Developments in Environmental Science, Volume 7

A. Li, S. Tanabe, G. Jiang, J.P. Giesy and P.K.S. Lam (Editors)

ISSN: 1474-8177/DOI:10.1016/S1474-8177(07)07012-X

Chapter 12

Persistent Toxic Substances in the Philippine Environment

Maricar S. Prudente, Govindan Malarvannan and Shinsuke Tanabe*

Abstract

This chapter provides a comprehensive review of the studies on persistent toxic substances (PTS) in the Philippines environment. Many of these persistent organic pollutants (POPs) including pesticides and industrial chemicals, which were either banned or restricted for use in most northern industrialized countries, are still in use in some developing countries. This review focuses on organochlorine compounds (OCs) such as dichlorodiphenyltrichloroethane and its metabolites (DDTs), hexachlorocyclohexane isomers (HCHs), chlordane compounds (CHLs) and hexachlorobenzene (HCB) in the Philippines environment and biota. It also includes a review of residue levels of industrial chemicals such as polychlorinated biphenyls (PCBs), unintentional contaminants such as polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) and also the new candidates of POPs, polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs). Environmental monitoring of POPs in the Asia-Pacific region, including the Philippines, revealed apparent POPs contamination particularly of PCBs and dioxins. Consequently, these studies suggest higher risk and exposure of the general populace to these toxic contaminants, more so for people residing near dumping site areas, where elevated concentrations of PCDD/Fs have been noted. PBDEs and HBCDs in human breast milk samples are widely present in general population of the Philippines as that of OCs. It can be presumed that PBDEs may become a major environmental concern in the Philippines as they were found at elevated levels in our work and were higher than in Japan, an industrially developed country. HBCDs were also higher than those reported in other available reports. Although decrease in POPs contamination may have been observed recently on a global scale, developing countries, such as the Philippines, may act as

*Corresponding author: E-mail: msprudente@yahoo.com

potential sources for certain contaminants for many more years. Therefore, a more systematic and continuous multi-media monitoring of these toxic substances in the Philippines seem imperative. Human health implications and toxic effects to wildlife must likewise be investigated.

12.1. Introduction

The hazards associated with persistent organic pollutants (POPs) have been known for years and the knowledge on the extent of harm they cause has increased. The POPs chemicals are highly toxic, remain in the environment for long periods, become more concentrated as they go up the food chain, and can spread thousands of kilometers from the point of emission. The weight of scientific evidence strongly suggests that overexposure to certain POPs can cause serious immune and metabolic effects, neurological defects, reproductive anomalies, cancer and other abnormalities in both humans and animals. Bioaccumulation of these compounds has been related to serious toxic threats. The continued production and consumption of pesticides in several countries have also brought unprecedented awareness that these toxic chemicals may elicit impact on animal health and the environment. These chemicals may disrupt the delicate balance of the environment's various interdependent components (Hoekstra et al., 2003). It is well recognized, however, that characterization of the potential adverse effects of exposure, including but not limited to monitoring of the distribution, fate, interaction, effects, and/or impact of pesticides on population dynamics within the ecosystem, is one of the complex fields in risk management activities. Its complexity is further aggravated by such limitations as lack of technical expertise, limited laboratory facilities, inadequate funding, and weak regulations and enforcement programs, particularly in developing countries.

Apart from POPs, several other toxic halogenated chemicals also exist in the environment as a result of their use in many industrial processes. Among these, polybrominated diphenyl ethers (PBDEs) and hexabromocyclododecanes (HBCDs), commonly used as flame retardants, have routinely been added to consumer products for several decades in a successful effort to reduce fire-related injury and property damage. Recently, concern for this emerging class of chemicals has risen because of the occurrence of several classes of brominated flame retardants (BFRs) in the environment and biota. PBDEs are additive flame retardants and the highest production group of BFRs currently in use. The structure of PBDEs is similar to that of polychlorinated biphenyls (PCBs). PBDEs are however, typically produced at three different degrees of bromination, i.e., Penta-BDE, Octa-BDE and Deca-BDE, and classified according to their average bromine content. HBCDs are white crystalline powder, with 74.7% bromine produced from bromination of cyclododecatriene (a butadiene trimer), resulting in the formation of three isomers (α, β, and γ), with the γ isomer being the predominant product. HBCDs are susceptible to thermal degradation.

In May 1995, the UNEP Governing Council decided that an international assessment be undertaken on an initial list of 12 POPs (known as the dirty dozen), which included: aldrin, chlordanes, dichlorodiphenyltrichloroethane and its metabolites (DDTs), dieldrin, dioxins, endrins, furans, hexachlorobenzene (HCB), heptachlor, mirex, PCBs, and toxaphene. In February 1997, UNEP convened an Intergovernmental Negotiating Committee (INC) to prepare a legally binding instrument for implementing international action, initially focused on the 12 POPs. Subsequently, on May 21–23, 2001, diplomats from around the world gathered in Stockholm, Sweden and signed the Stockholm Convention Treaty on Persistent Organic Pollutants, which represents the efforts by the global community to restrict and ultimately ban the use of these chemicals. The treaty also aims to ensure environmentally sound management and chemical transformation of POPs waste and prevent the emergence of chemicals with POPs-like characteristics. As of April 2006, 151 countries have signed the treaty and 121 States including the Philippines and one regional economic integration organization had ratified, accepted, and approved it to signify their intentions for the global actions to reduce POPs and their release to the environment (UNEP, 2006).

The Philippines is one of the archipelagic countries of the Southeast Asian region, which has a land area of approximately 300,000 km^2 and a coastline that extends to ~36,289 km. Its estimated population is ~85 million, where 39 million occupy the coastal areas. Its main industries include agriculture and fisheries. With its strategic geographical position, agricultural and industrial development, the Philippines has become an important site for studies dealing with environmental pollution monitoring during the last decade.

This chapter provides a comprehensive review of the studies on persistent toxic substances (PTS) in the Philippines environment. Available information on PTS in the Philippines was compiled on the basis of investigations conducted within the framework of multilateral cooperative research between Japan and the Philippines through the Core University Program of the Japan Society for the Promotion of Science (JSPS) and the Asia-Pacific Mussel Watch Program. Results from other laboratories were likewise included to derive greater insights into the transport, fate and distribution and bioaccumulation features of PTS and its possible implications on human health in particular, and the quality of the environment in general. This paper focuses on organochlorine compounds (OCs) such as DDT and its metabolites, hexachlorocyclohexane isomers (HCHs), chlordane compounds (CHLs), and HCB. It also includes a review of residue levels of industrial chemicals such as PCBs, polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) and also the new candidates for POPs, PBDEs and HBCDs. The cited values of residual concentrations from various literatures were rounded off to two significant digits for comparison purposes.

Overall, the toxicology database of OCs and BFRs in the Philippines are very limited; the current literature is incomplete and often conflicting. Many animals—including whales, dolphins, seals, birds, and humans—have already been found to be contaminated with these substances, and the levels appear to be increasing in the developed countries, whereas in the developing countries such as the Philippines not much studies has been carried out and needs detailed studies on the present scenario.

12.2. Characteristics of the Philippines agricultural sector

The Philippines is a predominantly agricultural country, with more than half of the population living in the rural areas. Rice and corn are the main staple crops for the majority of the farming population while the major cash crops include coconut, sugarcane, banana, and pineapple. The country being an archipelago, fish and other marine products, particularly prawns and seaweeds, are also significant elements of the agricultural economy. Another factor to note is the role of women in agricultural production. Official figures show that women compose 35% of the agricultural labor force in the Philippines. Their role has affected not only their economic productivity but also their health and that of their children. Women in the Philippines, like their Asian counterparts, have been assigned menial tasks like transplanting, weeding, spraying, and harvesting, which could expose them to unreasonable levels of chemicals. Some agrochemicals have been known to cause infertility, spontaneous abortion, stillbirths, and birth defects; toxic properties may also be passed on to the infant through breast milk. In spite of the UN Resolution calling for countries to prohibit the exposure of women of childbearing potential to hazardous chemicals, the socio-economic conditions prevailing in the Philippines are significant setbacks as far as enforcement is concerned.

12.3. Pesticide industry and usage profiles

The pesticide industry in the Philippines is entirely in the hands of the private sector, dominated by transnational companies. There are ~200 agricultural pesticide companies, including ~30 formulation plants, operating in the country. They include manufacturers, formulators, repackers, importers, distributors, traders, and suppliers. Pesticide companies in the Philippines, as in most countries, include most of the big transnational corporations—engaged in selling a wide range of agricultural, industrial, and consumer products—with assets that are larger than the gross national product of many developing countries, including the Philippines. For example, many chemical companies produce pharmaceuticals, dyes, surfactants, paints, and resins as well as pesticides and some produce photocopying papers, films for magnetic recording tapes, and facsimile transceivers and are involved in chromate mining operations. Giant transnationals like Hoechst, Bayer, Monsanto, Dow, American Cyanamid, Ciba-Giegy, Rhone-Poulenc, and Sandoz are diversified and are continuously growing through mergers and acquisitions.

