

The Analysis of pH Performance for Equalization Detention Time Design Case Study: WWTP2 PT. Jababeka Infrastruktur

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Abstract. PT. Jababeka Infrastruktur is an estate manager in Jababeka Industrial Estate. One of the PT. Jababeka Infrastruktur duty is to manage Wastewater Treatment Plant 2 (WWTP2). Most of the incoming wastewater in WWTP2 is coming from food industries, whereas potentially degradable to fatty acid and caused the pH to tend to be low and fluctuates. pH is one of the important parameters, especially in the biological wastewater treatment system as applied in WWTP2. pH value can affect the microorganism performance in decomposing the pollutant compound in wastewater. The pH control action is needed to make the treatment run better. **Objectives:** To know the primary settling tank (PST) with ~3 hours detention time performance in equalizing wastewater pH. Provide an analysis of the pH inlet performance by measuring the pH of wastewater, to develop the new equalization tank. **Method and results:** Statistical analysis of secondary data by comparing the standard deviation value of the wastewater before and after accommodated in PST also paired sample t-Test to see the performance of PST in equalizing of pH. Besides that, taken and measuring inlet wastewater pH in every one hour also adding to the previous wastewater inlet sample to determine the optimum wastewater detention time in terms of pH. **Conclusion:** PST was a significant unit process that can equalize the pH value. The observation of pH characteristic pattern by time showed that the optimum equalization time was 1-2 hours. This result can be a reference to more utilize of the existing PST.

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1 Introduction

Industrial wastewater is one of the serious problems in the industrialization era. Therefore, regulation about the green industry become an important issue [1]. One of the governments effort to minimize environmental pollution from industrial activities is by obligate new industries building to build in the industrial estate, this obligation has been set in Government Regulation Number 142 year 2015. To support the activities in the industrial estate, the estate manager obligates to provide basic infrastructure in the form of clear water treatment installation; drainage channel; lighting road installation; roads also wastewater treatment installation.

Generally, industrial estate is the source of pollution based on the amount of pollution that may be dispersed by rainfall which flows to the ground and groundwater. There are 2 pollution categories in this term, which are major short accident and minor continuous contamination [2]. In industrial estate, this accident should be better managed. Industrial estate environmental management is needed along with the high industry growth and the impact, in terms of ecology, social, economy, also the technology and good environmental management system support [3].

PT. Jababeka Infrastruktur is a subsidiary company of PT. Jababeka Tbk., which have a role as estate manager, one of the PT. Jababeka Infrastruktur duty is to manage Wastewater Treatment Plant 2 (WWTP2).

Since the beginnings of operation, WWTP2 has applied Oxidation Ditch biological treatment where these processes train consist of a.) Primary Settling Tank (PST) to separate suspended solid, foam, and scum, b.) Oxidation Ditch work to relieve organic and inorganic matter contained in wastewater, and also c.) Secondary Settling Tank (SST) to separate clear water and biological flocs. Since January 2019, WWTP2 apply Food Chain Reactor (FCR) biological treatment system, which is this technology that more efficient in energy and sludge generated less than the conventional sludge treatment [4].

The incoming wastewater into WWTP2 came from the residential, commercial area, and some of the industries in Jababeka Industrial Estate phase II and III. Most of the industries that discharge their wastewater into WWTP 2 are food industries, so the wastewater contains high organic compounds which potential to be decomposing and it makes the incoming wastewater pH in WWTP tend to be low and fluctuating. The unconstant of wastewater characteristic and the uncontrol time-periodic can complicate the process control, even the risk of failure can happen [5].

pH value is one of the important parameters and as an indicator of microorganism decomposition continuity in wastewater treatment [6]. Generally, optimum pH for microorganisms growth is 6.5 – 7.5, and most microorganisms can not survive in pH > 9.5 and < 4.0 [7].

Wastewater control effort should keep improving to maintain the wastewater treatment processes in WWTP2 can run well. pH control is one of the strategic efforts to manage the WWTP2 process.

The purpose of this research was to evaluate the primary settling tank (PST) performance as an equalization tank in terms of pH and to determine the optimum detention time of PST in terms of pH.

