International POPs Elimination Project

Fostering Active and Efficient Civil Society Participation in Preparation for Implementation of the Stockholm Convention

---

POPs Pesticides in China

Pesticide Eco-Alternatives Center (PEAC)

Fifth floor, Jie Cheng Dasha Building,
540 Bai Yun Road,
Kunming, Yunnan, 650224
P. R. CHINA
Tel: 86-871-573 2268
Fax: 86-871-573 2373
Email: peac_panchina@hotmail.com

P.R. China

April 2006

About the International POPs Elimination Project

On May 1, 2004, the International POPs Elimination Network (IPEN http://www.ipen.org) began a global NGO project called the International POPs Elimination Project (IPEP) in partnership with the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Program (UNEP). The Global Environment Facility (GEF) provided core funding for the project.

IPEP has three principal objectives:

- Encourage and enable NGOs in 40 developing and transitional countries to engage in activities that provide concrete and immediate contributions to country efforts in preparing for the implementation of the Stockholm Convention;
- Enhance the skills and knowledge of NGOs to help build their capacity as effective stakeholders in the Convention implementation process;
- Help establish regional and national NGO coordination and capacity in all regions of the world in support of longer term efforts to achieve chemical safety.

IPEP will support preparation of reports on country situation, hotspots, policy briefs, and regional activities. Three principal types of activities will be supported by IPEP: participation in the National Implementation Plan, training and awareness workshops, and public information and awareness campaigns.

For more information, please see http://www.ipen.org

IPEN gratefully acknowledges the financial support of the Global Environment Facility, Swiss Agency for Development and Cooperation, Swiss Agency for the Environment Forests and Landscape, the Canada POPs Fund, the Dutch Ministry of Housing, Spatial Planning and the Environment (VROM), Mitchell Kapor Foundation, Sigrid Rausing Trust, New York Community Trust and others.

This report is available in the following languages: English

POPs Pesticides in China

Project Overview

This report on POPs pesticides in China has been produced to investigate and describe background information on POPs pesticides that have been previously used and are possibly still in use in agriculture; summarize information on known levels of POPs pesticides and incidence of pollution; describe measures undertaken or to be undertaken by government to address POPs; outline the Chinese government's Stockholm Convention ratification process and its National Implementation Plan;, and other measures taken to curb the harms caused by POPs pesticides.

Project Activities

	Objective	Status	Self-satisfaction
1	Information gathering on POPs pesticides previously used and possibly still in use in Chinese agriculture	Finished	Very good
2	Information gathering on known levels of POPs pesticides and incidences of pollution in China	Finished	Very good
3	Information gathering on measures undertaken or to be undertaken by government to address POPs	Finished	Very good
4	Information gathering on the Chinese government's Stockholm Convention ratification process, the National Implementation plan, and other measures taken to curb harm caused by POPs pesticides	Finished	Very good
5	Raising awareness of local partners and other NGOs, and to the general public to some extent, on POPs pesticides and associated health risks	Finished	good
6	Strengthening of PEAC and partners information network, and possible advocacy work	Finished	Very good
7	Strengthening linkages with local groups, and helping to build their capacities and campaigning on POPs pesticides	Finished	Good

Project Team

Member	Responsibility	Time Contribution
Yang Song	Information & report	6months
Tu Wanli	Training & Information	3months
Mao Zhongshun	Training & Information	3months

Kuang Rongping	Advisor	1month

Description of Project Activities

Information gathering

Information on the relevant regulations and laws on POPs were collected and analyzed. Articles describing the current POPs pesticide situation were collected and a survey was implemented through relevant news and reports on the Internet, and through periodicals and other reports. In addition, information on the large number of POPs poisoning cases was recorded. These are described in the medical treatment literature, but almost none of them describe the details of the poisoning.

Training and public education

A farmer training workshop was held in Eryuan county of Dali Province during Jan. 8th—10th, 2006. Presentations about POPs problems were made to participants to inform them about the risks that POPs pose to health and environment. On December 3, 2005 and on January 20, 2006, a lecture on POPs issues was presented to PEAC's staff to empower them to promote POPs elimination in China. On March 1-3, 2006, a presentation on POPs problems was made to local NGOs in Kunming during the organic farming conference.

Outcomes and impacts

This project produced a lot of important information about the POPs situation in China. A report on POPs in China (in Chinese) will be published this year. The English version will be published in Pesticide Development in China: A Comprehensive Report. The English version of the paraquat report has been completed (see details below). The POPs training and information activities increased the awareness of about 120 people on the dangers of POPs, including local farmers, leaders and staff from local NGOs. This will provide an important basis for further work, policy advocacy and training.

POPs Pesticides in China

Introduction

Persistent Organic Pollutants (POPs) possess toxic properties, resist degradation, bioaccumulate and are transported, through air, water and migratory species, across international boundaries and deposited far from their place of release, where they accumulate in terrestrial and aquatic ecosystems [1].

POPs tend to have some or all of the following properties: 1) They are degraded very slowly and therefore are persistent in the environment; 2) Generally, POPs have low water solubility and high lipid solubility. This means they can dissolve easily in fats and oils and bio-accumulate in fatty tissues of living organisms. In this way, concentrations of these chemicals increase as they move up the food chain and finally impact human health; 3) Most of them are semi-volatile. They evaporate relatively slowly. Persistent substances with this property tend to enter the air, travel long distances on air currents, and then return to earth and bring about pollution worldwide. The colder the climate is the less POPs tend to evaporate, resulting in their migration to regions such as the Arctic, thousands of kilometers away from their original sources. Now in the Arctic, POPs are found in penguins and eggs of sea birds; 4)

POPs are highly toxic to human and other animals, and can cause cancer, genetic and teratogenic mutation. POPs can destroy or restrain neural and immune systems, destroy or disturb the endocrine system and secretion of hormones, and affect the reproductive health of human beings and cause growth failures and genetic defects [2~5]. Due to POPs' slow degradation, semi- volatility and severe harms to human beings, POPs have become a global environmental issue that must be addressed immediately.

On 23 May 2001, the Stockholm Convention, a legally binding treaty on Persistent Organic Pollutants, was signed by 90 countries including China. It entered into force on 27 May 2004. By the end of 2004, 151 countries had signed this convention, and 88 countries had ratified it. This convention is the third in a series of international conventions appealing for pollutant and propellant elimination after the Vienna Convention for the protection of the Ozone Layer and Framework Convention on Climate Change. On 25 June 2004, the convention was approved by the National People's Congress (NPC) of the People's Republic of China and entered into force on 11 Nov 2004 in China. According to the Convention, the Chinese government will submit the National Implementation Plan before 11 Nov. 2006 [4, 5].

