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Indicators of microbial beach water quality: Preliminary findings from Teluk Kemang beach, Port Dickson (Malaysia)



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ARTICLE INFO

Keywords:

Beach water
Total coliforms
E. coli
Perceived health symptoms

ABSTRACT

This study aims to determine the concentrations of total coliforms and *Escherichia coli* (*E. coli*) in beach water, Teluk Kemang beach. This study was also aimed to determine relationship between total coliforms, *E. coli* and physicochemical parameters. As perceived health symptoms among beach visitors are rarely incorporated in beach water studies, this element was also assessed in this study. A total of eight water sampling points were selected randomly along Teluk Kemang beach. Total coliforms concentrations were found between 20 and 1940 cfu/100 ml. *E. coli* concentrations were between 0 and 90 cfu/100 ml. Significant correlations were found between total coliforms and *E. coli* with pH, temperature and oxidation reduction potential. Skin and eyes symptoms were the highest reported though in small numbers. Microbiological water quality in Teluk Kemang public beach was generally safe for recreational activities except sampling location near with sewage outfall.

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Total coliform and *Escherichia coli* (*E. coli*) have been suggested as reliable indicators of sewage contamination. Recreational waters such as beach water are susceptible to fecal contamination which may increase in health risk associated with swimming in polluted beach water (Byappanahalli et al., 2008). According to Shuval (2003), there are more than 120 million cases of health risk cases caused by swimming and bathing in wastewater-polluted beach waters associated with exposure to microbial pathogens, which externally introduce as biological contaminants.

Port Dickson is the only coastal district in the state of Negeri Sembilan, one of the longest beaches in Malaysia with white sandy beaches facing calm sea of Straits of Malacca with a coastline stretching up to 18 km. Teluk Kemang beach located in Negeri Sembilan state of Malaysia attracts the most visitors each year, supported by numerous hotels and resorts that offer a wide range of accommodation, as well as with delicious seafood restaurants (Praveena and Aris, 2013). Insufficient sewage water treatment is one the most pressing environmental problems in Port Dickson (Law et al., 1991). There are eighty two wastewater pipe lines discharge wastewater including sewage from hotels and houses directly into the sea lead to degradation of the marine water quality (Kadaruddin, 1997). Dada et al. (2012) stated that is no single study has aimed to study the occurrence of fecal indicator bacteria in beaches and recognized health risks associated with the subject raises in Malaysia.

Thus, this study aims to determine fecal indicator bacterias (total coliform and *E. coli*) in Teluk Kemang public beach, Port Dickson. This study was also intended to study the relationship between concentrations of fecal indicator bacterias and physicochemical parameters of beach water. This study was also designed to determine commonly reported perceived health symptoms resulted from exposure. This study is considered as the first study to gather information on fecal indicator bacterias and perceived health risks symptoms among beach visitors. Output of this study can be used as a monitoring tool for other public beaches in Malaysia and elsewhere.

Water sampling was conducted in March 2013 during school holidays to represent the busiest condition of Teluk Kemang beach. A total of eight sampling points were selected randomly with 200–300 m distance between each station where bathers have their recreational water activities (Fig. 1). A total of 100 ml water samples were taken triplicates using Schott bottles at 100 m from wash zone of the beach. Water samples were placed immediately into the insulated ice box with ice pack under 1–4 °C and analyzed within the 12 h of collection. Total coliforms and *E. coli* were analyzed by membrane filtration method using a simultaneous detection technique with m-ColiBlue24[®] broth as described by Grant (1997). *In situ* parameters, namely pH, temperature, turbidity, salinity, dissolved oxygen (DO) and oxidation–reduction potential (ORP) were measured using YSI model 32 and Salinity Refractometer MASTER-S/MIIM, respectively. The readings were taken three times for each parameter at each sampling point.

A total of 117 respondents were calculated based on formula by Daniel (1999) to participate in questionnaire survey to determine

