Study on Residues of Organic Chlorinated Pesticides in Bohai Sea

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Abstract

In September, 2007, after China's fishing-closed period(from 14th June to first September every year), China-Japan Friendship Center for Environmental Protection has collected some samples from 10 cities and town in Bohai Region, including sea water, Chinese prawns and sea bass to study the residues of organic chlorinated pesticides there. According to *Manual for Sample Collection and Analysis*, we have analyzed the 14 organic chlorinated pesticides(OCPs) in labs and finally obtained detailed data. In this report, we will first give an introduction to Bohai Region and then give a brief introduction to our analysis.

Bohai Sea, shallow northwestern arm of the Yellow Sea, off the North China coast, is enclosed by the Liaodong Peninsula (northeast) and the Shandong Peninsula (south). The gulf's maximum dimensions are 480 kilometres from northeast to southwest and 306 kilometres from east to west. The strait leading to the gulf is about 105 kilometres in width. The mean depth of Bohai Sea is about 18 meters. The Yellow River, China's second longest river, discharges into the gulf. Two other major rivers draining into Bohai Sea include Hai River System and Liao River System, which constitute two of the five river systems in China. The gulf has long been used as a source of prawns and salt. There are both onshore and offshore petroleum deposits, and several oil refineries are located there. Bo Hai region is one of the most important economic zones with its GDP growing by more than 10 folds in the past 12 years. Bohai Region has covered some major cities from 3 provinces and 2 municipalities, such as Dalian(in Liaoning Province), Tangshan(in Hebei Province), Dongying (in Shandong province), Tianjin and Beijing. Bohai Sea is relative closed bay, interchange of sea water with ocean outside is weak, so the water quality of this area are influenced seriously by the activity of human.

We decided 6 sampling locations around Bohai Sea and also selected 3 sampling locations in South Huanghai Sea as a contrast. South Huanghai Sea is belongs to the fringe sea of Pacific Ocean. The depth of which is deeper than Bohai Sea. The area is about 300 thousand square kilometer. In addition, South Huanghai Sea is influenced by Black Current coming from Pacific Ocean further. Black Current is a famous warm current, the temperature of the water here is higher than that in Bohai Sea. The Black Current can agitate the seawater and abundant pabulum in the bottom will be moved up to the surface layer, then many fishes are bloom here. These situations are very different from Bohai Sea.

Sea basses which we collected varied widely in size, from 25 centimetres to a maximum, about 90 centimetres. The weight varied from 200 grams to 6500 grams. Significantly, the bigger ones have grown for much more years than the younger ones. So the residues of OCPs in them are quite different. It is reasonable to analyze them individually. Chinese prawns which we collected are in similar size. The average length is 20 centimetres, the average weight is 53 grams. So we analyzed them according to the sampling locations. The hexachlorobenzene, Chlordane, p,p'-DDD, p,p'-DDT and p,p'-DDE were detected widely in all samples. Aldrin, Dieldrin, Endrin, Heptachlor and Mirex were less than the quantification limit. We also analyzed the OCPs in livers of sea bass individually. The results showed that the concentration of OCPs in livers of sea fish was much higher than the mussels.

Key Words: Bohai Sea, organic chlorinated pesticides, prawn, sea bass

Monitoring on POPs and OCs Compounds in Aquatic Environment at Main Cities in Java Island

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Abstract

Since 2001, some Persistent Organic Pollutant (POPs) and Organochlorine (OCs) compounds at aquatic environment in Java Island were annually monitored in river water, seawater, sediment and since 2006, biota was included. Previous monitoring showed that some POPs compounds were detected on sediment and biota due to long usage in the past, strong affinity to organic sediment and fat. Even in very small concentration, it was also detected in river and seawater by desorption from sediment into water and or probably contamination from new application of POPs compounds.

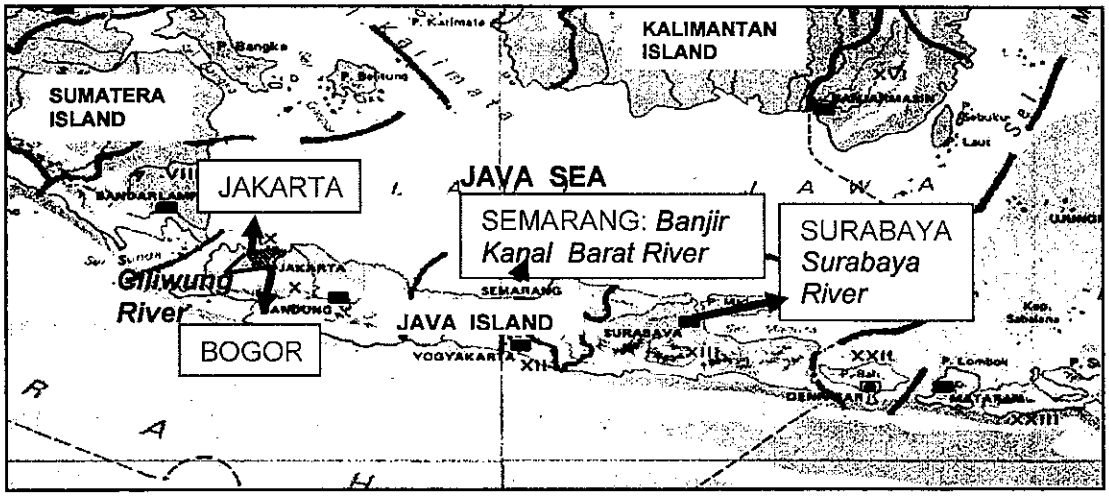

Fig.1 Sampling location

Three main cities (Jakarta, Semarang and Surabaya) in Java Island were chosen as the sampling location (fig.1) due to their high density of population and high frequency of pesticides application on both agriculture area and urban area. Those cities are located at northen part of Java Island. The sampling points were selected

at the river passing through the city from the upper reaches of river to the estuary at Java Sea. The main river selected for sampling point as follows:1. Ciliwung River that the upper reaches is located in Bogor, West Java. The down stream flows through the north of Jakarta City and last at the Jakarta Bay. 2. Banjir Kanal Barat River is located at Semarang City, Central Java. 3. Surabaya River is located at Surabaya City, East Java, flows to Madura Strait. Those rivers are running into the Java Sea that has known as busy pathway of Java Strait connecting Java Island and Kalimantan Island. Main activity of the strait is transportation followed by fishery.

River water and sediment were collected at 5-6 points between up stream of river to the estuary. Seawater was sampled at location where sea bass selected as biota sample was also collected (2 km from the land). The activities were conducted in wet season (April) and dry season (September) in order to see the season effect to the season towards the POPs and OCs concentration in the aquatic environment.

Through the analytical method recommended by UNU, The POPs compounds (hexachlorobenzene, heptachlor, aldrin, heptachlor epoxide, trans-chlordane, DDT-isomers, dieldrin, endrin, mirex) and OCs (lindan and metoxychlor) were examined in sample of water, wet sediment and sea bass muscle tissue.

As result, DDT and its metabolites were detected in water. More various kinds of POPs compound were detected in sediment. A few DDT and its metabolites also were detected in sea bass muscle tissue. Its concentrations were about tens ppt in water, tens ppb in sediment, some ppb in sea bass muscle tissue respectively. OCs (lindan and methoxychlor) were not detected in almost all sample except in sediment at one sampling point.

As far, the monitoring showed that POPs and OCs were detected in aquatic environment at the interest locations in Java Island. It probably could represent the POPs and OCs contamination status of some other locations in Indonesia.

