Assessment of Lower Songkhram River Basin Using WQI and Range of Four Water Quality Parameters

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Abstract

The use of the water quality index (WQI) and range of four parameters including dissolved oxygen (DO), p□, fecal coliform, biochemical oxygen demand (BOD) as simple indicators of the watersheds pollution was investigated and compared in the Lower Songkram River Basin (LSRB). The water quality of Songkram and On Rivers on the Lower Songkram River Basin were investigated during 2005 to 2006 and 2009 covering the wet season (June–November) and the dry season (December–May). It was found that the WQI was very useful for the classification of the waters monitored. The WQI was 71-90, which corresponds to ''good'' quality water at the sampling point of SO-01 to SO-05 on Songkram River and ranks from around 72-94 at sampling point of ON-01 to ON-04 On River, which corresponded to a classification of "good to excellent" quality. Although the quality indicated good level in terms of WQI, denoted that water quality assessed by individual of four parameters covered nine sampling points stations were bad to good level. □owever, a high linear relationship between the value of WQI and WQI covering four parameters was found. Therefore, a fast determination of WQI may be carried out knowing the values of four parameters, which are not costly measurements. The results show that the river is acceptable for the fishery and apply for the sustainability of water quality management of local government authorities (LGAs).

Keywords: On River, Pollution, Songkram River, Thailand, Water quality index (WQI).

1. Introduction

The Lower Songkhram River Basin (LSRB) is covered Songkhram and On Rivers, which is the crucial watershed in the Northeastern Thailand and is the important sources for agriculture, aquaculture, animal farming, raw water for municipal water supply, wastewater dilution, recreation, and others. Reducing water quality deterioration over the past years and increasing public participation in prevention and conservation of water quality is the extremely important goal of water quality management of many local government authorities (LGAs) in Thailand. Anyway, LGAs have faced cost of monitoring water quality of rivers, since there have been many indicators to be the representing water quality. One of a famous indicator is Water Quality Index (WQI) that is a 100 point scale that summarizes results from a total of eight different measurements when complete: pH, dissolved oxygen, suspended solid, biochemical oxygen demand, total phosphate, nitrate, and total suspended solid. This WQI has been recognized to classify surface water based on the use of standard parameters (Jonnalagadda and Mhere 2001). There have been many researchers attempting to discover a criterion for surface quality classification

based on the use of standard parameter for watershed quality. These studies have been studied, which are the quality index for environmental contamination contributed by mineral processing (Nasirian 2007); application of WQI of Bangpakong River, Thailand (Bordalo, Nilsumranchit, and Chalermwat 2001); and use of the WQI and dissolved deficit as simple indicators of watershed pollution (Sanchez et al. 2007).

Few WQI covered by a range of four parameters none are widespread used. This study looked at the appropriation of using a group of four parameter to describe water quality of LSRB by comparing with WQI covering eight parameters as well as find out the correlation of its water quality. Dissolved oxygen is parameter recognized to evaluate the surface water quality. This parameter is powerfully influenced by a combination of physical, chemical, and biological characteristics of surface water which is related to oxygen demanding substances, including algal biomass, dissolved organic matter, ammonia, volatile suspended solids, and sediment oxygen demand (Mulholland et al. 2005). pH is expressed the intensity of the acid or alkalinity condition of surface water and is the way expressing hydrogen-ion concentration. In the biological processes, pH must be controlled within a range favorable to particular organisms involved (Sawyer, McCarty, and Parkin 1994). Fecal coliforms are a group of bacteria, including E. coli and several closely related organisms that are commonly found in the intestinal tract of warm-blooded animals. Their presence in water suggests contamination with sewage or feces, which in turn could mean that disease-causing bacteria or viruses are present. Fecal coliforms and E. coli are bacteria whose presence indicates that the water may be contaminated with human or animal wastes. Microbes in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. They may pose a special health risk for infants, young children, some of the elderly, and people with severely compromised immune systems. (USEPA 2006). Biochemical oxygen demand (BOD) is usually defined as the amount of oxygen required by bacteria while stabilizing decomposable organic matter under aerobic conditions. The test BOD is widely used to determine the pollutional strength of domestic and industrial waste in terms of the oxygen that they will require if discharged into surface water in which aerobic conditions exist (Sawyer, McCarty, and Parkin 1994).