Pesticides sale in the Philippines grew tremendously over the years until the introduction of the integrated pest management (IPM) concept. From 1987 to 1989, the major pesticide companies in the Philippines put on the market 20,100 tons of pesticides. In the 1990s, the pesticide industry grew at an annual average of ~17.5%. In certain regions of the country, the annual increase in pesticide usage was as high as 500%.

In recent years, however, a pattern of reduction is seen with the continuous popular support for sustainable agriculture initiatives. Among the pesticides that are considered as POPs, endosulfan was most widely used over the last three decades. Endosulfan was misused as a molluscicide for golden snail control when organotin compounds became scarce due to regulation. Despite being banned for use in rice and being severely restricted in 1993, endosulfan is in continues use illegally due to inadequacies in the implementation of regulatory decisions (The Philippines, 1996).

12.4. National inventory of POPs in the Philippines

To meet its obligations under the Stockholm Convention on POPs, the Philippine government, through the Environmental Management Bureau of the Department of Environment and Natural Resources under a GEF-UNDP Grant, conducted an initial National Inventory of POPs (Factora et al., 2004). It was reported that 5 of the 12 POPs—aldrin, dieldrin, endrin, heptachlor, and toxaphene—have been banned in the Philippines since 1989. Although HCB and mirex have no reported use, importation, or production control in the country, and the provisions of Presidential Decree 1144 (National Pesticides Safety Program) will apply for these two pesticides also (Zosa, 1978). On the other hand, DDT is the only restricted pesticide and only the Department of Health is allowed to import the chemical in very small amounts for malaria control. The use of DDT started even before the 1960s and lasted until 1992, when permethrin, an alternative for DDT, was introduced. While chlordane was reported to be the most popular chemical for the control of termites, the inventory further revealed that until its prohibition in 1999, the chemical has been used in many projects and it is even utilized in the treatment of residential structures. Moreover, the survey found that significant quantities of PCBs were evidently present in the Philippines, mainly in electrical equipments. Approximately 8027 equipments were surveyed, of which 1.78% were positively identified as containing PCBs. Based on the inventory, there were 2,089,000 kg of PCB oils in the country contained in electric transformers, capacitors, and circuit breakers (Bravante and Moreno, 2005). It was further revealed that there is approximately 498 tons of PCB oil in the country and 1903 tons of oil are assumed to contain PCBs. PCBs in closed applications still exists in all the priority facilities covered by the survey (Factora et al., 2004).

On the other hand, the Environmental Division of the Industrial Technology Development Institute (ITDI) of the Department of Science and Technology (DOST) conducted a National Inventory of Dioxins and Furans (Pablo et al., 2004) using the UNEP Standardized Toolkit. It was found that the PCDD/Fs of each main source category and sub-category yielded 534.06 g toxic equivalents (TEQ) per annum as the total annual release to all environment compartments. Combustion processes emitted the highest levels of PCDD/Fs with 187.05 g TEQ yr^{-1} or 35% of the total annual releases, followed by power generation and cooking at 157.23 g TEQ yr^{-1}, and production of chemicals and consumer goods at 91.56 g TEQ yr^{-1}. It was further reported that uncontrolled combustion processes was found to be contributing to releases to three environmental media—air, land, and residues (Factora et al., 2004).

12.5. Contamination levels

In developing countries where food supply problems brought about by a growing population prevails, usage of OCs seems unlikely to decline or discontinue. Their usage is considered inevitable partly in tropical agro-ecosystems and public health programs to control pests and vector-borne diseases (Mowbray, 1988; Forget, 1991; Tanabe and Tatsukawa, 1991), respectively. Further, the use of these chemicals has been found to be less costly and therefore economically unavoidable for developing countries (Thao et al., 1993). As most developing countries are located in the tropical belt, where high temperature and heavy rainfall are very common, such climatic factors facilitate the specific distribution, behavior, and fate of these contaminants that will have far-reaching complications and ultimately contribute to global contamination (Tanabe, 1994). On the other hand, PCDDs, PCDFs, and coplanar PCBs are lipophilic-stable contaminants of great concern with respect to their toxic effects on humans and wildlife (Kunisue et al., 2004). In developed countries, the residue levels of these contaminants in various environmental media and biota have generally decreased (Alcock and Jones, 1996; Bradley, 2000; Noren and Meironyte, 2000). In contrast, a few studies have reported contamination status of these chemicals in developing countries, especially regarding human exposure (LaKind et al., 2001). Massive amounts of waste electric products (television, computer, etc.) used in the developed countries such as U.S.A, Japan, Canada, and Europe were exported as trash to Asian developing countries (Ueno et al., 2004). This fact was prominent in the case of PBDEs and HBCDs by the large quantity and increased usage in Asia. Their rapidly rising concentrations in the environment (Ueno et al., 2004; Kajiwara et al., 2006) may have potential effects on global terms in future.

12.5.1. Soils and sediments

Organochlorine (OC) residues in soils of the agriculture site of the Philippines were examined and found that DDT and HCH residue levels were comparable with the values reported from other countries (Lee et al., 1997) in the world (Table 12.1). Analysis of the composition of DDT and its metabolites in most of the soil samples showed higher percentages of *p,p′*-DDE than *p,p′*-DDT, which seem suggestive of the reducing usage of OCs such as DDT for agricultural purposes in the Philippines. HCH residue levels were also not high, suggesting partly their rapid dissipation through volatilization in tropical agro-ecosystem as pointed out in previous studies (Takeoka et al., 1991; Tanabe et al., 1991). These findings were further reflective of the decline in the usage of OCs for agricultural purposes in the country. This downward trend is likely to continue as the government has imposed strict ban on the usage, production, importation, and marketing of these chemicals for agricultural purposes from the

Table 12.1. PCB, DDT, and HCH concentrations (ng g^{-1} dry wt.) in soils from various countries

Location	Soil type	Year	PCBs	DDTs	HCHs	Reference
Philippines	Agriculture	1994	<1.0	1.2–200	0.1–5.2	Lee et al., 1997
Philippines	Dumping site	1994	30–200	50–1100	10–190	Lee et al., 1997
Indonesia (Jakarta)	Urban soil	2002–2003	NA	25	29	EMC, 2003
India (Chennai)	Dumping site	2000	180	24	30	Minh et al., 2006
India (Chennai)	Rural soil	2000	0.052	0.079	0.048	Minh et al., 2006
China (Pearl River Delta)	Non Agriculture	2000	NA	6.7	8.2	Fu et al., 2003
China (Pearl River Delta)	Agriculture	2000	NA	68	16	Fu et al., 2003
Cambodia (Phnom Penh)	Dumping site	1999/2000	140	350	1.7	Minh et al., 2006
Cambodia (Phnom Penh)	Rural soil	1999/2000	0.85	1.1	<0.01	Minh et al., 2006
South Korea	Urban soil	1996	NA	0.4	0.4–2.9[a]	Kim and Smith, 2001
Vietnam (Hanoi)	Rural soil	2000	0.73	3.2	0.14	Minh et al., 2006
Vietnam (Hochiminh)	Rural soil	2001	3.6	3.8	0.36	Minh et al., 2006
Vietnam (Hanoi)	Dumping site	2000	12	20	0.83	Minh et al., 2006
Vietnam (Hochiminh)	Dumping site	2001	22	23	0.37	Minh et al., 2006
Vietnam (Hanoi)	Various soils	1992	12	35	2.1	Thao et al., 1993
Egypt	Urban soil	1996	NA	1.4	2.3[b]	Ahmed et al., 1998
Ireland	Agriculture	1992	3.49	12	1.16	Grath, 1995
Ireland	Urban soil	1992	2.97	1.8	1.14	Grath, 1995
Russia	Agriculture	1992	1.4–92	0.34–28	0.04–16	Iwata et al., 1995
Slovak Republic	Waste site	1996	NA	11	12	Marta et al., 1997
Argentina	Agriculture	1996	NA	30	21	Miglioranza et al., 1999
United States	General soil	1998	5.9	NA	NA	Meijer et al., 2003
United States (Alabama)	Agriculture	1996	NA	50	0.23	Harner et al., 2001

Note: NA—Not available.
[a]Range is given when mean value is not available.
[b]Median value.

year 1977, as embodied in the National Pesticide Safety Program and mandated by Presidential Decree 1144 (Zosa, 1978). Although, HCB was officially banned from agricultural use in the country from 1972, other pesticides containing HCB as impurities might pose as one of the pollution sources. CHL residue levels were comparable with values of HCB found, while PCB residues were low in all the samples (Lee et al., 1997).