Contamination Status of Persistent Organic Pollutants in Fish from the Han River Estuary, Korea

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Abstract

Persistent organic pollutants such as PCBs, DDTs, and chlordanes accumulated in marine organisms through body surface or respiratory organs by diffusion and food intake. Organic pollutants accumulate in the human body over a lifetime, mainly through a diet. According to total diet study by Tsutsumi *et al.* (2001), mean daily intake of dioxin like compounds were highest from fish and shellfish. Since fish generally contain higher levels of organochlorines than any other food category, human's diets containing higher amounts of fish may be expected to lead to higher OCs intake. Consequently, determination of organochlorine concentration in fish is useful to understand the extent of aquatic contamination and to evaluate the possible risk for human. Fish and shellfish tissue monitoring serves as an important indicator of contaminated sediments and water quality as well, and many countries routinely conduct chemical contaminant analyses of fish and shellfish tissues as part of their comprehensive water quality monitoring program.

In order to assess the status of OCs contamination in fish inhabiting the coastal zone of Korea, we collected fish samples from Han River estuary from May 2005 to February 2007. The fish collected consists of several species because sampling of same species was difficult at all sites and seasons. Dorsal muscle tissue of fish was dissected from the whole body for analysis. Sampling location and fish species were presented in Fig. 1.

Polychlorinated biphenyls and organochlorine pesticides such as DDTs, HCHs, CHLs and HCB were detected in muscle homogenates of all the fish samples. The overall summary of OCs concentrations is presented in Figure 2. Polychlorinated biphenyls were the predominant contaminants with concentrations ranging from 8.46 to 1710 ng/g lipid weight (lw) and DDT compounds recorded the second highest concentrations with the range of 5.76 - 1170 ng/g lw. HCHs, CHLs and HCB concentration in fish were relatively low ranging 1.14 - 133 ng/g lw, 0.28 – 89.7 ng/g lw, and 0.09 – 61.0 ng/g lw, respectively. The OC levels are relatively lower than those found in harbor regions of Korea (Yim et al., 2004). Among DDT compounds, DDE is dominant with the average composition of 60±12% and followed by DDD (35±11%) and DDT (5±3%). Same signature was also observed in sediment collected from this region before, which indicating that the degradation of DDT is in progress in the coastal environment. Regarding the HCH isomers, high proportion of β-HCH (33±17%) and γ-HCH (46±19%) was observed in fish samples followed by α-HCH (15±6%), and δ-HCH (5±3%).

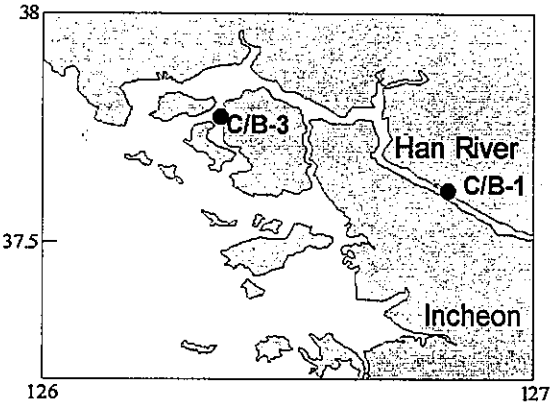

Figure 1. Sampling location of fish from Han River estuary

Risk-based screening value (SV) based on EPA method was calculated using the EPA approach to identify the primary chemicals of concern (Figure 2). About 90% of the fish samples showed the PCB concentrations exceeding the SV (5.04 ng/g). The concentrations of DDTs and dieldrin in fish exceeded their SVs at 47% and 20% of the samples, respectively, but the other compounds were mostly below SV values. Based on the estimated screening values, PCB, DDT, and

dieldrin compounds were identified as potential chemicals of concern in this region.

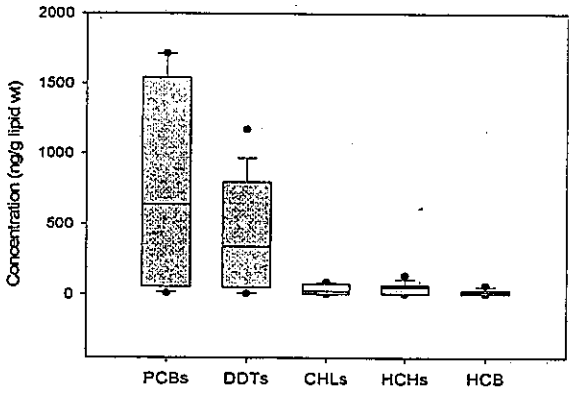

Figure 2. Concentration of organochlorine compounds if fish muscle samples from the Han River estuary.

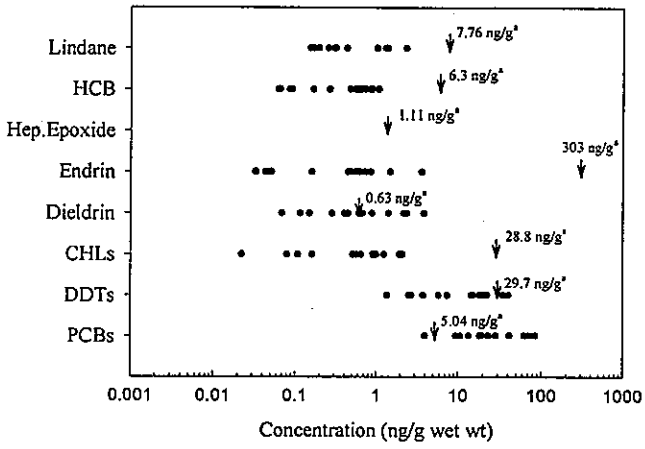

Figure 3. Comparison of organochlorine concentrations in fish muscle from the Han River estuary with estimated screening values for fish consumption risk.

Keywords: PCBs, organochlorine pesticide, Contamination, Fish, Screening value, Korea

Analysis of Selected POPs in Water from Selangor River, Malaysia and in Selected Sea Bass Samples.

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Abstract

The presence of POPs in Malaysian aquatic environment resulted from human activities has raised concerns on the water quality and safety of aquatic organism for domestic use. Although often present at trace levels, the ability of POPs to bio-accumulate is a concern owing to the possible adverse reactions from pesticides exposure to life beings. Due to the chemical nature of pesticides which rendered them persistent, monitoring programmes are conducted to assess the levels of pesticides in water and aquatic organisms. The present work is carried out with aim to assess the water quality of Selangor River for the selected pesticides (OC group) contamination. In addition to the river water monitoring, pesticides levels evaluation was also conducted in 'siakap' fish (sea bass). Selangor River is chosen as the sampling location as this river is not only providing fresh water supply to Selangor and Kuala Lumpur residents, it also flows through heavily developed area. Therefore, this river is exposed to many human activities from agricultural to tourism industries. Hence, this river is highly susceptible to chemical pollutions. This project is conducted as part of UNU hydrosphere monitoring program.

The river water samples were collected in two cycles, in June and August 2006. Ease of sampling allowed our sampling team to collect duplicate river water samples from nine stations along the Selangor River. Five fish samples were collected where four samples were purchased from the local market and one sample was caught by the local fisherman. One fish sample was a product of organic fish farming whereas the other four were wild fish origin. The water samples were transferred to the SUCXeS laboratory at the University of Malaya in chilled boxes and in ice packs. All samples

undergo thorough clean up process prior to GCMS analysis. The water samples were processed and extracted within 24-48-hour upon received. Liquid-liquid extraction method with ethyl acetate and dichloromethane was used in sample clean up. Preparations for fish sample require liquid-liquid extraction with hexane and ethyl acetate followed by further clean-up using amino and silica SPE cartridges. The GCMS method used were developed by UNU and Shimadzu corporations.

