PERSISTENT ORGANIC POLLUTANTS IN VIETNAM II: A CONCISE REVIEW OF TRENDS AND HUMAN HEALTH IMPLICATIONS

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Introduction

Global contamination and toxic effects of persistent organic pollutants (POPs) have been an emerging environmental issue and have received considerable attention during the past four decades. Although the extent of contamination by POPs has been dominant in industrialized nations, an increasing number of recent investigations have highlighted the role of Asia-Pacific region as a potential source of emission for these chemicals, particularly to pristine areas such as the Arctic and the Antarctic.[1] Because of the high toxic effects, particularly the endocrine disrupting properties, though the usage of POPs has been banned in developed nations during early 1970s, many developing countries have been continuing to use these chemicals until very recently for public health purposes. Therefore, temporal trends of the contamination by POPs and the possible implications of their magnitude of pollution on environmental quality and human health are critically important issues for developing countries. This paper provides a concise review of the studies dealing with persistent organic substances in Vietnam. Available data of POP contamination in Vietnam were compiled to help improve insight into the trends of contamination and possible toxic implications for environmental quality and human health.

Trends of contamination

There have been a few reports suggesting the role of the southern Asian region as possible emission source for the pristine areas such as the Arctic and the Antarctic.[2,3] Despite OCs were banned in most of the developed nations, high consumption of OC insecticides for enhancing food production and eradicating vector-born diseases has been a virtual fact in developing countries. While OC residues levels in developed nations showed a rapid decrease, the status of contamination in developing world seemed different with slower rate of decline. Though well-designed studies on the temporal trends of contamination in POP from Vietnam have been limited, trends of OC residues in river water and sediments from Red River estuary and human breast milk from women living in suburb areas of Hanoi and Hochiminh city were investigated along those lines.

Viet et al. (2002)[4] examined residue concentrations of DDTs and γ-HCH (lindane) the two most common insecticides used extensively in Vietnam, in water and sediments from Red River delta. River water and sediments were collected at the same locations annually in both dry and wet season and were examined for the trends of contamination during 1995-2001. DDT residues in water have declined relatively rapidly during 1995 – 1998 and remained constant until recent years at the levels below 10 ng/L. DDT residues in sediment dropped by a factor of 2 during 1997 - 2000. DDT was officially banned in Vietnam in 1995.[5] The reduction of DDT concentrations in both water and sediment from Red River, northern Vietnam indicate the effect of legislative action to reduce the degree of environmental pollution. An interesting result were observed for trends of lindane in sediment, showing peak concentrations in 1997 and lower levels during 1995-96 and 1999-2001. Recent studies examined HCH residues in sediment from different sites in Red River delta and estuary and elucidated that HCH concentrations in 1997 survey were also higher than those analyzed in sampling survey in 1995.[6] Such a fluctuation trend of HCH contamination suggests the sporadic input of this insecticide into the watershed of Red River. In general, result in water and sediment in recent years indicated a rapid decline of DDTs and HCHs in surface water, but slow reduction trend in sediment. There are indeed severe gap in the monitoring of trends of contamination in biota samples from Vietnam. Temporal monitoring of residue concentrations in biota will provide more realistic hints to understand trends of contamination in the environment.

In addition to the studies on the trends of POP levels in the environmental samples, time trends of human exposure is also an important issue for understanding the long term toxic impacts on general population. Minh et al. (2004)[7] assessed the decline rate of human exposure to DDTs and PCBs over the 10 years period (1989 and 2001) (Fig. 1). A first order kinetic approach has been used to estimate the declining rate of DDTs and PCBs in human breast milk collected from Vietnam. The decrease of persistent organic pollutants such as DDTs, PCBs and HCHs in human breast milk was suggested to follow first-order kinetic.[8] Another important factor for the assessment is half-life time ($t_{dec1/2}$) defined as the duration in which initial concentrations decrease to a half. On the basis of the residue concentrations of OCs in 1989 reported by Schecter et al. (1989)[9] and the levels in 2001 obtained by Minh et al. (2004)[7], the rate constant and $t_{dec1/2}$ were estimated.

