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Chapter 14

Persistent Organic Pollutants in Malaysia

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Abstract

The use of pesticides in Malaysia dated back since after the Second World War. These persistent pollutants were primarily used for agriculture and vector control. DDT, dieldrin and endrin found extensive use before they were banned recently. Most of the other persistent organic pollutants (POPs) have been banned in Malaysia. However, residues of these pesticides were found in various compartments of the environment such as water, sediment and biota. Non-pesticide POPs were not monitored as much but recent efforts have included monitoring and management of these POPs among other hazardous chemicals. This chapter presents the current status of POPs in Malaysia and various initiatives to manage these pollutants.

14.1. Introduction

Malaysia is situated in the tropical rainforest region and is traditionally an agriculture-based country. The use of pesticides for agriculture and vector control were quite extensive after the Second World War. Organochlorine pesticides (OCPs) such as DDT, dieldrin, and endrin had been used in agricultural plantations until they were banned in the late 1990s. High levels of persistent organic pollutants (POPs) such as lindane and endosulfan have been reported in water, sediment, and fish. Other POP pesticides were observed to be decreasing in concentration after they were banned from import and uses. Non-pesticide POPs are not well monitored in Malaysia. Inventory for PCBs is being developed and data on environmental levels of PCBs is scarce. Unintentionally produced POPs, dioxins, and furans, have practically not been studied in Malaysia. More effort should be put to monitor the status of the POP chemicals in Malaysia. For achieving a well-planned monitoring of these chemicals in Malaysia, gathering all the available information and evaluating the

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*Corresponding author: E-mail: sani@usm.my status of pollution in different facets of the environment and biota will form the first step in this direction.

14.2. Persistent organic pollutants (POPs) in Malaysia: An overview

Malaysia consists of Peninsular Malaysia, called West Malaysia, situated in mainland Southeast Asia and the two states of Sabah and Sarawak, called East Malaysia, situated in the northern part of Borneo Island. West Malaysia is made up of 11 states which, together with Singapore, gained independence from British rule in 1957 to form the Federation of Malaya. Malaysia itself was formed in 1963 with Sabah and Sarawak joining to form a 14-state nation. However, in 1965, Singapore left to become a separate country. Nine of the states are headed by sultans while the four states of Pulau Pinang, Melaka, Sabah, and Sarawak are headed by Heads of State (Yang Dipertua Negeri). Three Federal Territories have been created including Kuala Lumpur, Putrajaya, and Labuan. The main administrative center used to be Kuala Lumpur but has been recently moved to Putrajaya.

Malaysia is a constitutional monarchy and the country is headed by a king selected amongst the nine sultans and run by a prime minister elected in national elections. Malaysia has a population of 26.51 millions comprising Malay, Chinese, Indians, and several other ethnic groups (Jabatan Perangkaan Malaysia, 2006). The official language is Bahasa Melayu with English, Mandarin, Tamil, and other local dialects being spoken. The main religion is Islam but other religions are freely practiced.

Malaysia is traditionally an agriculture-based country and one of the world's leading producers of palm oil and rubber. However, it is gradually transforming into a multisector economy, particularly in the electronic and electrical appliance industries. Malaysia is fairly rich in natural resources such as petroleum, natural gas, timber, tin, copper, and iron ore (CIA, 2006). In fact, petroleum and natural gas products represented the second highest export group (USD 19.6 billion est.) behind electrical and electronic products in 2005 (Jabatan Perangkaan Malaysia, 2006). The gross domestic product (GDP) for 2005 was USD 130.5 billion with a GDP growth of 4.5% over the 2004 GDP. This amounted to a GDP per capita of USD 5035 for 2005 (Economist.com, 2006).

14.2.1. Physical and geographical settings

Malaysia lies above the equator between 2° and 8° N. West Malaysia and East Malaysia lie from 100° to 118° E, encompassing a large part of the

South China Sea. West Malaysia and East Malaysia are separated by about 640 km of the South China Sea. The total land area is 329,750 km^2 where West Malaysia has a total area of 131,573 km^2, Sarawak has a landmass of 124,449 km^2 and Sabah has a land area of 73,711 km^2. Approximately 80% of the combined land area is still covered with tropical rain forest while the remaining land is used for agriculture, namely, oil palm and rubber.

Figure 14.1 shows the map of Malaysia and the neighboring countries, which include Thailand in the north and Singapore to the south of Peninsular Malaysia while Brunei is sandwiched by Sabah and Sarawak in Borneo Island. Indonesia has the longest boundary line with Sarawak and Sabah while Sumatra Island is separated by the heavy shipping lane of the Straits of Malacca with Peninsular Malaysia. There are a few islands, the larger of which are Penang and Langkawi Islands in the Straits of Malacca while Tioman Island is situated in the South China Sea and Labuan Island off the coast of Sabah.

Topographically, West Malaysia is characterized by extensive coastal plains in the west and east with hilly and mountainous regions and steep slopes in the central mountain range of Titiwangsa and undulating terrain in other parts of the peninsular. Sabah is characterized by the western

Figure 14.1. Map of Malaysia and neighboring countries.

lowlands, the Crocker Range, the central uplands, and the eastern lowlands whereas Sarawak is characterized by a seaward fringe of peat swamp. However, the tropical forest covers much of the interior highland beyond the border with Kalimantan in Indonesia. There are only ~0.3% of water bodies in Malaysia which are mostly meandering rivers.

14.2.2. Climate and ecological characteristics

The climate of West Malaysia is equatorial, characterized by fairly high but uniform temperatures (ranging from 23 to 31°C throughout the year), high humidity and copious rainfall (averaging ~250 cm annually). There are seasonal variations in rainfall, with the heaviest rains from October to December. The eastern coastal region receives the most abundant rainfall where it averages over 300 cm year^{-1}. Sabah and Sarawak in East Malaysia are slightly cooler due to ocean cooling and frequent tropical rainstorms particularly during the monsoon season in November to March when these areas receive heavy rainfall.

Malaysia is blessed with a rich tropical rain forest, which is one of the most diverse and complex ecosystems in the world. The forest contributes to ~95% of the land covers in Malaysia providing rich timber and other forest products. The coastal regions are generally covered with peat swamp (3.3%) and the ecologically sensitive mangroves (1.8%) (UNEP/EAP-AP, 1999). In 2003, Malaysia exported 13.97 million m^3 of timber and timber products (MTC, 2006).

