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Organochlorines in sediments and mussels collected from coastal sites along the Pearl River Delta, South China

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Abstract: The level and pattern of residues of organochlorine pesticide and polychlorinated biphenyls(PCBs) were analyzed in sediment and mussel(*Perna viridis*) samples from ten coastal sites along the Pearl River Delta, South China. The range of total HCH was <0.01 to 0.29 ng/g freeze-dried weight in sediment, and <0.01 to 1.35 ng/g lipid weight in mussels. Average total DDTs concentrations ranged from <0.01 to 1.04 ng/g in sediment, and <0.01 to 148.5 ng/g in mussels. Average total PCB concentrations ranged from 16.4 to 198.6 ng/g in sediment, and from 41 to 729.2 ng/g in mussels. Organochlorine pesticide and PCBs in mussels and sediments presented similar distribution patterns. The regression analysis indicated that PCBs concentrations in mussels were significantly correlated($p<0.01$) with concentrations in sediments. However, their concentrations in mussels were several times higher than the concentration detected in surrounding sediments. The major fraction of DDT related compounds measured in mussels and sediments was DDD. Based on average PCB concentrations, penta-, hexa-, and tetrachlorobiphenyls were preferentially accumulated by mussels as compared to the average sediment composition. According to the present results, three organochlorine polluted "hot spot" sites, including Victoria Harbour, Lingding Yang and Huangmao Sea, were found in the Pearl River estuarine zone. HCHs, DDTs and PCBs in all mussel samples were below the limits of 2, 0.2 and 5.0 μg/g wet weight recommended by the Technical Group of Guangdong Coastal Zone Resource Comprehensive Survey and U. S. Food and Drug Administration.

Keywords: organochlorine pesticide; polychlorinated biphenyls; sediments; mussels; coastal waters

Introduction

Contamination of the marine environment associated with organochlorines has received increasing attention over the last thirty years. Particular attention has been focused on the coastal zone and estuaries, especially near metropolitan region(Sericano, 1990). The Pearl River estuarine, range from Daya Bay in the east to Changshan Islands in the west, supports large populations of marine organisms and extensive fisheries in the South China. Since the 1980s, there has been rapid economic development in the Pearl River Delta resulting in excessive discharge pollutants into the estuarine zone. It has been estimated that over 800 t of organochlorine contaminants is discharged through the river systems of the Pearl River Delta to its coastal environment (GPIRCSG, 1987).

In estuarine, sediments have often been thought of as final repositories for many organic contaminants, which reflect the longer terms contaminant loading of the environment. As filter feeders, mussels accumulate environmental contaminants in their soft tissues in proportion to the degree of contamination in the surrounding environment. In addition, analyses of environmental contaminants in mussels provide important information on the potential impact of seafood consumption on public health(Fang, 2001a; 2001b). This program is designed to monitor the current status and distribution of organochlorine contaminants in the Pearl River Estuary. The aim of study is (1) to describe the levels of hexachlorocyclohexanes(HCHs), dichlorodiphenyltrichloroethanes(DDTs) and polychorinated biphenyls(PCBs) in sediments and mussels collected from coastal sites along the Pearl River Estuary; (2) to identify the source of organochlorine pollution in the Pearl River Delta, and (3) to compare with the limits of organochlorine set for sediments and marine molluscs in international standards.

1 Materials and methods

1.1 Study areas

Sediment and mussel collection was carried out in December 2001 to February 2002 from ten sampling stations (S1 – S10, Fig. 1). Sampling sites were grouped into 3 different zones according to their geographic locations: Estuarine Zone, East Estuarine Zone and West Estuarine Zone(Fang, 2003). S1—S5 are located in East Estuarine Zone(including Daya Bay and Victoria Harbour of Hong Kong waters); S7 and S8 in Estuarine Zone (Lingding Yang); S9 and S10 in West Estuarine Zone (Huangmao Sea waters).

1.2 Sample collected and preparation

Sediment samples were collected with a Smith-McIntyne grab. At each site four separate grabs were taken. The sample was then placed in a clean glass jar, sealed with tinfoil and stored at $-20℃$ in dark conditions. The samples

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were freeze-dried, ground and passed through a 2-mm sieve and through mixed before extraction. Fifty-five mussels (*Perna viridis*) of 6—8 cm shell length were handed-picked at each station. Mussels were then placed in a clean glass tank containing clean seawater for 24 h to allow the voiding of gut content and frozen at −20℃ for later analysis. Only the soft tissue was used for the analysis of organochlorine compound. The mussel tissues were homogenized using a blender. The homogenized samples were placed inside clean tinfoil and stored in a freezer at −20℃ for 24 h. They were then freeze-dried in a freezer-drier (Lyph-Lock 12 Freeze Dryer W/ # 75102 12P ORT Drying Chamber) for about 7 days until a constant weight was reached.

