

ENVIRONMENTAL ASSESSMENT ON SELECTED ORGANOCHLORINES AND POLYCHLORINATED BIPHENYLS IN SEWER SYSTEM OF HANOI CITY

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Introduction

Covering an area of some 1000 km² and having a population of 3.5 million people, Hanoi (the capital and second largest city of Vietnam) and its vicinity is the major industrial and economic region in North Vietnam. During the recent decades, the fast development of industry in conjunction with high population growth have lead to toxic chemicals to enter the rivers of the city as the industrial, medical and domestic wastes are released untreated¹. In addition, the deterioration of the rivers and the reduction of streambeds have turned these rivers to be open sewers and the principal pollution sources in the city (Hanoi DOSTE, 2003; GHK, 2005; Hanoi Water Discharge Company, 2006), thereby posing a long-term threat to groundwater that is used for drinking water production².

Persistent organochlorine pesticides (OCPs) and polychlorinated biphenyls (PCBs) were widely used in Vietnam since the 1960s for different purposes in agriculture, industry and public health. In 2009, nine contaminants were added to the list of Persistent organic pollutants (POPs) under the Stockholm Convention. Contamination of PCBs are one of the most concerning issue due to its toxicity and large quantity in use. In this study, we analyzed selected OCP and PCBs in sediment samples collected from sewer system in Hanoi city to understand their levels and occurrence in the environment.

Materials and methods

Sample collection

Twenty-two sediment samples were collected in May 2006 from the sewer system in Hanoi City, including the five rivers Nhue, To Lich, Lu, Set, Kim Nguu and the Yen So Lake (Fig. 1). A fraction of the Set River and the Kim Nguu River is discharged into the Yen So Lake. The samples were collected in urban (TL1, TL2, TL3, TL4, L1, L2, L3, S1, S2, KN1, KN2) and suburban districts (TL5, TL6, TL7, N1, N2, YS1-6). Upon arrived at the laboratory, the samples were air-dried, ground, sieved to 1 mm, and stored at -200C until analysis.

Chemical Analysis

Seven PCB congeners (IUPAC numbers: PCB 28, 52, 101, 118, 138, 153 and 180) and a set of organochlorine pesticides were analyzed. Those OCPs are DDTs, HCHs, Chlordane compounds, Aldrin, HCB, heptachlor and mirex. The total concentration of PCB (PCBs) was calculated based on the sum of seven PCB congeners by multiplication with the value of four, which corresponds to the theoretical contribution of those congeners to Aroclor 1254³. Sediment samples were analyzed for PCBs and OCPs at CETASD applying the EPA 3620B, EPA 8082, and EPA 8081A methods (EPA, 1996) with slight modifications for sample extraction and extract cleanup (Hoai et al., 2010).