The river water analysis results showed pesticides residues at ng/L level found in four samples from the two sampling cycles. The residues detected were DDT, DDD and mirex (summarized in Table 1). The residues were detected at sampling stations where the surrounding activities are predominantly agriculture based. HCB and DDT were detected in the fish samples, products of organic farming and local market respectively (Table 2). Information on the surroundings of the fish sampling sites was not known. However we could suggest the controlled environment in organic fish farming could expose the fish to many chemicals, pesticides alike, as disease preventive measures. This could result in the possibility of pesticides traces to be found in the fish. On the other hand, dilution factor of chemical entities in the water from point source to open sea could hint almost zero pesticides detection in the wild fish. Nevertheless, these results showed persistent characteristic of OC pesticides as the use of OC based pesticides have been limited in Malaysia. In fact, DDT has been banned by Malaysian Board of Pesticides since 1995. Leaching from the agricultural sites and continuous land development has caused the pesticides to find their way into the water system and aqua life.

In order to ensure the reliability of the analysis data, control measures were taken not only during sample collection but also during analysis. For the sample collection, samples were transferred in chilled boxes to prevent degradation of chemicals in the samples and processed immediately. Quality control for analysis was fulfilled by including the internal standards and surrogate standard in sample analysis (Tables 3 and 4).

Table 1: Summary of pesticides detected in the river water samples

Sample Number	Compound	Observed Value	Unit	MDL (ng/L)	Sample Date	Temperature Deg C	Use/Surroundings
1SR01A	p,p'-DDD	0.0428	ng/L	0.0079	6/18/06	28.22	Agricultural, residential and land development
1SR01A	p,p'-DDT	0.1236	ng/L	0.0215	6/18/06	28.22	Agricultural, residential and land development
1SR05A	p,p'-DDD	0.0438	ng/L	0.0079	6/18/06	28.00	Agricultural and land development
1SR01B	p,p'-DDD	0.0388	ng/L	0.0079	8/21/06	29.24	Agricultural, residential and land development
1SR03B	Mirex	0.0478	ng/L	0.0158	8/21/06	26.46	Agricultural, residential and land development

Table 2: Summary of pesticides detected in the fish samples

Sample Number	Compound	Observed Value	Unit	MDL (ng/g)	Sample Date	Length (cm) / weight (kg)	Use/Surroundings
F1A	HCB	0.8360	ng/g	0.63	7/11/07	30.0 / 0.55	Fish farming (obtained from market)
F1B	HCB	0.7968	ng/g	0.63	7/11/07	30.0 / 0.55	Fish farming (obtained from market)
F3A	p,p'-DDT	2.6278	ng/g	1.94	7/15/07	28.0 / 8.99	Obtained from Giant Supermarket (wild fish)
F3B	p,p'-DDT	2.0622	ng/g	1.94	7/15/07	28.0 / 8.99	Obtained from Giant Supermarket (wild fish)

Table 3: Recovery and repeatability check for pesticides in deionized water at 5ppb (n=5)

Compound	Recovery (%)			Repeatability (ng/ml)				
	Average	Deviation	CV	Average	Deviation	CV (%)	3s	10s
HCB	93.33	3.482	3.73	4.67	0.174	3.74	0.52	1.74
Heptachlor	94.14	5.045	5.36	4.71	0.252	5.36	0.76	2.52
Aldrin	84.80	1.192	1.41	4.24	0.062	1.45	0.18	0.62
trans-chlordane	96.15	5.177	5.38	4.81	0.259	5.38	0.78	2.59
o,p'-DDE	97.49	2.918	2.99	4.88	0.145	2.98	0.44	1.45
cis-chlordane	94.37	2.429	2.57	4.72	0.122	2.58	0.36	1.22
Dieldrin	93.83	3.796	4.05	4.69	0.190	4.05	0.57	1.90
p,p'-DDE	94.68	3.320	3.51	4.74	0.166	3.51	0.50	1.66
o,p'-DDD	96.99	2.245	2.31	4.85	0.112	2.32	0.34	1.12
Endrin	84.64	1.917	2.27	4.23	0.098	2.32	0.29	0.98
p,p'-DDD	95.57	1.557	1.63	4.78	0.079	1.65	0.24	0.79
o,p'-DDT	91.97	2.401	2.61	4.60	0.122	2.66	0.37	1.22
p,p'-DDT	97.45	4.250	4.36	4.87	0.215	4.42	0.65	2.15
Mirex	92.89	3.172	3.41	4.64	0.158	3.40	0.47	1.58
p,p'-DDT-13C (%)	101.65	1.143	1.12	101.65	1.143	1.12		

Table 4: Recovery and repeatability check for pesticides in fish (n=5)

Compound	Recovery 50ppb (%)			Repeatability (10ppb)				
	Average	Deviation	CV	Average	Deviation	CV (%)	3s	10s
HCB	99.81	0.985	0.99	10.58	0.063	0.60	0.19	0.63
Heptachlor	101.06	0.860	0.85	11.09	0.055	0.49	0.16	0.55
Aldrin	99.62	1.274	1.28	10.17	0.098	0.97	0.30	0.98
trans-chlordane	99.20	0.836	0.84	10.32	0.097	0.94	0.29	0.97
o,p'-DDE	99.28	1.359	1.37	10.23	0.102	1.00	0.31	1.02
cis-chlordane	99.54	0.941	0.94	11.48	0.060	0.52	0.18	0.60
Dieldrin	102.10	1.582	1.55	10.26	0.081	0.79	0.24	0.81
p,p'-DDE	99.83	1.145	1.15	10.31	0.125	1.21	0.37	1.25
o,p'-DDD	96.72	0.885	0.91	10.97	0.044	0.40	0.13	0.44
Endrin	94.07	1.657	1.76	11.42	0.338	2.96	1.02	3.38
p,p'-DDD	96.14	0.878	0.91	11.15	0.030	0.27	0.09	0.30
o,p'-DDT	96.04	0.674	0.70	11.05	0.140	1.27	0.42	1.40
p,p'-DDT	94.71	1.166	1.23	11.21	0.194	1.73	0.58	1.94
Mirex	99.01	1.188	1.20	11.28	0.115	1.02	0.35	1.15
p,p'-DDT-13C (%)	96.70	3.347	3.46	103.70	4.118	3.97		

Monitoring of POPs' In Pakistan –River Water Bodies and Shrimps

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Abstract

Total 19 samples were collected from five rivers and Arabian Sea in two seasons i.e. pre monsoon and post monsoon to know the level of POPs' pollution in Pakistan. The collected samples were analyzed for fourteen compounds i.e. Heptachlor, Aldrin, trans-chlordane, cis-chlordane, Dieldrin, Endrin, p,p'-DDT, HCB, o,p'-DDT, o,p'-DDE, p,p'-DDE, p,p'-DDD, o,p'-DDD & Mirex, by using GSMS QP 2010 Shimadzu-Japan. Aldrin and Dieldrin were identified in the samples collected from Sutlaj River located at Islam Reservoir in dry and wet seasons. Heptachlor and o,p'-DDD were identified in samples collected from Ravi River located at Balloki Reservoir and Lahore near the Indian border in pre monsoon season. p,p'-DDT and o,p'-DDT were determined in the sample collected from Chenab River located at Marala Barrage in dry and wet seasons respectively. Aldrin was identified in the samples collected from Indus River located at Guddu Reservoir in dry and rainy seasons. 10 Shrimps samples were analyzed for the determination of POPs' in the ecosystem, o,p'-DDE was identified in three shrimps samples and p,p'-DDE was found in only one sample.