The objectives of this paper are to present the existing situation of Lower Songkhram River Basin (LSRB) quality and to apply WQI in relation to WQI covering four parameters, in order to find out the simple method to evaluating watershed quality.

2. Research Method

2.1 Study Areas

Songkharm River Basin (SRB) is encompassed four provinces in Northeastern Thailand, namely Udon Thani, Nong Khai, Sakon Nakhon, and Nakhon Phanom. The basin covers an area approximately 13,128 km^2, just about 54.83% of SRB surrounded by Sakon Nakhon, in the region of 21.49% surrounded by Nong Khai, approximately 14.57% of SRB inside Nakhon Phanom, and approximately 9.11% within Udon Thani. The Songkhram headwater are situated in chain of the Phu Phan Mountain and flow in north direction, then turns towards east and after 420 km joins Mekong River at Bann Chaiburi, Nakhon Phanom province. Several major tributaries join the Songkhram River from the north (e.g. Mao and Hi rivers) and from the south (On and Yam

rivers) forming one extensive lowland floodplain system. Songkhram wetland is a permanent freshwater flood plain lake, with a creek system with levees, scrub, savannah and herbaceous swamp as shown in Figure 1.

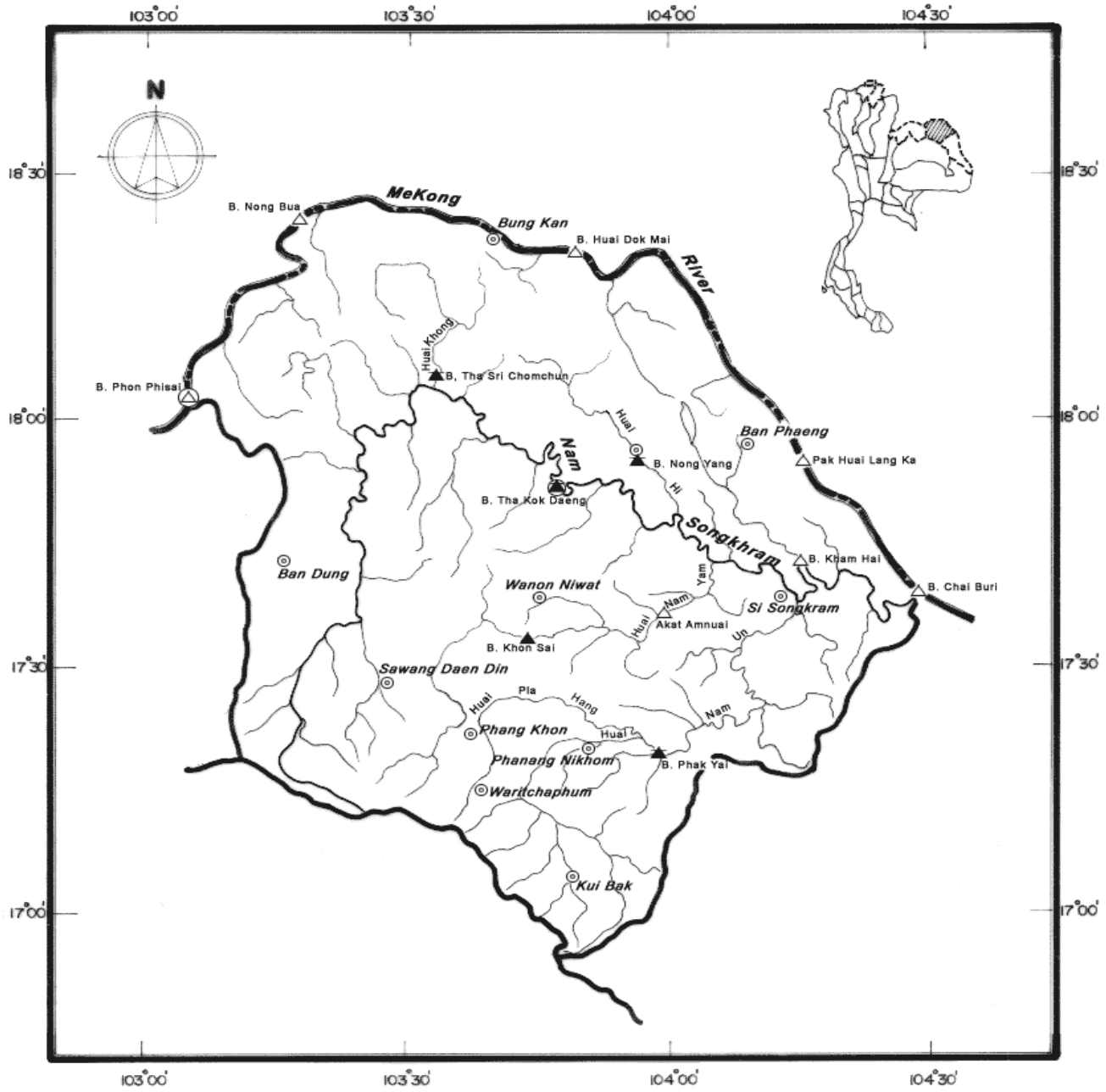

Figure 1: Location of Songkhram River Basin

