PERSISTENT ORGANIC POLLUTANTS IN VIETNAM I: A CONCISE REVIEW OF CONTAMINATION LEVELS AND PATTERNS

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Introduction

Vietnam is located at the center for the Southeast Asian region; it has more than 300 km coastal lines and two major agricultural production areas: the Red River Delta in the north and the Mekong River Delta in the south. These two deltas inhabited by approximately more than 30 million people and are one of the most densely populated areas in the world. The Red River and Mekong Driver delta have recently become one of the most productive agricultural regions of Southeast Asia. Such a strategic geographical position and rapid agricultural development of Vietnam have made this country become an important subject for extensive studies dealing with environmental pollution during the last three decades. This paper provides a concise review of the studies dealing with persistent organic substances in Vietnam. Available data of POP contamination in different environmental compartments in Vietnam were compiled to understand the status and patterns of contamination, their transport behavior and fate in tropical agro-ecosystem.

Widespread Contamination

Comprehensive monitoring surveys have been conducted during early 1990s to examine the distribution of POPs such as PCBs, DDTs, HCH and HCB in air, water and sediments from estuary environments from various countries in Asia-Pacific comprising Japan, India, Vietnam, the Philippines, Thailand, Indonesia, Malaysia, the Philippines and Australia[1]. These investigations revealed higher residues of DDTs and HCHs in air and water from coastal and estuarine areas in the developing countries of tropical and subtropical regions (India, Thailand and Vietnam), rather than developed nations (Japan and Australia). The distribution in air, water and sediments from northern, central and southern regions of Vietnam showed relatively higher DDT concentrations, supporting the concept of widespread contamination of this insecticide throughout the country. This result suggests extensive use of DDT for agricultural purposes in the past and for malaria control until very recently. Interestingly, in a survey conducted about 10 years later (1998/99) covering an extended area along Red River and Duong River, the two biggest rivers in northern Vietnam, elevated concentrations of DDTs, HCHs and CHLs were reported[2]. The levels of DDTs, HCHs and CHLs in Red and Duong River were apparently higher than those reported in the 1990s surveys. In addition, wastewater collected from extensive human activities areas such as canals of Tu Liem district, suburb Hanoi (northern Vietnam) and Thi Nghe River, Hochiminh city (southern Vietnam) contained elevated concentrations of DDTs. It is interesting to note that the levels examined in a recent survey[2] (in suburb Hanoi) were even higher than those reported a decade ago[1]. Although backgrounds of analytical methods and sampling locations are different among studies, these observations suggest that the use of DDT for malaria control were relatively extensive and has remained until very recently in both northern and southern Vietnam.

To understand the magnitude of contamination of POPs in Vietnam, residue concentrations in air, water and sediments were compared with those in other countries in Asia-Pacific (Fig. 1). Higher contamination of DDTs in Vietnamese coastal environments was recorded, again indicating the extensive use of this insecticide in Vietnam. Interestingly, elevated PCB residues were also observed in water and sediments from Mekong River estuary, southern Vietnam; and the levels were comparable to those reported in some locations in India, Japan and Australia (Fig. 1). High PCB contamination in Vietnam observed during our survey in early 1990s could be derived from both the electrical equipments imported from industrialized nations like former Soviet Union and Australia and the leakages from army weapons extensively used in Indochina War during 1961-71.[3]

