A Need for Monitoring of Heavy Metals and Organotin Compounds in the East Coast of Johor

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ABSTRACT

Coastal marine environment receives contaminant from land-based and marine-based activities. Rapid development in agriculture, industry and urbanisation, and high shipping activities will contribute to heavy metals and organotin contamination in the coastal environment. As coastal environment is very productive in terms of fisheries activities and ecotourism, it is very important to monitor the contamination of these hazardous chemicals such as heavy metals and organotin. Several indicators such as sediments and intertidal molluscs have been identified to be good monitoring agents for heavy metals and organotin in the coastal marine environment. Continuous development and human activities need continuous environmental monitoring for better management of pollutants as well as human and environmental health and maintaining the biodiversity. Elevated concentration of heavy metals and organotin compounds in south of Johore may influence the environmental quality of the east coast of Johor. This paper discusses the status of heavy metals and organotin contamination in east Johor and the possibility of monitoring activities.

Introduction

Heavy metals and organotin compounds are two main important hazardous chemicals in the environment. Rapid development in agriculture, industrialisation, urbanisation and transportation contribute to the elevation of these hazardous chemicals in the environment in general and coastal ecosystems in particular. Coastal environment receives input of chemicals contamination from land-based and sea-based activities. Human activities inland release effluent and cause surface runoff into the aquatic systems which then flow into the river systems to the estuaries and finally the coastal environment that supports high biodiversity including human food resources. Contamination of hazardous chemicals from sea based activities is mainly from shipping activities, aquaculture and tourisms and recreation.

As has been discussed elsewhere, hazardous chemicals from land-based and marine activities accumulated in the sediment and organisms living in the area (Chua et al. 1989; Ismail 1993; Ismail and Rosniza 1997; Ismail 2006; Adeel and Miyazaki 2006; Ismail 2007). Hamid and Sindhu (1993) reported that the electronic and semiconductor industries in Peninsular Malaysia contributed more than 69,000m^3 per annum of sludge containing metals. Piggery wastes in Sepang River in the west coast, for example, have been reported to contribute more than 60% of copper and zinc in surface sediments (Ismail and Rosniza 1997). Tannery waste is also one of the toxic and hazardous to living things in Malaysia due to its high content of Cd and other heavy metals (Haroun et al. 2007).

The eastern coast of Johor is facing a similar phenomenon that faced in the west coast. Demand from the public for jobs, economic enrichment and changes of lifestyles has forced the development of agriculture, industrialisation, urbanisation, transportation, and tourism and fishing activities. Modern lifestyles for example, have caused increasing uses of pharmaceutical and personal products. Hospital wastes now are also increasing. Hospital products consist of about 80% domestic wastes and 20% of other chemicals including radioactive materials, pharmaceuticals, cytotoxic agents, pathological wastes and hazardous wastes including heavy metals. These wastes have enormous potential to cause irreversible health damage and need proper treatment and concern by the local authorities (Idris and Saed 2002). Anthropogenic metals in the aquatic environment for example, are of ecotoxicological concern since the metals concentrations released into the ecosystem could pose damaging and negative impacts on the health and safety of the aquatic environment. The eastern coast of Johor is rich in the biodiversity of coastal and marine flora and fauna. The existing mangroves, sea grasses, corals and mudflats ecosystems serve as a quality habitat for organisms that interact with each other to establish a stable and productive ecosystem. If the habitat for marine organisms is contaminated, it can result in the uptake of residues by filter-feeding molluscs, fish, crustaceans, birds, micro and meiofauna, algae and other vegetation in the surrounding environment. Potential effects to human health should be considered if, for example, filter-feeder molluscs are harvested for human consumption adjacent to aquaculture or boating activities.

Maintaining biodiversity, sustainable development and environment protection from hazardous chemical pollutions are among the major interrelated subjects that are always discussed at all levels when someone talks about development, environmental management and public health and environment. The monitoring and assessment of biodiversity and pollutants such as heavy metals and organotin are very important and a great challenge in Malaysia (Basiron 1988). Recent studies have revealed that several animal species have suffered adverse health effects from exposure to chemicals pollutants. These chemicals are persistent in the environment and cause toxicological effects to the organisms. This paper will review some works related to heavy metals and organotin in eastern Johor and vicinity areas and suggest some future monitoring activities.

