EVALUATION OF PHYSICAL, CHEMICAL, AND BIOLOGICAL PARAMETERS IN PEKAPURAN BANJARMASIN WASTE WATER TREATMENT PLANT (WWTP), INDONESIA

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ABSTRACT:

Background: Waste water is water that contain hazardous materials that can endanger human life, other living beings, and environments. This research aims to analyze the differences before and after the treatment of waste water using physical parameters (temperature and Total Solid Suspense (TSS)), chemical parameters (pH, Biochemical Oxygen Demand (BOD), Nitrate-Nitrogen (NO_3-N), Total Factor Productivity (TF-P), oil and fat), and biological parameters (*E.Coli*).

Methods: The research design was an observational analytic using a cross-sectional approach. A Paired t-test and Wilcoxon test were used to analyze the impact before and after the treatment of Pekapuran Banjarmasin WWTP in 2015.

Results: The results in the WWTP of Pekapuran showed the average values before and after treatment in TSS (*p*-value=0.009), pH (*p*-value=0.001), NO_3-N (*p*-value=0.037), TF-P (*p*-value=0.005), oil and fat (*p*-value=0.028), *E.Coli* (*p*-value=0.002), temperature (*p*-value=0.053) and BOD (*p*-value=0.0162). There were significant differences ($p \leq 0.05$) in the value of TSS, pH, NO_3-N, TF-P, oil and fat and *E.Coli* before and after the treatment in Pekapuran Banjarmasin WWTP. Although, there were no differences ($p \leq 0.05$) in BOD and temperature before and after the treatment in Pekapuran Banjarmasin WWTP.

Conclusions: Although there was a difference before and after the treatment, there was still a possibility to the other parameters that excess of the standard. So, it was not guarantee an improvement of the quality of the waste water. Pekapuran Banjarmasin WWTP maintenance and repair the WWTP system and monitor and evaluate the facilities and procedure of WWTP routinely.

Keywords: Waste water; Physical parameters; Chemical parameters; Biological parameters

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INTRODUCTION

Waste water is liquid or filth from households, industries and other public places containing hazardous materials that could endanger human life, other living beings, and environments. According to Ministry of Environment Regulation Republic Indonesia No. 5 of 2014 on Waste Water Quality Standard, domestic waste water is waste water that comes from effort and/or settlement activities, restaurants, offices, commercial, apartments, and dormitories. For that reason the Company Waste Water Banjarmasin City (Local Company PD PAL Banjarmasin, Indonesia) established the feasibility study designated in the regional companies on the 24th of August 2006 [1, 2].

Based on data of average incoming water quality examination in PD PAL Banjarmasin 2015, BOD in WWTP Pekapuran was 14.22 mg/l; based on Government of Republic Indonesia Regulation

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Table 1 Difference of temperature, pH, BOD, NO_3-N, TF-P, oil and fat, and *E.Coli* before and after treatment in 2015

Month	Temperature (2 l)		TSS (2 l)		pH (2 l)		BOD (5 l)		NO_3-N (5 l)		TF-P (5 l)		Oil and fat (2 l)		*E.Coli* (100 ml)	
	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A
Jan	26.3	26.5	25	21	6.92	7.19	15.1	10.8	0.358	0.324	3.79	2.71	1.2	0	900	140
Feb	26.8	26.8	30	18	7.07	7.1	15.1	12.4	0.337	0.326	3.56	2.38	2.4	0	160000	280
Mar	27.4	27.6	37	26	6.99	7.05	14.2	11.6	0.314	0.309	4.45	3.31	2.1	0	160000	275
Apr	27.1	27.2	26	19	6.91	7.23	16.1	10.7	0.367	0.334	4.81	3.26	1.2	0	160000	350
May	27.4	27.5	22	18	6.93	7.19	9.26	7.48	0.309	0.273	3.15	2.24	1.8	0	500000	70
Jun	27	27	12	0.0059	6.9	7.06	9.6	7	0.079	0.0992	3.2438	1.8945	2.5	1.5	3900000	29400
Jul	27	27	194	15	7	7.36	13.9	14	0.022	0.2484	2.1792	2.2267	66.5	4	1900000	49400
Aug	27	27	11	2	7.06	7.44	13.51	12.26	0.0380	0.0699	2.7732	2.6299	2.5	1.5	19000	520
Sep	28	28	11	18	7.15	7.15	12.5	14.3	0.622	0.7496	3.177	3.4358	0.005	0.005	39000	1600
Oct	28	28	29	4	7.18	7.42	18.12	10.12	0.091	0.3537	4.3578	3.7469	1.2	0	39000	1660
Nov	28	28	39	4	7.04	7.37	13.39	21.42	0.116	0.4287	7.348	4.1899	2.4	0	45000	979
Dec	27	27	11	14	7	7.3	19.9	18.02	0.099	0.4494	4.8194	4.4691	2.1	0	1100	59
Avg	**27.3**	**27.3**	**37.2**	**13.2**	**7.0**	**7.2**	**14.2**	**12.5**	**0.2**	**0.3**	**3.9**	**3.0**	**1.2**	**0**	**577000**	**7061.08**

