DISTRIBUTION OF PERSISTENT ORGANIC POLLUTANTS AND POLYCYCLIC AROMATIC HYDROCARBONS IN SEDIMENT SAMPLES OF VIETNAM

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ABSTRACT

Distributions of 8 kinds of persistent organic pollutants (POPs), and 63 compounds of polycyclic aromatic hydrocarbons (PAHs) in surface sediment samples of Hanoi, Hue, and Ho Chi Minh were investigated by high resolution gas chromatography/high resolution mass spectroscopy (HRGC/HRMS). These compounds in a sediment sample of Osaka were monitored for comparison. Concentration of Σ DDTs, Σ HCHs, Σ CHLs, Σ PCBs and Σ PAHs in Vietnam were 0.19-140ng/g-dry, 0.009-0.60ng/g-dry, N.D.-9.0ng/g-dry, 0.11-110ng/g-dry and 31-6200ng/g-dry, respectively. Concentrations of these compounds in urban areas were higher than those in rural areas. Concentrations of Σ DRINs (Aldrin, Endrin, Dieldrin), Heptachlor, Heptachlor Epoxide, and HCB (hexachlorobenzene) in Vietnam were lower than those of the other compounds.

KEYWORDS

High resolution gas chromatography/high resolution mass spectroscopy, Osaka, PAHs, PCBs, POPs, Sediment sample, Vietnam,

INTRODUCTION

Stockholm convention on POPs was held on May 2001. More than 120 participated countries adopted it and decided twelve compounds as POPs that consist of the intentional compounds and the unintentional by-products produced on a industrial processes. The former are DDTs (*p,p*-DDT, etc.), HCHs (α -HCH, etc.), CHLs (*trans*-Chlordane, etc.), Toxaphene, DRINs, HCB, PCBs, and Mirex, and the latter are PCDDs and PCDFs.

Most of the counties have been taking a great interest in the problems of POPs. In Southeast Asia and South Asia, a great deal of POPs has been used since 1960s [1,2]. POPs released to the environment has been transported through the air and water to regions such as the Arctic region [3]

far from their original sources. Moreover, POPs have bioaccumulated in fatty tissues of living organisms as their physical properties of lower water solubility and/or higher fat solubility.

Many surveys on POPs in environment of Vietnam have been conducted by using gas chromatography/ electron captured detector (GC/ECD). However, the detail investigation on the components of the pollutants such as the congeners and/or isomers of PCBs had not been done yet.

Table 1 List of sediment samples of Vietnam and Osaka

Code	Sampling Site	Sampling Date	Water Content , %	Weight , g-dry	Remarks
HN1	Truc Bach Lake, Hanoi	27/July/2002	70	6.0	Wet
HN2	West Lake, Hanoi	27/July/2002	70	6.1	Wet
HU1	Lang Co Lagoon, Hue	13/January/2002	-	12.5	Dried(a)
HU2	ThuyTu Langoon, Hue	12/January/2002	-	12.5	Dried(a)
HU3	Cau Hai Lagoon, Hue	10/January/2002	-	12.5	Dried(a)
HU4	R. Huong, Hue	10-12/January/2002	-	12.5	Dried(a)
HC1	BenNghe Chanel, Ho Chi Minh	18/July/2002	53	9.5	Wet
HC2	R. Saigon, Ho Chi Minh	16/July/2002	42	11.7	Wet
HC3	ThiNghe Chanel, Ho Chi Minh	16/July/2002	52	9.6	Wet
HC4	R. Saigon, Ho Chi Minh	16-18/July/2002	-	12.5	Dried(a)
HC5	MyHung Chanel, Ho Chi Minh	16-18/July/2002	-	12.5	Dried(a)
Y1	R. Yamato, Osaka	-	62	7.7	Wet

(a):Sieved 0.12mm.

In this experiment, we reported the polluted condition of POPs, PCBs and PAHs in sediment samples of Vietnam investigated by HRGC/HRMS. The sediment sample of Osaka was investigated for comparison. The sampling locations were 2 sites in Hanoi, 5 sites in Ho Chi Minh, and 4 sites in Hue and 1 site in Osaka as shown in Table 1.