Method

This paper is based on the available literature which includes scientific technical reports, reviews, publications from local and international organisations, and my own observations. Aggressive development along the coastal environment will cause adverse changes of ecological systems involving physical, chemical and biological aspects. Literature on the assessment of chemicals such as heavy metals and organotin, biodiversity along the coastlines, potential contamination through human activities along the rivers, coastal and inland activities was analysed. In much of the literature it has been shown that urbanisation, municipal waste, industrialisation, agriculture and transportation contribute to the elevation of hazardous chemicals in the coastal environment (Adeel and Miyazaki 2006). Shrimp farming for example, can affect the environment in different ways, i.e. toxic chemicals, antibiotics and nutrients (Graslund and Bengtsson 2001). The eastern coast of Johore is not exempted from contamination by hazardous chemicals since there is great demand on developments, economic growth, fishing and tourism industries. The scientific papers and documents analysed may help to assess the potential threat in the eastern Johor coastline. Therefore it is necessary to make an assessment of the development strategies in the areas and review the potential threat of hazardous chemicals in the coastal environment. Based on the status of heavy metals and organotin contaminations in the east of Johor, monitoring strategies can be recommended.

Discussion

Many aspects of human activities cause chemicals pollution in the marine environment, pollutions and biological impacts by hazardous chemicals, and some examples of current status of biodiversity and environmental problems in the world were well reported in the book 'Mankind and the Ocean' (Adeel and Miyazaki 2006). A vast majority of human activities are directly or indirectly dependent on oceans, including shipping and transportation, fishing and food supply, recreation and tourism, and offshore explorations for minerals and petroleum. Therefore an understanding of all physical, chemical and biological processes is very important for the survival of human beings.

Coastal development, economic pressures and population densities will affect the ecological changes in the coastal environment. Understanding the background status of physical, chemicals, biodiversity and ecology of the coastal environment is very important. The natural physical, chemical, and biological processes are known to have a great impact on human society and the various ecosystems.

The eastern coast of Johor is now facing the pressure of development due to current demand for fish landing, tourisms and human concentration. The development will change the physical landscape of land and erosion, followed by other development for human settlement, industry and agriculture. Subsequently, the developments will contribute to solid waste and other hazardous chemical pollution. Land-based sources of pollution, such as industrial effluents, untreated municipal sewage and runoff from agricultural areas, are among the biggest threats to the coastal areas and vicinity of the river mouth caused by any development. Some areas of the eastern coast of Johore have a potential sink for inland pollutant and may affect the marine organisms living in the coastal areas. As is well known, coastal areas including estuary, mangroves, corals and sea grasses bed are very important habitats for marine life to breed, grow and live. Local communities, industries and commerce in the eastern Johor may rely directly on the marine resources. For their benefit, the government together with the local communities need to plan all the developments carefully and provide good coastal environment management strategies. A good monitoring system is needed. So far, as reported by DOE (2006), certain areas in east Johor coast are still clean from hazardous chemicals pollution.

Heavy Metals

There is not much literature on heavy metals in Johor coastal areas. The few studies include these by Jothy et al. 1983; Ismail et al. 1995; Shazili et al. 1995; DOE 2006 and Shazili et al. 2006. A lot of literature has reported on heavy metals contamination in south of Johor, Singapore and the Straits of Malacca. High elevated levels of heavy metals in the Straits of Johor for examples probably influence the south east of Johor coast due to water current, shipping activities, migration of suspended particulate matter, organisms and atmospheric deposition. Few studies on the Straits of Johor have reported high anthropogenic put of heavy metals to the water, sediment and accumulate in the biota.

Yap et al. (2007) reported high anthropogenic input of heavy metals in surface sediments samples collected from the Pasir Gudang area compared to other areas in the Straits of Malacca. Sediment collected from Pasir Puteh was more polluted with Cd, Cu, Ni, Pb and Zn compared to sediment from Tanjung Piai (Yap et al. 2006b). Yap et al (2006a) also reconfirmed that the eastern part of the causeway was more polluted than the western part after analysing samples of *Perna viridis*. *Perna viridis* collected from Senibong, Telok Jawa, Kg Masai and Kg Pasir Puteh contained higher Cd, Cu, Fe, Pb, Ni and Zn compared to samples collected from Kg Sg Melayu, Kg Gelang Patah dan Pantai Lido. *Perna viridis* collected from the northern part of eastern Johore, like Nenasi and Kuala Pontian showed lower metals accumulation compared to other areas including south of Johor (Yap et al. 2006c). Bayen et al. (2004) also reported the east of the Johor Straits was found to be more contaminated with heavy metals then the west of the Straits when they used *Perna viridis* as a bioindicator to assess the levels of heavy metals and pesticides in Singapore waters.

