TWELVE POPS IN TAIWAN

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Over the past few years, issues emphasizing the impact of environmental endocrine disrupters have focused on a dozen persistent organic pollutants (POPs), namely dioxins, furans, endrin, aldrin, DDT, chlordane, dieldrin, heptachlor, hexachlorobenzene (HCB), mirex, polychlorinated biphenyls (PCBs), and toxaphene. Among these 12 POPs, nine are organochlorine pesticides. These chemicals exhibit resistance to biological, physical, and chemical breakdown processes in the environment and can accumulate in organisms. Furthermore, atmospheric transportation renders them global contaminants, and they can even be detected in the polar environments, as well as in organisms in these regions. POPs can alter the early development and normal reproductive, neurological, and immunological functions in humans as well as wildlife, resulting in adverse health effects and ecological disturbance. Some of the POPs were also classified as carcinogenic to humans.

In 1997, the United Nations Environment Programme (UNEP) was requested by different governments to convene negotiations of treaties to reduce and/or eliminate releases of POPs into the environment. At the same time, academic and governmental scientists and various environmental groups also suggested immediate actions by UNEP and others to address POPs problems. On 10 December 2000 in Johannesburg, South Africa, diplomats from 122 countries finalized the text of a legally binding treaty for POPs. The treaty is expected to be formally adopted and signed by plenipotentiaries at a diplomatic conference in Stockholm on 22 May 2001. Although the whole processes for resolving the POPs problem via this commitment will still take several years, this is an important step for protecting our present and future generations and our ever fragile ecosystems from POPs.

Under the Taiwan Pesticide Control Act (TPCA), Taiwan banned from agricultural use organochlorine pesticide POPs consecutively from 1971. Starting in 1988, the Taiwan Environmental Protection Administration (TEPA) listed the 10 of the 12 POPs (excluding dioxins and furans) as regulated toxic chemicals under the Taiwan Toxic Substances Control Act (TTSCA). Table 1 outlines the current statuses of the 10 POPs in Taiwan. However, due to the persistency of these compounds and the quantity used during the early years, they are still prevalent in different environmental matrices, such as soil, sediment and biota, even though over 10 years have passed since the complete banning. Information regarding these toxic chemicals in our environment, as well as in the general population in Taiwan, is very limited and not up-to-date. Moreover, human exposure via different pathways, especially via ingestion of contaminated foods, and the associated risks have not been characterized. POPs management in Taiwan still has a long way to go.

Recently, we conducted a study to gather all the 12 POPs information available to us in Taiwan, in order to gain insight into POPs contamination in our environment. This study was funded by TEPA, and the results provide basic yet vital information for future works on environmental management of POPs. In the following paragraphs, we summarize the results of our investigation.

Dioxins and furans are the most toxic among POPs and are generated mostly by various kinds of incineration processes, such as municipal waste incineration and cement production. We estimated a total of 57 g-TEQ of dioxins/furans released into the environment annually from several different sources. However, we think this figure is underestimated because not all known sources of dioxins/furans were included for the assessment. Full discussions and the calculation scheme were detailed in our report for TEPA. Table 2 illustrates the inventory of dioxins/furans emissions in Taiwan.

Determination of dioxins/furans in the environment has only been done during the past 10 years in Taiwan. Most of the studies focused on the Er-Jen River area, Tainan, where open-air incineration of scrape metals and cables/wires for reclamation of precious metals were located from the 1970’s to the present. Data from reports on dioxins/furans analysis in samples from different environments are tabulated in Table 3.

A research group from Taiwan National Cheng Kung University recently quantified human levels of dioxins/furans. Using samples from the same blood bank, they reported averages of 43 and 67 pg-TEQ/g-lipid in human serum samples analyzed in 1998 and 1999, respectively. In 1998, in a survey of dioxins/furans levels in serums from 50 residents near an incinerator in Tainan before it’s commence for operation, they found an average level of 47.3 pg-TEQ/g-lipid.

There was no information available regarding dioxins/furans in regular foods in Taiwan.