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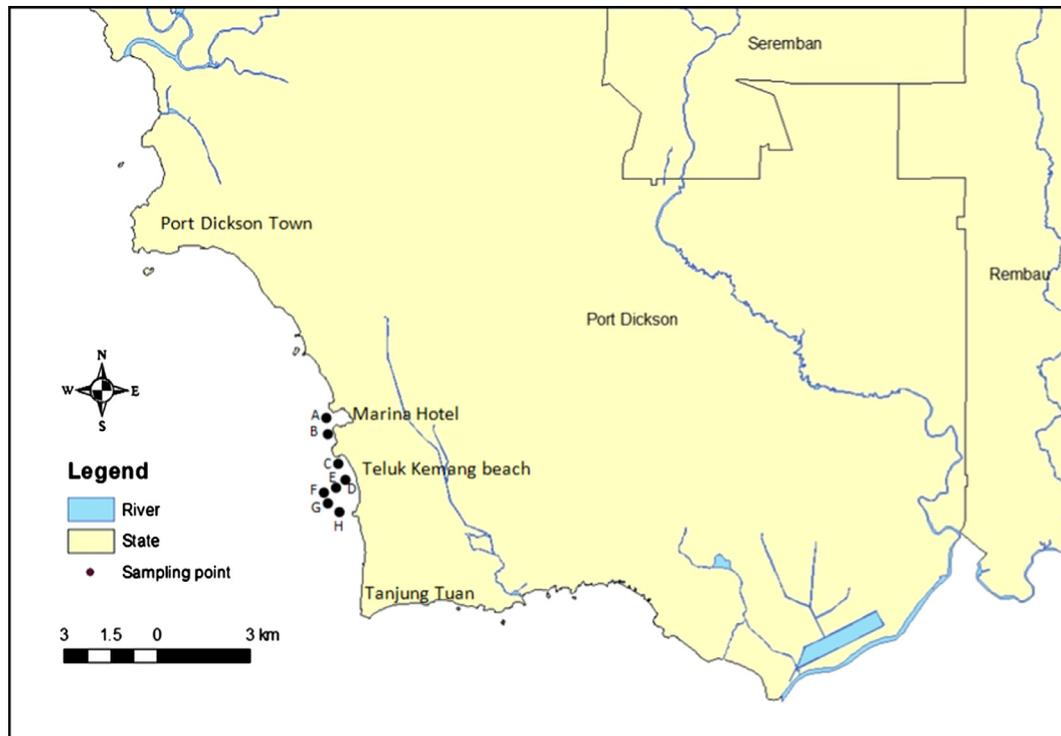


Fig. 1. Sampling points in this study.

exposure behaviors and perceived health symptoms of beach visitors. These respondents were interviewed individually to fulfill the questionnaire. Initially, the questionnaire was pretested and Cronbach's alpha value of 0.71 was obtained to ensure consistency of the questionnaire.

Statistical analysis was performed using IBM SPSS (Statistical Package for Social Science) software Version 21. Descriptive statistics were used to detect spatial variation of fecal indicator bacteria while correlation analysis was undertaken to study relationship between concentrations of fecal indicator bacteria and physicochemical parameters.

Fig. 2 shows mean concentrations of total coliforms and *E. coli* at eight sampling locations in Teluk Kemang public beach, Port Dickson. Total coliforms concentrations were found highest at sampling point A (1940 ± 191 cfu/100 ml) and lowest at sampling point H (20 ± 20 cfu/100 ml). *E. coli* concentrations were also found the highest also at sampling point A (90 ± 30 cfu/100 ml) and lowest at sampling points G and H where *E. coli* was not detected.

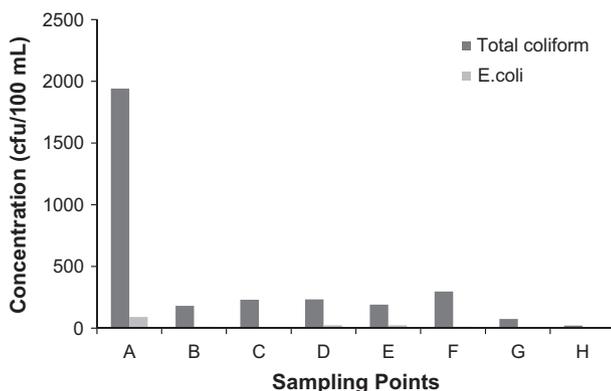


Fig. 2. Total coliforms and *E. coli* at eight sampling locations.

The highest concentrations of total coliforms and *E. coli* were found at sampling point A as it is located at the sewage outlet near Marina Hotel. There was a decreasing trend of total coliforms from sampling point C to H (except for point F) as the distance from point A increased. This is probably due to dilution of bacterial density as the sewage outfall distance increase.

In this study, total coliforms concentration at sampling point A near sewage outfall area has exceeded the USEPA limit (1000/100 ml) while other sampling points were safely under the limit. For *E. coli* concentration, Malaysian Marine Water Quality Criteria and Standards (DOE, 2011) set the limit of 100 MPN/100 ml while USEPA (1986) recommended 200 cfu/100 ml for recreational purposes. Based on these standards, none of these sampling points have exceeded the standard values. Therefore, all the sampling points were safe for public recreational activities except for point A.

