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Reduction Of Dissolved Ammonia with the Stripper Method in pH and Temperature Variations

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Abstract. Condensate Polishing System (CPS) regeneration waste from PT. Bhimasena Power Indonesia has an ammonia level of 932 mg N/L. Therefore, research on reducing dissolved ammonia waste is very important. Research gaps in reducing dissolved ammonia waste include the effects of time variations and dissolved ammonia concentrations, the effect of water quality, and the impact of using methods on the environment. The purpose of this study was to determine the effect of variations in pH and temperature on the effectiveness of separating ammonia waste and to obtain optimum pH and temperature values for the separation of dissolved ammonia waste. The method used in this experiment is the stripper method. The results showed that the process of reducing dissolved ammonia using the stripper method reached an optimum value at a temperature of 45 °C and pH 12. Under these conditions, a reduction value of 0.75 mg N/L was obtained. So it can be concluded that the stripper method can reduce dissolved ammonia waste properly. The impact of this research can develop a more effective and environmentally friendly waste treatment method.

Keywords. Liquid Waste, Ammonia, Stripper, pH, Temperature

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1. Introduction

PT. Bhimasena Power Indonesia as a steam power producer, in its activities, uses ammonia to protect the surface of the boiler pipes from corrosion by forming a protective layer. Corrosion on the surface of the pipe wall can be caused by a reaction between water and the metal used in the boiler pipe. The process of using ammonia produces complex metal ammonia compounds which function to protect metal surfaces from direct contact with water.

The use of ammonia in an aqueous environment can produce an effective protective layer to prevent corrosion on the surface of the pipe wall [1]. Mixing of ammonia and pressurized steam during the process is used to turn turbines, this steam is then condensed and may contain contaminants that affect the quality of boiler water [2]. Processing is carried out to remove unwanted substances from condensate water using the Condensate Polishing System (CPS), which aims to reduce impurities through ion exchange using resins. Waste from CPS regeneration contains high concentrations of ammonia and can pollute the environment if disposed of without treatment. Therefore, treatment must be carried out before waste from regeneration is discharged into the environment [3].

The threshold for the concentration of ammonia in wastewater in Indonesia is stipulated by the Ministry of Environment and Forestry through the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia Number 3 of 2010. According to this regulation, the threshold for the concentration of ammonia in wastewater for industrial areas is 50 mg/L, while for residential areas, trade, and services it is 10 mg/L (Ministry of Environment, 2010). If the concentration of ammonia on the surface of the water increases, it can cause fish in the water to die. Ammonia levels in water are affected by the pH value, which can determine whether ammonia is toxic or not. If the pH is low and the concentration of ammonia is high, the surface water becomes toxic to fish. Conversely, if the pH is high and the concentration of ammonia is low, the water on the surface is also toxic to fish in the waters [4].

the use of a combination of aeration and biofilter processes can reduce ammonia concentrations by up to 80% in fish processing industrial wastewater [5]. In addition, the use of zeolite-based adsorbents can reduce ammonia concentrations by up to 97% in textile industry wastewater. The study used the stripper method to reduce the ammonia content in liquid waste by using air or inert gas as a stripping agent [6].

The study used the stripper method to reduce the ammonia content in liquid waste by using air or inert gas as a stripping agent. In this process, liquid waste is run at high temperatures and pressure so that ammonia can be separated from the waste and collected in gaseous form [7]. The advantage of the stripping method is that it can be used to reduce the ammonia content in large amounts of liquid waste in a short time [8]. The purpose of this study was to determine the effect of variations in pH and temperature on the effectiveness of separating ammonia waste using the stripper method and to obtain optimum pH and temperature values in an effort to separate dissolved ammonia waste using the stripper method.

2. Methods

Take 1000 mL of boiler waste water, then fill it into the beaker glass. Turn on the stirrer stove, and set it to 60 rpm. Adjust the pH of the wastewater according to experiments (10, 11, and 12). Heat to the experimental temperature (35ºC, 40ºC, and 45ºC). Turn on the pump, and flow the water to the stripper column. Also, turn on the blower to make contact with wastewater so that the ammonia reduction process occurs. Maintain operating conditions for 15 minutes, then take samples.

2.1 Ammonia Test

Testing the levels of ammonia using two methods, namely ammonia High Range and Low Range. Prior to analysis using the ammonia Hight Range, the pH was set to 7 using 30% HCl. Next, start the 342 N and Ammonia HR TNT program on the DR 3900 Portable Hach spectrophotometer. Next, a blank was prepared by adding 0.1 mL of distilled water into the first tube, while the test sample was prepared by adding 0.1 mL of ammonia sample into the second tube. In each tube, reagent 1 (Ammonia Salicylate Reagent Powder) and reagent 2 (Ammonia Cyanurate Reagent Powder) were added, then closed and homogenized and allowed to stand for 20 minutes. After that, the first tube (blank) is inserted into the cuvette and zero is pressed to calibrate. The second tube (sample) was then inserted into the cuvette and analyzed for the concentration of ammonia at a wavelength of 655 nm.