Dioxins and furans are not regulated under either TPCA or TTSCA, since they are not commercial products. However, there are a few regulations for their emission into the environment. For instance, dioxins/furans concentrations in stack flue gas for municipal waste incinerators treating wastes over 300 tons per day should be less than 0.1 ng-TEQ/m^3. TEPA has just started to regulate small and medical waste incinerators. Taiwan Bureau Standards, Metrology and Inspection adopted an interim standard of 5 pg-TEQ/g-lipid for milk and dairy products after the dioxin contamination incident in Belgium last year.

PCBs are still in service for electrical capacitors and transformers in Taiwan until 31 December 2000. Releases of PCBs from known sources in the environment cannot be calculated due to limited information, but were considered minor. However, PCBs were found to be ubiquitous environmental contaminants in Taiwan. Heavy contamination was detected at the Er-Jen River area and at several storage areas for discarded equipment containing PCBs. There were only a few reports focusing on dioxin-like (or coplanar) PCBs, which exhibited similar toxicity to dioxins/furans. Table 4 summarizes PCBs levels in different environment matrices and foods.

Average background levels of PCBs in Taiwanese were reported to be in the range of several ppb by different investigators during and after the Yu-Cheng incident involving ingestion of PCBs contaminated rice oil during 1979, but the present level (within the last 10~15 years) has not been investigated. An average of 6.5 pg-TEQ/g-lipid for coplanar PCBs in two pooled serum samples from children was reported in 1994.

Use of PCBs will be banned as of 31 December 2000 under TTSCA. Taiwan Waste Management Act also authorized TEPA to regulate the treatment, storage and disposal of wastes containing PCBs. The maximal contamination levels (MCLs) of PCBs in various types of foods have been set by Taiwan Department of Health (TDOH).

Nine organochlorine pesticides among the 12 POPs have been banned in Taiwan for about 10 years or so, but there were several investigations which showed their presence in our environment. Table 5 shows the data in the literature. It should be noted that there was no information on toxaphene, chloradane, and mirex.

There was only very little information about organochlorine pesticides in food products. TDOH, as well as other governmental agencies, did not have food inspection programs running on a routine basis for these chemicals, although they had set MCLs for foods. Taiwan also imports a variety of foods from the mainland China, as well as some Southeast Asian countries, where regulation and management of these POPs are far from stringent and sound. This problem has not yet been addressed. No data on POPs levels in humans is available, as the latest report regarding the 9 organochlorine pesticides in Taiwanese was published in 1985.

TEPA has set different regulations for the 9 organochlorine pesticides, such as levels in water bodies, hazadous waste identification, treatment, storage, and disposal, but not in drinking water.

In conclusion, there is very little information regarding the 12 POPs in Taiwan’s environment. Food consumption is recognized to be the most important exposure pathway for human uptake of POPs. For dioxins/furans, this pathway was estimated to comprise over 90% of all background exposures. In Taiwan, this information is also very limited compared to that in industrialized countries. Without this, risk for the general population cannot be estimated, and consequently, risk management cannot be planned and initiated. Our government needs to recognize the current situation of POPs in Taiwan and to face the problems, which have become not merely regional, but international and global. At the same time, development of different strategies and consequent actions for reducing the releases of and human exposure to POPs are very critical and essential to not only protect our health, but ecological integrity in Taiwan.

Table 1. Current statuses of the 12 POPs in Taiwan.

POPs	**CAS No.**	**TPCA**	**TTSCA**
Chlordane	57-74-9		1988/5/3 banned from use of all purposes, except for researches
DDT	50-29-3	1973/8/1 banned from agricultural use	1989/5/2 banned from use of all purposes, except for researches
Aldrin	309-00-2	1975/1/1 banned from agricultural use	1989/5/2 banned from use of all purposes, except for researches
Dieldrin	60-57-1	1975/1/1 banned from agricultural use	1989/5/2 banned from use of all purposes, except for researches
Endrin	72-20-8	1971/7/1 banned from agricultural use	1989/5/2 banned from use of all purposes, except for researches
Heptachlor	76-44-8	1975/1/1 banned from agricultural use	1989/5/2 banned from use of all purposes, except for researches
HCB	118-74-1		1989/5/2 banned from use of all purposes, except for researches
Mirex	2385-85-5		Never been used
Toxaphene	8001-35-2	1983/7/19 banned from agricultural use	1989/5/2 banned from use of all purposes, except for researches
PCBs	1336-36-3		1988/6/22 banned from manufacture, import, and sale. 2001/1/1 banned for all purposes, except for research

Note: Dioxins and furans are not regulated either under TPCA or TTSCA, since they are not commercial products.