Wood et al. (1997) reported the Straits of Johor was contaminated by heavy metals such as Cu, Zn, Pb and Cd. They suggested that high levels of Pb and Zn near the causeway were due to anthropogenic input such as vehicles traffic across the causeway and industrial discharges near shore. Any disturbance by ocean current or through human activities will cause heavy metals to be released in to the environment and probably in soluble forms and readily absorbed by aquatic organisms. Studies by Nayar et al. (2004) have shown that intensive dredging, reclamation, construction and shipping activities in Ponggol Estuary, Singapore may have led to resuspension and bioavailability of particulate metals. They reported that tin, lead, nickel, cadmium and copper in particulate and dissolved fractions and sediments from Ponggol Estuary, east of the Johor Straits ranged from ND-92 ppm, ND-303.2 ppm, ND-2818.4 ppm, ND-74.4 ppm and ND-1117.7 ppm respectively. High impact on heavy metals released into the environment because of human activities was also reported earlier by Sin et al. (1991) and Goh and Chou (1997). Available toxic metals released from sediments may cause toxicity to organisms if accumulated included bacteria. High concentrations of copper, for example can cause toxicity to phytoplankton and autotrophic bacteria (Nayar et al. 2003).

Cuong et al. (2005) also reported that samples from east of the Johor Straits was found to be 1-5 times more contaminated with heavy metals than the west side of the Straits. They analysed samples of surface waters, sediments and biota from the mangrove areas in Sungai Buloh and Sungai Khatib Bongsu which are south of the Johor Straits flowing from Singapore. They reported elevated levels of heavy metals might damage the growth and development of mangrove in the area.

Studies on heavy metals in fish, shellfish and fish products are still limited in Malaysia. Few studies on the levels of heavy metals and their risks have been reported (Law and Singh 1991; Ismail et al. 1995; Yap et al. 2004; Agusa et al. 2005). On the offshore environment there are not many reports on the contamination of hazardous chemicals such as heavy metals. Ismail et al. (1995) reported that trace metals in sea water, sediments and prawn collected from the Mersing coastline in general were low (Table 1). Those background data had never been compared to those on the eastern coast of Johor until now.

Shazili et al. (2006) reviewed the status of heavy metals in aquatic sediments in Malaysia including heavy metals in sediment of the offshore of eastern Johor. Off shore levels of heavy metals in sediment are still low and comparable to the background levels of heavy metals. In certain areas of coastal areas such as Mersing and Sedili estuary, Shazili et al. (1995) reported high Cu, Zn and Pb in *Thais* compared to other areas in the northern east coast of Peninsular Malaysia. Elevated levels of heavy metals in the estuary's sediment and biota may be due to inland input.

TABLE 1: Heavy Metals Concentrations in Surface Water, Sediment and Commercial Prawn Collected from Mersing Waters (Ismail et al. 1995)

Metals	Sediment $\mu g g^{-1}$	Surface Sea Water $\mu g l^{-1}$	Prawn $\mu g g^{-1}$
Cd	0.38	0.93	0.09-0.80
Cu	7.61	0.07	0.8-24
Pb	27.52	0.34	0.06-5.9
Zn	38.97	0.05	5-16

The marine water quality status analysed by DOE (2006) showed that major contributors for the changes of marine water quality are from total suspended solids followed by oil and grease e-coli and heavy metals such as Cu, Pb, Hg, and Cd. High activities in the industries in Johor contributed to air pollution, including suspended particular matter (SPM). SPM may deposit into the coastal areas carrying pollutants such as heavy metals. In the whole Malaysia, Johor was among the high contributors of air pollution sources after Selangor in 2005 (DOE 2006). Zhang et al. (2007) reported the atmospheric transport of trace elements had been found to be an important pathway for their input to the ocean including coastal marine environment.

Wu and Ting (2006) reported that fly ash from a municipal solid waste incinerator in Singapore was very fine and contained a significant amount of toxic heavy metals such as Al, Pb and Zn. Fly ash is hazardous due to the volatile toxic metals that concentrate and accumulate in the ash. The most abundant elements present in fly ash were oxygen and calcium. High concentration of these elements was due to the formation of metal oxides and lime spray treatment during the incineration process. Other elements included Al, C, Cl, K, Mg, Na, S and Si. Most of these major constituents were volatile elements which were formed due to high temperature and excellent burnout during the incineration process. The minor constituent heavy metals included Fe, Pb, Ti and Zn. Other heavy metals such as Ba, Cd, Co, Cr, Cu, Mn Ni, and Sr were found in trace amount. Particle size distribution of municipal solid waste fly ash ranged from 0.04 to 100 μm. This phenomenon may become one of the atmospheric deposition sources into the coastal and ocean environment.