As for the dumpsite soils collected from Smokey Mountain, a 29 hectare former dumpsite area within metropolitan Manila, highly significant DDT, HCH, and PCB residue levels were found, which could be attributed to the extensive usage of these chemicals for public health and the industries from where the wastes were dumped in the area (Lee et al., 1997). The high levels of DDT residues and marked proportion of *p,p′*-DDT found could be attributed to its recent usage for the control of vector-borne diseases such as malaria. Smokey Mountain was used as an open dumpsite until its closure in 1994 and this area has been reported to be home to ~3000 families and 14,000 individuals, which translates to a population density of ~463 persons per hectare (Abad, 1991). With no provisions for community health care, Smokey Mountain may be considered a malarial area. As such, the Government's Department of Health through its Malaria Eradication Service Division, conducts residual spraying of DDT, for malaria control purposes until its phase-out, all over the country by virtue of a memorandum issued by the Secretary of the Department of Health (Flavier, 1992). Moreover, mean concentrations of CHLs detected and the proportions of CHL compound found suggest that technical mixture of CHLs is still in use for public health purposes, for example as termiticides, in urban and industrialized areas.

Significant levels of PCBs were also detected and attributing to the fact that Smokey Mountain could be a dumping ground for PCB contaminated wastes. This observation lends support to results of a study conducted by Thao et al. (1993), which suggested that soil contamination of PCBs could likely to occur at some point sources for PCB storage and usage especially on cases where facilities for the proper use and disposal of PCBs may be lacking as in Smokey Mountain. HCB residues in Smokey Mountain (dumping site soils) were found much higher when compared to those in agricultural soils (Lee et al., 1997). It was suspected that the main source of HCB residues at the dumpsite soil could be fungicide application and its release as an impurity of several industrial and chemical products and as a byproduct in various chlorination processes and combustion system of wastes.

In another study conducted by Minh et al. (2003), concentrations of PCDD/Fs and coplanar PCBs were determined in soils from dumping sites in the Philippines, Cambodia, India, and Vietnam. Residue levels in dumpsite soils were apparently greater than those soils collected in agricultural or urban areas far from dumping sites, suggesting that dumpsites are potential sources of PCDD/Fs and related compounds. Mean concentrations of PCDD/Fs and coplanar PCBs in soils from dumping sites were the highest in the Philippines, followed by soils from Vietnam, Cambodia, and India. Further, observed PCDD/F concentrations in soils from dumpsites in the Philippines and Cambodia were found to be comparable or even higher than those reported for dioxin-contaminated locations in the world (Minh et al., 2003). Homologue profiles of PCDD/Fs in dumping site soils in the Philippines reflected patterns of samples representing typical emissions. Uncontrolled burning of solid wastes by waste pickers and low-temperature burning with the formation of methane gas are plausible explanations for the formation of dioxins in dumping sites. Estimated flux of PCDD/Fs to dumpsite soils from the Philippines was the highest and was found to be even greater than those from other locations in the world (Table 12.2). Considerable loading rate at 3900 mg yr^{-1} (35 mg TEQ yr^{-1}) of PCDD/Fs in the Payatas dumpsite in the Philippines suggest that Payatas dumpsite is a potential reservoir for PCDD/Fs. Possible implications on human health and wildlife living near dumping sites are of great concern and deserve further comprehensive studies.

Table 12.2. Estimated flux of PCDD/Fs to soils in dumping sites in various countries

Country	Flux (ng m^{-2} yr^{-1})	
	Mean	Range
Philippines[a]	17,000	13,000–21,000
India[a]	990	290–4500
Cambodia[a]	2900	31–19,000
Vietnam—Hanoi[a]	4100	83–34,000
Vietnam—Hochi Minh[a]	67	3.8–160
Hongkong[b]	2800	840–4030
Australia[b]	13	10–16
Germany[b]	97	51–140
Spain[b]	100	72–130
United Kingdom[b]	180	170–220
Yukon Territory, Canada[b]	6.6	1.2–15
British Columbia, Canada[b]	64	4.2–350
Michigan, USA[b]	80	52–110
Indiana, USA[b]	1280	1260–1290

[a]Data from Minh et al., 2003.
[b]Data from Wagrowski and Hites, 2000 (as cited in Minh et al., 2003).

Lee et al. (1997) also found high residue levels of CHLs, PCBs, and DDTs in sediments from Manila Bay and its inflowing rivers, which could imply recent usage of these contaminants for public health purposes as the bank of Pasig River is full of residential shanties, where water and vector-borne diseases are more likely to occur. HCH and DDT levels in Pasig River sediments were comparable with those found in similar areas in other tropical countries. HCB concentrations in Pasig River sediments was low, which affirmed the findings of our previous study (Iwata et al., 1994), attributing the trend to the rapid evaporation from water phase to atmosphere because of the prevailing high temperature in this tropical area. However, the mean DDTs concentration in the sediments from Pasig River was found to be higher than those reported from Taiwan, Thailand, Malaysia, and India. The relatively high DDT concentrations suggest that DDT has been used until recently for public health purposes as discussed earlier. Interestingly, highest range of PCB concentrations were found in sediments from Pasig River among the samples analyzed and the principal source of PCB contamination is still unclear, but industrial effluents along the river coat is possible considered.

12.5.2. Biological samples (bivalves, waders, cetaceans and fish)

The green mussels (*Perna viridis*), being filter feeders, are considered to be highly suitable for culture in the coastal areas. These mussels have become one of the most valuable mariculture organisms produced in Asia (Goldberg et al., 1978). The Philippines is one of those countries that have ventured into large-scale exploitation of green mussel. As early as the 1950s, the Philippines was one of the countries outside Europe to have explored the possibilities of intensive mussel culture. Thus, in 1955, the first commercial mussels farm started its operation, marking the beginning of a mussel industry that has proved to be as lucrative as the oyster industry (Yap et al., 1979; Guerrero et al., 1983). Despite the fact that mussels are part of the nation's diet, monitoring studies on the residues of toxic contaminants in this seafood is rather limited.

Monirith et al. (2003), conducted a study to assess the levels of toxic contaminants in green mussels collected from Philippines' coastal waters, particularly in the major mussel culture areas within the framework of the Asia-Pacific Mussel Watch program. Among the OCs, PCBs were observed to be generally prominent in green mussels analyzed. Relatively higher PCB levels were measured in green mussels collected around Manila Bay area, which may imply that PCB contamination could be from the highly populated and industrialized cities. Based among the Asian countries the PCB levels reported in bivalve mollusks (Table 12.3),

Table 12.3. Mean concentrations of OCs (ng g^{-1} lipid wt.) in mussels from Asian countries

Countries	Lipid (%)	PCBs	DDTs	HCHs	CHLs	HCB
Philippines	1.8	290	21	1.8	54	<0.80
Cambodia	1.3	35	23	<0.30	<0.30	1.2
China	2.0	120	16,000	44	190	56
Hong Hong	1.2	310	7700	18	240	<1.5
India	1.7	340	380	120	35	4.0
Indonesia	1.5	87	70	3.0	7.3	0.70
Japan	1.3	3000	270	28	550	8.2
South Korea	2.4	170	150	14	25	2.3
Malaysia	1.3	56	90	3.7	140	0.80
Vietnam	1.1	160	4400	5.8	17	1.0
Russia	2.0	3200	630	45	56	4.5
Singapore	2.7	90	110	12	28	<0.40

Note: Data from Monirith et al. (2003).

values found in green mussels from the Philippines were similar to those found in Hong Kong, but higher than those found in mussels from South Korea, Vietnam, and China. However, PCB levels in mussels from the Philippines were lower than those in mussels from Russia, Japan, and India. CHL concentrations in green mussels from the Philippines' coastal waters proximal to urbanized and industrialized areas were observed to be a magnitude higher than the levels in mussels collected from the coasts of rural areas. Similar to PCBs, this spatial difference is suggestive that CHL contamination may be coming from thickly populated and industrialized areas. On an international basis, monitoring data on CHL residues in bivalves is rather scarce. Nevertheless, comparable levels of CHLs were found in green mussels from the Philippines' coastal waters (Prudente et al., 1999). On the other hand, DDT and HCH concentrations obtained for green mussels in the Philippines were lower than those found in mussels from all the other Asian countries (Table 12.3). HCB concentrations were the lowest and the uniform HCB concentrations found in green mussels from the various study sites were within the same range as the levels detected in green mussels from the coastal waters of Thailand (Prudente et al., 1999). It has been reported that HCB contamination may have originated from usage of fungicides or as an impurity in pesticide formulations, a byproduct of various chlorination processes, and the combustion of industrial and municipal wastes (Kannan et al., 1994).

