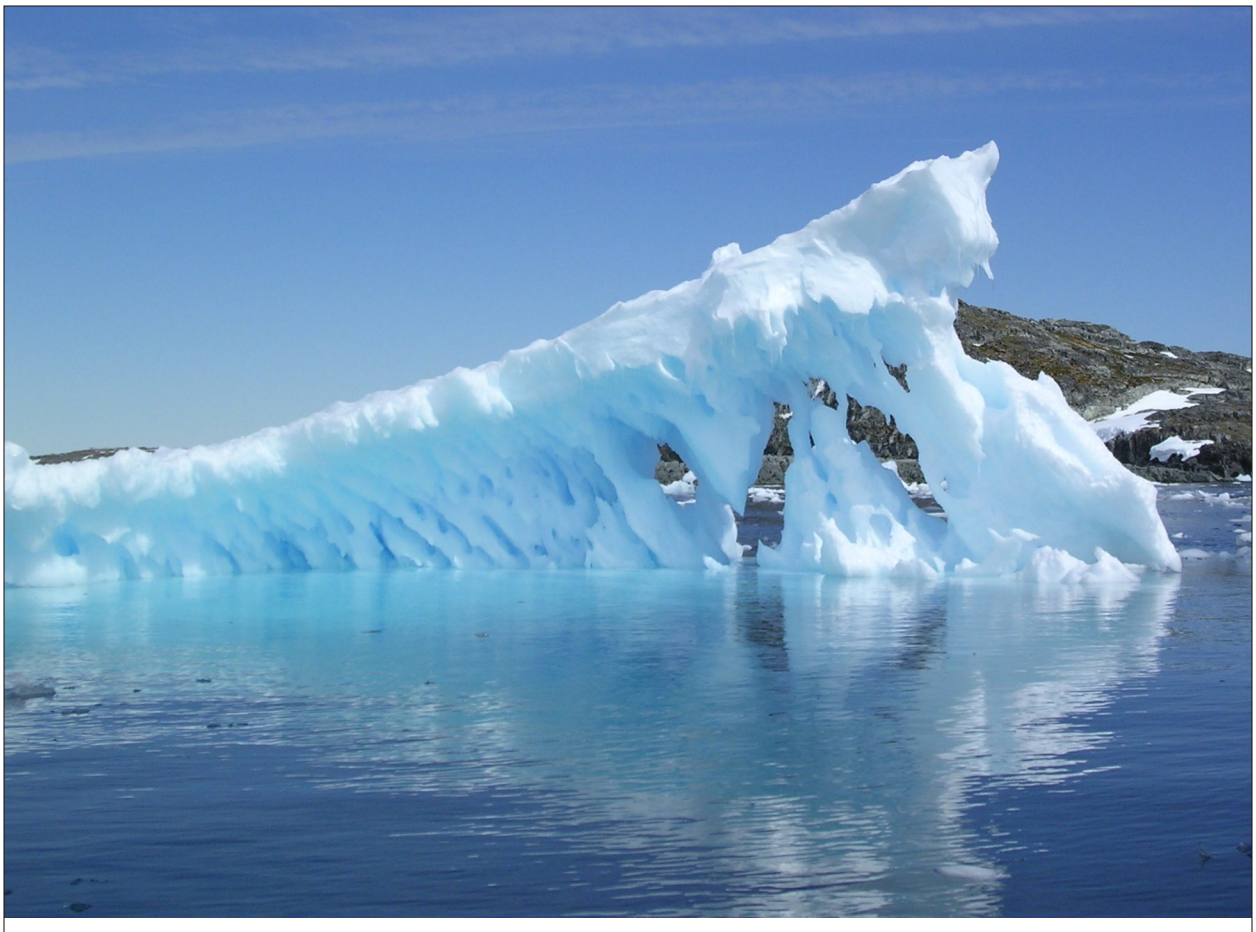

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A Brush up on Water Quality Studies of Port Dickson, Malaysia