SRB is the basin in Thailand where fresh water from precipitation, streams, and overland flow. The water from Mekong River which causes supplementary water of Songkhram River in wet season to be vary spatially and temporally as well as wetlands season in the basin. The lower Songkram is a flood plain with freshwater swamp forests, marshlands and small streams. The swamp forests provide livelihoods for people living in this area. There are various types of land use in SRB, particularly agricultural areas as well as husbandry activities which can cause various kinds of environmental impacts. Major economic activities at present include paddy rice

farming, fishery, and field crops e.g. corn, cassava, sugarcane, and soybean. Moreover, at present the eucalyptuses and rubber plantation to be varying spatially which cause reduced wetland area in SRB.

A map of the area is shown in Figure 2. A range of water quality parameters were measured from nine sampling stations including five sampling stations on Songkram River (SO01 to SO05) and four sampling station on On River (ON01 to ON04).

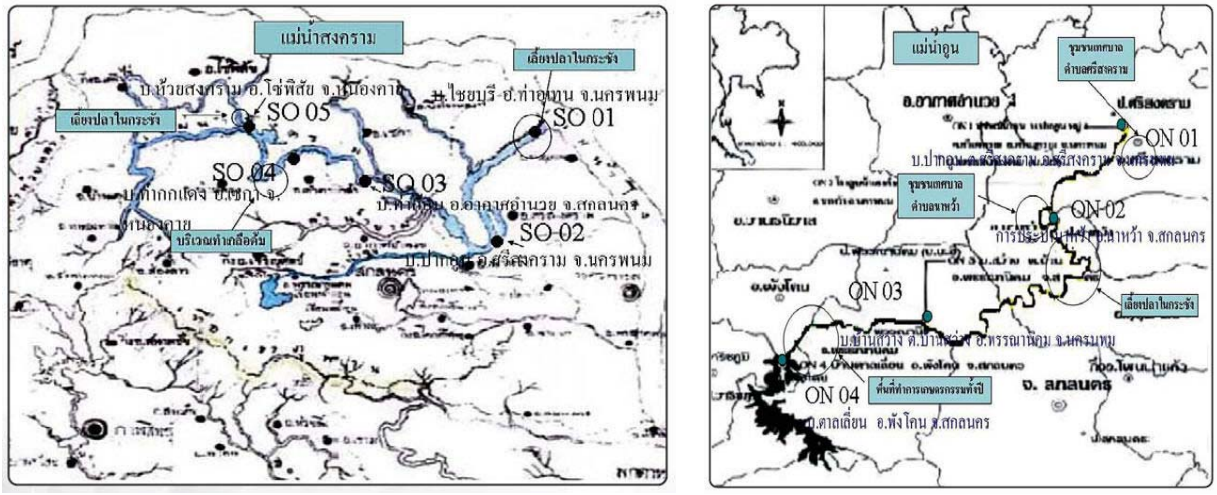

Figure 2: Sapling Stations of Songkhram River Basin

2.2 Sampling Methods

Sampling of Lower Songkhram River Basin was conducted during 1 year. Anyway, recorded quality water information of 2005-2006 has been obtained from Pollution Control Department, while raw data of water quality of 2007 and 2009 obtained from Regional Environmental Office 9 and field investigation respectively. There are total 9 water sampling stations locate in SRB; the Songkhram River contains 5 water sampling points and 4 sampling points of On River, as shown in Table 1.