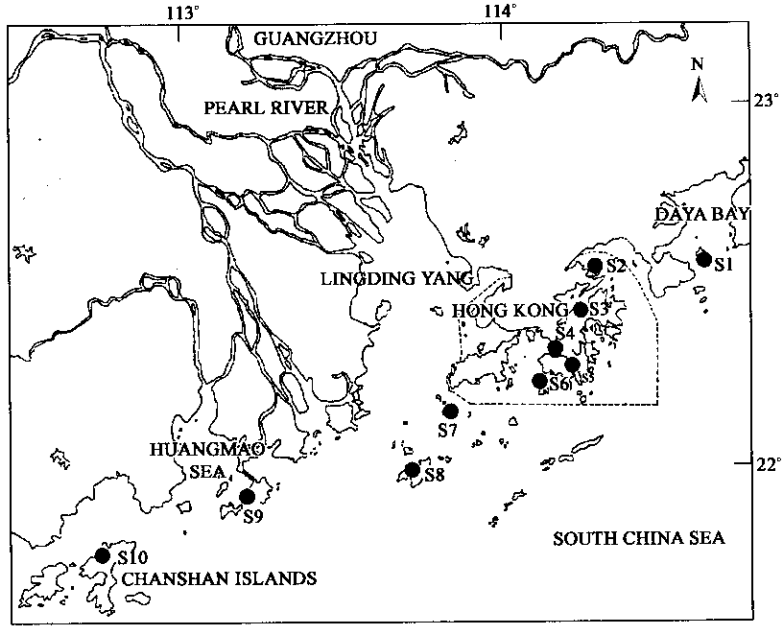

Fig. 1 The Pearl River Delta coastal waters and the locations of sampling sites 1—10
S1: Lajia Island; S2: Kot O Chau; S3: Lok Wo Sha; S4: Tsim Sha Tsui Pier; S5: North Point Pier; S6: Yung Shue Wan; S7: Guishan Island; S8: Dawanshan Island; S9: Gaolan Island; S10: Shanzhuo Harbour

1.3 Sample extraction

Sample extraction was performed according to the method described in AOAC(1990). Approximately 40 g of freeze-dried sediment samples(Boon, 1986) was placed in a soxhlet apparatus and allowed to soak with 10 ml of acetone and *n*-hexane (1:1, v/v) for 10 h at 80℃ (Hutzinger, 1974). By evaporating the extract to approximately 20 ml. About 6 g of freeze-dried mussel samples were transferred to soxhlet apparatus, and then extracted with 80 ml *n*-hexane (for *pestiscan*) at 80℃ for 8 h. The lipid content was measured by evaporating the solvent until a constant weight was obtained. 20 ml *n*-hexane was added to dissolve the lipid before clean-up procedure. Sediment and mussel extract were subjected to a clean-up procedure.

1.4 Sample cleaned-up

The extract was subjected to cleaned-up with concentrated sulfuric acid (Hernandez, 1987) followed by a florisil cleaned-up(AOAC, 1990). Twenty ml of extract was transferred into a separating funnel. An additional internal standard, Octachloronaphthalene(OCN), was added to sediment or mussel samples that were analyzed for coplanar congeners. Ten ml concentrated sulfuric acid was added to the extracts slowly, and shaken vigorously for 2 min. The inorganic layer was decanted. Several portions of 10 ml sulfuric acid were used until the clear inorganic layer appeared. Hydrocarbons and other colored biogenic compounds were removed by sulfuric acid wash. The organic layer was washed with 2% sodium sulfate until the inorganic layer had pH $\geqslant$ 7. The extracts were concentrated to appropriate 1 ml. Activated granular copper was added to the sedimentary extracts to remove sulfur. A micro florisil column was prepared. The sample was quantitatively transferred to the florisil column and the sample was eluted to a total volume of 10 ml with *n*-hexane. Co-extracted polar compounds were removed by florisil chromatography.

