Reducing the ammonia content of hospital liquid waste by active carbon plastic ore adsorption

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Abstract: Considerable visits from patients increases the content of ammonia within the liquid waste of the hospital which, in turn, results in water pollution. Adsorption of active carbon is an alternative technology in reducing the ammonia level of liquid waste. This research aims at revealing the contact time of active carbon plastic ore towards the degression of ammonia level of liquid waste. This research was an experiment designed by Pretest-Postest design with control. The population of the research was all the liquid waste taken from the influent of RSUD Al Ihsan Bandung, while the sample of the research was taken from the population by time combining collection technique. The collected data was then analysed using ANOVA. The results of the research show that the average of the degression percentage for contact time of sixty minutes is 1,840%, 90 minutes 35.07% and 120 minutes 48.77%. The value of t acquired from ANOVA testing is 0.001, smaller than 0.05 (α 5%). There is significant influence of the variations of contact time of active carbon plastic ore on the degression of ammonia level of liquid waste. The results of the research could be utilised by the hospital to manage its liquid waste.

Keywords: ammonia; liquid waste; adsorption; active carbon; plastic ores.

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1 Introduction

The hospital is a public health service with high operational hours and operates daily. The high number of patient visits will increase the ammonia parameter problem in the hospital's liquid waste, this is because the patient's urine is a contributor to the high level of ammonia in hospital waste. Ammonia is also easily soluble in water, raising the pH of the water into a base, so the water becomes polluted (Banon and Suharto, 2008). High levels of ammonia cause irritation to the respiratory tract and cause water pollution (Widyastuti, 2006). Hospital is obliged to manage the resulting liquid waste in order to meet quality standards that are safe for the environment. Furthermore, required alternative technology that can reduce the level of ammonia liquid waste hospital, one of which is the adsorption process using activate carbon. The raw materials of activate carbon can come from plants, carbon-containing waste or minerals such as bone, softwood, husk, coconut shell, coconut husk, coal (Sembiring and Sinaga, 2003). One of the active carbon that can be used is active carbon that is made from plastic waste (LDPE) which is used as plastic ore.

Waste occupies an important role in environmental pollution issues in both big cities and villages. This poorly managed waste will be a means of disease transmission as well as a vector of infectious disease vectors (Suprapto, 2005). The increase in population and lifestyle is very influential on the volume of waste generated. The composition of waste generated from human activities is organic waste as much as 60%–70%, the rest (30%–40%) is non-organic waste, the composition of non-organic waste 14% in the form of plastic waste. Most types of plastic waste are plastic bags. The plastic waste, if it achieved certain level, would potentially pollute the environment. Given that the nature of plastic that is difficult to decompose so as to reduce soil fertility and contaminate the waters. Therefore plastic waste should be utilised. Plastic wastes of polyethylene type can be recycled as an activator of active carbon for the adsorption process in liquid waste treatment (Purwaningrum, 2016).

2 Description of the scenarios

Activate carbon plastic ore contains carbon (C) and nitrogen (N) compounds, these compounds can reduce organic materials such as polycyclic aromatic hydrocarbons, aromatic hydrocarbons, aldehyde and others (Budiyantoro, 2010). The activate carbon from the plastic ore (LDPE) is suitable as an adsorption medium because in each backbone of the polymer there are 1000 carbon compounds (Kumar et al., 2011).

The working principle of activate carbon in reducing ammonia waste is the absorption of a substance (molecule or ion) on the surface of the adsorbent through the adsorption process. The adsorption rate generally increases with the decreasing temperature. Contact time is the decisive factor in the adsorption process. The molecular adsorption force of a solute is increased when the contact time with the active carbon is prolonged. The old contact time allows diffusion process and the adsorption of the adsorbed solute molecules is better (Suharto, 2011).

