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Marine Pollution at Northeast of Penang Island

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Abstract: Oceans cover large area of earth surface and it is important for humans to protect from pollution. Malaysia has large marine areas which consist of islands, coastal and sea areas which are facing pollution problem due to the rapid urbanization and industrialization. This study investigated sources of marine pollution occurred at area near a reclamation project at the northeast of Penang Island. Three locations were chosen for water sampling which included Sg. Fetes, North Tanjung Tokong and Gurney Drive. Experiments were conducted to investigate the parameters namely Chemical Oxygen Demand (COD), pH, Dissolved Oxygen (DO), the presence of *Coliform* and *E. coli*, nitrate nitrogen, Total Phosphorus (TP) and turbidity. Visual observation during the site visit was also recorded. Laboratory results show that Gurney Drive is the most polluted location compared to other sampling points as it received flows from the existing island. The highest COD was 550 mg/L recorded at Gurney Drive followed by 290 mg/L at Sg. Fetes and 187 mg/L at North Tanjung Tokong. This study shows that the marine pollution was contributed from various sources with different impacts and resulted from the discharge from the existing mainland itself. Thus, pollution input should be controlled and mitigated for better water quality in the future.

Keywords: Marine pollution, wastewater, water quality

INTRODUCTION

The marine ecosystem is the largest system on the planet in term of size (Jha, 2004) and in Malaysia, with many islands, coastal areas and seas whose marine environment is generally rich in marine biodiversity (Ching, 1998), the beach area in Malaysia is one of the main contributors into Malaysia Ecotourism (Hassan, 2008). Coastal area also important for the country as they provide as much as 30 to 40 % of fish landing and 1659 km² of mangrove area in Malaysia (Spalding *et al.*, 1997). It is important for humans to protect the marine from pollution to preserve the biodiversity of the earth. In addition to that, shoreline erosion and flooding are protected by sea grass beds, mangroves and coral reef and have been affected by river discharges in Malaysia (Tunji *et al.*, 2012).

The ocean floor is natural resources for marine life as well as for human. The ocean provides oil and gas for energy needs worldwide, sources of seafood and habitats for the marine life. The oceans are also for moving materials and goods which are transported from one place to another using ships and barges. Many cities in Malaysia such as Port Klang, Pasir Gudang and Penang are developed because of this sea transportation industry occurred in those locations.

Marine pollution is generated by land, atmospheric and sea sources (Kasmin, 2010). In Malaysian coastal waters, oil and grease, suspended solids and *Escherichia coli* (*E. coli*) are identified as being the

main contaminants of coastal environment. Main contribution to the marine pollution comes from land-based activities such as wastewater, solid waste, agricultural run-off (BOBLME, 2011).

Over the years, Malaysia's marine environment continues to face serious problem mostly due to the water pollution. Urbanization and industrialization along the coastal areas and from the mainland has been identified as the major contributors towards the marine pollution (Mustafa and Mariani, 2011).

Rivers play an important part in assimilating and carrying the industrial and municipal wastewater and runoff from agricultural farm, roadways and streets (Carpenter *et al.*, 1998). These wastes from industrial, municipal and agricultural will contribute to the river and marine pollution. The garbage thrown by the public into the river also will affect the quality of the river (Chan, 2012). The river water will flow as well with the waste directly to the sea. This will lead to marine pollution and will endanger the aquatic population (Mansoor and Safia, 2007).

It is thus vital to prevent and control the water pollution to have better quality of marine environment. Water quality and pollution are determined by the measurement of the physical, chemical, biological, microbiological and radiological parameters of the river and sea water samples. Department of Environment Malaysia (DOE) has introduced Malaysian Interim Marine Water Quality Standards (IMWQS) to monitor and access the marine environmental quality and

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Table 1: Location of study area

Locations	Area
Location 1	Main river (Sg. Fetes) that draining into the sea at the south of Penang
Location 2	North of Penang, near Tanjung Tokong. The area is protected by the breakwater
Location 3	Near Gurney drive

Interim National Water Quality Standards Malaysia (INWQSM) for other water body in Malaysia (DOE, 2010).

Rapid development in Penang has cost it negative environmental impact to the marine zone. Marine zone of the Penang is heavily polluted due to the activities of land reclamation and the direct sewage discharge into the sea (Sivalingam, 1984). This study illustrates how improperly treated sewage and waste from the hinterland contributes to the polluted coastal waters.