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ABSTRACT

Port Dickson is the only coastal district in Negeri Sembilan, Malaysia which is a favourite weekend getaway for people from Malaysia as well as Singapore. Impacts of tourism activities, shipping, refineries, land reclaiming activities, coastal zone management construction and insufficient sewage water treatment are the most pressing environmental problems that have caused deterioration of water quality in Port Dickson. Thus, bearing in mind all the impacts towards water quality of Port Dickson, water quality studies related to Port Dickson are briefly reviewed. This is to provide an overall viewpoint of current situation of water quality status, identify and prioritize future studies and regulatory plans in Port Dickson. Extensive Port Dickson water quality studies were done from 1999 to 2002 so far, Port Dickson waters have been analyzed in terms of physico-chemical parameters, nutrients, organic carbon, microbiological and heavy metals to indicate environmental pollution. However, limited studies were available on heavy metal concentration in coastal waters of Port Dickson. After 2002, fewer studies were conducted in terms of water quality in Port Dickson. This review output showed that water quality related studies in Port Dickson are clearly needed to be increased and strategized in terms of research objectives. Looking into pollution factors in Port Dickson, accumulation of heavy metals in water, sediment and biomonitors studies are crucial at this point of time. Future studies on heavy metals are crucial to understand impacts of different ecological compartments from various anthropogenic sources. Future studies in Port Dickson should also give a focus in utilization of this resource in order fill in the knowledge gap and provide clear direction in sustainable development of this precious resource. Amid these findings, real extent of contamination in Port Dickson will give direction helpful recommendations on environmental management and pollution control in this area.

Key words: Port Dickson, coastal, water quality studies, environmental pollution

INTRODUCTION

Port Dickson is the only coastal district in the state of Negeri Sembilan. It is of major economic and domestic tourist destination to the state (Gopinath *et al*., 2000). In terms of economic importance, Port Dickson has a port with two major oil refineries. Port Dickson is one of the white

sandy beaches facing calm sea of Straits of Malacca with a coastline stretching up to 18 km. It has one of the longest beaches in Malaysia. A series of warm beaches streams towards Malacca, extending slightly past the cape of Tanjung Tuan. Bagan Pinang, Teluk Kemang and Blue Lagoon attract the most visitors each year, supported by numerous hotels and resorts that offer a wide range of accommodation, as well as delicious seafood restaurants and hawker stalls that line the coastal strip. The sandy white beaches of Port Dickson have been also documented even by top international tourist magazines as one of the best and most beautiful in the country (Lee and Mohamed, 2009; Schwartz, 2005; Thanapalasingam, 2005).

During the last five decades, Straits of Malacca received a large of waste loadings from municipal, industrial, agricultural and shipping discharges (Chua *et al*., 1997). Similarly, Port Dickson sea received heavy metal pollution due to growth in tourism, shipping, small industries and urbanization (Schwartz, 2005; Thanapalasingam, 2005). Moreover according to Kadaruddin (1997), there are eighty two wastewater pipe lines discharge wastewater including sewage from hotels and houses directly into the sea in northern part of Port Dickson. These discharges lead to degradation of the marine water quality causing significant negative impacts on marine ecosystem in water and sediment quality and coral reefs in particular. Additionally, Department of Environment found that majority of the coastal waters was polluted by suspended solids, *E. coli* and oil and grease (Department of Environment, 2006). According to Law *et al*. (1990), daily crude and refined oil handlings at the terminals, port as well as transportation of heavy maritime tanker in the Straits of Malacca would undoubtedly impacted on the water quality of the Port Dickson coastal waters (Gopinath *et al*., 2000). Law *et al*. (2002) concluded that impacts of holiday maker activities, shipping, oil tankers, refineries, land reclaiming activities, coastal zone management construction and insufficient sewage water treatment are the most pressing environmental problems that have caused deterioration of water quality in Port Dickson.

Bearing this in mind, this review is an attempt to gather all the existing information on water quality studies conducted in Port Dickson. An overall viewpoint is to give a clear picture of current situation of water quality status, identify and prioritize future studies and regulatory plans in Port Dickson.

DESCRIPTION OF THE STUDY AREA

Port Dickson is located in Negeri Sembilan (Lat. 2°30.08' N; Long. 101°29.94' E), western coast of Peninsular Malaysia (Fig. 1). Beaches in Port Dickson extend up to 18 km from north Tanjung Gemuk to south Tanjung Tuan. It has a port, two refineries, numerous condominiums on land and coral reefs, mangroves and sand beaches in coastal waters. Port Dickson are edged by coconut trees, rows of palms and banyan trees. Port Dickson enjoys a tropical climate and receives an average annual rainfall of 2381 mm. The annual temperature ranges from 21 to 32°C and humidity varies between 80 and 90%. Generally coastal waters of Port Dickson waters are shallow about 20 m and well mixed (Law *et al*., 2002).