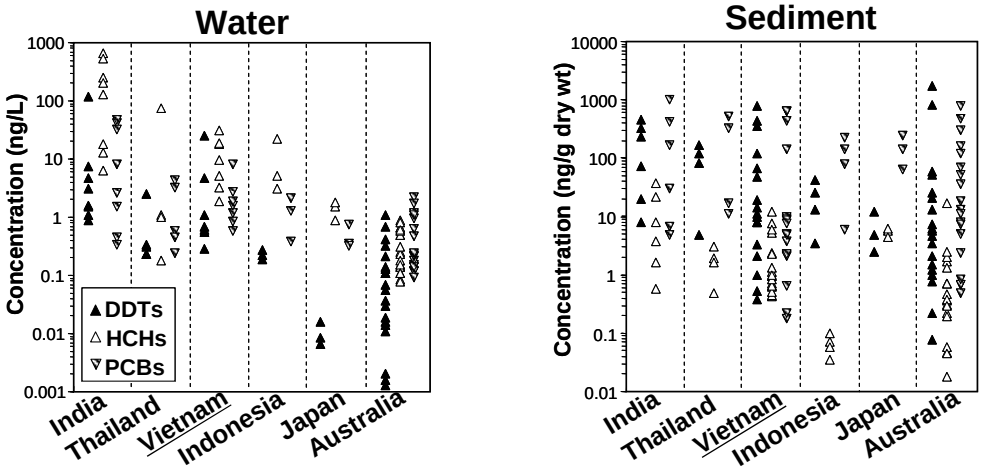

Figure 1. Residue concentrations of persistent organochlorines in water and sediments in coastal and estuary areas from Asia-Pacific countries including Vietnam. Data from Iwata et al., 1994.[1]

As for biological samples, an extensive study on OC contamination in fish and mussels from Asia-Pacific countries including Vietnam were carried out by Kannan et al. (1995)[4] and Monirith et al. (2003)[5]. Similar to sediment samples, a relatively uniform distribution of OCs was observed in fish in various countries in Asian Pacific region. In Vietnam, residues levels of DDTs were relatively high in both surveys in 1990 and 1997. Mussels collected from coastal areas in north and middle of Vietnam contained elevated DDT concentrations.[5] Subsequent surveys conducted by Nhan et al. (1998[6], 1999[7]) examined OC distribution in clams from different sites along the northern coasts, and results showed a very similar distribution to sediment samples. In particular, residue concentrations of DDTs, HCHs and PCBs were relatively high in the sites near border of China and a decreasing trend was noticed toward southern coast lines. At the two estuary areas: Hai Phong harbor with extensive human and industrial activities, and Thai Binh province, one of the most rice production areas in Vietnam, higher concentrations were again observed. In general, the feature of distribution and magnitude of contamination in sediment and biota (fish and bivalves) was very similar in both local and regional scale, which can be characterized by the enhanced volatilization of semi-volatile organic compounds in high temperature prevailing tropical ecosystems.

International comparison of DDT residues in fish, mussels and birds from Vietnam indicated relatively higher levels of DDTs in Vietnamese samples (Fig. 2). Results of recent surveys in Asia-Pacific Mussel Watch Program showed that DDT levels in Vietnamese mussels were lower than those in mussels from southern China and Hong Kong, but higher than those collected from most of other countries in East Asian region.[5] Kannan et al. (1995)[4] reported mean concentration of DDT in fish from Vietnam were the highest among India, Thailand, Indonesia and Australia. Contamination pattern were similar for birds, which showed that DDT residue levels in some resident species in Vietnam were among the highest values reported for the Asian countries surveyed[11]. It is interesting to note that though the recent amounts of DDTs used in Vietnam were lower than those of other countries in the region, the extent of DDT contamination in environmental samples in Vietnam was higher. This observation suggests that the application of DDTs in Vietnam has continued until very recently, resulting in elevated contamination of these compounds in different species occupying low to high trophic levels in food chain.

Dioxin contamination

Southern Vietnam has long been considered as a well known region where Agent Orange was extensively sprayed during 1961-71 in the American War, resulting in severe dioxin contamination in various environmental media and food chain including humans. During the last three decades, Schecter and co-workers have been conducting a number of investigations on the dioxin contamination in southern Vietnam, including sediment,

foodstuffs and particularly, human samples living near the "hot spot" of dioxin contamination (e.g. Schecter et al., 1990[16], 1995[17], 2001[18]).

