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ANALYSIS OF LIQUID WASTE TREATMENT AT PT PLN (PERSERO) STEAM POWER PLANT (PLTU) UPK NAGAN RAYA

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Abstract

The Operation of a Steam Power Plant (PLTU) can produce waste, one of which is liquid waste. Liquid waste will be processed at the Wastewater Treatment Plant (WWTP). The data in this study were collected through direct observation and interviews with the environmental department. This research was conducted at PT PLN (Persero) UPK Nagan Raya. The results showed that there were several sources of liquid waste, namely from boiler blowdown, water treatment plant (WTP), chemical cleaning, condenser cooling water, and fuel oil or lubricants. The resulting liquid waste discharge is 3,604 m3/day. At the PLTU PT PLN (Persero) UPK Nagan Raya there is a liquid waste treatment facility called the Wastewater Treatment Plant (WWTP). Chemical and physical processes occur in wastewater treatment at WWTP. There is no waste water quality that exceeds the quality standard limit. As long as the PLTU is still operating, it will produce liquid waste which will be processed at the WWTP.

Keywords: ***Liquid Waste, Steam Power Plant, Wastewater Treatment Plant***

1. INTRODUCTION

Steam Power Plant (PLTU) is one of the most important power plants in industrial activities. The way the power plant works is to process demineralized water into dry steam to drive a turbine and turn on a generator so that it can produce electrical energy. One of the main alternative fuels used in PLTU activities is coal.

Steam power plant (PLTU) is a type of generating system that uses hot steam to drive a turbine so that it turns on a generator and produces electricity. The hot steam used comes from the process of cooking water in the boiler, this power plant uses coal or fuel oil to heat water. In its operation, PLTU generally has several components such as boilers, turbines, condensers and generators (Rianta, 2020).

In addition to the 4 main components, the steam power plant (PLTU) is also equipped with a Wastewater Treatment System called the Wastewater Treatment Plant (WWTP). As we know, wastewater from the operation of a steam power plant (PLTU) contains many hazardous polluted substances that can cause health problems to humans and pollute the surrounding environment if not treated first. The amount of wastewater generated and disposed of during the operation of the PLTU reaches 80% of the amount of water used. In this regard, PLTU must implement a liquid waste control system in a systematic, thorough and orderly manner, both in the production process (in-pipe pollution prevention) and after the production process (end-pipe pollution prevention). The purpose of waste control in the production process is to minimize the amount of waste generated and the toxicity of its contamination. The purpose of waste control after the production process is to reduce the content of pollutants in wastewater so that when it is disposed it meets the quality standards set by the government. This wastewater treatment is carried out in accordance with the Regulation of the Minister of the Environment No. 08 of 2009 concerning wastewater quality standards for thermal power generation businesses, the waste generated comes from the main process, supporting activities, and activities that produce waste water containing oil (Sahlan & Razak, 2013).

PT PLN (Persero) UPK Nagan Raya is located in Suak Puntong District, Nagan Raya Regency, Aceh Province, has 2 power plant Operational Units with a capacity of 2x110 MW. The main equipment owned is a boiler, turbine, condenser and generator. While the Wastewater

Treatment Plant (IPAL) or what is called the Wastewater Treatment Plant (WWTP). In the production process, PT PLN (Persero) UPK Nagan Raya uses sea water which is processed into fresh water through the Water Treatment Plant process in order to fulfill the requirements for filling in the boiler. After that the water is flowed into the boiler and heated using coal as fuel until the process produces steam. Then the steam is flowed into the turbine to turn on the generator and generate electricity. The electricity is supplied to the Aceh Province and its surroundings. As long as the PLTU is still operating, it can produce liquid waste which will be processed at the WWTP.

The process of a steam power plant (PLTU) that uses water as the main raw material will produce liquid waste containing chemicals which include changes in water pH, suspended solids, oil and fat, Free Chlorine (Cl2), Total Chromium (Cr). , Total Copper (Cu), Dissolved Iron (Fe), Total Zinc (Zn) and Phosphate (PO4). Therefore, it is necessary to treat the liquid waste before it is disposed of.