Beginning with the list of POPs in Stockholm Convention, this paper reviews the production and use of POPs, status of research on POPs pollution, and challenges facing the elimination of POPs in China. Finally, some recommended approaches for the elimination of POPs in China are also proposed.

I. Persistent Organic Pollutants in the Stockholm Convention

The Convention includes 12 POPs (see Table 1), 9 of which are organochlorine pesticides (OCPs): aldrin, dieldrin, endrin, chlordane, heptachlor, mirex, toxaphene, DDT and hexachlorobenzene (also an industrial chemical and by-product); one is an industrial chemical and by-product, polychlorinated biphenyls (PCBs); the final two are polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzo-p-furans (PCDFs), which are industrial by-products [4].

Table 1 Persistent Organic Pollutants listed in the Stockholm Convention

Category	**Chemical**
Organochlorine Pesticide	Aldrin, chlordane, dieldrin, DDT, endrin, heptachlor, hexachlorobenzene, mirex, toxaphene,
Industrial Chemical	Hexachlorobenzene, PCBs
By-products	Dioxins, furans

II. The Production and Use of POPs in China

This review considers production and use based on the organizing categories of organochlorine pesticides (OCPs), industrial chemicals and, and industrial by-products respectively (see Table 2).

2.1 Organochlorine pesticides

China is a major agricultural producer and OCPs were the primary pesticides produced and used in China from 1960s to 1980s. Among the nine OCPs listed in the Stockholm Convention, five of them were mass-produced and overused: chlordane, DDT, heptachlor, hexachlorobenzene, and toxaphene. Since the regulation for pesticides registration was implemented in 1982, chlordane, heptachlor, and toxaphene were banned, but the registration of DDT has remained and hexachlorobenzene is still being produced [7].

China's historical DDT production totaled 398,100 tons before the restrictions, and DDT is still being produced on a small scale to synthesize trichlorodicofol and for export. From 1981-1995, 30 tons of DDT was imported and 29, 000 tons were exported. Before restrictions, DDT was used widely in China, with historical application totaling about 400,000 tons, representing 20% of historical use worldwide. A smaller amount of toxaphene was produced, with an output of 24,000 tons from 1960 to 1984. Production and use of toxaphene was officially banned in 1980. Hexachlorobenzene was not considered a priority for manufacturing by the previously state-controlled chemical industry in China. Only 2,000 tons were imported to synthesize sodium pentachlorophenate and pentachlorophenate, and only 28 tons was exported. Chlordane was used to control termites and underground pests, with a total output of about 3,000 tons from 1977 to 1978. Chlordane was banned in 1979. Heptachlor was also used to control termites and underground pests from 1967 to 1969 and.17 tons were produced.

Overall, the data shows that in 1970, the total use of OCPs such as HCH, DDT and toxaphene was 191,700 tons which was 80.1% of the total use of pesticides. In the early 1980s, the usage of OCPs in 2,258 counties was still 78% of the total use of pesticides in China [4, 8].

2.2 PCBs

China began to produce PCBs in 1965 and used them widely, but in 1974, most factories stopped using them and selected alternative chemicals. During this period, 10,000 tons of PCBs were produced. About 9,000 tons of PCBs were used in capacitors and about 1,000 tons of PCBs were used as additive for oil paint, printing ink and lubricating oil, etc. Furthermore, from the 1950s to 1980s, China imported a large number of capacitors containing PCBs from Belgium, France and other countries without knowledge of their contents. Most of these capacitors have been disposed of. A Chinese government- organized study on PCBs pollution showed that there are around 20,000 tons of obsolete/ discarded capacitors containing PCBs. PCB content in scrap capacitors was more than 90% and PCB pollution in oil of imported transformers was above 50% [4, 8].

2.3 Dioxins (PCDDs) and furans (PCDFs)

PCDDs and PCDFs are present both in final industrial products and industrial wastes. The major sources of PCDD and PCDF pollution are trash burning, incineration of medical and industrial waste, incineration of toxic waste such as PCBs, cement kilns burning hazardous waste, the metallurgical industry and so on. Moreover, the chlor-alkali industry, dyeing industry (with chloranil), organochlorine industry, waste water from the bleaching of paper industry, and water treated with sodium pentachlorophenate for the prevention of schistosomes can also produce PCDD and PCDF pollution. Additionally, PCDDs can also emerge from automobile exhaust.

Research shows that China's output of pentachlorophenate and sodium pentachlorophenate per year totals up to 10,000 tons, which is 20% of the total world output. China's annual output of PCDDs and PCDFs resulting from impurities in pentachlorophenate and sodium pentachlorophenate is more than 100 kg. More seriously, the PCDD and PCDF content in wastes produced by the pentachlorophenate and sodium pentachlorophenate industry is much higher, totaling, respectively, 4.7 tons and 5.7 tons annually. Additionally, China is a major producer of chlorine and alkali in the world, which can produce 5.1kg (I-TEQ international toxic equivalents) of PCDDs and PCDFs through salt sludge. Furthermore, according to China's future 10-year plan, 3% of wastes will be incinerated. It is predicted that the resulting input of PCDDs and PCDFs into environment will increase [4, 8].

Table 2 Production and Use of POPs in China

POP	Production and Use	Import/Export
DDT	398,100 tons produced; also being produced on a small scale for export and trichlorodicofol synthesis.	30,000 kg imported and 29,000 tons exported (from 1981 to 1995).
PCBs	About 10,000t produced domestically. Banned in the early 1980s. Obsolete stocks exceed 20,000t	Late 1970s to early1980s: high volume of capacitors and transformers were imported
Hexachlorobenzene	Not one of the primary chemicals used or manufactured in China.	About 2,000 tons imported; exported 28 tons pentachlorophenate and sodium pentachlorophenate
PCDD/Fs	Many sources. Considering only production of pentachlorophenate and sodium pentachlorophenate, the output of PCDD/Fs were,	

	respectively, 4.7 and 5.7 tons annually.
Aldrin	Not produced on a large scale
Dieldrin	
Endrin	
Mirex	Production not industrialized
Chlordane	About 3,000 tons produced (from 1977 to 1978); stopped in 1979
Toxaphene	Less than 24,000 tons produced (from 1960 to 1984), stopped in 1980.
Heptachlor	17,000 tons produced (from 1967 to 1969)

III. Status of Research on POPs in China

In China, the usage of organochlorine compounds began in the 1960s and peaked in the 1970s. For historical and development reasons, China did not pay close attention to the pollution caused by these organochlorine chemicals. Background information on POPs is lacking and related research in this field is needed. Compared to data availability internationally, there are fewer reports on organic chemicals in China [9]. Table 3 lists the pollution level of OCPs in some regions and rivers of China.

