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BOD loading in domestic wastewater treatment system of Phetchaburi Municipality, Phetchaburi Province, Thailand

Sivanh Khonesavanh[a], Onanong Phewnil[a,b], Kittichai Duangmal[a] and Watcharapong Wararam[a,b]

[a]*Department of Environmental Science, Faculty of Environment, Kasetsart University, Bangkok, Thailand*
[b]*The King's Royally Initiated Laem Phak Bia Environmental Research and Development Project, Chaipattana Foundation, Thailand*
Correspondence to Onanong Phewnil
Department of Environmental Science, Faculty of Environment, Kasetsart University, Bangkok, 10900 Thailand
Tel +6681-824-8649 E-mail: onanong.p@ku.th

Abstract

This research aimed to study the change of BOD loading and wastewater quality during the year 2015 to 2020 in Phetchaburi Municipal–wastewater treatment system, Phetchaburi province. The scope of this study consisted of 4 parts: 1) sewage drainage systems in Phetchaburi Municipality area 2) Klongyang wastewater collection pond 3) 18.5 km-HDPE wastewater pipeline and 4) oxidation pond system at the Royally Initiated Laem Phak Bia Environmental Research and Development Project. Wastewater from 5 stations which were household point sources (WW1), influent of Klongyang wastewater collection pond (WW2), effluent of Klongyang wastewater collection pond (WW3), influent of oxidation pond (WW4) and effluent of oxidation pond (WW5). Water samples were analyzed in laboratory for pH, Biological Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Fat Oil and Grease (FOG), Total Phosphorus (Total-P), Total Nitrogen (Total-N), Total Coliform Bacteria (TCB) and Fecal Coliform Bacteria (FCB). The results found that distance and time play vital role on the BOD loading which decreased from sewage drainage system in municipal area, Klongyang wastewater collection pond, 18-km. HDPE wastewater pipeline and oxidation pond. The BOD loading was highest at the municipal point sources, approximately 4,557 kg/day. When the wastewater flows through the station WW2, WW3, WW4 and WW5, the BOD loading decreased to 489, 357, 242 and 67 kg/day, respectively. Overall, 4,490 BOD kg/day were treated by the Phetchaburi Municipal wastewater treatment system, and it also reduced FOG, TP, TN, TCB and FCB from the household point sources to effluent of the wastewater treatment system.

Keywords: BOD loading, domestic wastewater, Phetchaburi Municipality

1. Introduction

Nowadays, wastewater of megacity in Thailand has been increasing trend, especially municipality has high density population. According to the information of the Pollution Control Department (PCD), Ministry of Natural Resources and Environment (2002) said that about 80 percent of domestic wastewater came from water consumption. Domestic wastewater is generated from the daily activities of the people who have been living in the community and other activities such as cooking and cleaning, housing estate, public health service, educational institutions, various business establishments, etc. These activities produce domestic wastewater with a complex composition. It is mainly contaminated with organic compounds which is generally known Biochemical Oxygen Demand (BOD) (Sawyer, 2003; Metcalf and Eddy, 2004; Henze, 2008). In addition, domestic wastewater is contaminated with nutrients such as nitrogen and phosphorus, produced by microbial biodegradation processes (Arceivala, 1973). When wastewater is discharged into river, it will be directly affected to water quality and aquatic ecosystem. Therefore, wastewater should be treated before discharge to natural water sources.

Phetchaburi Municipality is a big city in Thailand which has population around 30,000 people and latent population around 10,000 people which produce wastewater around 7,200 m^3/day (Manlika, 2015). It has been collecting wastewater from household at Klongyang wastewater collection station and pump into HDPE pipeline by closed system for distance 18.5 kilometers. The pipeline conveyed wastewater 6,167 m^3/day to The King's Royally Initiated Laem Phak Bia Research and Development Project (LERD) (Jinjaruk, 2014). It was located at Laem Phak Bia Sub-district, Ban Laem District, Phetchaburi Province, Thailand, (at UTM 1442240 to1443480 N and 0617780 to 0619271 E) that initiated by the King Rama 9. The project has been operating since the middle of 1994 (Chunkao et al., 2000).