Studies by Shuhaimi-Othman (2007) on heavy metals concentrations in surface water collected from Sungai Rompin showed they were within background levels. The metals were Cu, 2.37 ± 1.03 $\mu g l^{-1}$, Pb 1.26 ± 0.03 $\mu g l^{-1}$, Zn 6.70 ± 1.85 $\mu g l^{-1}$. High levels of Cd (7.63 ± 3.04 $\mu g l^{-1}$) reported in surface water need to be confirmed. In general, those levels were lower than the data reported in the rivers flowing to the Straits of Malacca and samples collected from Sedili and Mersing estuaries.

Past studies have shown elevated levels of heavy metals in the eastern part of the causeway in the Straits of Johore in sediments, surface water and biota. High human activities in industries, shipping, dredging, reclamation and aquaculture may contribute to the distribution and elevated levels of heavy metals in the environment. Shipping activities, water current, bottom sediments disturbance and the migration of marine life may transport the contaminants to other areas such as the eastern coast of Johor including sea grasses and coral reef environment. The eastern coast of Johor consists of many coral reefs, sea grass and mangrove spots which are important for marine life and tourism. Atmospheric deposition of contaminant from nearby areas and SPM is unavoidable and uncontrollable. Anthropogenic activities in the south of Johore, Straits of Johor and the island of Singapore may affect those pristine ecosystems. Flammang et al. (1997) reported the decreasing gradient of metals concentrations in corals and sediments correlating with distance from Singapore and industrial activities in Singapore. This may contribute to the elevated levels of heavy metals and have an important effect on the coral reef.

Monitoring of heavy metals in sediment is easy compared to biota even though they do not represent the exact levels of chemicals in the organisms which may cause toxicity. Bryan and Langston (1992) had recommended using sediment as a tool to assess human impact on the aquatic environment. The advantages of using sediment are that they play a major role in the transport and storage of metals, they are frequently used to identify sources of pollutants spatially and temporally and they can be used to locate the main sink for heavy metals. Heavy metals are persistent in the marine environment. A significant persistence of chemical, or its by-products, can influence organisms in contact with environment and organisms in other ecosystems through bioaccumulation, biomagnification or physical transport through air, water or soil (Uitto and Adeel, 2006).

In the monitoring process, many tools have been suggested for effective and easy monitoring procedures. Besides using sediment as a monitoring agent, many researchers have suggested that intertidal organisms can also be a tool for monitoring hazardous chemicals including heavy metals. A mussels watch programme has been established using mussels as a biomonitoring agent as they represent other living organisms and reflect the quality of the environments (Goldberg, 1975). In Malaysia there are many reported data on using *Perna viridis* as a biomonitoring agent for heavy metals in the intertidal environment. Intertidal molluscs such as *Thais, Cherithedia, Telescopium, Nerita, Anadara, Isognomon alatus, and Perna viridis* are among the indicator organisms to be used as monitoring agents for heavy metals in the intertidal marine environment as suggested by Ismail (2006). Molluscs, including bivalves and gastropods are commonly used as bioindicators of environmental contaminants (Peerzada et al. 1990). In Singapore Cuong et al. (2005) used *Nerita lineate, Nerita albicilla, Polymesoda expansa, Telescopium, Thai gradate, Thai clavigera and Myomenippe hardwicki* as bioindicators for heavy metals study. These species are abundant in the intertidal areas of Peninsular Malaysia and represent different groups of habitat, behaviour, tropics levels, physiology and feeding habit. They are easily available and analysed, and also reflect the quality of the environment. The monitoring of hazardous chemicals such as heavy metals is very important in the management of environmental quality and maintaining the environmental health in the coastal marine environment

Organotin Compounds

Organotin pollution in the coastal environment can originate from many human activities. Among the popular sources of organotin pollution in the marine environment are shipping activities. Organotin compounds have been widely used as toxic additives in antifouling paints since the 1970s and are known as a well-established environmental threat (Marcillo and Porte 1998 and Donard et al. 2001). The principal antifouling compound in use for the last four decades is tributyltin (TBT) (Bennett 1996; Champ and Seligman 1996). Organotin compounds leaching from antifouling have caused many deleterious effects on non target aquatic organisms, including imposex and abnormal shells (Gibbs et al. 1988 and Waldock and Thain 1983).

