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Persistent Organic Chemicals in Malaysian Waters: A Review

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Abstract: A critical review of the levels of persistence organic chemicals in Malaysian waters from 1980 to 2002. This review concentrated on the detection several toxic substances by groups of scientists in the marine environment, evaluated their quantities and provides estimates of their potential danger for the health of both marine life and humans. The compounds include polycyclic aromatic hydrocarbons, tributyl-tin and pesticides. In summary, the levels of some persistent organic chemicals is lower compared with other Southeast Asia countries and the levels in this region still at the medium level compared with more urbanized and industrialized regions in the West. Nevertheless, continuous monitoring and investigations on the level of the persistent organic chemicals are needed in Malaysia. Transboundary pollution potential should be taken as an important consideration in any development project especially in Southeast Asia.

Key words: Marine, pollution, Malaysia

THE MELACCA STRAITS

The Melacca Straits are bordered by four countries; Malaysia, Thailand, Indonesia and Singapore. However, the navigational channel passes through the territorial seas of Malaysia, Indonesia and Singapore (Chua *et al*., 2000). The Straits of Melacca is located between the East coast of Sumatra Island in Indonesia and the West coast of Peninsular Malaysia and is linked with the Straits of Singapore at its South-east end (Fig. 1). The straits is bordered on the North-west by a line from Ujong Baka (5°40'N, 95°26'E) which is the North western tip of Sumatera Island, Indonesia, to Laem Phro Chao (7°45'N, 104°20'E), the South extremity of Ko Phukit Island, Thailand and on the South-east by a line from Tahan (Mountain) Datok (1°20'E, 104°20'N) and Tanjung Pergam (1°10'E, 104°20'N) (Hamzah and Basiron, 1997).

SOUTH CHINA SEA

Covering an area of 3.8 million square kilometers (Fig. 1), the South China Sea which includes the Gulf of Thailand and Tonkin is a marginal sea surrounded by land with access to it between West Malaysia and Indonesia at the Kalimantan Straits in the Southwest and the Philippines and Taiwan at the Luzon Straits to the Northeast (Morton and Blackmore, 2001). Countries that have major influence on the claims to the sea include China, Malaysia, the Philippines and Vietnam, although Thailand, Indonesia and Taiwan have also exerted some claims.

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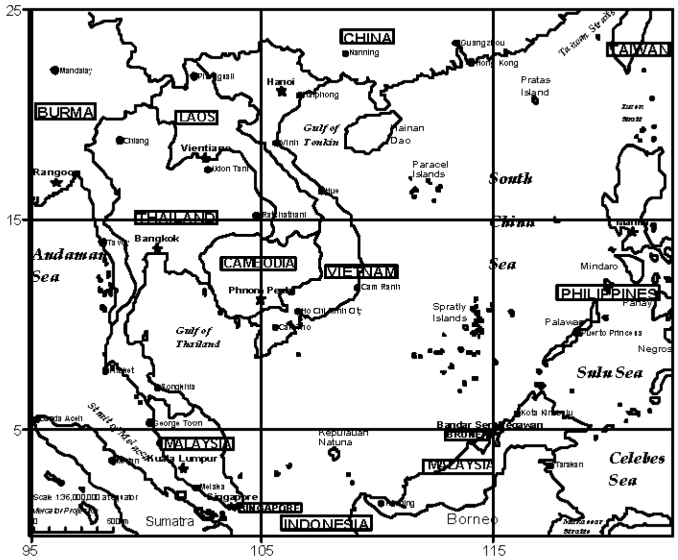

Fig. 1: Map of Straits of Melacca and South China Sea

The South China Sea has significant islands including Hainan in the Northwest, Palawan in the Southeast and hundreds of smaller islands, atolls, submerged reefs and banks. The island groups of the South China Sea are all disputed and sovereignty is claimed over them by a number of countries. Conflict has arisen over them in recent years caused by perceived national rights. Disputed boundaries in the South China Sea include areas in the Gulf of Tonkin between Vietnam and China and the Spratly islands off the coast of Sabah between Malaysia, China and the Philippines, which it is estimated to posses six billion barrels of oil (Morton and Blackmore, 2001). With vast mineral resources as well as fisheries resources, it is no surprise that the South China Sea is a hotbed area for overlapping sovereignty claims.

MARINE POLLUTION

For close to 30 years, most academics studying the phenomena of marine pollution have adhered to a definition developed by a UN body, the Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) (Anonymous, 1997), who define it as the introduction of man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazard to human health, hindrance to marine activities including fishing, impairment of quality for use of sea-water and reduction of amenities (Graya and Bewersb, 1996; Kullenberg 1999; Chua *et al*., 2000; Islam and Tanaka, 2004).

The definition has two important qualities. Firstly, it is an action oriented. Marine pollution is conceptualized as a human activity, thereby omitting all natural activities that could potentially have damaging effects on the ocean eco-system. So, for example, earth quakes or volcanic eruptions that emanate from the ocean floor and subsequently damage or change already existing ocean eco-systems would not be considered pollution. Secondly, the definition is amenable to measurement. Marine pollution is harmful and its danger can be identified in a variety of ways. For example, it is easy to see the deleterious effects that oil spills have on the sea birds and mammals that happen to run into them. Scientists likewise can readily identify various toxic substances found in the marine environment, measure their quantities and provide estimates of their potential danger for the health of both marine life and humans.

