) and Napropamide (No.30) showed lower values in recovery. As shown in Fig. 2, when QFF was stored for 7 days in the atmosphere, the recoveries of 8 species were nearly equal to zero, and those of many pesticides decreased to below 80%. On the other hand, when the C18 treated with the standard solution was stored for 24 h in the atmosphere, the recoveries of all pesticides, except for MPP (No.21), Captan (No.27) and Napropamide (No.30), distributed

within $100\pm 20\%$. Only MPP showed a small value. After the C18 was kept for 7 days in the atmosphere, the distribution of the recoveries on C18 was similar to that on QFF kept in the atmosphere.

When disks containing pesticides were sealed in vessels for 24 h and for 7 days, the recoveries of the pesticides ranged almost within $100\pm 20\%$ on both QFF and C18, as shown in Fig. 3. Therefore, these disks can be applied to practical use for a collector of pesticides in the atmosphere, and the disk should be sealed in a vessel after it had been used for collection.

All pesticides could be determined well without further purification. Furthermore, it took only 1 h to prepare the solutions for GC/MS analysis after the sampling. The collected sample could be kept at room temperature for 1 week if the disks were sealed in closed vessels. These facts show that this

Table 4 Comparison between QFF+XD and QFF+C18^a

No.	Compound	Recovery, %						
		QFF+XD (n=2)			QFF+C18 (n=4)			CV% ^c
		QFF	XD	Total	QFF	C18	Total	
1	DDVP	nd	72	72	nd	95	95	13
2	BPMC	50	63	113	64	41	105	8
3	Pencycuron	77	nd	77	110	nd	110	9
4	α-HCH	nd	104	104	nd	98	98	14
5	HCB	nd	100	100	nd	78	78	9
6	Simazine	82	23	106	94	10	104	5
7	β-HCH	nd	117	117	nd	97	97	15
8	γ-HCH	nd	112	112	nd	89	89	9
9	Propyzamide	47	53	100	68	33	101	7
10	Diazinon	63	17	80	72	14	86	14
11	TPN	nd	119	119	nd	101	101	2
12	IBP	68	20	88	92	7	99	7
13	MBPMC	82	29	110	93	10	103	4
14	Tolclofos methyl	nd	68	68 ^b	nd	89	89	1
15	Metalaxyl	63	48	111	76	27	103	8
16	Dithiopyr	66	50	116	79	29	108	8
17	MEP	38	63	100	58	57	115	7
18	Malathion	73	17	89	84	11	95	8
19	Thiobencarb	60	16	75	73	25	98	2
20	Dimethylvinphos	74	20	94	90	9	99	8
21	MPP	16	27	44 ^b	16	31	47 ^b	12
22	Chlorpyrifos	13	59	72	20	72	92	4
23	Fthalide	20	102	121	30	83	113	4
24	Pendimethalin	9	52	60 ^b	45	51	96	9
25	Methyldymron	65	11	76	88	nd	88	9
26	Isofenphos	8	nd	8 ^b	12	nd	12 ^b	54
27	Captan	nd	14	14 ^b	nd	10	10 ^b	21
28	CVMP	80	20	100	101	9	111	5
29	Butamifos	19	nd	19 ^b	31	nd	31 ^b	51
30	Napropamide	48	15	63 ^b	49	13	62 ^b	22
31	Flutolanil	76	13	89	96	nd	96	5
32	Isoprothiolane	66	5	71	74	5	78	7
33	DDE	nd	106	106	nd	94	94	5
34	Buprofezin	82	11	93	97	6	103	9
35	TBE	79	14	93	94	7	100	6
36	Isoxathion	58	16	73	77	13	89	4
37	DDD	16	95	111	25	79	104	4
38	Mepronil	79	17	96	99	5	104	5
39	CNP	37	72	109	67	47	114	9
40	DDT	12	73	85	23	68	91	5
41	Iprodione	94	21	115	101	nd	101	6
42	Pyridaphenthion	70	10	80	104	6	110	13
43	EPN	56	11	67 ^b	77	7	84	19
44	Ethofenprox	78	10	88	97	nd	97	12
45	Silafluofen	82	15	97	95	nd	95	6

a. Ten cubic meters of air was passed at a flow rate of 10 l min⁻¹ at 20°C. b. Recovery was less than 70%. c. CV% of total recovery.

method is applicable for conveniently monitoring more than 40 kinds of pesticides in the atmosphere.

