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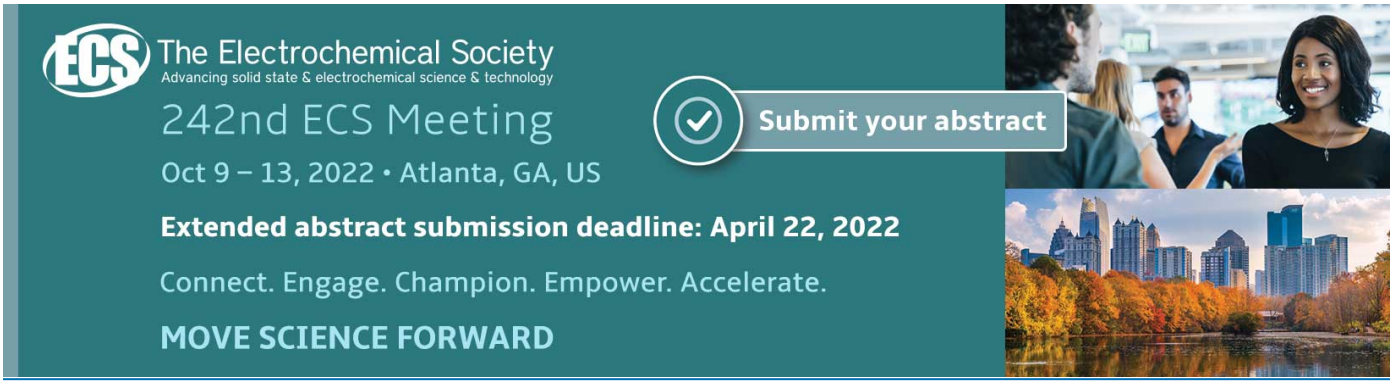

The Study of Ammonia Removal in Wastewater Using Natural Granular Zeolite Filter

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Abstract. The wastewater generated from all industries should discharge into the estate sewerage system, which flows to the centralized wastewater treatment plant (WWTP) of Jababeka Industrial Estate. One of the wastewater parameter problem is ammonia. This research to study ammonia removal using natural granular Zeolite filter in wastewater by variations of granular size and different volume (expressed as height) of Zeolite to meet the required standard. This experiment was carried out using artificial samples of 75 mg/L of ammonia in the laboratory scale that indicate with APHA, AWWA, and WEF, no 4500-NH_3 as the analysis method. The result proved that using a natural Zeolite filter could reduce the ammonia concentration, with the efficiency of removal was 91.6%. The 0.5cm granular size at the height of 5 cm (289.25 cm^3 of Zeolite) with a result of 6.25 mg/L after 120 minutes and the 0.5 cm grain size at the height of 6 cm (347.81 cm^3 of Zeolite) can achieve the same performance after a shorter time of 60 minutes. Both results were below the ammonia's Jababeka Wastewater Quality Standard of 10 mg/L.

1. Introduction

The river that becomes the source of raw water is the Kalimalang River (West Tarum Canal) and the Cikarang River[1]. Because of industrial growth, there are negative and positive impacts. The positive impact is on the economy country's growth, whereas the negative impact is on reduce environment's quality[2]. Jababeka Industrial Estate located in Cikarang, Bekasi, takes the raw water from the west Tarum channel for servicing water requirements of about 5000 ha of industrial and residential areas. The wastewater generated from all industries should discharge into the estate sewerage system, which flows to the centralized wastewater treatment plant (WWTP). One of the wastewater parameter problem is ammonia. Based on references on Jababeka, many industries have ammonia quality in their wastewater of 75-50 mg/L which exceeds the standard of 10 mg/L. In this research using the highest ammonia wastewater quality which is 75 mg/L.

Environmental management very much needed for industrial estates because industrial growth continues to develop and has a profound impact, which is economical and social, ecological, and appropriate technological support is needed and a conducive Environmental Management System[3]. Then the technology to treat industrial waste is developed to provide the best alternative solutions[4]. In selecting alternative wastewater treatment technologies, it is necessary to pay attention to the quantity and quality of water to be treated as well as available resources and economic viability[4].