1.5 Sample analysis

PCBs, DDTs and HCHs were detected and quantitatively analyzed by a Hewlett Packard 6890 gas chromatograph equipped with an electron capture detector (GC-ECD). A DB-5 capillary column, 30 m × 0.25 mm ID (0.25 μm film thickness)(J & W Scientific Co. Ltd., USA) was used for primary separation. The system was controlled by a Hewlett Packard workstation. The oven temperature was programmed to keep the initial temperature at 80℃ for 0.5 min, and then raised to 240℃ at the rate of 4℃/min, and finally held for 30 min at 240℃. Injector and detector temperature were set at 270℃ and 300℃, respectively. Sample volumes of 1 μl were automatically injected. Nitrogen

was used as the make-up gas.

The analytes were quantitated against a set of authentic National Institute of Standard and Technology (NIST) (Gaithersburg, MD) standards that were injected at four different concentrations to calibrate the instrument and to compensate for the nonlinear response of the detector. Octachloronaphthalene (OCN) was used as an internal standard, which was used to correct the loss in clean-up procedure, variability in the injection sample and drift in the retention times of congeners. It was added to the sample prior to the clean-up procedure. Relative retention times to OCN were used to identify PCB congeners. Only those peaks located within the proper range of retention time for the different chlorinated congeners were counted for quantification. Ninety-six domains were identified, and each domain consisted of one to four congeners. The individual congeners are summed to calculate the total PCB. Average chlorine numbers were calculated by dividing the sum of the products of homologue concentration times the homologue chlorine number 1—10 by total PCB concentration using the equation(Evans, 1991). Pesticides are quantified against a set of standards containing organochlorine pesticides at known concentration which are injected at three different concentrations to calibrate the instrument and to compensate for a non-linear response of the electron capture detector.

1.6 Data analysis

Kruskal-Wallis one way analysis of variance was used to calculate significant differences in HCHs, DDTs and PCBs concentrations between samples from different sites. Regression analysis was used to identify relationships between contaminant concentrations in mussel tissues and sediments. The planned comparisons(Student's t-test) were then used to elucidate the difference between different zones.

1.7 Quality control

The quality assurance in this study has included that the use of internal standard, replicate analysis of calibration standards and samples, as well as the use of PCB free reagents and glassware. Pre-cleaning of all glassware involves extensive washing with micro cleaning solution, rinsing with distilled water and combustion at 400℃ for 4 h. Analytical blanks were undertaken following the same procedure and did not reveal any peaks corresponding to the chemical monitored. The standard reference material (SRM 1974a, NIST) was carried through the entire analytical scheme for each set of eight samples. For all data reported, SRM values were within 78%—105% of the consensus value.

2 Results

A total of 30 sediment and 30 mussel samples were analyzed for α-HCH, β-HCH, γ-HCH, p,p'-DDD, p,p'-DDE, p,p'-DDT and PCB isomers in this study. The mean concentrations as well as the sum of individual compounds within each category are presented in Tables 1 and 2. According to Kruskal-Wallis analysis of variance for sediments and mussels collected from ten sites, significant differences ($p < 0.05$) were observed between the highest and lowest levels recorded for HCHs, DDTs and PCBs, respectively.

Table 1 Concentrations of HCHs, DDTs and PCBs in sediments collected from the Pearl River Delta coastal waters, December 2001 to February 2002 (ng/g, dry weight basis)

Station	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
α-HCH	ND	ND	ND	ND	ND	ND	0.10	0.08	0.10	0.03
β-HCH	0.04	ND	ND	0.06	0.08	0.04	0.07	0.05	0.11	0.03
γ-HCH	ND	ND	ND	ND	ND	ND	0.06	0.08	0.08	0.02
ΣHCHs	0.04	ND	ND	0.06	0.08	0.04	0.23	0.21	0.29	0.08
p,p'-DDE	ND	0.02	ND	0.19	0.10	0.06	0.24	0.24	0.23	0.28
p,p'-DDD	ND	0.02	ND	0.43	0.26	0.12	0.60	0.39	0.63	0.51
p,p'-DDT	ND	ND	ND	0.13	0.12	0.06	0.14	0.16	0.18	0.21
ΣDDTs	ND	0.04	ND	0.75	0.48	0.24	0.98	0.79	1.04	1.00
Di-PCBs	2.35	ND	ND	ND	3.07	ND	2.87	1.04	0.38	ND
Tri-PCBs	0.58	0.97	3.43	6.16	10.48	5.04	7.88	0.70	0.58	4.76
Tetra-PCBs	0.21	4.91	4.90	15.39	23.96	11.57	32.11	14.51	9.59	21.18
Penta-PCBs	4.93	7.73	4.87	74.53	26.80	19.97	76.98	24.30	33.33	44.15
Hexa-PCBs	3.76	11.52	2.76	42.88	36.62	21.58	25.36	32.85	39.55	12.64
Hepta-PCBs	3.17	15.72	6.70	38.60	51.86	9.52	28.17	31.91	29.81	11.19
Octa-PCBs	0.95	1.25	0.34	12.90	14.18	1.24	9.93	11.89	9.79	1.09
Nona-PCBs	1.00	ND	ND	8.14	7.04	ND	1.00	ND	0.29	ND
ΣPCBs	16.4	42.1	23.0	198.6	174.0	68.9	184.3	117.2	123.3	95.0