Concentrations of BFRs (PBDEs and HBCDs) and OCs in the muscle and liver of skipjack tuna collected from the offshore waters of various regions in the world, including the Philippines were recently conducted

Table 12.4. Concentrations of PBDEs, HBCDs and OCs (ng g^{-1} fat wt.) in the liver of skipjack tuna collected from offshore waters and open seas

Location	*N*	BL (cm)	BW (kg)	PBDEs	HBCDs	PCBs	DDTs	CHLs	HCHs	HCB
Off-Philippines	5	42	1.5	14	0.86	190	98	17	<0.13	1.7
North Pacific-1	5	44	1.8	5.8	25	110	30	43	28	9.4
North Pacific-2	10	47	2.2	16	29	250	96	60	1.2	6.1
North Pacific-3	5	79	11	6.4	1.1	530	93	25	0.82	3.8
Off-Japan-1	5	49	2.6	7.7	32	170	48	35	11	7.2
Off-Japan-2	5	52	3.3	11	45	800	180	150	6.7	7.6
Japan Sea	5	63	5.6	20	6.5	900	510	110	2.5	5.1
East China Sea-1	5	58	3.9	34	44	620	630	85	13	1.4
East China Sea-2	5	61	5.2	23	28	580	290	57	4.4	2.7
Off-Taiwan-1	4	61	4.9	53	27	980	420	100	8.1	3.9
South China Sea	1	31	0.5	21	3.2	140	670	38	6.7	2.2
Bay of Bengal	2	47	2.0	1.8	0.27	120	410	13	7.8	1.5
Off-Indonesia	2	47	2.0	3.1	0.41	50	31	7.8	1.4	1.3
Off-Seychelles	3	55	3.6	ND	ND	14	39	33	<0.29	1.7
Off-Brazil	4	55	3.7	13	0.28	460	92	63	2.7	2.4

Note: Data from Ueno et al., 2003, 2004, 2006.
PBDEs and HBCDs – Muscle; OCs – Liver samples; ND – Not detected.

(Ueno et al., 2003, 2004, 2006). PBDEs, HBCDs, and OCs were detected in all the samples off the Philippines suggesting widespread contamination of these compounds in the Philippines environment (Table 12.4). Among the organohalogen compounds, PBDE levels in the Philippines were found to be higher than those in Japan, India, Indonesia, and Brazil and lower than China and Taiwan. In the case of HBCDs the levels were found almost equal to India and Indonesia and one magnitude lower than Japan, China, and Taiwan. The observed ranges of this compound seemed to indicate a spatial variability that might be due to exposure to different background residue levels in the environment. PCBs and DDTs were the predominantly identified compounds in the case of OCs. PCBs were higher in tunas from the offshore waters of temperate regions in Asia. DDTs were the predominant compounds in tuna samples from tropical regions, including the Philippines, which could be reflective of continued use of DDT until recently in the region. Such patterns of PCB and DDT contaminations were also observed in a previous monitoring survey of cetaceans in the Asia-Pacific region (Prudente et al., 1997).

To our knowledge, there are very few studies that examined OCs contamination in higher trophic animals from the Philippines. A survey on migrant and resident waders collected from Calatagan Bay, Philippines was conducted (Kunisue et al., 2003) and among the OCs measured in the resident waders, PCBs were the prominent compounds followed by DDTs, CHLs, HCHs, and HCB. This pattern was found to be similar to

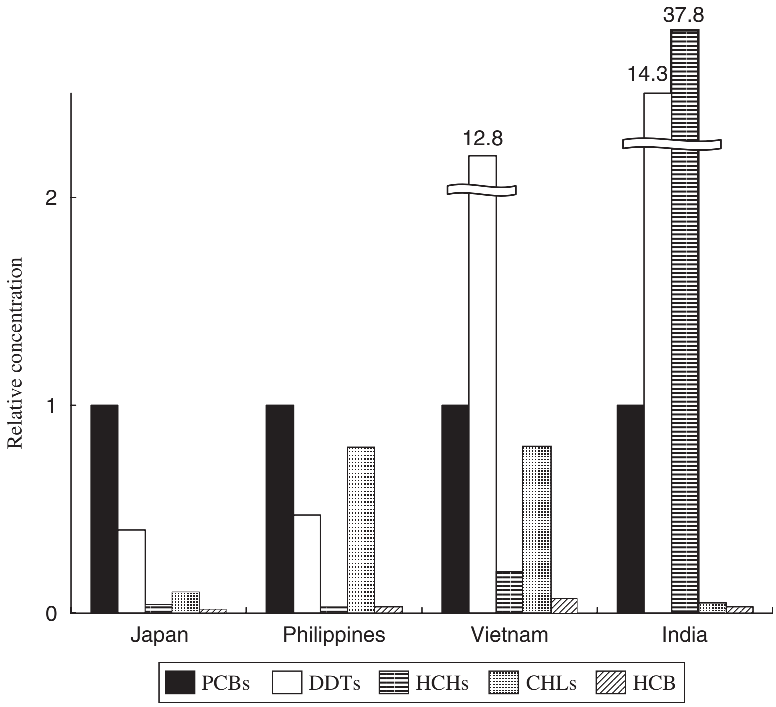

Figure 12.1. Mean relative concentrations of OCs to PCBs in resident waders from various Asian countries (Kunisue et al., 2003).

those waders collected from Japan, suggesting that notable PCB contamination of biota in these countries is still occurring (Fig. 12.1) (Kunisue et al., 2003). It can be gleaned further that the relative concentrations of CHLs in waders from Calatagan was higher than that from other countries, while the residue levels of other OCs were generally low. As for the migrant species, the composition of OCs followed the order of DDTs > PCBs > HCHs > CHLs > HCB, which also holds true with the waders collected from Vietnam (Fig. 12.2). This result seem to indicate that on their migratory routes, wader species collected from Calatagan Bay could be wintering and feeding in areas of high DDT usage. These observations confirm the notion that DDTs and PCBs are highly persistent, less biodegradable, and are retained in the animal's body for a long time (Tanabe and Tatsukawa, 1991). This suggests that the accumulation features of OCs in migratory waders reflect not only the pollution status in the area of collection, but also in stopover sites, breeding and wintering grounds. DDTs and PCBs were the dominant

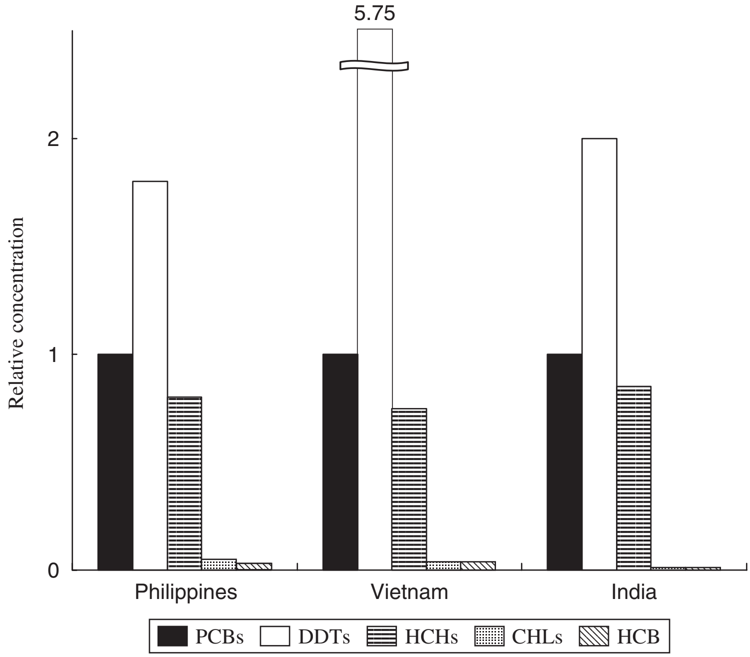

Figure 12.2. Organochlorine residue patterns in migratory migrant waders from the Philippines, Vietnam, and India (Kunisue et al., 2003).

contaminants in short-distance migrants from the Philippines. It is known that many species from the Philippines have their breeding grounds around Persian Gulf, Red Sea, and Caspian Sea (Hoyo et al., 1996). High concentrations of PCBs were also detected in Caspian seals and fishes from Caspian Sea and PCBs' release into this environment could be continuing (Kajiwara et al., 2002). Moreover, the accumulation pattern in short-distance migrants from Calatagan Bay was almost similar to those from Vietnam. In both countries, the relative concentrations of HCHs in short-distance migrants were slightly higher than those found in resident birds. These results are indicative that short-distance migrants from Calatagan Bay and Vietnam may have their breeding grounds or stopover sites in China, since China is known to have widely used HCHs and DDTs (Wu et al., 1982; Li et al., 1996; Zhu et al., 1999). While long-distance migrants from Calatagan Bay showed similar trends to short-distance migrants, indicating that the long-distance migrant waders might have been exposed to high levels of DDTs in their stopover sites and breeding grounds. In addition, relative concentrations of HCHs in long-distance migrants from the Philippines and Vietnam were slightly higher than those found in short-distance migrants. This finding could be suggesting that these long-distance migrant birds might have been exposed to HCHs in the Arctic regions, which are known to be polluted by HCHs due to the long-range atmospheric transport from the southern hemisphere (Muir et al., 1999).