3.1 Organochlorine pesticides

In China, there are a number of studies on DDT and HCH pollution, but systematic monitoring for other OCPs has not been conducted. Data shows that the content of OCPs (especially DDT) has decreased in soil, water, sediments, food, organisms, human bodies and human breast milk, but the average content is still much higher than that in developed countries.

3.1.1 Residue of organochlorine pesticides in human bodies

In Beijing, the concentration of DDT in breast milk was 6.45 mg/kg in 1982, but the concentration had fallen to 0.73mg/kg in 2002. In Shanghai, the concentration of DDT in breast milk was 11.4μg/g in 1988, and fell to 1.3 μg/g in 2002. In both regions, the levels of daily DDT intake in infants was below the WHO's Acceptable Daily Intake (ADI) figures [10, 11]. In other regions in China, like Yixing region (in Shanghai) and Xiaogan region (in Hubei province), it is also possible to detect OCP residues in human breast tissues, fat tissues and blood, but the concentrations were below national safety standards [12, 13]. These data show that OCPs were still detected in human bodies, breast milk and breast tissues, and although the residue of OCPs has decreased rapidly, it was much higher than that in European countries in the same year. The rate at which OCP residue decreased in human tissues was also different across regions. Compared with the late 1980s, in the late 1990s, the rates of OCPs residue in human bodies in Nanchang, Chengdu and Beijing decreased by 60%-90%, but in Changchun, Changsha and Shanghai, rates only decreased by 15%-20% [10].

3.1.2 Organochlorine pesticide pollution in water and sediments

Almost in all rivers, bays and harbors in China, DDT and its metabolites and other OCPs were found both in water and sediments [14~20]. DDT and its metabolites, isomers of HCH, aldrin, dieldrin, hexachlorobenzene, heptachlor and other OCPs were found in all samples from the sediments in Lake Taihu. The residue levels of HCH and DDT were higher than that in other rivers in China, but they were lower than those found in the sediments of bays in China [21]. In the Huangpu River, the levels of OCPs in sediments progressively increased in samples from upriver to downriver [22]. In the Liaohe River, the distribution of DDT and its metabolites was unbalanced between water and sediments [23]. It was reported that the levels of DDT were relatively low in sediments from northern Chinese river/estuary systems while the values of DDT were high in South China [24]. Some studies showed that there are still inputs of DDT in some rivers, such as in the Beijing Guangting Reservoir and Yongdinghe River and in the estuary of the Pearl River [25~27]. Furthermore, in Tibet, DDT and HCH were found in the water and sediment of Lake Co Ngoin and Lake Yamzho Yumco, although DDT and HCH were rarely used in these regions. It is possible that OCPs used in countries to the south of Tibet were transported north through the Bengal warm current [28].

3.1.3 Organochlorine pesticide pollution in soil and air

The residues of OCPs have been found in soils in many regions of China. Different residue levels were found in Beijing suburban regions, Nanjing region, seven counties in the Ningbo region, and in Shenzhen [29-32]. In some of these regions, the residue level was high. In Tianjin region, p,p'-DDT and p,p' -DDE were the main pollutants in soils, the maximum residue levels were 874 ng/g and 348 ng/g respectively. This is the highest level reported by any author in any researched region of China [33~34].

Some studies showed there were residues of OCPs in air particles in some regions. Tongqing et al. (2000) has detected the residue level of OCPs in air particles in Hohhot city both in summer and winter and found that the residue level in summer was higher than that in winter [35]. In Beijing, Liu Yanan et al. studied airborne OCPs residues within residential and academic areas of Beijing University (both indoor and outdoor air). The data showed no significant difference in residue levels in residential and academic buildings however, indoor concentrations of DDT and HCH were much higher than outdoors [36].

3.1.4 Organochlorine pesticide pollution in food and other organisms

The main avenue for human exposure to HCH and DDT is through residues on food products, so this problem has received a lot of attention. Early studies showed that DDT and other OCP residues could still be found in eight kinds of food items (belonging to three food categories) in Guangdong province ten years after OCPs were banned [37]. In Hubei, the residue level of OCPs in some livestock feed was high [38] and in Nanjing, OCP residue on vegetables was lower than national standard, but OCP residue was found on all vegetables [39]. The concentration of DDT in pine needles in China was 34 times higher than that of Sweden and 8 times higher than that of Southern France [40].

Additionally, residues from DDT and other OCPs were also found in tea, fish, mussels, crustaceans, and even in algae, which is regularly used as a food product in China [41~47].

DDT and other OCPs have been found in the environment, in food products, and the tissues of organisms. To make matters worse, there continue to be inputs of DDT and other OCPs in some regions. If OCPs are to be eliminated, there is still a long way to go.

Table 3 Organochlorine Pesticide Pollution in Regions and Rivers of China

Regions/rivers	Media	Concentration	Reference
Huangpu River	Surface sediment	2.65-19.54 ng/g	HU Xiongxing et al.(2005)
Xiamen Sea area	Surface sediment	DDTs: $(1.91\text{-}16.6)\times10^{-9}$ mg/mg	ZHANG Yuanbiao & LIN Hui (2004)
Xiamen-Jingmen Sea area	Surface sediment	DDTs:2.97-9.16 ng/g	CHENG Weiqi et al. (1996)
Xiamen Western Bay	Surface sediment	DDTs:4.45-311 ng/g	YUAN Xindong et al.(2001)
Estuary of Mingjiang	Surface sediment	DDTs: 6.17-30.70 ng/g	YUAN Xindong et al.(2001)
Yangtze Estuary tidal-flat	Surface sediment	1.25~36.01 ng/g	YANG Yi et al.(2003)
Lake Yamxho Yumco	Sediment	DDT:5.37 ng/g	ZHANG Weilin et al (2003)
Lake Co Ngoin	Sediment	DDT:2.39 ng/g	ZHANG Weilin et al (2003)
Zhujiang	Sediment	DDT:11.1 ng/g	YING Wu et al.(1999)

Middle and lower reaches of Liaohe	Sediment	0.45 ~ 7.26 ng/g	ZHANG Xiufang & DONG Xiaoli (2002)
Taihu	Sediment	p,p'-DDE:1.432 ng/g	YUAN Xuying et al. (2003)
Beijing University	Air particle	Indoors: 0.401 ng/m^3 Outdoors: 0.424 ng/m^3	LIU Yanan et al.(2004)
Huhehaote	Air particle	p,p'-DDE, in winter:0.085 ng/m^3 in summer:0.108 ng/m^3	TONG Qing et al. (2000)
Beijing Guangting Reservoir-Yongding water system	Water	DDT:0 - 46.80 ng/L	KANG Yaohui et al. (2003)
Lake Yamxho Yumco	Water	DDT:0.27 ng/L	ZHANG Weilin et al (2003)
Lake Co Ngoin	Water	DDT:0.30 ng/L	ZHANG Weilin et al (2003)