2.3 Field Determinations and Laboratory Analyses

Filed determination of pH, conductivity, temperature, dissolved oxygen, turbidity, and total dissolved solid were conducted using portable equipments followed by the Standard Methods for the Examination of Water and Wastewater (APHA 1999). Laboratory analyses were performed for the measurement of total coliform bacteria, feacal coliform bacteria, biochemical oxygen demand (BOD), nitrate (NO_3^-), total phosphate (TP), suspended solid (SS), total suspended solid (TS), heavy metal, and Organochlorine. These parameters were also measured by using the methodology recommended by the Standard Methods (APHA 9999). In addition, a range of heavy metals and pesticide were measured including cadmium (Cd), manages (Mn), lead (Pb), zinc (Zn), copper (Cu), and Organochlorine.

Table 1: Surface Water Quality Sampling Points of Lower Songkram River Basin

Sampling Points	Location	Co-ordinates		Parameters		
		Latitude	Latitude	Basic parameter	Heavy metal	Pesticides
01SO	Bann Chaiburi bridge, Nakhon Phanom	N 443489	N 443489	/	/	/
02SO	Bann PakUn, Nakhon Phanom	N 420114	N 420114	/	/	
03SO	Bann Tarkon bridge, Sakon Nakhon	N 389380	N 389380	/		
04SO	Bann Tarkokdang bridge, Nong Khai	N 370590	N 370590	/	/	
05SO	Bann Huai Songkhram, Nong Khai	N 338658	N 338658	/		/
01ON	Mouth ofUn River , Nakhon Phanom	N 419948	N 419948	/	/	
02ON	Water Supply Nawa Project, Sakon Nakhon	N 406040	N 406040	/	/	/
03ON	Bann Sawang, Sakon Nakhon	N1026652	N1026652	/		
04ON	Bann Tanrean, Sakon Nakhon	N 368629	N 368629	/		

Note: Basic Parameter = temperature, pH, salinity, conductivity, turbidity, DO, BOD, TCB, FCB, TS, SS, TDS, NO_3-N, and TP

Heavy metal = Cd, total Cr, Mn, Ni, Pb, Zn, Cu, Hg

Source: Regional Environment Office 9, 2007.

2.4 Data Analysis

Bivariate was applied to analyze the correlation between WQI covering a range of four water quality parameter namely pH, DO, FCB, and BOD and value of WQI covering eight parameter. Pearson correlation and P-value were tested for the correlation of a range of four water quality and WQI and the observed significance level respectively (Mendenhall and Sincich 2003). A WQI was applied to measure watershed quality. The group of eight parameters was measured by using WQI that are followed by the determination of Pollution Control Department (PCD 2004). Raw data for each individual parameter, namely dissolved oxygen, pH, biochemical oxygen demand, fecal coliform bacteria, nitrate, total phosphate, suspended solid, and total solid were provided for presenting a cumulative derived, numerical expression defining a certain level of water quantity. The water quality in different years will be compared with the Standard Value for Surface water proposed by Pollution Control Department (PCD) as presented in Table 2.

Table 2: General Water Quality Index (WQI)

WQI	Value of water quality	Compare with water quality standard
0-30	Very bad	5
31-60	Bad	4
61-70	Medium	3
71-90	Good	2
91-100	Excellent	1

Remark:

Class 1: Extra clean fresh surface water resources used for conservation not necessary pass through water treatment process require only ordinary process for pathogenic destruction and ecosystem conservation where basic organisms can breed naturally.

Class 2: Very clean fresh surface water resources used for consumption which requires ordinary water treatment process before use and used for aquatic organism of conservation, fisheries, and recreation.

Class 3: Medium clean fresh surface water resources used for consumption, but passing through an ordinary treatment process before using and used for agriculture.

Class 4: Fairly clean fresh surface water resources used for consumption, but require special water treatment process before using, and used for industry.

Class 5: The sources which are not classification in class 1-4 and used for navigation.

3. Results and Discussions

3.1 Water Quality of Songkram River

The basic Songkram River quality in 2009 of wet season (WS) revealed that water temperature ranged between 27.8 and 31.4 C^{o}, pH ranged from 5.26 to 6.81, turbidity ranged from 15.00 to 63.17 NTU, conductivity ranged from 104 to 173 µS/cm, total solid ranged from 110 to 196 mg/l, suspended solid ranged from 4 to 18 mg/l, and total dissolved solid ranged from 68 to 91 mg/l. In addition, the measurement of heavy metals and Organochlorine were carried out in August 2009 of Songkram Rivers as shown in Table 3. The results revealed that cadmium is presented higher than quality of surface water, determined by 0.05 mg/l, which may not appear severe. The results for heavy metals acquired from Pollution Control Department during 2005-2006 covering DS (March) and WS (August) are also presented in Table 3.