Table 2. Dioxins/furans emission inventory in Taiwan

Sources	Emission factors/ concentrations	Annual activity rate/material consumed	Emissions (g-TEQ/year)	%	Note
Municipal waste incinerators	570 ng/ton waste	21,900 ton/day	3.745(a)	6.6	Estimated by TEPA, assuming 21 incinerators at full operation at 2001
Coal combustion power plants	0.087 ng/kg coal	$38.678x10^{6}$ton	3.365(a)	5.9	Based on consumption of coal at 1999
Industrial oil combustion	0.2 ng/L fuel	$16.874x10^{9}$ L	3.375(a)	6.0	Based on data from 1997
Cement kilns (no hazadous waste)	0.29 ng/kg	$23.85\ x10^{6}$ton	6.917(a)	12.2	
Asphalt mixing plants	14 ng/ton	$13x10^{6}$ton	0.182(a)	0.32	
Vehicle fuel combustion (unleaded gasoline)	1.7 pg/km	11047.4km/car	0.103(a)	0.18	Based on 5.5 million automobiles at 2000
Cigarette smoking	8.6 pg/pack	92 pack	0.0174(a)	0.03	Taiwan population of 22 million
Electric arc furnaces	1.15 ng/kg raw matls.	$6x10^{9}$ kg	6.90(a)	12.2	assuming production equal to amount of raw materials consumed
Secondary aluminum smelting	13.1 ng/kg raw matls.	$33.5x10^{6}$kg	4.39(a)	7.75	assuming production equal to amount of raw materials consumed
Secondary copper smelting	779 ng/kg raw matls.	33,979,859kg	26.47(a)	46.7	assuming production equal to amount of raw materials consumed
Bleached pulp/paper mills	0.97(w)-1.71%，0.07(l)-0.12%，0.13(p)-0.23%				Based on 4.97% of the total emission for this category in USA
2,4-D	0.7μg/kg	205316kg	0.144(l)	0.25	
Vinyl chloride manufacturing	0.01~10mg/100ton VCM raw matls.	$1.494x10^{6}$ton PVC	0.142~141.2(a)		Not included in the summation of the total dioxin emissions
Sewage sludge incineration	6.94 ng/kg raw matls.	4,800ton/year	0.033(a)	0.06	
Land application of sewage sludge	50 ng/kg	69,350ton/	3.47(p)		Not included in the summation of the total dioxin emissions
TOTAL	56.68 g-TEQ/year			100	

Note: Emission factors were adopted from USEPA's 1998 report "The Inventory Of Sources Of Dioxin In The United States".
(a) air
(l) land
(w) water
(p) product, and not released into the environment

Table 3. Dioxins/furans concentrations in various environmental media in Taiwan.

Locations	Sample type	Concentration (TEQ)	Sample size	Note	Year of report
Er-Jen River Area	soil	0.034~13,450 ng/g (d.w.)	6	Near a metal reclamation facility	1992
	sediment	17.6 ng-PCDD+PCDF/g (d.w.)	1	In Er-Jen River	
	Buttom ash	51 ng-PCDD+PCDF/g (d.w.)	1	Metal reclamation bottom ash	
	sediment	0.014~14.2 ng/g (d.w.)	12	In Er-Jen River	1995
	fish	37~2084 pg/g (d.w.)	8	In Er-Jen River	
	sediment	5.72~12,200 ng/g (d.w.)	9	In fish culture ponds near Er-Jen River	1995
	milkfish	0.03~40.1 pg/g (d.w.)	5	In fish culture ponds near Er-Jen River	1995
	crabs	139.4，149.3 pg/g (d.w.)	2	In fish culture ponds near Er-Jen River, heptapancreas	
	milkfish	0.025~0.784 pg/g (d.w.)	8	Fish market	
A pentachlro-phenol plant	soil	0.239~1357 ng/g (d.w.)	13		1997
	tilapia	0.247 ng/g (d.w.)	1	In fish culture ponds near the plant	
	milkfish	0.024~0.123 ng/g (d.w.)	3	In fish culture ponds near the plant	
A organo-chlorine pesticide plant	soil	0.271~1.69 ng/g(d.w.)	2		1998
	soil	0.022~0.084 ng/g (d.w.)	2		
	sludge	0.017~0.027 ng/g (d.w.)	1		
	sediment	0.018~0.054 ng/g (d.w.)	1	Waterway	
A non-organo-chlorine pesticide plant	soil	0.031 ng/g (d.w.)	1		
	soil	0.005 ng/g (d.w.)	1		
	sludge	0.199 ng/g (d.w.)	1		
	sediment	0.019 ng/g (d.w.)	1	Waterway	