Low Range ammonia testing before analysis, adjust the pH to 7 using 30% HCl. Start the 342 N, Ammonia LR TNT program on the DR 3900 Portable Hach spectrophotometer, then prepare a blank by adding 2 mL of distilled water to the first tube and prepare a test sample by adding 2 mL of ammonia sample to the second tube. In each tube, reagent 1 (Ammonia Salicylate Reagent Powder) and reagent 2 (Ammonia Cyanurate Reagent Powder) are added. Then close the tube and homogenize it, let stand for 20 minutes. After 20 minutes, insert the first tube (blank) into the cuvette, and press zero to calibrate. Next, insert the second tube (sample) into the cuvette, and press read to get the results of the concentration of ammonia in the sample at a wavelength of 655 nm.

Calculation:

$$\text{Ammonia levels (mg N/L)} = C \times fp \quad (1)$$

with the understanding:
C = Levels obtained from measurement results (mg/L).
fp = Dilution factor.

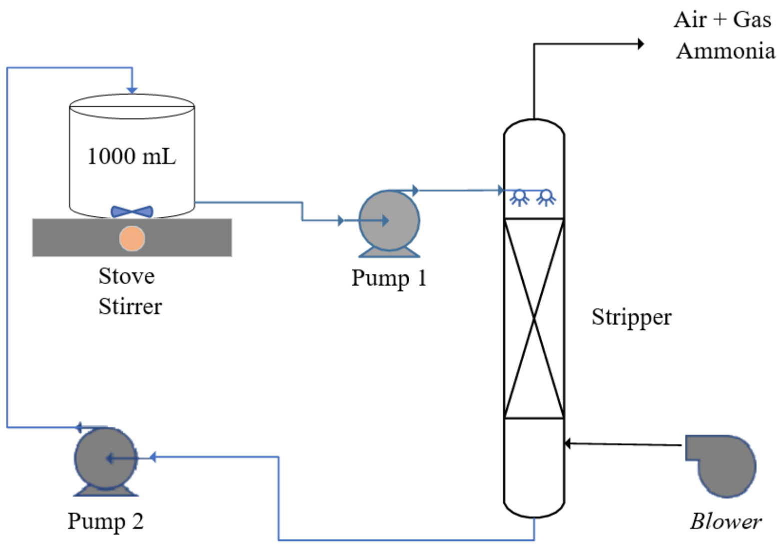

Figure 1. Design of Ammonia Separation Equipment

3. Results and Discussion

3.1 The effect of variations in pH and temperature on the effectiveness of separating dissolved ammonia waste

Reducing dissolved ammonia waste by varying pH and temperature using the stripper method can affect the process of reducing dissolved ammonia in it. This study used a variation of pH 10, 11, and 12 with a temperature variation of 35ºC, 40ºC, and 45ºC and an initial ammonia content of 932 mg N/L. After conducting experiments on reducing dissolved ammonia waste, the reduction effectiveness value (mg N/L) was obtained as follows:

Table 1. Results of Dissolved Ammonia Research

pH/Temperature	10	11	12
35 °C	**78,7**	70,8	65,6
40 °C	2,97	1,93	1,6
45 °C	1,55	1,13	**0,75**

From Table 1 it can be seen that the largest reduction in ammonia was obtained from experiments at pH 12 and a temperature of 45°C. The reduction result is 0.75 mg N/L with a reduction percentage of 99.91%. While the smallest value was obtained from experiments at pH 10 and temperature of 35 °C. The reduction result is 78.7 mg N/L with a reduction percentage of 91.55%.

The results showed that the efficiency of ammonia removal depends on the temperature and pH used. Higher temperature and pH lead to better ammonia removal efficiency [9]. If the temperature is too low, the efficiency of reducing ammonia will decrease, because it is more difficult for ammonia to escape from the solution at lower temperatures [10]. If the temperature is too high the solution can become too viscous and the reduction process becomes ineffective. The effective temperature range for the stripper method is 50 -70ºC and the optimal pH is in alkaline conditions [11].