14.2.3. Industrial and agricultural activities

The major exports of Malaysia in 2004 were electronic and electrical machinery (67.7%), petroleum and liquefied natural gas (7.3%), chemical and chemical products (7.3%), palm oil (5.3%), and textiles and clothing (2.7%) (Economist.com, 2006). Several multinational companies producing electronic and electrical goods have set up their production plants in designated industrial zones throughout the country. The chemical industry, which is governed by the Chemical Industry Council Malaysia, represents various industries dealing with products such as petrochemical, pharmaceutical, oleochemical, agricultural chemicals as well as domestic chemicals such as detergents and cosmetics. The oil palm industry is very important to the Malaysian economy from agricultural and industrial perspectives. The Malaysian Palm Oil Board, an institution established in 1998 under the Malaysian Palm Oil Act (Act 582), plays an important role in organizing and promoting the palm oil industry of Malaysia by carrying out research related to planting, production, harvesting, extraction, processing, storage, transportation, use, consumption, and marketing of oil palm and oil palm products.

Beside oil palm, rubber and cocoa are the other major agricultural crops in Malaysia with 1.3 and 0.1 million farmed hectares, respectively compared to 3.1 million hectares of oil palm plantations. Rice, the staple food of Malaysians, is grown in the low regions of north Peninsular Malaysia and Sabah but the production is insufficient to support the demand for rice. Other agricultural crops are pepper, produced mostly in Sarawak and various fruits and vegetables grown primarily for local consumption.

14.2.4. Marine environment

Malaysia has an extensive coastal line and the country is divided between the west and east by the South China Sea. The west coast of West Malaysia shares the Straits of Malacca with Sumatra Island. The Straits of Malacca, together with the Java Sea, South China Sea and the Gulf of Thailand, are part of the rich marine environment of the shallow Sunda Shelf. In recent years, the Straits of Malacca has become a very important shipping route connecting the oil rich West Asia to the Far East. Shipping accidents have occurred more frequently in these shallow and narrow channels (Chua et al., 2000). The South China Sea, on the other hand, is poorly understood in terms of its marine biota, ecology, and the human impacts upon it. However, it is anticipated that anthropogenic impacts, such as the over-exploitation of marine resources and pollutions, will threaten the sea (Morton and Blackmore, 2001).

The marine environments around Malaysia are rich in natural resources including fisheries, coral reefs, sea-grass beds, and mangroves, lining the coastlines. Petroleum and natural gas resources are quite abundant in the South China Sea where offshore mining and oil prospecting activities predominate significantly.

14.3. Sources of POPs in Malaysia

Historically, pesticides have been used in Malaysia to control pests in rubber, cocoa, and oil palm plantation since 1955 (Conway, 1973). DDT and dieldrin were introduced to control ring bark borer (*Endoclita hosei*) in Sabah's cocoa plantations in 1959 and continued to be used from 1960 to 1965. Other pesticides such as endrin, technical grade HCH, lindane, lead arsenate, and trichlorphon were also used in the cocoa plantations. Oil palm plantations in West Malaysia saw the use of DDT, dieldrin, and endrin to control cockchafers, bagworm, and rhinoceros beetles from 1956 up to 1964 (Conway, 1973). Even though rubber trees were relatively free from pest attacks, it was found that cockchafer grubs caused severe damage to young rubber trees. Before the Second World War, laborious hand digging was the only form of control but after the war, heptachlor was used as 0.1% emulsion to control the pests.

Rice fields in West Malaysia have also been sprayed with dieldrin, lindane, trichlorfon, and diazinon since 1955 to control rice borer pests. Their applications were terminated when it was discovered that several rice field fishes were found dying within 24 h after the application of 0.1% dieldrin spray in Tanjung Karang (Kok, 1973). The control of malaria mosquito vectors in the Borneo states of Sabah, Sarawak, and Brunei, using DDT and dieldrin at the rate of 2 g and 0.6 g m^{-2} of dwelling areas from 1955 to 1963, was very successful and became a model for World Health Organization (WHO) campaigns in other countries. However, the excessive use of these pesticides caused a decline in the population of house cats, which feed on the dead or infected cockroaches and house lizards (*geckos*). This in turn saw such an increase in the rat population and a near outbreak of house infestation that "operation cat drop" was undertaken by the WHO in cooperation with the Royal Air Force in Singapore (Conway, 1973).

14.3.1. Sources of pesticide POPs

Pesticides have been in use in Malaysia following the Second World War to control pests in agricultural plantations, namely rubber, oil palm, and cocoa. The regulation on the importation and handling of these pesticides comes under the Pesticide Act 1974. Under the Act, all pesticides imported into and used in Malaysia have to be registered with the Pesticides Board Malaysia. Importers have to supply information such as trade names, active ingredients, amounts, and formulations. The Pesticides Board reviews the registration of these pesticides from time to time when toxicity and ecotoxicological data become available. The 1997 registration listed a total of 1767 formulations of pesticides and herbicides. A number of POP chemicals was also in the registration list, including DDT, chlordane, endosulfan, lindane, atrazine, 2,4-D, chlorpyrifos as well as tri-*N*-butyltin naphthenate (Pesticides Board Malaysia, 1997). However, in the latest register, there are 2279 formulations of pesticides and herbicides while most of the controversial pesticides had been deregistered. Since there are no manufacturing facilities for these POP pesticides in Malaysia, most of them have been either banned or voluntarily withdrawn by the local importers. However, the use of endosulfan and lindane was still being allowed but limited to certain sectors. Endosulfan is not allowed to be used in cocoa and pepper plantations while lindane was only allowed in the oil palm and coconut plantations before it was totally deregistered in 2003 (Sufian Yek, 2005).

Chlordane and DDT were deregistered in 1997 and 1999, respectively. The registrations of aldrin, dieldrin, and heptachlor were not renewed and thus were banned in the early 1990s. Some of the POPs not on the Stockholm Convention list have also been banned including lindane and other HCH isomer mixtures, pentachlorophenol, and 2,4,5-T. There are still a number of persistent pesticides in use and this is a major concern. Pesticides such as endosulfan, atrazine, chlorpyrifos, and tributyltin (TBT) remain on the registration list and are available in the market. Endosulfan, even with known high toxicity effects to biota and humans, are still being used in Malaysia. It is being extensively used in rice fields in the northern region of West Malaysia to control rice borers and golden snails.

There is no available information on the amount of pesticides being imported into the country. Some POP chemicals such as DDT, dieldrin, and endrin had been in use following the Second World War until they were banned or de-registered. For instance, DDT was used to control malaria both in East and Peninsular Malaysia (since 1961 in the former and 1967 in the later) until it was replaced by delta-methrin and other pesticides after 1998. A record on the use of DDT as insecticide residual spray between 1991 and 1998 showed that ~253,989 kg of DDT had been applied as 25% emulsified concentrate or as 75% water-dispersible powder. The impact of interventions in malaria control using primarily DDT saw a drastic reduction of more than 70% recorded malaria cases (Hashim, 2003).