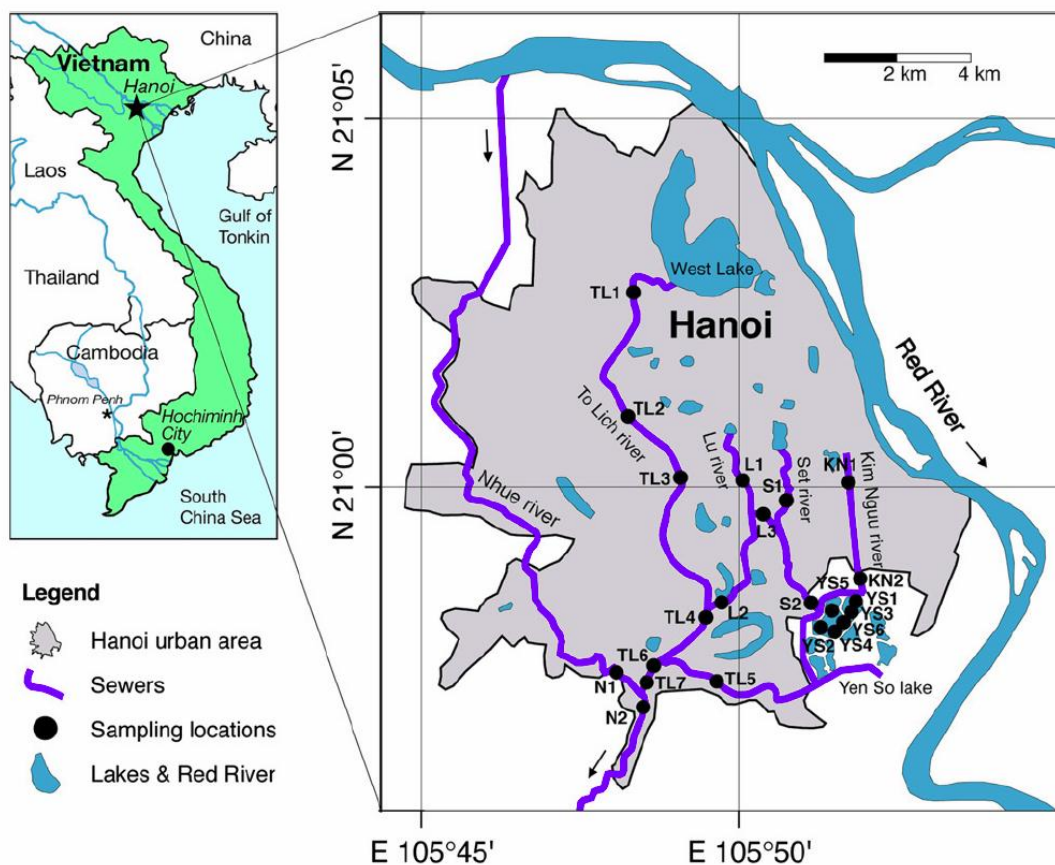


Fig. 1: Sampling sites in sewer system of Hanoi City (May 2006)

Results and discussion

Concentrations of OCPs are shown in Table 1 together with coordination of sampling sites in Hanoi. Among target compounds, only PCBs, DDTs, β -HCH and HCB were found with concentration above detection limits. In general, the concentrations followed the order DDTs (mean 135 ng/g) > PCBs (mean 104 ng/g) > HCHs (mean 3.8 ng/g) > HCB (mean 3.5 ng/g). This pollution pattern agrees well with observations in sediments of the Hanoi rivers in 1997⁴.

Minh et al⁵ revealed a similar pollution pattern (DDTs>PCBs>>HCHs, HCB) in human breast milk of Hanoi citizens in 2000. These facts demonstrate that DDTs and PCBs are the two dominant pollutants in the environment of Vietnam. The pollution pattern of DDTs and PCBs in this study varied depending on the sampling locations (comprising the rivers Nhue, To Lich, Lu, Set, Kim Nguu and the lake Yen So).

The spatial distribution shows significantly higher concentrations of DDTs, PCBs, and HCB in the rivers Kim Nguu and Set. As a result, the Yen So Lake, a reservoir receiving water from these two rivers, is polluted with relatively high levels of PCBs (20–384 ng/g) and OCPs (17–109 ng/g DDTs, up to 12 ng/g HCB).

The sediment concentrations of OCPs in the Yen So Lake were even higher than in the rivers Nhue, To Lich, and Lu. In conjunction with the rivers Lu and Set, the higher levels of PCBs and OPCs at the upper streams (sites TL1, TL2, TL3, and KN1) compared to those at the lower streams (TL4, TL5, TL6, TL7, and KN2) of the rivers To Lich

Table 1: Concentrations of major OCPs and PCBs in sediment samples collected from Hanoi (ng/g dry wt)

Sample	Location	Location		TOC (%)	PCBs ^a	DDTs ^b	β-HCH	HCB
		Latitude	Longitude					
Nhue River	N1	N 20°57'263"	E 105°48'444"	3.1	153	12	<0.2	1.1
	N2	N 20°57'144"	E 105°48'472"	2.3	22	14	<0.2	1.3
To Lich River	TL1	N 21°02'403"	E 105°48'364"	7.5	50	50	12	<0.2
	TL2	N 21°00'923"	E 105°48'270"	2.7	44	47	<0.2	<0.2
	TL3	N 21°00'106"	E 105°49'083"	6.0	26	26	<0.2	0.87
	TL4	N 20°58'237"	E 105°49'501"	2.0	9.2	61	0.8	3.3
	TL5	N 20°57'577"	E 105°48'795"	5.5	70	24	<0.2	2.4
	TL6	N 20°57'615"	E 105°48'752"	4.7	14	6.4	<0.2	<0.2
	TL7	N 20°57'166"	E 105°48'466"	1.0	1.3	11	<0.2	<0.2
Lu River	L1	N 21°00'072"	E 105°50'090"	5.3	42	11	<0.2	3.2
	L2	N 20°59'486"	E 105°50'462"	9.9	122	103	17	<0.2
	L3	N 20°58'409"	E 105°49'707"	7.6	78	73	<0.2	<0.2
Set River	S1	N 20°59'587"	E 105°50'594"	4.1	36	680	<0.2	5.3
	S2	N 20°58'313"	E 105°51'228"	5.6	139	215	<0.2	11
Kim Nguu River	KN1	N 21°00'028"	E 105°51'717"	11	328	1100	<0.2	1.4
	KN2	N 20°58'560"	E 105°51'923"	10	237	82	<0.2	22
Yen So Lake	YS1	N 20°58'471"	E 105°51'881"	6.4	210	79	<0.2	<0.2
	YS2	N 20°58'201"	E 105°51'266"	9.1	24	17	13	8.0
	YS3	N 20°58'395"	E 105°51'793"	9.0	384	67	<0.2	<0.2
	YS4	N 20°58'130"	E 105°51'406"	8.3	98	109	<0.2	12
	YS5	N 20°58'299"	E 105°51'418"	7.5	20	27	<0.2	<0.2
	YS6	N 20°58'308"	E 105°51'659"	6.7	80	33	36	<0.2