Recent scientific studies on marine mammals in the Philippines revealed that at least 18 and possibly 27 species of cetaceans are found in the Philippine seas (Tan, 1995). This apparent diversity however, is threatened by the ongoing destruction of their ecological support systems and increasing competition for food, as well as whale and dolphin fisheries that are reportedly being practiced in the southern part of the country. Numerous investigations have emphasized that the seas and oceans should be considered as significant sinks for toxic and bioaccumulate contaminants. In particular, marine mammals, such as whales, dolphins, and seals, living in these areas are at the top of the food chain, and are known to have extremely high rates of contaminant accumulation, hence are believed to be facing high risk in the ecotoxicological context (Tanabe et al., 1994). In this perspective, Kajiwara et al. (2006) studied the accumulation of these contaminants in the lipid-rich blubber tissues of one spinner dolphin (*Stenella longirostris)* collected from the tropical waters of northeastern Sulu Sea in the Philippines.

The mean concentration of PBDEs, DDTs, and PCBs detected in these cetaceans from Sulu Sea, Philippines were lower than those reported in the other Asian countries (Table 12.5). DDTs and PCBs levels in these cetaceans were found to be considerably higher than other OCs. However, PBDE, DDT and PCB residue levels in the Philippines were very much lower than those in Hong Kong and Japan. These observations showing relatively significant DDT residue levels in tropical species reflect DDT origination from the tropics. Apparently higher DDT residue levels found in air and water samples from tropical and subtropical coastal waters than those from the temperate ones (Iwata et al., 1994) confirm this notion. Moreover, as evidenced by Iwata et al. (1993, 1994), less movable nature of DDTs through long-range atmospheric transport might have led to the significant contamination of tropical surface seawater as well as tropical species. Meanwhile, mean CHL levels detected in the cetaceans in this study were found to be higher than those in India and an order of magnitude lower than those in other Asian countries (Table 12.5). The mean concentration of HCHs and HCB levels in the Philippines were similar to the levels found in Indian dolphins, but one or two magnitude lower than those of other Asian countries.

Table 12.5. Mean concentrations (ng g^{-1} lipid wt.) of PBDEs and OCs in the blubber of cetaceans collected from Asian waters

Species	n	Lipid (%)	PBDEs	PCBs	DDTs	CHLs	HCHs	HCB
Phillippines								
1996 Spinner dolphin	3	38	36	3600	16,000	540	110	220
Japan								
1998–2000 Finless porpoise								
Seto Inland Sea	5	61	730	120,000	76,000	21,000	3300	280
Pacific Coast	2	47	620	29,000	32,000	4800	950	690
1999 Harbour porpoise	3	87	73	2200	3300	1000	730	710
2000 Dall's porpoise								
truei-type	5	87	57	9000	11,000	4200	1200	860
dalli-type	5	86	530	18,000	31,000	5200	1900	580
2001 Melon-headed whale	5	68	320	24,000	27,000	4100	210	270
1999 Pacific white-sided dolphin	5	69	690	8700	14,000	3300	900	460
2000–2001 Stejneger's beaked whale	5	71	530	19,000	110,000	4500	2700	690
Hong Kong								
2000–2001 Finless porpoise	6	46	600	13,000	120,000	740	250	160
1997–2001 Indo-Pacific humpback dolphin	7	31	1900	45,000	190,000	2200	720	280
India								
1992 Indo-Pacific humpback dolphin	2	57	11	2000	75,000	160	110	16
1990–1992 Spinner dolphin	3	47	6.8	1600	48,000	160	220	28

Note: Data from Kajiwara et al. (2006).

12.5.3. Human exposure

Limited data are available on human exposure to organohalogen compounds in the Philippine environment. A survey conducted by our group (Prudente et al., 2004) reported considerably lower levels of OC residues in breast milk samples from Payatas, an open dumpsite area in the suburbs of Metropolitan Manila area, compared with those found in human breast milk samples collected from other countries in Asia. DDT residues were found to range from 35–570 ng g^{-1} lipid wt., while PCB residues ranged between 39–160 ng g^{-1} lipid wt. It was further revealed that the contamination pattern of OCs in human breast milk resembled those observed among marine mammals (Prudente et al., 1997). The bioaccumulation pattern of OCs in human breast milk from the Philippines (DDTs > PCBs > CHLs > HCHs > HCB) were reported by Kunisue et al. (2002). In a most recent study on the measurement of OCs such as DDTs, PCBs, CHLs, HCHs, HCB, TCPMe, and BFRs including PBDEs and HBCDs in 33 human breast milk samples from the Philippines carried out in our laboratory (Malarvannan et al., 2007), all the compounds were detected in all the samples, indicating their widespread contamination in the Philippines. DDTs were the predominantly identified compounds in all the samples at an average of 170 ng g^{-1} lipid wt., followed by other compounds in the order of PCBs (70 ng g^{-1} lipid wt.), CHLs (12 ng g^{-1} lipid wt.), PBDEs (7.2 ng g^{-1} lipid wt.), HCHs (5.5 ng g^{-1} lipid wt.), HCB (2.4 ng g^{-1} lipid wt.), TCPMe (2.2 ng g^{-1} lipid wt.), and HBCDs (0.84 ng g^{-1} lipid wt.). The concentrations of other organohalogen compounds were 1–3 orders of magnitude less than those of DDTs and PCBs. The observed residue level pattern (DDTs > PCBs > CHLs > PBDEs > HCHs > HCB > TCPMe > HBCDs), is different from other Asian developed and developing countries (DDTs > PCBs > HCHs > CHLs > HCB > PBDEs) (Sudaryanto et al., 2005), indicating different exposure patterns to organohalogen compounds in the general population of the Philippines. Interestingly, PBDEs may become a major environmental concern in the Philippines as they were found at elevated levels in our work and were higher than in Japan, an industrially developed nation (Hites, 2004, Sudaryanto et al., 2005). HBCDs were also higher than those reported in other available reports (Covaci et al., 2006).

However, the accumulation pattern of OCs in human milk was different from that found in mussels from the Philippines coastal environment (Monirith et al., 2003), which showed higher levels of PCBs and CHLs, probably because of the difference in exposure routes. However, DDTs were consistently the prevalent OCs in both samples, indicating that DDTs are the major environmental contaminants in the Philippines environment.

In a subsequent study conducted by Kunisue et al., (2004), it was reported that dioxins and related compounds (DRCs) were detected in all the human breast milk collected from dumpsite areas. The concentrations of PCDDs in human breast milk from the Payatas dumpsite in the Philippines ranged from 29 to 730 pg g^{-1} lipid wt. It was also noted that the level of TEQ in human breast milk from the Philippines (12 pg TEQ g^{-1} lipid wt.) was lower than that from developed countries but comparable with that from other developing countries (Schecter et al., 1990; Paumgartten et al., 2000) (Fig. 12.3). Similarly, in the third round of WHO-coordinated dioxin exposure study on levels of dioxin-related compounds in human milk of Filipino mothers (Pablo et al., 2005), it was found that contamination in Filipino breast milk was among the lowest when compared to other countries. To understand the magnitude of exposure to DRCs by infants, daily intake (DI) from human breast milk observed in this study were estimated based on the assumption that an infant ingests 700 ml milk perday and that the weight of an infant is 5 kg (Hooper et al., 1997). Daily intake from human breast milk from the Philippines was in a range of 1.9–130 pg TEQ kg^{-1} d^{-1} (mean: 39 pg TEQ kg^{-1} d^{-1}), which exceeded the tolerable daily intake (TDI) set by WHO at 1–4 TEQ kg^{-1} d^{-1}.