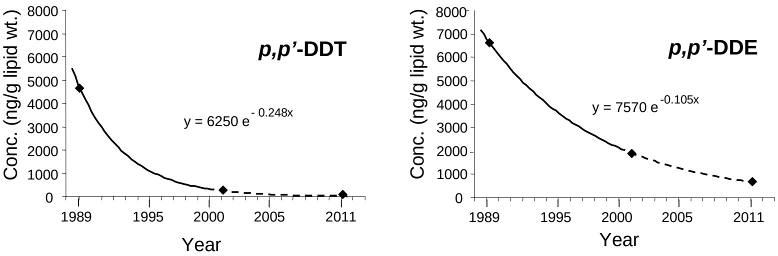

Figure 1. Estimation of time trend curve of p,p-DDT and p,p-DDE residues in human breast milk in Vietnam

Residue levels of *p,p'*-DDT have decreased from 4700 to 2700 ng/g lipid wt. in over 10 years with $t_{dec1/2}$ of around 3 years. On the other hand, *p,p'*-DDE decreased rather slowly with a $t_{dec1/2}$ of 6 years. This result is somewhat in agreement with those in Sweden showing half-life time 4 and 6 years for *p,p'*-DDT and *p,p'*-DDE, respectively.[8] The slightly shorter of half-life time observed here could be due to the tropical climate that exist in Vietnam may have facilitated volatilization of *p,p'*-DDT in the environment leading to its faster decrease in food chains (and thus in humans). The estimated half-life time is fairly beneficial for assessing the trend of DDT contamination in Vietnamese human breast milk. Assuming that the decrease trend of DDTs remains more or less constant, we can estimate the DDTs levels reaching approximately 700 ng/g lipid wt in the year 2011 (Fig. 1). However, lower residue levels in future can be expected if the use of DDTs is completely phased out from now.

3. Implications for environmental and human health

Widespread contamination by OC insecticides, particularly DDTs in different environmental samples of Vietnam has been apparent as indicated in our survey in early 1990s. In a survey of estuarine sediments collected from various locations from the northern to southern part of the country, high concentrations of DDTs were observed.[10] The Environment Canada has recently updated the sediment quality guidelines for protection of the aquatic life. The Interim Fresh water Sediment Quality Guidelines (ISQGs) and the Probable Effect Levels (PELs) for *p,p'*-DDE are 1.42 and 6.75 ng/g dry wt, respectively, while these values for *p,p'*-DDT are 1.19 and 4.77 ng/g dry wt. Among the 18 locations examined throughout Vietnam during the survey in early 1990s (Iwata et al., 1994), about half of the sediment samples contained *p,p'*-DDE and *p,p'*-DDT greater than the ISQG values. Some samples collected from the municipal sewage canals contained elevated levels of DDTs, far exceeding the probable effect levels (PELs). PCB concentrations in Vietnamese sediments in these locations were also beyond the PEL level for PCBs. Taking into account these facts, it is important to note that the magnitude of contamination by DDTs in Vietnam is of concern and warrant further studies.

As for PCDD/Fs, the formation of these contaminants in open dumping sites in Asian developing countries raised a considerable human health concern for not only communities living near the dumping sites, but also for people who live far away because PCDD/Fs may undergo atmospheric transport and deposit in distant areas. For risk assessment of soils contaminated by dioxins and related compounds, The Agency for Toxic Substances and Disease Registry (ATSDR) proposed guidelines recommending that areas having soil concentrations within the range from 50 to 1000 pg TEQ/g should be evaluated for bioavailability, ingestion rates, community concerns, etc., and soils with the concentrations over 1000 pg TEQs/g should be considered for stronger actions like health studies, exposure investigations, etc. Japanese Government recently issued new standards for dioxins in soil, establishing 1000 pg TEQ/g as the maximum acceptable level and those within 250 – 1000 pg TEQ/g be kept under surveillance. Many soil samples in dumping sites contained TEQ concentrations exceeding 250 pg/g TEQs[11], suggesting the necessity of continuous monitoring. Particularly, some soils from Cambodia and Hanoi dumping sites contained TEQ concentrations beyond the level of 1000 pg/g, suggesting their potential for causing adverse health risk for humans and wildlife.

