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Water Quality Situation of the Tha Chin River and the Riverbank Community's Understanding

Chitsanuphong Pratum*†, Noppol Arunrat*, Sukanya Sereenonchai*, Jung-Chen Huang and Tian Xu****
*Faculty of Environment and Resource Studies, Mahidol University, Nakhon Pathom, 73170, Thailand
**School of Environmental Science and Engineering, Shanghai Jiao Tong University, Shanghai, 200240, PR China
†Corresponding author: Chitsanuphong Pratum

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ABSTRACT

The Tha Chin River is a branch river of the Chaophraya River, which is one of the four main rivers in the central area of Thailand. Currently, the Tha Chin River is experiencing serious problems regarding water quality. Our study was carried out to analyse the river quality status, classify the health of the river according to Water Quality Index (WQI) and assess the riverbank community's understanding of the Tha Chin River water quality. The results indicated that the water quality in the estuary of the Tha Chin River has been seriously polluted. In addition, the results also found that the WQI of the wet period was significantly lower than that of the dry period at p-value < 0.05. While the results from the riverbank community's understanding assessment revealed that they feel the water quality in this river is still good, especially in the upstream and the midstream. Therefore, the assessed water quality according to WQI method showed that the riverbank community had a misunderstanding of the water quality of the Tha Chin River.

INTRODUCTION

The Tha Chin River is one of Thailand's most important rivers, which starts in Chainat province and flows into the Gulf of Thailand at Samut Sakhon province. In addition, it plays a vital role in the lives of over two million people living in this basin. The river is used for agriculture and fisheries, especially in the upstream and the midstream. Besides the agriculture, the industrial and domestic users are two other major consumers of water from the Tha Chin River. Currently the Tha Chin River is experiencing serious problems regarding water quality. One of these problems is the high amount of pollution in the river; e.g. wastewater dump from several sources, oil spillage, and water hyacinths, etc. (Arends et al. 2016). In addition, the result of Nampim (2015) showed that most of the people who live around the Tha chin River have low relationship with it. They always make water pollution by discharging their garbage directly into the river. The results of the rivers' water quality monitoring indicated that the Tha Chin Rivers have been facing water pollutant problems with low quality according to the Surface Water Quality Standard, especially in the lower part of the river (Regional Environmental Office 5, 2018b). The major source of pollutant discharge in the upper part of the Tha Chin River is communities and agriculture, while industries and agriculture play as a major contributor in the lower part of the river (Simachaya et al. 2000).

Various management approaches have been applied to tackle the water pollution problems in the Tha Chin River such as: establishing receiving water quality standards and classification based on existing beneficial uses and loading reduction policies, setting up effluent standards for major pollution sources such as buildings, factories, and etc., monitoring receiving water quality and effluent from the point-source pollution, regulating the expansion of the industry especially those with the production of toxic substances and the discharge of high organic matters, constructing central treatment plants in major municipalities, and setting up the Wastewater Management Authority in the region. Implementation of public awareness is part of water quality management, which provides community awareness and understanding of water quality.

Therefore, the objectives of this study were to analyse the river quality status, classify the health of the river according to Water Quality Index (WQI) and assess the riverbank community's understanding of the water quality of the Tha Chin River.

MATERIALS AND METHODS

Study area: The Tha Chin River is a branch river of the Chaophraya River, which is one of the four main rivers in the central area. The river flows from north to south through four provinces and finally ends in the Gulf of Thailand (Fig. 1). The total length of the Thachin River is approximately

320 km. The river has 5.30-11.50 m of water depths and 46-500 m of width, which is an important area for agriculture, agro-industry and local community residents.

The water quality has declined significantly over the past two decades, mainly due to waste from municipal wastewater, agricultural activities, and industrial operations (Regional Environmental Office 5 2011). The main source of diffuse pollution comes from agricultural activities and animal husbandry by agriculture, which occupies roughly 52% and 21% of the basin's area, respectively (Thaipichit Burapa et al. 2010). In this study, sampling sites had been examined in 4 stations cut across the upstream areas, the midstream areas, as well as the estuary area (Table 1). All these stations were served as the control stations to represent the actual condition of the Tha Chin River. The samplings were conducted during two seasons; dry period (April 2018) and wet period (August 2018), representing the characteristics of the river.

Parameter analysis: The parameter analysis for this research was divided into 4 parts, all of which were used to assess the riverbank community's understanding and the attitudes of the changes in the Tha Chin River water quality.