Shapiro-wilk test of normality showed total coliforms and *E. coli* concentrations were not normally distributed ($p < 0.05$). Therefore, Spearman's rho correlation coefficient test was performed to assess relationships between the concentrations of total coliforms, *E. coli*, and physicochemical parameters (Table 1).

Both concentrations of total coliforms and *E. coli* were negatively correlated with pH. pH in seawater does not contribute much to the survival of fecal coliform as they are almost constant in seawater (Solíc and Krstulovic, 1992). Besides, total coliforms and *E. coli* concentrations were positively correlated with oxidation reduction potential. Increased water turbulence caused by the boating activities might have both increased the oxygen level and also resuspended the bottom sediments in the seawater. This might have caused the positive correlation between both variables. In addition, oxidation reduction potential and bactericidal activity of water decrease with increasing pH (Park et al., 2005). In this study, *E. coli* was found negatively correlated with dissolved oxygen. It might be caused by dissolved oxygen consumption resulting from organic compounds microbial decomposition (Pope, 1995). High concentrations of oxygen can cause oxidative stress on

Table 1
Spearman's rho correlation coefficient between total coliforms, *E. coli* and physicochemical parameters.

Variables	pH	Temp.	DO	Salinity	ORP	Turbidity	TC	EC
pH	1.00	−0.729**	0.525**	−0.530**	−0.548**	0.262	−0.813**	−0.795**
Temp.		1.00	−0.363	0.634**	0.358	−0.233	0.524**	0.450*
DO			1.00	−0.242	−0.060	0.079	−0.273	−0.610**
Salinity				1.00	0.227	−0.270	0.376	0.358
ORP					1.00	−0.607*	0.504*	0.536**
Turbidity						1.00	−0.229	−0.208
TC							1.00	0.624**
EC								1.00

Notes: DO: dissolved oxygen; ORP: oxidation–reduction potential; TC: total coliforms; EC: *E. coli*.

* Significant at $p < 0.05$.

** Significant at $p < 0.01$.

Table 2
Perceived health symptoms among respondents.

Health symptoms	Yes		No	
	N	Percentage (%)	N	Percentage (%)
Gastroenteritis	2	1.9	106	98.1
Respiratory symptoms	15	13.9	93	86.1
Skin symptoms	22	20.4	86	79.6
Eye symptoms	21	19.4	87	80.6
Ear symptoms	4	3.7	104	96.3
Open wound infection	6	5.6	102	94.4
Presence of symptoms	55	47	62	53

E. coli cells which resulted in reduced or inhibited growth and cause the inverse relationship (Baez and Shiloach, 2013). A high concentration of dissolved oxygen in seawater could also enhance microbial inactivation by solar ultraviolet radiation (Hughes, 2003), thereby reducing the number of bacteria.

There is no any studies have incorporated fecal bacteria concentrations with perceived health risk symptoms among beach visitors due to swimming. Perceived health symptoms in Teluk Kemang beach was collected using the questionnaire. Perceived health symptoms received by Table 2 shows results of perceived health symptoms among the respondents. Over half of the respondents reported having no symptoms at all. Skin symptoms and eye symptoms, although in small number, were the highest symptoms.

Total coliforms concentrations were found highest at sampling point A (1940 ± 191 cfu/100 ml) and lowest at sampling point H (20 ± 20 cfu/100 ml). *E. coli* concentrations were also found the highest also at sampling point A (90 ± 30 cfu/100 ml) and lowest at sampling points G and H where *E. coli* was not detected. All the sampling points at the Teluk Kemang public beach were within the bacteriological standard for beach water except for total coliforms at sampling point A which exceed the 1000/100 ml limit by USEPA (1986). Concentrations of total coliforms and *E. coli* were highest at sampling point A compared to other points as it was near the sewage outfall. Concentrations of total coliforms and *E. coli* in beach water were significantly influenced by physicochemical factors (pH, temperature, dissolved oxygen, and oxidation reduction potential). There was no significant number of complaints on perceived health symptoms among the respondents from exposure to the bathing water at Teluk Kemang public beach. Only skin and eyes symptoms were reported in low number of cases. Microbiological water quality in Teluk Kemang public beach was generally safe for recreational activities for public. Further extra efforts are crucial to focus on causal dose-related relationship between actual health symptoms due to beach water exposure, exposure behavior and beach water quality (fecal bacteria).

Acknowledgments

The authors would like to thanks Miss Nurul Syazani Yuswir and Miss Raihanah Chokeli for their help during sampling. Thanks to staff of the Microbiology Laboratory (FPSK) for their help. Thanks to Centre of Marine Science (COMAS), Universiti Putra Malaysia for their boat service and sampling assistances.

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