Impact of climate and land use on *Escherichia coli* in the Chao Phraya river

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Abstract:
This study examines the land use and microbial quality in the Chao Phraya river during dry season (April 2014). Water samples were collected at the depth of 0.5 and 2 meters from water surface along the river and determined Total coliform bacteria (TCB) and Escherichia coli (E. coli). The long period of dry season and heavy rain make high discharge pollution from land surface into the river. The highest of E. coli was found in urban area (1.95×10^4 MPN/100 mL) followed by industrial, residential and agricultural area, respectively. This indicates nonpoint source pollution from the city. In addition, TCB/E. coli of those areas has low value which indicates the contaminant in the river came from fecal warm blood animal and human.

Keywords: Chao Phraya river; Coliform; E. coli; water quality

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1. Introduction
Climate change is caused by human activity and natural variability which resulted in global warming, high temperature (both of air and water), drought area, high sea levels, flooding, ecosystem disruption, and also water resources quality and quantity. During dry season and drought condition, most of pollutants were accumulated in the soil for long time period. Then, they were leached into the water resources by rainfall during wet season. Zhang et al. (2013) also reported the main impacts of microbial water quality in dry and wet season were human activities and storm runoff, respectively. In addition, water quality could be changed due to land use patterns, namely agricultural, industrial or commercial areas depending on the types of pollutant and its physical-chemical characteristics in the soil. Microbial analysis is important because pathogenic bacteria in water resources are risk to human health. It shows impolitic for water consumption. Mostly, microbial analysis for detecting pathogen is difficult, whereas coliform bacteria measurement is easy to culture. *E.coli* is the member of fecal coliform bacteria, indigenous to the intestinal tract of humans and warm-blooded animals. Therefore, the presence of coliform bacteria indicates that other pathogenic organisms of fecal origin may be present.

Chao Phraya river is the main river in the central part of Thailand. It flows through several land use patterns such as residential, agriculture, urban and industrial area from Nakhon Sawan province to the gulf of Thailand (total length of 379 kilometers). There are 3 parts of the river; upper, middle and lower of Chao Phraya river. Each part of the river has different water quality standards. The maximum allowance numbers for Total coliform bacteria (TCB) and Fecal coliform bacteria (FCB) for upper river are 5,000 and 1,000 MPN/100 ml, respectively. The maximum allowance numbers for TCB and FCB are 20,000 and 4,000 MPN/100 ml, respectively for middle river. There is no microbial quality specified in the lower river. This study aims to explore the microbial water quality of the river using total coliform and *E. coli* as the indicators in difference land use areas during dry season.

2. Methods
Fifteen water samples were collected at the 0.5 and 2 m depth from water surface along the Chao Phraya river as shown in Fig. 1. Land uses can be categorized as R-residential, A-agricultural, U-urban

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and I-industrial areas as shown in Table 1. Then, they were collected in the sterilized polyethylene plastic bottles and stored in iced box. The samples were analyzed as soon as possible no later than 24 hours by MPN method (Colilert test, IDEXX, 2014). Temperature, pH, dissolved oxygen (DO), electrical conductivity (EC), TKN and BOD were also measured.
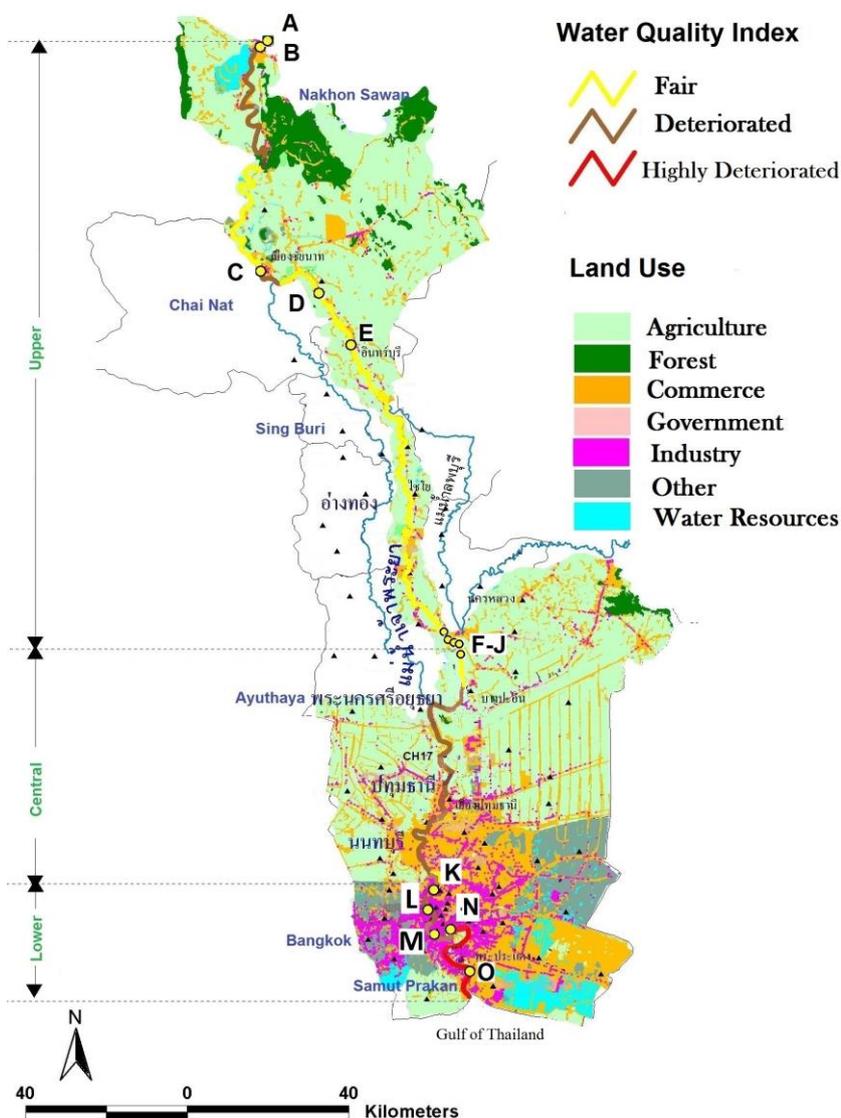