Note: ND: < 0.01

2.1 HCHs

HCHs in sediments were generally present in low concentrations. Total HCH ranged from < 0.01 to 0.29 ng/g with a mean concentration of 0.075 ng/g dry wt. Relatively high HCHs concentrations were found in Gaolan Island(S9: 0.29 ng/g), in Huangmao Sea. Concentrations of HCHs in mussel samples were, in general, higher than those detected in sediment samples from the same stations. Total HCH concentrations ranged from < 0.01 to 1.35 ng/g with a mean concentration of 0.34 ng/g lipid wt. As in sediment samples, the highest HCHs concentration in mussels was found in Gaolan Island(1.35 ng/g).

Table 2 Concentrations of HCHs, DDTs and PCBs in mussels collected from the Pearl River Delta coastal waters, December 2001 to February 2002(ng/g, lipid weight basis)

Station	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10
Lipid content, %	4.1	5.3	3.8	7.4	8.0	5.1	7.0	6.8	4.1	3.2
α-HCH	ND	ND	ND	ND	ND	ND	0.41	0.21	0.51	0.10
β-HCH	0.31	ND	ND	0.35	0.33	0.32	0.34	0.36	0.43	0.26
γ-HCH	ND	ND	ND	ND	ND	ND	0.29	0.20	0.41	0.12
ΣHCHs	0.31	ND	ND	0.35	0.33	0.32	1.04	0.76	1.35	0.48
p,*p*'-DDE	ND	0.20	ND	46.8	50.8	29.19	104.0	49.52	68.13	22.12
p,*p*'-DDD	ND	ND	ND	32.62	41.17	21.13	197.4	86.1	72.26	10.41
p,*p*'-DDT	ND	0.20	ND	21.89	40.74	12.7	19.62	9.94	8.15	4.05
ΣDDTs	ND	0.40	ND	132.71	101.31	63.02	321.01	145.56	148.54	36.58
Di-PCBs	1.4	ND	0.3	21.85	18.3	1.3	0.7	6.9	8.4	ND
Tri-PCBs	2.25	1.6	1.15	60.65	46.65	15.35	11.92	22.87	10.48	5.35
Tetra-PCBs	4.05	17.15	1.85	151.91	134.12	65.45	97.69	87.15	78.52	28.88
Penta-PCBs	7.3	42.08	13.8	240.87	249.54	103.20	179.38	141.68	58.86	36.70
Hexa-PCBs	16.15	44.58	15.53	147.85	203.2	76.26	211.69	92.87	96.12	38.83
Hepta-PCBs	34.85	44.15	8.38	50.98	57.71	19.15	143.63	82.95	28.23	7.05
Octa-PCBs	18.25	11.05	ND	10.8	15.5	2.9	9.4	34.09	3.8	2.5
Nona-PCBs	16.55	ND	ND	11.4	4.2	0.3	14.6	8.7	6.5	ND
ΣPCBs	100.8	160.6	41.0	696.3	729.2	283.9	669.0	477.2	290.9	121.8

Note: ND: < 0.01

2.2 DDTs

DDT and its metabolites were detected in 70% of the sediment samples in this study. Average total DDTs concentrations ranged from < 0.01 to 1.04 ng/g with a mean value of 0.51 ng/g dry wt. The highest DDTs concentrations were mainly encountered in sites from Gaolan Island (1.04 ng/g) and Shanzhou Harbour (1.00 ng/g). DDTs were the most abundant chlorinated pesticides in mussel samples. Levels of chlorinated pesticides in mussels were, in general, higher than those detected in sediment samples from the same stations. Total DDT concentrations in mussels ranged from < 0.01 to 148.5 ng/g with an average value of 94.9 ng/g lipid wt. As in sediments, higher DDTs concentrations were found in Lingding Yang and Huangmao Sea. Samples from Guishan Island presented the highest DDTs concentrations (321.01 ng/g).