MATERIAL AND METHODS

Compounds examined

The POPs examined in the present study were DDTs (*o,p'*-, *p,p'*-DDT, *o,p'*-, *p,p'*-DDD, *o,p'*-, *p,p'*-DDE), HCHs (α -, β -, γ -, δ -HCH), CHLs (*trans*-, *cis*-Chlordane, *trans*-, *cis*-Nonachlor, Oxchlordane), DRINs (Aldrin, Endrin, Dieldrin), Heptachlor, Heptachlor Epoxide, HCB, and PCBs. Sixty-two compounds of PAHs were shown in Table 3.

Clean-up Method

The 10-20g of wet and/or dry sediment was extracted three times with 25mL acetonitrile by using ultrasonic extraction. The extracts were cleaned up with the acetonitril / n-hexane partition followed by 5% hydrous silica gel column chromatography. The first fraction eluted with a 20ml of n-hexane was treated with 5g of reduced granular copper (60-80mesh). The second fraction eluted with a 50mL of 1% acetone/n-hexane was submitted for PAHs analysis. The third fraction was eluted with a 40mL of 10% acetone/n-hexane. Each fraction was added with a 100ng of fluoranthene-d12 and submitted for POPs analysis. An 1 μ L of each concentrate was analyzed by HRGC/HRMS (HP5890/JEOL JMS700D). The detail procedure of pretreatment was described in Manual [4]

published by Ministry of the Environment, Japan.

RESULTS AND DISCUSSION

DDTs

Analytical results of DDTs were shown in Table2. Means of ΣDDTs in Hanoi, Hue, Ho Chi Minh, and Osaka were 43ng/g-dry, 1.3 ng/g-dry, 36 ng/g-dry, and 13 ng/g-dry, respectively. The concentrations of ΣDDTs in the urban area of Hanoi (HN1, HN2), Ho Chi Minh (HC1, HC3), and Osaka (Y1) (13-143ng/g-dry) were higher than those of the rural area (less than 5.5 ng/g-dry) .

HCHs

Analytical results of HCHs were shown in Table 2. Means of ΣHCHs in Hanoi, Hue, Ho Chi Minh, and Osaka were 0.54ng/g-dry, 0.13 ng/g-dry, 0.085 ng/g-dry, and 0.61 ng/g-dry, respectively. Those values were lower than those of DDTs. Iwata et al. [1] and Nhan et al. [5] had also reported that concentrations of HCHs in sediment samples of Vietnam were lower than those of DDTs. However, the HCHs concentration of air in Hue and that of water in West Lake of Hanoi was 12,000ng/m^3 [1] and 122ng/L [5], respectively. These results indicated that most of the HCHs in the environment, has not been adsorbed on the sediment, but dissolved into the river water and/or vaporized into the air because of its physical properties of volatility and water solubility.

CHLs

Analytical results of CHLs were shown in Table 2. Means of ΣCHLs in Hanoi, Hue, Ho Chi Minh, and Osaka were 0.57ng/g-dry, 0.012 ng/g-dry, 2.1 ng/g-dry, and 24 ng/g-dry, respectively. Concentrations of CHLs in HN1, HC1, HC3, and Y1 were 1.1-24ng/g-dry and those in HN2, HU1, HU2, HU3, HU4, HC2, HC4, and HC5 were N.D.-0.18ng/g-dry. The highest values was observed in Osaka, although the usage of CHLs had been prohibited since 1986 in Japan.

PCBs

Analytical results of PCBs homologues were shown in Table 3. Mean concentrations of PCBs in Hanoi, Hue, Ho Chi Minh, and Osaka were 21ng/g-dry, 0.46ng/g-dry, 33ng/g-dry, and 67ng/g-dry, respectively. Concentrations of PCBs in HN1, HN2, HC1, HC3, and Y1 were 21-110ng/g-dry and those in other locations were 0.11-7.3 ng/g-dry. Thus, concentrations of PCBs homologues in urban areas were higher than those in rural areas. The concentrations of ΣPCBs reported in Hanoi [5] and Ho Chi Mihn City [1,6] were the same level of the present study. The detail concentrations of the congeners were also shown in Table 3.