WATER QUALITY STUDIES CONDUCTED IN PORT DICKSON, MALAYSIA

Water quality studies of Port Dickson coastal waters were done mainly to use as an indicator of environmental pollution focusing on physico-chemical parameters, nutrients, organic carbon, microbiological and heavy metals (Table 1). Studies were done with international

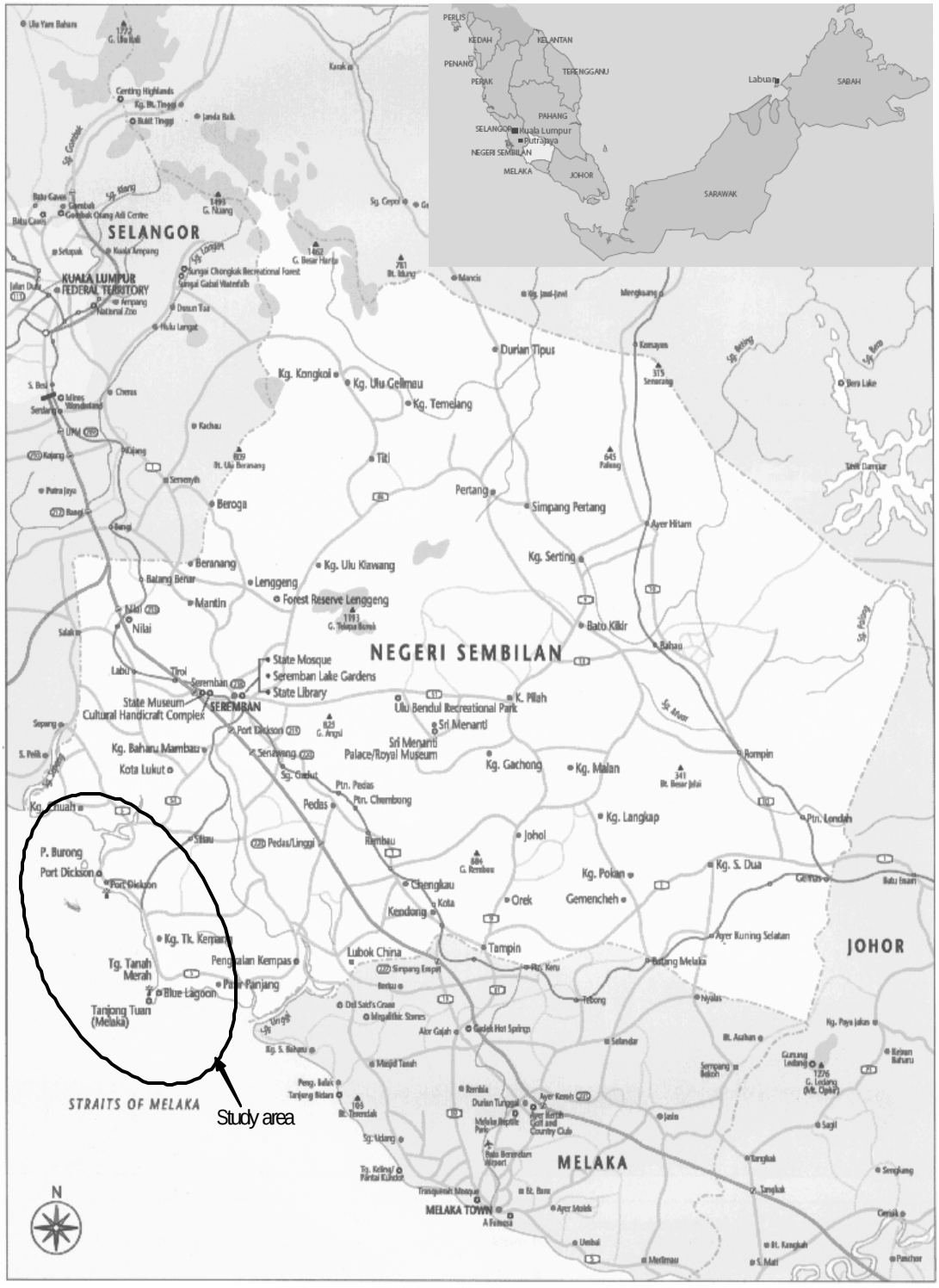

Fig. 1: Study area is indicated on the map

Table 1: Past water quality studies conducted in Port Dickson, Malaysia

Location	Parameter	Water	Source
	Physico-chemical parameters		
Coastal water of Port Dickson	Salinity	30 psu	Ibrahim *et al*. (2003)
	Temperature	29°C	
	Dissolved oxygen	4.25 mg L^{-1}	
Teluk Kemang	pH	8.10-8.20	Abu Hena *et al*. (2000)
	Temperature	29-32°C	
	Salinity	30-31 ppt	
Teluk Kemang	Dissolved oxygen	7.90-8.00 mg L^{-1}	Abu Hena *et al*. (2000)
Batu Empat	Dissolved oxygen	0.89 mg L^{-1}	
Center of Marine Science	Dissolved oxygen	0.65 mg L^{-1}	
Batu Lapan	Dissolved oxygen	0.59 mg L^{-1}	
Blue Lagoon	Dissolved oxygen	0.52 mg L^{-1}	
Coastal water of Port Dickson	pH	7.87-8.10	Sidik *et al*. (1995)
	Temperature	29.5-31.0°C	
	Salinity	28.0-31.0 ppt	
	Dissolved oxygen	5.75-6.35 mg L^{-1}	
	Nutrients		
Teluk Kemang	**Nitrate**	0.017-0.051 mg L^{-1}	Abu Hena *et al*. (2000)