2.3 PCBs

Average total PCB concentrations ranged from 16.4 to 198.6 ng/g with a mean concentration of 104.3 ng/g dry wt. were detected in the samples. Sediments with the highest PCB concentrations were found at Victoria Harbour of Hong Kong waters (North Point Pier 198.6 ng/g and Tsim Sha Tsui Pier 174 ng/g). The chlorine numbers of PCBs found in sediments ranged from 4.49 to 6.28, with the average number of 5.57. PCB congeners were detected in all the mussel samples collected from the Pearl River estuarine zone. The total PCB concentrations ranged from 41 to 729.2 ng/g with average concentrations of 357.1 ng/g lipid wt. Highest PCB concentrations, 729.2 and 696.3 ng/g, were detected at Victoria Harbour of Hong Kong waters (Tsim Sha Tsui Pier and North Point Pier), respectively. High PCB concentrations were also recurrent in samples from Lingding Yang (Guishan Island 669 ng/g and Dawanshan Island 477.2 ng/g). The chlorine numbers of PCBs found in mussels ranged from 5.04 to 6.88, with the average number of 5.54.

3 Discussion

3.1 Organochlorines pollution in the Pearl River Delta

3.1.1 HCHs

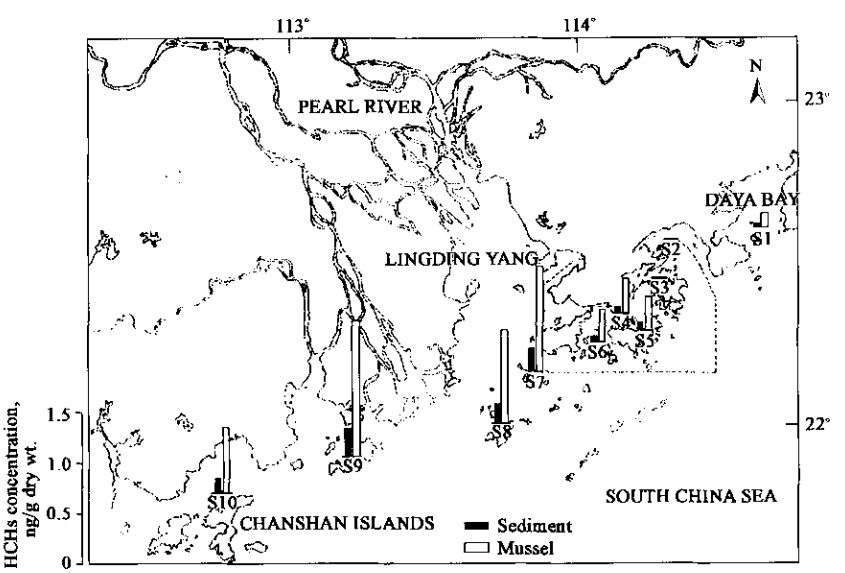

Fig. 2 HCHs contamination of sediments and mussels from the Pearl River Delta costal waters

In this study, HCHs were detected in eight sediment and mussel samples at trace concentrations. In general, the individual HCHs present in the highest abundance in sediment samples were also found in the highest concentrations in mussel tissue. Levels of HCHs concentrations in sediment and mussel samples collected from the Estuarine Zone and Western Estuarine Zone were higher than that from the Eastern Estuarine Zone (including Hong Kong waters and Daya Bay waters) ($p < 0.01$) (Fig. 2). All HCH isomers were found in sediment and mussel samples

collected from Estuarine Zone and Western Estuarine Zone. HCHs in sediment samples from these sites contained average of α-HCH 38%, β-HCH 33% and γ-HCH 29%, respectively; HCHs in mussel samples from these sites contained average of α-HCH 31%, β-HCH 42% and γ-HCH 27%, respectively. However. HCHs in Hong Kong waters and Daya Bay sediment and mussel samples only contained β isomers. It has been reported that β-HCH is mainly used in Asia areas (Pearce, 1989). These background levels probably reflect HCHs use in this area in the past years.

3.1.2 DDTs

Comparing with the tissue concentrations in mussels DDTs in sediment samples were very low. Fig. 3 shows the DDTs contamination of sediments and mussels from the Delta's coastal waters. The results indicated that DDTs pollution spot mainly occurred at Lingding Yang, Huangmao Sea and Victoria Harbour. Although the production of DDT was banned in the Pearl River Delta in 1983(Wolfe, 1984), this compound and its metabolites were still presented in sediment and mussel tissues of the Pearl River estuarine zone. It was estimated that half-life for DDT was up to 20 years under environmental conditions (Woodwell, 1971). It was in agreement with the reports that rather high level of DDT and DDE were observed in surface sediments from two sites in the Victoria Harbour(Lo, 1988).