Notes: B: value before treatment A: value after treatment

82 of 2001, BOD had not suitable with water quality criteria (namely 3 mg/l). The average value of TF-P was 3.97; it was not suitable with water quality criteria (namely under 0.2 mg/L). Besides that, *E.coli* amounted to 298,000 amt/100 ml was not suitable with the water quality of 1,000 amt/ml. Although temperature of TSS, pH, NO_3-N, oil and fat still were not suitable with the water quality criteria [3].

The high level of domestic WWTP Pekapuran provides a significant impact on the quality of health of people living along the riverbanks, which includes diarrhea and skin diseases. Based on data from 10 diseases collected from the working area of the WWTP Pekapuran, there are 488 cases of diarrhea and gastroenteritis; and 360 cases of dermatitis [4, 5].

Therefore, waste water treatment needs to be handled properly and sustainably, so that waste water into the body of water is safe for public health and the environment [4]. The objectives of this research were to examine and evaluate the quality of waste water (temperature, TSS, pH, BOD, TF-P, NO_3-N, oil, fat, and *E.coli*) before and after treatment in WWTP Pekapuran Banjarmasin in 2015.

METHODS

This research was an observational analytic using cross sectional study. The study was conducted at the WWTP Pekapuran Banjarmasin, a district in Kalimantan Selatan province, Indonesia. The WWTP Pekapuran Banjarmasin is a waste water treatment plant owned by Banjarmasin Local Government, which providing water to the Banjarmasin community.

During the year 2015, the domestic water samples were collected before and after treatment in WWTP Pekapuran Banjarmasin by sampling officer of Banjarmasin Local Government, Indonesia. Water samples were collected monthly from January to December 2015 using combined sample time method; in which samples were collected in the same sampling spots in a different time in a day. Two litters, 5 litters, and 100 ml of samples were collected for physical parameters, chemical parameters, and biological parameters respectively.

Secondary data of PD PAL quality check was used, the data was processed and analyzed with the SPSS program using univariate analysis to explain the distribution of each independent variable and bivariate analysis using paired T-test and Wilcoxon test.

RESULTS

The results of the temperature, Total Solid Suspense (TSS), pH, Biochemical Oxygen Demand (BOD), Nitrate-Nitrogen (NO_3-N), Total Factor Productivity (TF-P), oil and fat, and *E.Coli* of the waste water treatment in WWTP Pekapuran before and after treatment were shown in 2015 (Table 1).

The value of the physical parameter based on Table 1, the waste water temperature in 2 liters sample were 27 to 28.5 ºC, which qualified with criteria of Government Regulation No.82 Year 2001, ranged from 24.64 to 30.64 ºC. It was known that the waste water temperature had increased.