Hydrocarbons

A hydrocarbon is an organic chemical compound that is comprised only of carbon (C) and hydrogen (H) atoms. Many oils, fats, waxes, solvents and paraffin are either hydrocarbons or contain large hydrocarbon sub-units. Hydrocarbons are natural chemical compounds made up of carbon and hydrogen (Peachey, 2003).

All hydrocarbons fall under one of the three following categories depends on their carbons bonding. That is saturated hydrocarbons, unsaturated hydrocarbons and polycyclic aromatic hydrocarbons. The least dangerous is saturated hydrocarbons because they have no double, triple or aromatic bonds between carbons. Unsaturated hydrocarbons have at least one double or triple bond between carbons and the most lethal is Polycyclic Aromatic Hydrocarbons (PAHs). They have at least one aromatic ring of carbons (Zakaria *et al*., 2002; Young *et al*., 2004).

PAHs are the type of hydrocarbons that are causing major problems (Peachey, 2003). Sources of PAHs include oil spills, road run off and burning wood and coal. They are mutagenic (causes body mutations), morphogenic (causes deformities), carcinogenic (causes cancer) and teratogenic (causes fetal mutations) (Zakaria *et al*., 2002; Pufulete *et al*., 2004). The fact alone that we expose ourselves daily to these chemicals when we know how dangerous they are is amazing, but the fact that we are killing our planets wildlife through our carelessness is catastrophic.

The impact of oil pollution on the ecology of coastal and marine ecosystems is particularly destructive following massive oil spills caused by maritime accidents (Chua *et al*., 2000; Yamamoto *et al*., 2003). However, gas exchange between the water and the atmosphere is decreased by oil remaining on the surface of the water, with the possible result of oxygen depletion in enclosed bays where surface wave action is minimal (Hawkins *et al*., 2002). Coral death results from smothering when submerged oil directly adheres to coral surfaces and oil slicks affect sea birds and other marine animals (Furness and Camphuysen, 1997).

Tributyl-tin (TBT)

Organotin compounds have developed into an important commodity since the 1960 with antifouling TBT paints having brought large financial savings in the shipping industry (Sudaryanto *et al*., 2004). On the other hand, TBT is so toxic that it had adverse affects on non-target organisms such as oysters and gastropods (Kan-Atireklap *et al*., 1997; Hsia and Liu, 2003). It is also well documented that TBT can be accumulated to a high level by some marine vertebrates, including fish, fish eating birds and marine mammals such as dolphins. These adverse effects have prompted a restriction of TBT usage in many countries e.g., USA, France, Switzerland, New Zealand and Japan (Morton and Blackmore, 2001).

Pesticides

A pesticide is any substance or mixture of substances intended for preventing, destroying, repelling or mitigating any pest (Barakat, 2004). Though often misunderstood to refer only to insecticides, the term pesticide also applies to herbicides, fungicides and various other substances used to control pests. Under United States law, a pesticide is also any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant (United State Environmental Protection Agency) (Charnley and Patterson, 2003).

The use of agriculture chemicals is the main cause of pesticide pollution in the marine environment. It is estimated that in East Sumatera alone about 3780 t of insecticides, 110 t of fungicides, 291 t of rodenticides and 22 t of herbicides are used annually (Chua *et al*., 2000). It is inevitable that some of these chemicals are leached to rivers and to coastal and estuarine environments finally ending up in the marine sediments.

Nutrients

Nutrient source in the marine environment can be broadly categorized into: point sources, which are domestic sewage effluent including human and household waste and urban waste water, industrial discharges, including detergents and shipping discharges of sewage and grey water (Nixon *et al.* 2001). Secondly, diffuse sources which are: agriculture run-off includes inputs of inorganic fertilizers, slurry and silage that contaminate watercourses and transported into the sea via rivers, natural background inputs including rock weathering, lightening, soil leaching and dead/decaying organic matter and deposition of atmospheric nitrogen oxides from burnt fossil fuels can contribute to the nitrogen budget of oceans (Billen *et al.*, 1999).

The relative contribution of each source varies over time according to land use, climate, technology, national and international regulations. There is also variation between coastal waters due to their associated dispersion rates. Whilst nutrients are essential for life in the oceans, there is growing concern over the accelerated nutrient enrichment of coastal waters as a result of human activities, known as cultural eutrophication. The adverse impacts on water quality threaten the ecology and use of the marine environment. Cultural eutrophication is considered to be one of the fundamental causes of the increased occurrence of algal blooms-an explosion in the growth of marine phytoplankton (Grizzetti *et al.*, 2003).

DETECTION OF VARIOUS ORGANIC CHEMICALS IN MALAYSIAN WATERS

The major areas of study/survey are shown in Fig. 2.