Several studies have been looking at wastewater treatment utilizing Zeolite as a low-cost absorbent[5]. The efficient removal of high Phosphorus and Ammonium was accomplished at 89%-99% and 88%-99%[5]. Zeolite is naturally formed from seawater and ash, a mineral of volcanic origin also present in Andean Fold and has a common Zeolite type, it called clinoptilolite[6]. The natural

Zeolite surface area is 24.9 m^2/g[7]. This research to study ammonia removal using natural granular Zeolite filter in industrial wastewater by variations of grain size and different volume (expressed as height) of Zeolite to meet Jababeka standard. A list experimental was achieved using artificial wastewater (aqueous ammonium solution) and Zeolite filter with some grain size to examine Ammonia's removal. A list experimental was finalized using artificial wastewater with reducing the height of Zeolite filter to saw the result was still delivered the same quality or not.

2. Research method

2.1. Research framework

The diagram of the research framework was shown below

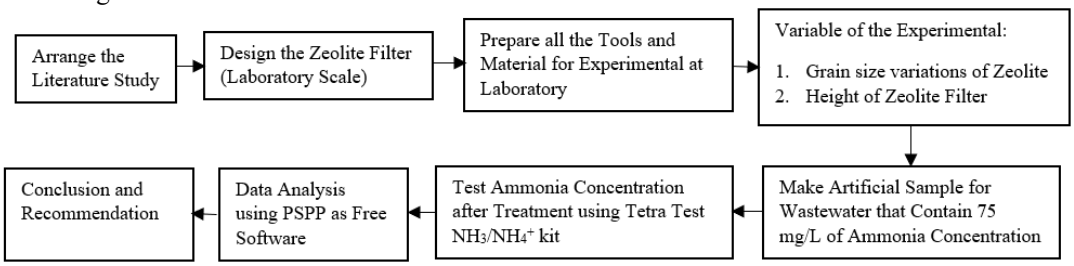

Figure 1. Research Framework.

2.2. The preparation

This stage was the step of making artificial samples. The artificial sample was made based on APHA, AWWA, and WEF, no 4500-NH_3 method[12]. The first step of making an artificial sample of 75 mg/L of ammonia was to dissolve 0.3819 g Ammonium Chloride, which already dried at 100 °C in a volumetric flask 1000 ml. After that, pipetting 50 ml Ammonium chloride to another 1000 ml volumetric flask and fill with ammonia-free water until the mark for making an artificial sample. To know Ammonia concentration before treatment, piping 1 ml of artificial sample in 1000 ml volumetric flask, then put it into 25 ml of volumetric flask and using the Tetra test NH_3/NH_4^+ kit to know the Ammonia concentration. The preparation of natural Zeolite manually broke the zeolite stone, after that separating it and measuring it according to its grain size.

2.3. The design of zeolite filter

The design of the Zeolite filter used a flow rate of 5.72 L/s, the result from the equation below with a 10% safety factor[9]

$$Q = 5.20 + 10\% = 5.72 \text{ L/s} \quad (1)$$

Then, calculate the height of the Zeolite filter with the equation below[9].

$$\text{Height of Zeolite} = 0.16 + \mathbf{3.38}\ (\Delta \boldsymbol{p}) \quad (2)$$

$$= 0.16 + 3.38\ (0.7) = 2.526\ m$$

$$A = 1.5 \text{ x } 1.5 = 2.25\ m^2 \quad (3)$$

Information: $\Delta p = water\ collumn$

Then, calculate the speed of water with equation below[9].

$$V = \frac{Q}{A} \quad (4)$$

$$V = \frac{5.72\ L/s}{2.25\ m^2} = 0.00254\ m/s$$

This research was conducted by the laboratory scale, which was 0.014% from reference size or became 2.85 L/hr of flow rate. It took a sample every 30 minutes, so it became 1,425 ml/30min, and

the volume was 347.8125 cm^3. The granular zeolite height was 6.133 cm, with the diameter of the granular zeolite filter was 8.5 cm. As supporting media, the Zeolite did not pass when the water flow at the bottom of the filter was using gravel. The design and structure can be seen in **Table 1, 2**.

Table 1. The design criteria of filter for different grain size.