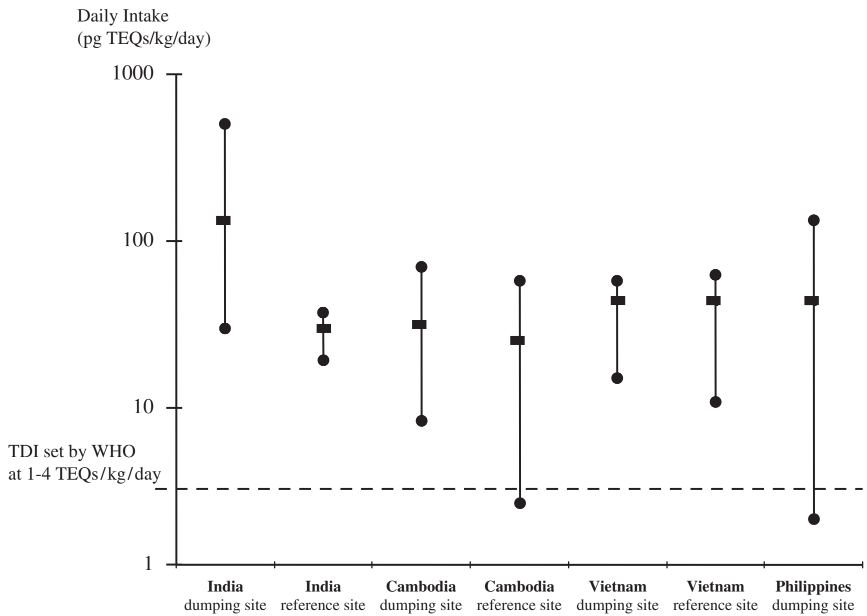

Figure 12.3. Estimated daily intakes of TEQs from human breast milk based on the assumption that an infant ingests 700 ml milk per day and that the weight of an infant is 5 kg (Hooper et al., 1997).

In a related study conducted by Minh et al. (2003), PCDD/F concentrations in some soil samples from the Philippines, Cambodia, India, and Vietnam exceeded environmental guideline values, suggesting potential health effects on humans and wildlife living near the dumpsites. Human intakes of dioxins via soil ingestion and absorption by dermal exposure were estimated to be highest in people of the Philippines followed by Cambodia, India, and Vietnam. 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 dumpsites. Findings in this study underscored the serious health risk on people living near dumpsite areas considering the hundreds of people scavenging in the dumpsite area and even living there (as in the case of Payatas dumpsite in the Philippines). Moreover, the study addressed the issue that open dumping sites are potential sources of PCDD/Fs and related compounds, and dioxin contamination in dumpsites may become a key environmental problem in developing countries, particularly in the Philippines.

12.6. Management and regulation of POPs in the Philippines

The Philippine Senate ratified the Stockholm Convention in 2004 making the Philippines the 51st party to the Stockholm Convention. Further, the Philippine government through its Environmental Management Bureau (EMB) of the Department of Environment and Natural Resources (DENR) has conducted enabling activities as part of its obligation to the Convention. This enabling activity project was conducted through the support of the Global Environment Facility (GEF) channeled through the United Nations Development Program (UNDP) (Bravante and Medina, 2004). Among the activities that have been conducted were: establishment of a coordination mechanism, which includes the formation of a Technical Working Group on POPs management, a Project Steering Committee, and the Regional Interagency Committee (RIAC) on POPs; capacity building activities; conduct of capacity and needs assessment; conduct of an Initial National Inventory and Public Awareness; and information campaign activities.

To articulate the country's commitment to the Convention, Philippine POPs Environmental Policy has been drafted (Madrazo and Ang, 2005). This policy was formulated upon agreement and acceptance by the stakeholders and stated as follows:

Consistent with the policy of the State to protect the environment and promote the general welfare and health of the people and their right to a balanced and healthful *ecology, the Philippines commits itself to implement policies, strategies and actions designed to eliminate the production and use of Persistent Organic Pollutants (POPs) and minimize the release of unintentional POPs by-products covered by the Stockholm Convention. The Philippines shall execute the National Implementation Plan to meet its obligations under this Convention.*

The Philippines is in its final stages in the process of formulating a National Implementation Plan (NIP) that aims toward identifying national actions and programs parallel to the objectives of the Stockholm Convention (Madrazo and Ang, 2005). The development of a national document such as NIP in the Philippines is a relatively long process as it was necessary to have core-enabling activities be completed so as to provide the baseline information needed in formulating the NIP. Workshops and focus group discussions were frequently held among the stakeholders (government and non-government agencies) to ensure their extensive involvement, as the actual development of the NIP is a consultative process. With the results of the enabling activities, the Philippine NIP aims to present the current status of POPs in the country, set the priorities for future activities to protect human health and the environment, and to indicate and formulate procedures for implementing any necessary policy and regulatory reforms, capacity building and other programs (Madrazo and Ang, 2005).

Based on the activities that were initially conducted for the enabling activity project (Bravante and Medina, 2004), it was reported that little is known about POPs in the country and that even the users have minimal understanding of their hazards. As no comprehensive data on POPs is available for use as baseline information, a more comprehensive inventory is needed for the Philippines to have an actual measure of the risks that must be managed and addressed in the NIP. The Initial National Inventory conducted showed that POPs have already been banned in the country except HCB and mirex, which have no recorded use, importation or production in the country. Significant amounts of PCBs mainly come from electric transformers and capacitors. Dioxins and Source Inventory by DOST showed that there are numerous sources of dioxins and furans in the country, which emit significant quantities of dioxins and furans into the environment. No treatment facility in the country that deals with the destruction of POPs and other toxic hazardous wastes are present in the country (Bravante and Moreno, 2005).

There are existing legal mandates that cover the management of POPs and other toxic and hazardous substances in the country. In June 1999, the Philippine Congress enacted the Philippine Clean Air Act (Republic Act 8749), wherein Section 32 addresses POPs and Section 20 incorporates a provision calling for a ban on incineration. Furthermore, pursuant to the provisions of the Republic Act 6969 otherwise known as Toxic Substances and Hazardous and Nuclear wastes Control Act of 1990, DENR Administrative Order No. 29, Series of 1992, otherwise known as the "Implementing Rules and regulations of RA6969" and other applicable laws, rules and regulations, Chemical Control Order for PCBs was promulgated and took effect on March 19, 2004. Furthermore, DENR developed a list of Priority Chemical List (PCL) and the Philippines Inventory of Chemicals and Chemical Substances (PICCS), which are scheduled for updating every five years. To date, the Philippine Congress has yet to ratify House Bill 5429 otherwise known as the "Philippine Hazardous and Nuclear Wastes Management Act of 2003", that aims to protect human health and the environment from the potential risks of hazardous and radioactive wastes within the framework of sustainable development through the formulation and implementation of integrated and comprehensive waste management systems. This act when passed into law can help pave the way for a real solution to the country's hazardous waste management problems from collection, treatment, storage and disposal (Madrazo, 2004).

12.7. Conclusion and recommendations for future research

During the last decade, environmental monitoring of persistent organic pollutants in the Asia-Pacific region, including the Philippines, revealed apparent POPs contamination particularly of PCBs and dioxins. Consequently, these studies suggest higher risk and exposure of the general populace to these toxic contaminants, more so for people residing near dumping site areas, where elevated concentrations of PCDD/Fs have been noted. Although decrease in POPs contamination may have been observed globally, developing countries, such as the Philippines, could be potential sources for certain contaminants. Therefore, a more systematic and continuous multi-media monitoring of these toxic substances seem imperative. Human health implications and toxic effects to wildlife must likewise be investigated. Lack of data in terms of measured concentrations and threshold values may require the conduct of systematic appraisal using data on BFRs and POPs releases and ecotoxicological properties to measure environmental risks. Active participation in international cooperative research programs would help the Philippines in its need for capacity building on appropriate advanced technologies and laboratory facilities to carry out these studies.

ACKNOWLEDGMENTS

The studies we have conducted were supported by grants from the Environmental Science and Technology in the Core University Program between Japan Society for the Promotion of Science (JSPS) and the Department of Science and Technology (DOST) of the Philippines and the 21st Center of Excellence (COE) Program of the Ministry of Education, Culture, Sports, Science and Technology, Japan. We express our profound gratitude and gratefulness to Prof. An. Subramanian of the Center for Marine Environmental Studies of Ehime University, Japan for his critical reading of this manuscript.

REFERENCES

Abad, R., 1991. Smokey Mountain. In Philippine Studies. 1, 263.

Ahmed, M.T., Ismail, S.M.M., Mabrouk, S.S., 1998. Residues of some chlorinated hydrocarbon pesticides in rainwater, soil and ground water and their influence on some soil microorganisms. Environ. Int. 24, 665–670.

Alcock, R.E., Jones, K.C., 1996. Dioxins in the environment: A review of trend data. Environ. Sci. Technol. 30, 3133–3143.

Bradley, D., 2000. Stamping out dioxin in food? Environ. Sci. Technol. 34, 504-A.

Bravante, A., Medina, L., 2004. The Philippine Enabling Activity Project: Initial assistance to the Philippines to meet its obligations under the Stockholm Convention on Persistent Organic Pollutants. Proceedings of the 1st Asian Regional Research Programme on Environmental Technology. (ARRPET); Feb. 27, 2004, Don Enrique Yuchengco Hall, De La Salle University-Manila, pp. 7–14, ISSN:1656-2801.

Bravante, A., Moreno, I., 2005. PCB Management in the Philippines. Proceedings of the 2nd Asian Regional Research Programme on Environmental Technology. (ARRPET); Feb. 18, 2005, De La Salle–College of St. Benilde Angelo King International Center, pp. 8–13, ISSN:1656-2801.