Hydrocarbons

Early studies on hydrocarbon in the Straits of Melacca began with Phang *et al.* (1980) which found concentrations of between 10 to 120 ppb of petroleum hydrocarbon in the coastal waters off Penang. In 1989, two studies in the near shore (Law and Veellu, 1989) and offshore (Law and Yeong, 1989) waters of Port Dickson analyzing water and sediments found concentration of between

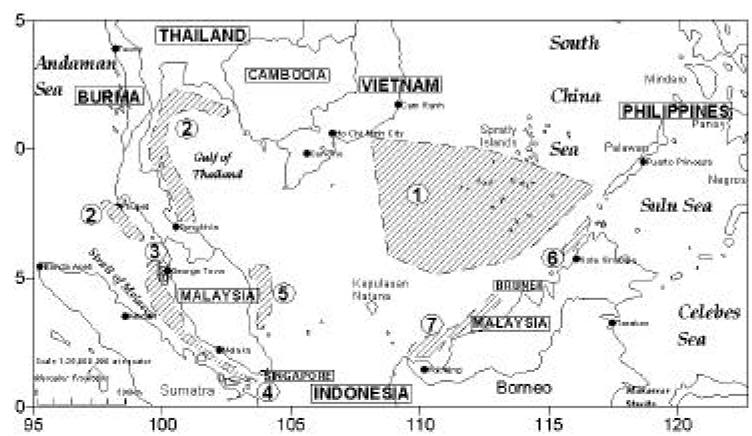

Fig. 2: Areas of detection of persistent organic chemicals in Malaysian waters. 1: Yang *et al.* (1998), 2: Kan-Atireklap *et al.* (1997), 3: Hossain *et al.* (1999) and Sivalingam *et al.* (1982), 4: Law and Ravinthar (1989), Law and Yeong (1989) and Moradi *et al.* (1999), 5: Law and Rahimi (1986), Law and Zulkifli (1987), 6: Law (1990) and 7: Law and Libis (1988)

2.52 to 73.34 ppb (mean of 32.24 ppb) and 14.69 to 150.28 ppb (mean of 66.71 ppb) of hydrocarbon in the water samples from nearshore and offshore stations respectively. For sediment samples, the concentrations found were between 2.1 to 70.4 ppm for nearshore stations and 21.73 to 77.06 ppm for offshore stations, respectively. This would indicate that the offshore waters are more polluted than the near shore areas in Port Dickson.

Studies by Zakaria *et al*. (2002) on the distribution of PAHs in sediments from rivers and estuaries in Malaysia (sampling was conducted in the West coast of peninsular Malaysia and the Straits of Melacca) found concentration of PAHs (3-7 rings) ranging between 4 to 924 ppb. The study also identified two major routes of petrogenic PAH pollution input into the aquatic environment which is (1) spillage and dumping of waste crankcase oil and (2) leakage of crankcase oils from vehicles onto road surface subsequently washed out by street runoff.

Hydrocarbon studies in the South China Sea was conducted in the coastal waters off Terengganu by Law and Rahimi (1986), coastal waters off Pahang by Law and Zulkifli (1987), Sarawak coastal waters by Law and Libis (1988) and Coastal waters off Sabah by Law (1990). The results are shown in Table 1.

In the South China Sea, studies on dibenzothiophene which is a heterocyclic sulfur polynuclear aromatic compound by Yang *et al*. (1998) on sediments from 22 different sampling sites found the concentrations ranging from 11 to 66 ppb dry sediment in all sampling locations. Present study also found that the concentration were higher in nearshore sediment samples where the probable source pathways include terrestrial runoff, crude oil pollution and input from airborne particulates formed from combustion process. It is interesting to note that some of the stations are located adjacent to the coastal waters of Sarawak and Sabah thus, the researcher indirectly implies that the probable source pathway of the pollution is from East Malaysia.

Tributyl-tin (TBT)

Reports and studies on the contamination of butyltin compounds in the Melacca Straits and the South China Sea are few and far apart. In Thailand, a study by Kan-Atireklap *et al*. (1997) on green mussel (*Perna viridis*) conducted in the Gulf of Thailand (which is a part of the South China Sea) and the Andaman Sea (adjacent to the Straits of Melacca) indicated that butyltin contamination was widespread, particularly in high boating areas and in coastal aquaculture facilities (Table 2). The concentration of butyltin compounds (BTs) ranges from <3-45 ppb for monobutyltin (MBT), 1-80 ppb for dibutyltin (DBT) and 3-680 ppb for TBT.

Pesticides

Organochloride compounds were widely used in rapidly developing countries in South East Asia for agriculture, pest control and for public health purposes. From one of the earliest study in the Straits of Melacca by Sivalingam *et al*. (1982), pp'-DDE pollution in mussel tissue from six stations on the Penang Island ranged from 3.7 to 17.4 ppb (dry weight basis) and a concentration of 7.11 to 8.12 ppb dry weight basis found in mussels from three stations in Singapore (Table 3). The same study also detected 99.9 to 599.9 ppb (dry weight basis) and between 139.8 to 256.4 ppb of polychlorinated biphenyls (PCBs) in green mussel samples from Penang and Singapore, respectively. Present study also found that no other organic chlorinated hydrocarbon compounds were detectable in the marine bivalve at either location. The researchers concluded that tropical features result in high rate of degradation, purification or geographical separation of these compounds rendering them undetectable.