Fig. 1 Sampling points**.**

Table 1 Sampling name and location

River part	Sampling code	Location (Land use)	Sampling code	Location(Land use)	Sampling code	Location(Land use)
Upper	**A**	Pak Nam Pho (R)	**B**	Dechatiwong Bridge (R)	**C**	Muang, Chainat(R)
	D	Sappaya (A)	**E**	Inburi (A)	**F**	Wat Thagarong(R)
	G	Chedi Sri Suriyothai (R)	**H**	Ayutthaya Hospital(R)	**I**	Wat Bangkhunprom(R)
Middle	**J**	Portuguese Settlement (R)				
Lower	**K**	Rama 7 Bridge (U)	**L**	Rama I Bridge (U)	**M**	Rama 9 Bridge (U)
	N	Chongnonsi WWTP (U)	**O**	Prapradaeng (I)		

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3. Results and discussion
3.1 Effect of climate change on E.coli
This year, dry season in Thailand appears on November (2013) through May (2014). Long period of dry weather make heavy rain and storm in the upper Chao Phraya river (R, A) in April. It drives more surface runoff causing high contamination into the river. In 2012, Pollution Control Department (PCD) reported that water quality in the upper river was fair and in the lower river was deteriorated. TCB and FCB in upper and lower of Chao Phraya river also exceeded the water quality standard. High *E. coli* implies the high amount of pathogen which also high risk to human health. From this study, the range of pH, water temperature (°C) and DO (mg/L) along the Chao Phraya river were 7.0-7.6, 30.1-31.9 and 4.2-7.3, respectively.

Measured BOD along the river is higher than maximum allowance concentration in the surface water quality standard, except for D and E sampling points (Agriculture area). The maximum allowance of BOD concentrations in the upper, middle and lower river are 1.5, 2 and 4 mg/L, respectively. It can be seen from Fig. 2 that high BOD and *E. coli* are found in urban area (K-N) and decrease in industrial area (Prapradaeng, O). The high amount of coliforms because there are a lot of buildings and households released wastewater directly into the river. Hong et al. (2010) reported levels of coliforms had close relationships with pH, temperature, suspended solid, organic and inorganic nutrients in water. However, *E.coli* decreased in O sampling point, whereas BOD was still high. It can be explained that low flow of river during dry period led the salt intrusion into the river. This can be checked by measurement of EC. It was found that EC of 13.36 mS/cm was found in this sampling point. Solic & Krstulovic (1992) stated that coliform bacteria can be diminished in case of high temperature and salinity.
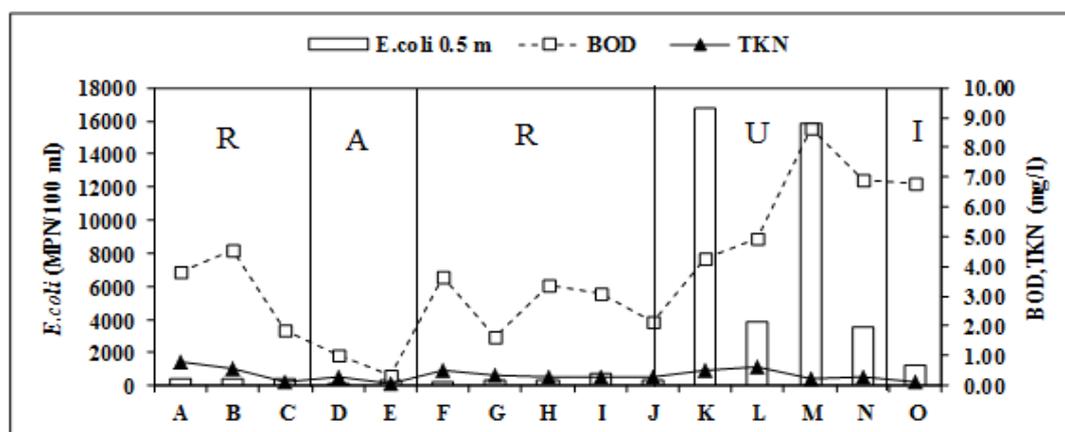