LITERATURE REVIEW

Penang Island is an island of 293 km² located in the Straits of Malacca. The study area for this investigation were the coastal area at north and south of Penang and the main river that draining into the sea area at the south of Penang as in Table 1. Three locations were chosen for the water sampling. Sg. Fetes was chosen because it is directly discharged storm water from the mainland. On the other hand, North Tanjung Tokong is located above the reclamation land which the water body is not been disturbed by any development. The third location was around Gurney Drive which is slightly south of the reclamation area.

The objective of this investigation was to study the water pollution within Penang coastal area. The study aims to study the effect and contribution for the pollution occurs to the urban storm water runoff from the existing island.

METHODOLOGY

For the purpose of this study, the site area was visited on 23rd February 2012 for visual observation and collection of water samples at selected locations. There were three points for water sampling collection which were Sg. Fetes, North Tg. Tokong and Gurney Drive as shown in Fig. 1.

Visual observation: During the site visit, the physical characteristics of the waters at the study area were observed based on their water color, odor, visible sewage and solid waste.

Samples collection and preservation: The water samples from each location are collected using 20 L bottles and stored inside cool room at temperature of 4°C to maintain the chemical and biological properties of the water samples.

At each location, a 25 L of sample were collected and also in situ measurements of water temperature



Fig. 1: Sampling locations (based map sourced from Google earth)

were taken. Furthermore, visual observation were carried out at the study site area for their water color, smell/odor, any foam or oily sheen, turbidity, any visible sewage, solid waste (litter/garbage etc.), color of stream bottom and/or any algae growth. All the samples taken were kept in cold room to lower the microorganism degradation activity. The water samples were analyzed in the laboratory for Chemical Oxygen Demand (COD), pH, Dissolved Oxygen (DO), the presence of *Coliform* and *E. coli*, Nitrate, Total Phosphorus (TP) and turbidity.

Chemical Oxygen Demand (COD): Two mL of water samples from each location and distilled water as blank were placed into the COD vials. Samples from each location were prepared in triplicates for more reliable result. The samples were then placed into digester block for two hours at 150°C. Then, the samples were cooled down to the room temperature and the COD value was measured using Spectrometer.

The COD test used chemical potassium dichromate that oxidize organic and inorganic substance in the sample to measure the oxygen equivalent consumed by organic matter in the three different samples.

Dissolved Oxygen (DO): Dissolved Oxygen (DO) test was conducted to measure the concentration of oxygen in the samples. An adequate amount of dissolved oxygen in water is necessary for marine life. Three hundred mL of water samples from each location was transferred into the Biochemical Oxygen Demand (BOD) bottles. The DO meter was calibrated before taking the reading. The DO meter was placed into the bottle for a while to allow the reading to stabilize.

pH: Hundred mL of water samples from each location were transferred into a small beaker. The pH meter was calibrated then the pH meter was placed into the beaker and the reading was recorded.

Total Coliform and *E. coli*: The Most Probable Number (MPN) was used for the measurement of Total *Coliform* and *E. coli*: Hundred mL of water samples

from each location plus Colilert reagent was transferred into a Quanti-Tray and sealed. The tray with the sample was placed inside the incubator for 24 h. Then, the water samples were observed based on their color for total *Coliform*. For *E. coli*, the samples were observed under UV light and positive cells were recorded.

The *Coliforms* and *E. coli* are good indicators of the potential contamination of a water source and have been used to determine the general quality of water. An experiment was conducted to detect the amount of bacteria in 100 mL in each three of the water sample.

The device used is called Quanti-Tray/2000. This equipment is designed to count the amount of bacteria in 100 mL samples using IDEXX-d Substrate reagent product. The 100 mL sample was added with Colilert powder and poured into the Quanti-Tray/2000 and sealed. The sealed tray was incubated to develop the population for 24 h. After 24 h, numbers of positive large and small wells were counted and Most Probable Number (MPN) was determined. Wells that turned into yellow proved the presence of total *Coliforms* and wells that glow blue under the fluorescent light proved the presence of *E. coli* in the samples tested.

Total phosphorus: Five mL of water samples from each location were placed into the Total Phosphorus vial. Samples from each location were prepared in triplicates. Then, one Potassium Persulfate was transferred into the vials. The vials were placed in the digester block at 150°C for 30 min. Next, the vials with the samples were cooled down to room temperature. Two mL of NaOH solution was transferred into the vials. Then the vial was placed into the spectrometer as the blank. One pack of PhosVer 5 was added into the same vial and was mixed for 30 sec. After two minutes reaction periods, the vial is wiped and inserted into the 16 mm cell holder and the reading was taken in mg/L PO_4^{3-} .