3.2 Optimization of pH and temperature in the separation of dissolved ammonia waste with the stripper method

Determination of the optimum value of pH and temperature from the research results in Table 1. can be done through the graph as follows:

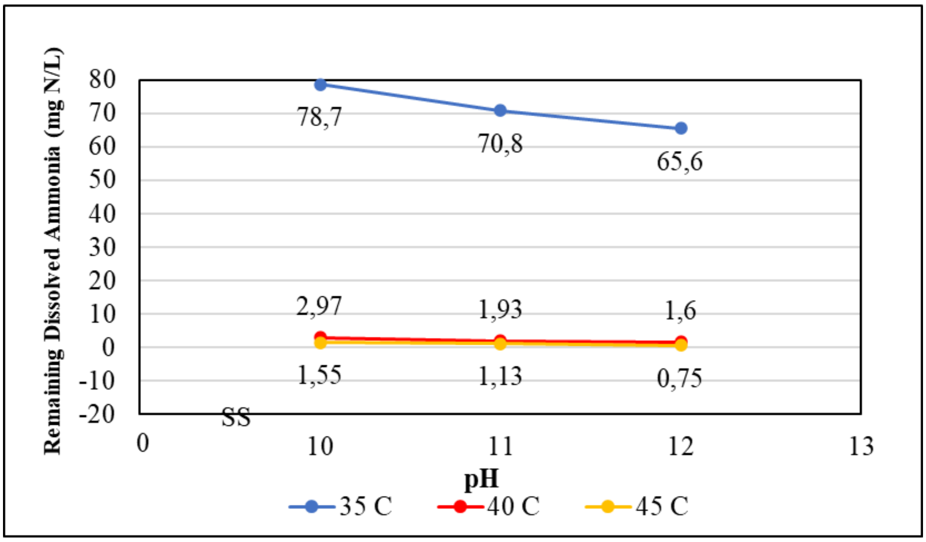

Figure 1. Graph of the Relationship Between pH vs. Remaining Dissolved Ammonia

Figure 1 shows that the variation in pH in this study affected the process of separating dissolved ammonia using the stripper method. This proves that increasing the pH above 9.25 will increase volatility due to the increasing concentration of hydroxide ions (OH^-) in the solution so that some of the ammonia dissolved in the solution will react with hydroxide ions and form ammonia, which is more volatile [11]. The lowest reduction value was obtained in experiments with pH 10 with a reduction percentage of 91.55% and the highest value was obtained at pH 12 with a reduction percentage of 99.91%.

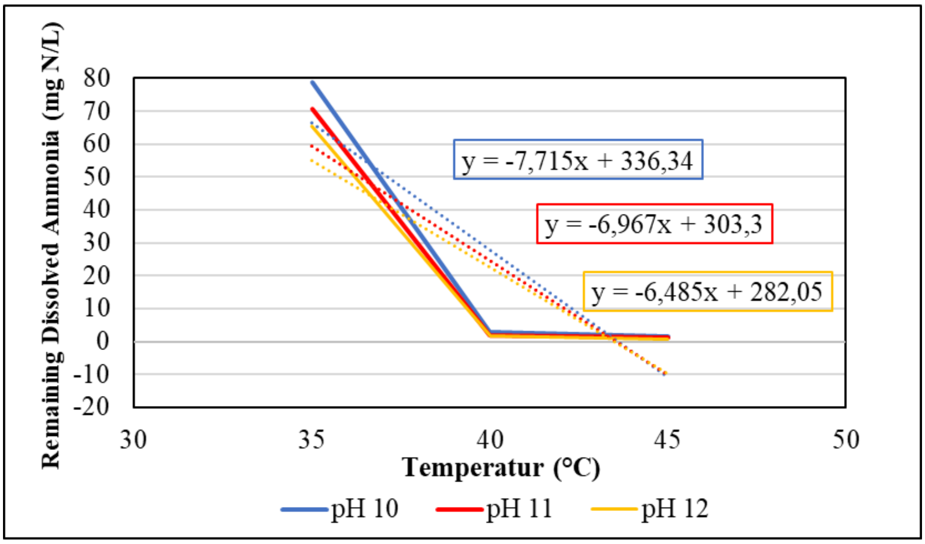

Figure 2. Graph of Relationship Between Temperature and Remaining Dissolved Ammonia

Figure 2 shows that the process of reducing dissolved ammonia by the stripper method takes place significantly at a temperature of 40 °C. At 45 °C the ammonia reduction process still occurs and reaches the optimal point. In simple chemistry, increasing the temperature will accelerate the evaporation of dissolved ammonia.The reduction of dissolved ammonia by the stripper method reached an optimum value at a temperature of 45 °C and pH 12. It can be seen that under these conditions a reduction value of 0.75 mg N/L was obtained with a reduction percentage of 99.91%.

Based on the water pollution control policy in Permen LH Number 05 of 2014 wastewater quality standards, the allowable ammonia level is 1-10 mg/L and based on the Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No: P.68/Menlhk/Setjen/Kum.1/8/2016 Domestic Wastewater Quality Standards, the allowable ammonia level is 1-10 mg/L [12].

From the existing policy, it can be seen that at a temperature of 40 °C and pH 10, a reduction value of 2.97 mg N/L is obtained with a reduction percentage of 99.68%. This is evidence that the pH and temperature in this study have met the government's quality standards. So when applied in industry, there is no need to raise the pH to 12 and the temperature to 45 °C because it will increase the production cost of the treatment.