Bacteriological parameters: The analysis was conducted as follows: total coliform bacteria (TCB) and faecal coliform bacteria (FCB) were quantified by multiple-tube fermentation technique. All of the bacteriological parameters were performed according to the standard methods (APHA 2012).

Physico-chemical parameters: The analysis was conducted as follows: Dissolved oxygen (DO) was measured using the electrometric measurement method. The 5-day biochemical oxygen demand (BOD_5) test, a method widely used as the standard method for determining the concentration of biodegradable organics in wastewater (Chang et al. 2004), was then carried out. BOD_5 was measured using the azide modification method. The parameter for a measure of the health of the water in natural bodies (Aziz et al. 2004), ammonia-nitrogen (NH_3-N) was measured using the nesslerization method. All of the physico-chemical parameters were performed according to the standard methods (APHA 2012).

Water quality index analysis (WQI): WQI is a rating that reflects the influence of different quality variables (Sener et al. 2017). WQI was developed by Thailand's Pollution Control Department (PCD) that has been practiced in various countries. Standard methods for the examination of surface water source are used as a tool for guidelines in maintaining

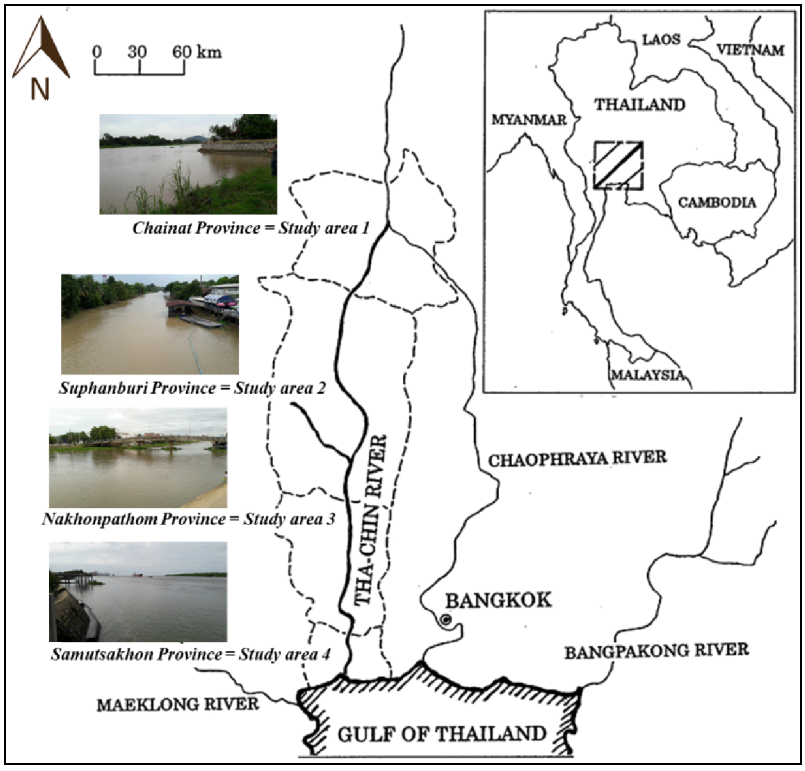

Fig. 1: The location of the Thachin River.
Source: Adapted from Mahujchariyawong & Ikeda (2001)

Table 1: Sampling sites and their location.

Sampling sites	Location	GPS coordinates
TC1	The upstream of the Tha Chin River, Wat Sing District, Chainat province	X 0613466 Y 1687742
TC2	The midstream – (early stage) of the Tha Chin River, Sam Chuk District, SuphanBuri province	X 0617814 Y 1631712
TC3	The midstream – (final stage) of the Tha Chin River, Nakhon Chai Si District, Nakhon Pathom province	X 0617811 Y 1631711
TC4	The estuary of the Tha Chin River, MueangSamutSakhon District, SamutSakhon province	X 0628321 Y 1526179

Table 2: WQI Interpretation.

Rating of water quality[a]	WQI value[a]	Descriptive language[b]
Seriously Polluted	0-30	Unacceptable. Can be used for transportation only.
Poor	31-60	Freshwater resources that are not clean. Consumption requires specific or advanced treatment process before use.
Fair	61-70	Freshwater resources that are medium clean. Consumption requires conventional water treatment process before use.
Good	71-90	Freshwater resources that are very clean. Consumption requires ordinary water treatment process which minor.
Excellent	91-100	Freshwater resources that are extra clean. Consumption requires only ordinary process for pathogenic destruction.