The concentration of TSS in waste water undergone treatment had been qualified, ranged from 0.0059 to 26 mg/l, this value corresponded to the criteria of Government Regulation No.82 Year 2001 under 50 mg/l. The concentration of TSS in

Table 2 Result of Paired-t-test and Wilcoxon test of temperature, pH, BOD, NO_3-N, TF-P, oil and fat, and *E.Coli* before and after treatment

	Temperature	TSS	pH	BOD	NO_3-N	TF-P	Oil and fat	*E.Coli*
***p*-value**	0.053	0.009	0.001	0.162	0.037	0.005	0.028	0.002
Probability level	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Result	p>0.05	p<0.05	p<0.05	p>0.05	p<0.05	p<0.05	p<0.05	p<0.05

waste water had decreased. The pH of waste water had been qualified, ranged from 7.04 before treatment to 7.24 after treatment (this value suitable with criteria of Government Regulation No.82 Year 2001 are 6-9). The concentration of pH in waste water had increased.

The value of the chemical parameter, the concentration of NO_3-N in waste water had been qualified, ranged from 0.0699-0.7496 mg/l. Where this value was suitable with the criteria of Government Regulation No.82 Year 2001 at 10 mg/l. The concentration of NO_3-N in waste water had increased. The concentration of TF-P in waste water had not been qualified, ranged from 1.8945-4.4691 mg/l, did not correspond with the criteria of Government Regulation No.82 Year 2001; it was under 0.2 mg/l. The concentration of oil and fat in waste water had been qualified, ranged from 0-4 ug/l. Where this value was suitable with the criteria of Government Regulation No.82 Year 2001 at under 1000 ug/l. The concentration of oil and fat had decreased.

The value of the biological parameter, the number of *E.Coli* in waste water had not been qualified, ranged from 59-49400 amt/100 ml. Where this value was not suitable with the criteria of Government Regulation No.82 Year 2001 at under 1000 amt/100 ml. The concentration of *E.Coli* in the waste water decreased.

DISCUSSION

Temperature of the waste water treatment in WWTP Pekapuran

The result of Paired t-test showed *p*-value=0.053 (p> 0.05). It means that the "Null hypothesis" (Ho) Ho was accepted. There was no difference between the average of temperature value before and after treatment in WWTP Pekapuran. The temperature increased before and after the treatment 0.18%. Waste water generally had a higher temperature than the local air temperature. The effect of temperature could be annoying; and it left a chemical reaction to aquatic life. Hot temperature waste would disrupt certain biota. The level of oxidation agents was greater at higher temperature; and decay seldom occured at low temperature [4, 6].

The decomposition occurs due to the concentration of high temperatures. Decomposition resulting odor creates higher the concentration of microbes and inorganic substances in the water. Without concentration of microbes in high water and disinfection, there is higher possibility of waterborne occurrence [4, 7, 8].

The rise in temperature caused by the performance WWTP which process waste water with a more focused treatment to reduce parameters such as BOD, TSS, and *E.coli.* The concentration of temperature affected the content of BOD which happened when the concentration was not at normal temperature. It would interfere with the performance of aerobic bacteria to decompose organic matter in waste water. The optimal temperature for the activity of bacteria was in the range 25-35 °C. The increased temperature was a factor causing an increase in the concentration of NO_3-N while the increased in temperature due to the activity of microbes in decomposing material generates energy in the form of heat released into the environment [6, 9].

Total solid suspense (TSS) of the waste water treatment in WWTP Pekapuran

The result of Wilcoxon test showed *p*-value = 0.009 (p< 0.05), rejecting the "Null hypothesis" (Ho). There was a difference between the average of TSS value after the treatment in WWTP Pekapuran. The TSS percentage decreased before and after the treatment 64.43%. TSS were solids causing turbidity of the water; it did not dissolve and settle immediately. Suspended solids consisted of particles whose size and weigh less than the sediment, such as clay, certain organic materials, cells of specific microorganisms and so forth [9]. The concentration of TSS decreased before and after causing TSS through the stages and the final clarifier primary clarifier which could decrease the concentration of TSS [10].