14.3.2. Industrial sources

The sources of unintentionally produced POP chemicals, polychlorinated dibenzodioxins (PCDD), polychlorinated dibenzofurans (PCDF), and hexachlorobenzene (HCB), has been estimated through the National Implementation Plan (NIP) for Malaysia. However, an official report has not been made public. The draft final report on the assessment of unintentionally produced chemicals conducted by Universiti Sains Malaysia indicated that the estimated total release of PCDD/PCDF from various industrial activities was 27.18 g TEQ year^{-1} (Universiti Sains Malaysia, 2004). The main contributing source was attributed to waste incineration accounting for ~50% of the total release of PCDD/PCDF even though currently, Malaysia does not have large domestic waste incineration facilities. There are a number of small waste incinerators in the larger islands with capacities between 3 and 10 tons day^{-1} and several small medical waste incinerators. There is a privately managed chemical/industrial waste treatment facility centrally located at Bukit Pelandok, ~100 km south of Kuala Lumpur which handles all 107 categories of scheduled wastes listed under the Environmental Quality (Scheduled Wastes) Regulations 1989. The chemical waste incineration plant operates a high temperature rotary kiln with an efficient flue gas cleaning system. The plant has the capacity of 33,000 tons year^{-1} and meets the PCDD/PCDF emission limit of 0.1 ng m^{-3}. From 1998 to 2004, ~15.5 tons of PCBs, 57 tons of pesticide stockpiles, and 22 tons of transformer oil had been treated in this facility (Idris, 2004).

There are a number of high temperature metal production and processing plants in Malaysia, which have contributed to the release of PCDD/PCDF. Chemical industries in Malaysia are dominated by the petroleum industries where there are six major oil refineries with a total capacity of ~500,000 bbl day^{-1}, a LNG processing plant in Sarawak and several oil terminals. Consumer products industries are not expected to release significant amounts of PCDD/PCDF except for pulp and paper production. Currently, there are 19 paper manufacturing companies in Malaysia with several production facilities throughout the country. The biggest paper production facility is the Sabah Forest Industries located at Sipitang, Sabah. Malaysia has a paper producing capacity of slightly more than one million tons per year which is still 50% less than the annual demand (Haron, 2002).

The release of PCDD/PCDF from transport activities was estimated to be very minimal and not reported for uncontrolled combustion processes (Universiti Sains Malaysia, 2004). In the Department of Environment Malaysia 1997 report, the major sources of air pollution in 1996 were motor vehicles, 82%, power stations, 9%, industrial fuel burning, 5%, industrial production processes, 3%, domestic and commercial furnaces, 0.2%, and open burning at solid waste disposal sites, 0.8% (Afroz et al., 2003). Leaded gasoline has been phased out since 1998 and most cars have been fitted with catalytic converters since then. Consequently, a minimal release of PCDD/PCDF is expected from motor vehicles that are mainly from diesel-powered vehicles. The released air pollutions monitored were CO, NO_2, SO_2, O_3, and suspended particulate matters.

A recent study by Omar et al. (2002) showed that the total polycyclic aromatic hydrocarbons (PAHs) concentrations in the atmospheric particles and roadside soil particles collected in Kuala Lumpur were 6.28 ng m^{-3} and 0.22 μg g^{-1}, respectively.

Domestic waste management is a burning issue in Malaysia. The Malaysian government is planning to build a large solid waste incineration plant in Broga, south of Kuala Lumpur which has a proposed capacity of 1500 tons day^{-1}. However, the initiative has met with opposition from local communities and several non-governmental organizations (NGO) (CAP, 2005). Currently, there are 246 waste disposal sites throughout Malaysia but most of them are not properly planned and managed. Open dumping is commonly practiced and more often than not, leachates have been found to seep into the nearby rivers where drinking water is sourced from Landfill fires are quite common sights which would definitely release PCDD/PCDF into the atmosphere. Other sources of PCDD/PCDF are widely practiced open burning of domestic wastes and frequent forest fires from neighboring countries. A major haze episode in Southeast Asia occurred in 1997 where it was estimated that 60 Tg of forests and vegetation were burned, producing thick smoke covering the whole of Malaysia and neighboring countries (Liew, 1998). Beside PCDD/PCDF, large amount of PAHs are also released during forest fire.

14.3.3. Polychlorinated biphenyl (PCBs) inventory

PCBs are not manufactured in Malaysia and the import of PCBs has been banned since 1995. However, there are still old transformers and capacitors in use that contain PCB-contaminated oil (Hashim, 2001). Since 1998, PCB stockpiles and PCB-contaminated transformer oils have been properly disposed of at the Kualiti Alam Integrated Waste Management Centre, Bukit Pelanduk. A total of 15.5 tons of PCBs and 22 tons of transformer oils was incinerated at the site from 1998 to 2004 (Idris, 2004). There is no available record on the total import of PCBs and PCB containing products. Under the National Implementation Plan for compliance to the Stockholm Convention, an exercise to produce a PCB inventory for Malaysia has been carried out but the report has not been made public.

14.3.4. Regional sources

Most of the countries in the region have banned the production, import, and use of most POP pesticides. All the countries in Southeast Asia are parties to the Stockholm Convention and have made every effort to reduce and eliminate the use of these chemicals in compliance with the Convention. However, the safe disposal of existing stockpiles and the availability of good alternative pesticides in this mainly agricultural region are some of the issues that need to be addressed very quickly (UNEP, 2002). Indonesia had the capacity to produce ~7000 tons of DDT per year but the production plant was closed in 1992. An average of 2500 tons of DDT had been used every year in various parts of Indonesia (Purwono and Agustina, 2002). Thailand had been increasingly importing OCPs from ~5000 tons in 1971 to 34,000 tons in 1999. Extensive uses of pesticides in Thailand were reflected in the results of the studies by the Department of Agriculture from 1993 to 1999 where more that 40% of samples were analyzed positive for pesticides with a concentration range of <0.01–$1.21\,\text{ug L}^{-1}$ for water and <0.01–$7.43\,\text{mg kg}^{-1}$ for sediments (Chareonsong, 2002). DDT had been extensively used in countries in the region following the Second World War until it was banned in the late 1990s. Viet Nam, for instance, was using ~200 tons a year in 1992–1994 to control the spread of malaria (UNEP, 2002).

The regionally based assessment of persistent toxic substances for the Southeast Asian region (UNEP, 2002) had suggested a possible hot spot for the presence of PCDD/PCDF in Viet Nam where defoliant agents contaminated with PCDD/PCDF had been aggressively sprayed during the Vietnam War between 1962 and 1971. The application of herbicides such as 2,4-D and 2,4,5-T had resulted in the release of ~170 kg equivalent of TCDD (Le, 2002). With the persistency and long-range capability of PCDD/PCDF, it is possible that Malaysia, among other countries in the region, will be affected. PCBs were not manufactured in the region and its importation has been banned in all of the countries since the early 1990s. Inventories on stockpiles and PCB-contaminated equipment are being produced by countries in the region under the NIP initiatives for the Stockholm Convention.