Application to environmental samples

This method was used to monitor pesticides in air at a residence area. Three disks (QFF+C18-1+C18-2) fixed to the filter folder in series were used as a collector (see Fig. 1). Prior to spraying pesticides, the air in the sampling area was passed through disks with 10 l min⁻¹ for 24 h to check the field blank. Eight pesticides (DDVP, Diazinon, TPN, MEP, Malathion, Isoxathion, Iprodione and EPN) were sprayed as a diluted aqueous solution containing about 1 g of each pesticide to the plant on 12th of September, 1999, at 8 to 9 a.m. Sampling of the air was started at 7 a.m. on the day sprayed, and the disks were changed to new ones every 12 h, except the last sampling, which was for 24 h. The results are given in Table 5. Since no

pesticide was detected in C18-2, the total concentration was obtained from the sum of the pesticides on QFF and C18-1. A slight amount of DDVP and TPN was detected in the field-blank sample. The first sample, after the pesticides had been sprayed, contained a considerable amount of pesticides, except for Iprodione. Iprodione was not detected in the air, due to the higher detection limit, as shown in Table 1, and low volatility, as shown in Table 5. A drastic decrease of the pesticides in air was observed between the first and second samples. DDVP, TPN and MEP were detected mainly on C18; however, Diazinon, Malathion, Isoxathion and EPN were detected mainly on QFF. These differences in the behavior were the same as that in the recovery test. These results can be explained by the differences in the vapor pressures, as shown in Table 5. As a result, this method is applicable for a practical environment, and an appropriate result could be obtained.

Fig. 2 Storage stabilities of pesticides in the open condition. Number of pesticide is the same in Table 1. ○: QFF; ▲: C18. (a): The sample was kept for 24 h. (b): The sample was kept for 7 days.

Fig. 3 Storage stabilities of pesticides in the closed condition. Number of pesticide is the same in Table 1. ○: QFF, ▲: C18. (a): The sample was kept for 24 h. (b): The sample was kept for 7 days.

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Table 5 Atmospheric concentration of the pesticides sprayed in the residence area

Start time	9/11 9:00	9/12 7:00	9/12 19:00	9/13 7:00	9/13 19:00	9/14 7:00
End time	9/12 7:00	9/12 19:00	9/13 7:00	9/13 19:00	9/14 7:00	9/15 7:00
Sample volume (m ³)	12	6.5	6.5	6.4	6.7	12
Temperature (°C)	28.0±2.1	29.5±1.3	25.1±1.0	30.8±2.7	26.6±1.7	23.5±2.0
Humidity (%)	75±10	67±6	88±5	66±11	84±7	87±10
Compound ^a (VP ^b /mPa)	QFF + C18 ^c (QFF) ^d /ng m ⁻³					
DDVP (1600 at 20°C)	8 (nd)	3200 (3)	32 (nd)	10 (nd)	11 (nd)	3 (nd)
Diazinon (0.097 at 20°C)	nd (nd)	310 (310)	13 (11)	6 (6)	8 (6)	nd (nd)
TPN (<1300 at 40°C)	2 (nd)	43 (3)	14 (nd)	23 (nd)	17 (nd)	3 (nd)
MEP (7.2 at 20°C)	nd (nd)	270 (42)	76 (nd)	58 (11)	64 (nd)	13 (nd)
Malathion (5.3 at 30°C)	nd (nd)	260 (250)	47 (34)	36 (36)	50 (35)	9 (nd)
Isoxathion (<0.13 at 25°C)	nd (nd)	62 (58)	nd (nd)	nd (nd)	21 (13)	nd (nd)
Iprodione (0.027 at 20°C)	nd (nd)	nd (nd)	nd (nd)	nd (nd)	nd (nd)	nd (nd)
EPN (0.126 at 25°C)	nd (nd)	46 (46)	nd (nd)	nd (nd)	nd (nd)	nd (nd)

a. The pesticides listed in the table were sprayed on 12th of September at 8:00 to 9:00 a.m. b. Vapor pressure. c. Total atmospheric concentration. d. Atmospheric concentration calculated from the detected amount on QFF. nd: not detected.

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