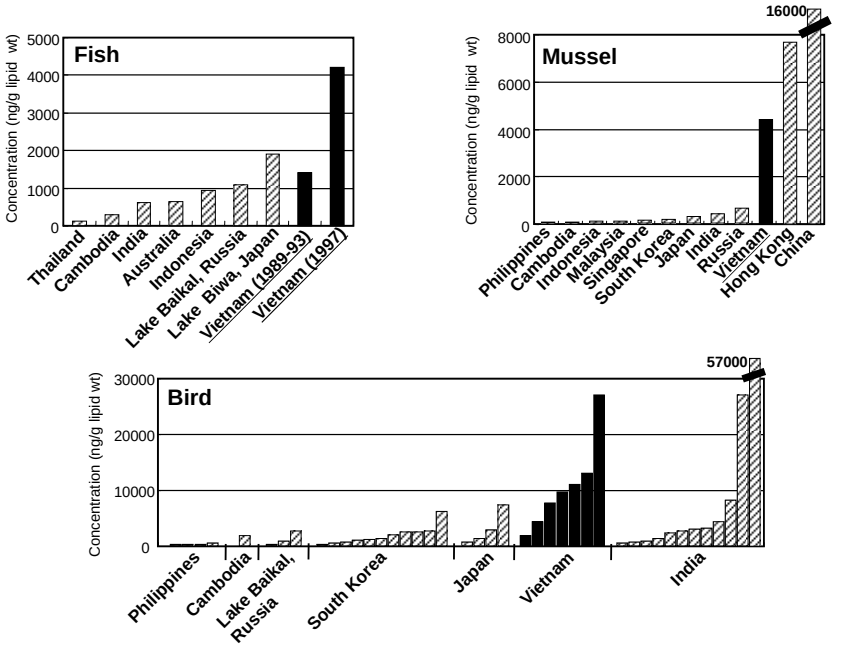

Figure 2. Comparison of DDT residue levels in fish, mussels and birds from Asia-Pacific countries including Vietnam. Data for fish were cited from Kannan et al., 1995[4]; Nakata et al., 1995[8]; Gugure et al., 1997[9]; Kunisue et al., 2002[10] and Minh et al., 2002[11]; mussels from Monirith et al., 2003[5]; and birds from Tanabe et al., 1998[12]; Hoshi et al., 1998[13]; Choi et al., 2001[14]; Minh et al., 2002[11]; Kunisue et al., 2003[15] and Monirith et al., 2003[5].

In general, the dioxin contamination as a result of Agent Orange can be characterized by the predominant of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), the major contaminants of the herbicide 2,4,5-T, a constituent of Agent Orange. 2,3,7,8-TCDD is one of the most toxic congener and has received the most attention. Recently, Dwernychuk et al. (2002)[19] surveyed soils, sediments, and foods from Aluoi Valley, a "hot spot" of Agent Orange spraying and the former US Army Base sites. The highest concentration of PCDD/Fs in soil were 2200 pg/g dry wt, which were much higher than those in background levels in many industrialized countries in the world. Of a greater concern, however, are high levels of PCDD/Fs in breast milk, a major dietary intake for breast-fed children. Survey throughout the valley indicates that breast-fed infants of primiparas groups had intake values that 27-fold exceeding the Tolerable Daily Intake (TDI) proposed by WHO. This fact highlighted a new environmental issue that first child exposed to high level of contaminants and therefore be at higher risk.

Except for the dioxin problems caused by Agent Orange in southern Vietnam, there have been no studies investigating the contamination status, bioaccumulation characteristics, fate and toxic implications of dioxins in a tropical environment in Vietnam until our laboratory reported this concern regarding dioxin contamination in dumping sites for municipal wastes in 2003[20]. These open dumping sites are usually located near human habitats; therefore, exposure to various toxic chemicals that originated from dumping sites is of serious concern because of the effects on human health, wildlife and environmental quality. Our recent survey indicates that the concentrations of PCDD/Fs in soils from dumping sites in Hanoi were significantly higher than those in Hochiminh city. Mean and range concentrations in dumping sites from Hanoi were 6100 pg/g dry wt (95 pg/g

TEQs), range, 125-50,500 pg/g dry wt (0.4-850 pg/g TEQ). However, in general, dioxin residues in soils from Vietnam were less than those in other Asian countries examined in this study, indicating less dioxin contamination in Vietnam. However, one soil sample contained very high concentration of PCDD/Fs (50 ng/g dry wt basis; 850 pg/g TEQs).[20] This level is greater than most of the background levels soils in industrialized countries and even higher than those reported for dioxin-contaminated locations in the world. In addition, it is interesting to note that PCDD/F levels in soils collected from dumping sites were significantly higher than those in agricultural and resident soils collected far from dumping sites. These results suggest that open dumping sites could be a potential source of dioxins in Vietnam and deserve further studies.

Acknowledgements

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