The study of ammonia treatment in liquid waste using activate carbon has been done for several times. The results of Syafalni's study (2012) shows that using granular activate carbon and zeolite filter can decrease COD by 59,46%, ammonia 60,82% and colour 58,4%. Fikri et al. (2016) reveal that using activate carbon ore with diameter of 1 cm can reduce ammonia by 47.8% and phosphate 47.9%. Another study shows that with a weight of 3 grams of plastic ore capable of lowering phosphate levels of 45.45% (Wardhana, 2013).

The number of studies that have been done with regard to activate carbon of plastic ore, indicates that active carbon ore can process liquid waste. This research is a further research, the purpose of research to reveal the influence of various length of contact time of adsorption process using activate carbon of plastic ore to decrease of ammonia level of hospital liquid waste. The difference of this study with the previous research is the variation of contact time used.

3 Study methods

Types of research undertaken include experimental research (laboratory scale) with pretest-postest design with control. The design of this study was grouping control and randomised treatment groups, pretest studies in the control group and treatment group followed by intervention in the treatment group and posttest after treatment. Intervention was done by contacting the activate carbon of plastic ore in the hospital liquid waste to be processed /derived ammonia levels. The aim of this research was to reveal the influence of various time of contact of adsorption process using activate carbon of plastic ore to decrease of ammonia level of hospital's liquid waste. The sample population was all liquid waste taken from RSUD Al Ihsan, Bandung Regency, while the sample of the research was a portion of liquid waste taken from the population by the sampling combined time technique. This study used a complete randomised design (RAL) because the experimental material was considered homogeneous. The number of repetitions (replication) in this study was determined based on the number of treatments performed. There were three treatments with contact time of 60 minutes, 90 minutes and 120 minutes. By using RAL then the number of repetitions is six times.

The activate carbon of plastic ore used in this research was plastic ore made from low-density polyethylene plastic (LDPE) plastic bags. Plastic ore production was done in the following way:

a Washing the plastic bag with running water.

b Cutting plastic into small parts.

c Drying plastic pieces in the sun until the pieces are dry.

d Inserting plastic pieces into the carbonace furnace, then turning on the lighter to do the thermal process of the device.

e Collecting the carbon liquid into a bucket containing water for the carbon freezing process.

f Cut out the already frozen carbon as long as 1 cm.

g Dissolve the activation process by soaking the generated ores using 24 hours acetone solution. Then dry in the open air and in the heat with sunlight.

h Soak active carbon ore plastic using HCL 1 M for 2 hours, then dry in the open air and heated with sunlight.

The resulting plastic ore was then fed into the test tube to be contacted with the hospital's liquid waste. The initial characteristics of hospital liquid waste included ammonia levels of 41.90 mg/L, pH value of 9.25 and temperature of 25°C. In detail how the research work was as follows:

a Filling the test tube with the hospital's liquid waste to be contacted with active carbon ore. The liquid waste was contacted with active carbon ore for 60 minutes, 90 minutes and 120 minutes.

b Taking samples of hospital liquid waste before and after being contacted with active carbon ore for 60 minutes, 90 minutes and 120 minutes, as well as control.

c Examining the ammonia, pH and temperature of the hospital's liquid waste samples before being contacted with active carbon ore.

d Examining the ammonia, pH and temperature of the hospital's liquid waste sample after being contacted with active carbon ore.

e Checking the ammonia, pH and temperature levels of the controls.

f Activated iron ore carbons after use in the study can be reactivated by soaking using acetone solution for 24 hours.

Further measurement and examination data were processed and univariate-analysed to reveal the average of ammonia levels before and after contact with activated carbon the plastic ore, as well as a percentage reduction in ammonia levels after contact with active carbon ore. Furthermore, bivariate analysis was done by using ANOVA test.

Figure 1 Reactor of plastic ore, activate carbon of plastic ore and test tube (see online version for colours)

4 Results and discussions

Based on the results of the examination, the initial ammonia levels (raw water), ammonia on the control, as well as the ammonia of the hospital liquid waste after contact with the active carbon of the plastic ore, can be seen in Table 1.