Covaci, A., Gerecke, A.C., Law, R.J., Voorspoels, S., Kohler, M., Heeb, N.V., Leslie, H., Allchin, C.R., De Boer, J., 2006. Hexabromocyclododecanes (HBCDs) in the environment and humans: A review. Environ. Sci. Technol. 40, 3679–3688.

EMC (Environmental Management Center), 2003. Monitoring of persistent organic pollutants in the coastal hydrosphere of Indonesia. Environmental Monitoring and Governance in the East Asian Hydrosphere. Country report, UNU, Japan. http://landbase.hq.unu.edu/Data.htm

Factora, K., Bansuli, C., Rivera, C., Esguerra, R., Faller, L., Gallardo, S., 2004. Inventory of POPs in the Philippines. Proceedings of the Asian Regional Research Programme on Environmental Technology. Feb. 27, 2004, De La Salle University-Manila, pp. 15–24, ISSN: 1656-2801.

Flavier, J., 1992. In Memorandum Circular: Department of Health. Manila, Philippines, 1.

Forget, G., 1991. Pesticides and the Third World. J. Toxicol. Environ. Health 32, 11–31.

Fu, J., Mai, B., Sheng, G., Zhang, G., Wang, X., Peng, P., 2003. Persistent organic pollutants in environment of the Pearl River Delta, China: An overview. Chemosphere 53, 1411–1422.

Goldberg, E.D., Bowen, V.T., Farrington, J.W., Harvey, G., Martin, J.H., Parker, P.L., Risebrough, R.W., Robertson, W., Schneider, E., Gamble, E., 1978. The mussel watch. Environ. Conserv. 5, 101–125.

Grath, D.M.C., 1995. Organic micropollutant and trace element pollution of Irish soils. Sci. Total. Environ. 164, 125–133.

Guerrero, R.D., Yap, W.G., Handog, L.G., Tan, E.O., Torres, P.N., Balgos, M.C., 1983. The Philippines recommends for mussels and oysters. PCARRD Tech. Bull. 26-A, 46.

Harner, T., Bidleman, T., Jantunen, L.M.M., Mackey, D., 2001. Soil-air exchange model of persistent pesticides in the United States cotton belt. Environ. Toxicol. Chem. 20, 1612–1621.

Hites, R.A., 2004. Polybrominated diphenyl ethers in the environment and in people: A meta-analysis of concentrations. Environ. Sci. Technol. 38, 945–956.

Hoekstra, T., O'Hara, M., Fisk, A.T., Borga, K., Solomon, K.R., Muir, D.C.G., 2003. Tropic transfer of persistent organochlorine contaminants (OCs) within an Arctic marine food web from the southern Beaufort-Chukchi seas. Environ. Pollut. 124, 509–522.

Hooper, K., Petreas, M.X., She, J., Visita, P., Winkler, J., McKinney, M., 1997. Analysis of breast milk to assess exposure to chlorinated contaminants in Kazakstan: PCB and organochlorine pesticides in Southern Kazakstan. Environ. Health Perspect. 105, 1250–1254.

Hoyo, J.D., A. Ellit and J. Sargatal, (Eds.), 1996, Handbook of the Birds of the World. Lynx Edicions, Barcelona, Spain.

Iwata, H., Tanabe, S., Aramoto, M., Sakai, N., Tatsukawa, R., 1994. Persistent organochlorine residues in sediments from Chukchi Sea, Bering Sea and the Gulf of Alaska. Mar. Pollut. Bull. 28, 746–753.

Iwata, H., Tanabe, S., Sakai, N., Tatsukawa, R., 1993. Distribution of persistent organochlorines in the oceanic air and surface seawater and the role of the ocean on their global transport and fate. Environ. Sci. Technol. 27, 1080–1098.

Iwata, H., Tanabe, S., Ueda, K., Tatsukawa, R., 1995. Persistent organochlorine residues in air, water, sediments and soils from the Lake Baikal region, Russia. Environ. Sci. Technol. 29, 792–801.

Kajiwara, N., Kamikawa, S., Ramu, K., Ueno, D., Yamada, T.K., Subramanian, A., Lam, P.K.S., Jefferson, T.A., Prudente, M., Chung, K.H., Tanabe, S., 2006. Geographical distribution of polybrominated diphenyl ethers (PBDEs) and organochlorines in small cetaceans from Asian waters. Chemosphere 64, 287–295.

Kajiwara, N., Niimi, S., Watanabe, M., Ito, Y., Takahashi, S., Tanabe, S., Khuraskin, L.S., Miyazaki, N., 2002. Organochlorine and organotin compounds in Caspian seals (*Phoca caspica*) collected during an unusual mortality event in the Caspian Sea in 2000. Environ. Pollut. 117, 391–402.

Kannan, K., Tanabe, S., Tatsukawa, R., 1994. Biodegradation capacity and residue pattern of organochlorines in Ganges River dolphins from India. Toxicol. Environ. Chem. 42, 249–261.

Kim, J.H., Smith, A., 2001. Distribution of organochlorine pesticides in soils from South Korea. Chemosphere 43, 137–140.

Kunisue, T., Watanabe, M., Iwata, H., Subramanian, A., Monirith, I., Minh, T.B., Baburajendran, R., Tana, T.S., Viet, P.H., Prudente, M., Tanabe, S., 2004. Dioxins and related compounds in human breast milk collected around open dumping sites in Asian developing countries: Bovine milk as potential source. Arch. Environ. Contam. Toxicol. 47, 414–426.

Kunisue, T., Watanabe, M., Someya, M., Monirith, I., Minh, T.B., Subramanian, A.N., Tana, T.S., Viet, P.H., Prudente, M., Tanabe, S., 2002. PCDDs, PCDFs, PCBs and organochlorine insecticides in human breast milk collected from Asian developing countries: Risk assessment for infants. Organohalogen Comp. 58, 285–287.

Kunisue, T., Watanabe, M., Subramanian, A., Sethuraman, A., Titenko, A.M., Qui, V., Prudente, M., Tanabe, S., 2003. Accumulation features of persistent organochlorines in resident and migratory birds from Asia. Environ. Pollut. 125, 157–172.

LaKind, J.S., Berbin, C.M., Narman, D.Q., 2001. Infant exposure to chemicals in breast milk in the United States: What we need to learn from a breast milk monitoring program. Environ. Health Perspect. 109, 75–88.

Lee, D.B., Prudente, M.S., Tanabe, S., Tatsukawa, R., 1997. Organochlorine residues in soils and sediments from Manila and nearby provinces, Philippines. Toxicol. Environ. Chem. 60, 171–181.

Li, Y.F., McMillan, A., Scholtz, M.T., 1996. Global HCH usage with 1° by 1° longitude/latitude resolution. Environ. Sci. Technol. 29, 2877–2885.

Madrazo, A., 2004. Updates on House Bill 5429. Proceedings of the Asian Regional Research Programme on Environmental Technology National Workshop. February 27, 2004, Yuchengco Hall, De La Salle University-Manila, pp. 1–6, ISSN: 1656-2801.

Madrazo, A., Ang, M., 2005. Update on the Philippine National Implementation Plan (NIP) for the Stockholm Convention. Proceedings of the Asian Regional Research Programme on Environmental Technology National Workshop. February 18, 2005, De La Salle – College of St. Benilde, Angelo King International Center, Manila, Philippines, pp. 1–7, ISSN: 1656-2801.

Malarvannan, G., Kunisue, T., Isobe, T., Takahashi, S., Sudaryanto, A., Prudente, M., Tanabe, S., 2007. Specific Accumulation of Organohalogen Compounds in Human Breast Milk from the Philippines: Levels, Distribution, Accumulation Kinetics and Infant Health Risk. Proceedings of the International Symposium on Pioneering Studies of Young Scientists on Chemical Pollution and Environmental Changes, November 17–19, 2006, Ehime University, Matsuyama, Japan, pp. 175–178.

Marta, V., Viktor, P., Jana, K., Jnn, U., 1997. Analytical methods for the determination of organochlorine compounds—Application to environmental samples in the Slovak Republic. Chromatography A 774, 333–347.

Meijer, S.N., Ockenden, W.A., Sweetmen, A., Breivik, K., Grimalt, J.O., Jones, K.C., 2003. Global distribution of PCBs and HCB in background surface soils: Implications for sources and environmental processes. Environ. Sci. Technol. 37, 667–672.

Miglioranza, K.S.B., Moreno, J.E.A., Moreno, V.J., Osterrieth, M.L., Escalate, A.H., 1999. Fate of organochlorine pesticides in soils and terrestrial biota of Los Padres pond watershed, Argentina. Environ. Pollut. 105, 91–99.