Keywords: Water bodies, POPs', Ecosystem, Shrimps, Impacts of POPs'

Organochlorine Pesticides in Water and Sea Bass in Selected Coastal Sites in the Philippines

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Objective:

To determine the concentration of organochlorine pesticides in sea bass (*Lates Calcarifer*) and water from selected coastal areas in the Philippines.

Methodology:

A. Sampling Plan:

1. Identify (in coordination with the Fisheries Aquatic Resources Management Council (FARMC) of the Bureau of Fisheries and Aquatic Resources (BFAR) some coastal areas where wild sea bass (*Lates Calcarifer*) can be caught. Select two coastal sites in Luzon and two in the Visayas
2. For each site, purchase 3 sizes of fish (small, medium and large) from a fisherman. Collect 3 pieces of fish for each size. Store in the freezer the whole fish when analysis cannot be started immediately. Thaw before sample preparation.
3. Collect one liter water sample from the area where the sea bass is caught (0.5 km -2 kms from the shoreline). Collect one water sample (2-1 liter bottles) from each site per sampling period as recommended in the standard methods for analysis of organochlorine pesticides in water (APHA)

Rational for selection of the sites:

Only two sites in Luzon were identified by FARMC where wild sea bass can be caught. These sites are in Naic, Cavite in Manila Bay and in Tagkawayan in Quezon Province.

Several sites in Bohol island and in Cebu Province in the Central Visayas were identified by FARMC. Sampling in these areas would entail considerable expense because we have to take air transportation to get to these areas. Considering the limited budget for this year's project, we decided to get samples from one area in Bohol and one area in Cebu.

B. Actual Sampling

In Luzon, sampling was done only at Tagkawayan, Quezon in Ragay Gulf as no sea bass could be caught in Naic, Cavite. Water sample was collected about ½ kilometer from the shore in Tagkawayan. Nine fish samples of varying sizes were collected. These were classified according to size and weight as small, medium and large corresponding to three composite samples for analysis.

In the Visayas, sampling was done in Barra, Roxas City and in Estancia, Ilo-ilo. One water sample was collected about ½ kilometer from each coastal shore. One fish sample was collected in Roxas City and 7 fishes were collected in Estancia, Ilo-ilo. The fishes from Estancia were classified into 2 groups by length and size. The number and the size of fishes collected in Luzon and Visayas were limited by the availability of the fish caught in the wild.

The locations of the planned and actual sampling sites are shown in Figure 1.
The details of the sampling sites, sampling conditions and the samples collected from each site are listed in Table 1.Photos of the fish samples are shown in Fig 2.

Interaction with people who cooperate with the sampling team has always been an enjoyable experience with the UNU researchers. During sampling, the researchers get a chance to explain to the fishermen cooperators what the UNU project is about. In most cases, many of the fishermen are enthusiastic to help and are very

interested to know the outcome of the sampling from their localities. Figure 2 shows some photographs of the sampling sites and the people who cooperated with the sampling team for this project.

C. Quality Control:

Reagent Blank

One reagent blank was analyzed per batch of analysis. There were 2 batches of 1 to 2 samples per batch of analysis for water samples and 2 batches of 9-12 samples per batch of analysis for the fish samples.

Recovery Test

Table 2 shows the results of recovery of 25 ng spike for 2 batches for water samples and 100 ng spike for 2 batches for fish samples

Quantitation Limit

Table 3 shows the results of the repeated injections of 10 ppb standard solution and the calculation for the quantitation limits for water and fish analysis

Recovery of Surrogate

The recovery of p,p'-DDT-$^{13}C_{12}$ with nominal concentration of 100 ng for water samples and with nominal concentration of 20 ng for fish samples are shown together with the result of OCPs analysis in Tables 4 and 5

D. Analysis Procedure:

The analysis method for water contained in the UNU Manual for Water and the method for fish in the UNU Manual for Aqua Organisms were applied in water and fish samples respectively.

Results of Analysis

The results of analysis of duplicate water samples from the three selected coastal sites in Table 4 showed that organochlorine pesticides were not detected based on the quantitation limit of the UNU method.

The results of analysis of three trials of composite samples of fishes collected from Tagkawayan, Quezon in Luzon and in Roxas City and in Estancia in Ilo-ilo in the Visayas in Table 5 showed that organochlorine pesticides were not detected based on the quantitation limit of the UNU Method. The differences in the length and weight of the groups of fish samples did not indicate a difference in the OCPs contamination in the fish.

Table 2a. Recovery of spiked OCPs in water samples

Batch 1	Spike Soln.	Spk TQ FS W	NET of TQ FS W	% Recovery	Batch 2	Spike Soln.	Spk EI FS W	NET of EI FS W	% Recovery
		Concentration., ppb					Concentratiom., ppb		
alpha BHC	22.206	23.383	23.383	105	alpha BHC	23.2549	23.7602	23.7602	102
beta BHC	17.389	21.4739	21.4739	123	beta BHC	22.7896	23.6046	23.6046	104
gamma BHC	20.5422	21.6323	21.6323	105	gamma BHC	23.5695	21.4449	19.0941	81
delta BHC	18.6519	16.9342	16.9342	91	delta BHC	23.376	17.0678	17.0678	73
HCB	22.726	13.6238	13.6238	60	HCB	21.8082	14.5102	14.5102	67
Heptachlor	23.5163	17.8734	17.8734	76	Heptachlor	20.1426	17.5967	17.5967	87
Aldrin	21.4697	17.0719	17.0719	80	Aldrin	23.4227	16.2043	18.2344	78
Heptachlor epoxide	20.0453	22.867	22.867	114	Heptachlor epoxide	22.1155	21.0159	21.0159	95
gamma chlordane	20.9404	22.1911	22.1911	106	gamma chlordane	20.6309	20.7917	20.5	99
o,p' DDE	22.6827	24.8969	24.8969	110	o,p' DDE	21.2462	21.0043	21.0043	99
Endosulfan I	21.337	23.9209	23.9209	112	Endosulfan I	23.797	21.8703	21.8703	92
alpha chlordane	21.3498	22.9484	23.9484	112	alpha chlordane	19.3485	20.2802	20.3602	105
trans nonachlor	22.0951	22.8449	22.6449	102	trans nonachlor	19.8003	20.1259	20.1259	102
Dieldrin	19.3817	21.9241	21.9241	113	Dieldrin	21.1879	20.7247	20.9937	99
p,p' DDE	22.4559	24.6479	24.6479	110	p,p' DDE	21.0338	20.7943	20.7943	99
o, p' DDD	20.6742	22.8447	22.8447	110	o, p' DDD	21.0722	22.0777	22.0777	105
Endrin	20.8132	21.9345	20.5345	99	Endrin	20.7378	20.5303	20.5303	99
Endosulfan II	16.2592	14.9953	14.9953	92	Endosulfan II	20.7515	3.9228	3.9228	19
p, p' DDD	17.7242	18.8874	18.8874	107	p, p' DDD	21.8337	21.1048	21.1048	97
cis nonachlor	20.228	20.776	20.776	103	cis nonachlor	21.0703	20.5376	20.5376	97
o, p' DDT	20.5054	20.4246	20.5246	100	o, p' DDT	19.8019	21.7113	21.4008	108
p, p' DDT	20.466	22.154	22.154	108	p, p' DDT	20.533	20.6367	20.6367	101
Methoxychlor	18.9728	10.596	11.596	61	Methoxychlor	20.7529	6.8885	6.8885	33
Mirex	21.8739	19.6585	19.6585	90	Mirex	22.5805	20.6945	20.6945	92
p,p' DDT 13C12	85.1195	85.4024			p,p' DDT 13C12	87.8635	85.2738		
% Recovery		100			% Recovery		97		