Phosphorus is a nutrient used by organisms for growth. Water samples that contain phosphorus may cause algae growth in quantities sufficient to cause taste and odor problems in drinking water supplies (DEP, 2012). Moreover, dead and decaying algae can cause oxygen depletion problems which in turn can kill aquatic life.

Turbidity: The turbidity measurement was measured by Hach 2100P Turbidity meter. Ten mL of water samples from each location were transferred into a small bottle then placed into the turbidity meter for the measurement. Turbidity of water is caused by suspended particles, primarily of clay, silt, organic matter and microorganisms (MECC, 2012). For this study, 10 mL of diluted samples were tested by using turbidity meter.

Nitrate: Ten mL of water samples from each location were placed into the cuvette. Then, one NitraVer 5 pack was transferred into the cuvette. Blank was prepared using same procedure but no NitraVer 5 transferred into the samples. Samples from each location were prepared in triplicates for more reliable result. The Nitrate value was measured using Spectrometer (NO_3-N).

Nitrates are essential plant nutrients, but in excess amounts they can cause significant water quality problems. Along with phosphorus, nitrates in excess amounts can accelerate eutrophication, causing dramatic increases in aquatic plant growth and changes in the marine life (EPA, 2012).

Results from these experiments are presented in the following section.

RESULTS

Water quality standards have been established to protect users from health and other adverse consequences of poor water quality. Based on Interim National Water Quality Standards for Malaysia (INWQS) for freshwater case, the COD value for Sg. Fetes which was 290 mg/L is too high and the river is unsuitable for drinking and other activities. The COD results for North Tanjung Tokong and Gurney Drive also were high (187 and 550 respectively) and no activities are allowed in using that water. The presence of high COD may indicate faecal contamination from human or organic matter from non-human sources that can restrict water use (UNDSA, 2007).

Summary of the visual observation of the physical characteristics at the three selected locations is given below in Table 2 and photos of the locations are as in Fig. 2 to 4.

Table 2: Visual observation of water samples

Parameters	Observations		
	Location 1 (Sg. Fetes)	Location 2 (North Tanjung Tokong)	Location 3 (Gurney drive)
Water color	Dark brownish	Clear	Black
Foam/oily sheen	Yes	No	Yes
Odor	Slightly smell	Odorless	Very smelly
Turbidity (observed)	Very turbid	Not turbid, clear	Very turbid
Visible sewage	Present	Not present	Present
Solid waste	Present (garbage and plastics)	Not present	Present (garbage, plastics)
Algae growth	Present	Not present	Not present
Bottom of the stream	Not visible	Visible	Not visible



Fig. 2: Location 1-Sg. Fetes downstream



Fig. 3: Location 2-north of Tg. Tokong



Fig. 4: Location 3-beachfront of Gurney drive

Besides that, the pH value for Sg. Fetes was 6.91; North Tanjung Tokong and Gurney Drive have higher pH value which was 8.0 and 7.48, respectively. Most water bodies have pH range of 6 to 8. If the pH falls below 6, it has harmful effects for the ecological (Lenntech, 2012). Extreme pH can kill adult fish and invertebrate life directly and can also damage developing fish. When the pH of freshwater becomes highly alkaline, the effects to marine life include death and damage to outer surfaces.

The following photos in Fig. 2 to 4 show the visual condition at each location visited.

The experiments conducted proved that in Sg. Fetes the DO value was the lowest which was 2.63 compared to the highest DO in North Tanjung Tokong was (4.89 mg/L) followed by Gurney Drive (3.67 mg/L). According to INWQS, the lower the value of DO, the polluted the water body is. The oxygen dissolves by diffusion from the surrounding air and waste product of photosynthesis. Green plants and some bacteria only can do the photosynthesis process. Thus, in this case Tanjung Tokong maybe potentially good for living marine life because it has high DO.