Minh, N.H., Minh, T.B., Kajiwara, N., Kunisue, T., Subramanian, A., Iwata, H., Tana, T.S., Baburajendran, R., Karuppiah, S., Viet, P.H., Tuyen, B.C., Tanabe, S., 2006. Contamination by persistent organic pollutants in dumping sites of Asian developing countries: Implication of emerging pollution sources. Arch. Environ. Contam. Toxicol. 50, 474–481.

Minh, N.H., Minh, T.B., Watanabe, M., Kunisue, T., Monirith, I., Tanabe, S., Sakai, S., Subramanian, A., Sasikumar, K., Viet, P.H., Tuyen, B.C., Tana, T., Prudente, M., 2003. Open dumping site in Asian developing countries: A potential source of polychlorinated dibenzo-*p*-dioxins and polychlorinated dibenzofurans. Environ. Sci. Technol. 37, 1493–1502.

Monirith, I., Ueno, D., Takahashi, S., Nakata, H., Sudaryanto, A., Subramanian, A., Karrupiah, S., Ishmail, A., Muchtar, M., Zheng, J., Richardson, B., Prudente, M., Duc Hue, N., Tana, T., Tkalin, A., Tanabe, S., 2003. Asia-Pacific mussel watch: Monitoring contamination of persistent organochlorine compounds in coastal waters of Asian countries. Mar. Pollut. Bull. 46, 281–300.

Mowbray, D.L., 1988. Pesticide use in the South Pacific. UNEP Regional Seas Reports and Studies No. 89 and SPREP Topic Review. No. 26, UNEP, p.275.

Muir, D., Braune, B., DeMarch, B., Norstrom, R., Wagemann, R., Lockhart, L., Hargrave, B., Bright, D., Addison, R., Payne, J., Reimer, K., 1999. Spatial and temporal trends and effects of contaminations in the Canadian Arctic marine ecosystem: A review. Sci. Total. Environ. 230, 83–144.

Noren, K., Meironyte, D., 2000. Certain organochlorine and organobromine contaminants in Swedish human milk in the perspective of past 20–30 years. Chemosphere 40, 1111–1123.

Pablo, A., Silverio, C., Pasagui, M.V., 2005. Levels of dioxin, furans and dioxin-like PCBs in Human Milk from Filipino Mothers. Proceedings of the Asian Regional Research Programme on Environmental Technology National Workshop. October 28, 2005, Yuchengco Hall, De La Salle University-Manila, pp. 8–17, ISSN:1656-2801.

Pablo, A., Silverio, C., Pasagui, V., Marquez, A.T., 2004. Inventory of Dioxins and Furans in the Philippines. Proceedings of the Asian Regional Research Programme on Environmental Technology National Workshop. February 27, 2004, Yuchengco Hall, De La Salle University-Manila, pp. 25–32, ISSN:1656-2801.

Paumgartten, F.J.R., Cruz, C.M., Chahoud, I., Palavinskai, R., Mathar, W., 2000. PCDDs, PCDFs, PCBs and other organochlorine compounds in human milk from Rio de Janeiro, Brazil. Environ. Res. 83, 293–297.

Prudente, M., Aguja, S., Kunisue, T., Tanabe, S., 2004. Persistent organic pollutants in human breast milk. Proceedings of the Asian Regional Research Programme on Environmental Technology- National Workshop. February 27, 2004, Yuchengco Hall, De La Salle University-Manila, pp. 33–33F, ISSN:1656-2801.

Prudente, M.S., Ichihashi, H., Kan-Ateriklap, S., Watanabe, I., Tanabe, S., 1999. Butyltins, organochlorines and metal levels in green mussels (*Perna viridis*) from the coastal waters of the Philippines. Fish. Sci. 65(3), 441–447.

Prudente, M.S., Tanabe, S., Watanabe, M., Subramanian, A.n., Miyazaki, N., Suarez, P., Tatsukawa, R., 1997. Organochlorine contamination in some odontoceti species from the North Pacific and Indian Ocean. Mar. Environ. Res. 44, 415–427.

Schecter, A., Starti, J.R., Rose, M., Wright, C., Parker, I., Woods, D., 1990. Chlorinated dioxin and dibenzofuran levels in human milk from Asia, Pakistan, Southern Vietnam, the southern U.S. and England. Chemosphere 20, 919–925.

Sudaryanto, A., Kajiwara, N., Tsydenova, O., Iwata, H., Adibroto, T.A., Yu, H., Chung, K.H., Subramanian, A., Prudente, M., Tana, T.S., Tanabe, S., 2005. Global contamination of PBDEs in human milk from Asia. Organohalo. Compd. 67, 1315–1318.

Takeoka, H., Ramesh, A., Iwata, H., Tanabe, S., Subramanian, A.N., Mohan, D., Magendran, A., Tatsukawa, R., 1991. Fate of HCH in the tropical coastal area, South India. Mar. Pollut. Bull. 22, 290–297.

Tan, J. L., 1995. A field guide to whales and dolphins in the Philippines. Bookmark, Makati, Metro Manila, Philippines. p.125.

Tanabe, S., 1994. International mussel watch in Asia-Pacific. Mar. Pollut. Bull. 28, 518.

Tanabe, S., Iwata, H., Tatsukawa, R., 1994. Global contamination by persistent organochlorines and their eco-toxicological impact on marine mammals. Sci. Total Environ. 15, 163–177.

Tanabe, S., Ramesh, A., Sakashita, D., Iwata, H., Tatsukawa, R., Mohan, D., Subramanian, A.N., 1991. Fate of HCH (BHC) in tropical paddy field: Application test in South India. Int. J. Environ. Anal. Chem. 45, 45–53.

Tanabe, S., Tatsukawa, R., 1991. Persistent organochlorines in marine mammals. In: Jones, K.C. (Ed.), Organic Contaminants in the Environment. Elsevier, New York, pp. 275–289.

Thao, V.D., Kawano, M., Tatsukawa, R., 1993. Organochlorine residues in soils from Taiwan, Thailand and Vietnam. Environ. Pollut. 81, 61.

The Philippines. 1996. Philippine Case Study: A Developing Country's Perspective on POPs. IFCS Meeting on POPs, June 17-19, 1996, Manila, The Philippines. http://www.chem.unep.ch/pops/indxhtms/manexp7.html

Ueno, D., Alaee, M., Tanaka, Marvin, C., Muir, D.C.G., Macinnis, G., Reiner, E., Crozier, P., Furdui, I.V., Subramanian, A., Fillmann, G., Lam, P.K.S., Zheng, G.J., Muchtar, M., Razak, H., Prudente, M., Chung, K.H., Tanabe, S., 2006. Distribution and transportability of hexabromocyclododecane (HBCD) in the Asia-Pacific region using skipjack tuna as bioindicator. Environ. Pollut. 144, 238–247.

Ueno, D., Kajiwara, N., Tanaka, H., Subramanian, A., Fillmann, G., Lam, P.K.S., Zheng, G.J., Muchtar, M., Razak, H., Prudente, M., Chung, K.H., Tanabe, S., 2004. Global pollution monitoring of polybrominated diphenyl ethers using skipjack tuna as bioindicator. Environ. Sci. Technol. 38, 2312–2316.

Ueno, D., Takahashi, S., Tanaka, H., Subramanian, A., Fillman, G., Nakata, H., Lam, P.K.S., Zheng, J., Muchtar, M., Prudente, M., Chung, K., Tanabe, S., 2003. Global pollution monitoring of PCBs and organochlorine pesticides using skipjack tuna as bioindicator. Arch. Environ. Contam. Toxicol. 45, 378–389.

UNEP. 2006. Status of ratification of the Stockholm Convention. April 24, 2006. UNEP/POPS/COP.2/INF/14 http://www.pops.int/documents/meetings/cop_2/meetingdocs/270406/K0651271%20COP2-INF14.pdf

Wagrowski, D.M., Hites, R.A., 2000. Insights into the global distribution of polychlorinated dibenzo-*p*-dioxins and dibenzofurans. Environ. Sci. Technol. 34, 2952–2958.

Wu, T.C., Lee, D.J., Wang, Y.S., Chen, Y.L., 1982. Organochlorine residues in riverine sediments from Taiwan. J. Chin. Agri. Chem. Soc. 20, 1.

Yap, W.G., Young, A.L., Orano, C., De Castro, M.T., 1979. Manual on mussel farming. Aquaculture Extension Manual No. 6, Southeast Asian Development Center, Aquaculture Department, Iloilo, Philippines, 17 pp.

Zhu, X., Liu, J., Sodergren, A., 1999. Occurrence and distribution of organochlorine residues and metals in sediments, water and fish in the catchments area of lake Baiyangdian, China. Toxicol. Environ. Chem. 68, 287–296.

Zosa, M., 1978. In Restricted Pesticides in the Philippines (leaflet), Fertilizer and Pesticide Authority, Philippines.