The overall average percentages of DDT and its metabolites were different in mussels and sediments. The proportion of DDD(55.64%) was significantly higher than DDE(25.56%) and DDT(18.80%) in sediment sample. The mean percentages of DDD were different in mussels (48.59%) and sediments(55.64%), the proportion of DDE was significantly higher in mussels (39.07%) than in sediments(25.6%). These differences may be related to uptake, metabolism and depuration mechanisms for DDT compounds in mussels(Sericano, 1990). It can be found that DDD is the predominant forms of DDTs in sediment and mussel samples from this coastal zone. DDTs can be metabolized to DDE under aerobic conditions and to DDD under anaerobic conditions by microorganisms (Ramesh, 1991). An active degradation of DDT may happen in this marine environment. Some authors suggested that DDE was a major hydrolysis product of DDT, which appeared to be more persistent in the aquatic environment than its parent compound(Wolfe, 1977). However, it seems that the high concentration of DDD in sediments and mussels from this area was due to easier metabolism of DDD than DDE.

3.1.3 PCBs

Fig.4 shows the PCBs concentrations in sediment and mussel samples collected from ten locations along the Pearl River Delta coastal waters. It was indicated that PCBs pollution occurred mainly in two regions: East Estuarine Zone and Estuarine Zone. In general, the individual organochlorine present in the highest abundance in sediment samples were also found in the highest concentrations in mussel tissues. The regression analysis indicated that PCBs concentrations in mussels were significantly correlated (r = 0.8628, n = 10, $p < 0.01$) with concentrations in sediments. Linear correlations showed a high level of agreement between PCB patterns in the exposure environment (mussels and sediments) in this study.

PCB congeners of 56/60, 85/116, 77/110, 106/118/149, 114/134/143 and 137/176 (IUPAC No.; the "/" indicates co-eluting congeners) could be found in sediments from 10 sampling sites. Similar isomeric composition of PCB residues was observed in mussel samples. It also noted that mussels accumulate highly toxic coplanar PCB, such as the toxic planar PCB 118 and 138(Safe, 1982), which were up to 8.67 ng/g and 7.9 ng/g from some investigated stations. As in sediment samples, 66/93/95, 90/101, 124/135/144, 153 and 138/163/160/164 were only observed in mussel samples from East Estuarine Zone (Hong Kong waters and Daya Bay). However, 84/92/155 and 82 could be found in mussel samples from Estuarine Zone (Lingding Yang) and West Estuarine Zone(Huangmao Sea). When compared with the isomeric composition of PCB residues in sediment and mussel samples it could be found that the similar pattern was found in mussels collected from the PCB-contaminated locations. Such as the patterns of PCB 60/93/95, 84/92/155, 90/101, 85/116, 77/110, 106/118/149, 124/135/144, 107/108/147, 105, 137/176 and 138/163/160/164 could be found in sediment and mussel samples from North Point Pier. PCBs discharged into the Pearl River are rapidly adsorbed onto particulate matter and transported into the estuary. They are ultimately deposited at bottom sediments (Tang, 1983). Sediments in aquatic ecosystems of estuarine zone can act as a source of contaminants, which then can be accumulated in the marine bivalves(Feng, 1998).

The average composition of PCBs was different in sediments compared to mussels. Sediments PCB congeners were dominated by penta-(28.46%), hexa-(22.01%) and heptachlorobiphenyls (21.73%) and, to a lesser extent, by tetrachlorobiphenyls (13.26%). They represented more than 85% of the total sedimentary PCB load. In mussels, PCBs were largely dominated by penta- (30.06%) and hexachlorobiphenyls (26.69%), with some tetra-(18.67%) and heptachlorobiphenyls (13.16%), which represented more than 88% of the total mussel PCB load. The results indicated that penta- and hexa-chlorinated PCB were selectively accumulated in *Perna viridis* whereas highly lipophilic PCB with more than seven chlorine atoms was found in negligible concentrations. Similar finding was also found in Blue mussels *Mytilus edulis* (Lee, 1996).

