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Ammonia Liquid Waste Processing Using Electrolysis Method

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Abstract

This study uses an ammonia waste water treatment system using 6 lanes and uses a batch-continuous system with electrolysis. Ammonia liquid waste content before and after electrolysis was analyzed using the Nessler method and analyzed using the Spectrophotometry method at a wavelength of 460 nm. Ammonia liquid waste with ammonia content can be used between 18,000-22,000 ppm used as a test sample. The results of this study indicate that the decrease in ammonia concentration every time is directly proportional to the amount of strong current and the number of electrode cells applied. The difference in number, by using 1 pair of cells can reduce 49.19%, 3 pairs of cells by 67.89%, and 5 pairs of cells by 85.08%. In the variation of electric current, 1; 5; 10; and 15 amperes produce 34.03%, respectively; 55.99%; 67.68% and 83.28%. On variations in the influence of the flow rate of 250; 500; 750; 1,000; and 1,250 mL/minute resulting from a decrease in the concentration of ammonia is relatively the same, i.e. concentrations between 82 to 84%. The rate of decrease in ammonia concentration at the liquid level reaches 85.08% by using a variation of 5 pairs of electrode cells with a strong current of 15 amperes. The flow rate used is 250 mL/minute, the electrolysis process is carried out for 8 hours. The modification of the wastewater treatment system by using this electrolysis method is feasible for ammonia liquid waste treatment.

Keywords: Electrolysis, ammonia liquid waste, electrode cells, current strength, flow rate, stainless steel

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INTRODUCTION

Liquid waste containing ammonia is organic waste which is very dangerous for the survival of living things. Ammonia gas is a dangerous pollutant if it often inhaled into the respiratory system [1]. The toxic nature of this non-ionized ammonia will be high in low temperature and high pH environments, while at low pH most of the ammonia will ionize into ammonium ions (NH_4^+) [2].

One source of ammonia waste comes from petrochemical plants producing urea fertilizer. In the production process of urea fertilizer industry will produce waste products that cannot be used anymore [3]. The ammonia content in the inlet pool at the PT Pupuk Sriwidjaja Palembang Waste Water Treatment Plant reaches 16970 ppm per day. The ammonia waste is treated in the Hydrolizer-Stripper and Heat Exchanger, by turning it back into ammonia and CO_2 gas. However, not all of them successfully converted into ammonia and CO_2 gas. Ammonia liquid waste still contains ammonia content of more than 500 ppm. This does not meet environmental quality standards. Furthermore, the ammonia waste is sent to the emergency pond and entered into equalization to be neutralized into ammonium compounds by injecting sulfuric acid (annual report PT Pupuk Sriwidjaja Palembang, 2018).

Research on ammonia wastewater using this electrolysis method focuses on modification of the electrolysis system, where, in general, the electrolysis process takes place in one vessel with one pair of electrode cells using a batch system [2-15]. The electrolysis method is a method of breaking molecules into their constituent atoms by using an electric current

that passes through the two electrode poles in the electrolysis of ammonia. The reduction in ammonia concentration using the electrolysis method is influenced by the initial concentration of ammonia [16].

MATERIALS AND METHODS

Materials

Ammonia liquid waste treatment by electrolysis method is carried out using electrolysis vessels made of plastic 2 mm thick, with a length of 60 cm, width 25 cm, and height 21 cm. This electrolysis vessel consists of 6 lanes and 5 dividers made of acrylic with a thickness of 2 mm acrylic, the distance of each barrier is 10 cm. The electrodes used are made of stainless steel with a length of 15 cm, width 3 cm, and a thickness of 2 mm. These electrodes consist of positive electrodes and negative electrodes, both of which are connected to the DC digital supply power supply PS-305D which is equipped with Ammeters and Voltmeters. The electrode cell is clamped with a crocodile clamp inserted into the electrolysis vessel with the distance of the two electrode cells is 2 cm. Ammonia concentration in ammonia liquid waste at PT. Sriwidjaja Fertilizer will be measured by involving the influence of the number of electrolysis cells, electric current, and flow rate using Stainless Steel electrodes. The design of the tool refers to the waste storage pond in PT Pupuk Sriwidjaja Palembang as shown in Figure 1.