Table 1 Initial ammonia level, controls and treatment

Repetition	*Initial ammonia level (mg/L)*	*Ammonia level on control (mg/L)*	*Ammonia level after contact with active carbon of plastic ore (mg/L)*		
			60 minutes	*90 minutes*	*120 minutes*
1		41.87	35.10	28.30	21.20
2		41.87	35.19	28.63	19.67
3	41.90	40.36	33.67	26.43	19.84
4		40.20	31.14	25.08	22.18
5		40.20	31.22	24.25	20.59
6		40.36	33.57	26.40	21.90
Average	41,90	40,81	33.31	26.51	20.73

Based on Table 1, it can be seen there is a difference of ammonia levels after hospital liquid waste was contacted with different contact time variations. The ammonia level for contact time of 60 minutes ranged from 31.14 mg/L to 35.19 mg/L, for a contact time of 90 minutes ranging from 24.25 mg/L to 28.63 mg/L and for 120 minutes contact time ranged between 19.67 mg/L to 22.18 mg/L. According to the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 on Wastewater Quality Standard, the ammonia level for business and/or health service facility is 10 mg/L.

Based on Table 2, it can seen that the initial temperature value of the hospital's liquid waste before contacting the activate carbon of the plastic ore and on the control is 25°C. There was no difference in temperature value after contact with activate carbon ore, for contact time of 60 minutes and 90 minutes 24.8°C to 25°C while for 120 minutes contact time ranged from 24.7°C to 25°C. For volatile compounds, adsorption is carried out at room temperature or whenever possible at lower temperatures (Cecen and Ozgur, 2011).

Table 2 Initial temperature, control and treatment values

Repetition	*Initial temperature (°C)*	*Temperature on control (°C)*	*Temperature after contact with active carbon of plastic ore (°C)*		
			60 minutes	*90 minutes*	*120 minutes*
1	25	25	25	25	25
2	25	25	25	25	24.8
3	25	25	24.8	24.8	24.7
4	25	25	25	25	24.8
5	25	25	25	24.8	24.8
6	25	25	24.9	24.9	24.8

The initial pH value of hospital liquid waste before being contacted with activate carbon of plastic ore and control is 9.25, while temperature on control is between 9.15 to 9.25. There was a difference in pH value after contact with activate carbon of plastic ore, for a contact time of 60 minutes ranging from 9.10 to 9.12, for a 90 minute contact time ranging from 9.05–9.08, while for 120 minutes contact time ranged between 9.02–9.04. If the nature of the acid compound then the adsorption process will run optimally at its acid pH, otherwise if the alkaline uptake properties, then the adsorption process will run optimally at the base pH (Cecen and Ozgur, 2011). The pH value data can be seen in Table 3.

Table 3 Initial pH, control and treatment values

Repetition	*Initial pH value*	*pH on control*	*pH value of contact with active carbon of plastic ore*		
			60 minutes	*90 minutes*	*120 minutes*
1	9.25	9.25	9.10	9.06	9.04
2	9.25	9.25	9.10	9.06	9.02
3	9.25	9.20	9.11	9.05	9.02
4	9.25	9.15	9.12	9.08	9.05
5	9.25	9.15	9.12	9.08	9.04
6	9.25	9.20	9.11	9.05	9.04

The decrease in ammonia levels in the wastewater after contact with the iron ore's active carbon is shown in Table 4.

Based on Table 4, it can be seen that the average percentage of ammonia level decrease after contact with activate carbon of plastic ore for 60 minutes is 18.40%, contact time for 90 of 35.07% and contact time for 120 of 48.77%.