The high concentration of TSS caused turbidity; and disturbing the disinfection process for the

absorption of some colloidal bacteria may protect the organism from the disinfectant. Disruption would cause the water disinfection process; and it became a good medium for bacteria to breed. This can cause infectious diseases because water is a good medium for bacteria. An infectious disease caused by the water called water-borne diseases. As for *some-borne* diseases are common in Indonesia, which includes cholera, dysentery, and abdominal typus [7, 8, 11]. Primary clarifiers were solids separation process and initial deposition. Most solids would sink to the bottom like a primary clarifier, whereas the final one was the deposition of advanced clarify seeing lowering the concentration of TSS [10].

pH of the waste water treatment in WWTP Pekapuran

The result of Paired t-test showed *p*-value = 0.000 ($p< 0.05$) rejecting the Ho, there were differences between the average of pH value after the treatment in WWTP Pekapuran. The pH percentage increased by 3.28%. pH was a measure of the acidity that is determined based on the high and low concentration of hydrogen ions in the water. The pH value of the water was used to determine the condition of acid (hydrogen ion concentration) of waste water. The pH scale ranged from 1-14, pH value range 1-7 including acid conditions. pH 7-14 included alkaline conditions; and pH 7 included neutral conditions [4, 12].

Waste water made normal pH of sterile water, whereas the wastewater had a high pH or low pH water. This can kill necessary microorganisms for the purposes of certain biota. Likewise other beings could not live such as fish and other aquatic fauna. Besides the waste water had a low pH water, it became corrosive often resulting metal becomes more rusted pipe [8, 9].

The increased in pH was due to the performance of the WWTP which process waste water with a more focused treatment to reduce parameters such as BOD, TSS, and *E.coli.* The pH value affected the BOD content of the waste water because if the pH value was not normal it would interfere with the performance of aerobic bacteria to decompose organic matter in waste water (the preference pH of microorganisms was between 7 to 8.5) [9, 12, 13].

BOD of the waste water treatment in WWTP Pekapuran

The result of Paired t-test showed *p*-value = 0.162 ($p> 0.05$), accepting the null hypothesis. There was no difference between the average of BOD value after the treatment in WWTP Pekapuran. The BOD percentage increased after the treatment by12%. BOD was the amount of oxygen needed by microorganisms in the water to break down (degrade) organic material in the water. BOD value indicated the amount of dissolved oxygen required by aerobic microorganisms to break down or effluent in the water. Therefore the BOD value did not indicate the actual amount of organic material, only measure the relative amount of oxygen necessary to oxidize the waste material.

In each zone, the waste treated by growing biomass on the disk contained in the zone and then flew to the next zone. Alternately biomass grown on Rotating Biological Contactor (RBC); it would come into contact with oxygen in the air at the time of being on the water and contacting with water and pollutant compounds. At the time of the contact oxygen is transferred to the water in the zone. Possible concentrations of BOD was not eligible because they had not been the optimal absorption of oxygen water and possible contact with not rotating/interruption of RBC [14].

The NO_3-N of the waste water treatment in WWTP Pekapuran

The result of Paired t-test showed *p*-value = 0.037 ($p< 0.05$), rejecting the null hypothesis. There was no difference between the average of NO_3-N value before and after treatment in WWTP Pekapuran. The NO_3-N percentage increased before and after the treatment at 43.47%. NO_3-N was the main form of nitrogen in natural waters and a major nutrient for plant growth and algae. Nitrate nitrogen was very soluble and stable in water. This compound was produced from the oxidation of nitrogen compounds in the perfect water [15].

The high nitrate concentrations could be toxic and could affect people's health, such as irritation of the skin and tissue damage of the skin. Ingested will cause severe digestive tract problem [8, 16, 17].

The TF-P of the waste water treatment in WWTP Pekapuran

Based on Table 2, the result of Paired t-test showed *p*-value = 0.005 ($p< 0.05$), rejecting the null hypothesis. There was no difference between the average of TF-P value before and after treatment in WWTP Pekapuran. The TF-P percentage decreased before and after the treatment which was 23.42%. Total phosphate in the waste water was a portion of the phosphate in waste water society; and it was in the form of inorganic orthophosphate (PO, HPO, HrPO) which increase as much as 25% of the total

phosphate [18]. When the waste water discharged into rivers/water bodies contains high concentrations of high TF-P, this could lead to silting due to eutrophication. It was also bad for the source of raw water for taps [8, 18].