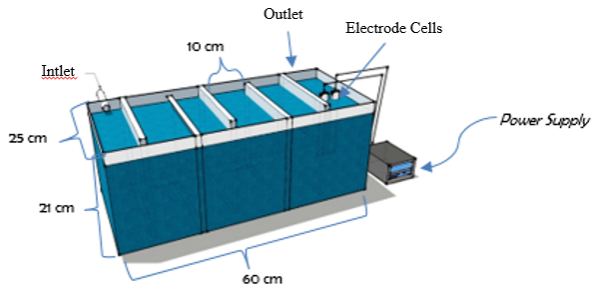

Figure 1. Electrolytic Vessel Design with 1 Pair of Electrode Cells

Analysis Data

Ammonia liquid waste samples piped as much as 2 mL using a goiter pipette, put into a 50 mL volumetric flask. Furthermore, 1 mL of Nessler's solution was added, squeezed to the limit using demineralize water. The test sample was allowed to stand for 10 minutes; the absorbance value was measured using a spectrophotometer with a wavelength of 460 nm. The analysis was carried out in duplicate. For a blank treatment, the solution is the same as the sample treatment without adding samples. The ammonia content is calculated by formula:

ppm NH_3 : $y = ax \pm b$

where :

y : Concentration
a : Slope
x : Absorbance
b : Intercept
Fp : dilution factor (IK-LKP002)

RESULTS AND DISCUSSION

Modification of Ammonia Liquid Waste Management Systems

Modification of the ammonia wastewater treatment system follows the current state of the existing waste collection pool model at PT Pupuk Sriwidjaja Palembang. Ammonia waste was used as much as 20 liters with continuous flow for 8 hours. Modifications to the design of ammonia liquid waste treatment equipment can be seen in Figure 2.

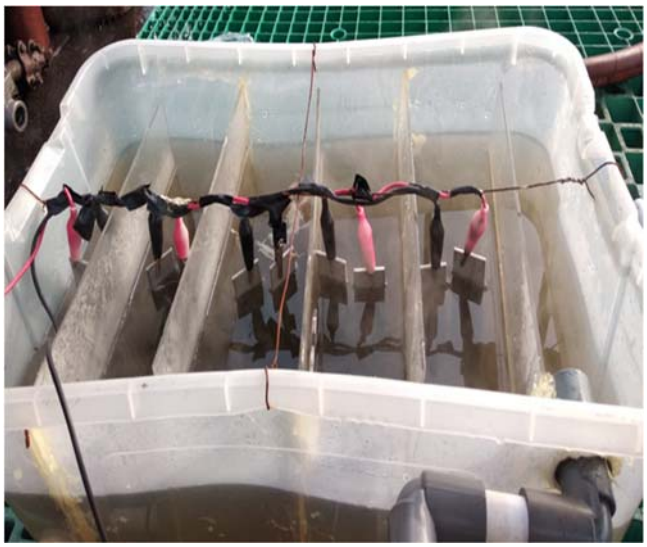

Figure 2. Modification of Ammonia Liquid Waste Management Device Design

Effect of Cell Counts on Decreasing Ammonia Concentration

In the electrolysis process, the effect of the number of cells on the reduction in ammonia concentration in ammonia liquid waste is carried out by comparing the variations in the number of cells, namely: 1, 3, and 5 pairs of electrode cells with a strong current of 15 amperes. The flow rate used is 500 mL/min, the electrolysis process is carried out for 8 hours. From the electrolysis, process data are obtained

as in Table 1 and implemented in the graph in Figure 3.

Table 1. Effect of Cell Counts on Ammonia Concentration Reduction

Time (hour)	Ammonia Concentration (ppm)		
	1 Pair cells	3 Pairs cells	5 Pairs cells
0	18.738 ±0,14	20.326 ±0,10	19.025 ±0,12
1	17.142 ±0,14	18.821 ±0,11	16.795 ±0,13
2	15.978 ±0,12	16.254 ±0,13	12.101 ±0,12
3	14.832 ±0,10	13.720 ±0,10	9.936 ±0,11
4	13.994 ±0,11	10.842 ±0,14	6.066 ±0,16
5	12.802 ±0,10	9.537 ±0,13	4.423 ±0,10
6	12.023 ±0,13	8.836 ±0,10	3.910 ±0,14
7	10.644 ±0,12	8.251 ±0,12	3.127 ±0,14
8	9.525 ±0,12	6.518 ±0,11	2.839 ±0,10

