HISTORICAL USAGE AND POLLUTION STATUS OF HCH AND DDT IN TAIHU LAKE BASIN

Wu HL[1], Jia HL[1], Zhou L[1], Yang M[1], Liu Y[1], Li YF[2,1]
[1]International Joint Research Center for Persistent Toxic Substances (IJRC-PTS), Dalian Maritime University, 1 Linghai Road, 116026, Dalian, China; [2]Science and Technology Branch, Environment Canada, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4

Abstract
This paper investigated the historical usage of HCH and DDT in the Taihu Lake Basin (TLB) and contamination status of these two pesticides in different matrices, such as soil, air, water, sediment, fish, birds, and human milk, in the region. The total usage of HCH and DDT was 619 kt and 43 kt, consisting of 14% and 16% of the total nation's usage. Concentrations of HCH and DDT in all matrices had a declined trend from 1980s to 2000s, indicating the results of the ban of the 2 pesticides in China. This study also shows the "biomagnification effect", which is the increase in concentration of HCH and DDT occurs in a food chain. Although the use of technical HCH was much higher than DDT in TLB, concentrations of ∑DDT were higher than ∑HCH in most matrices in this region, most likely due to more persistencce of DDT than HCH in those matrices. The current pollution levels of HCH and DDT in different matrices in the TLB at the beginning of 2000s are also estimated.

Introduction

Hexachlorocyclohexane (HCH) and Dichlorodiphenyltrichloroethane (DDT) are inexpensive, persistent, broad-spectrum, non-systemic ingested, and contact organochlorine pesticides (OCPs)., Although the use of these two pesticides in agriculture have been banned in China since 1983 due to their toxic and bioaccumulated nature, they have still been observed in the Chinese environment.

Taihu Lake Basin (TLB), including the city of Shanghai, parts of Jiangsu and Zhejiang provinces, is one of the most developed regions in China, and also one of the areas with the highest usage of both technical HCH and DDT in China. In 1980, the usage of technical HCH was 10 kg/hm^2 in the rice paddy in Taihu Lake Region[1]. Between 1952 and 1984, an accumulated usage of technical HCH was 500 kt and 300 kt in Jiangsu and Zhejiang, respectively[2,3]. There have been 5 technical HCH and DDT manufactories in Taihu Lake Basin historically, and only one (Yangzhou Chemical manufacture) continues to produce DDT used for dicofol production now.

The objectives of this study are to compile usage inventories for HCH and DDT, and to assess the current contamination level by these 2 pesticide in environment in the TLB.

Usage Inventories

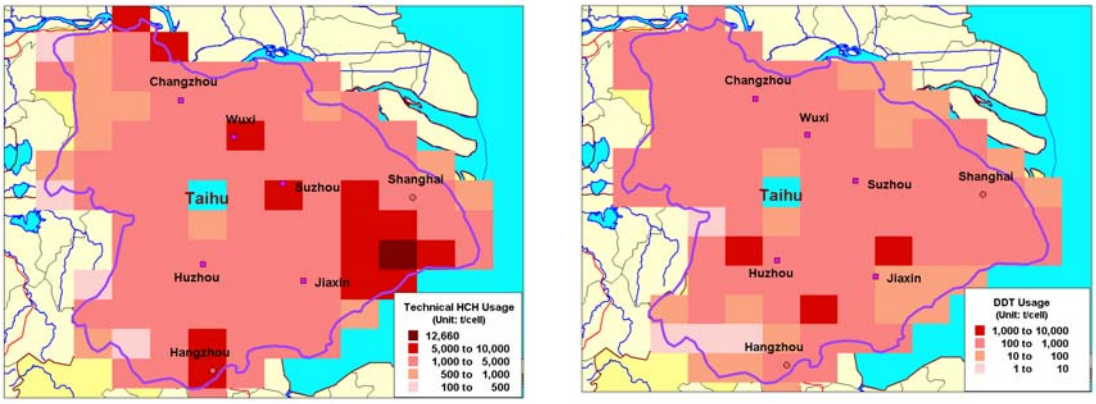

Fig.1 Distribution of accumulated technical HCH (left) and DDT (right) usage between 1952 and 1984 on croplands in TLB with 1/4° longitude by 1/6° latitude resolution. The size of the grid cell is approximately 25 km by 25 km.