Table 3 continued

Pearl River artery Estuary	Water	DDT: in high flow season: 0.52~1.13 ng/L, in low flow season: 5.85~9.53ng/L	YANG Qingshu et al(2004)
The Di'er Songhua River	Water	71 ng/L	LI Mingxue et al. (1989)
Dayawan	Water	DDT:26.8~975.9 ng/L	QIU Yaowen et al. (2002)
Yangtze River	Water	DDT:1.68 ng/L	YU Gang et al (2004)
Middle and lower reaches of Liaohe	Water	7.59 ~ 34.98 ng/L	ZHANG Xiufang & DONG Xiaoli (2002)
Dongguan	Soil	DDT:3.49 μg/kg	ZHANG Tianbing et al.(2005)
Nanjing region	Soil	6.3 ~ 1050.7 μg/kg	AN Qiong et al. (2005)
Tianjin region	Soil	p,p'-DDT: 27.5 ng/g, p,p'-DDE:18.8 ng/g	GONG Zhongming et al. (2003)

3.2 PCBs pollution

Generally, the residue levels of PCBs in China's watersheds were much lower than that in the major rivers in Europe, but some watersheds were polluted by PCBs. In the Min River Estuary, the range of PCB levels was 0.204~2.47 ug/L in water, 3.19~10.85 ug/L in porewater and 15.13~57.93 ug/kg in sediments. Compared with test results from other estuaries and gulfs, the pollution of PCBs in the Min River Estuary was relatively serious. The concentration of PCBs in water exceeded the standards of the US EPA, and some of the sediment pollution levels exceeded reference standards [48]. In the Tonghui River, the residue level of PCBs exceeded the standard set by China; this shows that Tonghui River was polluted [49]. The residue levels of PCBs in surface water at some sites in Jiangsu province were also above the Chinese national standard of 20 ng/L (set by the Environmental Quality Standards for Surface Water) [50].

Studies also showed that while the PCBs residue levels in sediment were generally low, PCBs were found in 100% of samples, and sediments in some systems were polluted severely. Some early studies showed that sediments in the Di'er Songhua River and river mud of one coastal city in Southeast China were severely contaminated with PCBs [51,52]. In the early 1990s, the average PCBs residue level in sediments of Chinese rivers was 10.5~25.5 ng/g [53], much higher than PCBs residue found in Tibetan soils [54]. Additionally, PCBs were found in ocean sediment on the shore near Qingdao, Xiamen, and the Yangtze Estuary, and so on. Although the pollution had not reached severe levels in these regions, close attention is necessary due to the high rate of detection [14, 16, 20, 54~57].

PCBs were also found in aquatic organisms. In the Yangtze River Estuary and coastal areas, the concentration of PCBs in animals ranged from 43.7 - 1260.4 ng/g, with an average value of 342.5 ng/g. This showed that animals were contaminated by PCBs to some extent, and that contamination of PCBs had reached a moderate level [45]. In Dalian Bay, PCBs were also found in oysters and pearl mussels [58]. Furthermore, bio-concentration of PCBs through the food chain was reported in China. In the Pearl River near Guangzhou, the average PCBs content was 2.3 ng/L in waters, 31.52 ug/kg in sediment, and 181.77 ug/kg in benthic organisms, which illustrates the significant concentrating and amplifying phenomena taking place between water, sediment and benthic organisms [59]. In the Pearl River Delta, concentrations of PCBs were determined in water, surface sediments and fish from testing in freshwater fishponds in four different sites. The results showed that the concentrations of PCBs ranged from 8.0 - 24.03 ng/L in water, 7.32 to 36.23 ng/g dry weight in sediments, and 80.01 - 191.66 ng/g in fish [60]. In the Huai River, the concentration of PCBs in fish was one or two times higher than the concentration in sediments [61].

PCBs have also been widely found in China's soil and pollution in areas where chemicals have been stored has been especially severe [62]. In addition, it was reported that PCBs can only permeate in sediments and soils due to their low water solubility [52]. In one polluted site, Meng Qingyi et al. found that the concentrations of PCBs in pure air as well as air particles were high, but the concentrations in pure air were much higher than those in the particles found in air [63].

3.3 PCDD/F pollution

There have been few studies on PCDD/Fs in China, but the chemicals have been found in human blood, milk, water, sediments and aquatic organisms. PCDD/Fs levels in human blood, milk and sediments were markedly higher in areas affected by schistosomiasis, because sodium pentachorophenate had been used for about 30 years. [64]. Parts of Lake Ya-Er were also heavily polluted by PCDD/Fs [65]. Although PCDD/Fs were found in a number of organisms, the pollution levels were not high. In coastal areas near Qingdao, the PCDD/Fs levels in pearl mussels were much lower than those found on the coasts of the Mediterranean [66]. After the first tests of PCDD/Fs levels in oysters and marine mussels from Dalian Bay, data showed that PCDD/Fs could be found in both oysters and marine mussels [58]. Zhang Jiangqing et al. reported that fish in one water system were polluted by PCDD/Fs, but the level was below EU standards [67].

3.4 Summary of research status on POPs

From the above, it is clear that POPs have been found in humans and animals, water, sediments, and air. Some POPs, especially OCPs, have caused severe pollution; most seriously, there are still emissions of POPs in China. These studies contribute useful momentum for the elimination of POPs and implementation of the Stockholm Convention, but most were dated, and focused heavily on coastal and developed regions in China. Due to the fact that research began only recently as well as the technical and geographical limitations, we do not have a clear and comprehensive picture of the level of POPs pollution in China. It is critical to strengthen efforts for further national investigation of POPs pollution.

IV. Actions China Has Taken to Eliminate POPs

China signed the POPs Convention in 2001, but before that, China took actions on several POPs such as stopping PCB use in 1974 and banning DDT in 1983. Some policies and regulations related to some specific POPs have been legislated. Furthermore, SEPA and the Ministry of Electric Power and Industry asked relevant departments in writing to carry on a national investigation on the use, storage and obsolete stocks of PCBs in 1995.

Before the signing of the POPs Convention, the Chinese government has done some preparative work. In September 1999, a negotiation group for POPs techniques was established by State Environment Protection Administration of China (SEPA), Ministry of Agriculture of China (MAC), the Ministry of Health of China (MHC), and other official departments. In addition, in December 2000, a POPs workgroup was also set up by the Foreign Trade Office of SEPA. These two groups did a lot of work to pave the way for the signing of the POPs Convention. In March 2001, an international conference on POPs was co-organized by SEPA and the World Bank in Beijing. Some domestic departments, institutions and universities/colleges, and some multilateral and bilateral organizations participated in this conference.