	Phosphate	0.061-0.071 mg L^{-1}	
	Ammonium	0.421-0.463 mg L^{-1}	
Coastal water of Port Dickson	Ortho-phosphate	0.006 mg L^{-1}	Law *et al*. (2000)
	Organic phosphorus	0.141 mg L^{-1}	
	Ammonium	0.009 mg L^{-1}	
	Nitrate	0.016 mg L^{-1}	
	Nitrite	0.004 mg L^{-1}	
Port Dickson	Ortho-phosphate	0.043 mg L^{-1}	Law *et al*. (1991)
	Ammonium	0.019 mg L^{-1}	
	Nitrate	0.040 mg L^{-1}	
	Nitrite	0.006 mg L^{-1}	
Coastal water of Port Dickson	Nitrate	0.050-0.187 mg L^{-1}	Sidik *et al*. (1995)
	Phosphate	0.011-0.029 mg L^{-1}	
	Ammonium	Nd – 0.007 mg L^{-1}	
Coastal water of Port Dickson	Dissolved organic phosphorus	0.078 mg L^{-1}	Law and Chu (1990)
	Ortho-phosphate	0.017 mg L^{-1}	
Coastal water of Port Dickson	Dissolved organic phosphorus	0.116 mg L^{-1}	Law *et al*. (2001)
	Ortho-phosphate	0.021 mg L^{-1}	
Coastal water of Port Dickson	Ammonia	2.83 mg L^{-1}	
	Nitrate	1.57 mg L^{-1}	
Batu Empat	Ammonium	0.006 mg L^{-1}	Law *et al*. (2002)
	Nitrate	0.025 mg L^{-1}	
	Nitrite	0.004 mg L^{-1}	
	Phosphate	0.019 mg L^{-1}	
Center of Marine Science	Ammonium	0.006 mg L^{-1}	
	Nitrate	0.033 mg L^{-1}	
	Nitrite	0.007 mg L^{-1}	
	Phosphate	0.027 mg L^{-1}	
Batu Lapan	Ammonium	0.006 mg L^{-1}	
	Nitrate	0.036 mg L^{-1}	
	Nitrite	0.008 mg L^{-1}	
	Phosphate	0.027 mg L^{-1}	

