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Baseline

Fecal indicator bacteria in tropical beach sand: Baseline findings from Port Dickson coastline, Strait of Malacca (Malaysia)

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ABSTRACT

This pilot study aims to assess *Escherichia coli* (*E. coli*) contamination and its perceived health risks among beachgoers in ten tropical beach sands along Port Dickson coastline (Malaysia). This study also aims to determine the relationship between perceived health symptoms and tropical beach sand exposure behavior. The concentration of *E. coli* in tropical beach sand ranged from 60 cfu/100 g to 4113 cfu/100 g. *E. coli* contamination was the highest at Tanjung Gemuk (4113 ± 30 cfu/100 g) and the lowest at Tanjung Tuan (60 ± 15 cfu/100 g); the high level of contamination could be due to the location of the former at the sewage outlet of nearby hotels. Skin symptoms were the most predominant among the health symptoms indicated by beachgoers. Exposure duration was significantly correlated with the perceived health symptoms among beachgoers in the beaches studied.

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Fecal contamination in recreational beaches is represented by the number of fecal indicator organisms in coastline water and perceived health risks caused by microbial pathogen exposure (Bonilla et al., 2007). *Escherichia coli* (*E. coli*) is a reliable organism to assess sewage contamination and is highly correlated with bather illness (Byappanahalli et al., 2008; Noble et al., 2003). Bonilla et al. (2007) reported that tropical beach sand is often unnoticed as a favorable reservoir for fecal indicator organisms. The surface area and cracks of sand provide a potentially suitable environment for the growth and multiplication of microbes (Bonilla et al., 2007; Shibata et al., 2004). Most studies have focused on fecal indicator organisms in tropical beach water and their health risks (Ahmad et al., 2014; Crowther et al., 2001; Praveena et al., 2015; Praveena et al., 2013; Shibata et al., 2004). However, the presence of fecal indicator organisms in tropical beach sand and their perceived health risks among beachgoers remain unexplored, especially in the tropical beaches of Southeast Asia, including Malaysia.

This study aims to determine fecal indicator organisms (*E. coli*) in tropical beach sands along Port Dickson coastline, Strait of Malacca (Malaysia). This study is the first to perform a pilot-scale epidemiological investigation to collect information on *E. coli* contamination and perceived health risk symptoms among beachgoers by obtaining tropical beach sand samples along the coastline (Malaysia). This study also determines the relationships between perceived health symptoms and tropical beach sand exposure behavior. As CNN Travel (2016) has listed the

top ten best Malaysian beaches for holidays, beach management has been the focus to increase local and international visitors in tropical beaches in Malaysia.

This study was performed in ten beaches along Port Dickson coastline, Strait of Malacca (Malaysia). Port Dickson coastline is about 90 km south of Kuala Lumpur and the only coastal district in the state of Negeri Sembilan (Malaysia). Tropical beach sand sampling was conducted in ten public beaches located along Port Dickson coastline (Fig. 1). Beach sand samples were collected from swash zones to represent the sand in contact with the outer fringes of beach water at low and high tides. At each sampling location, tropical beach sand samples were collected at a depth of 10 cm by using a stainless steel soil auger and stored in sterile Whir-Pak sampling bags, stored in the dark at 4 °C during the transportation to the laboratory for immediate processing and analysis. Tropical beach sand samples (100 g) were shaken vigorously in 100 mL of sterilized deionized water (USEPA, 2003) for 1 min to suspend the bacteria. After shaking, the supernatant of tropical beach sand extracts was collected after settling for 30 s. *E. coli* in the supernatant was analyzed using membrane filtration (APHA, 1995). A total of 100 mL of the supernatant was passed through 0.45 µm Whatman filter paper by vacuum filtration. The filter paper with collected *E. coli* was placed on lauryl sulfate broth and incubated at 44 °C overnight. Yellow colonies on the filter paper were counted as *E. coli* and reported as colony-forming units per 100 mL (cfu/100 mL).

The responses of 151 respondents were assessed using a formula proposed by Daniel (1999), with a prevalence value of 0.063 reported by Heaney et al. (2014) with an increase in 25% considering non-response rate (Särndal and Lundström, 2005). The questionnaire was adapted and modified from a public survey on marine water quality