Table 3: Heavy Metal Concentrations in Songkram River by 2005-2006 and 2009

Sampling Point	Season	Year	Cd (ug/l)	Cr (ug/l)	Mn (mg/l)	Ni (ug/l)	Pb (ug/l)	Zn (mg/l)	Cu (ug/l)
SO01	Dry	2005	<0.50	<2.0	0.19	<5.0	<5.0	<0.02	<2.0
SO02		2005	<0.50	<2.0	0.08	<5.0	<5.0	<0.02	<2.0
SO04	(March)	2005	<0.50	<0.20	0.20	<5.00	<5.00	<0.02	<2.00
SO01	Wet	2005	<0.50	<2.0	0.05	<5.0	<5.0	0.06	<2.0
SO02		2005	<0.50	<2.0	0.04	<5.0	<5.0	<0.02	<2.0
SO04	(August)	2005	<0.50	<2.0	0.05	<5.0	<5.0	<0.02	<2.0
SO01	Dry	2006	<.50	2.4	0.03	<.50	<5.0	<.02	<.50
SO02		2006	<.50	<2	0.08	<.50	<5.0	<.02	<.50
SO04	(March)	2006	<0.50	2.1	0.21	<5.00	<5.00	<0.02	<2.00
SO01	Wet	2006	<0.50	<2.0	0.04	<5.0	<5.0	<0.02	<2.0
SO02		2006	<0.50	<2.0	0.04	<5.0	<5.0	<0.02	<2.0
SO04	(August)	2006	<0.5	2	0.06	<5.0	<5.0	<0.02	<2.0
SO01		2009	ND	-	ND	-	ND	0.618	0.009
SO02	Wet	2009	0.015	-	ND	-	0.010	0.151	0.003
SO03	(August)	2009	0.016	-	ND	-	ND	0.039	ND
SO04		2009	0.078	-	0.040	-	ND	0.532	0.081
SO05		2009	0.079	-	ND	-	ND	0.285	0.079

Remark: Unit of heavy metal in 2009 is presented in mg/l unit.

Source: Pollution Control Department, 2006 and field measurement, 2009

Table 4 shows water quality of Songkram River covered by the five sampling points. The water quality data of 2005 and 2006 acquired from Pollution Control Department, while data of 2008 and 2009 obtained from regional environmental office 9 and field investigation respectively. The results revealed that the classification of Songkram River quality considering individual parameter ranged between class 2 and class 4, which correspond to “good” and “bad” water quality respectively. These classes are conserved for fisheries, recreation, and consumption with special treatment process before using agriculture and industry. The Notification of Pollution Control Department, published in the Royal Government Gazette, Vol. 116, Part 53, dated July 6, B.E.2542 (1999) recommended that Songkram River would be conserved surface water quality for achieving class 3 that corresponds to “medium” quality surface water.

Dissolved oxygen (DO) ranged from 2.70 to 9.15 mg/l, total coliform bacteria ranged from 2.00 to 23,000 MPN/100 ml, feacal coliform bacteria ranged from not detected to 4,500 MPN/100 ml, and biochemical oxygen demand ranged from 0.52 to 5.70 mg/l.

Table 4: Seasoning Water Quality of Songkram River during 2005-2006, and 2008-2009