In Thailand, a study by Kan-Atireklap *et al*. (1997) on green mussel (*Perna viridis*) conducted in the Gulf of Thailand and the Andaman Sea indicated that organochloride contamination was

Table 1: Detection of hydrocarbons in Malaysian waters from 1980 to 2002

Media/organism	Location	Concentration	References
Sediments	Rivers leading to the Straits of Melacca	20-924 ppb PAHs	Zakaria *et al.* (2002)
	Klang Estuary	19-431 ppb PAHs	
	Klang coast (inshore)	9-39 ppb PAHs	
	Straits of Melacca (offshore)	4-73 ppb PAHs	
Sediment/water	Straits of Melacca near-shore waters off Port Dickson	2.1-70.4 ppm dry weight (sediment) 2.52-73.34 ppb (water)	Law and Veelu (1989)
Sediment/water	Straits of Melacca coastal waters off Port Dickson	21.73-77.06 ppm dry weight (sediment) 14.69-150.28 ppb (water)	Law and Yeong (1989)
Water	Straits of Melacca coastal waters off Penang	10-120 ppb	Phang *et al.* (1980)
Sediment/water	South China Sea coastal waters Terengganu	6.43-1332.13 ppm) dry weight (sediment 10-1750 ppb (water)	Law and Rahimi (1986)
Sediment/water	South China Sea coastal waters Pahang	10.73-85.26 ppm dry weight (sediment) 9.49-65.56 ppb (water)	Law and Zulkifli (1987)
Sediment	South China Sea	11-66 ppb dibenzothiophene	Yang *et al.* (1998)
Sediment/water	South China Sea coastal waters Sarawak	2.92-1153.53 ppm dry weight (sediment) 13.11-545.1 ppb (water)	Law and Libis (1988)
Sediment/water	South China Sea coastal waters Sabah	19.84-226.42 ppm dry weight (sediment) 31.61-163.66 ppb (water)	Law (1990)
Mussel	Sangkar Ikan, Langkawi	8.46 ppb PAHs	Moradi *et al.* (1999)
	Kuala Perlis	48.08 ppb PAHs	
	Tanjung Dawai, Kedah	5.43 ppb PAHs	
	Penang	17.74 ppb PAHs	
	Bagan Lalang, Selangor	8.94 ppb PAHs	
	Lukut, Negeri Sembilan	8.36 ppb PAHs	
	Pasir Panjang, N Sembilan	4.73 ppb PAHs	
	Pantai Lido, Johore	18.81 ppb PAHs	
	Pasir Puteh, Johore	73.64 ppb PAHs	
Sediment	Estuarine zone for the whole straits of Melacca	150.61 ppm (oil and grease), 0.81 ppm (total alifatic hydrocarbon), 3.14 ppm (PAHs), 2.5 ppm (PCB)	Wood *et al.* (1999)
	Island zone for the whole straits of Melacca	73.92 ppm (oil and grease), 0.44 ppm (total alifatic hydrocarbon), 1.84 ppm (PAHs), 0.83 ppm (PCB)	

Table 2: Tributyl-tin (TBT) detection in green mussel in Thailand waters

Media/organism	Location	TBT concentration	Reference
Perna viridis	Thailand (Gulf of Thailand and Andaman Sea)	3-680 ppb	Kan-Atireklap *et al.* (1997)

widespread, particularly in coastal aquaculture facilities (Table 3). Among the organochloride residues examined, dichlorodiphenyltrichloroethane compounds (DDTs) were found to be the highest (1.2-38 ppb), followed by PCBs (0.01-20 ppb), chlordane compounds (CHLs) (0.25-5.9 ppb), hexachlorocyclohexane (HCHs) (<0.01-0.33 ppb) and hexachlorobenzene (HCB) (<0.01-0.12 ppb) (Table 3).

Table 3: Detection of pesticides in Malaysian waters from 1982 to 2000

Media/organism	Location	Concentration	References
Perna viridis	Penang, Malaysia	3.7-17.4 ppb (dry weight basis) pp'-DDE 99.9-599.9 ppb (dry weight basis) PCB	Sivalingam *et al.* (1982)
	Singapore	7.11-8.12 ppb (dry weight basis) pp'-DDE 139.8-256.4 ppb (dry weight basis) PCB	
Perna viridis	Thailand (Gulf of Thailand Andaman sea)	1.2-38 ppb DDT 0.01-20 ppb PCB 0.25-5.9 ppb CHL <0.01-0.33 ppb HCH <0.01-0.12 ppb HCB	Kan-Atireklap *et al.* (1997)
Sediment	Sg. Muda (coast) Penang	0.94 ppb BHC 0.1314 ppb Hept 1.7 ppb Endosulphan 0.25 ppb Aldrin	Hossain *et al.* (1999)
	Teluk Aling (4 km offshore)	0.61 ppb BHC 0.234 ppb Hept 0.32 ppb Endosulphan 0.14 ppb Aldrin 0.31 ppb DDT	
Blood Cockles *Anader granosa*	Sg. Muda (coast) Penang	0.21 ppb Linden 0.08 ppb Aldrin 0.19 ppb Hept 0.21 ppb Dieldrin 0.15 ppb Endrin	
Green Mussel *Perna viridis*	Coastal Penang	0.38-11.28 ppb BHC 0-78 ppb DDT	
Sediment	Estuarine zone for the whole Straits of Melacca	2.2 ppb DDT 1.26 ppb Heptachlor 2.48 ppb Hept epoxide 0.87 ppb Aldrin 0.66 ng g^{-1} Dieldrin 0.34 ppb alpha-chlodire 0.4 ppb gamma-chloride 0.23 ppb oxychloride <0.02 ng g^{-1} cis-Nonachlor 0.17 ppb trans-Nonachlor <0.02 ppb alpha-Endosulfan <0.02 ppb beta-Endosulfan 1.38 ppb endosulfan sulfate 0.39 ppb lindane 0.53 ppb endrine 1.68 ppb hexachlorobenzene	Wood *et al.* (1999)
	Island zone for the whole Straits of Melacca	0.45 ppb DDT 0.7 ppb heptachlor 0.75 ppb hept epoxide 0.48 ppb aldrin <0.02 ppb alpha-chlodire 0.33 ppb gamma-chloride <0.02 ppb oxychloride <0.02 ppb cis-Nonachlor <0.02 ppb trans-Nonachlor <0.02 ppb alpha-Endosulfan <0.02 ppb beta-Endosulfan <0.02 ppb endosulfan sulfate <0.02 ppb lindane <0.02 ppb endrine 1.13 ppb hexachlorobenzene	