[a]Pollution Control Department (2016); [b]National Environment Board (1992).

Thailand's river water quality (Prakirake et al. 2009). Five water quality parameters include DO, BOD_5, NH_3-N, TCB, and FCB were used to determine WQI. In addition, WQI obtained by Calculator Online (Pollution Control Department 2016). The computed WQI values are classified into five categories as Table 2.

Assessment of the riverbank community's understanding: The information on the riverbank community's understanding and attitudes of the changes in the Tha Chin River water quality derived from the riverbank community leader interviews. The riverbank community is the people who live around the Tha Chin River more than 30 years with their residences located within 500 meters from the river and observed the changes in the river from the past to the present. This study was an in-depth interview with 2 leaders in each sampling sites.

Statistical analysis: Descriptive analysis was used to describe the measures of the water quality situation and the riverbank community's understanding of the changes in the Tha Chin River water quality. In addition, Paired-sample t-test was used to assess the relationship of WQI with the Tha Chin River.

RESULTS AND DISCUSSION

Water Quality Situation

Bacteriological and physico-chemical parameters analysis: The level of DO was likely to decrease from the upstream area (TC1) to the estuary (TC4). The contents of the DO recorded at the waters are between 2.5 - 5.9 mg/L in the dry period and 6.4-1.6 mg/L in the wet period, respectively. Low dissolved oxygen values were measured at the estuary (TC4) where pollutants were effective. However, in the wet period, DO is lower than that in the dry period. The continuous decrease of DO is the result of an important polluting load resulting from the accumulation of urban and industrial wastes (Igbinosa & Okoh 2009). The optimum value for good water quality is between 4-6 mg/L of DO, which ensures healthy aquatic life in a water body (Alam et al. 2007, Awannavar & Shrihari 2008).

On the other hand, other parameters (namely; BOD_5, TCB, FCB and NH_3-N) were likely to increase from the upstream area (TC1) to the estuary (TC4). The contents of the BOD recorded at the waters are between 1.9-4.2 mg/L in the dry period and 3.0-6.0 mg/L in the wet period, respectively. When comparing the dry period analysis results with those of the wet period, higher BOD_5 concentrations were measured in the wet period. Biochemical oxygen demand (BOD) is a measure of the amount of DO that bacteria will consume while decomposing organic matter under aerobic conditions. Natural organic detritus and organic waste from man-made (such as wastewater treatment plants, failing septic systems, agricultural and urban runoff, and so on) act as a food source for water-borne bacteria. Bacteria decompose these organic

materials using DO, thus reducing the DO present for fish (Northeast Georgia Regional Development Center 2001). The contents of the NH_3-N recorded at the waters are between 0.2-2.7 mg/L in the dry period and 0.1-0.4 mg/L in the wet period, respectively. When comparing the dry period analysis results with those of the wet period, higher NH_3-N concentrations were measured in the dry period, except in the upstream of the Tha Chin River. NH_3-N analysis showed that the dry period had more NH_3-N concentration than that of the wet period. NH_3-N is an important factor affecting the freshwater quality (Sener et al. 2013). In addition, NH_3-N is also very toxic to fish, even at very low concentrations (Debels et al. 2005).

In term of bacteriological parameter, the estuary (TC4) was the worst water quality compared with the other parts, which showed the number of bacteria that is a thousand times higher than those found in the other water sample stations. The contents of the TCB recorded at the waters are between 7.9×10^3 and 3.5×10^5 MPN/100 mL in the dry period and 1.7×10^3 and 5.0×10^5 mg/L in the wet period, respectively. When comparing the dry period analysis results with those of the wet period, higher TCB concentrations were measured in the dry period, except at the estuary of the Tha Chin River. In the FCB parameter, the FCB found in the dry period ranged between 4.6×10^2 and 1.3×10^5 MPN/100 mL and 4.0×10^2 and 5.0×10^5 mg/L in the wet period, respectively. The higher FCB concentrations were measured in the dry period of the midstream. During wet period, the upstream and the estuary have the higher FCB concentrations. The coliform bacteria group can be used as indicators of cleanliness and contamination of human and animal waste in water resources, which is usually found in the gastrointestinal tract of humans and animals (Ashbolt et al. 2001, Eleria &Vogel 2005). The coliform bacteria groups consist of two groups; total coliform bacteria (TCB) and fecal coliform bacteria (FCB). FCB is found only in faeces of warm-blooded animals. Therefore, FCB was used for good indicator of the risk of contamination of pathogens in the gastrointestinal tract in water resources (Ashbolt et al. 2001).