The major concern for the region is the open burning of domestic wastes and forest fires in the tropical forest belt of Southeast Asia that resulted in severe hazes and the release of hazardous airborne chemicals, particularly PAHs. It became such a regional crisis that a Regional Haze Action Plan was instituted in 2001 to address the issue of transboundary haze (ASEAN, 2006).

14.4. Levels of POP contamination in Malaysia

The extensive use of pesticides has resulted in high levels of contamination in every environmental compartment in Malaysia. Reports as early as 1981 found that high levels of widely used pesticides, such as aldrin, dieldrin, DDT, and HCHs, had contaminated river water, sediments, and fish (Abdullah, 1995). In the review, the author summarized the findings of several earlier studies on levels of pesticide pollutions in aquatic environments in Malaysia as shown in Table 14.1. Studies conducted in the early 1980s showed high levels of dieldrin (200–500 ng L^{-1}), aldrin (100–1800 ng L^{-1}), and lindane (100–600 ng L^{-1}) in water and much higher levels in sediments and rice field fish. DDT and endosulfan were also found in rice fields and marine fish at levels of 800 ng/kg and 5400 ng/kg, respectively (Abdullah, 1995). A comprehensive survey on the pesticide residues in Peninsular Malaysian waterways was conducted in 1989–1990 by Tan et al. (1991) who found several pesticides such as dieldrin, endrin, DDT, heptachlor and endosulfan in the range from not detected to as high as 68.7 ng L^{-1}. Being surrounded by large bodies of seawater, quite an extensive amount of data is available on concentration of POPs in fishes and marine organisms. However, very few studies have been reported on POP contamination in terrestrial biota and humans.

14.4.1. POPs contaminations in water

Iwata et al. (1994) reported an exceptionally high concentration of HCHs in the Selangor River water in central Peninsular Malaysia at 900 ng L^{-1} as

Table 14.1. Organochlorine pesticides in Malaysian aquatic environments prior to 1990 (Abdullah, 1995)

Location	Year compounds	Compounds	Levels (range/mean)
Krian River Basin, Perak	1981		
Water		Dieldrin	200–500 ng L^{-1}
		Aldrin	100–1800 ng L^{-1}
		Lindane	100–600 ng L^{-1}
Sediment		Dieldrin	800–4700 ng kg^{-1}
		Aldrin	100 ng kg^{-1}
		Lindane	400–800 ng kg^{-1}
Rice field fish		Dieldrin	6.6–24.9 ng g^{-1}
		Aldrin	0.3–1.1 ng g^{-1}
		Chlordane	2.8–17.1 ng g^{-1}
Tanjung Karang, Selangor	1982		
Water		Lindane	100 ng L^{-1}
Fresh water fish		Lindane	10–100 ng g^{-1}
Penang	1984–1987		
Rice field and marine fish		Dieldrin	0.2 ng g^{-1}
		DDT	0.8 ng g^{-1}
		Endosulfans	5.4 ng g^{-1}

compared to water samples from Thailand (0.18–75.00 ng L^{-1}) and Viet Nam (1.90–19.00 ng L^{-1}) in their study on persistent organochlorines in air, water, and sediments from Asia and Oceania. In a more recent study (Leong et al., 2003) on the same Selangor River, it was reported that all nine sampling locations recorded the presence of lindane ranging from 16.87 90.32 ng L^{-1}. More alarmingly, the nearby Klang River was found to contain the high level of 1953.2 ng L^{-1} of lindane as well as other pesticides. Industrial formulation activities and irresponsible dumping of contaminated waste and agricultural run-off may be the reasons for the high levels of lindane in the Selangor and Klang Rivers. The latest report in this monitoring program (Mustafa, 2005) has shown a drastic decrease in the lindane concentration in the Selangor River water (not detected to 64 ng L^{-1}). This may be attributed to the fact that lindane had been deregistered for use in Malaysia in 2003. Our study (Tan, 2001) on levels of OCPs in several rivers in northern Peninsular Malaysia reported much lower levels of HCHs in the range from not detected to 8.88 ng L^{-1} suggesting the localized contamination of lindane in the Selangor area. However, studies in three farming regions in Peninsular Malaysia and Sabah (Lee et al., 2003) have reported high levels of most pesticides in water as well as sediments. Water samples collected in the Muda River rice basin in 1998 found it to contain high levels of heptachlor epoxide (567.1–3606.0 ng L^{-1}) and dieldrin (316.3–568.0 ng L^{-1}) but no DDTs or HCHs. Water samples from Kundasang in Sabah have been found to contain relatively high levels of α-endosulfan (236.9–718.3 ng L^{-1}), lindane (ND-464.2 ng L^{-1}), and 4,4′-DDT (ND-442.3 ng L^{-1}). Cameron Highland regions which supply fresh vegetables to local markets in Malaysia were found to have water samples containing high concentrations of most pesticides such as aldrin (ND-1107.5 ng L^{-1}), 4,4′-DDT (442.0–450.7 ng L^{-1}), and lindane (ND-113.6 ng L^{-1}).

Table 14.2 summarizes available data on selected POP contamination in water in Malaysia. DDTs were found in most rivers in Malaysia but the concentration levels varied from region to region with centrally located rivers being detected to be highly contaminated. Surprisingly, DDTs concentration increased in these rivers as compared to rivers from other parts of the country even after DDT was banned from use in 1999. Endosulfans were not detected in most rivers in the 1989 survey but were found at relatively high concentrations in later studies (Table 14.2). Concentrations of other pesticides in river waters have also been reported in these studies. In the earlier study (Tan et al., 1991), aldrin, dieldrin, endrin, and heptachlor were also found in some of the rivers. The concentration levels were ND-0.5 ng L^{-1} for aldrin, ND-0.3 ng L^{-1} for dieldrin, ND-3.2 ng L^{-1} for endrin, and 0.3–3.4 ng L^{-1} for heptachlor. Our study

Table 14.2. Selected OCPs contamination (ng L^{-1}) in several river waters in Malaysia

Year	Location	DDTs	HCHs	Endosulfans	References
1989	Selangor River	9.6	ND	ND	Tan et al. (1991)
1989	Muda River	69.4	ND	ND	Tan et al. (1991)
1989	Perai River	4.8	ND	ND	Tan et al. (1991)
1989	Perak River	0.6–20.9	ND–1.4	ND–0.5	Tan et al. (1991)
1990	Selangor River	1.7	900	–	Iwata et al. (1994)
1998	Muda River	ND	ND	ND–128.2	Lee et al. (2003)
1998	Cameron	458.7–504.2	ND–113.6	47.8–260	Lee et al. (2003)
1998	Kundasang, Sabah	ND–442.3	ND–464.2	236.9–718.3	Lee et al. (2003)
1998	Muda River	0.9–3.1	0.3–4.2	1.0–24.4	Tan (2001)
1999	Perai River	2.6–5.4	1.7–12.1	0.2–4.9	Tan (2001)
2000	Perak River	ND–23.0	ND (all)	ND–13.0	Tan (2001)
2002	Selangor River	ND–417.6	ND–90.3	ND–285.7	Leong et al. (2003)
2002	Klang River	ND–184.2	ND–1953.2	ND–242.1	Leong et al. (2003)
2004	Selangor River	ND–165	ND–64	ND–1663	Mustafa (2005)

in the Perai and Juru Rivers in 1999 (Tan, 2001) found that aldrin concentrations were ND-1.1 ng L^{-1}, while dieldrin, and endrin concentrations were 0.9–3.0 and 0.2–2.2 ng L^{-1}, respectively. However, a survey at nine stations along the Perak River, one of the longest rivers in Peninsular Malaysia, revealed the absence of other pesticides beside DDT and endosulfan.