Table 3. Dioxins/furans concentrations in various environmental media in Taiwan. (continued)

Location	Sample type	Concentration	Sample size	Note	Year of report
A pulp/paper mill	soil	0.25~0.46 pg/g (d.w.)	2	Pooled samples	1999
	soil	1.13~0.30 pg/g (d.w.)	2	Pooled samples	
	sediment	2.84~7.74 pg/g (d.w.)	2	Wastewater ponds and waterway	
	sludge	3.84~26.52 pg/g (d.w.)	2	Wastewater treatmet	
Different rivers	sediment	0.031~9.634 pg/g (d.w.)	12	12 rivers in Taiwan	1995
Dan-Shei River	sediment	0.03~4.7 pg/g (d.w.)	17		1997
Dan-Shei River	sediment	5.39~8.73 pg/g (d.w.)	16		1999
To-Cheng River	sediment	1.90~2.82 pg/g (d.w.)	4		
Pu-Tsi River	sediment	1.76~1.94 pg/g (d.w.)	4		
Hsing-Chiu area	sediment	0.7~4.6 pg/g (d.w.)	6	waterways	1998
Dan-Shei River	Fish	0.4~3.8 pg/g (w.w.)	10		1998
To-Cheng River	Fish	0.5~0.6 pg/g (w.w.)	3		
Pu-Tsi River	fish	0.7 pg/g (w.w.)	1		
Pu-Tsi River	oyster	1.0 pg/g (w.w.)	1		
Chong-Kong River	fish	0.2、0.5 pg/g (w.w.)	2		
Pu-Tsi River	Fish	0.039~0.171 pg/g (w.w.)	5		1999
To-Cheng River	Fish	0.036~0.137 pg/g (w.w.)	3		
Coastal areas	oyster	0.042~0.447 pg/g (w.w.)	12	From northern to southern Taiwan	
	Tuna fish	0.01~0.83 pg/g (d.w.)	6	Fish market, ave. 0.32 pg/g (d.w.)	1999
	oysters	0.01~1.40 pg/g (d.w.)	10	Fish market, ave. 0.55 pg-TEQ/g (d.w.) or 0.11 pg/g-w.w.	
Chong-Li city	air	0.47、0.20 pg/m^3	2		1999
cities	Leaves	0.32~3.4 pg/g(d.w.)	14	Pine trees	1997
Yung-Kang, Tainan	Leaves	0.25~1.26 pg/g(d.w.)		Banyan trees, near a incinerator	1997

Table 4. PCBs concentrations in various environmental media and foods in Taiwan.