As a developing country, funding support is very important to the implementation of POPs Convention. After signing the POPs Convention, the Chinese government was actively sought international support. Up to date, China has received funding support from Italy, the Global Environment Facility (GEF) and the World Bank. Now, some of these projects have been carried on.

In April 2003, a leader group for implementing the POPs Convention consisting of some departments of SEPA was founded and as well an adjunctive steering implementation office. The leader group is responsible for the negotiation of important issues and making important decisions. The steering office was formally established as the implementation office in March 2004 and is responsible for the negotiation and management of specific affairs of implementing the POPs Convention.

In September 2003, the leader group for organizing the national implementation plan of POPs Convention (NIP) was set up. The group consists of the National Development and Reform Commission, the Ministry of Foreign Affairs, the Ministry of Finance, the Ministry of Business Affairs, the Ministry of Science and Technology, MAC, MHC, the Ministry of Construction of China (MCC), SEPA, General Administration of Customs and the State Electricity Regulatory Commission. According to the Convention, China will submit the NIP to UNEP in November 2006. Up until now, four technical negotiation meetings for the NIP have been held and delegates from 11 domestic ministries/administrations (members of the leader group for organizing NIP), 5 international organizations like GEF and some universities/academic institutions, like Tsinghua University, Beijing University and Chinese Academy of Sciences attended the meetings. After these meetings, the draft of NIP was finished. Five regional outreach and discussion actions for the NIP will be held to get suggestions across the nation in March to May in 2006.

In order to raise public awareness of POPs, SEPA has organized at least five international conferences on POPs and delegates from many fields all over the country attended. Furthermore, some websites were built up where the public can learn about POPs and get useful information. For example, SEPA's website: www.zhb.gov.cn, and www.china-pops.org set up by the implementation office of SEPA.

In addition, the Chinese government and other organizations have held some trainings for researchers, technicians and persons in charge from different industries.

V. Obstacles and Challenges for POPs Elimination in China

According to the Stockholm Convention, production of nine kinds of OCPs shall end within ten years of the Convention entering into force. The use of PCBs should be eliminated in equipment (including transformers, capacitors or other receptacles containing liquid stocks) in a safe, efficient and environmentally sound manner by 2025, and PCDD/Fs should be reduced through best available techniques and best environmental practices [1]. Among the nine pesticides listed in the Stockholm Convention, DDT and hexachlorobenzene are still being produced and used in China. Furthermore, over 10,000 tons of PCBs in China are not managed in a scientifically sound way. The outputs of POPs in industrial by-products cannot be clearly quantified because there are many industries which release them. China faces many obstacles to the elimination of POPs and implementation of the Stockholm Convention due to the reasons outlined below.

5.1 POPs pollution is continuing

Although most POPs are no longer legal for manufacture or use, pollution still exists. In some regions, pollution is severe due to a long history of use of OCPs and other POPs. A number of reports have showed that in some regions there are new inputs of POPs into the environment, causing additional pollution.

5.2 Basic studies and systematic monitoring on POPs are weak

China has a long history of producing and using OCPs, and the quantity of OCP stockpiles is not yet clear due to the complicated structure of production and distribution, as well as the vast territory where the chemicals have been used and stored. Compared with international knowledge, POPs research in China is lagging and evaluation of pollution has not been comprehensive, due to the fact that research began only recently and focused heavily on coastal and developed regions. Furthermore, the present data focuses almost exclusively on the 1980s and 1990s; very little research reflects current pollution conditions. In addition, with the exception of DDT, China has not systematically monitored any of the POPs.

5.3 Inadequate funding and monitoring technology

Because China has used OCPs and other POPs widely and lacks basic data on production and application, and because POPs have been impacting the environment and human health for a long time, the scope of necessary research, environmental reclamation, and development of alternatives is wide and comes with a high price tag. In addition, the techniques currently used in China for managing polluted sites, environmental reclamation, and developing pesticide alternatives are currently based on outdated technology and lags behind the developed world.

54.4 Pollution management lacks standardization and consistency

The State Environment Protection Administration of China (SEPA) is in charge of managing and monitoring POPs pollution with the cooperation of a number of official departments. The Ministry of Agriculture of China manages pesticide production and use, the Ministry of Health of China supervises POPs residues in food and the Ministry of Construction of China uses chlordane and mirex. Some other departments and state-owned enterprises are involved in releasing PCDD/Fs. It is very difficult to network and organize all the government departments to combat POPs if each department's management ability is limited. A standardized, integrated, and consistent pollution management system does not yet exist in China.

5.5 The current regulatory framework for POPs is insufficient

Although China has instituted many policies and regulations related to POPs, as a rule these regulations have gaps and loopholes. The systems of regulations are based on two overarching policies: Pesticide Management Regulations and Dangerous Chemical Management Regulations (see Table 4). Most of the current policies and regulations were not designed to target POPs, although they may include some of the POPs in a number of regulations. Relevant and explicit policies or regulations targeting POPs-related environmental problems are still lacking [68]. As of this writing, there were no authorized criteria or specific legislation related to POPs in laws or regulations enacted by the State Council.

5.6 Public awareness of the environment and POPs is low

In daily life, popular awareness of environmental protection is weak: it is easy to find toxic garbage like used batteries and plastic utensils abandoned everywhere. Most Chinese people do not know what POPs are, let alone their environmental and health hazards, so it is difficult to explain how to stop their release and input in people's daily life.