4. Conclusions

From the research results it is proven that variations in pH and temperature can affect the effectiveness of reducing dissolved ammonia by the stripper method. Reduction of dissolved ammonia by the stripper method reaches an optimum value at a temperature of 45 °C and pH 12. In this condition, there is an increase in the concentration of ammonia in the form of NH3 and dissolved ammonia molecules come out of the solution more easily, achieving a reduction effectiveness of 99.91% with a reduction value of 0.75 mg N/L. This may assist in the development of more effective methods of reducing dissolved ammonia in the future.

References

[1] F. M. Alptekin and M. S. Celiktas, “Review on Catalytic Biomass Gasification for Hydrogen Production as a Sustainable Energy Form and Social, Technological, Economic, Environmental, and Political Analysis of Catalysts,” *ACS Omega*, vol. 7, no. 29, hal. 24918–24941, 2022, doi: 10.1021/acsomega.2c01538.

[2] T. Cheng, X. Zhou, L. Yang, H. Wu, and H. Fan, “Transformation and removal of ammonium sulfate aerosols and ammonia slip from selective catalytic reduction in wet flue gas desulfurization system,” *J. Environ. Sci. (China)*, vol. 88, no. x, hal. 72–80, 2020, doi: 10.1016/j.jes.2019.08.002.

[3] N. Imchuen, Y. Lubphoo, J. M. Chyan, S. Padungthon, and C. H. Liao, “Using cation exchange resin for ammonium removal as part of sequential process for nitrate reduction by nanoiron,” *Sustain. Environ. Res.*, vol. 26, no. 4, hal. 156–160, 2016, doi: 10.1016/j.serj.2016.01.002.

[4] M. A. W. Nurul Hikmah, Tuty Alawiyah, “View of Analisis Kadar Ammonia (Nh3) Di Perairan Sekitar Pabrik Karet Daerah Banjarmasin Menggunakan Spektrofotometri Visible,” *J. Pharm. Care Anwar Med.*, vol. 4, no. 2654–8364, hal. 20–30, 2021, [Daring]. Tersedia pada: http://jurnal.stikesrsanwarmedika.ac.id/index.php/jpcam/article/view/38/51

[5] P. A. Suriasni, F. Faizal, C. Panatarani, W. Hermawan, and I. M. Joni, “A Review of Bubble Aeration in Biofilter to Reduce Total Ammonia Nitrogen of Recirculating Aquaculture System,” hal. 1–19, 2023.

[6] Y. Lv and M. Liu, “Corrosion and fouling behaviours of copper-based superhydrophobic coating,” *Surf. Eng.*, vol. 35, no. 6, hal. 542–549, 2019, doi: 10.1080/02670844.2018.1433774.

[7] F. M. Ferraz, J. Povinelli, dan E. M. Vieira, “Ammonia removal from landfill leachate by air stripping and absorption,” *Environ. Technol. (United Kingdom)*, vol. 34, no. 15, hal. 2317–2326, 2013, doi: 10.1080/09593330.2013.767283.

[8] H. Haslina *et al.*, “Landfill Leachate Treatment Methods and Its Potential for Ammonia Removal and Recovery - A Review,” *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1051, no. 1, hal. 012064, 2021, doi: 10.1088/1757-899x/1051/1/012064.

[9] M. Zhang, M. Yu, Y. Wang, C. He, J. Pang, and J. Wu, “Operational optimization of a three-stage nitrification moving bed biofilm reactor (NMBBR) by obtaining enriched nitrifying

bacteria: Nitrifying performance, microbial community, and kinetic parameters," *Sci. Total Environ.*, vol. 697, hal. 134101, 2019, doi: 10.1016/j.scitotenv.2019.134101.

[10] L. Cao *et al.*, "Evaluation of ammonia recovery from swine wastewater via a innovative spraying technology," *Bioresour. Technol.*, vol. 272, no. October 2018, hal. 235–240, 2019, doi: 10.1016/j.biortech.2018.10.021.

[11] A. Zangeneh, S. Sabzalipour, A. Takdatsan, R. J. Yengejeh, and M. A. Khafaie, "Ammonia removal form municipal wastewater by air stripping process: An experimental study," *South African J. Chem. Eng.*, vol. 36, no. March, hal. 134–141, 2021, doi: 10.1016/j.sajce.2021.03.001.

[12] Menteri Lingkungan Hidup dan Kehutanan, "Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia Nomor R: P.68/Menlhk-Setjen/2016 Tentang Baku Mutu Air Limbah Domestik," *Peratur. Menteri Lingkung. Hidup dan Kehutan. Republik Indones.*, hal. 1–13, 2016.