Sampling Point-Season	DO (mg/l)	TCB*	FCB*	pH	BOD (mg/l)	NO3-N (mg/l)	TP (mg/l)	SS (mg/l)
I. 2005 year								
SO01-D	2.70	3,000	1,700	7.10	1.70	0.20	0.06	5
SO02-D	5.00	5,000	400	7.30	1.60	0.45	0.06	21
SO03-D	7.20	2	2	7.80	0.80	0.04	0.02	23
SO04-D	7.80	200	2	7.80	0.80	0.12	0.03	20
SO05-D	3.60	700	2	7.30	1.60	0.06	0.07	14
SO01-W	4.28	1,300	110	6.34	1.30	0.02	0.04	16
SO02-W	4.99	210	80	6.32	1.30	0.01	0.04	9
SO03-W	5.27	230	130	6.43	0.60	0.05	0.04	10
SO04-W	5.82	500	80	6.55	0.60	0.05	0.04	10
SO05-W	5.32	2,800	2,400	6.89	0.60	0.06	0.05	12
I. 2006 year								
SO01-D	5.32	790	230	6.90	1.50	0.27	0.03	5
SO02-D	7.82	330	1.80	6.88	1.20	0.33	0.05	18
SO03-D	7.15	450	1.80	6.90	1.20	0.09	0.04	9
SO04-D	9.15	780	450	7.00	1.20	0.19	0.03	15
SO05-D	4.50	1.8	1.80	7.05	0.60	0.05	0.05	11
SO01-W	4.70	2,200	270	6.92	0.80	0.02	0.03	5
SO02-W	4.30	790	130	7.06	0.80	0.02	0.02	7
SO03-W	5.20	490	20	7.20	0.70	0.04	0.02	7
SO04-W	5.20	330	170	7.40	3.50	0.03	0.02	11
SO05-W	5.77	1,400	70	7.50	1.10	0.04	0.06	16
IV. 2007 year								
SO01-D	3.85	140	140	-	0.52	-	-	-
SO02-D	4.83	130	130	-	0.82	-	-	-
SO03-D	5.40	80	80	-	0.62	-	-	-
SO04-D	7.81	220	140	-	0.83	-	-	-
SO05-D	2.70	2,200	2,200	-	1.34	-	-	-
SO01-W	4.00	7,800	4,500	-	0.95	-	-	-
SO02-W	5.00	23,000	2,000	-	0.63	-	-	-
SO03-W	6.00	2,000	2,000	-	0.69	-	-	-
SO04-W	5.00	7,800	2,000	-	0.74	-	-	-
SO05-W	5.00	11,000	4,500	-	0.68	-	-	-
IV. 2009 year								
SO01-W	4.11	4,900	500	6.23	1.10	0.413	ND	10
SO02-W	4.26	5,000	ND	6.81	1.60	0.524	ND	18
SO03-W	4.74	3,400	ND	5.66	5.70	0.458	ND	4
SO04-W	3.98	500	ND	5.27	1.30	0.352	ND	8
SO05-W	3.90	1,100	ND	5.26	0.95	0.418	ND	4

Remark: D= Dry season; W= Wet season; (-): Non measurement

TCB= Total Coliform Bacteria; FCB= Feacal Coliform Bacteria (MPN/100 ml)

3.2 Water Quality of On River

Surface water of On River in wet season by 2009 revealed that temperature ranged between 28.4 and 33.9, pH ranged from 6.08 to 6.42, turbidity ranged from 47.62 to 103.36 NTU, conductivity ranged from 39.60 to 161 µS/cm, total solid ranged from 90 to 228 mg/l, suspended solid ranged from 20 to 54 mg/l, and total dissolved solid ranged from 21 to 85 mg/l. In addition, the measurement of heavy metals was carried out in August 2009 of On River as shown in Table 5. The results revealed that heavy metal presented in On River not appear severe, without getting higher than surface water quality.

Table 5: Heavy Metal Concentrations in On River in 2005-2006

Sampling Point	Season	Year	Cd (ug/l)	Cr (ug/l)	Mn (mg/l)	Ni (ug/l)	Pb (ug/l)	Zn (mg/l)	Cu (ug/l)
ON01	Dry	2005	<0.50	<2.0	0.09	<5.0	<5.0	<0.02	<2
ON02		2005	<0.50	<2.0	0.09	<5.0	<5.0	<0.02	<2
ON01	Wet	2005	<0.5	<2.0	0.04	<5.0	9.5	<0.02	<2.0
ON02		2005	<0.5	2.9	0.07	<5.0	<5.0	<0.02	2.1
ON01	Dry	2006	<0.50	2.9	0.1	<5.00	<5.00	<0.02	2.7
ON02		2006	<0.50	3.4	0.09	<5.00	<5.00	<0.02	2.3
ON01	Wet	2006	<0.50	<2.0	0.06	<5.0	<5.0	<0.02	<2.0
ON02		2006	<0.50	<2.0	0.08	<5.0	<5.0	<0.02	<2.0
ON01		2009	0.014	-	ND	-	ND	0.076	ND
ON02	Wet	2009	0.016	-	ND	-	ND	0.079	ND
ON03	(August)	2009	0.015	-	ND	-	ND	0.033	ND
ON04		2009	0.016	-	ND	-	ND	0.035	ND