Table 2 Concentrations of POPs in sediment samples of Vietnam and Osaka

compounds＼location	HN1	HN2	HU1	HU2	HU3	HU4	HC1	HC2	HC3	HC4	HC5	Y1
p,p'-DDT	1.9	4.9	0.29	0.48	0.24	0.43	1.3	0.10	14	0.54	0.041	1.0
p,p'-DDD	15	15	0.19	0.51	0.39	0.33	15	2.9	79	1.8	0.023	5.0
p,p'-DDE	21	20	0.22	0.49	0.21	0.34	9.0	2.2	34	1.4	0.079	3.7
o,p'-DDT	1.1	1.2	0.11	0.14	0.032	0.091	0.18	0.029	1.1	0.087	0.025	0.31
o,p'-DDD	2.8	2.4	0.094	0.12	0.059	0.074	3.0	0.15	13	0.33	0.010	2.3
o,p'-DDE	0.65	0.61	0.054	0.064	0.017	0.026	0.34	0.13	1.4	0.10	0.012	0.40
ΣDDTs	37	40	0.70	1.5	0.84	1.1	26	5.2	127	3.8	0.14	10
α-HCH	0.21	0.16	0.069	0.069	0.015	0.015	0.013	0.009	0.037	0.048	0.017	0.13
β-HCH	0.17	0.17	0.087	0.024	N.D.	N.D.	0.054	N.D.	0.11	0.018	0.019	0.38
γ-HCH	0.14	0.074	0.12	0.033	N.D.	N.D.	N.D.	N.D.	N.D.	0.056	N.D.	N.D.
δ-HCH	0.077	0.081	0.055	0.023	N.D.	N.D.	N.D.	N.D.	0.040	N.D.	N.D.	0.090
ΣHCHs	0.60	0.48	0.33	0.15	0.015	0.015	0.068	0.009	0.19	0.12	0.036	0.61
trans-Chlordane	0.54	0.034	0.010	0.007	0.016	N.D.	0.37	0.014	3.1	0.084	N.D.	7.6
cis-Chlordane	0.29	N.D.	0.013	N.D.	N.D.	N.D.	0.34	0.014	2.9	N.D.	N.D.	7.2
Oxychlordane	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
trans-Nonachlor	0.20	N.D.	N.D.	N.D.	N.D.	N.D.	0.20	N.D.	2.1	0.064	N.D.	6.1
cis-Nonachlor	0.042	N.D.	N.D.	N.D.	N.D.	N.D.	0.15	N.D.	0.80	0.036	N.D.	2.6
ΣCHLs	1.1	0.034	0.023	0.007	0.016	N.D.	1.1	0.028	9.0	0.18	N.D.	24
Aldrin	N.D.	0.008	N.D.	0.054	N.D.	N.D.	N.D.	0.012	0.095	N.D.	N.D.	0.054
Dieldrin	0.65	N.D.	N.D.	N.D.	N.D.	N.D.	5.9	N.D.	6.2	N.D.	N.D.	0.54
Endrin	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.10
ΣDRINs	0.65	0.008	N.D.	0.054	N.D.	N.D.	5.9	0.012	6.3	N.D.	N.D.	0.70
Heptachlor	0.96	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.41
HCB	0.23	0.034	0.015	0.017	0.020	0.023	8.9	0.11	16	0.14	0.014	N.D.
Heptachlor Epoxide	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.066	N.D.	N.D.	N.D.

N.D.;Not Detected, Unit;ng/g-dry.

Table 3 Concentrations of PCBs in sediment samples of Vietnam and Osaka

congener＼location	HN1	HN2	HU1	HU2	HU3	HU4	HC1	HC2	HC3	HC4	HC5	Y1
MoCBs	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.11	0.12	N.D.	0.16
DiCBs	0.43	0.33	0.13	0.18	N.D.	0.15	2.6	0.21	4.2	0.34	0.088	31
TriCBs	2.2	1.8	0.38	0.28	0.11	0.12	16	1.2	31	1.0	0.10	14
TeCBs	3.3	3.8	0.18	0.13	N.D.	N.D.	7.2	1.5	18	0.69	N.D.	7.9
PeCBs	9.3	10	0.073	0.088	N.D.	N.D.	6.8	2.0	19	0.80	N.D.	6.5
HxCBs	4.8	4.6	N.D.	N.D.	N.D.	N.D.	7.5	1.5	19	1.1	N.D.	4.8
HpCBs	0.68	0.61	N.D.	N.D.	N.D.	N.D.	3.2	0.66	10	0.69	N.D.	1.4
OcCBs	0.17	N.D.	N.D.	N.D.	N.D.	N.D.	0.79	0.21	2.6	0.22	N.D.	0.35
NoCBs	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.12	N.D.	0.36	N.D.	N.D.	N.D.
DeCBs	0.14	N.D.	N.D.	N.D.	N.D.	N.D.	0.43	N.D.	1.7	N.D.	N.D.	0.073
ΣPCBs	21	21	0.77	0.67	0.11	0.27	44	7.3	110	5.0	0.19	67

N.D.; Not Detected, Unit;ng/g-dry.