Table 4 Percentage of ammonia decrease

Repetition	*Percentage of ammonia decrease after contact with active carbon of plastic ore (%)*		
	60 minutes	*90 minutes*	*120 minutes*
1	16.17	32.41	49.37
2	15.95	31.62	53.02
3	16.58	34.51	50.84
4	22.54	37.61	44.83
5	22.34	39.68	48.78
6	16.82	34.59	45.59
Average	18.40	35.07	48.77

Looking at the research data, the longer the contact time, the decrease in ammonia level is greater. The results of statistical analysis obtained p value (p-value) of 0.001 is smaller than 0.05 (α 5%). Thus, there is a significant influence between the variation of contact time of activate carbon of plastic ore to the decrease of ammonia level in the liquid waste of the hospital. This proves that activate carbon of plastic ore has the ability to reduce ammonia levels and is very useful in the processing of liquid waste, especially hospital wastewater. Activate carbon of plastic ore can reduce ammonia because it contains carbon compound as its main compound. There is an adsorption phenomenon that there is an attraction force between the absorbed substance (ammonia compound) and the absorbent substance (active carbon of plastic ore). O the adsorption process, the adsorbed molecule travels through the bulk of the gas phase to the solid and diffuses on the pore surface of the adsorbent solid through the van der waals force so that the ammonia is absorbed into the pores of the active carbon of the plastic ore, thus reducing or decreasing the ammonia level of the hospital liquid waste (Pujaatmaka and Hadyana, 1999).

Adsorption is the process of mass transfer on the surface of the pores in the adsorbent granules. Mass transfer that occurs through the boundary between two phases namely; gas-solid and liquid-solid. Adsorption takes place through a process; mass transfer from the liquid to the grain surface, diffusion from the grain surface into the grains through the pore, mass transfer from the liquid in the pore to the pore wall, adsorption on the pore wall. Adsorption can occur due to surface energy and surface tensile forces. There are several factors affecting adsorption absorption, including temperature, pH and contact time (Cecen and Ozgur, 2011). Based on the result of research, there is variation of temperature value at each treatment, but still in the temperature range for the adsorption process of ammonia compound. The occurrence of temperature fluctuations in the wastewater affected the surrounding environment, including air humidity and air temperature. Ammonia is a volatile compound so that the treatment of the ammonia compound should have the same liquid temperature as room temperature ranging from 20°C to 25°C (Fikri and Veronica, 2018). With the temperature corresponding to the nature of the composition, the adsorption process will run optimally.

Variations of pH values occurred in each treatment. The decrease and increase of pH is influenced by various times of contact of activate carbon in each treatment, because the pH value greatly affects the condition of the hospital's liquid waste itself, because ammonia is an organic compound with molecular form of negatively charged nitrogen ions and three positively charged hydrogen ions (Pujaatmaka and Hadyana, 1999). To

achieve an increase in percentage reduction in ammonia levels in hospital wastewater is required longer contact time. This is proven, the contact time of 120 minutes can reduce the highest ammonia level. The lower the ammonia level due to the absorption of ammonia into the active carbon pore cavity. So the longer the contact time will occur deposits of ammonia compound into the pores of the active carbon until there is saturation (Hamidi et al., 2011). The increase of percentage reduction of ammonia level in hospital liquid waste is influenced by temperature and pH of liquid waste itself. The higher the temperature then the adsorption process will be slow. A good pH value for the adsorption process should be at its highest value or in accordance with the absorptive properties that will be in contact with the active carbon. If the nature of the acid compound then the adsorption process will run optimally at its acid pH, on the contrary if alkaline uptake properties, then the adsorption process will run maximum at the base pH (Cecen and Ozgur, 2011).

5 Conclusions

Based on the result of the research, there is an influence of the variation of the duration of contact of activating carbon of plastic ore to the decrease of ammonia level of the hospital. The results show that the decrease in ammonia levels in the waste decreases with increasing length of waste in contact with active carbon of plastic ore. Despite the decline, the ammonia content is still above the quality standard, which according to the Regulation of the Minister of Environment of the Republic of Indonesia Number 5 of 2014 on Wastewater Quality Standard, the ammonia level for the business and / or health service facility is 10 mg/L.

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