DISCUSSION

The existing environmental issues and potential environment threats demand serious conditions. The pollution levels detected in studies compiled for this paper indicate that pollution will play a major role in the in the future and pollution management in the Straits of Melacca and South China Sea must be address. Although, pollution figures are still within limits, we must ensure that the resources will be taken care of for the future generations. Management of the Straits of Melacca and South China Sea resources has to address four main problem areas: (1) minimizing pollution; (2) enforcement of regulations for controlling pollution from all sources; (3) oil spill prevention and control and (4) marine environment protection, rehabilitation and compensation for damages.

From the studies reviewed, it can be said that the level of persistent organic chemicals in the Malaysian waters are still at the acceptable level and comparable to results in other Southeast Asia countries. It must be noted though that there studies reviewed were from the early 80's so they may not actually reflect the current situation in the Malaysian coastal waters. Today, it is believe that the level of persistent organic chemicals in Malaysia and Southeast Asia water had been increased because of the rapid population growth and urbanization. From the studies reviewed it may be conclude that the majority of persistent organic chemicals pollution that occurs in Malaysia and this region waters originates from urbanization (sewage waters, industrial), agricultural activities (nutrients, pesticide and sediment) and transporting (boating and shipping). According to Anonymous (1990), the primary sources of marine pollution are found on the land, causing pollution in coastal fishing areas.

Hydrocarbons

Present review clearly shows that the main hydrocarbons detected in Malaysia waters are mainly Polycyclic Aromatic Hydrocarbons (PAH). The results show there are higher concentration of PAHs in the urbanization and industrialized locations. Petrogenic input (used crankcase oil and input from street dust and traffic sources) is a major control on the PAHs contamination in Malaysia and it maybe concluded that the Malaysian aquatic environments have been more heavily impacted by petrogenic input than have those of the industrialized countries. The concentrations of hydrocarbons are widely range from urban rivers to open ocean. From the study reviewed clearly showed that concentrations of hydrocarbons in environmental samples (sediments, waters and mussels) collected near major townships are generally higher than those rural samples.

One of major threats of hydrocarbons pollution in Malaysia waters comes from oil spilling from offshore oil production and shipping. Law (1994) stated that the single largest contributor of oil spill from transportation activities has been identified to be from tanker operations associated with ballasting the tanks for the return voyage from ports of discharge. It may conclude that the hydrocarbons concentration mainly PAHs in Malaysia waters is still low- moderate compared with other more industrialized areas of the world (developed countries) such as United States, Canada, Europe, Australia and Japan (Zakaria *et al*., 2002).

However, more documented hydrocarbons research needed in this region because the concentrations and distributions of hydrocarbons maybe influenced by the climatic characteristics (dilution by the rainstorm). Therefore, the mixing and magnitude of sources and transport mechanisms of hydrocarbons in Malaysia and Southeast Asia maybe different as compared to other regions found at higher latitudes (Zakaria *et al*., 2002).

Tributyl-tin (TBT)

There is still lack of information and documented research on TBT pollution in Malaysia and Southeast Asian countries. It is believed that the level of TBT pollution in this region waters has been increased because an increasing of waters activities such as fisheries, boating and shipping activities.

TBT is toxic at nanogram per liter level (Champ and Seligman, 1996). It may be concluded that shipping and boating is the main source of TBT pollution in this region especially in coastal aquaculture facilities and high boating areas. In these facilities, TBT was used as antifouling agent in paints applied on boats and fish net, lumber preservatives and slimicides in cooling system. TBT based antifouling paints are still being used on larger vessels especially commercial vessels which consume about 75% of total TBT used as antifouling paints (Kan-Atireklap *et al*., 1997). More research is needed in this area to know current situation of this pollution.