Note: Unit of heavy metals in 2009 is presented in mg/l unit

Source: Pollution Control Department, 2006 and field measurement, 2009

Table 6 show the surface water classification of On River also ranged between class 2 and class 4, which corresponds to “good” and “bad” water quality respectively. These classes are conserved for fisheries, recreation, and consumption with special treatment process before using agriculture and industry. Dissolved oxygen (DO) ranged from 2.60 to 8.90 mg/l, total coliform bacteria ranged from 110 to 110,000 MPN/100 ml, feacal coliform bacteria ranged from not detected to 50,000 MPN/100 ml, and biochemical oxygen demand ranged from 0.17 to 5.60 mg/l. The results of consideration of four parameters found that water quality of On Rivers was varied into class 2 to class 4, which is not achieved by Water Quality Standards (Same as Standards of Water Classification). The Notification of Pollution Control Department, published in the Royal Government Gazette, Vol. 116, Part 53, dated July 6, B.E.2542 (1999) recommended that On River would be conserved surface water quality for achieving class 3 that corresponds to “medium” quality surface water.

The application of using water quality of LSRB for fish pond culture found that suitable DO value should be higher than 5 mg/l (Tuntoolavest and Pornprapa 2001). Information obtained from group discussion that held on 12 September 2009, key informant indicated that they have faced with low value of DO that is less than 3.5 mg/l. This situation influenced having less chance to achieved high quality and quantity of fish in pond culture.

Table 6: Seasoning Water Quality of On River by 2005-2006, and 2008-2009

Sampling Point-Season	DO (mg/l)	TCB*	FCB*	pH	BOD (mg/l)	NO3-N (mg/l)	TP (mg/l)	SS (mg/l)
I. 2005 year								
ON01-D	5.50	400	2	7.30	1.50	0.44	0.06	37
ON02-D	2.60	700	2	7.50	1.80	0.37	0.07	12
ON03-D	6.40	230	2	8.10	1.30	0.06	0.05	46
ON04-D	7.10	1,300	80	7.50	0.90	0.03	0.04	8
ON01-W	5.30	1,300	500	6.40	1.50	0.01	0.04	19
ON02-W	5.30	400	210	6.70	1.50	0.04	0.05	22
ON03-W	4.50	3,000	500	6.40	0.60	0.04	0.05	10
ON04-W	6.60	50,000	50,000	6.70	0.60	0.04	0.07	7
I. 2006 year								
ON01-D	5.56	110	66	7.10	5.60	0.36	0.04	44
ON02-D	3.43	340	140	7.20	1.40	0.30	0.04	8
ON03-D	5.85	2,700	1.80	7.02	0.60	0.07	0.04	38
ON04-D	8.90	660	450	6.75	0.60	0.01	0.04	36
ON01-W	3.80	790	130	7.20	0.90	0.05	0.03	8
ON02-W	5.70	3,500	1,700	7.40	1.20	0.10	0.04	18
ON03-W	4.10	1400	610	7.10	1.22	0.04	0.04	18
ON04-W	5.20	4600	450	7.20	1.11	0.04	0.08	42
III. 2007 year								
ON01-D	4.37	300	300	-	0.44	-	-	-
ON02-D	4.33	220	220	-	0.40	-	-	-
ON03-D	5.02	1,400	1,400	-	0.69	-	-	-
ON04-D	8.32	1,200	900	-	0.17	-	-	-
ON01-W	4.00	110,000	14,000	-	0.94	-	-	-
ON02-W	4.00	34,000	6,800	-	1.24	-	-	-
ON03-W	4.00	6,800	2,000	-	1.24	-	-	-
ON04-W	4.00	11,000	1,800	-	0.90	-	-	-
III. 2009 year								
ON01-W	4.64	3,300	ND	6.35	1.90	0.389	0.02	20
ON02-W	5.19	3,300	200	6.42	4.70	0.386	0.03	46
ON03-W	4.83	3,300	200	6.14	1.30	0.318	0.03	54
ON04-W	5.11	13,000	ND	6.08	1.70	0.355	0.03	22

Remark: D= Dry season; W= Wet season

TCB= Total Coliform Bacteria; FCB= Feacal Coliform Bacteria (MPN/100 ml)

3.3 The Use of the WQI and Range of Four Parameters

In order to evaluate the feasibility of using WQI and range of four water quality parameter of Songkhram and On Rivers, the value of these parameters were evaluated in the different sampling stations as shown in Table 7. It was found that the value of WQI covering four parameter was 67 to 96, which corresponds to ‘‘medium to excellent’’ water quality at the nine sampling point LSRB, while the value of WQI covering eight parameters was 71 to 94, which corresponded to a classification of “good and excellent” water quality. The correlation between value of WQI covering eight parameter and WQI covering four parameters showed a highly significant (ρ <0.001) with a positive relationship. Considering bivariate analysis, it was revealed that a range of four parameters played a crucial role in determining variations in WQI in during period of 2005 to 2006 and 2009 (r=0.494, ρ <0.001).