The hydraulic retention time (HRT) of wastewater from point sources to wastewater collection station take time 1.2 hours, 29 hours inside collection station, and 7.5 hours from collection station to oxidation pond, totally 37.7 hours (Jinjaruk et al., 2018). The water quality may change along the distance. So, this research focused on BOD loading change from household point sources through HDPE pipeline and oxidation pond.

2. Materials and Methods

2.1 Scope of Study

The data was analyzed from year 2015 to 2020. The scope of this study consisted of 4 parts, including: (1) sewage drainage systems in Phetchaburi Municipality area (2) Klongyang wastewater collection pond (3) 18.5 km-HDPE wastewater pipeline and (4) oxidation pond system at LERD, as shown in Figure 1.

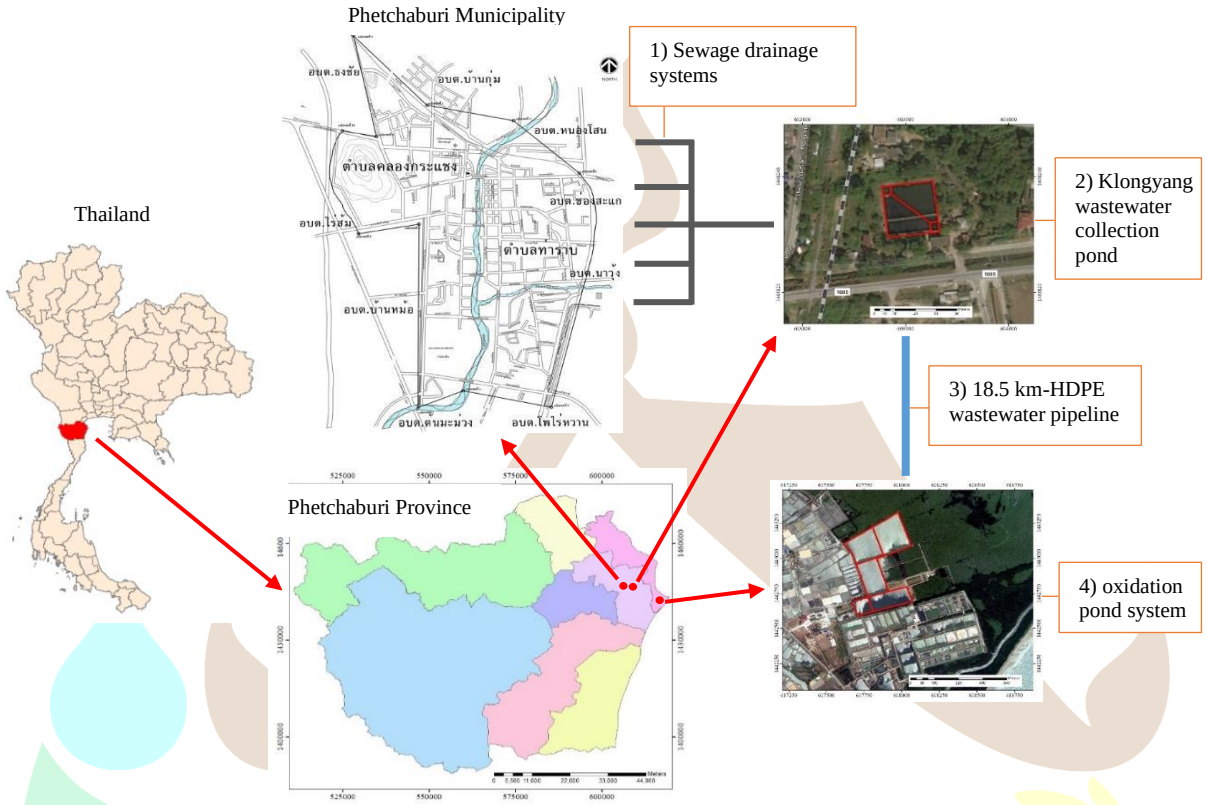

Figure 1. Scope of the study.

There were 5 wastewater sampling points which were household point sources (WW1), influent of Klongyang wastewater collection pond (WW2), effluent of Klongyang wastewater collection pond (WW3), influent of oxidation pond system (WW4) and effluent of oxidation pond system (WW5) (Figure 2).