Pesticides

Relatively high levels of pesticides found in the agricultural and urbanization area in Malaysia and Southeast Asia especially organochlorine pesticides. DDT is one of the most organochlorine pesticides used in this region since 1950. DDT has been extensively used as malaria repellent and as an agricultural pesticides until the use has been successfully limited and was finally banned for all applications in 1994 (Anonymous, 1997). In spite of this, persistent organochlorine pesticides are still circulating in Malaysia and Southeast Asia ecosystem that are simultaneously being exposed to increasing pollution loads resulting from rapid population growth, urbanization and agroindustrial development. Some research has been conducted on organochlorine pesticides in Malaysia and Thailand from 1982 to 2000 showed that various concentration of organochlorine pesticides and its metabolites have been found in various environmental and biological samples. The concentration of DDT in Malaysia coastal waters is still low-medium, ranging from 0-2.2 ppb in 1999 compared to Thailand and other Southeast Asia country. It appears that concentration of DDT declined in Southeast Asia coastal waters after the restriction introduced. However, Chan *et al*. (1999) reported worring fact of DDT and DDE levels were high in certain isolated areas of South China Sea suggesting either illegal dumping or local industrial use.

Table 4: Nutrient detection in Malaysia waters from 1990-2002

Media/organism	Location	Concentration	Reference
Surface layer water	Coastal waters off Port Dickson	0.46 μM ortho-phosphate	Law and Chu (1990)
Water (1-20 m)	Coastal eaters off Port Dickson	0.46 PO_4^{-3}-μg-at P L^{-1}	Law *et al*. (1991)
		1.1 NH_4^+μg-at P L^{-1}	
		0.65 NO_3^+μg-at P L^{-1}	
		0.14 NO_2^+μg-at P L^{-1}	
Surface layer water	Perlis	0.11 PO_4^{-3}μg-at P L^{-1}	Law *et al*. (1995)
		0.9 NH_4^+μg-at P L^{-1}	
		1.3 NO_3^+μg-at P L^{-1}	
		0.15 NO_2^+μg-at P L^{-1}	
Surface layer water	Straits of Melacca (from Langkawi to Johore)	0.242 μM ortho-phosphate	Law *et al*. (2000)
Surface layer water	Straits of Melacca (from Langkawi to Johore)	0.06 μM ortho-phosphate (March 1998)	
		0.11 μM ortho-phosphate (Nov. 98)	
Bottom layer water	Straits of Melacca (from Langkawi to Johore)	0.72 μM ortho-phosphate (March 1998)	Tengk Rozaini (1999)
		0.26 μM ortho-phosphate (Nov. 98)	
Water	Straits of Melacca (from Langkawi to Johore)	0.341 PO_4^{-3}-μg-at P L^{-1}	
		1.365 NH_4^+μg-at P L^{-1}	
		1.345 NO_3^+μg-at P L^{-1}	
		0.06 NO_2^+μg-at P L^{-1}	Law *et al*. (2002)

Concentrations of heptachlor were relatively low in comparison to overseas data ranging from <0.131`4 ppb (Hossain *et al*., 1999) -1.26 ppb (Wood *et al*., 1999). The detection of some organochlorine pesticides isomers (Table 3) in some locations may suggest usage of those pesticides in Malaysia. However it may be concluded that the level of pesticides in Malaysia waters in the present study was much lower than other Asian countries such as India and Indonesia.

The spatial differences in pesticides residue levels in some of environmental samples collected from several locations along coastal waters of Malaysia suggested that pesticides especially organochlorine pesticides were widely used in Malaysia. Although an organochlorine pesticide such as DDT was banned in Malaysia, their current sources still remain in the aquatic environment. When compared to other data, residues level of organochlorine pesticides and some others pesticides in Malaysia's marine environment have been declining.

Nutrients

Generally the level of orthophosphate in Straits of Melacca were low ranging from 0.06-0.72 μM between 1990-2000 (Table 4). Low orthophosphate levels were found in the surface water and then increased rapidly with increasing depth (Tengku Rozaini, 1999). There was no distinct variation of ammonium, nitrite and nitrate level in Straits of Melacca. However, further studies to trace the source and the impact of this rich nutrients and the impact of this rich nutrients on ecological of the Straits of Melacca.

CONCLUSION

In summation, level of some Persistent Organic Chemicals (POCs) is still low compared with other Southeast Asia countries and the level of Persistent Organic Chemicals (POCs) in this region still at the medium level compared with more urbanized and industrialized region in the world. However, continuous monitoring and investigations on the level and of the Persistent Organic Chemicals (POCs) are needed in Malaysia. Transboundary pollution potential should be taken as an important consideration in any development project especially in Southeast Asia.

REFERENCES

Anonymous, 1997. Report on global environment outlook. United Nation Environment Programme. Chapter 2.

Barakat, A.O., 2004. Assessment of persistent toxic substances in the environment of Egypt. Environ. Int., 30: 309-322.

Billen, G., J. Garnier, C. Deligne and C. Billen, 1999. Estimates of early-industrial inputs of nutrients to river systems: Implication for coastal eutrophication. Sci. Total Environ., 243-244: 43-52.

Champ, M.A. and P.F. Seligman, 1996. An introduction to Organotin Compounds and Their use in Antifouling Coatings. In: Organotin: Environmental Fate and Effects, Champ, M.A. and P.F. Seligman (Eds.). Chapman and Hall, London, ISBN: 0-412-58240-6, pp: 1-26.