Table 4 Policies and regulations related to POPs in China

Policy/regulation	Year of adoption
Environmental Protection Law of the People's Republic of China	1989
Law of the People's Republic of China on Prevention and Control of Water Pollution	1984
Marine Environment Protection Law of the People's Republic of China	1982 (Amended:1999)
Law of the People's Republic of China on the Prevention and Control of Environmental Pollution by Solid Waste	1995 (Amended:2004)
Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution	1995 (Amended:2000)
Regulation of the People's Republic of China on pesticide management	1997 (Amended:2001)
Regulation of People's Republic of China on Controlled Chemicals	1995
Regulations of the People's Republic of China on the Control over Safety of Dangerous Chemicals	1987 (Amended:2002)
Ordinance on Pesticide registration	1982
Ordinance on Safety Application for Pesticide	1982
Regulation for Preventing Environmental Pollution of Ploy-chlorinated Biphenyls and Their Wastes	1991
Regulations for Environmental Management on the First Import of Chemicals and the Import and Export of Toxic Chemicals	1994
Regulation for Registration Management on Dangerous Chemicals	2000
Measures for Registration Management on Dangerous Chemicals	2002
Control Standard on Polychlorinated Biphenyls for Wastes (GBL3015-91)	1992
Environmental Quality Standard for Surface Water(GB3838-2002)	2002
Quality Standard for Ground Water (GB/T14848-93)	1993
Determination Standard for BHC, DDT, Lindane and Other OCPs (GB7492-87)	1987
Soil Quality--Determination of BHC and DDT--Gas Chromatography (GB/T14550-93)	1993
Organisms Quality—Determination of BHC and DDT---Gas Chromatography (GB/T14551-93)	1993
Environmental Quality Standard for Soils (GB15618-95)	1995
Standard for Safety Application of Pesticides (GB4285-89)	1989
Classification and Symbol for Chemicals in Common Use (GB13690-92)	1992
List of Hazardous Goods (GB12268-90)	1990
Classification, Sort and Number for High Toxic Goods (GB57-93)	1993
The Rule of Nomenclature for Dangerous Goods (GB7694-87)	1987
Identification Standard for Hazardous Wastes (GB5085-1996)	1996

Table 4 Continued

Standard for Pollution Control on Hazardous Waste Storage (GB18597-2001)	2001
General Technique Condition for Transportation Packaging of Hazardous Goods(GB12463-90)	1990
General Rule of Storage for Chemicals in Common Use(GB15603-1995)	1995
Rule of Sort Division for Transportation Packaging of Hazardous Goods(GB/T15098-94)	1994
Environmental Protection Control Standard for Imported Waste(GB16487-1996)	1996
Standard for Pollution Control on the Security Landfill Site for Hazardous Wastes(GB18598-2001)	2001
Standard for Pollution Control on the Security Landfill Site for Municipal Solid Waste(GB16889-1997)	1997
Standard for Pollution Control on Hazardous Wastes Incineration(GB18484-2001)	2001
Standard for Pollution Control on the Municipal Solid Waste Incineration(GB18485-2001)	2000

VI. Recommendations for the Elimination of POPs in China

As a developing country, China faces many challenges for the elimination of POPs, as mentioned above. Implementation of the Stockholm Convention and POPs elimination faces challenges, which have aroused concern among many people. Here are some suggestions:

6.1 Strengthen research, increase basic data and develop practical monitoring techniques

A comprehensive picture of POPs pollution in China is not available due to the limited number of research projects and geographical limitations on these projects. However, the basic data gained from these investigations, such as stockpile, production, and pollution conditions (like input, transportation, distribution, release, toxicity and trend of pollution, etc.), can serve as a basis for further research and investigation. Furthermore, in order to eliminate POPs and restrict their release, monitoring and analysis techniques and development of alternatives are very important. China lags far behind developed countries in this field. It is urgent to strengthen studies on basic information and develop practical techniques of POPs research in China.

6.2 Enhance public education

Because POPs are both highly toxic and highly persistent (long term), and most people are not aware of these chemicals, increased public awareness is necessary. Through public education, people will learn more about POPs including sources, hazards, etc. This will encourage the public to alter their habit of using some POPs products like OCPs, or change their methods of waste disposal. Such education should focus not only on the general public, but also on technicians and managers, in order to encourage them to improve their production techniques and eliminate POPs.

6.3 Encourage interdisciplinary and international cooperation

A cumulative effort across different academic fields, like environmental science, economics, law, and sociology is necessary to eliminate POPs. Furthermore, POPs are a global environmental issue and some developed countries have developed approaches for facing the challenge, so to develop international cooperation is very useful for China.

6.4 Perfect the existing policy framework for regulating POPs

Although there are some laws/regulations and standards related to POPs in China, many need to be amended or revised to agree with the Stockholm Convention. In addition, systems for pollution monitoring, managing and risk-evaluation of POPs should be also strengthened in a method that is suitable for implementation in China.

6.5 Encourage NGOs to assist with POPs control

Current efforts to control POPs involve scientists, decision- makers, industry, NGOs and other stakeholders. The NGO community in China is increasingly large, flexible, and skilled in community work. In the effort to control POPs, NGOs can provide valuable services including basic background research and public education. If governments can encourage and support NGOs' participation in the effort, undoubtedly, the burdens of governments will be lightened.

References

[1]Stockholm Convention on Persistent Organic Pollutants,UNEP,2001,
[2] SHEN Ping. Stockholm Convention and persistent organic pollutants (POPs). Chemistry Education, 2005,6:6-10(in Chinese)
[3] SHI Bi-qing, LI Gui-ling. Persistent organic pollutants (POPs) and the harm. Journal of EMCC,2005.3,15(1):42-44 (in Chinese)
[4] YU Gang, NIU Jun-feng, HUANG Jun et al. Persistent Organic Pollutants: a new global environmental problem [M]. Science Press, 2005 (in Chinese)
[5] LIU Zheng-tao. Environmental Behavior Characteristics and Research Progress of Persistent Organic Pollutants. Research of Environmental Sciences,2005,18(3):93-102 (in Chinese)
[6] LI Bao-hui. Progress of elimination for persistent organic pollutants. Shangdong Environment, 2001(101):40-41 (in Chinese)
[7] HUANG Jun, YU Gang, Qian Yi. The problems of persistent organic pollutants in China and their research countermeasures. Environmental Protection,2001.11:3-6 (in Chinese)
[8] JIANG An-xi, Liu Li-yan, Li Yi-fan, et al.Pollution and control of persistent organic pollutants in China. Journal of natural science of Heilongjiang University,2004.6,21(2):98-101 (in Chinese)
[9] YU Gang, HUANG Jun, ZHANG Pengyi. Persistent organic pollutants: one of the important global environmental problems. Environmental Protection,2001.4:37-39 (in Chinese)
[10] YU Hui-fan, ZHAO Xu-dong, ZHANG Xiao-ming, et al. The investigation on basic contents of organochlorine pesticides in human milk during consecutive period in Beijing urban areas. Chin. J. Prev. Med.,2005.1,39(1):22-25 (in Chinese)
[11] LI Yan-hong, GUO Chang-yi, WANG GUO-quan, et al.Dynamic study on the accumulative levels of benzene hexachloride (BHC)and dichloro-diphenyl-trichloroethane (DDT) in the mothers' milk in Shanghai. J. Environ. Occup. Med.,2003.6,20(3):181-185 (in Chinese)
[12] LI Wei-hua, ZHNAG Yun-hui, FAN Qi-yuan, et al. Current status of organochlorine pesticides contamination in foodstuffs and human breast fat tissues. J. Environ. Occup. Med, 2005.2,22(1):14-16 (in Chinese)
[13] LIU Shou-liang, Qin Qi-fa, LI Qi-quan, et al. Analysis of the accumulative levels of organochlorine pesticides in human body fat and blood in Xiaogan.J. Environ.Health,2004.7,21(4):238-240 (in Chinese)
[14] ZHANG Yuan-biao, LIN Hui. Concentrations and distributions of DDTs, HCHs and PCBs. Journal of Oceanography in Taiwan Strait,2004,23 (4):421-428 (in Chinese)
[15] CHEN Weiqi, ZHANG Luoping, XU Li, et al. Concentrations and distributions of HCHs, DDTs and PCBs in surface sediments of sea area between Xiamen and Jinmen.Journal of Xiamen University(natural science),1996,35(6):936-940 (in Chinese)
[16] ZHANG Luoping, CHEN Weiqi, LIN Liangmu, et al. Concentrations and distribution of HCHs, DDTs, and PCBs in surface sediments of Xiamen western bay. Tropic Oceanology,1996,3(1):91-95 (in Chinese)