The concentration of TF-P in waste water had decreased. This was because TF-P has gone through the process of biological treatment; and it was in the process RBC. In the decomposition process occurs RBC pollutant compounds by microorganisms that grown on rotating discs. Microorganisms grew and attached to rotor disk form a biomass/biofilm. Biomass was grown on a disk contained in the zone and then flew to the next zone. Alternately biomass grown on RBC would come into contact with oxygen in the air at the time of being on the water. The next moment into contact with water and pollutant compounds possible concentrations of BOD was not eligible because they have not been the optimal absorption of oxygen in contact with water and might not spin/interrupt of RBC [14, 19].

Oil and fat of the waste water treatment in WWTP Pekapuran

The result of Wilcoxon test showed *p*-value = 0.028 ($p < 0.05$), rejecting the null hypothesis. There was difference between the average of oil and fat value before and after treatment in WWTP Pekapuran. The oil and fat percentage decreased before and after the treatment at 86.24%. Oil and fat were the amounts of weight layer on the surface of the waste water that forms a membrane. So that it could inhibit the oxidation process under aerobic conditions. Oil and fat were organic materials; they are fixed and difficult to describe the bacteria [9]. Oil and fat formed a thin layer on the surface of the water and covered the surface resulting in limited oxygen into the water. This happened because the oil and fat had a specific gravity less than water. Layers of oil and fat also blocked the sunlight so that photosynthesis by aquatic plants did not last. As a result, the oxygen produced during photosynthesis should not happen; and the oxygen in the water was low [8, 9].

This increased might be related to the fact that the oil and fat had been through a pretreatment for separating oil and grease from waste water. In addition to decrease the concentration of oil and fat, it occured because it has passed the stage sand filter and a carbon filter, which served to filter solids remaining in the water. So the water produced was more clear [14].

***Escherichia Coli (E.Coli)* of the waste water treatment in WWTP Pekapuran**

The result of Wilcoxon test showed *p*-value = 0.002 ($p < 0.05$) rejecting the null hypothesis. There was difference between the average of *E.Coli* value after the treatment in WWTP Pekapuran. The *E.Coli* percentage decrease before and after the treatment at 98.77%. *Escherichia coli* was a bacteria that was normally found in the human intestine and excreted in large quantities along with healthy human feces. *Escherichia coli* was a bacteria that became the main species of coliform bacteria. *E.Coli* had the ability to ferment lactose at a temperature of 44 °C. Besides that, *E.Coli* was also the bacteria from feces and presence of these bacteria in water indicates that the presence of fecal contamination in water bodies [20, 21].

If water containing *E.Coli* was consumed, it would possibly appear water-borne diseases. *E.Coli* could be harmful to health since it was known that *E.Coli* bacteria were part of the normal microbiota of the digestive tract; and it had evidence certain strains capable of causing moderate to severe gastroenteritis in humans and animals. *E.Coli* could also cause acute diarrhea, which can be grouped into three categories namely enteropathogenic (gastroenteritis caused acute in newborns until the age of 2 years), enteroinaktif and enterotoxigenic (caused by diarrhea in children older children and adults). It also reported when *E.Coli* in the intestine into the bladder, it could cause sinusitis which is an inflammation of the mucous membranes of the organ [8, 21].

The number of *E.Coli* was decreased because it passed the stage of disinfectant/chlorine. The function of disinfection was to kill pathogenic microorganisms in the water so as not to disturb surrounding communities [14].

CONCLUSION

Based on the results of the research in WWTP Pekapuran in Banjarmasin in 2015, there was a significant difference before and after treatment at TSS (*p*-value=0,009), pH (*p*-value=0,001), NO_3-N (*p*-value=0,037), TF-P (p-value=0,005), oil and fat (*p*-value=0,028), and *E.coli* (*p*-value=0,002). Whereas there were no significant differences in temperature (p-value = 0.053) and BOD (*p*-value = 0.0162). Due to the excess of the standard quality parameters such as BOD, TF-P, and *E. Coli*, WWTP Pekapuran have to always maintain and repair.

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