2 Method

Refer to the objectives research mentioned in the introduction section, the research framework was arranged as follows:

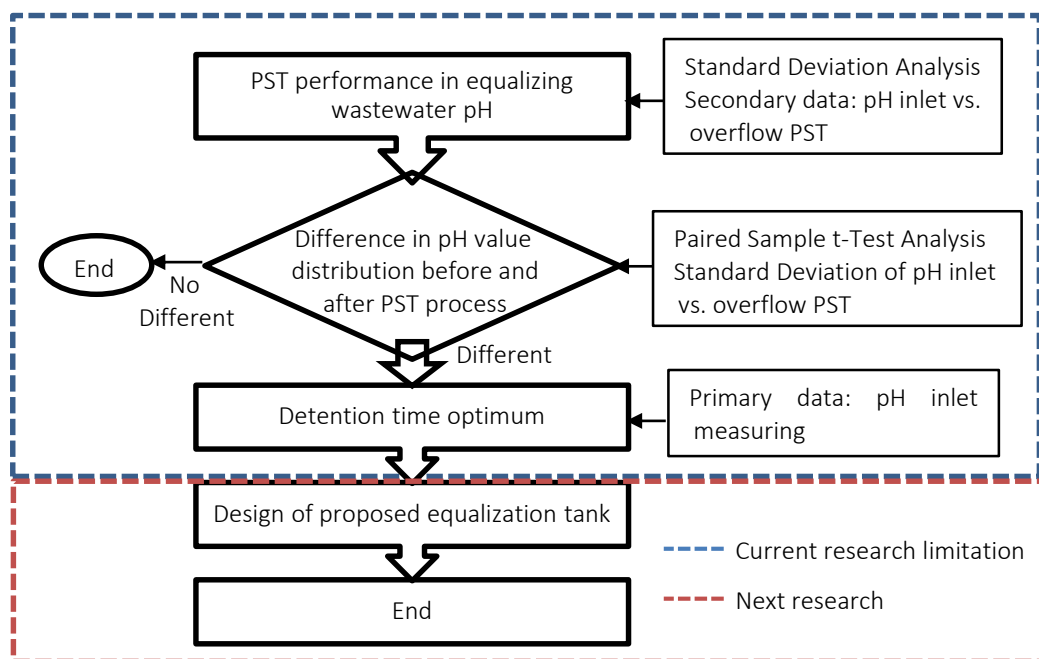


Fig. 1. Research Framework

Figure 1 showed that this research is initial research for developing the study to design of equalization tank.

This research conducted in 5 weeks, start from 29 July 2019 – 30 August 2019 in WWTP2 PT. Jababeka Infrastruktur, Jababeka Industrial Estate – Bekasi.

The data needed in this research were secondary data to analyze PST performance as an equalization tank in terms of pH in WWTP2 PT. Jababeka Infrastruktur. Secondary data used in this research were average daily inlet pH in WWTP2 and the overflow of PST pH on July 1, 2018 – January 21, 2019.

Secondary data was used to analyze the PST performance as an equalization tank in terms of pH, it was analyzed by statistic standard deviation and paired sample t-test analysis.

The standard deviation shows the distribution of data from the analysis results and gives a good indication of how close the data is to the other data. The standard deviation is usually denoted by SD or σ and can be calculated by the following formula [8] :

$$SD = \sqrt{\frac{\sum (xi - \bar{x})^2}{n-1}} \quad (1)$$

Where :

SD = Standard Deviation

$\bar{x}$ = average value

xi = the measured value of each test

n = number of analyzes (repetition)

Standard Deviation is the most widely used distribution measure. If the spread is very large towards the average value, then the value of SD (σ_X) will be large, but if the spread of data is very small to the average value then the SD (σ_X) will be small too [8].

To analyze the pH value distribution before and after the treatment in this research used paired sample t-Test. Different tests are used to evaluate certain treatments for the same sample at two different observation periods [9] and can be calculated by the following formula :

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2} - 2r \left| \frac{s_1}{\sqrt{n_1}} \right| \left| \frac{s_2}{\sqrt{n_2}} \right|}} \quad (2)$$

Where :

$\bar{X}_1$ = Sample 1 average

$\bar{X}_2$ = Sample 2 average

S_1 = Sample 1 standard deviation

S_2 = Sample 2 standard deviation

r = correlation between the two samples

Paired sample t-test is one of the testing methods used to assess the effectiveness of the treatment, marked by differences in the average before, and the

average after treatment is given [9]. The basis for the decision to accept or reject H_0 in this test is as follows [10] :

1. If $t_{\text{arithmetic}} > t_{\text{table}}$ and probability (Asymp.Sig) < 0.05 , then H_0 is rejected and H_a is accepted.
2. If $t_{\text{arithmetic}} < t_{\text{table}}$ and probability (Asymp.Sig) > 0.05 , then H_0 is accepted and H_a is rejected.

H_0 means there is no difference between before and after treatment in the sample, while H_a means there is a difference between before and after treatment in the sample [10].