PCB concentrations in river waters have not been studied or reported except for one sample studied by Tanabe's group (Iwata et al., 1994) where it was found that total PCB concentration was 0.45 ng L^{-1} in the sample taken from the Selangor River. We have monitored other POP chemicals such as PAHs, phenols, and phthalate esters in river waters. In the 1998 study (Tan, 2001), we found that the Perai River contained 357–2644 ng L^{-1} of total PAHs, 3625–4380 ng L^{-1} of total phenols, and 3215–14855 ng L^{-1} of total phthalate esters. The Muda River was found to contain 986–1507 ng L^{-1} of PAHs, 210–1114 ng L^{-1} of phenols, and 964–6096 ng L^{-1} of phthalate esters. The Perak River, on the other hand, was relatively free from PAHs (17–435 ng L^{-1}) and phenols (26–214 ng L^{-1}) but highly contaminated with phthalate esters, especially near the estuary with concentration levels ranging from 175 to 17,929 ng L^{-1}.

There was only one report on the levels of POPs in surface seawaters (Iwata et al., 1993). The authors reported studies on seawaters from various parts of South Asia. The surface water from the Straits of Malacca was found to contain 480 pg L^{-1} of HCHs, 9.4 pg L^{-1} of chlordanes, 6.4 pg L^{-1} of DDTs, and 20 pg L^{-1} of PCBs. South China Sea was found to contain similar levels of the POP contaminations.

14.4.2. POP contaminations in sediments and soil

Contaminations of several OCPs in sediments collected in Malaysia had been studied in 1981 where dieldrin and lindane were found at levels of 0.8–4.7 μg kg^{-1} and 0.4–08 μg kg^{-1}, respectively in sediments taken from the Krian river basin in Perak (Abdullah, 1995). Iwata et al. (1994) found in the 1990 sampling of the Selangor River that there were 1.8 μg kg^{-1} DDTs, 0.18 μg kg^{-1} HCHs, 1.0 μg kg^{-1} chlordanes, and <5.0 μg kg^{-1} PCBs in a sediment sample. Similar concentration levels were observed in a 1992 study (Tan and Vijayaletchumy, 1994) on sediment from Selangor River with 4.03 μg kg^{-1} HCHs and 5.35 μg kg^{-1} of endosulfans. A report by Lee et al. (2003) revealed very high concentrations of several pesticides in sediments collected in Cameron Highlands and Kundasang in Sabah where extensive vegetable farming is carried out. Sediments collected in the Cameron Highlands areas contain all of the OCPs studied including 4,4′-DDT (21.1–22.6 μg kg^{-1}), endrin (19.9–98.7 μg kg^{-1}), and aldrin (6.7–39.6 μg kg^{-1}), amongst others. Sediments from Kundasang were reported to contain high levels of aldrin (42.1–92.0 μg kg^{-1}), endrin (32.0–53.1 μg kg^{-1}), and 4,4′-DDT (18.8–26.3 μg kg^{-1}). In the same report, however, sediment samples from the Muda River basin were found to contain substantially lower pesticide residues such as aldrin (ND-83.4 ug g^{-1}) and lindane (16.1–33.4 μg kg^{-1}).

Our studies on levels of OCPs in sediments collected from rivers in northern Peninsular Malaysia showed similar distributions (Hossain, 2001; Tan, 2001; Syahidah et al., 2003). Table 14.3 summarizes the concentration levels of some of the POP chemicals in sediments collected in Malaysia. Two studies have reported on coastal sediments from the west coast of Peninsular Malaysia. In the 1995 study, Wood et al. (1999) reported the presence of most OCPs in sediment samples collected in this area. The mean concentrations of the OCPs were similar to the findings of our study (Hossain, 2001) on similar samples 4 years later (Table 14.3). For example, the total heptachlor found was 3.74 μg kg^{-1} in the 1995 study and 1.84 μg kg^{-1} in the 1999 survey.

Beside OCPs, studies on other POP chemicals in sediments have also been conducted. In 1992, we conducted a study (Ibrahim et al., 1996) on levels of PAHs in Langkawi Island when a major oil spill occurred in the vicinity. Due to quick and efficient recovery operations, minimal impact of the oil spill was experienced with the total PAHs found being in the range of 34–273 μg kg^{-1} which was slightly above the concentration of controlled samples. Contamination of PAHs, particularly in coastal sediments, was attributed to oil tankers carrying crude oil from the Middle East in the Straits of Malacca and the off-shore oil platform in the South China Sea (Zakaria et al., 2001).

Table 14.3. Selected OCPs contamination ($\mu g\ kg^{-1}$) in sediments in Malaysia

Year	Location	DDTs	HCHs	Endosulfans	References
1981	Krian River	–	1.0–8.8	–	Abdullah (1995)
1988	Sabah	0.1–34.7	0.1–1.1	–	UNEP (2002)
1990	Selangor River	1.8	0.18	–	Iwata et al. (1994)
1992	Bernam River	–	3.52	0.96	Tan and Vijayaletchumy (1994)
1992	Selangor River	–	4.03	5.35	Tan and Vijayaletchumy (1994)
1995	Straits of Malacca, coastal sediment	ND–6.84	ND–2.36	ND–3.42	Wood et al. (1999)
1998	Muda River	ND	32.7–92.2	3.0–13.3	Lee et al. (2003)
1998	Cameron	38.3–78.3	19.0–113.8	1.54–25.5	Lee et al. (2003)
1998	Kundasang, Sabah	28.3–63.6	27.5–61.7	ND–18.7	Lee et al. (2003)
1998	Muda River	–	0.93	1.67	Tan (2001)
1999	Straits of Malacca, coastal sediment	0.2–3.6	0.6–9.7	0.1–9.5	Hossain (2001)