Table 1: Continued

Location	Parameter	Water	Source
Blue Lagoon	Ammonium	0.004 mg L^{-1}	
	Nitrate	0.071 mg L^{-1}	
	Nitrite	0.010 mg L^{-1}	
	Phosphate	0.024 mg L^{-1}	
	Heavy metals		
Surface water of Port Dickson	Pb	0.001 mg L^{-1}	Nuchsin *et al.* (2003)
	Cd	<0.001 mg L^{-1}	
	Cu	<0.001 mg L^{-1}	
	Zn	<0.001 mg L^{-1}	
	Ni	0.001 mg L^{-1}	
	Pesticide		
Surface water of Port Dickson	Organochlorine	0.5-1.0 ppt	Nuchsin *et al.* (2003)
	Microbiological		
Surface water of Port Dickson	Coliform bacteria	750 MPN/100 mL	Nuchsin *et al.* (2003)
Batu Empat	Fecal coliform bacteria	7.9 MPN/100 mL	Law *et al.* (2002)
Center of Marine Science	Fecal coliform bacteria	3.7 MPN/100 mL	Law *et al.* (2002)
Batu Lapan	Fecal coliform bacteria	72.0 MPN/100 mL	Law *et al.* (2002)
Blue Lagoon	Fecal coliform bacteria	5.3 MPN/100 mL	Law *et al.* (2002)
Saujana beach	Total coliform	2.44 CFU/100 mL	Hamzah *et al.* (2011)
	Fecal coliform	2.38 CFU/ 100 mL	
	Fecal streptoccocci	1.88 CFU/100 mL	
Kemang Indah beach	Total coliform	2.72 CFU/ 100 mL	
	Fecal coliform	2.70 CFU/ 100 mL	
	Fecal streptoccocci	3.30 CFU/ 100 mL	
Teluk Kemang beach	Total coliform	2.94 CFU/ 100 mL	
	Fecal coliform	2.42 CFU/ 100 mL	
	Fecal streptoccocci	3.32 CFU/ 100 mL	
Blue Lagoon	Total coliform	1.56 CFU/ 100 mL	
	Fecal coliform	1.80 CFU/ 100 mL	
	Fecal streptoccocci	1.90 CFU/ 100 mL	
	Organic		
Seawater of Port Dickson	Particulate organic carbon	<100 μg L^{-1}	Ichikawa (2003)
	Particulate organic carbon	245 μg L^{-1}	Ichikawa *et al.* (2002)
	Particulate organic carbon	325	Ichikawa *et al.* (1999)
	Hydrocarbon		
Port Dickson waters	Petroleum hydrocarbon	151.24 μg L^{-1}	Law *et al.* (2002)
	Petroleum hydrocarbon	14.69-150.28 μg L^{-1}	Law *et al.* (1991)
	Petroleum hydrocarbon	2.52-73.34 ppb	Law and Veellu (1989)

(Japan International Cooperation Agency, Partnerships in Environmental Management for the Seas of East Asia, International Centre for Living Aquatic Resources Management, World Fish Centre), local (Malacca Straits Research and Development Centre, Malaysian Department of Fisheries, Malaysia Fisheries Society), universities grants as well as local and foreign researchers collaborations. Most of Port Dickson water quality studies were done in collaboration between Universiti Putra Malaysia and Japan International Cooperation Agency by organizing five expeditions on Straits of Malacca from 1999 to 2002. Other water quality studies on Port Dickson waters were done namely focusing on microbiological and nutrients. Few studies were available on

heavy metal concentration in coastal waters of Port Dickson. So far, heavy metals studies were done by Nuchsin *et al.* (2003) focusing on Cd, Cu, Ni and Zn in surface water of Port Dickson. Latest study on water quality of Port Dickson water is done by Hamzah *et al.* (2011) focusing on to evaluate level of fecal pollution at Port Dickson beaches using total coliform and fecal coliform.

Substantial mixing occurs in southern part of Port Dickson district including near shore areas and coastal fringe. On the other hand, flushing appears to be limited particularly around Port Dickson town. Littoral movements are expected to be influenced by the outflows from Lukut and Sepang rivers in the north and Linggi River in the south. Ibrahim *et al.* (2003) showed that variations of surface water temperature, salinity and dissolved oxygen in Port Dickson waters. Freshwater inflow, rainfall and monsoon in the central section of Straits of Malacca are crucial factors of these variations.