Besides secondary data, primary data also needed to analyze the optimum detention time of wastewater pH in WWTP2 to analyze the optimum detention time of wastewater based on the pH parameter. The primary data used in this research is 20 ml of inlet wastewater in every hour and measured by using portable pH meter. The portable pH meter used should has calibrated. After measured the inlet wastewater, add the new inlet wastewater to the previous inlet wastewater and measured by the same pH meter. This sampling has been done on Monday – Friday, July 29th, 2019 – August 30th, 2019 in work hour (8 A.M until 5 P.M). 23 data gotten and grouped into groups based on the pH value pattern and first inlet pH. After grouping, counting the average pH value in each hour for every group to see the pattern pH value changes in each group.

3 Results and Discussion

3.1 Primary Settling Tank Performance in Equalizing the Wastewater pH

Standard deviation analysis used to see the high and low values of pH fluctuations that occur and the possibility of neutral pH after the composite. Here is the standard deviation of each month of the inlet wastewater and the overflow primary settling tank which taken from average daily secondary data:

Table 1. Standard Deviation Value of Inlet and Overflow Primary Settling Tank pH (Source: Data Calculation)

Time	Standard Deviation	
	Inf	Ops
Jul-18	0.769	0.723
Aug-18	0.598	0.355
Sep-18	0.677	0.306
Oct-18	0.463	0.322
Nov-18	0.289	0.25
Des-18	0.335	0.334
Jan-19	0.328	0.232

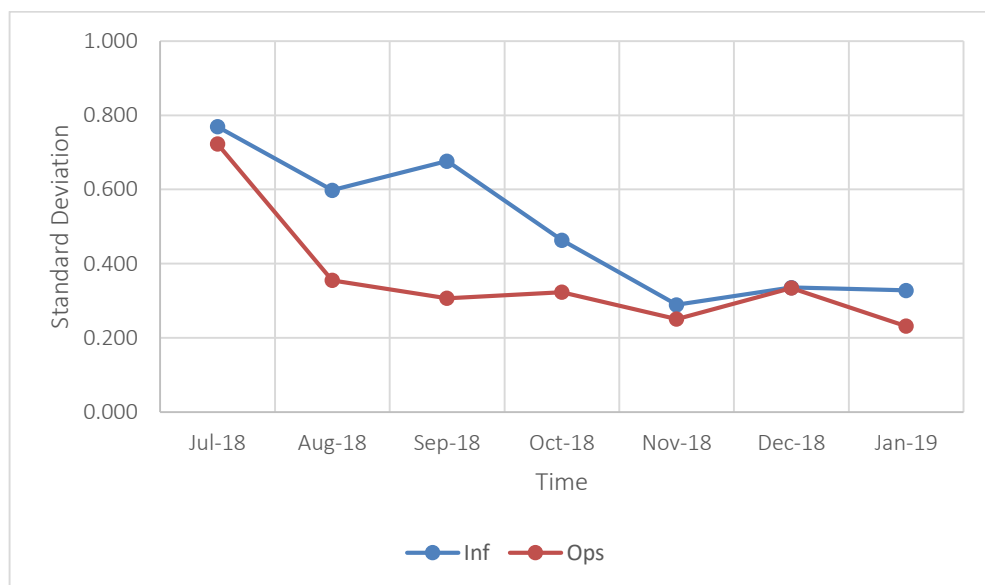


Fig. 2. Standard Deviation Value (Source: Data Calculation)

Based on table 1 and figure 2 above, the standard deviation of overflow primary settling tanks wastewater pH in July 2018 - January 2019 was lower than the standard deviation of influent wastewater pH. This means the pH of the wastewater that has been composite in the primary tank was more stable than the wastewater inlet pH.

3.2 Difference in pH Value Before and After Primary Settling Tank Process

To prove the difference in pH fluctuations between the wastewater that was composite in the primary tank and those that were not composite statistically, paired-sample t-test analysis was used. Here is the result of the paired sample t-test:

Table 2. t-Test Value

t-Test: Paired Two Sample for Means

	<i>inf</i>	<i>ops</i>
Mean	0,49425108	0,360521908
Variance	0,03593088	0,027468165
Observations	7	7
Pearson Correlation	0,73470816	
Hypothesized Mean Difference	0	
df	6	
t Stat	2,69498163	
P(T<=t) one-tail	0,01790718	
t Critical one-tail	1,94318028	
P(T<=t) two-tail	0,03581436	
t Critical two-tail	2,44691185	

Based on table 2 and figure 2 above, t-statistic is 2.695 and the direction of these differences was one direction (positive direction), Meanwhile, the value of t used is the t critical one-tail 1,94. This means t statistic is greater than t critical, so H_0 is rejected or there is a difference between the wastewater that was composite in the primary tank and those that were not composite.