This study aims to determine and analyze the processing of liquid waste at the steam power plant (PLTU) PT PLN (Persero) UPK Nagan Raya and to compare the quality of the treated liquid waste with the established quality standards. Other objectives of this study are (1) to determine the amount of liquid waste generated from the operational activities of PT PLN (Persero) UPK Nagan Raya, (2) to determine the existing liquid waste treatment facilities at PT PLN (Persero) UPK Nagan Raya, (3) To find out the wastewater treatment process in PT PLN (Persero) UPK Nagan Raya, and (3) To analyze the data from the measurement of the quality of the liquid waste based on the pollutant parameters.

2. IMPLEMENTATION METHOD

The method used in this research is a descriptive survey conducted by interview and research observation by analyzing waste treatment at the Steam Power Plant (PLTU) PT PLN (Persero) UPK Nagan Raya. The object of this research is the facilities and processes of waste treatment at PT PLN (Persero) UPK Nagan Raya. This research was conducted from March 2022 to May 2022 at PT PLN (Persero) UPK Nagan Raya.

The data collection procedure used is primary data obtained by direct observation of the object of research and direct interviews with employees in the field of waste or environmental treatment at PT PLN (Persero) UPK Nagan Raya. While secondary data is obtained by collecting references in the form of data such as company documents, government regulations, books, and articles related to the research conducted.

The procedures in this study include data collection procedures, data processing and data analysis. Data collection activities: (1) sources of wastewater contained in PT PLN (Persero) UPK Nagan Raya, (2) processes or procedures in wastewater treatment, (3) wastewater treatment systems from PT PLN (Persero) UPK Nagan Raya, and (4) Quality of treated water from PT PLN (Persero) WWTP UPK Nagan Raya. Data processing activities are carried out to obtain data related to technology or equipment and chemicals used in the waste treatment process. Data analysis activities are aimed at obtaining measurement data on the chemical characteristics of wastewater after it has been processed from the WWTP and comparing the treated wastewater data with the wastewater quality standards in accordance with the Regulation of the Minister of the Environment No. 08 of 2009.

3. RESULTS AND DISCUSSION

3.1 Results

3.1.1 Source and Amount of Wastewater from PLTU PT PLN (Persero) UPK Nagan Raya

Based on data obtained from research results at the Steam Power Plant (PLTU) PT PLN (Persero) UPK Nagan Raya there are five sources of water waste, namely the source of waste water from *boiler blowdown*, *desalination plant*, *Mix bed regeneration*, *chemical cleaning* and operational activities in the laboratory. The liquid waste discharge generated from *boiler*

blowdown, *desalination plant*, *mix bed regeneration*, chemical cleaning and operational activities in the laboratory is an average of 3,604 m3/day.

3.1.2 Liquid Waste Treatment Facility for PLTU PT PLN (Persero) UPK Nagan Raya

At PLTU PT PLN (Persero) UPK Nagan Raya there is a liquid waste treatment facility called the *Wastewater Treatment Plant* (WWTP). *Wastewater Treatment Plant* (WWTP) is *plant* a wastewater *boiler blowdown*, *desalination plant*regeneration *mix bed*, *chemical cleaning* and operational activities in the Laboratory will be accommodated and processed at WWTP. This waste treatment facility has a water-tight sewerage system. The used water from the operation of the steam power plant (liquid waste) will not be discharged directly into the surrounding waters because it contains hazardous pollutants that can pollute the environment.

In principle, the processing at WWTP has similarities with the pre-treatment system. Wastewater that is treated at the WWTP is also wastewater with the characteristics of low impurities (low levels of impurities). In WWTP there are processes of aeration, neutralization, coagulation, flocculation, and sedimentation. While in the pre-treatment system there are processes of disinfection, coagulation, flocculation, and filtration (gravity air scrubbing filter).