Chan, H.M., K.M. Chan and M. Dickman, 1999. Organochlorines in Hong Kong fish. Mar. Pollut. Bull., 39: 346-351.

Charnley, G. and J. Patterson, 2003. Review of procedures for protecting human subjects in recent clinical studies of pesticides. Reg. Toxicol. Pharmacol., 38: 210-223.

Chua, T.E., R.L.G. Ingrid, R. Adrian, R.B. Stella, B. Gervacio and M.C. Ebarvia, 2000. The Melacca straits. Mar. Pollut. Bull., 41: 160-178.

Furness, R.W. and K. Camphuysen, 1997. Seabirds as monitors of the marine environment. ICES J. Mar. Sci., 54: 726-737.

Graya, J.S. and J.M. Bewersb, 1996. Towards a scientific definition of the precautionary principle. Mar. Pollut. Bull., 32: 768-771.

Grizzetti, B., F. Bouraoui, K. Granlund, S. Rekolainen and G. Bidoglio, 2003. Modelling diffuse emission and retention of nutrients in the Vantaanjoki watershed (Finland) using the SWAT model. Ecol. Modell., 169: 25-38.

Hamzah, B.A. and M.N. Basiron, 1997. Funding partnership for safer navigation and cleaner environment in the Straits of Melacca some preliminary thoughts: Sustainable Financing Mechanisms: Public sector-private sector partnership. Ross, S.A., C. Tejam and R. Rosales, (Eds.). Proceedings of the Regional Conference on Sustainable Financing Mechanisms for the Prevention and Management of Marine Pollution, 1997, Quezon City, Philippines, pp: 87-103.

Hawkins, S.J., P.E. Gibbs, N.D. Pope, G.R. Burt, B.S. Chesman *et al*., 2002. Recovery of polluted ecosystems: The case for long-term studies. Mar. Environ. Res., 54: 215-222.

Hossain, M.M., Z.B. Din and M.S. Ibrahim, 1999. Bioconcentration and availability of organochlorine pesticides (OCP) in bivalces and marine sediment from the West coast of Peninsular Malaysia. Proceedings of the International Conference on the International Oceanographic Data and Information Exchange in the Western Pacific (IODE_WESTPAC).

Hsia, M.P. and S.M. Liu, 2003. Accumulation of organotin compounds in Pacific oysters, *Crassostrea gigas*, collected from aquaculture sites in Taiwan. Sci. Total Environ., 313: 41-48.

Islam, M.S. and M. Tanaka, 2004. Impacts of pollution on coastal and marine ecosystems including coastal and marine fisheries and approach for management: A review and synthesis. Mar. Pollut. Bull., 48: 624-649.

Kan-Atireklap, S., S. Tanabe, J. Sanguansin, M.S. Tabucanon and M. Hungspreugs, 1997. Contamination by butyltin compounds and organochlorine residues in green mussel (*Perna viridis*, L.) from Thailand coastal waters. Environ. Pollut., 97: 79-98.

Kullenberg, G., 1999. Approaches to addressing the problems of pollution of the marine environment: An overview. Ocean Coastal Manage., 42: 999-1018.

Law, A.T. and Y. Rahimi, 1986. Hydrocarbon Distribution in the South China Sea. In: Matahari Expedition '85, Mohsin, A.K.M., M. Ibrahim and M.A. Ambak (Eds.). Pertanian Unversity Publication, Malaysia, ISBN: 0-8194-4247-X.

Law, A.T. and M. Zulkifli, 1987. Distribution of Petroleum Hydrocarbon in the South China Sea. In: Matahari Expedition '86, Mohsin, A.K.M., M.A. Ambak and A.B.D. Ridzwan (Eds.). Pertanian Unversity Publication, Malaysia, ISBN: 84-85632-87-7.

Law, A.T. and S. Libis, 1988. Pertroleum Hydrocarbon Distribution in the Coastal Waters off Sarawak. In: Matahari Expedition 87': A Study on the Offshore Waters of the Malaysian EEZ, Mohsin, A.K.M. and M. Ibrahim (Eds.). Pertanian Unversity Publication, Malaysia, ISBN: 84-482-3104-x, pp: 61-67.

Law, A.T. and C.H. Yeong, 1989. Petroleum hydrocarbons in the water and sediment of Port Dickson coastal waters, Straits of Melacca. Proceedings of the 12th Annual Seminar of the Malaysian Society of Marine Science, Nov. 18, University Malaya.

Law, A.T. and R. Veellu, 1989. Petroleum hydrocarbon along the coastal area of Port Dickson. Pertanika, 12: 345-348.

Law, A.T., 1990. Petroleum Hydrocarbon Distribution in the Coastal Waters off Sabah. In: Ekspedisi Matahari `89: A study on the offshore waters of the Malaysian EEZ, Khair, A., M. Mohsin, M. Zaki, M. Said, M. Ibrahim and H.J. Mohamed (Eds.). Pertanian Unversity Publication, Malaysia, ISBN: 983-287184-0, pp: 57-64.