Specification	*Filter A*	*Filter B*	*Filter C*
Height of Zeolite	6 cm	6 cm	6 cm
Volume of Zeolite	347.8125 cm^3	347.8125 cm^3	347.8125 cm^3
Diameter of Zeolite Filter	8.5 cm	8.5 cm	8.5 cm
Grain Size of Zeolite	0.5 cm	0.7 cm	0.9 cm
Thickness of supporting media (gravel)	7.5 cm	7.5 cm	7.5 cm
Flow rate of sample	1,425 ml/30min	1,425 ml/30min	1,425 ml/30min

Table 2. The design criteria of filter for different volume (expressed as height).

Specification	*Filter D*	*Filter E*
Height of Zeolite	6 cm	5 cm
Volume of Zeolite	347.81 cm^3	289.25 cm^3
The diameter of the Zeolite Filter	8.5 cm	8.5 cm
Grain Size of Zeolite	0.5 cm	0.5 cm
Thickness of supporting media (gravel)	7.5 cm	7.5 cm
Flow rate of sample	1,425 ml/30min	1,425 ml/30min

2.4. Variable of the experiment

The control variable in this experiment was the artificial sample consist of 75 mg/L ammonia concentration. This experiment's independent variable was 6 cm height of Zeolite filter in each grain size of Zeolite filter. It reduced the height of the Zeolite filter in one specific grain size of the Zeolite filter. A dependent variable in this experiment was the amount of the total decrease of Ammonia concentration based on the factor of an independent variable.

2.4.1. Grain Size Variations of Zeolite Filter

The experiment used three different grain size of Zeolite, which is 0.5 cm, 0.7 cm and 0.9 cm continuation from the references, E. Yogavanny "Treatment of brackish groundwater by zeolite filtration in Sumur Tua Wonocolo, Kedewan, Bojonegoro, East Java" [14].

2.4.2. Volume (expressed as height) of Zeolite Filter

As shown in **Table 1**, use 6 cm (347.8125 cm^3) of height in each grain size, and as shown in **Table 2**, using 6 cm (347.8125 cm^3) and 5 cm (289.252875 cm^3) of height in the best grain size.

$$A = 3.14 \; x \; (\frac{d}{2})^2 \tag{5}$$

$$= 3.14 \; x \; (\frac{8.5 \; cm}{2})^2 = 56.72 \; cm^2$$

$$H = \frac{V}{A} \tag{6}$$

$$= \frac{347.81 \; cm^3}{56.72 \; cm^2} = 6.133 \; cm$$

3. Result and discussion

3.1. Data collection analysis

The Ammonia concentration in 1000 ml of the volumetric flask that is put into a bucket and connects to the tap flow through a bottle filled by Zeolite then flows into the chamber. Every 30 minutes, pipetting 1 ml Ammonia after treatment then test with Ammonia test kit to know the ammonia concentration, it is achieved below.

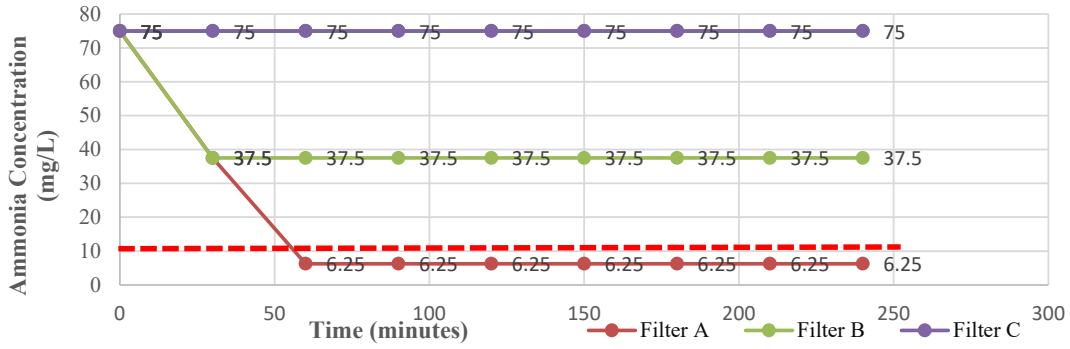

Figure 2. The result of ammonia concentration after treatment based on grain size (source : experimental data)