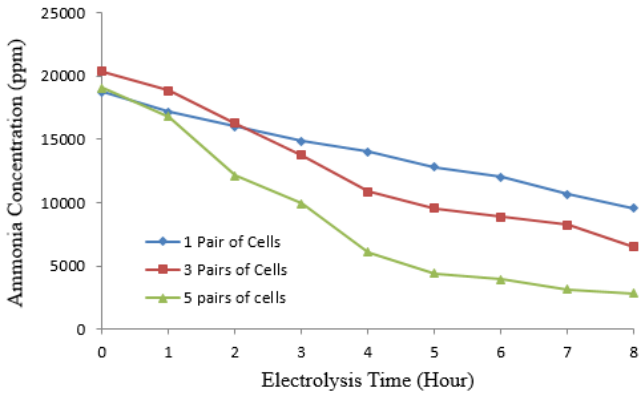

Figure 3. Curve effect of cell count during electrolysis time

Based on Figure 3 it can be seen that the decrease in ammonia concentration is higher with an increasing number of electrolysis cells and based on Table 1 the highest decrease is found in the variation of 5 pairs of electrode cells with the percentage of reduction reaching 85.08. This data shows that the greater number of electrode cells used will make the surface area of the electrode more extensive so that it will further accelerate the electrolysis process. The addition of electrode cells will be very effective in the process of electrolysis. The greater the surface area of the electrode cell, the contact between the electrolyte solutions (ammonia waste) with the electrode cell will be even greater [12].

The Effect of Electric Current on Decreasing Ammonia Concentration

The effect of electric current on the decrease in ammonia concentration, in this study the electrolysis process was carried out at various currents, namely 1, 5, 10, and 15 ampere with a flow rate of 500 mL/min for 8 hours using 5 pairs of electrode cells. From the electrolysis, process data are obtained as in Table 2 and Figure 4.

Table 2. Effects of Electric Current on Decreasing Ammonia Concentration

Time (hr)	Ammonia Concentration (ppm)			
	1 A	5 A	10 A	15 A
0	20.417 ±0,12	19.952 ±0,11	19.361 ±0,12	20.733 ±0,13
1	19.791 ±0,14	18.644 ±0,14	17.045 ±0,10	17.129 ±0,10
2	18.553 ±0,11	17.264 ±0,12	15.753 ±0,13	15.057 ±0,12
3	18.003 ±0,13	16.248 ±0,12	13.664 ±0,12	12.409 ±0,13
4	17.798 ± 0,12	15.142 ±0,10	10.657 ±0,16	7.866 ±0,16
5	16.856 ± 0,10	13.909 ±0,14	9.761 ±0,12	6.051 ±0,16
6	16.173 ±0,11	11.620 ±0,10	8.021 ±0,11	4.463 ±0,13
7	15.026 ±0,13	9.739 ±0,13	7.437 ±0,13	3.926 ± 0,11
8	13.469 ±0,12	8.781 ±0,11	6.257 ±0,14	3.361 ± 0,13

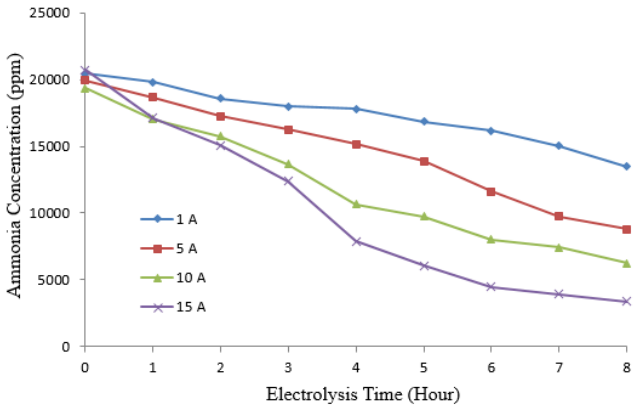

Figure 4. Curve effect of electrical current during electrolysis time

From Figure 4 it can be concluded that the largest percentage decrease in ammonia concentration is at 15 amperes with the percentage decrease in ammonia concentration reaching 83.2%. The greater the current and voltage used is directly proportional to the amount of ammonia degraded according to the law of faraday. The mass of the substance produced (ammonia degraded) by an electrode during the electrolysis

process (G) will be directly proportional to the amount of electric charge to be used (Q). Where the amount of electric charge (Q) is the product of the strong electric current (i) and the time (t) needed during the electrolysis process.