Using the same method given by Li et al.[3-5], inventories of technical HCH and DDT with a 1/4° longitude by 1/6° latitude resolution were produced and given by Figure 1. The total usage of technical HCH and DDT was 300 kt and 27 kt, taking up to 7% and 10% of the whole country, respectively.

Residue Levels

Residues in soil. Soil concentrations of HCH isomers and DDT metabolizes for 1979 and 2000-2001 in TLB are presented in Figure 2. Both technical HCH and DDT in soils in TLB reduced dramatically, from 450 to 0.7 ng/g dw (dry weight) for HCHs and from 6700 to 8 ng/g dw for DDT.

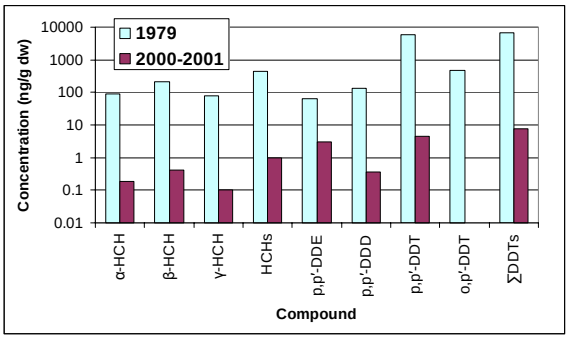

Fig. 2 Soil concentrations of HCH isomers and DDT metabolizes for 1979[6] and 2000-2001[7] in Taihu Lake Basin.

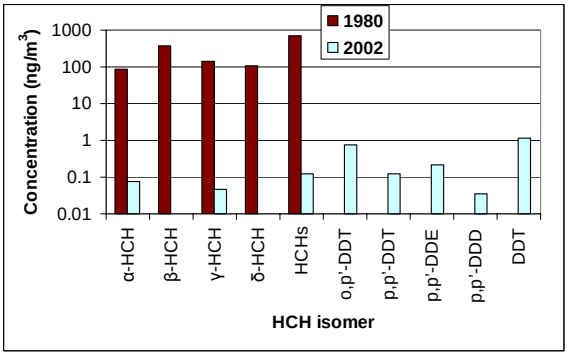

Fig. 3 Air concentrations of HCH isomers and DDT metabolizes for 1980[6] and 2002[8] in TLB.

Residues in air. Figure 3 depicts air concentrations of HCH isomers for 1980 and 2000 and DDT metabolizes for 2000 in TLB. Total HCHs in air in the TLB reduced from 1,280 ng/m^3 in 1980 to 0.12 ng/m^3 in 2002. Total DDTs in air in the TLB was 1.1 ng/m^3 in 2002.

Residues in water. Water concentrations of HCH isomers for 1979, 1980-1988, and 1999-2000 in TLB are shown in Figure 4. Total HCHs in surface water in Taihu reduced from 1,670 ng/L in 1979[6] to 5.2 ng/L in 1999-2000[10]. Total DDTs in surface water in Taihu was 1.3 ng/L in 1999-2000[10].

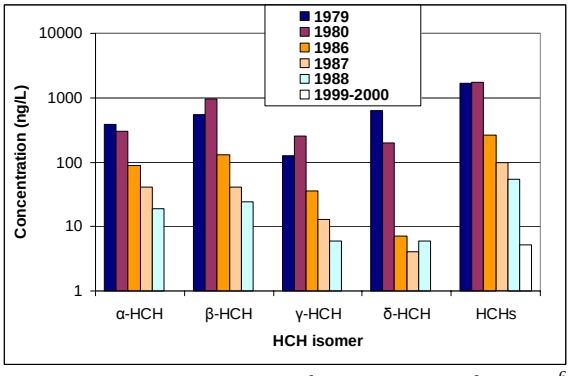

Fig. 4 Water concentrations of HCH isomers for 1979[6], 1980-1988[9], and 1999-2000[10] in TLB.