Fig. 2 The amounts of BOD, TKN and *E.coli* at 0.5 m depth.

3.2 Effect of land use and water depth on microbial quality
Fig. 3 shows that the highest *E. coli* of 1.95×10^4 MPN/100 mL was found in urban area and followed by industrial, residential and agricultural area, respectively. The high fecal contamination implies the risk of pathogenic organisms in the river. The number of *E. coli* at 2 m depth was higher than 0.5 m depth (see Fig. 3). In the residential area at Nakhon Sawan province, the sewers of drainage storm water are in underground and end at the river. Coliform bacteria can settle down to the river bottom and accumulate; hence the activities of the motor boats could disturb the water and then brought back the coliform bacteria from the bottom to the upper surface. Previous researches (Crabill et.al., 1999; Joo An et.al., 2002) also reported the *E. coli* association with particles in the bottom sediments have resuspended from boating activities. The numbers of *E.coli* at 0.5 m were higher than at 2 m depth in agricultural and some points in residential areas in Ayutthaya province

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because less feces contaminants discharge on surface water from household and buildings. In addition, the ratio of TCB/*E. coli* in U type has low value of 23.4 and 12.9 for 0.5 and 2 m depth, respectively (Fig. 3). This indicates feces contamination from municipal wastewater discharges, septic tank leachate and nonpoint sources of human and warm blood animal wastes.
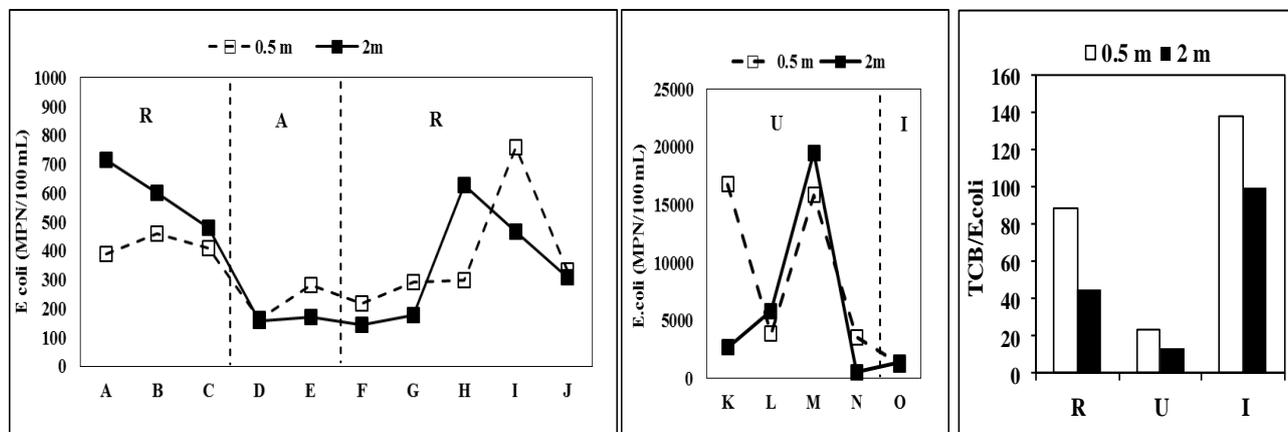

Fig. 3 *E. coli* and TCB/*E. coli* in 0.5 m and 2 m depth.

4. Conclusion

Climate change affects water quality in an indirect way due to drought, low water level in the river leading to the increase in bacterial accumulation in the bottom of river. However, water quality also depends on land uses. The highest of *E. coli* was found in urban area, the lower part of the river, which indicated high health risk for direct water uses.

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