PAHs

Analytical results of PAHs were shown in Table 4. Mean concentrations of ΣPAHs in Hanoi, Hue,

Ho Chi Minh, and Osaka were 1900ng/g-dry, 160ng/g-dry, 2800ng/g-dry, and 4900ng/g-dry, respectively.

Table 4 Concentrations of PAHs in sediment samples of Vietman and Osaka

compounds\location	HN1	HN2	HU1	HU2	HU3	HU4	HC1	HC2	HC3	HC4	HC5	Y1
Σ2-rings	27	23	10	8.3	6.0	4.6	170	2.5	170	12	3.5	17
Acenaphthylene	0.7	0.7	N.D.	N.D.	N.D.	0.2	2.7	N.D.	4.5	0.8	0.4	2.0
Biphenylene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.4	N.D.	0.4	N.D.	N.D.	5.2
Acenaphthene	1.0	0.8	N.D.	N.D.	N.D.	N.D.	2.3	N.D.	2.2	0.5	N.D.	1.5
Fluorene	12	10	0.8	0.9	0.5	1.3	11	1.1	12	3.6	1.1	12
9,10-Dihydroanthracene	2.3	2.1	N.D.	0.2	N.D.	N.D.	13	0.2	9.2	5.3	0.2	9.9
9,10-Dihydrophenanthrene	3.4	3.1	0.3	0.4	0.2	0.4	24	0.4	14	9.2	0.4	16
Dibenzothiophene	5.7	5.1	0.7	0.9	0.4	0.9	34	2.2	44	3.9	0.5	49
Phenanthrene	24	21	6.5	6.8	2.8	7.3	46	3.0	53	13	3.9	8.4
Anthracene	21	21	1.5	1.2	0.6	0.7	17	1.9	28	2.9	0.7	150
1-Phenylnaphthalene	20	15	3.6	4.0	1.6	6.1	43	6.6	71	11	2.4	17
o-Terphenyl	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	0.9	N.D.	1.8	0.3	N.D.	17
2-Methylphenanthrene	13	10	2.7	2.3	0.9	1.9	57	2.8	71	6.9	0.9	11
2-Methylanthracene	9.5	8.2	0.4	0.3	N.D.	0.2	28	4.1	47	3.0	0.2	7.1
9-Methylanthracene	4.6	4.4	0.2	0.2	N.D.	0.2	21	3.3	43	3.0	N.D.	38
2-Phenylnaphthalene	6.0	5.0	1.3	1.2	0.6	1.1	13	1.2	24	2.1	0.4	11
3,6-Dimethylphenanthrene	5.8	5.1	0.4	0.4	0.2	0.3	29	1.4	53	5.0	0.2	0.9
m-Terphenyl	1.9	1.5	0.7	0.5	0.2	0.4	3.8	0.3	5.7	1.1	N.D.	45
p-Terphenyl	0.9	0.6	N.D.	N.D.	N.D.	N.D.	1.1	N.D.	3.3	0.4	N.D.	0.5
9,10-Dimethylanthracene	6.1	3.6	N.D.	N.D.	N.D.	0.5	75	8.0	130	15	0.3	N.D.
Σ3-rings	140	120	19	19	8.0	22	420	37	620	87	12	400
1,2,3,4-Tetrahydrofluoranthene	0.5	0.4	N.D.	N.D.	N.D.	N.D.	2.0	0.2	2.9	0.5	N.D.	250
4H-Cyclopenta[def]phenanthrene	21	18	0.9	1.0	0.4	1.0	23	7.2	41	4.8	0.7	94
Fluoranthene	79	69	6.0	5.7	3.1	4.5	73	16	73	13	1.9	12
Pyrene	200	170	12	13	5.9	7.6	210	57	190	43	3.3	28
Benzo[b]fluorene	53	48	1.2	0.8	0.8	0.6	70	19	170	16	0.4	3.6
1,1-Binaphthyl	0.8	0.6	N.D.	N.D.	N.D.	N.D.	6.9	0.7	14	1.2	N.D.	1.1
9-Phenyanthracene	3.3	2.4	N.D.	N.D.	N.D.	N.D.	18	2.1	37	3.7	N.D.	150
Benz[a]anthracene	96	79	3.8	3.9	2.7	1.7	170	25	260	16	0.5	49
Triphenylene/Chrysene	30	25	1.8	1.9	1.2	1.2	46	7.7	47	7.2	0.4	38