Table 1. Details of sampling sites, sampling conditions and samples collected for the UNU 2007 Monitoring Project

Location	Coordinates		Date and time of sampling	Weather Conditions	Water Samples		Sea Bass Samples	
	latitude	longitude			Sampling condition	Sample Code	Sampling Condition	Sample Code
Tagkawayan, Quezon Coastal Area in Ragay Gulf	13°57'30N	122°32'10E	July 18, 2007, 2:30 P.M	Sunny	Collected at surface Depth of water, 3m	TQFS-W	Wild 9 samples (165-205grams) collected within several days	TQFS-S1 TQFS-S2, TQFS-S3
Barra, Roxas City Coastal Area: Mouth of Panay River in Visayan Sea	11°35'09N	122°43'08E	September 19, 2007 9:15 A.M	Cloudy, Drizzling	Collected at surface Depth of water, 2m	RCFS-W	Wild One sample (921 grams) collected over one week monitoring of catch	RCFS-S
Estancia, Ilo-ilo Coastal Area Visayan Sea	11°27'12N	123°09'21E	September 19, 2007 1:15 P.M	Cloudy, Raining	Collected at surface Depth of water, 3m	EIFS-W	Wild 7 samples (106-194 grams) collected in one day	EIFS-S1 EIFS-S2

Table 2b. Recovery of spiked OCPs in fish samples

Batch 1 Concentration	Spk Soln. ng/ml	Spk (ng/g ww.)	Net Spk TQFS S3 (ng/g ww.)	% Recovery	OCPs Batch2 Concentration	Spk Soln. ng/ml	Spk (ng/g ww.)	Net Spk RCFS S ng/g ww	% Recovery
Weight of fish sample		5.0938			Weight of fish sample		5.0701		
OCPs					OCPs				
HCB	88.1383	17.30305	8.842965959	51	HCB	89.1463	17.58275	13.3109012	76
Heptachlor	92.3119	18.1224	12.89793474	71	Heptachlor	92.2644	18.19775	16.6231633	91
Aldrin	92.2625	18.11271	14.6914288	81	Aldrin	91.951	18.13593	19.9714404	110
trans-chlordane	92.964	18.25042	17.92084495	98	trans-chlordane	96.0642	18.9472	19.3855945	102
o,p'-DDE	92.3964	18.13899	17.09792297	94	o,p'-DDE	93.3314	18.4082	18.4488077	100
cis-chlordane	91.6063	17.98388	17.73100632	99	cis-chlordane	88.5452	17.46419	18.4875051	106
Dieldrin	95.1756	18.6846	17.59601869	94	Dieldrin	101.549	20.02899	19.2748325	96
p,p'-DDE	91.4724	17.9576	16.92693078	94	p,p'-DDE	92.3981	18.22412	18.2643143	100
o,p'-DDD	99.6412	19.56127	19.44652322	99	o,p'-DDD	100.1738	19.75776	20.7432595	105
Endrin	94.4493	18.54201	17.71834387	96	Endrin	94.5181	18.64226	23.7746198	128
p,p'-DDD	101.7301	19.97136	20.49593447	103	p,p'-DDD	100.394	19.80119	22.7779609	115
o,p'- DDT	91.6527	17.99299	19.71940429	110	o,p'- DDT	90.2016	17.79089	20.8777379	117
p,p'-DDT	95.333	18.7155	19.78151871	106	p,p'-DDT	97.7109	19.27199	21.4959665	112
Mirex	92.6843	18.19551	19.07852684	105	Mirex	91.7801	18.10223	19.2259522	106
Other OCPs					Other OCPs				
alpha-BHC	90.1924	17.70631	0	0	alpha-BHC	91.9116	18.12816	0	0
beta-BHC	117.0444	22.97782	0	0	beta-BHC	119.9585	23.65999	20.7429439	88
gamma-BHC	98.9811	19.43168	17.45873415	90	gamma-BHC	99.4115	19.6074	21.4314708	109
delta-BHC	102.8066	20.18269	0	0	delta-BHC	104.3244	20.5764	0	0
Heptachlor epoxide	95.7454	18.79646	18.4304803	98	Heptachlor epoxide	95.2158	18.77987	18.5812114	99
Endosulfan I	97.8713	19.21381	20.53653461	107	Endosulfan I	98.4025	19.40839	17.4699537	90
trans-nonachlor	93.8148	18.41745	17.73228238	96	trans-nonachlor	95.153	18.76748	19.9120833	106
Endosulfan II	97.4692	19.13487	0	0	Endosulfan II	103.7696	20.46697	0	0
cis-nonachlor	92.4895	18.15727	19.4194511	107	cis-nonachlor	96.8946	19.11098	20.0568036	105
Methoxychlor	98.0242	19.24383	19.55817458	102	Methoxychlor	101.547	20.0286	22.3811945	112
p,p'-DDT-13C12	20.0484		18.8876		p,p'-DDT-13C12	20.6168		19.3628	
% Recovery			94		% Recovery			94	

Table 3. Quantitative Limit for water and fish analysis

OCPs	Concentration, ng/ml 1	2	3	4	5	Mean	s	3s	10s	QL 10s D.F=1ml/1000ml	QL Water µg/L	QL 10S D.F. = 1mL/5g	QL Fish ng/g
HCB	10.4712	10.9376	10.7026	10.8664	10.5484	10.70524	0.19959	0.598769	1.995897	0.001996	**0.002**	0.399179	**0.4**
Heptachlor	11.2431	11.174	11.5194	11.2405	10.9848	11.23236	0.191876	0.575628	1.918759	0.001919	**0.002**	0.383752	**0.4**
Aldrin	10.3267	10.5934	10.4247	9.8237	10.2997	10.29364	0.286795	0.860386	2.867953	0.002868	**0.003**	0.573591	**0.6**
trans-Chlordane	12.2404	12.1796	11.5789	12.7039	10.9025	11.92106	0.695737	2.08721	6.957365	0.006957	**0.007**	1.391473	**1**
o,p'-DDE	11.5518	10.6802	11.1401	11.2835	10.4091	11.01294	0.462353	1.387059	4.62353	0.004624	**0.005**	0.924706	**0.9**
cis-Chlordane	9.1713	9.9413	10.5949	10.4923	9.9359	10.02714	0.567204	1.701611	5.672038	0.005672	**0.006**	1.134408	**1**
Dieldrin	11.7506	10.7	11.6986	12.7363	10.7534	11.52778	0.840273	2.520818	8.402727	0.008403	**0.008**	1.680545	**2**
p,p'-DDE	11.0287	10.5734	10.5088	11.1706	10.305	10.7173	0.366272	1.098817	3.662723	0.003663	**0.004**	0.732545	**0.7**
o,p'-DDD	11.0813	10.7577	11.4021	10.8219	10.8381	10.98022	0.265979	0.797936	2.659786	0.00266	**0.003**	0.531957	**0.5**
Endrin	8.8344	9.1919	8.4644	8.2399	9.5277	8.85166	0.523763	1.57129	5.237633	0.005238	**0.005**	1.047527	**1**
p,p'-DDD	10.6122	9.9475	9.6587	9.8508	10.4394	10.10172	0.405472	1.216415	4.054716	0.004055	**0.004**	0.810943	**0.8**
o,p'-DDT	9.2118	9.5873	10.1948	9.1636	9.6988	9.57126	0.418546	1.255639	4.185463	0.004185	**0.004**	0.837093	**0.8**
p,p'-DDT	10.4461	10.2997	10.0144	10.3849	10.7542	10.37986	0.266707	0.800121	2.667069	0.002667	**0.003**	0.533414	**0.5**
Mirex	11.1348	11.0459	11.0176	10.7403	11.2906	11.04584	0.20123	0.603689	2.012297	0.002012	**0.002**	0.402459	**0.4**
Other OCPs													
alpha BHC	10.7331	11.4038	11.523	11.363	11.9887	11.40232	0.449391	1.348173	4.493909	0.004494	**0.004**	0.898782	**0.9**
beta BHC	11.4739	12.2798	12.0837	13.6534	12.3349	12.36514	0.797077	2.391232	7.970772	0.007971	**0.008**	1.594154	**2**
gamma BHC	11.3529	10.1557	10.9363	10.148	10.571	10.63278	0.518925	1.556774	5.189246	0.005189	**0.005**	1.037849	**1**
delta BHC	9.8073	11.6817	10.8503	11.0604	11.515	10.98294	0.737746	2.213238	7.377459	0.007377	**0.007**	1.475492	**1**
Heptachlor epoxide	10.658	9.5393	9.5299	11.7042	10.4251	10.3713	0.903035	2.709106	9.030354	0.00903	**0.009**	1.806071	**2**
Endosulfan I			12.7898	8.6642	9.796					0			
trans nonachlor	10.084	10.0473	11.0688	12.0315	10.3921	10.72474	0.837574	2.512722	8.37574	0.008376	**0.008**	1.675148	**2**
Endosulfan II										0			
cis nonachlor	8.939	10.6215	10.5672	10.5918	10.8457	10.31304	0.776074	2.328223	7.760742	0.007761	**0.008**	1.552148	**2**
Methoxychlor	10.2384	11.6314	11.2678	10.9907	11.2244	11.07054	0.518647	1.555942	5.186472	0.005186	**0.005**	1.037294	**1**