[17] YUAN Dongxing, YANG Dongning, CHEN Meng, et al. Concentrations and distribution of polycyclic aromatic hydrocarbons and organo-chlorides in surface sediments of Xiamen western harbour and Minjiang estuary. Acta Scientiae Circumstantiae,2001,21(1):107-112 (in Chinese)
[18] QIU Yao-wen, ZHOU Jun-liang, Maskaoui K., et al. Study on polychlorinated biphenyl congener and organochlorine insecticides in Daya bay. Marine Environmental Science,2002,21(1):46-51 (in Chinese)
[19] LIU Xian-ming, XU Xue-ren, ZHANG Xiao-tian, et al. Organochlorine pesticides and PCBs in Dalian bay. Marine Environmental Science,2001,20(4):40-44(in Chinese)
[20] YANG Yi, LIU Min, XU Shi-yuan, et al. Distribution of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) in the tidal beach surface sediments of Yangtze estuary. China Environmental Science, 2003, 23 (2): 215 – 219 (in Chinese)
[21] YUAN Xu-yin, WANG Yu, CHEN Jun , et al. Organochlorine residues of sediments in Taihu lake and its risk evaluation. Environmental Science,2003,24(1):121-125 (in Chinese)
[22] HU Xiong-xing, HAN Zhong-hao, Zhou Ya-kang, et al. Distribution of organochlorine pesticides in surface sediments from Huangpu river and its risk evaluation. Environmental Science,2005,26(3):44-48 (in Chinese)
[23] ZHANG Xiu-fang, DONG Xiao-li. Organic chlorinated pesticides in middle and lower reaches of Liaohe. Journal of Dalian Institute of Light Industry.2002,21(2):102-104 (in Chinese)
[24] Ying Wu, Jing Zhanga, Qing Zhou. Persistent organochlorine residues in sediments from Chinese river/estuary systems. Environmental Pollution, 1999, 105 :143-150
[25] KANG Yuehui, LIU Peibin, WANG Zijina, et al. Persistent organochlorinated pesticides in water from Guanting Reservoir and Yongdinghe river, Beijing. Journal of lake science, 2003.6,15(2):125-132(in Chinese)
[26] YANG Qing-shu, MAI Bi-xian, FU Jia-mo, et al. Spatial and temporal distribution of organochlorine pesticides (OCPs) in surface water from the pearl river artery estuary. Environmental Science, 2004,25(2) :150-156 (in Chinese)
[27] YANG Qing-shu, MAI Bi-xian, FU Jia-mo, et al. Studies on organochlorine pesticides (OCPs) in waters of the Pearl River artery estuary water. China Environmental Science, 2005, 25 (Suppl.): 47 – 51 (in Chinese)
[28] ZHANG Wei-ling, ZHANG Gan, QI Shi-hua, et al. A preliminary study of organochlorine pesticides in water and sediments from two Tibetan lakes. Geochemica, 2003,32(4):363-367(in Chinese)
[29] SHI Yajuan, GUO Feifan, MENG Fnaqiao, et al. Temporal trend of organic chlorinated pesticides residues in soils of orchard, Beijing. Acta Scientiae Circumstantiae,2005,25(3):313-318 (in Chinese)
[30]AN Qiong, DONG Yuanhua, WANG Hui, et al. Residues and distribution character of Organochlorine pesticides in soils in Nanjing area. Acta Scientiae Circumstantiae, 2005, 25 (4):470 – 474 (in Chinese)
[31] ZHAO Ling, MA Yongjun. Analysis of residues of organochlorinated pesticides in agricultural environment. Agricultural Environment and Development,2001,1:37-39 (in Chinese)

[32] ZHANG Tian-bin, RAO Yong, WAN Hong-fu, et al. Content and compositions of organochlorinated pesticides in soil of Dongguan City, China. Environmental Science, 2005, 25 (Suppl.): 89 – 93 (in Chinese)

[33] GONG Zhongming, WANG Xuejun, LI Benggang, et al.. The residues distribution of DDT and its metabolites in soils from Tianjing region, China. Acta Scientiae Circumstantiae,2003,23(4):447-451(in Chinese)

[34] GONG Zhong-ming, CAO Jun, ZHU Xue-mei, et al. Organochlorine pesticides residues in agricultural soils from Tianjing. Agro-Environmental Protection,2002,21(5):459-461(in Chinese)

[35] TONG Qing, FENG Shenying, RUAN Yuying, et al. Distribution of organochlorine pesticides on the different diametral atmospheric particulate. Environmental Chemistry,2000,19(4):306-312 (in Chinese)

[36] LIU Ya-nan, LANG Chang, WU Shui-ping, et al. HCHs and DDTs in indoor airborne particles. Environmental chemistry,2004,23(5):562-567 (in Chinese)

[37] JIANG Yue-bi. Analysis of residues in parts foods in Guangdong province. Guangdong health prevention,1996,22(4):67-68 (in Chinese)

[38] ZHAO Yunfeng, YUAN Zonghui, WU Yongning. The identification analysis of contamination source of organochlorine pesticides in 2000 total diet study of Hubei province. Chinese journal of food Hygiene,2004,16(5):397-464 (in Chinese)

[39] GAO Hongjian, JIANG Xin. Bioaccumulation of organochlorine pesticides and quality safety in vegetables from Nanjing suburb. Acta Scientiae Circumstantiae,2005,25(1):90-93 (in Chinese)

[40] XU Dian-dou, ZHONG Wei-ke, DENG Lin-lin, et al. Studies on the organic chlorine HCH and DDT in pine needles. China Environmental Science, 2002, 22 (6): 481 – 484 (in Chinese)