Residues in sediment. Figure 5 presents sediment concentrations of HCH isomers and DDT metabolizes for 2000-2001[7] in Taihu Lake. In 2000-2001, concentrations in sediments in Taihu Lake was 0.43 ng/g dw for total HCHs and 0.72 ng/g dw for total DDTs.

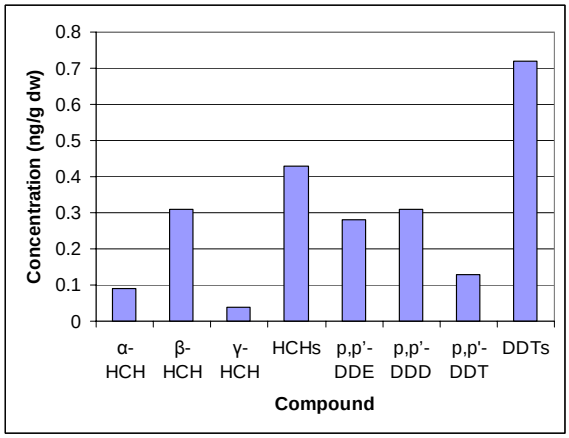

Fig. 5 Sediment concentrations of HCH isomers and DDT metabolizes for 2000-2001[7] in Taihu Lake.

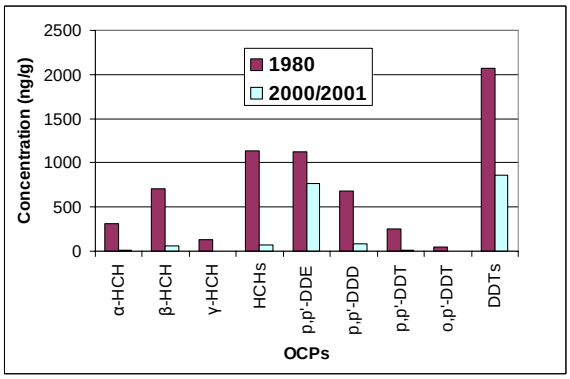

Fig. 6 Concentrations of HCH isomers and DDT metabolizes in fish for 1980[6] and 2000/2001[7] in TLB.

Residues in fish.
Figure 6 depicts concentrations of HCH isomers and DDT metabolizes for 1980[6] and 2000/2001[7] in fish in TLB. Total HCHs in fish in the TLB reduced from 1,140 ng/g in 1980 to 70 ng/g in 2000/2001, and total DDTs reduced from 2,070 ng/g in 1980 to 860 ng/g in 2000/2001.

Residues in birds.
Concentrations of HCH isomers and DDT metabolizes in birds for 2000/2001[7] in TLB are shown Figure 7. Average concentrations in birds were 250 ng/g for ∑HCH and 5,100 ng/g for ∑DDT in the TLB.

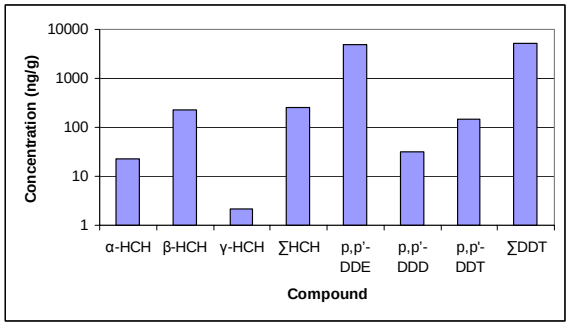

Fig. 7 Concentrations of HCH isomers and DDT metabolizes in birds for 2000/2001[7] in TLB.

Residues in human milk. Figure 8 presents concentrations (ng/g milk fat) of HCH isomers and DDT metabolizes for 1983, 1986, 1988, and 2001 in Shanghai[11]. Concentrations in human milk (in ng/g milk fat) in Shanghai reduced from 22,600 in 1983 to 1,700 in 2002 for β-HCH, the major isomer in HCH in human milk, and from 13,900 in 1983 to 1,200 in 2002 for p,p'-DDE, the major metabolize in DDT in human milk. It is interesting to note that the greatest drop was between 1986 and 1988 for β-HCH, but between 1988 and 2002 for p,p'-DDE. The reason for this is not clear.