Another source of organotin pollution is the plastic-related industries. About 70% of the global organotin production is devoted to the application of mono- and di-alkyltin derivatives as heat and light stabilisers during the processing of plastics materials such as PVC, polyurethane foam, silicones and glass coatings (Takahashi et al. 1999). Municipal solid waste consists of all these plastic products. Leached out and degraded plastic may contribute organotin compounds into the environment in the form of gasses or dissolve into aquatic systems. Pinel-Raffaitin et al. (2007) reported that the diversity and variability of the organotin contamination in the form of organotin in lechate and methylethyltin and methyltin compounds in biogases were released from municipal solid waste landfill sites activities to the environment. These phenomena can lead to the release of biologically harmful species of organotin into the environment if no efficient effluent treatment is applied.

Organotin compounds are extremely toxic (Fent, 1996 and Morcillo and Porte, 1998). TBT has endocrine disrupting properties in marine gastropods at levels lower than 10 ngl^{-1} (Fent 1996). The phenomenon of imposex has previously been reported to occur in Singapore and Malaysian waters (Ismail et al. 2004; Tong et al. 1996; Tan 1997, 1999). The relationship between imposex incidence and TBT contamination has been documented else-where. Horiguchi et al. (1994) estimated 10 to 20 ng TBT/g wet tissue could cause imposex in *T. clavigera* and *T. bronni*. In Singapore coastal environment concentrations of TBT were between 10-100 times the thresholds required to induce imposex in gastropods and shell thickening in bivalves (Basheer at al. 2002).

Shipping activities in the Straits of Malacca, Singapore waters and the South China Sea have shown elevated levels of organotin compounds and accumulated in the biota. Sudaryanto et al. (2004) reported high TBT in sediment, fishes and mussels collected from Malaysian waters. Studies in BTs compounds in the west coast of peninsular Malaysia and Straits of Johor showed some elevation of BTs compound in water, sediments and green mussels *Perna viridis*. The concentrations of MBT, DBT and TBT in sediments from the west coast of Peninsular Malaysia were in the range of 4-242 μgkg^{-1} dry wt., 1-186 μgkg^{-1} dry wt., and 0.7-228 μgkg^{-1} dry wt. respectively. The concentrations of MBT, DBT and TBT in sediments from the Straits of Johore were in the range of 83-542 μgkg^{-1} dry wt., 30-232 μgkg^{-1} dry wt., and 41-492 μgkg^{-1} dry wt., respectively. BTs in the Straits of Johor were higher than in the west coast of Peninsular Malaysia.

Similar findings were observed by Harino et al. (2007) (Table 2). They found that PTs levels in Johor Straits were within the range of the west coast of Peninsular Malaysia, but BTs were higher in samples from the Johor Straits compared to the west coast of Peninsular Malaysia. So far in Malaysia, the contamination of OTs is more serious than alternative compounds that were recently introduced. MBTs were higher compared to TBTs in many stations especially in the Johor Straits. This shows that the degradation of

TABLE 2: Organotin Compounds in Surface Sediment from the West Coast of Peninsular Malaysia and Straits of Johor (Harino et al. 2007).

Organotins	West Coast of Peninsular Malaysia	Straits of Johore	Green lipped Mussels *Perna viridis*
MBT	4-242 μgkg^{-1} dry wt.	83-542 μgkg^{-1} dry t.	41-102 μgkg^{-1} dry wt.
DBT	1-186 μgkg^{-1} dry wt.	30-232 μgkg^{-1} dry wt.	3-5 μgkg^{-1} dry wt.
TBT	0.7-228 μgkg^{-1} dry wt.	41-492 μgkg^{-1} dry wt.	8-32 μgkg^{-1} dry wt.
MPT	<0.1-121 μgkg^{-1} dry wt.	41-66 μgkg^{-1} dry wt.	<0.1-22 μgkg^{-1}
DPT	0.4 – 27 μgkg^{-1} dry wt.	5-29 μgkg^{-1} dry wt.	<0.1-5 μgkg^{-1}
TPT	0.1 – 34 μgkg^{-1} dry wt.	0.3-34 μgkg^{-1} dry wt.	nd
Diuron	<0.1-5 μgkg^{-1} dry wt.		
Irgarol-1051	<0.1-14 μgkg^{-1} dry wt.		
Sea nine 211		Nd	
Dichlofluanid		Nd	

TBT is faster than the input rates in these areas. Generally, as Malaysia is in the tropical area, higher degradation rates are expected due to high temperatures and high light-intensity. Fundamental ecological knowledge is needed in order to plan and manage the coastal environment and ecological changes. High levels of BTs in the east side of the Johor Straits need further attention for the benefit of eastern Johor since the areas are still pristine and are a potential fisheries resource and tourism attraction.