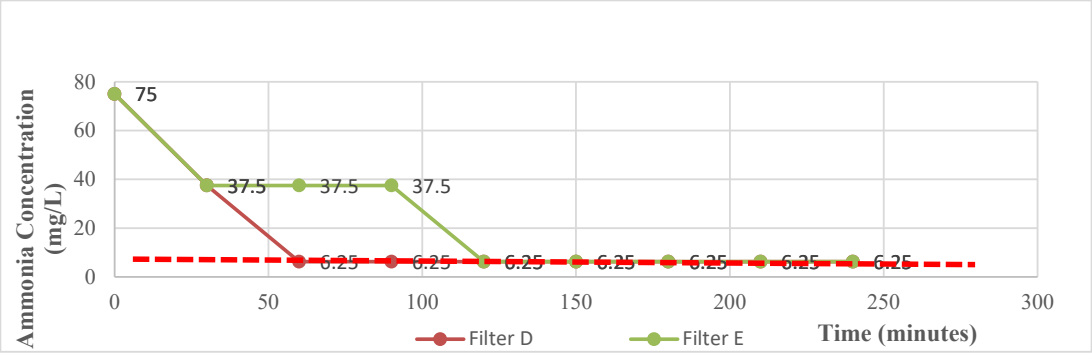

Figure 3. The result of Ammonia concentration after treatment based on height (source : experimental data)

From **Figure 2**, The grain size of 0.5 cm could reduce ammonia until 6.25 mg/L from an initial concentration of 75 mg/L, so this was the best result because of the result of 0.5-grain size (6.25 mg/L after treatment) under the Estate Wastewater Quality Standard of Jababeka. The reason for the 0.5-grain size could reduce Ammonia concentration until 6.25 mg/L because the surface area is higher than 0.7-grain size and 0.9-grain size. Then using 0.5-grain size, reduced the height of the Zeolite filter became 5 cm to saw the result was still delivered the same quality or not. From **Figure 3**, Even though the height was 6 cm (347.8125 cm3) after 60 minutes, already 6.25 mg/L, the chosen one was the height of 5 cm (289.252875 cm^3) because it saved filter size.

In this research, it can reduce the concentration of ammonia by 91.6% higher than research of filtration using natural adsorbents, namely activated charcoal from coconut shells, zeolite granules, silica sand, anthracite, ferrolite (active sand), small gravel with a diameter of 0.5 – 1 cm, palm fiber, ordinary sand, ordinary charcoal with a decrease in ammonia concentration by 63.6%[11]. However, the research conducted in this report was lower in reducing ammonia concentration compared to research conducted on biofiltration of hospital wastewater using water hyacinth biofilter for 6 days of contact and was able to reduce ammonia levels by up to 98%[12]. However, in this research the difference is the filtration using only one natural adsorbent, namely Zeolite compared to the two experiments.

From both the figure above, there was a difference between control (raw wastewater) and after treatment proved by statistical analysis below used PSPP software as tools to analyze that there was a difference in before and after treatment. PSPP is a substitute for IBM SPSS Statistics[16]. PSPP is a free application for statistical software and mathematical to analyze the data[13]. The result of statistic based on grain size and height as follows.

Table 3. The result of statistic based on grain size.

Grain Size	*T value*	*T table*	*P(sig)*	*P alpha*
0.5 cm	7.22	2.306	0	0.05
0.7 cm	8	2.306	0	0.05
0.9 cm	NaN	2.306	NaN	0.05
Anova	-	-	0	0.05

Table 4. The result of statistic based on height.

Height	*T value*	*T table*	*P(sig)*	*P alpha*
6 cm	7.22	2.306	0	0.05
5 cm	6.26	2.306	0	0.05
Anova	-	-	0.55	0.05

4. Conclusion and Recommendations

The result proved that using a natural Zeolite filter could reduce the ammonia concentration. The 0.5 cm grain size at the height of 5 cm (289.25 cm^3 of Zeolite) can achieve the result of 6.25 mg/L after 120 minutes from initial 75 mg/L or with the efficiency of removal until 91.6%. The 0.5 cm grain size at the height of 6 cm (347.81 cm^3 of Zeolite) can achieve the same efficiency removal performance after a shorter time of 60 minutes. Both quality performance results are meet the Estate Wastewater Quality Standard of Jababeka (10 mg/L of ammonia concentration). Further research could use this research as the basis of the proposed study on the removal of ammonia. Recommendations for the future researcher, experiments should be conducted with less height and smaller size grain of Zeolite filter.

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