Table 4. Concentration of OCPs in water samples

OCPs	Ragay Gulf		Visayan Sea		Mouth of Panay River / Visayan Sea		MDL, NSRI	UNU,QL
	Tagkawayan, Quezon		Estancia, Iloilo		Barra, Roxas City			
	TQFS-WA	TQFS-WB	EIFS-WA	EIFS-WB	RCFS-WA	RCFS-WB		
	Concentration, ug/L based on NSRI MDL Limit							
HCB	ND	ND	ND	ND	ND	ND	0.009	0.002
Heptachlor	ND	ND	ND	ND	ND	ND	0.002	0.002
Aldrin	ND	ND	ND	<MDL	<MDL	ND	0.001	0.003
trans-Chlordane	<MDL	<MDL	ND	ND	ND	ND	0.004	0.007
o,p'-DDE	ND	ND	<MDL	ND	<MDL	<MDL	0.002	0.005
cis-Chlordane	<MDL	<MDL	ND	ND	<MDL	ND	0.002	0.006
Dieldrin	ND	ND	ND	ND	ND	ND	0.001	0.008
p,p'-DDE	ND	ND	<MDL	ND	<MDL	<MDL	0.001	0.004
o,p'-DDD	ND	ND	ND	<MDL	<MDL	ND	0.002	0.003
Endrin	ND	ND	0.0045	ND	ND	ND	0.002	0.005
p,p'-DDD	ND	ND	<MDL	ND	<MDL	ND	0.0009	0.004
o,p'-DDT	<MDL	ND	ND	ND	ND	ND	0.002	0.004
p,p'-DDT	ND	<MDL	ND	ND	<MDL	<MDL	0.002	0.003
Mirex	ND	ND	ND	ND	ND	ND	0.002	0.002
Other OCPs								
alpha BHC	ND	ND	ND	ND	ND	ND	0.002	0.004
beta BHC	ND	ND	ND	ND	ND	ND	0.02	0.008
gamma BHC	ND	ND	<MDL	ND	ND	<MDL	0.002	0.005
delta BHC	ND	ND	ND	ND	ND	ND	0.02	0.007
Heptachlor epoxide	ND	ND	ND	ND	ND	ND	0.002	0.009
Endosulfan I	ND	ND	ND	ND	<MDL	<MDL	0.02	
trans nonachlor	ND	ND	<MDL	ND	ND	<MDL	0.002	0.008
Endosulfan II	ND	ND	ND	ND	ND	ND	0.009	
cis nonachlor	ND	ND	<MDL	ND	<MDL	ND	0.0008	0.008
Methoxychlor	ND	ND	ND	ND	ND	ND	0.0004	0.005
% Rec.: p,p'-DDT-$^{13}C_{12}$	100.2	99.6	97.9	92.8	93.0	97.0		

NSRI limit is based on 3s of repeated (n=8) analysis of 3-25 ppb spiked sample.
UNU limit is based on 10s of repeated injection of 10 ppb standard solution in the GCMS
All samples are ND based on UNU QL

Table 5. Concentration of OCPs in fish samples

	TQ FS1			TQ FS2			TQ FS3			EI FS1			EI FS2			RC FS1			QL, UNU
	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	a	b	c	
% Moisture, ave		80.20			81.90			81.20			76.50			77.60			76.00		
Wax, mg/g		3.59			2.92			4.30			3.93			3.75			4.52		
OCPs								Concentration, ng/g wet weight											
HCB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.40
Heptachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.38
Aldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.57
trans-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.39
o,p'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.92
cis-Chlordane	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.13
Dieldrin	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.68
p,p'-DDE	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.73
o,p'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.53
Endrin	ND	2.20	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.05
p,p'-DDD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.81
o,p'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.84
p,p'-DDT	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.53
Mirex	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.40
Other OCPs																			
alpha BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.90
beta BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.59
gamma BHC	ND	ND	3.40	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.04
delta BHC	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.48
Heptachlor –epox.	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.81
Endosulfan I	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.20	ND	ND	ND	1.70	ND	2.20	
trans nonachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.68
Endosulfan II	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	
cis nonachlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.55
Methoxychlor	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1.04
% Rec.: p,p'-DDT-13C12,	92.20	91.32	98.10	99.10	84.50	82.80	87.60	89.40	98.50	97.40	82.40	87.80	61.90	89.90	99.80	97.40	97.80	102.60	

Persistent Organic Pollutants in Singapore's Environment

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Introduction

Over the years, widespread contamination of persistent organic pollutants (POPs) such as organochlorine pesticides (OCPs) have caused great harm to human beings and the environment. These xenobiotic pollutants are toxic and ubiquitous in the global environment [1-3]. As these pollutants are lipophilic and persistent in nature, they can readily undergo bioaccumulation and biomagnification in the food chain [4,5]. Certain POPs such as lindane have already been identified to be possible carcinogens and there is growing evidence that these chlorinated compounds have the potential to cause endocrine disruption in biota by impacting upon reproductive and hormonal functions [6,7]. POPs are introduced into the environment via atmospheric deposition, oil spillages, sewage discharges, and the food chain through the consumption of seafood [8]. In consideration of the health hazards posed by these chlorinated compounds, production of POPs has been banned in many countries. Nonetheless, OCPs has continued to be routinely detected in marine life, wildlife, human adipose tissues, serum, breast milk, soils and sediments because of their former use, accidental spills, high persistence and low biodegradability [9-11]. Analysis of pesticides at trace levels in the environmental and food samples poses special challenges for analytical chemists, since the pesticides are present at low level concentrations.

The objective of the present investigation was to determine the concentrations of POP residues in the coastal waters, seafood samples and human tissue samples in order to attempt the determination of the status and trends of contamination by POPs in the Singapore environment.

Monitoring of Seawater, Shrimps and Human Tissue

Selection of locations and sampling conditions

Surface seawater samples (from 13 locations) were collected along the Singapore coastline from 2002 to 2006 (Figure 1) Surface seawater samples were collected in precleaned glass bottles and seawater samples were stored at -4°C until analysis. There are no seasons in Singapore. Weather conditions are generally constant, usually warm, humid and abundant rainfall can be experienced throughout the year.