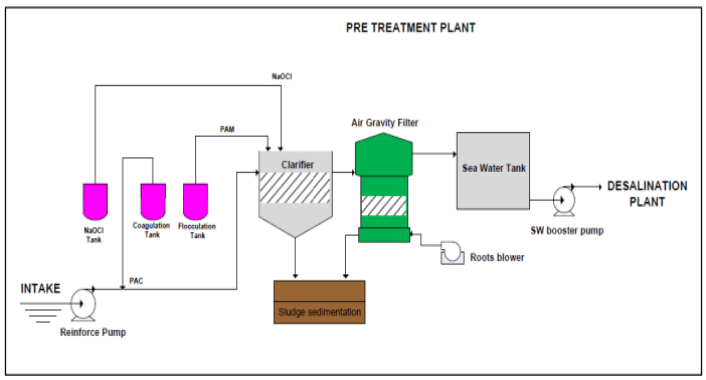

Figure I. Process Diagram Pretreatment Plant

3.1.3 Liquid Waste Treatment Process from PT PLN (Persero) UPK Nagan Raya Steam Power Plant

The process or procedure for treating liquid waste originating from the blowdown boiler and water treatment plant (WTP) is processed at the Wastewater Treatment Plant (WWTP) which will be accommodated in wastewater storage ponds. This treatment consists of aeration, neutralization, coagulation, flocculation, sedimentation, and final neutralization processes.

At WWTP there are chemical and physical processes in the treatment of liquid waste. Physical wastewater treatment occurs in the water storage pond, where wastewater from the neutralizing water pond and the Water Treatment Plant (WTP) unit is deposited in this pond. Physical wastewater treatment aims to separate solids in the water without the use of chemicals. The process of chemical wastewater treatment occurs when the addition of alkali (base) and acid (acid). The addition of these chemicals aims to adjust the pH and precipitate large and heavy particles.

Waste water originating from the PLTU activity will be accommodated in the *Waste water Storage Pond*. At the PLTU there are 2 *Wastewater Storage ponds*. Then in this pond an aeration process will be carried out, namely the process of adding air to the pond. The purpose of aeration is to increase the air content in the water, remove chemical compounds, which equalizes wastewater and cools wastewater naturally, because some wastewater has a hot temperature, such as wastewater from the condenser cooler. After going through the process at the *Waste Water Storage Pond* , the waste water is pumped to the *neutralizing tank*. In *the neutralizing tank* , the pH will be

neutralized. If the wastewater is acidic (pH <7) then an alkaline/alkaline compound will be added. On the other hand, if the wastewater is alkaline (pH > 7) then an *acid*. The addition of this compound is carried out until the pH of the wastewater becomes neutral, which is in the range of 6-9. After the *neutralizing tank*, the wastewater will enter the Coagulation tank. In this process, chemical coagulant is added and stirred in the tank quickly. The function of the coagulant is to make flocs so that the TSS content in the wastewater can go down. After that the wastewater will enter the flocculation tank. In this tank flocculation process, flocculant chemicals are added. The function of the flocculant is to increase the weight or mass of the flocs formed from the coagulation process. So the flocs will settle to the bottom.

From the Flocculation tank the wastewater will flow to the *Clarifier tanks*. *clarifier tank* is for sedimentation. Sedimentation is the process of deposition of sediment. In this process, the flocs will settle below the surface because they have a heavy density. Meanwhile, wastewater with reduced TSS content will be at the top. Then the wastewater will flow in overflow to *the final neutralizing pit*. In *the final neutralizing pit* , the pH will be checked again. If the wastewater is acidic (pH <7) then an alkaline/alkaline compound will be added. On the other hand, if the wastewater is alkaline (pH > 7) then acid compounds will be added until the wastewater is neutral. After that, the waste water *overflows* into the *Purified Water Pit*. In *Purified Water Pit* , the wastewater is ready to be disposed of. Before being discharged into the sea, the wastewater will be checked first so that it is in accordance with the quality standards set in the Minister of Environment Regulation No. 08 of 2009 concerning waste water quality standards. If in checking there are parameters that are not in accordance with the quality standard, the wastewater will be returned to the initial process, namely the *Wastewater Storage Pond* until the wastewater parameters are in accordance with the quality standard.