^a PCBs: Sum of seven PCB congeners (PCB 28, 52, 101, 118, 138, 153, and 180) by multiplication with the value of four according to Froescheis et al. (2000).

^b DDTs: Sum of o,p'-DDE, p,p'-DDE, o,p'-DDD, p,p'-DDD, o,p'-DDT, and p,p'-DDT.

The sediment concentrations of DDTs varied from 12 to 14 ng/g in the Nhue River, 6.4–61 ng/g in the To Lich River, 11–103 ng/g in the Lu River, 215–680 ng/g in the Set River, 82–1100 ng/g in the Kim Nguu River, and 17–109 ng/g in the Yen So Lake. All the collected sediment samples contained DDTs and the highest concentration was observed at site KN1 (1100 ng/g), which is located in the highly populated center of Hanoi City. Fig. 2 illustrates the patterns of DDT compounds detected in sediments from this study and those calculated for sediments in 1997⁴. A decreasing trend of the (DDE + DDD)/DDTs ratios and an increasing trend of DDT/DDE ratios as well as DDT/DDTs ratios among sediments collected in 1997 and 2006 were recognized, revealing additional recent input of DDT to the environment⁶. Particularly, a ratio of DDT/DDE up to 14 (DDT occupied 88% among DDTs) in a sediment sample collected at site KN1 signified a very recent input of DDT to the Hanoi sewer system. DDT might originate from leakage from remaining stockpiles and unsecured landfills, or vector control and hygienic purposes^{4,5}. Minh et al.⁷ suggested a further source of DDTs might be the insecticide Dicofol, which contains DDT as a byproduct.

Similar to DDTs, the PCBs spanned a relatively wide range. The sediment concentrations of PCBs varied from 22 to 153 ng/g in the Nhue River, 1.3–70 ng/g in the To Lich River, 42–122 ng/g in the Lu River, 36–139 ng/g in the Set River, 237–328 ng/g in the Kim Nguu River, and 20–384 ng/g in the Yen So Lake (Fig. 2). In the Sai Gon-Dong Nai River Basin, Hochiminh City, Minh et al.⁵ reported PCB levels to decline 3–6 times lower than those in the early 1990s. However, PCB levels in sediment of Hanoi showed an opposite trend. Ranging from 1.3 to 384 ng/g (mean 104 ng/g), the sediment levels of PCBs measured in this study revealed a clear increase compared to 0.79–40 ng/g (mean 13 ng/g) in 1997⁴, quantification using Arochlor 1254 and 15–120 ng/g (mean 45 ng/g) in 1999. Since sediment samples were collected in the dry season in this study and at the onset of the

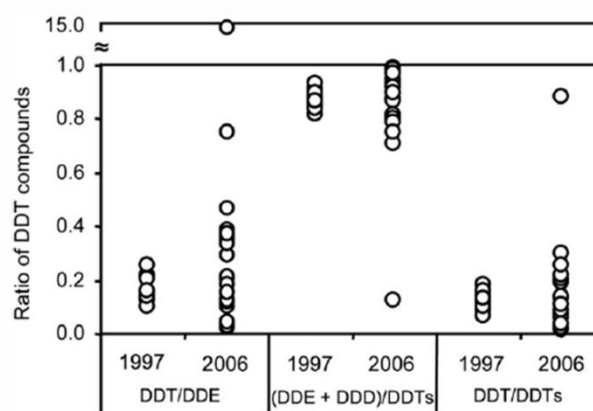


Fig. 2: Ratios of DDT compounds in sediments collected in 1997 and 2010

rainy season in 1997, the different amount of water drained through the sewer system might affect the washout of suspended particle containing PCBs. However, by evaluating the temporal trend of PCBs in soils collected in Hanoi City in 2006⁸ reported clearly increasing concentrations of PCBs compared to levels in 1990s. In addition, in a sediment survey conducted in 1995, Nhan et al.⁴ reported a relatively low PCB concentration of 5.64 ng/g in the dry season in an irrigation canal close to the Nhue River. Hence, the observation made in this study raises serious concern on the increase of PCB levels in Hanoi City.

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