Naphthacene	37	9.1	N.D.	N.D.	N.D.	N.D.	47	4.9	80	8.4	N.D.	3.8
7-Methylbenz[a]anthracene	2.0	1.6	N.D.	N.D.	N.D.	N.D.	11	N.D.	15	0.6	N.D.	240
Σ4-rings	520	420	25	26	14	17	670	140	930	120	7.2	620
Benzo[b]fluoranthene/Benzo[j]fluoranthene	81	62	12	9.4	6.0	3.8	120	17	120	12	0.7	580
Benzo[k]fluoranthene	80	58	11	8.7	5.0	3.0	86	17	220	10	0.7	1800
Benzo[e]pyrene	130	99	18	14	8.4	5.7	170	27	300	22	1.0	150
Benzo[a]pyrene	250	190	10	8.4	8.4	4.5	530	66	940	35	0.6	160
Perylene	390	280	17	14	14	20	1200	1500	670	1100	1.0	1.1
3-Methylcholanthrene	6.6	4.0	0.2	N.D.	N.D.	N.D.	18	3.7	65	1.1	N.D.	5.9
7-Methylbenzo[a]pyrene	27	16	1.2	0.9	1.0	0.4	49	9.8	150	12	N.D.	55
9,10-Diphenylanthracene	1.9	N.D.	N.D.	N.D.	N.D.	N.D.	0.3	N.D.	N.D.	N.D.	N.D.	18
1,2,3,4/1,2,5,6-Dibenzanthracene	8.5	4.9	0.8	0.6	0.4	0.2	10	1.8	26	0.9	N.D.	450
Σ5-rings	980	710	71	56	43	38	2200	1600	2500	1200	4.0	3200
Indeno[1,2,3-cd]pyrene	150	97	31	18	14	7.5	180	27	510	19	1.0	300
Benzo[ghi]perylene	260	160	39	25	19	10	340	37	750	28	1.2	140
Anthanthrene	56	30	1.4	1.2	0.9	4.1	120	37	360	29	1.9	19
Naphtho[2,3-a]pyrene	39	16	5.1	2.5	2.9	0.8	23	4.2	110	0.8	N.D.	73
3,4,8,9-Dibenzopyrene	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.
Σ6-rings	510	300	77	46	37	23	660	110	1700	77	4.1	530
Coronene	63	34	17	9.7	7.4	4.1	63	5.3	267	5.0	0.4	87
Σ7-rings	63	34	17	9.7	7.4	4.1	63	5.3	267	5.0	0.4	87
ΣPAHs	2200	1600	220	170	120	110	4200	1900	6200	1500	31	4900

N.D.;Not detected, Σ2-rings;Naphthalene, Benzo[b]thiophene, 1-,2-Methylnaphthalene, Biphenyl, 2,6-,2,7-,1,3-,1,4-, 2,3-,1,5-,1,2-Dimethylnaphthalene, 2,3,5-Trimethylnaphthalene, Unit;ng/g-dry.

CONCLUSION

The survey on the pollution of POPs, PCBs, and PAHs in surface sediment samples of Hanoi, Hue, and Ho Chi Minh was conducted. These compounds in sediment of Osaka were monitored for

comparison. Concentration of ΣDDTs, ΣHCHs, ΣCHLs, ΣPCBs and Σ63PAHs in Vietnam were 0.19-140ng/g-dry, 0.009-0.60ng/g-dry, N.D.-9.0ng/g-dry, 0.11-110ng/g-dry and 37-6900ng/g-dry, respectively. These concentrations in urban areas were much higher than those in rural areas. These results indicated that most of DDTs and CHLs were not used as agricultural chemicals but as insecticides for purpose of the health services.

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