Some analysis parameters of water in each of the direction towards the source of the Tha Chin River are provided in Table 3.

Water quality index analysis: The computed WQI values are between 31 and 57 in the dry period; and between 24 and 48 in the wet period as given in Table 4. The highest water quality during the dry period in the midstream (early stage) was 66 as shown in the data, while the highest water quality during the wet period in the upstream was 48 as shown in the data. During both of the dry and wet periods, the estuary of the Tha Chin River has the lowest quality. The mean WQI_s of the upstream, the midstream (the mean between early stage with final stage), and the estuary revealed a poor and seriously polluted quality of 52.5±6.4, 50.0±4.9 and 27.5±4.9 of the data, respectively.

The water quality in the Tha Chin River was reflected for the land activities within the catchment area. The WQI analysis shows that the Tha Chin River status is moderately polluted both in dry and wet periods. This was supported by the moderate development of the land use in the upstream and the midstream while the land use in the estuary was highly developed. The anthropogenic activities such as agriculture, industry, and fishery were expected to influence the stability of the water quality in the river (Hasan et al. 2015). In addition, the results found that WQI values of the wet period were significantly lower than those of the dry period at p-value <0.05. The surface runoff may not be good for water quality during the wet period, during which it will wash away the pollutants and soil into the river (Webb & Nobilis 2007). The study of Singh et al. (2013) found that seasonal variation will affect the water quality of the river. Most pollution from activity of people who live around river, especially agricultural activities, is more visible in rainy season (Mahujchariyawong & Ikeda 2001, Medeiros et al. 2017). Thus, the pollutant-load into the river by flush out during the wet period was increased. The sources of water pollution can be classified into: (1) point source; and (2) non-point source (Sinaulan et al. 2013).

The riverbank community's understanding of changes in the water quality: The assessment of the riverbank community's understanding were carried out in two parts: (1) the water quality situation and (2) the cause of water pollution. According to the opinion of people in the riverbank community at upstream, the river water quality is still good. It is also used for agricultural activities and public consumption. In the early stage of the midstream, both quality and quantity of the river are acceptable without any negative effects on the riverbank community. At the same time, the river becomes dirtier than it used to be, judging from noticeably more garbage and water hyacinth in the final stage of the midstream. In the case of the estuary, the riverbank community felt that the water quality is not as good as before. There might be some wastewater from the industries along the river and from the cargo ship, which can cause water pollution.

A comparison of river community understanding and WQI analysis found that the river community had a misconception about the water quality of the Tha Chin River (Fig. 2). From WQI analysis, the water qualities of the upstream and the midstream were poor. Consumption requires specific or advanced treatment process before use. Meanwhile,

Table 3: Bacteriological and physicochemical parameters of water by refer to the direction towards the source of the Tha Chin River.

Parameter	Upstream			Midstream (early stage)			Midstream (final stage)			Estuary		
	Dry period[a]	Wet period[b]	AVE.[b]	Dry period[a]	Wet period[b]	AVE.[b]	Dry period[a]	Wet period[b]	AVE.[b]	Dry period[a]	Wet period[b]	AVE.[b]
DO (mg/L)	5.9	6.4	6.2	5.2	5.4	5.3	4.0	3.2	3.6	2.5	1.6	2.1
BOD_5 (mg/L)	2.2	3.0	2.6	1.9	5.0	3.5	1.9	4.0	3.0	4.2	6.0	5.1
TCB (MPN/100mL)	9.2×10^3	2.0×10^3	5.6×10^3	7.9×10^3	3.0×10^3	5.5×10^3	7.9×10^3	1.7×10^3	4.8×10^3	3.5×10^5	5.0×10^5	4.3×10^5
FCB (MPN/100mL)	4.6×10^2	1.7×10^3	1.1×10^3	2.7×10^3	1.1×10^3	1.9×10^3	3.3×10^3	4.0×10^2	1.9×10^3	1.3×10^5	5.0×10^5	3.2×10^5
NH_3-N (mg/L)	0.2	0.4	0.3	0.4	0.3	0.4	0.7	0.3	0.5	2.7	0.1	1.4

[a]DRAFT 2018 the water quality report of the Tha Chin River and branch canal (Regional Environmental Office 5 2018a).
[b]The average number of dry period and wet period.