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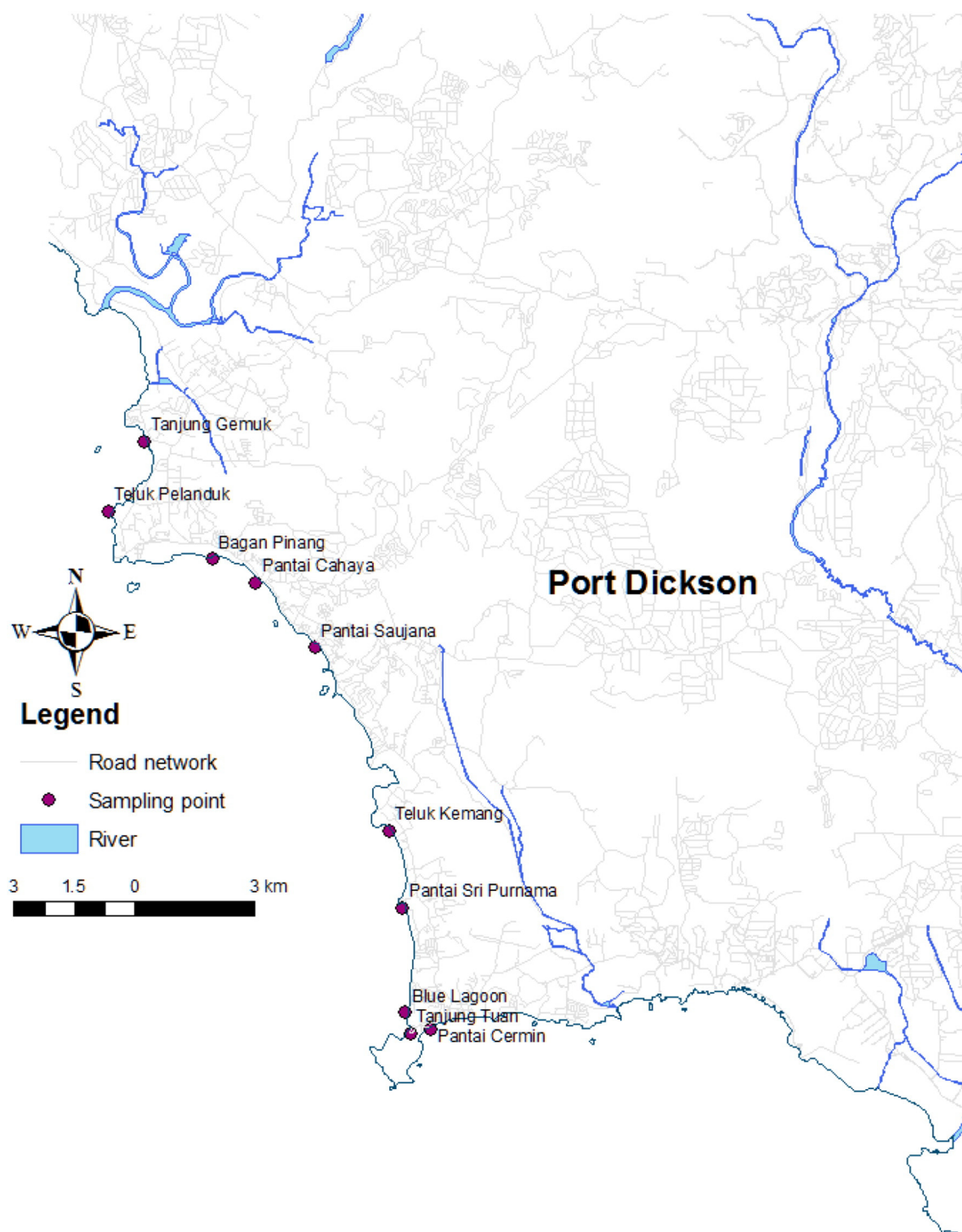


Fig. 1. Tropical beach sand sampling locations at ten public beaches located along Port Dickson coastline.

by Ministry of Marine Resources, Cook Islands (2014) to obtain the perceived health symptoms by beach sand exposure. The questionnaire survey was pretested with Cronbach alpha value of 0.71, which represents the consistency of the questionnaire. The respondents playing beach sand were contacted by telephone after 7–12 days from the initial beach interview to determine health symptoms that they have experienced.

Statistical analysis was performed using IBM SPSS (Statistical Package for Social Science) software Version 21. Descriptive statistics were used to detect spatial variation of *E. coli* in beach sand, whereas bivariate analysis was conducted to determine significant associations between

tropical beach sand exposure and perceived health symptoms with a 5% level of significance.

Fig. 2 shows the number of *E. coli* colonies in tropical beach sand were the highest at Tanjung Gemuk (4113 ± 30 cfu/100 g) and the lowest at Tanjung Tuan (60 ± 15 cfu/100 g). The highest concentration of *E. coli* found in Tanjung Gemuk beach sand may be due to its location at the sewage outlet of nearby hotels. The number of *E. coli* colonies in beach sand presented a decreasing trend from Tanjung Gemuk to Pantai Cahaya, which is probably due to dilution with increasing sewage outfall distance (Praveena et al., 2013). *E. coli* colonies of 100 cfu/100 g were also found in the beach sands of Pantai Cahaya. This finding could be

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