According to Nuchsin *et al.* (2003), low heavy metal concentration in surface water of Port Dickson was detected. The heavy metals concentration is also were below than Indonesian Seawater Quality Standard. Similarly, organochlorine pesticide concentration was also below the limit of Indonesian Seawater Quality Standard. Nuchsin *et al.* (2003) concluded that industries and all agricultural activities did not affected water quality of Port Dickson. Nutrients such as phosphorus and nitrate are normally low in seawater. However, with contamination by man activities will result in an increase of nutrients concentration in water. This will lead to adverse environmental effects including eutrophication. A comparison of dissolved organic phosphorus and Ortho-phosphate levels reported by Law and Chu (1990) as well as Law *et al.* (2001) indicated an increase in the concentration. This clearly shows that major inputs sources of phosphorus occur in Straits of Malacca contribute phosphorus concentration in Port Dickson waters. Law *et al.* (2001) explained that higher levels of nitrate and ammonium detected in Port Dickson waters showed that water quality of Malacca Strait is deteriorating. According to Chua *et al.* (1997), chemical and biological fluxes are greatly influenced by freshwater discharges from rivers from Peninsular Malaysia and Sumatra Island. Straits of Malacca are relatively shallow and receive nutrients from rivers of adjacent land. Moreover, monsoonal changes also influence nutrients levels. Arinardi (1992) showed that nutrients levels found to be higher during rainy season. In terms of organic carbon concentration, Ichikawa (2003) found low concentration of particulate organic carbon in Port Dickson waters. However, study done by Ichikawa *et al.* (2002) found that particulate organic carbon concentration was significantly higher (179-310 μg L^{-1}). Ichikawa *et al.* (2002) also demonstrated that particulate organic carbon variation is related to chlorophyll concentration and phytoplankton production. Organic matter of terrestrial origin is also a crucial source of particulate organic carbon in Straits of Malacca. These results supported that nutrient enrichment in Port Dickson waters also increases organic production in water column. Large industrial activities and population are factors that contribute to the organic matter in water. Presence of two major oil refineries in Port Dickson influence hydrocarbon concentrations in water. Law and Azahar (1990) indicated that hydrocarbon levels ranged from 0.77-7.87 μg L^{-1} in water. There was little difference in hydrocarbon levels between nearshore and offshore areas indicating that hydrocarbons were coming in mainly with ballast water from international waters. Study done by Law *et al.* (2002) found that Straits of Malacca is divided into two distinct water depths namely shallow and deep water portion. Port Dickson is the dividing point. Former water portion contains about 10% of total water of Straits of Malacca. Dilution capacity of shallow water is much lower than deep water portion which impacts of pollutants will be more severe (Law *et al.*, 2002). Microbiological studies to indicate water quality in Port Dickson showed Port Dickson beaches were

not safe for human activities with body contact such as swimming (Hamzah *et al.*, 2011). Kadaruddin (1997) stated that there are 82 wastewater pipe lines discharge wastewater including sewage from hotels and houses directly into the sea. These discharges lead to degradation of the marine water quality. Past studies done by Law *et al.* (2002) and Nuchsin *et al.* (2003) also showed the similar trend on degradation of water quality caused by coliform bacteria.

FUTURE WATER QUALITY STUDIES IN PORT DICKSON, MALAYSIA

Despite a long history in water quality studies in Port Dickson, Malaysia, gaps still remain to be addressed. Continuous collaborations between local and international researchers and research by local universities to conduct coral reefs studies are initiatives to collect needed information needed. As environmental pollution is the main problem in this area, studies related to it must be conducted. Moreover, studies on heavy metal, hydrocarbon, nutrient and microbiological need to be done in study area to update current information available in this review. Comparison between updated information and previous water quality data are needed to understand impact of pollution and environmental changes. Community participation is also a gap that needs to be addressed in the management of coastal waters. Science-driven management with community participation must be designed with clear goals and past experience for verifiable information to help future initiatives. Importantly, public should have access to information in order to understand better the value of their environment. This role can be played by mass media to continually remind people of the value of water quality.

CONCLUSION

This review highlights conducted water quality studies on waters of Port Dickson. Water quality studies focusing on physico-chemical parameters, nutrients, organic carbon, microbiological and heavy metals were done in Port Dickson. In a nutshell, water quality studies in Port Dickson are mainly to indicate environmental pollution. This review indicated that water quality studies in Port Dickson have a long way to move forward in conducting various studies. Summary of all the studies done is to give insights to current situation of water quality status in Port Dickson. This will also help to identify and prioritize future studies and regulatory plans for a better water management in Port Dickson. Identification and prioritization of future studies that can be conducted in Port Dickson waters is crucial to fill in the knowledge gap and address sustainable performance towards environment at the outset.

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