Organochlorine pesticides in the air of Guangzhou and Hong Kong, South China

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Introduction

Organochlorine pesticides (OCPs) are a group of persistent organic pollutants (POPs) which are to be eliminated or reduced on the release into the environment under the Stockholm Convention on Persistent Organic Pollutants adopted by many countries. After prohibition of the use of many POPs, including PCBs and organochlorine pesticides in the developed countries, emission sources of a number of POPs (such as DDTs and HCHs) in the last 20 years were shifted from developed countries in the Northern Hemisphere to the developing countries in the tropical and sub-tropical regions, largely in South and Southeast Asia, owing to the late production ban and present legal and illegal application in agriculture and for the control of certain diseases, such as malaria, typhus and cholera. Due to their volatility and persistence in the air, organochlorine pesticides (OCPs) are subject to long-range atmospheric transport (LRAT). Therefore, OCPs released in the tropical and subtropical environments could be dispersed rapidly through air and water, and tend to be redistributed at a global scale. There were recent studies in North America showed that the atmospheric transportation from these regions across the Pacific Ocean might be one of the major contributing sources for OCPs in the Canadian west coast and arctic regions. The Asian low-latitude regions feature a typical monsoon climate. There has been little research, to our knowledge, concerning the role of Asian monsoon in the processes of long-range atmospheric transport of these pesticidalPOPs.

The Pearl River Delta (PRD), including Hong Kong and Macao, located in the south coast of China, and covering an area of about 42,794 km^2, is one of the rapid developing regions in China over the last three decades. The region is under strong influence of the Asian monsoon system. A few investigations on OCPs in various environmental media of the PRD have been recently conducted. These studies not only detected higher concentrations of HCHs and DDTs in water, sediment, fish, and human breast milk in Guangzhou, the center of the PRD, and also found a similar problem in Hong Kong where no HCHs and DDTs were presently used. The objectives of the study was to assess the concentrations levels, seasonal patterns and potential LRAT of these pesticidalPOPs in the atmosphere in the PRD.

Methods

Sampling was conducted simultaneously at the two sampling sites for a consecutive 24 h period during the whole day and night on a biweekly base from December 2003 to December 2004. The air samples were collected with a high-volume air sampler (Anderson Type), at a flow rate of 330 m3·day-1. Suspended particulate was retained on a Whatman quartz microfiber filter (QFF) (Grade GF/A, 20.3 × 25.4 cm), and vapor phase absorbed on a polyurethane foam plug (PUF) (length 8.0 cm, diameter 6.25 cm, density 0.023 g·cm-3). The PUF and filters were Soxhlet extracted with dichloromethane, the extracts were fractionated and clean-up on a silica/aluminum oxide column. Quantification was done on an HP-6890 GC-ECD, with selected samples being confirmed by GC-MS. Field blanks (including PUF penetration test), lab blanks, and surrogate recovery reported good data quality control.

Results and discussion

The 20 target OCPs in this study were quantified against a six point calibration curve. Aldrin, endrin, aldelydeendrin, ketoneendrin, and methoxychlor were not detected in all samples. Heptachlor epoxide, diedrin, sulfate indosulfan and β-HCH were lower than method detection limit (MOD) in over 70% of the samples. Heptachlor and δ-HCH could not be quantified due to interference from unknown compounds. The concentrations of α-HCH, γ-HCH, CC, TC, *p,p'*-DDE, *p,p'*-DDD, *o,p'*-DDT, *p*,*p*'-DDT, and endosulfan were reported in Table 1.

The average concentrations of α and γ- hexachlorocyclohexane (HCH), *trans*-chlordane(TC), *cis*-chlordane(CC), *p,p'*-DDT, *p,p'*-DDE, *p,p'*-DDD, *o,p'*-DDT, endosulfan α and β in the air of Guangzhou were 134, 539, 871, 1340, 627, 207, 93, 846, 246 and 60 pg m^{-3}, respectively; and in Hong Kong were 46, 51, 389, 380, 358, 56, 53, 191, 148 and 20 pg m^{-3}, respectively. In general, the concentrations of OCPs increased from the winter to the summer except for α-HCH which showed no clear seasonal pattern. Higher levels of γ-HCH and *o,p'*-DDT found in Guangzhou, relative to Hong Kong, could be attributed to the present usage of lindane and Dicofol in the Pearl River Delta.

As shown in the figure, a strong DDT pollution event was identified from June 20-August 12, 2004 in both cities, along with a sharp drop of o,p'-DDT/DDT and DDE/DDT ratios. And a strong pollution plume of endosulfan, a pesticide in cotton culture, of which no local application was recorded, was observed from August 25-October 19, 2004. A Clausius–Clapeyron analysis reported these air DDT and endosulfan pollution event can not be well explained by temperature-dependent surface evaporation. The results of 5 and 10 days air back trajectory analysis indicated that the unusual high *p,p'*-DDT levels in summer in both cities could be related to the Asian summer monsoon originated from South Asia, where large quantities of technical *p,p'*-DDT may still be used. The high concentrations of endosulfan in winter in the study area suggested an atmospheric transport by the winter monsoon from East China, where endosulfan is being used as insecticide in cotton fields. The results demonstrated that Asian monsoons may play an important role in the long-range atmospheric transport of POPs in Asia.

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Table 1: Mean concentrations of POPs measured in Guangzhou and Hong Kong

	α-HCH	γ-HCH	TC	CC	p,p'-DDE	p,p'-DDD	p,p'-DDT	o,p'-DDT	Endosulfan 1	Reference
Hong Kong	46±28 (5-108)	51±63 (5-261)	389±381 (7-1602)	380±358 (7-1496)	56±26 (8-151)	53±58 (3-235))	358±718 (6-2625)	191±18 (7-673)	148±212 (	This study
Guangzhou	134±70 (41-313)	539±797 (5-2639)	871±443 (127-1789)	1335±989 (129-4185)	207±151 (28-579)	93±85 (8-378)	627±740 (22-2836)	846±618 (86-2014)	246±291 (	This study
India	(530-27400)	(380-8170)			(400-5790)	(140-520)	(60-1020)	(0-150)		Rajendran et a,., 1999
Korea	169±250 (20.6-830)	50.5±86.6 (4.8-326)	5.0±9.4 (0.2-35.0)	3.7±7.1 (0.1-26.1)	34.6±51.3 (2.6-185)	6.2±18.3 (<5.6-67.0)	21.0±34.6 (<1.0-121)			Yeo et al., 2004
Japan	103±67 (14-281)	40±22 (10-98)	70±89 (2-401)	61±76 (<1-329)	5.3±4.2 (<0.3-17.8)	<2(<2-<2)	6±7 (<2-25)			Murayama et al., 2003
Chicago	110±40	150±80	130±80	120±70		100±50	70±60			Bidleman et al., 1998
Belize		63±22	34±39	32±42	458±127	35±45	556±356	145±45		Algeria et al., 2000
Vietnam	60.8	11.5	0.63	1.34	0.52		0.17	0.38		Hassal et al.,

	(0.72-311)	(0.15-57.8)	(0.08-3.27)	(0.11-5.51)	(0.03-4.44)		(0.04-0.62)	(0.04-1.87)		1998

Fig 1: Seasonal variations of HCH, trans- and cis- chlordane (TC, CC), DDT and endosulfan (I, II) in the atmosphere in Hong Kong (left) and Guangzhou (right)