Table 4: WQI values and water source quality assessment.

Positions	Dry period		Wet period		AVE.[a]	
	WQI	Status	WQI	Status	WQI	Status
Upstream	57	Poor	48	Poor	52.5±6.4	Poor
Midstream (early stage)	66	Fair	41	Poor	53.5±17.7	Poor
Midstream (final stage)	53	Poor	40	Poor	46.5±9.2	Poor
Estuary	31	Poor	24	Seriously polluted	27.5±4.9	Seriously polluted
AVE.[b]	51.8±14.9	Poor	38.3±10.1	Poor	45.0±12.1	Poor

[a]The average by the period; [b]The average by the river position.

the water quality of the estuary was found to be unacceptable and only suitable for transportation.

The riverbank communities felt the water quality in this river is still good, especially in the upstream and the midstream. Since, they have a good memory of the past about the Tha Chin River, the perception that the water is good enough has been instilled in them. However, in contrast with the people's opinion, the WQI analysis showed that the Tha Chin River has poorer water quality (Fig. 2). The behaviour of a human is influenced by a variety of environment variables, and many individual factors, experiences, and events. In addition, several individual variables such as skills, personality, perceptions, and experiences also affect behaviour and understanding (Gibson et al. 2011), while the understanding is thought process that organizes and gives meaning to the information captured by the senses (Robert 2011). The change of water quality was supported by the growth of population and pollution load. In addition, the hydrodynamic process is also the key to influencing the presence and concentration of waste in the river environment (Sinaulan et al. 2013).

CONCLUSIONS

The water quality assessment of Tha Chin River (in terms of WQI analysis) showed that the riverbank community had a misunderstanding about the water quality. The riverbank communities feel that the water quality is still good, especially in the upstream and the midstream. Most of the riverbank communities use the sense of water quality assessment; in other words, they try to rely on themselves for water quality assessment. The Regional Environmental Office 5 is the main agency that provides knowledge about the water quality of the Tha Chin River (Regional Environmental Office 5 2018b). However, this knowledge may not be well passed onto the people in all the areas of the riverbank community. Therefore, it should be studied how to provide them with more effective knowledge.

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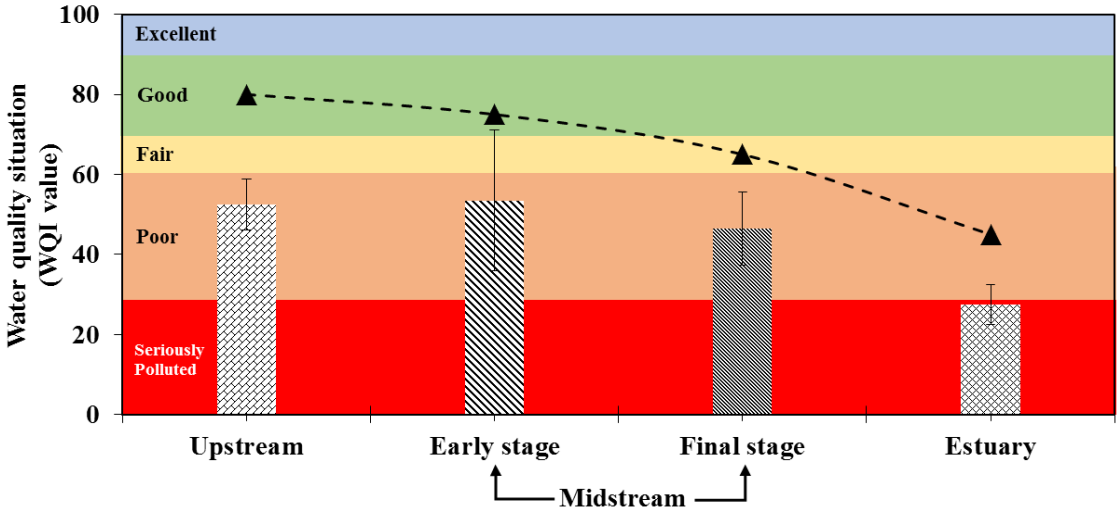

Fig. 2: Riverbank community's understandings compared with the WQI values (Dash line-the attitude of the river community; Pattern fill column-WQI value).

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