Location	Sample type	Concentration	Sample size	Note	Year of report
Er-Jen River	soil	max. 11.7 μg/g-d.w.	4	Man-Li area	1991
	soil	1.8 μg/g-d.w.	2	bank	1991
	sediment	0.17 μg/g-d.w.	1	bank	
		0.05~1.80 μg /g-d.w.	3	estuary	
	soil	0.45~77 μg /g-d.w.	6	Near a reclamation facity	1991
	sediment	1.6 μg /g-d.w.	1		
	sediment	ND~0.837μg/g-d.w.	20		1998
	sediment	0.67~2.19 μg /g-d.w.	5	0~35 cm sediment	2000
	fish	123.3~2746.5 ng/g-d.w.	8	In the river	1995
	fish	140~9060 ng/g-d.w.	37	In the downstream，average:1020 ng/g-d.w.	1994
		ND~450 ng/g-d.w.	9	In the upstream，average:275 ng/g-d.w.	
	fish	ND~172.5 ng/g-d.w.		In the river	1997
		0.10~0.43 ng/g-d.w.		In the estuary and Key-Long River	
	sediment	9~1030 pg-TEQ/g-d.w.	9	coplanar PCBs	1995
	fish	12~120 pg-TEQ/g-d.w.	8	coplanar PCBs	
	fish	1.13~153 pg-TEQ/g-d.w.	5	Milkfish in culture ponds	1995
	crab	525 pg-TEQ/g-d.w.	1	In fish culture ponds, heptapancreas	
	crab	2,700 pg-TEQ/g-d.w.	1	In the estuary	
	fish	0.195~1.03 pg-TEQ/g-d.w.	3	Fish market	
Dan-Shei River	water	0.01~11.62 μg /l	35		1988
	sediment	0.007~0.121 μg /g-d.w.	5		
	soil	0.0116~0.0437 μg /g-d.w.	4	banks	
	sediment	ND~0.658 μg /g-d.w.	52		1980
	water	ND~1 μg /l	56		
	sediment	0.006~0.066 μg /g-d.w.，		21rivers (0~5 cm)	1994
		0.002~0.030 μg /g-d.w.		21rivers (5~15 cm)	
		0.002~0.033 μg /g-d.w.		21rivers (>20cm)	

Table 4. PCBs concentrations in various environmental media and foods in Taiwan. (continued)

Location	Sample type	Concentration	Sample size	Note	Year of report
Da-Han River	sediment	ND~0.474μg/g-d.w.	24		1998
Wu River	sediment	ND~0.406μg/g-d.w.	20		1998
Kau-Pin River	water	<1~2 ng/l	5		1990
	water	Max. 129 ng/l	3	Wastewater from a pulp/paper mill	
	soil	7~13,707 ng/g	14	An industrial park	
		ND~32 ng/g	14	Different locations	
Northern Taiwan	soil	1.6~960 ng/g	14	Taipei and Tau-Yeng areas	1993
	air	<1~48 ng/m^3	10	Different locations	1990
		119 ng/m^3	1	Coastal areas	
		Max. 75,000 ng/m^3	10	An industrial park	
Southern Taiwan	air	3.22~7.77 ng/m^3	20	Petrochemical and refinery, average 5.02 ng/m^3	1996
		2.62~7.12 ng/m^3	32	Metrpolitain area, average 4.75 ng/m^3	
		1.74~3.37 ng/m^3	12	Rural areas, average 2.61 ng/m^3	
Southern Taiwan	air	2.50 ng/m^3	20	rural	1996
		5.91 ng/m^3	13	An industrial park	
		4.51 ng/m^3	26	urban	
	fish	ND~248 ng/g-lipid	133	Highest 2177.8 ng/g-lipid	1980
	dairy	1.9~395.9 ng/g-lipid	56	Average 82.4 ng/g-lipid	
	fish	0.6~687 ng/g			1984, 1986,1987,1991
	meat	0.7~133.5 ng/g			
	egg	0.1~66.6 ng/g			
	dary	ND~395.9 ng/g			
Key-Long river	fish	5.3 ng/g-w.w.		upstream	1998
		21.25 ng/g-w.w.		downstream	
		23.91 ng/g-w.w.		downstream	

Table 4. PCBs concentrations in various environmental media and foods in Taiwan. (continued)