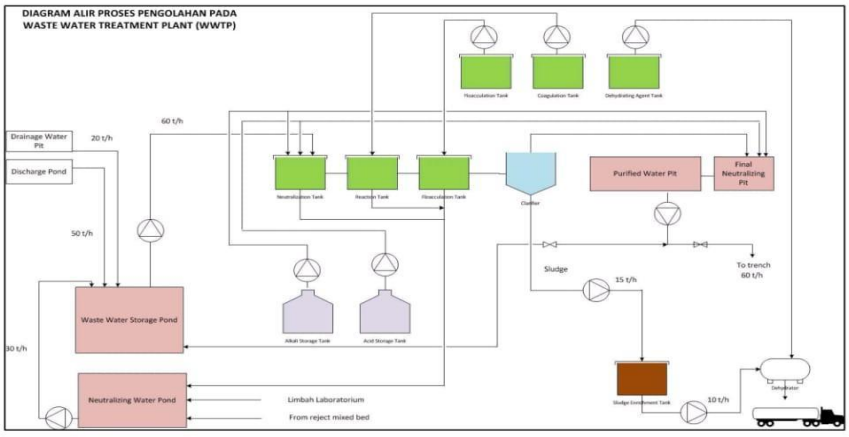

Figure II. WWTP Process Flow Diagram
(*Source: Environmental Affairs Section of UPK Nagan Raya. 2019*)

3.1.4 Quality of Liquid Waste from PT PLN (Persero) UPK Nagan Raya Steam Power Plant (PLTU)

1. Quality of Liquid Waste in Quarter-IV of 2021

Based on the results of the implementation of environmental monitoring in Quarter-IV of 2021, the quality of wastewater output from WWTP PLTU PT PLN (Persero) UPK Nagan Raya at the Inlet and Outlet sections carried out in October, November and December 2021 shows that all the parameters that have been measured at the inlet and outlet of the liquid waste treatment at the WWTP do not exceed the quality standard limits in accordance with the Regulation of the Minister of the Environment No. 08 of 2009 which discusses the quality standards of wastewater for businesses and/or thermal power plant activities.

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Table 1 Data on the results of measuring the quality of liquid waste Inlet WWTP WWTP PLTU Nagan Raya Quarter-IV 2021

	Test Parameters	Result			Quality Standards	Unit	Measurement Methods
		October	November	December			
***WWTP Inlet* 2021**	pH (In situ)	7,60	7,80	7,90	6,0-9,0	-	SNI 6989.11-2019
	Suspended Solids	5,60	4,60	14,20	100	Mg/L	SNI 06-6989.3-2004
	Oils And Fats	1,60	1,80	2,00	10	Mg/L	SNI 6989.10-2011
	Free Chlorine ($Clen_2$)	0,05	0,05	0,07	0,5	Mg/L	SNI 6989.19.2009
	Total Chromium (Cr)	<0.0107	<0.0107	<0.0107	0,5	Mg/L	APHA 3120-2017
	Total Copper (Cu)	<0.0071	<0.0071	<0.0071	1	Mg/L	APHA 3120-2017
	Dissolved Iron (Fe)	<0.0029	<0.0029	0,367	3	Mg/L	APHA 3120-2017
	Total Zinc (Zn)	<0.0141	0,05	0,032	1	Mg/L	APHA 3120-2017
	Phospat (PO_4)	0,27	0,04	<0.018	10	Mg/L	APHA 4500-PO_4^{3-}2017

Source: Results of analysis October , November and December 2021

Table 2 Data on the results of measuring the quality of liquid waste Outlet at the WWTP PLTU Nagan Raya

	Test Parameters	Result			Quality Standards	Unit	Measurement Methods
		October	November	December			
WWTP *Outlets* 2021	pH (In situ)	7,60	7,80	7,90	6,0-9,0	-	SNI 6989.11-2019
	Suspended Solids	3,40	4,40	3,40	100	mg/L	SNI 06-6989.3 2004
	Oils And Fats	1,40	1,60	1,80	10	mg/L	SNI 6989.10-2011
	Free Chlorine ($Clen_2$)	0,03	0,01	0,01	0,5	mg/L	SNI 6989.19.2009
	Total Chromium (Cr)	<0.0107	<0.0107	<0.0107	0,5	mg/L	APHA 3120-2017
	Total Copper (Cu)	<0.0071	<0.0071	<0.0071	1	mg/L	APHA 3120-2017
	Dissolved Iron (Fe)	<0.0029	<0.0029	<0.0029	3	mg/L	APHA 3120-2017