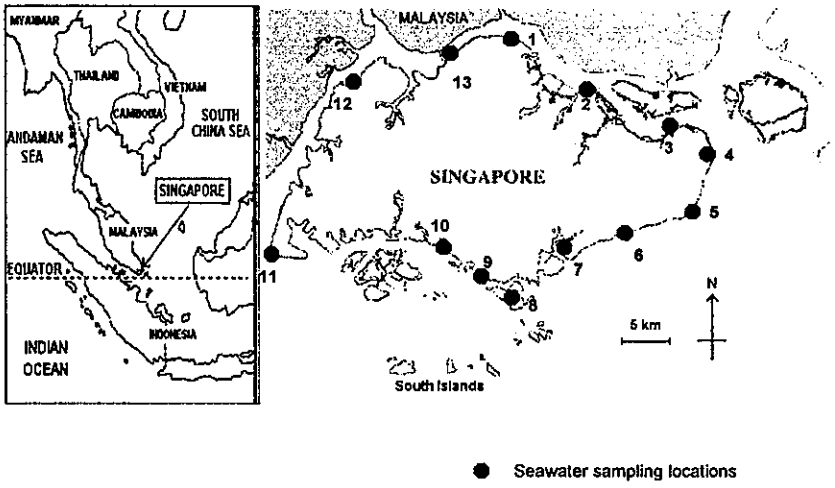

Figure 1. Baseline monitoring locations 2002-2006

Shrimp samples were purchased local supermarket and extracted and analysed for the presence of POPs. Specific sources of the shrimp sample were not known, however (it is believed that most were imported from (a) foreign country or countries).

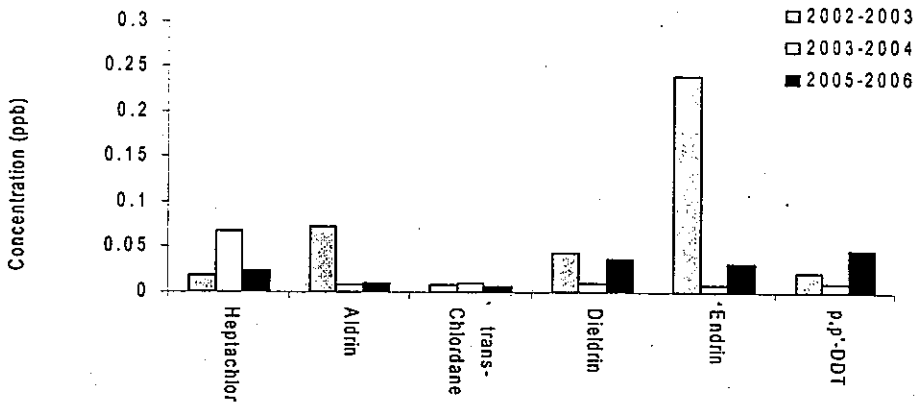

Figure 2. Concentration of selected pesticides monitored in Singapore's coastal waters from 2002 to 2006

POPs in seawater samples

Figure 2 shows the concentration data of selected pesticides from the 2002 to 2006 monitoring programmes. Pesticides were detected in all 13 sampling locations. Results from this study illustrate the extent of pollution of these compounds and despite the relatively small size of the overall sampling area, there was considerable variation in the concentration levels from the sites. The overall mean concentration of OCPs varied from 0.01 to 0.23 μg/L and the highest amounts of endrin was detected at year 2002-2003 sampling period. However, the overall concentrations were within the limits of 0.04 μg/L in recent years. Surprisingly, *p-p'*-DDT concentration has increased slightly over the years. This could be due to its longer half-life time (over 5 years) and regular inputs derived, perhaps, from agriculture runoff from foreign countries (these may also include industrial, manufacturing discharge and municipal sewage disposal).

Analysis of shrimp samples and comparison with water samples

Human exposure to POPs can occur by various routes, with food being the primary source. A number of studies have shown that the major food sources for these organic pollutants are fat-containing animal products, including shrimp and other seafood samples [25]. We have collected shrimp samples from different supermarkets around Singapore and analysed them for POP contamination.

Twenty-five shrimp samples were sampled. The concentrations of pesticides in the samples were in the range of between 0.01 and 0.04 ng/g. In comparison with seawater samples, for obvious reasons (since the shrimps were all imported), there is no distinct trend observed in terms of the link to bioaccumulation.

Determination of pesticides in human ovarian cancer tissue samples

All human ovarian samples used in this study were collected following approval from the Domain Specific Review Board, National Health Group, Singapore. Samples were collected from patients post-operatively and immediately stored at −80°C. Since the amount of each cancer tissue sample was too small to use the United Nations University/Shimadzu Corporation method, we have developed a novel microextraction technique to quantify pesticides and chlorinated biphenyl (CB) congeners concentrations [12] in these samples. The concentrations of these compounds present in the ovarian cancer tissues are reported in Figure 4. Two compounds, *p,p'*-DDD (P=0.009) and *p,p'*-DDT (P=0.045) showed statistically significant differences in the accumulation patterns in benign cases compared to cancer cases.

Hexachlorobenzene and chlorobiphenyl-28 (CB-28) showed higher accumulation in cancer tissue (10 cancer cases). However, the p values (0.094 and 0.117 respectively) were not statistically significant. The study has to be carried out on a larger sample set to get more meaningful results. Nevertheless, this preliminary study [12] is highly promising insofar that microextraction is a feasible technique for extracting low concentrations of POPs from small amounts of biological tissue.