Law, A.T. and C.H. Chu, 1990. Chemical Oceanography Observation in the Coastal Waters off Port Dickson Malaysia. In: Advances in Fisheries and Marine Science, Ibrahim, M., H.J. Muhammad, P. Ismail, A.T. Law and S.C. Cheah (Eds.). Pertanian Unversity Publication, Malaysia, ISBN: 967-89-0654-4, pp: 140-149.

Law, A.T., N.A. Shazili, R. Yaakob, H.C. Liew, M.N. Saadon and L. Shamsudin, 1991. Coastal oceanographic studies in the Straits of Melacca and South China Sea: In Port Dickson coastal waters. Proceedings of the Seminar on Kebangsaan IRPA Rancangan Malaysia Kelima, Sektor Strategik, Dec. 16-19, Pulau Pinang, Malaysia.

Law, A.T., 1994. Oil pollution in the Malaysian Seas. Malaysian Fish. Soc., 6: 5-23.

Law, A.T., A. Arshad and F.M. Yusoff, 1995. Coastal oceanographic studies off Perlis, Straits of Melacca. Proceedings of the International Seminar on Marine Fisheries Environment, Mar. 9-10, Rayongg Resort, Thailand, pp: 263-281.

Law, A.T., M.K. Abdul-Rashid, C.H. Tan and Y.S. Yuen, 2000. Melacca Straits Expedition Cruise No. 1: Nitrogen and phosphorus distribution from Langkawi to Johore. Proceedings of International Conference on the Straits of Melacca, Apr. 19-22, Melacca, Malaysia.

Law, A.T., Y.S. Hii, K.J. Jong and M.L. Mok, 2002. JICA/UPM Melacca straits expedition no. 4: Petroleum hydrocarbon, nitrogen and phosphoris distribution. Proceedings of the 2nd International Conference on the Straits of Melacca, Oct. 15-18, Penang, Malaysia.

Moradi, A.M., M.P. Zakaria, J. Ali and H. Takada, 1999. Geographical distribution of polycyclic aromatic hydrocarbons in mussels from Malaysian coastal waters. Proceedings of the International Conference on the International Oceanographic Data and Information Exchange in the Western Pacific (IODE_WESTPAC).

Morton, B. and G. Blackmore, 2001. South China Sea. Mar. Polluti. Bull., 42: 1236-1263.

Nixon, S., B. Buckley, S. Granger and J. Bintz, 2001. Responses of very shallow marine ecosystems to nutrient enrichment. Hum. Ecol. Risk Assess., 7: 1457-1481.

Peachey, R.B.J., 2003. Tributyltin and polycyclic aromatic hydrocarbon levels in Mobile Bay, Alabama: A review. Mar. Pollut. Bull., 46: 1365-1371.

Phang, S., T.K. Hwand and T.T. Ang, 1980. A Study of the Hydrocarbon Content in the Coastal Waters Along the East Coast of Peninsular Malaysia. In: Coastal Resource of East Coast Peninsular Malaysia, Chia, T.E. and K.C. Joseph (Eds.). Penerbitan University Sains, Malaysia.

Pufulete, M., J. Battershill, A. Boobis and R. Fielder, 2004. Approaches to carcinogenic risk assessment for polycyclic aromatic hydrocarbons: A UK perspective. Reg. Toxicol. Pharmacol., 40: 54-66.

Sivalingam, P.M., I. Allapitchay, H. Kojiam and T. Yoshida, 1982. Mussel watch of PCBs and Persistent pesticide residues in *Perna virdis Linnaeus* from Malaysian and Singapore waters. Applied Geog., 2: 231-237.

Sudaryanto, A., S. Takahashi, H. Iwata, S. Tanabe and A. Ismail, 2004. Contamination of butyltin compounds in Malaysian marine environments. Environ. Pollut., 130: 347-358.

Tengk- Rozaini, T.M., 1999. Distribution of ortho-phosphate in the straits of Melacca. Proceedings of the International Conference on the International Oceanographic Data and Information Exchange in the Western Pacific (IODE_WESTPAC).

Wood, A.K., B. Ahmad, A.R. Mohd-Kamil and H. Jamaluddin, 1999. Organic Contaminants in Sediments of Melacca Straits. Proceedings of the International Conference on the International Oceanographic Data and Information Exchange in the Western Pacific (IODE_WESTPAC).

Yamamoto, T., M. Nakaoka, T. Komatsu, H. Kawai and K. Ohwada, 2003. Impacts by heavy-oil spill from the Russian tanker Nakhodka on intertidal ecosystems: Recovery of animal community. Mar. Pollut. Bull., 47: 90-98.

Yang, G.P., X.L. Lui and J.W. Zhang, 1998. Distribution of dibenzothiopene in the semiments of South China Sea. Environ. Pollut., 101: 405-414.

Young, S., L. Balluz and J. Malilay, 2004. Natural and technologic hazardous material releases during and after natural disasters: A review. Sci. Total Environ., 322: 3-20.

Zakaria, M.P., H. Takada, S. Tsutsumi, K. Ohno, J. Yamada, E. Kouno and H. Kumata, 2002. Distribution of polycyclic aromatic hydrocarbons (PAHs) in rivers and estuaries in Malaysia: Widespread imput of petrogenic PAHs. Environ. Sci. Technol., 36: 1907-1918.