Location	Sample type	Concentration	Sample size	Note	Year of report
Key-Long River	Fish	ND~839 ng/g-d.w.	36	Average: 73 ng/g-d.w.	1999
Dan-Shei River	Fish	ND~55.43 ng/g-w.w.	15	Average:13.0 ng/g-w.w.	1999
Da-Han River	fish	1.2~14.1 ng/g-w.w.	9		1999
Coastal area	oysters	ND~90.6 ng/g-w.w.	43		1999
	clams	33.52 ng/g-w.w.	1		
	fish	318.13 and 335.6 ng/g-w.w.	2		
	milkfish	229.8 ng/g-w.w.	1		
	shellfish	ND~74 ng/g-d.w.	12	Oyster, clams, mussel, average: 16ng/g-d.w.	1999
To-Cheng River	fish	0.072~0.333 pg-TEQ/g-w.w.	3		1999
Pu-Tsei River	fish	0.071~1.684 pg-TEQ/g-w.w.	5		
Coastal area	oysters	0.002~0.280 pg-TEQ/g-w.w.	14		
Taichoung	milkfish	0.00171~0.34 pg-TEQ/g-w.w.	4		1997
	fish	0.010 pg-TEQ/g-w.w.	10		
	tilapia	0.0102~0.0732 pg-TEQ/g-w.w.	6		
	fish	ND	10		
	cod	0.0694~2.08 pg-TEQ/g-w.w.	12	imported	

Table 5. Organochlrine pesticide POPs in Taiwan's environment and aquatic biota.

Sample type	DDT	Aldrin	Dieldrin	Endrin	Heptachlor	HCB	Note	Year of report
Soil	1974-92 ng/g, 1981-surface 47 ng/g and subsurface 11 ng/g							1985
	DDE 6.7 ng/g DDD 0.3 ng/g DDT 11.5 ng/g	0.4 ng/g	3.7 ng/g		0.3 ng/g epoxide- 0.9 ng/g		Asparagus field surface soil, ave.	1980
	DDE 5.7 ng/g DDD 0.9 ng/g DDT 9.1 ng/g	ND	1.3 ng/g		0.4 ng/g epoxide- 0.3 ng/g		Subsurface soil, ave.	
	TOCs 1.0~40.0 ng/g						Non-agriculture soil	1987
	DDT 30.17, DDD 0.05, DDE 35.91 ng/g	97.54 ng/g	17.41 ng/g		0.74 ng/g		1978, soil in tea fields	1984
	DDT 3.42, DDD 0.89, DDE 1.00 ng/g	1.10 ng/g	0.28 ng/g		One sample detected		1983, 200 samples in 100 tea fields	1984
	DDT 5.13, DDE 8.37 ng/g	7.32 ng/g	1.28 ng/g	ND	5.34 ng/g		12 areas in Taiwan	1997
	Total DDT2.4~78 ng/g						Northern Taiwan	1993
	DDE surface5.82, subsurface 3.54 ng/g, DDT<2 ng/g	<2 ng/g	<2 ng/g		<2 ng/g		204 soil samples	1997
Water	TOCs 0.01~0.36ng/L						Rivers and lakes	1987
	TOCs 0.1~10 ng/L							1987
	TOCs 0.01 ng/L						groundwater	1987
	ND	ND	ND	ND	ND		Pu-Tsie River and To-Cheng River	1998
	ND	ND	ND	ND	ND		Pu-Tsie River and To-Cheng River	1999
Sediment	8~70 ng/g						Coastal areas	1982
	DDT: ND~2.64, DDE: ND~3.89, DDD: ND~3.34 ng/g	ND~0.15 ng/g	ND~5.8 ng/g	ND~2.39 ng/g	ND~1.57 ng/g		Da-Han River	1998

TOCs: total organochlorines

Table 5. Organochlrine pesticide POPs in Taiwan's environment and aquatic biota. (continued)