Effect of Flow Rate against Ammonia Concentration

The effect of flow rate on the reduction of ammonia concentration in ammonia liquid waste carried out at various flow rates of 250, 500, 750, 1,000, and 1,250 mL/min. In this process, five pairs of electrode cells are used with a strong current of 15 amperes for 8 hours. Based on the data obtained from Table 1 and 2, a difference can be made from the reduction in ammonia concentration from the initial electrolysis time to 8 hours of the electrolysis process took place as listed in Table 3 and Figure 5.

From Figure 5, it can be concluded that the relationship between the decrease in ammonia concentration and the flow rate does not have a significant effect. This can be seen from the percentage decrease in ammonia concentration whose value is almost in the range between 82 to 84%

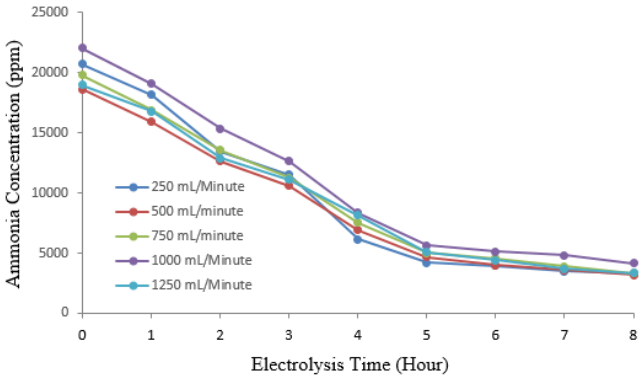

Figure 5. Curve effect of flow rate during electrolysis time

Initially the analysis was carried out for hours, apparently the results obtained were not optimal, and so the study was continued for 8 hours (normal working hours/day). This because this study did not use additional electrolyte solutions. The ammonia waste sample was directly electrolyzed. Ammonia waste used is 20 liters with flow continuously for 8 hours.

Table 3. The effect of Flow Rate against Ammonia Concentration

Time (Hour)	Ammonia Concentration (ppm)				
	250 mL/min	500 mL/min	750 mL/min	1000 mL/min	125±0 mL/min
0	20.724 ±0,12	18.593 ±0,11	19.766 ±0,12	22.014 ±0,13	18.948 ±0,14
1	18.146 ±0,13	15.924 ±0,14	16.882 ±0,13	19.061 ±0,15	16.791 ±0,11
2	13.429 ±0,19	12.647 ±0,11	13.554 ±0,11	15.336 ±0,11	12.880 ±0,19
3	11.486 ±0,12	10.607 ±0,15	11.270 ±0,10	12.632 ±0,15	11.104 ±0,14
4	6.132 ±0,14	6.936 ±0,16	7.536 ±0,11	8.353 ±0,14	8.129 ±0,16
5	4.219 ±0,17	4.674 ±0,12	5.019 ±0,17	5.659 ±0,12	5.072 ±0,17
6	3.928 ±0,14	4.011 ±0,11	4.570 ±0,15	5.101 ±0,11	4.417 ±0,19
7	3.468 ±0,16	3.604 ±0,12	3.908 ±0,11	4.840 ± 0,15	3.699 ±0,11
8	3.297 ±0,13	3.168 ±0,13	3.335 ±0,13	4.175 ±0,10	3.314 ±0,13

CONCLUSION

Modification of ammonia wastewater treatment by using electrolysis method has potential to reduce the ammonia concentration in ammonia liquid waste. Measurements using 5 pairs of electrode cells with a strong current of 15 amperes, the flow rate used is 500 mL/min using stainless steel electrolysis electrodes carried out for 8 hours to reduce the concentration of ammonia by 85.08%. Thus, the electrolysis method to reduce the concentration of ammonia in ammonia liquid waste is feasible to apply at PT Pupuk Sriwidjaja Palembang.

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