	Total Zinc (Zn)	<0.0141	<0.0141	0,0141	1	mg/L	APHA 3120-2017
	Phospat (PO_4)	0,04	<0.018	0,03	10	mg/L	APHA 4500-PO_4^{3-}2017

Source: The results of the analysis of October, November and December 2021.

2. Quality of Liquid Waste in Quarter-II of 2022

Based on the results of the implementation of environmental monitoring in Quarter-II of 2022, the quality of main process water and Desal Reject Water of PT PLN (Persero) UPK Nagan Raya in April shows that the calculation of the burden of wastewater pollution from the main process and sources of Desal Reject Water, all of the parameters measured do not exceed the quality standard limits set in the Regulation of the Minister of the Environment No. 08 of 2009 concerning "waste water quality standards for business and/or thermal power plant activities".

Table 3 Calculation of Main Process Wastewater Pollution Load

Parameters	**Unit**	**Quality Standards**	**Lab Analysis Results**	**Main Process Wastewater Polluting Load**	
					Unit
pH	-	**6-9**	7,20	-	-
TSS	mg/L	**100**	2,00	3.238	Kg
Oils and Fats	mg/L	**10**	2,20	3.5618	Kg
Chlorine Free ($Clen_2$)	mg/L	**0,5**	0,03	0.04857	Kg
Chromium (Cr)	mg/L	**0,5**	0,0107	0.0173233	Kg
Copper (Cu)	mg/L	**1**	0,0071	0.0114949	Kg
Iron (Fe)	mg/L	**3**	0,0510	0.082569	Kg
Zinc (Zn)	mg/L	**1**	0,0141	0.0228279	Kg
Phospat (PO_4)	mg/L	**10**	1,00	1.619	Kg

Remarks : Quality Standard Refers to Regulation of the Minister of Environment No. 08 of 2009 Appendix IA Sample testing is carried out by the Testing Laboratory of PT Anugrah Analisis Sempurna

Table 4. Calculation of Wastewater Pollution Load from Desal Reject Water

Parameters	**Unit**	**Quality Standards**	**Lab Analysis Results**	**Main Process Wastewater Polluting Load**	
					Unit
pH	-	6-9	7.60	-	-
Salinity	0/00	35	32.10	3713.30	Kg

Remarks : Quality Standard Refers to the Regulation of the Minister of Environment No. 08 of 2009 Appendix II Sample testing is carried out by the Testing Laboratory of PT Anugrah Analisis Sempurna

3.2 DISCUSSION

3.2.1 Wastewater Treatment Process at the Wastewater Treatment Plant (WWTP)

Waste Treatment is a process of processing disposal processes from machines to be reused and to neutralize again so that it does not pollute the environment. One of the waste waters that can damage the environment is wastewater from steam power plants (PLTU) (Karnadi, 2018).

Wastewater Treatment Plant (WWTP) is a place for wastewater treatment. Wastewater treatment at PT PLN (Persero) UPK Nagan Raya consists of aeration, neutralization, coagulation, flocculation, sedimentation, and final neutralization. Sources of wastewater in WWTP come from *boiler blowdown*, *neutralizing water pond*, and *discharge pond*.

Aeration is the process of adding air (oxygen) to water, in order to remove some chemical compounds, odors, make it homogeneous, and even out the pH and temperature of the water. This aeration process is carried out with the help of a compressor. Neutralization is the process of neutralizing the pH of water by adding chemical compounds that are acidic and/or basic (depending on the initial pH value). Wastewater consists of several sources, so the pH is not neutral. The pH quality of wastewater must be maintained in the range of 6 – 9. This figure is the standard for wastewater quality in the Regulation of the Minister of the Environment No. 8 of 2009.