14.4.3. POP contamination in fishes and marine organisms

Fishes and other marine organisms have been well monitored in Malaysian environments. Numerous studies had been reported on the levels of POPs, particularly OCPs in fishes since the early 1980s (Table 14.1). We conducted two studies on the levels of OCPs in several species of marine organisms from the Straits of Malacca. In the first study in 1999 (Hossain, 2001), we analyzed seven marine species for levels of OCPs. The results are presented in Table 14.4. DDTs, endosulfans, endrins, and HCHs were found in relatively high concentrations in all species studied. For examples, blood cockles (*Anadara granosa*) were found to contain 0.04–1.24 ng g^{-1} ww of DDT and 0.74–10.23 ng g^{-1} ww of HCHs which are equivalent to 3.2–99.2 and 59.2–818.4 ng g^{-1} lw, respectively. High concentrations of HCHs were found in bottom feeder species such as green mussels (*Perna viridis*) at 12.4–437.2 ng g^{-1} lw, shrimps (*Metapenaeous monoceros*) at 397.6–4313.3 ng g^{-1} lw and the blood cockles. However, marine fishes were found to have slightly lower concentrations of OCPs. Catfish (*Arius sp.)* were found to contain all OCPs in every sample analyzed, for example, DDT (11.5–367.8 ng g^{-1} lw) and HCHs (103.4–678.2 ng g^{-1} lw).

In the second study (Muhammad, 2006), we analyzed six species of fresh water fishes and seven species of marine organisms. Beside OCPs, we also analyzed congener-specific PCBs in order to determine the toxicity equivalent (TEQ) attributed to PCB contaminations in these samples. All samples of fresh water fishes collected in the northern region of

Table 14.4. Levels of OCPs in several species of marine organisms in Malaysia (Hossain, 2001)

Marine species	% Lipid (mean)	Concentration range of OCP (ng g^{-1} wet wt.)					
		Aldrin	DDTs	Dieldrin	Endosulfans	Endrins	HCHs
Blood cockle (*Anadara granosa*)	1.25	0.02–2.5	0.04–1.2	0.01–0.7	0.10–3.3	ND–3.3	0.74–10.2
Catfish (*Arius* sp.)	0.87	0.2–2.5	0.1–3.2	0.02–0.5	0.3–0.8	0.1–5.4	0.9–5.9
Green mussel (*Perna viridis*)	2.58	0.02–15.7	ND–7.8	ND–0.9	ND–2.6	ND–9.1	0.32–11.3
Jew fish (*Pennahia* sp.)	4.21	0–9.5	0.1–6.0	0.02–0.9	0.3–3.8	0.1–6.2	2.7–7.1
Mullet (*Valamugil* sp.)	1.54	ND–2.2	0.01–4.9	0.02–0.8	0.5–1.8	ND–13.0	0.3–8.3
Shrimps (*M. monoceros*)	0.83	0.2–26.5	ND–4.1	ND–0.6	ND–0.6	ND–2.7	3.3–35.8
Seabass (*Lates calcarifer*)	1.03	0.5–8.0	0–0.5	ND–1.0	0.01–3.4	ND–9.1	1.7–5.1

Peninsular Malaysia were found to contain endosulfans with mean values ($n = 5$ for each of six species) of between 2.1 and 2.6 ng g^{-1} ww (Table 14.5). Contrary to studies on water and sediment samples from the central region of Peninsular Malaysia (Lee et al., 2003), low levels of HCHs were found in these fish samples with mean concentrations ranging from 0.04 ng g^{-1} ww for the snakehead fish to 0.21 ng g^{-1} ww for the sultan fish. DDTs levels in these fish samples were comparable to other reported values for fishes in this region. PCB concentrations in these fresh water samples (7.8–22.5 ng g^{-1} ww) were slightly higher that those reported for fishes (1.5–10 ng g^{-1} ww) from this region (Kannan et al., 1995). The congener-specific analysis revealed that consistently high concentrations of PCB 167 were observed in most samples while the more toxic PCB 126 was only detected in the snakehead fish at the very low concentration of 0.03 ng g^{-1} ww. Toxicity equivalents calculated from these data showed similar TEQ values of ~200 pg g^{-1} TEQ lw for all species. The second part of the study (Muhammad, 2006) on marine organisms showed a similar distribution of OCPs and PCBs to that in the fresh water fishes (Table 14.6). Significantly high concentrations of DDTs and endosulfans were observed compared to HCHs. There seemed to be a decrease in levels of several pesticide residues for the same species when compared to the findings of an earlier study by Hossain (2001). A drastic

Table 14.5. Levels of POPs in several fresh water fishes in Malaysia (Muhammad, 2006)

Marine species	% Lipid (mean)	Concentration range of POPs (ng g^{-1} wet wt.)				
		DDTs	Endosulfans	HCHs	PCBs	PCBs (pg g^{-1} TEQ lw) (mean)
Catfish (*Clarias batrachus*)	1.08	ND–5.0	0.1–3.8	ND–0.2	0.08–33.9	268.4
Snakehead (*Channa striatus*)	1.03	0.8–3.6	0.8–4.8	ND–0.48	1.69–20.4	216.0
Gourami (*Trichogaster* sp.)	1.08	ND–2.2	0.4–3.9	ND–0.17	0.11–52.3	206.0
Javanese carp (*Puntius gonionotus*)	1.04	1.7–3.6	1.1–4.8	ND–0.22	0.04–22.2	211.8
Sultan fish (*Leptobarbus hoevenii*)	1.09	1.2–2.8	1.7–2.7	ND–0.35	5.2–43.7	204.7
Climbing perch (*Anabas testudineus*)	1.01	0.7–1.2	0.4–4.2	ND–0.4	0.38–14.2	174.5

Table 14.6. Levels of POPs in several marine species in Malaysia (Muhammad, 2006)

Marine species	% Lipid (mean)	Concentration range of POPs (ng g^{-1} wet wt.)				
		DDTs	Endosulfans	HCHs	PCBs	PCBs (pg g^{-1} TEQ lw) (mean)
Small mackerel (*Rastrelliger* sp.)	1.20	0.9–5.1	ND–2.5	ND–0.63	0.03–2.5	184.3
Bigeye croaker (*Pennahia macrophthalmus*)	1.16	1.4–3.3	1.1–5.4	ND–0.2	0.13–1.7	258.1
Mullet (*Mugil cephalus*)	1.35	0.4–1.7	0.6–2.1	ND–0.04	0.09–1.9	199.8
Queenfish (*Scombereroides commersonnianus*)	1.04	0.3–2.7	1.4–5.5	ND–0.4	0.07–5.2	194.1
Catfish (*Arius* sp.)	1.20	0.8–1.9	1.8–3.3	ND–0.09	0.18–3.3	362.4
Shrimps (*Metapenaeus* sp.)	1.04	1.4–1.7	0.3–1.6	0.02–0.4	0.12–2.1	257.9
Blood cockles (*Anadara granosa*)	1.06	0.6–2.0	0.1–1.7	0.02–0.4	0.05–3.7	197.2

example can be seen in shrimps; earlier, they had been found to contain between 3.3 and 35.8 ng g^{-1} ww of HCHs but a later study revealed a level of only 0.02–04 ng g^{-1} ww. Catfish samples were found to contain 0.1–3.2 ng g^{-1} ww of DDT in the earlier samples (Hossain, 2001) and 0.8–1.9 ng g^{-1} ww in the later study (Muhammad, 2006). PCB concentrations in these marine organisms were generally lower than in the fresh water fishes and comparable to the levels reported by Kannan et al. (1995). Toxicity equivalent values for these marine species were similar to the TEQ values for the fresh water fishes (Tables 14.5 and 14.6).