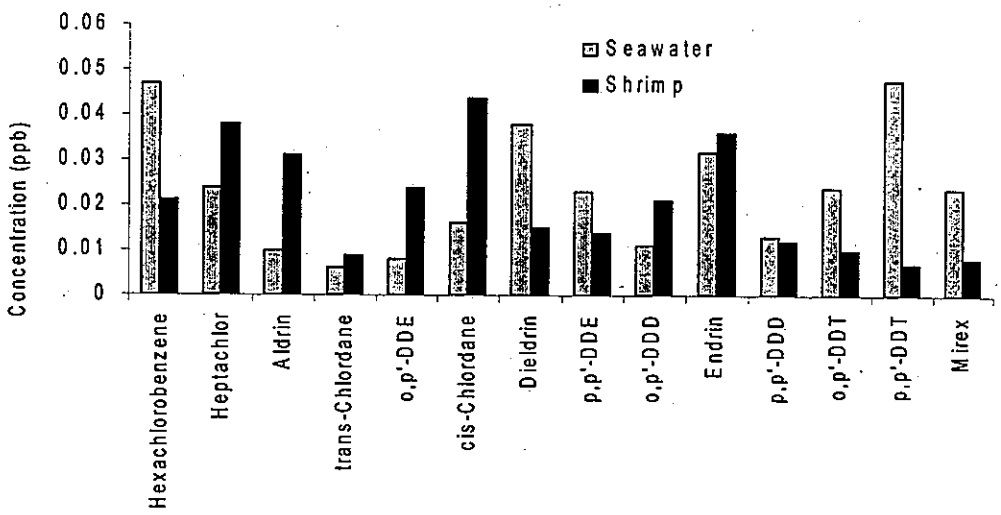

Figure 3. Concentrations of pesticides in shrimp and seawater samples

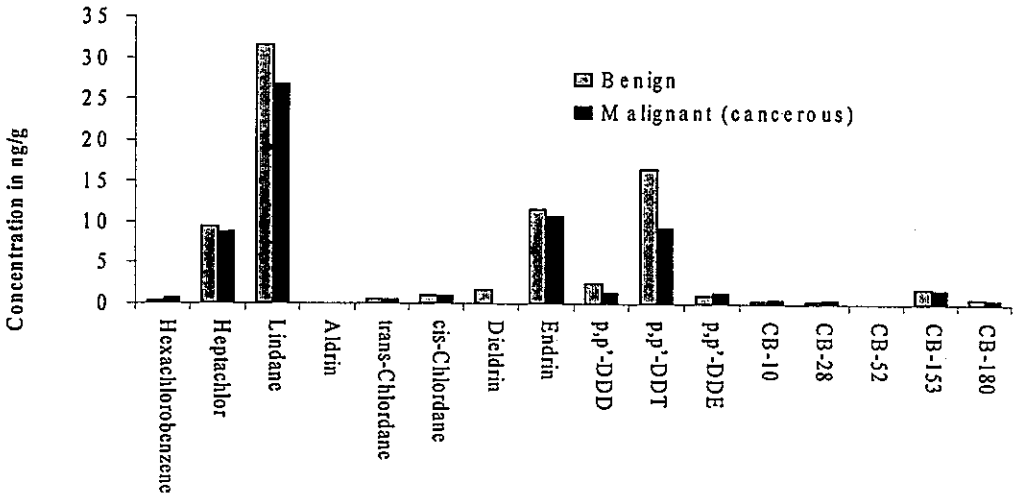

Figure 4. Concentrations of POPs in ovarian tissue samples

Conclusion

Current study shows the distribution of persistent organic compounds present in Singapore's environment and human tissue samples. The levels of POPs measured can be said to be in the moderate range. This is not surprising, as extensive agricultural activities in Singapore have been phased out for more than two decades. However, these POPs are persistent and atmospheric deposition could be

the source of entry to our environment. Conventional extractions such as liquid-liquid extraction and Soxhlet extraction are not selective enough to meet the needs for environmental monitoring, food safety and food regulatory requirements. Pesticide detection methods are becoming more specific and sensitive; yet, to achieve the desired specificity and sensitivity there is still a need for careful sample preparation. Trace level determination of the target compounds in a complex samples such as milk, blood or other biological matrices is particularly important as it can account for a significant amount of the variability of the extraction method.. More desirable are selective, simple and miniaturized sample preparation methods that are also environmentally-benign that can be applied to routine pesticide analysis. It is expected that a great deal of effort will continue to be expanded along this line in the foreseeable future.

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Monitoring and Policy of Persistent Organic Pollutants (POPs) in Thailand

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Abstract

The demand of agricultural productivity and the expansion of industry caused a rapid increase in the use of chemicals. In particular, during 1950-1970, most of the pesticides imported were organochlorines, which include such POPs as DDT, endrin, heptachlor and so on as shown in Table 1. Thailand has recognized the problem of chemical hazards, and considers the health and environmental concerns that they pose as apriority for action. Under the Stockholm Convention activities on Persistent Organic Pollutants (POPs), Thailand has developed a National Implementation Plan (NIP) to demonstrate how the obligation contained in Article 7 of Convention will be implemented. Most of POPs pesticides under the Stockholm Convention have been banned for importation since 1980. There are numerous chemicals considered as severely restrict or banned for agricultural and public health use as shown in Table 2. The use of POPs pesticides has been banned in Thailand for a long period of time. However, there are some stockpiles of obsolete and POPs pesticides scattered around the country. There are no specific measures for eliminating these stockpiles.

The survey and monitoring of organochlorine residues in the environment was first initiated in 1976 and had continued for ten year till 1985. The work was emphasized mainly on water, sediment, soil, fish and shellfish collected from various site in our country. In addition to share the data among the Asian countries, the cooperative monitoring program between Environmental Research and Training Center and the United Nations University was established under Environmental Monitoring and Governance in the Asian Coastal Hydrosphere Monitoring of POPs in the Asian Region in 2007.

Table 1 Import of pesticides during 1977-2003

Year	Insecticides	Fungicides	Herbicides	Other
	Quality (Ton/ai)	Quality (Ton/ai)	Quality (Ton/ai)	Quality (Ton/ai)
1977	2,806	1,131	2,874	44
1987	5,881	4,530	3,967	247
1997	7,526	4,588	14,403	610
2000	6,608	4,375	17,809	1,859
2001	21,255	5,369	20,662	1,569
2002	10,116	5,681	22,670	1,234
2003	10,622	6,732	31,879	1,353

Source: Department of Agriculture

Table 2 Organochlorine pesticides banned and/or restricted under the Ministry of Agriculture and Cooperatives, Thailand

chemicals	Date of Ban
HCHs	1980
dieldrin	1988
DDTs	1983 (AG) 1994 (PH)
aldrin	1988
endrin	1981
toxaphene	1983
heptachlor	1988
Mirex	1995
chlordane	1995 (PH) 2000 (AG)

Source: Department of Agriculture, AG: agricultural use, PH: public health use

The monitoring program was focused on fish samples from the Gulf of Thailand. The sampling locations were showed in Figure 1. The fish was collected 20 samples and analyzed for POPs such as heptachlor, endrin, aldrin, dieldrin, DDT-isomers. The objectives are to assess the status of POPs accumulation in fish samples and to know the relationship of POPs chemicals in biota and sediment samples.

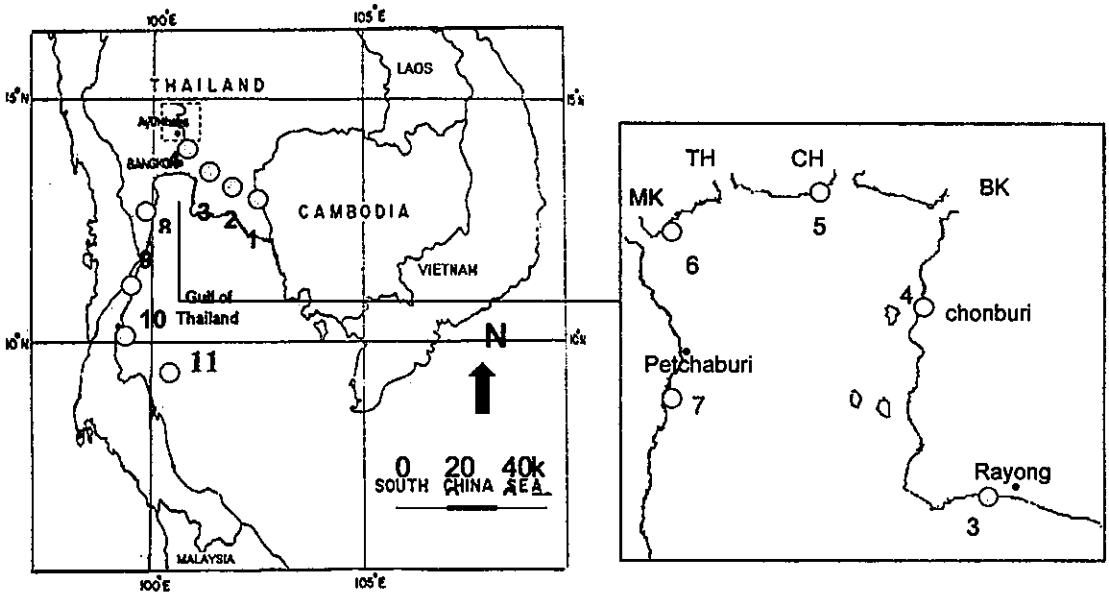

Figure 1 Sampling locations of fish samples from the Gulf of Thailand

Keywords: monitoring, UNU, POPs, fish, Gulf of Thailand