3.2 Optimum Detention Time

Generally, the industries in Jababeka Industrial Estate phase II and III turn in 24 hours, and to determine the optimum detention time of PST, the primary data was taken in every one hour. That sampling was done on workdays and work hours. It was because at that time the activities of industries are in the peak condition that the wastewater sample can be taken as the representative quantity and quality.

From primary data collection, 23 data were obtained and grouped into 4 groups, the purpose of this grouping is to see the pattern of wastewater pH value in each condition. Those 4 groups are :

- Group A

Group A, consists of 3 data which has first inlet pH range is 5.9 – 6.3 and the average of next inlet pH range is 6.4 – 6.8.

- Group B

Group B, consists of 6 data which has first inlet pH range is 6 – 6.4 and the average of next inlet pH range is 6.6 – 6.9.

- Group C

Group C, consists of 6 data which has first inlet pH range is 5.6 – 6.3 and the average of next inlet pH range is 6.4 – 6.8.

- Group D

Group D, consists of 8 data which has first inlet pH range is 7.1 – 7.5 and the average of next inlet pH range is 7.1 – 7.6.

The pattern of wastewater pH value in each group can be seen in the figure below:

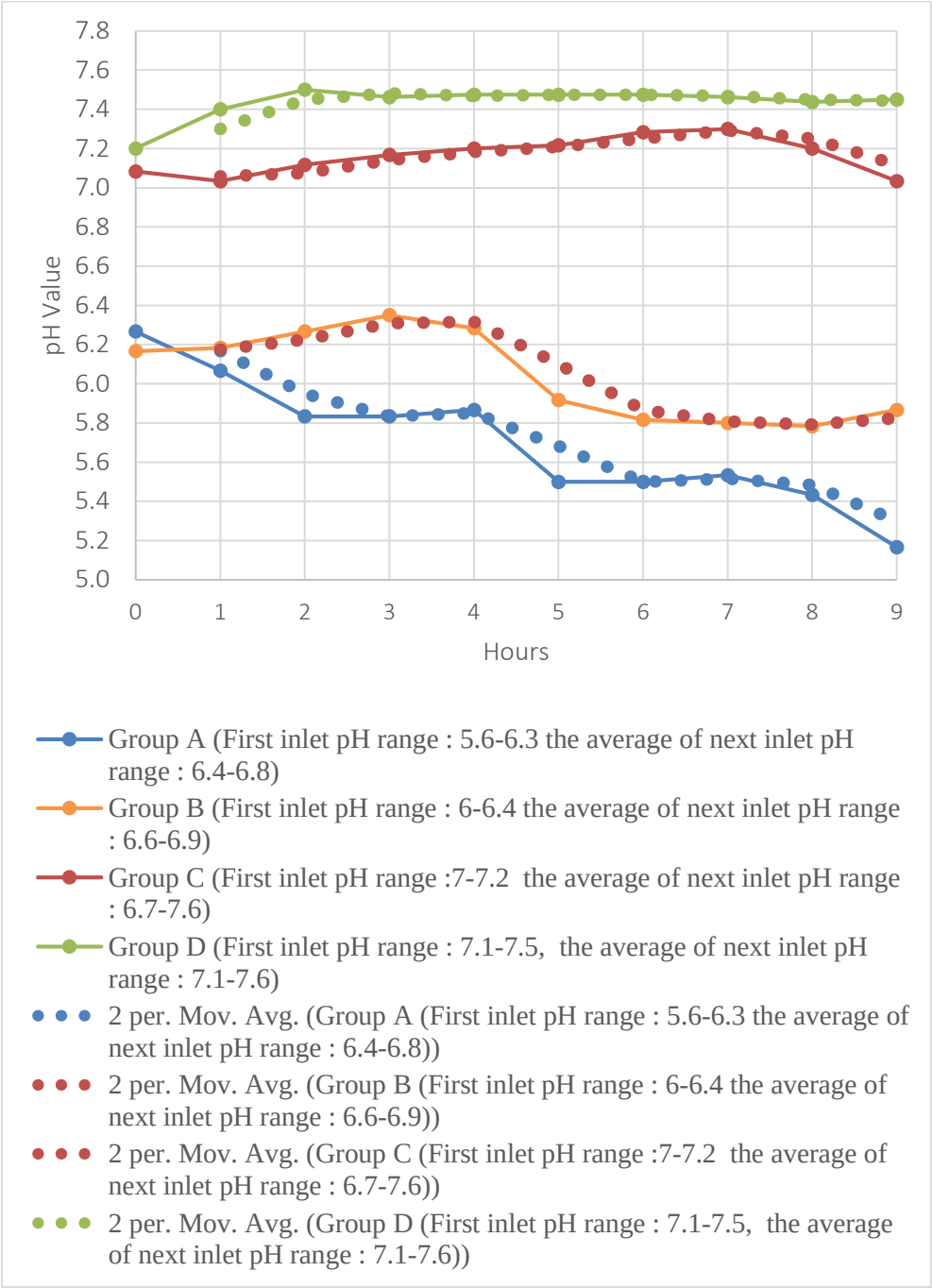


Fig. 3. The pattern of pH Change in Each Group (Source: Data Collection)

The graph of groups A, B, C, and D in figure 3 is similar to the moving average 2-period approach. The pattern has already checked with the equation of linear, exponential, logarithmic, polynomial, and power that were not appropriate tend.

Based on figure 3, the pH value pattern for wastewater with inlet pH value <7 (groups A and B) tend to fall on the next hour until a certain time. Therefore, for those groups that the preferred detention time is between 1-2 hours when the inlet wastewater pH value <7 has not got lower to be more acid. While groups C and D that have inlet pH value >7 the pH was relatively stable.

From the evaluation of groups A, B, C, and D patter showed that in between 1-2 hours of detention time, the pH was in the tolerable range.

Comply with the previous research which has been done about maximum detention time for equalization tank is 8 hours [11], while according to detention time for equalization time is 4-8 hours [12]. However, the results do not comply with the theoretical hydraulic detention time range is 1.5 – 2.5 hours with a typical value of 2 hours [13]. These differences can be caused by the differences in wastewater characteristics, temperature, and hydraulic profile.