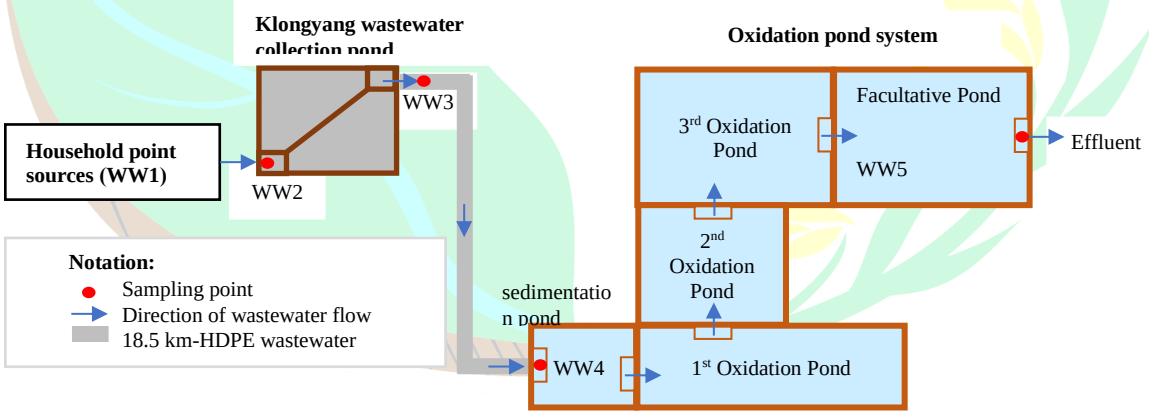

Figure 2. Wastewater sampling points from point sources to effluent of the study.

2.2 Data Collection

The secondary data related to various factors of research were collected, including:

1) The number of populations of Phetchaburi Municipality from year 2015 to 2020 obtained from The Bureau of Registration Administration (2013).

2) The rate of wastewater per person per day obtained from Pollution Control Department, Thailand (2010)

3) The amount of wastewater in the Klongyang wastewater collection pond during 2015-2020 obtained from LERD (2021).

4) The quality of wastewater in Phetchaburi Municipality obtained from LERD (2015) and LERD (2021).

2.3 Wastewater Quality Analysis

There were 6 parameters, consisted of pH, Biological Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Fat Oil and Grease (FOG), Total Phosphorus (Total-P) and Total Nitrogen (Total-N) which were defined by PCD (PCD, 2002), was needed to be consider. Not only these indicators, but also Total Coliform Bacteria (TCB) and Fecal Coliform Bacteria (FCB) were used for the changing of wastewater quality from point sources along the wastewater treatment system.

2.4 BOD Loading Evaluation

BOD loading of each sampling point as shown in the Figure 2 was calculated from volume of wastewater and BOD value (PCD and Environmental Engineering Society of Thailand, 2003), as shown in formular (1). The data was collected from Phetchaburi Municipality from year 2015 to 2020.

$$\text{BOD loading (kg/day)} = \frac{\text{Volume of wastewater } (m^3/\text{day}) \text{ x BOD (mg/L)}}{1{,}000} \quad \ldots (1)$$

3. Results and Discussion

3.1 Population of Phetchaburi Municipality

Phetchaburi Municipality is divided into 2 Sub-districts, namely Khlong Krachaeng Sub-district, area of 2 km^2 and Tha Rap Sub-district, area of 3.4 km^2 (Phetchaburi Municipality, 2020). According to the information of The Bureau of Registration Administration (2013), the population of Phetchaburi Municipality from year 2015-2020 had a tendency to decrease each year (Table 1). In 2015, there was a total of population about 22,935 people, and in the following years the population continued to decline until 2020, with a total of population 20,976 people. The population from year 2015 to 2020 has decreased by 1,959 people, or population rate of 8.5 percentages.

Table 1. The population of Phetchaburi Municipality from year 2015 to 2020

Sub-district/year	Population (person)					
	2015	2016	2017	2018	2019	2020
Tha Rap	12,697	12,536	12,244	12,096	11,791	11,588
Khlong Krachaeng	10,238	10,442	10,122	10,243	9,856	9,388
Total	22,935	22,978	22,366	22,339	21,647	20,976

3.2 Wastewater Generation Rate

According to the information of Pollution Control Department, Thailand (2012), the amount of wastewater discharged from buildings and households was approximately around 80 percentages of the total amount of water consumption, as shown in Table 2.