3.2 Source of organochlorines pollution in the Pearl River Delta

Agriculture is still important in the Pearl River Delta. HCHs and DDTs pollution mainly comes from the use of pesticides in this agricultural region. According to the statistical data (Lands Department of Guangdong Province, 1986) the use of pesticides in Guangdong Province was about 693000 t/a from 1978 to 1983. About 31892 t/a of organochlorine pesticides(DDTs and HCHs) was used in this area in 1983 (GPIRCSG, 1987). The discharge volume of organochlorines by four openings(Humen, Henmen, Hongqili and Jiaomen) into Lingding Yang is about 496.02 t/a (GPIRCSG, 1987). Huangmao Sea received about 93.7 t/a of organochlorine pesticides discharges through Hutiaomen and Yamen(GPIRCSG, 1987). Although the production of HCHs and DDTs was banned in Guangdong in 1983 the residues were still presented in sediments of Pearl River Estuary and continued to exert environmental effects by their remobilization over time.

In China about 10000 t of commercial PCBs production has been produced. Although PCB production ceased in China in 1974 it was believed that a large proportion of PCBs produced remained in use at present in old transformers and capacitors in the Pearl River Delta (Li, 1995). Commercial PCB preparation was widely used for other industrial purposes, including heat transfer fluids, carbon-less copy paper, plasticizer, and other uses. Other important pollution resource of PCBs may come from a pulp bleaching process in paper mill (Yang, 1994). It has been found that PCB and DDT residues were in pulp mill effluents. There are six large paper mills distributing in the Delta. Three mills(Guangzhou Paper Mill, Guangzhou People Paper Mill and Guangzhou Zhujiang Paper Mill) are located in Guangzhou, which total 80970×10^3 t/a of industrial waste water discharge into Lingding Yang by Humen. Three mills(Jiangmen Paper Mill, Jiangmen Xinhua Paper Mill and Zhongshan Paper Mill) are located in Jiangmen and Zhongshan. PCBs pollution may be produced from a pulp bleaching process in these paper mills.

As an industrial and commercial area, Hong Kong had housed various industrial plants of which some might have used PCBs in the past. It was estimated that over 3300 PCB capacitors had been in use or storage in Hong Kong in 1980s, a majority of which was owned by the power companies although others were in the hands of the industrial and commercial sectors (Morton, 1989). A phasing-out of PCB capacitors may occur in Hong Kong. This resulted in a large of PCBs washed away so that PCBs pollution existed there. Other resource may be by ships and ferry transport, shipyards, and by the discharges from sewage plants.

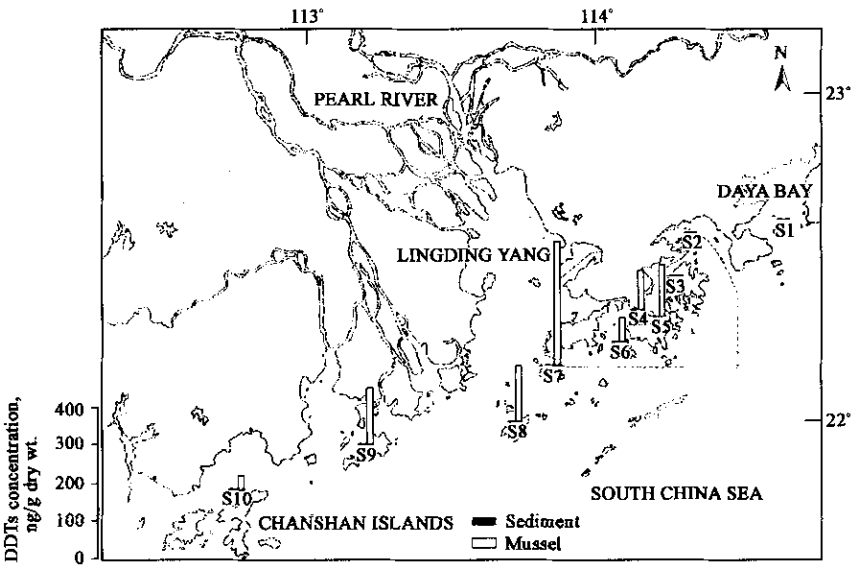

Fig.3 DDTs contamination of sediments and mussels from the Pearl River Delta coastal waters