In the perspective of human health implication, on the basis of the recent data of average seafood consumption reported by Food and Agriculture Organization of the United Nations, the average daily intake of PCBs and DDTs from seafood for different countries in Asia-Pacific region were estimated[12] (Table 1). Interestingly, results again showed that intakes of DDTs by Vietnamese population were apparently higher than those reported in other countries examined.

Table 1. Estimated daily intakes of persistent organochlorines via mussels by different populations in Asia-Pacific region

Country	Survey year	Seafood consumption[a] (g/person/day	Intake of PCBs[b] (ng/person/day)	Intake of DDTs (ng/person/day)	Intake of HCHs (ng/person/day)
Cambodia	1998	20	15	6.6	< 0.2
China	1999-2001	71	180	17000	57
Hong Kong	1998-99	69	260	8300	14
India	1998	13	49	55	26
Indonesia	1998	52	68	52	2.1
Japan	1994	196	5900	690	63
South Korea	1998	114	420	400	30
Malaysia	1998	156	160	220	< 1.6
Philippines	1998	77	440	31	2.3
Russia	1999	54	3400	650	54
Vietnam	1997	47	66	1900	2.8

[a]Seafood consumption data were cited from FAO Food Balance Sheets, FAO Statistics Division, FAO 2006

[b]Intakes were estimated on the basis of residue concentrations in mussels (Asia-Pacific Mussel Watch Program) reported by Monirith et al. (2003)[12]

In addition to the elevated exposure of DDT via seafood to Vietnamese general population, certain cohorts living near the municipal dumping sites may be at a higher risk by toxic substances: dioxins and dibenzofurans. A methodical approach has been developed to evaluate the risk of exposure to PCDD/Fs via soil ingestion and dermal absorption.[11]. Intakes of dioxins were estimated to be the highest in people of Philippines, followed by Cambodia, India, Hanoi (North Vietnam), and Ho Chi Minh City (South Vietnam). Intakes of PCDD/Fs by the people living near dumping sites were about 2 to 200-fold greater than those for the people in control sites, and thus emphasizing the greater health risk, threatening these people. Interestingly, the estimated intakes of dioxins via soil ingestion and dermal exposure for children were higher than those for adults, suggesting greater risk of dioxin exposure for children in dumping sites.[11] Further investigations should be focused on children and infants as they are the most susceptible group and have higher exposure levels to dioxins. The breast fed children intakes of PCDD/Fs estimated on the basis of residues in breast milk of women living in open dumping sites in Asian countries were given in Fig. 2. The intake estimated for Vietnamese were comparable to those in Cambodia but lower than in the Philippines and India.[13] In addition, it is important to note that intakes estimated for children living near the hot spot of dioxin contamination due to Agent Orange in southern Vietnam were still very high even after the Agent spraying ended almost 3 decades.[14] Thus, Vietnam could serve as suitable location for future research on possible toxic effects of dioxins on wildlife and humans due to the unique situation where both current and historical dioxin contamination exists for potentially large exposed population.

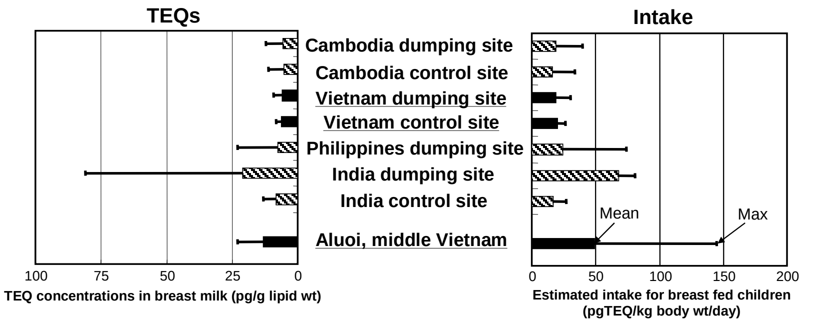

Figure 2. TEQ concentrations and estimated intakes of PCDD/Fs for breast fed children from open dumping sites and control site in Asian countries and Aluoi Valley, a former Agent Orange spraying during Vietnam War.

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