Table 2. The rate of wastewater per person per day

Region/year	Wastewater generation rate (liter/person/day)					
	2015	2016	2017	2018	2019	2020
Central	160-214	156-242	170-288	176-342	183-406	189-482
North	183	200	225	252	282	316
Northeast	200-253	216-263	239-277	264-291	291-306	318-322
South	171	195	204	226	249	275

From the Table 2 showed that Phetchaburi Municipality was in the central area of Thailand. The average rate of wastewater in the year 2012 and 2017 were 295 and 336 liters/person/day, respectively.

3.3 Wastewater Volume

The amount of wastewater generated from the source in Phetchaburi Municipality and the wastewater volume data in Khlongyang wastewater collecting pond in the year 2015 to 2020 were shown in Table 3.

Table 3. The volume of wastewater in Phetchaburi Municipality and Khlongyang wastewater collecting pond in the year 2015 to 2020

Area/year	Wastewater Volume (m^3/day)					
	2015	2016	2017	2018	2019	2020
Phetchaburi Municipality	6,766	6,779	7,515	7,506	7,273	7,048
Wastewater collection pond	5,085	5,362	4,745	4,826	4,866	5,261

The Table 3 showed that wastewater generated from Phetchaburi Municipality in the year 2015 to 2020 was approximately average of 6,766-7,515 m^3/day. While wastewater was collected from household point sources into wastewater collecting station around 4,745-5,362 m^3/day or 63-79 percentage of total wastewater volume. The collected wastewater conveyed to oxidation pond at LERD project.

3.4 Wastewater Quality

According to the information of LERD (2015), The source of wastewater in Phetchaburi municipality, such as commerce, fresh market, and residential area, had an average BOD of approximately 907 mg/L. It was used as a representative for wastewater characteristics from point

source at WW1. The information of LERD (2021) showed the data on the quality of wastewater in Khlongyang wastewater collection pond during the year 2015-2020 had identified characteristics of wastewater at WW2-WW5 as shown in Figure 3.