POPs in mussel studies have been used as indicators for persistent organic pollutions in the marine environments. Through the Global Mussel Watch Programme, large volumes of data were made available to assess the status of POPs in various regions of the world (UNEP, 2003). Rohani et al. (1992) reported that as high as 180.9 ng g^{-1} ww of HCHs were detected in mussels collected in the Penang coast, 123.7 ng g^{-1} ww of which was lindane. Monirith et al. (2003) collected mussel samples from 13 different locations throughout Malaysia in 1998–1999 and reported the levels of POP contaminations as part of the Global Mussel Watch Program (Table 14.7). The levels of POPs in mussels revealed the distribution of POPs contaminations in Malaysia. Levels of DDTs and HCHs were similar in all samples, either from Sabah in East Malaysia or from Peninsular Malaysia. However, chlordanes and PCBs were significantly higher in mussels from Peninsular Malaysia. Surprisingly, levels of HCHs in these

Table 14.7. Levels of POPs in mussels collected in Malaysia (Monirith et al., 2003)

Location	% Lipid (mean)	Concentration range of POPs (ng g^{-1} lw)			
		DDTs	Chlordanes	HCHs	PCBs
Kuala Penyu, Sabah	0.73	100	8.7	<1.4	7.5
Troyang, Sabah	0.65	32	4.1	3.1	8.3
Sangkar Ikan, Langkawi	0.92	95	41	9.4	6.0
Tanjung Rhu, Langkawi	1.1	16	2.5	4.9	5.1
Penang Bridge, Penang	1.0	71	180	<0.10	60
Bagan Lalang, Selangor	1.2	26	24	3.3	<4.2
Lukut, Negeri Sembilan	1.5	53	50	1.0	54
Pasir Panjang, Negeri Sembilan–1	1.8	71	41	4.8	24
Pasir Panjang, Negeri Sembilan–3	1.6	93	60	3.5	11
Tangjung Batu, Malacca	1.3	100	610	12	22
Pasir Putih, Johor–2	2.1	130	470	5.2	250
Pasir Puteh, Johor–3	2.1	270	170	<0.5	230
Butterworth, Penang	1.2	110	220	<0.8	42
Teluk Bahang, Penang[a]	2.6	17.6	–	155.4	–
Kerian Estuary, Kedah[a]	2.48	15.7	–	132.1	–
Muda Estuary, Kedah[a]	2.62	150.4	–	144.8	–

[a] *Source*: Hossain (2001).

mussels were significantly low even though numerous studies on HCHs in water and sediments reported high concentrations. Our study on mussels from three locations in northern region of Peninsular Malaysia showed high concentrations of HCHs and comparable levels of DDTs (last 3 entries in Table 14.7).

Contamination of butyltin compounds in Malaysian marine environments has been specifically reported (Sudaryanto et al., 2004a). In this study, 16 green mussel samples, 10 species of fish, and 13 sediment samples were collected from coastal waters of Peninsular Malaysia. The results on the butyltin contamination in green mussel from Malaysian waters were reported in earlier paper under the Asia-Pacific Mussel Watch Programme (Sudaryanto et al., 2002). Total butyltin compounds detected in the green mussels from Malaysian waters were relatively high particularly for samples collected in the aquaculture areas in the Straits of Malacca when compared to samples collected from other Asian countries except for from Hong Kong. The levels of TBT, which is normally the major constituent of butytin compounds, in the green mussel ranged from 3.5 ng g^{-1} ww. in samples collected from Sabah to 730 ng g^{-1} ww. in sample collected at Pantai Lido, Johore Bahru (Sudaryanto et al., 2002). Various types of fish collected in Malaysian waters recorded total butyltin contamination between 5.3 and 210 ng g^{-1} ww. The coastal sediment samples were found to contain 16–1400 ng g^{-1} dw of total butyltin compounds where the highest level was found in sediment collected in Pantai Lido, Johore Bahru. The levels of butyltin compounds in these samples were reported to be comparable to reported values from some developed countries but highest among Asian developing nations. The parent compound, TBT, was found to be higher than its degradation compounds, dibutyltin and monobutyltin suggesting very recent input of TBT to the Malaysian marine environment (Sudaryanto et al., 2004a). The high levels of butyltin compounds in Malaysia waters may be attributed to the high maritime activities particularly in the busy Straits of Malacca and the fact that TBT is still available in the Malaysian market (Pesticides Board Malaysia, 1997).

14.4.4. POP contaminations in humans

Studies on levels of POPs in the Malaysian population are either scarcely carried out or not reported. Two available reports described studies on human breast milk and human cord blood. In the first report, Sudaryanto et al. (2004b) described a study on breast milk samples collected from primiparas mothers from Penang and Kedah in 2003. The study found that levels of pesticides in ng g^{-1} lw. were as follows; DDTs (180–5700), HCHs (27–1000), chlordanes (8.2–54), and HCB (1.3–78). PCB levels were 23–450 ng g^{-1} lw. with high components of mono-ortho PCBs. PCDDs were found in the range 34–200 pg g^{-1} lw. and PCDFs were in the range of 3.3–20 pg g^{-1} lw. The calculated TEQ on the levels of PCDDs, PCDFs, and PCBs were between 3.0 and 24 pg g^{-1} TEQ lw. Based on the mean TEQ of 13 pg g^{-1} lw., the authors concluded that the levels of POP contaminations were much lower than those reported for the developed nations and slightly higher than those for developing countries (Sudaryanto et al., 2004b). It is interesting to note that a recently identified endocrine disrupter, *tris*(4-chlorophenyl) methane (TCPMe) was detected in all the human milk samples analyzed in this study. From the positive correlation between TCPMe and DDTs, the study suggested that technical DDT that have been used in Malaysia may be a source of TCPMe (Sudaryanto et al., 2005).

The other study on human cord blood collected in a Kuala Lumpur hospital (Benjamin Tan and Mustafa, 2003) reported that only chlopyrifos was found in 18% of the samples at levels of ND-1.15 ng mL^{-1} while other pesticides analyzed, such as lindane, diazinon, endrin, and endosulfans were not detected. In the same study, bisphenol-A and nonylphenols were detected in more than 80% of the samples at concentration levels of ND-4.05 and ND-15.17 ng mL^{-1}, respectively. Several alkylphenols were also found in these blood samples.