Sample type	DDT	Aldrin	Dieldrin	Endrin	Heptachlor	HCB	Note	Year of report
Sediment	DDT: ND~4.35, DDE: ND~1.80, DDD: ND~6.04 ng/g	ND~25.5 ng/g	ND~5.37 ng/g	ND~2.07 ng/g	ND~6.99 ng/g		Wu River	1998
	DDT: ND~5.57, DDE: ND~1.69, DDD: ND~3.90 ng/g	ND~20.2 ng/g	ND~1.29 ng/g	ND~1.99 ng/g	ND~26.3 ng/g		Er-Jen River	1998
	DDT:ND, DDD:ND~12.1, DDE:ND~19.6 ng/g	ND~4.25 ng/g	ND~5.43 ng/g	ND	ND		Ma-Chu and Kim-Man	1997
						Ave. 0.5~13.9 ng/g-d.w.	Rivers and esturies in Central and Southern Taiwan	1997
						Ave. 12.1~31.4 ng/g-d.w.	Kouhsoung and Pin-Dong coasts	2000
Fish	Total DDT 22~75 ng/g-w.w.						1972~1974, Da-Du River and Pu-Tsei River	1985
Wild oysters	Total DDT 72 ng/g-w.w.		8 ng/g-w.w.				1972~1974, Da-Du River and Pu-Tsei River	1985
Cultured oysters	Total DDT 6~63 ng/g-w.w.		ND~5 ng/g-w.w.				1972~1974, Da-Du River and Pu-Tsei River	1985
Shellfish	DDT 0~135, DDD ND~3.4, DDE 1.8~18 ng/g-d.w.						Coastal areas 1980~1982	1982

Table 5. Organochlrine pesticide POPs in Taiwan's environment and aquatic biota. (continued)

Sample type	DDT	Aldrin	Dieldrin	Endrin	Heptachlor	HCB	Note	Year of report
Fish	DDE highest 24.5 ng/g-d.w., DDD ND~5.9 ng/g-d.w., DDT ND~6.9 ng/g-d.w.	ND~3.4 ng/g-d.w.	ND~8.0 ng/g-d.w.		ND~8.4 ng/g-d.w.		Chong-Kang River	1995
	DDE 5.1~17.2 ng/g-d.w., DDD 4.5~8.4 ng/g-d.w.						Er-Jen River	1995
	DDE ave. 9.53 ng/g-d.w. (1.02~62.4 ng/g-d.w.), DDD ave. 4.96 ng/g-d.w. (0.52~68.5 ng/g-d.w.		Ave. 5.51 ng/g-d.w.(0.63~28.33 ng/g-d.w.)		Ave. 7.3 ng/g (0.40~34.14 ng/g-d.w.), Epoxide 5.38 ng/g-d.w. (0.42~71.0 ng/g-d.w.)		Key-Long River	1997
Shellfish	ave. DDE 4.4, DDT 4.1 (1.6~27.8 ng/g-d.w.)		<4 ng/g -d.w.	4.1 ng/g-d.w. (1.8~18.4 ng/g-d.w.)	Ave. 4.5 ng/g-d.w.(1.4~46.7 ng/g -d.w.)		Coastal areas, Kim-Man and Ma-Chu	1997
Shellfish	DDE 4.7~163, DDD 3.3~174, DDT3.7~216 ng/g-d.w.		ND	ND	ND		Coastal areas, Kim-Man and Ma-Chu	1996
Oysters	Total DDT ave. 307.0 ng/g-d.w.						Kim-Man	1996

Table 5. Organochlrine pesticide POPs in Taiwan's environment and aquatic biota. (continued)

Sample type	DDT	Aldrin	Dieldrin	Endrin	Heptachlor	HCB	Note	Year of report
Oysters	Total DDT 18.2 ng/g-d.w.						Coastal areas	1996
	Total DDT 337 ng/g-d.w.						Kim-Man	2000
	Total DDT 340 ng/g-d.w.						Ma-Chu	
	Total DDT 34.9 ng/g-d.w.						An-Pin, Tainan	
	Total DDT6.2 ng/g-d.w.						Pon-Hu	
Oysters/ shellfish	DDT 12.9~98.5, DDD 12.5~77.4, DDE 6.9~163.7 ng/g-d.w.						Ma-Chu (n=7)	1997
	DDT 124.5, 130.2 DDD 100.4, 139.1 DDE 52.0, 67.7 ng/g-d.w.						Kim-Man oysters (n=2)	
	DDT 6.2 ng/g-d.w.						Ma-Kong, Pon-Hu	
	DDE 5.4 ng/g-d.w.						Yung-Lin	
	DDT 8.5~124.0, DDD 11.5~57.3, DDE 6.4~21.3 ng/g-d.w.						Chei-Ding	