Coliforms are bacteria that are always present in the digestive tracts of animal, including humans and are found in their wastes. Total *Coliform* include bacteria

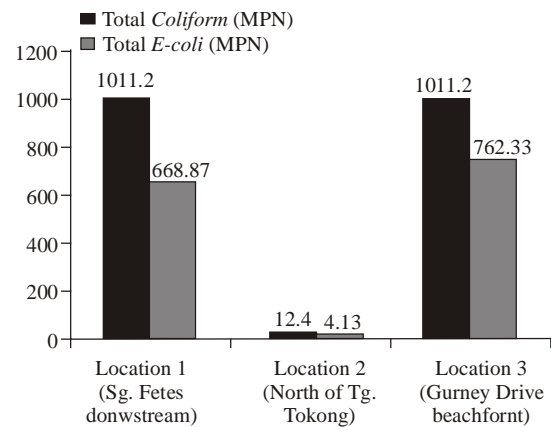


Fig. 5: Total *Coliform* and total *E. coli*

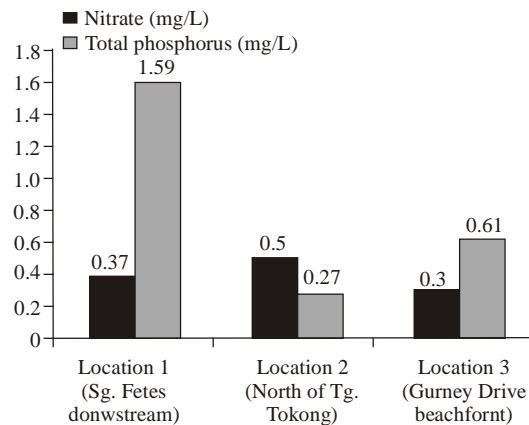


Fig. 6: Nitrates and total phosphorus

that are found in the soil, in water that has been influenced by surface water. *E. coli* is the major species in the fecal group *Coliform* group. Consequently, *E. coli* is considered to be the species of *Coliform* bacteria that is the best indicator of fecal pollution and the possible presence of pathogens (APEC, 2012). Based on INWQS, the total *Coliform* and *E. coli* presence are high and harmful for outer body contact. All three sites show presence of both type of bacteria with minimum value at north of Tg. Tokong as shown in Fig. 5.

From the experiments conducted, it shows that North Tanjung Tokong has the lowest value of phosphorus which was 0.27 mg/L followed by Gurney Drive (0.61 mg/L) and highest was in Sg. Fetes (1.59 mg/L). These values are considered high as the natural background levels for total phosphorus are generally less than 0.03 mg/L. The high concentration of phosphorus allows plants to assimilate more nitrogen before the phosphorus is depleted. Thus, when the amount of phosphorus is sufficient, elevated concentrations of nitrates will lead to algal blooms.

In Sg. Fetes and Gurney Drive, the values for nitrate were 0.37 and 0.3 mg/L, respectively. While in North Tanjung Tokong, the value was 0.5 mg/L and the

Table 3: Results from experiments conducted

Parameter	Location		
	Sg. Fetes	North Tanjung Tokong	Gurney drive
COD (mg/L)	290	187	550
pH	6.91	8.00	7.48
DO (mg/L)	2.63	4.89	3.67
Total Coliform (MPN)	1011	12	1011
<i>E. coli</i> (MPN)	669	4	762
Phosphorus (mg/L)	1.59	0.27	0.61
Nitrate (NO ₃ -N)	0.37	0.50	0.30
Turbidity (NTU)	73.90	21.40	1750.80

standard value for nitrate is below 0.5 mg/L as shown in Fig. 6. Thus, results show that the nitrate value for these three locations is considered acceptable to surrounding marine life.

Turbid water can reduce growth rate of marine life as it block the sunlight to go through into the water body. For turbidity measurement, Gurney Drive has the murkier water as it has the highest value 1750.8. In North Tanjung Tokong, it has the lowest value of turbidity which was 21.4 and this was well observed during the site visit. The water body here was the most clearly compared to the other locations and suitable for water recreation as the standard turbidity is 25 as summarized in Table 3.

CONCLUSION

As a conclusion, the most polluted water was in Gurney Drive as it receives water from polluted storm water from the main island. The entire discharged outlet from the main island eventually flows through the Gurney Drive. The water in North Tanjung Tokong was cleanest if compared to the other two locations; Sg. Fetes and Gurney Drive.

The pollution occurred in the water can be prevented when more restriction made to prevent direct discharge of polluted wastewater and wastes into the drain. Storm water and drains discharge outlets should be monitored before it is released into the seawater. Besides that, it is good to have separate drainage systems which have two drains; foul water and surface water. The foul water drain carries polluted water to the sewage treatment plant and the surface water drain should only flow uncontaminated rainwater and goes directly into the watercourse.

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