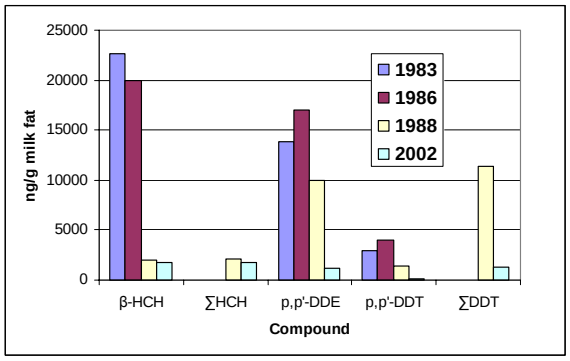

Fig. 8 Concentrations of HCH isomers and DDT metabolizes for 1983, 1986, 1988, and 2001 in Shanghai[11].

It is clear from TLB study that the solution to HCH and DDT was not dilution, because food chains will concentrate these pollutants. This is "Biomagnification effect", which is the increase in concentration of a substance, such as HCH and DDT, which occurs in a food chain. Although the use of technical HCH was much higher than DDT in TLB, concentrations of ∑DDT were higher than ∑HCH in most matrices in this region, most likely due to more persistencce of DDT than HCH in those matrices.

Among 4 isomers of HCH, only β-HCH is the most easily accumulated one in the top of food chain, such as the fish, birds, and human milk. Among DDT metabolizes, p,p'-DDE has the longest accumulation period. In human milk shown in Figure 8, β-HCH/∑HCH and p,p'-DDE/∑DDT are as high as 99% and 90%, respectively.

The estimated current pollution levels of HCH and DDT in different matrices in the TLB at the beginning of 2000s are shown in Table 1. More monitoring program should be carried on to obtain more accurate and satisfied temporal and spatial trends of these chemicals in this region.

Table 1. Estimated concentrations for HCH and DDT in different matrices in the TLB for the beginning of 2000s.

	Soil (ng/g dw)	Air (ng/m^3)	Water (ng/L)	Sediment (ng/g dw)	Fish (ng/g)	Bird (ng/g)	Human milk (ng/g milk fat)
HCH	1	0.1	5	0.4	70	250	1,700
DDT	8	1	1	0.7	800	5000	1,300

References

1. Ge DM. *Master Dissertation*, Yangzhou University 2002;10.
2. Gong ZM, Dong YH, An Q, Wang H, Li YD, Yang LZ, Ruan LZ, Zhang YM, Mauro F. *Envron. Sci.* 2001;2:110.
3. Li YF, Cai DJ, Shan ZJ, Zhu ZL. *Arci. Envion. Contai. Toxicol*. 2001;41:261.
4. Li YF, Cai DJ, Singh A. *Arci. Envion. Contai. Toxicol*. 1998;35:688.
5. Li YF, Cai DJ, Singh A. *Adv. Environ. Res.*1999;2:497.
6. Cai DJ, Yang PZ, Wang JL, Jiang XL, Shen JC, Chen R, Gong RZ. *Jiangsu Province Agriculture Academ*, 1985;12:10
7. Nakata H, Hirakawa Y, Kawazoe M, Nakabo T, Arizono K, Abe S-I, Kitano T, Shimada H, Watanabe I, Li W, Ding X. *Environ. Pollut* 2005;133:415.
8. Qiu XH, Zhu T, Li J, Pan HS, Li QL, Miao GF, Gong JC. *Environ. Sci. Technol*. 2004;38:1368.
9. Jiang XF, Chen SJ, Wang XF. *Chinese Envron. Sci. Technol*. 1989;6:5.
10. Feng K, Yu, BY, Ge D, Wong MH, Wang XC, Cao ZH. *Chemo.* 2003;50:683.
11. Li YH, Guo CY, Wang GQ, Yang YL, Zhu YP, Xu MZ, Yuan H, Zhang GY, Gao SS, Zhu XY, Zhao GY, Ruan SY, Yuan D, Wu LM. *Environ. Occup. Medi.* 2003;20:181.