Basheer et al. (2002) collected seawater from 26 stations around Singapore and analysed it for tributyltin (TBT), triphenyltin (TPT) and Irgarol-1051 (2-methylthio-4-tert-butylamino-6-cyclopropylamino-s-triazine). Their findings are in Table 3.

TABLE 3: Organotin Compounds in Surface Water from the Straits of Johore – Near Singapore (Basheer et al. (2002)

BTs	Concentrations μgl^{-1}	Highest levels recorded μgl^{-1}	Levels near east coast of Johore μgl^{-1}
TBT	1.44±0.60	3.20	1.4 – 2.40
DBT	1.07±0.80	3.80	–
MBT	0.34±0.50	1.60	–
TPT	<0.40	–	–
DPT	nd	–	–
MBT	nd	–	–
Irgarol-1051	2.00±1.20	–	–

Due to the high demand of petroleum and goods transportation in eastern industrialised countries such as Japan, Korea and China, organotin pollution in the coastal waters is unavoidable. The high rates of organotin compounds leaching out from shipping activities into seawater, elevating concentrations in the coastal environment and affecting the ecological systems have been well documented. These issues are well responded by marine scientists and they have suggested banning the use of organotin compounds as an antifouling agent. In October 2001, the International Maritime Organisation (IMO) adopted the international Convention on the Control of Harmful Antifouling System (AFS Convention), which prohibited the use of organotins as active ingredients in antifouling system for ships. Following the international restriction on the use of organotin-based antifoulants, paint manufacturers have developed many products as alternatives to the use of organotins. More than 20 chemical substances have been used or proposed as alternative compounds. In fact, aquatic pollution by alternative biocides has already been reported in some countries and alternative biocides such as Sea-nine 211, Diuron and Irgarol 1051 have been detected at the levels of sub ngl^{-1} and sub μgkg^{-1} in water and sediment from coastal areas respectively (Harino 2004). Basheer et al. (2002) reported the high levels of TBT in Singapore including the Straits of Johor were due to ship building industries, jetty, shipping lane and marinas. High levels of Irgarol-1051 in south-eastern Johor were also observed and probably related to the antifouling leachates from shipyards and marinas activities at Sembawang, Punggol and Pasir Gudang. The ban of TBT in shipping industries may cause elevated levels of Irgarol-1051 in the marine environment. Wide-spread increase in the use of Irgarol-1051 and similar chemicals as antifouling agents has been reported in several European countries such as France, Switzerland, Sweden and the United Kingdom. Singapore waters have been reported to be contaminated by TBT and Irgarol-1051. Since the east coast of Singapore contained high levels of those chemicals, the eastern coast of Johor might face a similar problem and have high ecotoxicological risks.

Alternative compounds Diuron, Irgarol 1051 and Sea nine 211 were high in the samples collected from the west coast of Johor and Straits of Johor. Why the levels were high was not clear. A recent toxicological study of Irgarol-1051 showed that this compound was highly toxic to non-target marine algae and that it was sufficiently stable to reach toxic concentrations in the environment (Dahl and Blanck 1996). Irgarol-1051 might inhibit the growth of algae along shorelines, changing biological communities and altering the ecology of coastal areas. Based on these finding, continuous monitoring is needed since the demand for alternative compounds is expected to be high in the future.

Many countries which have laws and regulations in controlling the use of organotin-based antifouling paints show TBT levels have declined in the environment

Conclusion

Based on the discussion above and the importance of the marine coastal environment as the source of marine life, biodiversity, fisheries products, ecotourism and potential ecological changes including contamination by hazardous chemicals, continuous monitoring is needed. It is important to preserve, protect, restore, and enhance the natural coastal resources. This includes identifying species and processes at risk and potential land-based and sea-based sources. Established bioindicators can be used as monitoring agents. The results of monitoring may help the management of coastal environment and maintaining their biodiversity. Appropriate emphasis also must be given to sustainable economic development along the coastal areas. Participation, cooperation, and coordination by the public, governmental agencies, and non-governmental organisation (NGO) should be strongly encouraged. Since some areas of the eastern coast of Johor are still pristine, serious consideration by the authority is needed.

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