14.5. Management of POPs in Malaysia

14.5.1. Existing regulations

Regulations for the management of chemicals in Malaysia are sufficient and are often being updated to handle new issues. The Pesticide Act 1974 is the principle legislation to regulate the management of pesticides in Malaysia. The Pesticides Board is set up to implement the Act under the jurisdiction of the Ministry of Agriculture, Malaysia; the Act includes the registration of all pesticides, herbicides and other chemicals used in agriculture, licensing for the storage and sale of pesticides, libeling and the registration of pest control operators. Several amendments have been made recently to the Pesticides Act (1974) such as the control of importation of pesticides as registration samples and control of possession or use of unregistered pesticides. All nine pesticide POPs under the Stockholm Convention are banned from import and use in Malaysia. Under the Pesticides Board decisions, lindane was banned in 2003; and recently, it was decided that endosulfan would be phased out effective from August 15, 2005 under the pesticide risk reduction program due to its extreme toxicity to fishes and other aquatic life (Sufian Yek, 2005).

Other related regulations on the management of pesticides are the Environmental Quality Act 1974, the Food Act 1983 and the Occupational Safety and Health Act 1994 (Sufian Yek, 2005). The primary objective of the Environmental Quality Act 1974 is to control the discharge of chemical and industrial wastes including pesticides into the environment, so that there will be no adverse effects on human health and the environment. The disposal of pesticides has not been a significant problem in Malaysia as it is an offence to discharge any toxic waste into the environment. There is a chemical waste treatment facility, which is able to handle all the chemical wastes produced in the country. The Food Act 1983 (under Schedule 16 of its Food Regulation 1985) prescribes the maximum residue levels of certain pesticides in food. The Occupational

Safety and Health Act 1994 provides the legislative framework to promote, stimulate and encourage high standards of safety and health of workers handling chemicals, including pesticides and hazardous wastes.

The Environmental Quality (Dioxin and Furan) Regulation 2004, which came into force on May 1, 2004, was devised to control the emission of dioxins and furans into the atmosphere from selected facilities (DOE Malaysia, 2005). The regulation was initially applied to various types of new and old incinerators in Malaysia, such as the domestic waste incinerators, schedule waste incinerators, sewage sludge incinerators and pulp and paper industry sludge incinerators. Under the regulation, new facilities would need to comply with a dioxin and furan emission of less that 0.1 ng/Nm^3 TEQ while existing installations are required to comply with the emission limit within 3 years of the regulation coming into force.

14.5.2. The Malaysian network for integrated management of chemicals and hazardous substances for environment and development (my-niche)

MyNICHE aims to enhance an integrated management and research approach to chemicals and hazardous substances in Malaysia. Even though it is still at a discussion stage, overwhelming response to the first Round Table dialogue indicated serious commitment of various stakeholders from relevant ministries and government agencies to industries and NGO. The network for integrated management of chemicals was proposed to assist the Government of Malaysia through various ministries and agencies in developing cooperation networks at local, national, and global levels to strengthen efforts in managing chemicals and hazardous substances including POPs (Lestari UKM, 2005). Under the proposal, six focus areas were initially defined as working approaches to the integration of chemical management. They are policy and institutional, transport and storage, trade and economy, green technologies and waste management, integrated chemical information system and inventories, and also chemical risk management. These focus areas would address issues relevant to chemicals such as pollutions, human health impact, environmental contaminations, sustainable resources, and economic well-being.

14.6. Data gaps

The peril of persistent toxic chemicals was realized long after tons of these chemicals had been spread throughout the world. Once hailed as perfect chemicals for their intended uses, these long lasting OCPs, for examples, become burden to the environment and ecosystems where they have been applied. In Malaysia, thousand of tons of these POP chemicals have been released to the environment but records of their applications were not properly kept and hardly available. Sources of pesticide POPs in Malaysia are probably not important as all of them have been banned from import and use. Stockpile of banned pesticides have been disposed but we are not able to verify the report (POP Seminar, 2005). Information on PCB inventory awaits the NIP of Malaysia report. Data on releases of PCDD/PCDF by various industrial sources is still incomplete where more accurate assessment should be carried out either using the toolkit (UNEP, 2001) or direct measurement at source.

Levels of pesticides in water, sediments and fishes are adequately known and studies are continuingly being conducted. However, levels of POP chemicals in air are hardly available probably due to lack or expertise and laboratory capability to measure very low levels of these pollutants. Data on pesticide residues in various foodstuffs is also lacking. Our laboratory in collaboration with Food Quality Control Department, Ministry of Health, Malaysia, among others are working to collect more data on POP contamination in food. Data on PCB residues in the environment is scarcely available probably due to difficulties in measuring these complex congeners. There are very few studies on PCB contamination have been reported by local researchers. Similarly, there are hardly any data on levels of PCDD/PCDF in the environment due to difficulty in analyzing these compounds.

In Malaysia, pollution studies generally focus on toxic metals as they are relatively easier to analyze by conventional atomic absorption spectroscopy. Numerous data on heavy metals such as cadmium, nickel, mercury, lead, and others in various environmental compartments have been reported (Yap et al., 2004). Capability and capacity to analyze organic pollutants at very low concentrations were only realized recently. The ASEAN-Canada Cooperative Program on Marine Science and the Environmental Monitoring and Governance of EDC Pollutions in the East Asian Coastal Hydrosphere projects and the Japanese Society for the Promotion of Science program were helpful in training local researchers and providing funds to acquire analytical instruments (UNEP, 2002). More reliable data on OCP levels in water, sediment, and fish have been reported. However, emerging POPs of concern such as chlorinated paraffins, alkylphenols, and organometallic compounds in Malaysia have not been reported.

14.7. POPs research and initiatives in Malaysia

There are a handful of research groups in Malaysia working on POP chemicals. Most of them are university based researchers working on chemical monitoring and analyses and toxicity studies. Analytical instruments such as gas chromatographs and mass spectrometers are available in most of the universities and research centers but technical expertise and fund for monitoring work are limited. There is no national program to study POPs pollutions in Malaysia, however, a number of programs will be commissioned to assess the status of POPs in compliance with the Stockholm Convention.

We are working with the Food Quality Control Department of the Ministry of Health to study the contamination of OCPs and PCBs in local fish and chickens. This project is in line with our current effort to assess the health risk arising from consumption of food contaminated with POP chemicals. The health risk assessment of POPs through dietary intakes project involved analyses of OCPs and PCBs in various foodstuff, initially raw materials which will be extended to cooked food. Unfortunately, we do not currently have the capability to analyze PCDD/PCDF in our laboratory but there are two high resolution mass spectrometers in the country that are capable of analyzing PCDD/PCDF. National and international collaborations will definitely improve the country capacity to monitor POPs not only those listed in the Stockholm Convention but other toxic chemicals found in the environment.

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