Table 7: Comparison of the Results Obtained for WQI by Using Four Parameter and WQI

Sampling point-Season	WQI of four parameters	Water classification Of four parameters	WQI	Water classification Of WQI
I. 2005 year				
SO01-D	67.33	medium	71.15	good
SO02-D	81.87	good	80.48	good
SO03-D	95.61	excellent	77.24	good
SO04-D	96.16	excellent	77.44	good
SO05-D	81.08	good	79.42	good
SO01-W	78.04	good	83.32	good
SO02-W	81.36	good	86.45	good
SO03-W	84.37	good	87.54	good
SO04-W	87.84	good	89.56	good
SO05-W	78.03	good	82.17	good
ON01-D	88.93	good	81.38	good
ON02-D	77.41	good	77.60	good
ON03-D	91.38	excellent	84.47	good
ON04-D	94.45	excellent	93.59	excellent
ON01-W	77.90	good	83.65	good
ON02-W	82.78	good	85.27	good
ON03-W	76.91	good	83.24	good
ON04-W	72.56	good	72.15	good

Table 7: Comparison of the Results Obtained for WQI by Using Four Parameter and WQI (continue)

Sampling point-Season	WQI of four parameters	Water classification Of four parameters	WQI	Water classification Of WQI
II. 2006 year				
SO01-D	83.87	good	84.78	good
SO02-D	93.77	excellent	88.32	good
SO03-D	93.28	excellent	77.29	good
SO04-D	86.68	good	73.94	good
SO05-D	86.69	good	86.80	good
SO01-W	82.78	good	87.63	good
SO02-W	83.62	good	87.51	good
SO03-W	89.38	good	90.51	good
SO04-W	81.03	good	85.45	good
SO05-W	90.18	good	86.78	good
ON01-D	79.56	good	76.45	good
ON02-D	78.93	good	83.05	good
ON03-D	91.94	excellent	86.52	good
ON04-D	87.24	good	86.25	good
ON01-W	81.69	good	85.57	good
ON02-W	80.22	good	83.18	good
ON03-W	77.11	good	81.24	good
ON04-W	83.25	good	81.39	good
III. 2009 year				
SO01-W	73.05	good	80.05	good
SO02-W	81.54	good	83.68	good
SO03-W	68.38	medium	76.41	good
SO04-W	72.49	good	79.38	good
SO05-W	73.04	good	80.94	good
ON01-W	79.65	good	81.92	good
ON02-W	73.77	good	75.01	good
ON03-W	78.11	good	76.96	good
ON04-W	80.54	good	83.90	good

Remark: D= Dry season; W= Wet season

4. Conclusions and Recommendations

In this research, a new and effective group of parameters represented WQI for classifying river quality has been developed and illustrated with the case study of the Lower Songkharm River Basin covering Songkhram and On Rivers in Thailand. The results revealed that the classification of Songkram and On Rivers quality considering individual parameter ranged between class 2 and class 4, which correspond to “good” and “bad” water quality respectively. These classes are conserved for fisheries, recreation, and consumption with special treatment process before using agriculture and industry. Considering value of WQI, the value of WQI covering four parameter was 67 to 96, which corresponds to ‘‘medium to excellent’’ water quality at the nine sampling point LSRB, while the value of WQI covering eight parameters was 71 to 94, which corresponded to a classification of

"good and excellent" water quality. The correlation between value of WQI covering eight parameter and WQI covering four parameters showed a highly significant (ρ <0.001) with a positive relationship. Considering bivariate analysis, it was revealed that a range of four parameters played a crucial role in determining variations in WQI. The results suggested that using WQI determined by a range of four parameters should take into account consideration in using and conserving LSRB. In addition, influencing factors and WQI is a crucial method to find out management measures for the sustainability of LSRB.

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