Coagulation is the process of adding chemicals, called coagulants, to water which causes destabilization of colloidal particles or TSS so that the aggregation of the destabilized particles occurs. With the addition of coagulant in wastewater, colloid stability can be destroyed so that colloidal particles can agglomerate (form flocs) (Benefield, Judkins, & Weand, 1982). The coagulation process is influenced by several important factors, namely coagulant concentration, wastewater pH, and stirring. These factors will determine the efficiency of the coagulation process (Soeswanto, 2010). After the coagulation process, it is generally followed by a flocculation process. Flocculation is a mechanism whereby small flocs that have been formed in the coagulation process form larger flocs to settle. The floc particles that have been stabilized then collide with each other and carry out a tug-of-war process and form even larger flocs. To form larger and heavier flocs, a chemical called flocculant is added in the flocculation process (Eddy & Calf, 2014). The flocculation process is influenced by the concentration of flocculants and stirring (Soeswanto, 2010).

Sedimentation is an integral part of the coagulation-flocculation process. In this process, wastewater will be separated between water and impurities (floc or sludge). The water will flow in overflow, while the sludge will settle and flow from the bottom of the clarifier. Thus, the impurities in the wastewater will be reduced. The dominant parameter in WWTP wastewater is TSS (total suspended solid) or colloids. TSS is an impurity or impurity substance that has stable bonds, so it is difficult to settle or tends to take infinite time to naturally precipitate. The particle size of TSS is about 1 *m* to 1 *nm*. To accelerate the deposition of TSS, coagulants and flocculants were added.

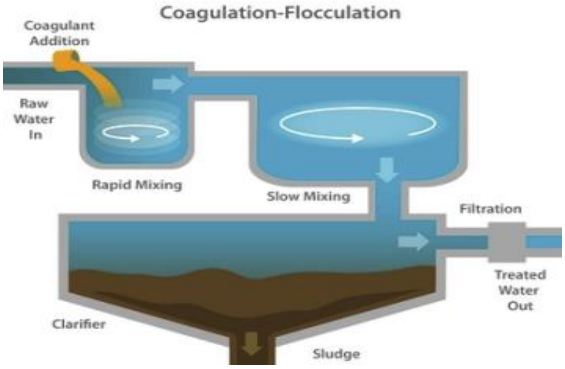

Figure III. Coagulation-Flocculation Process

(Source: (Bahrudeen, 2010)

3.2.2 Quality of Liquid Waste from the Steam Power Plant (PLTU) PT PLN (Persero) UPK Nagan Raya

The Steam Power Plant (PLTU) PT PLN (Persero) UPK Nagan Raya has a permit for the disposal of liquid waste and its waste water treatment channel which is separate from the rainwater channel. PLTU Nagan Raya also monitors the quality of liquid waste to prevent environmental pollution. The company also monitors the quality of liquid waste once a month at the WWTP. The measurement of the quality of the liquid waste from the PLTU Nagan Raya engine is carried out by taking samples at the site and measuring in situ for temperature and pH. Then the sample is taken to the laboratory for analysis. The location for monitoring liquid waste is carried out at the

WWTP/IPAL outlet waste water monitoring point (Main Process Source). Wastewater monitoring is carried out once a month at the WWTP from the PT PLN (Persero) UPK Nagan Raya power plant.

4. CONCLUSION

The operational activities of the Government PT PLN (Persero) UPK Nagan Raya's Steam Power Plant (PLTU) generates solid, liquid and gaseous waste. The facilities for processing liquid waste from the PT PLN (Persero) UPK Nagan Raya Steam Power Plant (PLTU) have been well integrated so that the liquid waste treatment process can produce waste with quality that meets the requirements. The wastewater treatment process from boiler blowdown, desalination plant, mix bed regeneration, chemical cleaning operational activities in the laboratory is processed through WWTP (Wastewater Treatment Plant). The liquid waste treatment process at the PT PLN (Persero) UPK Nagan Raya Steam Power Plant (PLTU) is a physical and chemical processing. The quality of the liquid waste has met the requirements because there are waste treatment facilities that have met the requirements.

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