[41]DOU Wei, ZHAO Zhongxian. Contamination of DDT and BHC in water, sediments and fish (Carassius auratus) muscle from Baiyangdian lake. Acta Scientiae Circumstantiae,1998,18(3):308-312 (in Chinese)

[42] ZHAO Daohui, Wu Jingwen, Yi Lei, et al. Analysis of residues of trichlorinedicofol ,HCH and DDT. Chinese Journal of Health Laboratory Technology,2004,14(3):327-328 (in Chinese)

[43] LUO Shichang, YU Hansheng. Studies on the contents of BHC and DDT in the organisms in the Pearl river estuary and adjacent sea area. Marine Science Bulletin,2001,20(2):44-50 (in Chinese)

[44] FANG Zhnaqiang, CHEUNG R.Y.H, WONG M. H. Concentrations and distribution of organochlorinated pesticides and PCBs in green-lipped mussels, Perna viridis collected from the Pearl river estuarine zone. Acta Scientiae Circumstantiae,2001,21(1):113-116 (in Chinese)

[45] LIU Hua-lin, LIU Min, YANG Yi, et al. Polychlorinated biphenyls and organochlorine pesticides in animals from the Yangtze river estuary and coastal areas. Environmental Science,2004,25(6):69-73 (in Chinese)

[46] YANG Yi, LIU Min, XU Shi-yuan, et al. Distribution of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) in the tidal beach surface sediments of Yangtze estuary. China Environmental Science, 2003,23(2): 215~219 (in Chinese)

[47] SHI Zhi, PAN Bo, HE Xin-chun, et al. DDT and its metabolites in water, suspended solid, sediments and fish in fishponds in Tianjin. Rural Eco-environment,2004,20(4):1-5 (in Chinese)

[48] ZHANG Zhuli, HONG Huasheng, YU GANG. Preliminary study on persistent organic pollutants (POPs)----PCBs in multi-phase matrices in Minjiang river estuary. Acta Scientiae Circumstantiae, 2002,22(6):788-791 (in Chinese)
[49] Zulin Zhang, Jun Huang, Gang Yu, et al. Occurrence of PAHs, PCBs and organochlorine pesticides in the Tonghui River of Beijing, China. Environmental Pollution,2004,249-261
[50] ZHOU Chunhong, BUI Chouyon, Hu Guangjiu, et al. The investigation of PCBs in the source of drinking water in Jinagsu province. Chemical Industy Time,2005,19(3):22-25 (in Chinese)
[51] LI Minxue, YUE Guichun, GAO Fumin, et al. Transport and distribution of PCBs and organochlorine pesticides in the second Songhua river. Environmental Chemistry,1989,8(2):49-54 (in Chinese)
[52] CHU Shaogang, XU Xiaobai, TONG Yiping. Transport and distribution of polychlorinated biphenyls in a polluted area. Acta Scientiae Circumstantiae,1995,15(4):423-432 (in Chinese)
[53] CHEN Jingsheng, GAO Xuemin, Qi Min, et al. The contents of polychlorinated biphenyl in river sediments in eastern China. Acta Scientiae Circumstantiae,1999,19(6):614-618 (in Chinese)
[54] YANG Yongliang, PAN Jing, LI Yue, et al., PCNs and PBDEs in the sediments from Qingdao Coast. Chinese Science Bulletin.2003,48(21):2244-2251(in Chinese)
[55] CHEN Manrong, Yu Lizhong, XU Shiyuan, et al. Spatial distribution of PCBs in the sediments of Changjinag estuary tidal flat. Marine Environmental Science,2003, 22(2)
[56] CHEN Manrong, Yu Lizhong, XU Shiyuan, et al. Research of PCBs pollution in tidal flat sediments of Yangtze river estuary. Environmental Science and Technology,2004, 27(5):24-34
[57] CHEN Manrong, Yu Lizhong, XU Shiyuan, et al. Spatial distribution of polychlorinated niphenyls(PCBs) contaminants in the tidal-flat sediments of Yangtze estuary. Marine Science Bulletin, 2003,5(2):22-28.
[58] YANG Zhi-jun, ZHANG Qing, NI Yu-wen. Distributions of PCDD/Fs and PCBs congeners in oysters and marine mussels. Ecology and Environment, 2004, l3(4): 512-51 (in Chinese)
[59] NIE Xiang-ping, LAN Chong-yu, LUAN Tian-gang, et al. Polychlorinated biphenyls in the waters, sediments and benthic organisms from Guangzhou reach of Pearl River. China. Environmental Science, 2001, 21 (5): 417-421 (in Chinese)
[60] NIE Xiang-ping, An Tai-cheng, YANG Yu-feng, et al. Analysis of PCBs in the sediments and fish from freshwater fishponds in the pearl river delta, China. Acta Ecologica Sinica,2005,25(5):1138-1145 (in Chinese)
[61] WANG Zi-jian, WANG Yi, MA Mei.. Assessing the ecological risk of sediment-associated polychlorinated biphenyls in Huaihe River. China Environmental Science, 2001,21(3) 262~265 (in Chinese)
[62] SONG Yun-heng, JIANG Di, DING Chao, et al. Monitoring survey of PCBs pollution in soils of stored spots. Environmental Monitoring in China, 2005,21(4):52-89 (in Chinese)
[63] MENG Qingyu, BI Xinhui, CHU Shaogang, et al. Preliminary study of the characterization and distribution of PCB congeners between vapor phase and aerosols in polluted area. Environmental Chemistry,2000,19(6):501-506 (in Chinese)

[64] Jiang Ke, Chen Yudong, Li Lingjun. PCDD/Fs in sodium pentachlorophenate (Na-PCP) and human blood, milk and sediment samples from Chinese schistosomiasis areas. Journal of Emvironmental Science,1995,7(1):52-59
[65] Wu Wen-zhong, K.-W. Schramm, B Henkelmann, et al. Survey on PCDDs and PCDFs in sediments and soils in Ya-er lake area, China. Chinese Journal of Oceanology and Limnology, 1998,16(1):45-53
[66] YANG Yong-liang, PAN Jing, YIN Xiao-cai, et al. Investigation of sedimentation fluxes, TEQ and sources of PCDD/Fs in Qingdao coastal sea. China Environmental Science, 2003,23(6): 635~639 (in Chinese)
[67] ZHANG Jiang-qing, ZHOU Jian, JIANG You-sheng, et al. Investigation on PCDD/Fs contamination level in 31 fish samples from a typical water area. Modern preventive Medicine, 2005,32(6):577-583 (in Chinese)
[68] WANG Tieyu, LU Yonglong, ZHANG Hong, et al. Contamination of persistent organic pollutants (POPs) and macroscopic countermeasures in China. Techniques and Equipment for Environmental Pollution Control,2004.11,5(11):21-26 (in Chinese)