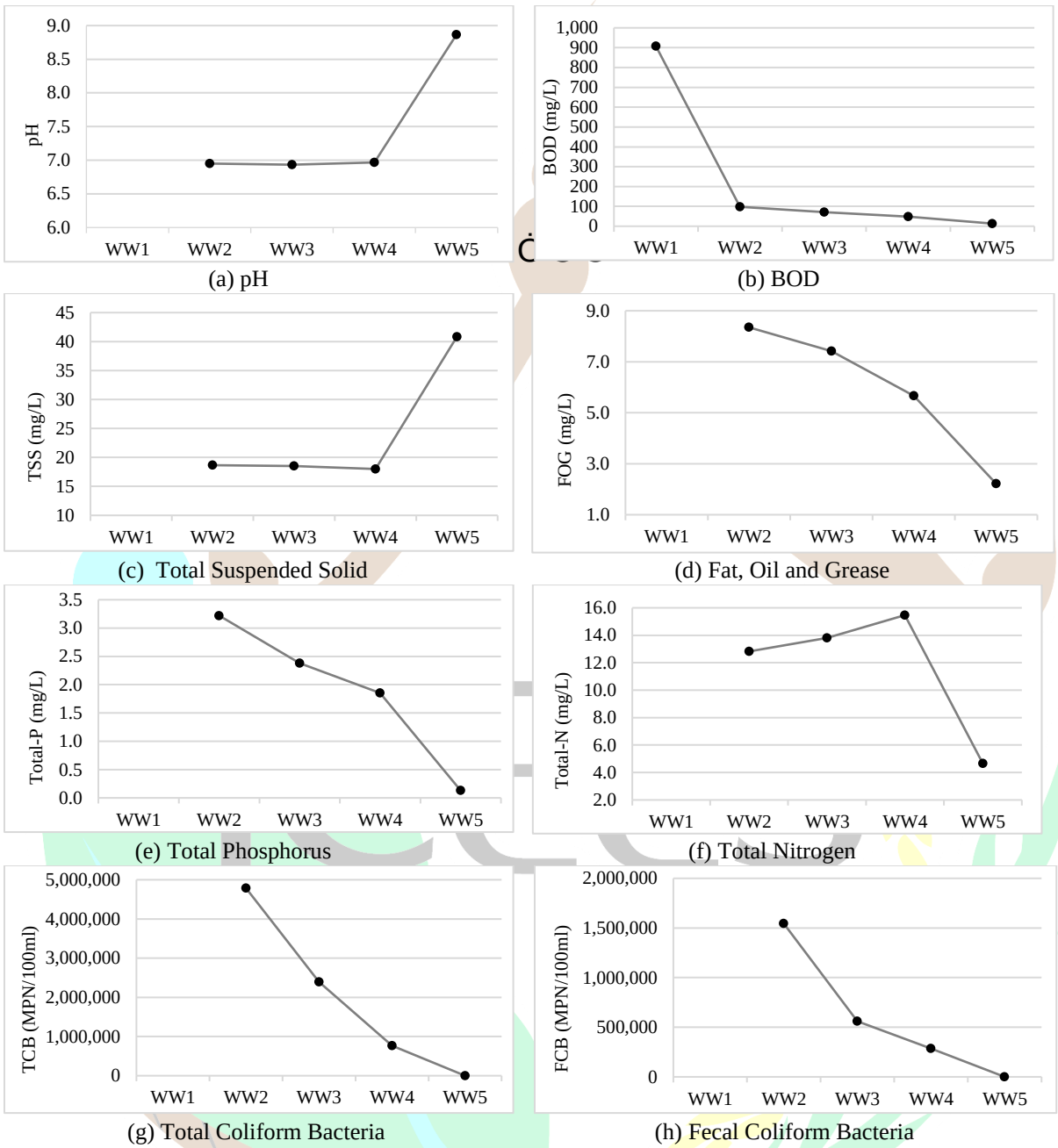

Figure 3. Wastewater quality in domestic wastewater treatment system of Phetchaburi Municipality during the year 2015 to 2020

The Figure 3 showed that 8 indicators of wastewater quality in the wastewater treatment system of Phetchaburi Municipality during the year 2015-2020 including pH, BOD, TSS, FOG, Total-P, Total-N, TCB and FCB. The results showed that wastewater quality was changed when

it flowed through each station (WW1 to WW5), and the wastewater quality indicators that WW1 did not study due to lack of the data, except BOD values of the year 2015 obtained from LERD (2015) as detailed below.

The Figure 3(a) illustrated value of pH of WW2 to WW4 had a little change between 6.9 to 7.0. When wastewater pass WW5 found pH value increased to 8.9. However, pH value at each station did not exceed the standard of effluent from community wastewater treatment system which limited between 5.5 to 9.

The Figure 3(b) showed value of BOD. It demonstrated that BOD had a tendency declining from WW1 which was 907 mg/L. When wastewater passed WW2 to WW5, BOD value slightly decreased from 97 to 13 mg/L. The results found that the efficiency of wastewater treatment system could remove BOD about 98.5 percent and BOD value of the effluent from oxidation pond did not exceed the standard of community wastewater treatment system effluent which limited of 20 mg/L.

The Figure 3(c) showed value of TSS which decreased from WW2 to WW4, 19 to 18 mg/L, but the value at WW5 increased to 41 mg/L. Due to high tiding of sea water affected to the stabilization pond effluent, the value of TSS at WW5 was a little higher than the standard of effluent from community wastewater treatment system which limited of 30 mg/L.

The Figure 3(d) showed value of FOG which was decreasing trendline from WW2 to WW5. The value of FOG at WW2 was 8.4 mg/L, and it slightly reduced to 2.2 mg/L at WW5. The FOG value at the last station did not exceed the standard of effluent from community wastewater treatment system which limited of 5 mg/L.

The Figure 3(e) showed value of Total-P decreased from 3.22 mg/L at WW2 to 0.13 at WW5. Total-P value of effluent at the last station was under the standard of effluent from community wastewater treatment system which limited of 2 mg/L.

The Figure 3(f) showed value of Total-N from WW2 to WW4. The trendline of graph was a little increased which had value between 12.8 to 15.5 mg/L, but WW5 decreased to 4.7 mg/L due to nitrification process occurred in oxidation pond by bacterial organic digestion process and phytoplankton could absorbed nitrogen for their growth. However, Total-N at each station did not exceed the standard value of effluent from community wastewater treatment system which limited of 20 mg/L.