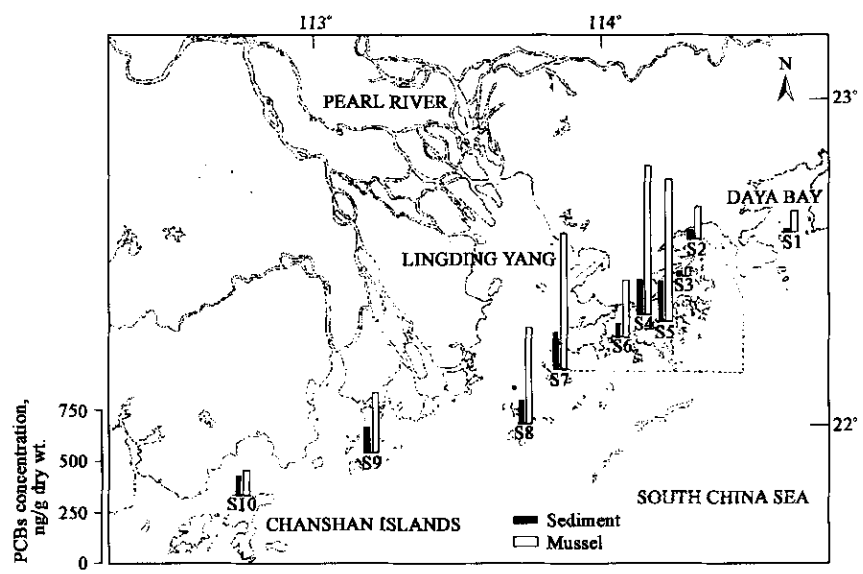

Fig. 4 PCBs contamination of sediments and mussels from the Pearl River Delta coastal waters

3.3 Public health concern

It has been proposed that the consumption of seafood is a major source of organochlorines to human populations (Westöö, 1978). The occurrence of elevated concentrations of DDT, DDE and HCH isomers in human breast milk in Hong Kong was of concern, and warrants further study, particularly in relation to the contamination of local seafood (Ip, 1989). The limits of HCHs and DDTs for marine mollusks of Marine Organism Pollution Assessment Standard (MOPAS) recommended by the Technical Group of Guangdong Coastal Zone Resource Comprehensive Survey are 2 and 0.2 μg/g(wet wt.). In this study HCHs and DDTs in all mussel samples were well below the limits. There are no limits set for PCBs available in MOPAS. PCBs concentrations measured in our samples were also below the limit of 5.0 μg/g(wet wt.) recommended by U. S. Food and Drug Administration(Meyer, 1990).

4 Conclusions

According to the present results, considerable contamination of PCBs in Tsim Sha Tsui Pier and North Point Pier was evident. Guishan Island and Dawanshan Island seemed to suffer from DDTs and PCBs contamination as judged by organochlorines concentrations in the mussels and sediments. In Herbao Island, contamination was mainly due to HCHs and DDTs. Three organochlorine polluted "hot spot" sites, including Victoria Harbour, Lingding Yang and Huangmao Sea, were found in the Pearl River Delta coastal waters.

HCHs, DDTs and PCBs in all mussel samples were below the limits of 2, 0.2 and 5.0 μg/g wet wt. recommended by the Technical Group of Guangdong Coastal Zone Resource Comprehensive Survey and U. S. Food and Drug Administration.

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Aquatic Ecotoxicology Research Group in the State Key Laboratory for Environmental Aquatic Chemistry (SKLEAC) is headed by Professor Zijian Wang. Other staffs include Dr. Mei Ma (associate professor) and Dr. Shengbiao Huang (assistant researcher), Mrs. Donghong Wang (assistant researcher) and Kaifeng Rao (Technician). There are 6 PhD candicates and 8 MS candidates in 2003.

The research activities cover chemical measurement and speciation in natural waters and water processes, toxicity bioassays and ecological and health risk assessment. The research group has developed tools for sampling and analysis of pesticides, phthalates, polychlorinated biphenyls (PCBs), polyaromatic hydrocarbons (PAHs), and volatile organic compounds (VOCs), based on GC-MS, GC, HPLC etc, and tools of bioassays. For bioassays, it uses luminescent bacteria, algae, invertebrates and fishes. For biomarkers, it uses Neutral Red Assay for cytotoxicity, MCF-7 cell line and h-ER recombinant yeast for environmental endocrine disruptors, EROD assay using H4IIE cells line for dioxin-like compounds, as well as other physiological and biochemical parameters of fish, such as vitellogenin induction assay.

The research activities are mostly aiming at evaluation of aquatic environment and processes in environmental engineering. For example, the group is developing criteria for safe water supply, assessment for the feasibility of advanced treatment technologies for water reclamation and reuse, ecological risk assessment on watershed scale, and health risk assessment for metals in drinking water in Beijing and Shanghai, and so on.

The research group is carrying out a numbers of research and development projects, including 2 sub-projects from 973, 3 projects from 863, 7 projects from Natural Science Foundation of China, 1 project from Natural Science Foundation of Beijing City, and 2 projects from Chinese Academy of Sciences. The annual project budget in the year 2003 is about 1 million RMB.