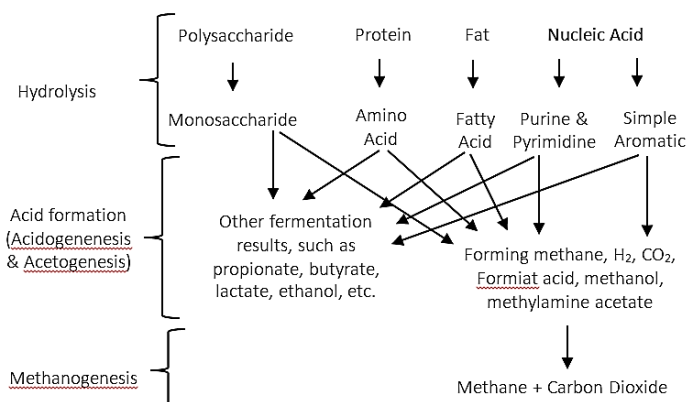


Fig. 4. Carbon Decomposition Flowchart Diagram. (Source: Metcalf & Eddy Inc. 1991)

Decreasing pH value in inlet wastewater which has pH value <7 (groups A and B) was suspected because of the high organic matter contained in wastewater, in which decomposition of organic matter by bacteria occurred. This phenomenon can

produce substrate and decrease of pH value [14]. The scheme of carbon decomposition shown in Fig. 4.

In the hydrolysis phase, organic matter is decomposed into simpler fatty acids. Optimum pH in hydrolysis phase is 5-6. Microorganism activities in this phase able to increase pH value, this increasing indicates decomposition organic matter microorganism activity such as carbohydrate decomposed into glucose [15]. The next process after hydrolysis are acidogenesis and acetogenesis which converts glucose, fatty acid, amino acid become organic acid such as acetate, propionate, etc by acidogenesis bacteria. The Acidogenesis and acetogenesis process able to decrease the value of pH [14]. During the decomposition process, the amino acid was released and become ammonia. The ammonia reacts with the CO₂ and creates alkalinity in the form of ammonium bicarbonate [16].

However, for wastewater with first inlet pH value >7 (group C and D), the pH increase in the next hours. The pattern of group C and D was suspected caused by the further pH value from the optimum range for hydrolysis process ($5 \leq \text{pH} \leq 6$). The further pH value from the optimum pH range may have caused a longer period for hydrolysis process [15].

4 Conclusions

Based on the observation, it can be concluded that PST was a significant unit process that can equalize the pH value. The observation of pH characteristic pattern by time showed that the optimum equalization time is 1-2 hours. This result can be a reference to more utilize of the existing PST. For further improvement, PT. Jababeka Infrastruktur recommended to age the inlet wastewater for 1-2 hours to decrease the inlet pH value fluctuation in WWTP2 before the wastewater treated in the biological treatment process.

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