The Figure 3(g) showed value of TCB at WW2 which was around 4,788,056 MPN/100 ml and it rapidly decreased to 142 MPN/100 ml at WW5 because sunlight destroyed bacterial cell by hydrogen peroxide which occurred in daytime and high radiation intensity. Furthermore, when the pipeline was closed, oxygen level in oxidation pond decreased. This might affect to bacterial cells. The TCB value at the last station (WW5) did not exceed the standard of surface water quality which limited of 20,000 MPN/100ml.

In addition, value of FCB shown in the Figure 3(h) was decreased as same as TCB. The value reduced from around 1,544,500 MPN/100 ml at WW2 to 15 MPN/100ml at WW5. This value did not exceed the standard value of surface water quality which limited of 4,000 MPN/100ml.

3.5 BOD Loading Change

From the data in Table 3 and Figure 3(b), wastewater volume and BOD values were calculated for the BOD loading value. The data of Phetchaburi Municipal wastewater treatment system during the year 2015-2020 could be calculated as shown in Figure 4.

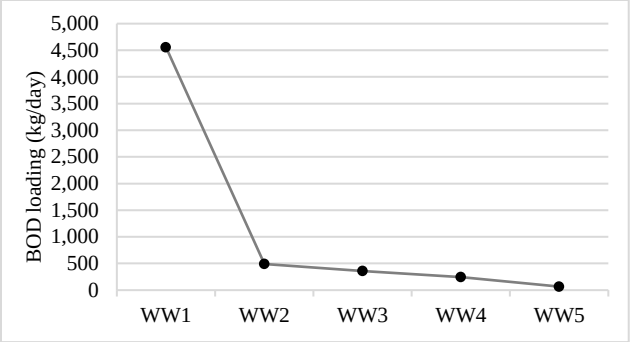

Figure 4. The changing of BOD loading in domestic wastewater treatment system of Phetchaburi Municipality during the year 2015-2020

The Figure 4 demonstrated the comparison of BOD loading from point sources to effluent of the wastewater treatment system decreasing trendline along HRT. BOD loading value was rapidly reduced from around 4,557 kg/day at WW1 to 489, 357, 242 kg/day at WW2, WW3 and WW4, respectively. It was gradually decreased until 67 kg/day at WW5. Efficiency of removal of BOD loading found that sewerage system at point sources had removed 4,068 kg/day, 132 at wastewater collecting station, 115 inside HDPE pipeline, and 235 kg/day at oxidation pond. Overall, Phetchaburi Municipal wastewater treatment system could remove BOD loading around 4,490 kg/day or 98.5 percentages.

BOD loading and the value of water quality indicators were decreased by anaerobic organic digestion in the sewerage pipeline, aerobic organic digestion in oxidation pond, photosynthesis of phytoplankton in oxidation pond and thermosiphon process in oxidation pond. In addition, hydrogen peroxide from water molecule broke up and dissolved oxygen molecules during sunlight radiation activated the reaction, TCB and FCB were reduced along HRT in the oxidation pond.

4. Conclusion

BOD loading data during the year 2015 to 2020 indicated that Phetchburi Municipality could be remove BOD loading values around 4,490 kg/day which were decreased from sewage drainage systems at point sources, wastewater collection pond, HDPE sewage pipeline and oxidation pond. The efficiency of BOD Removal was 98.5 percent because of anaerobic organic digestion in sewage pipeline and aerobic organic digestion in oxidation pond with other natural process such as photosynthesis, thermosiphon and plant uptake. Furthermore, other water indicators including pH, BOD, FOG, TSS, TP, TN, TCB and FCB had the values of effluent not exceed the standard limited.

The results of this research found that wastewater was approximately collected around 4,745 to 5,362 m^3/day, while the oxidation pond system was designed for containing volume of wastewater 10,000 m^3/day. Therefore, the wastewater treatment system had more efficiency to carry wastewater from the municipality around 5,255-4,638 m^3/day. This data might use for supporting efficiency of domestic wastewater management and operation plan of Phetchaburi Municipality.

5. Acknowledgements

The authors thank the staff of The King's Royally Initiated Laem Phak Bia Environmental Research and Development Project for their support. The project was conducted under and funded by the Chaipattana Foundation. The authors are grateful to the Eco-Science Community Research

Group (ESCRG), Department of Environment, Kasetsart University for providing personnel and laboratory support.

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