DEGRADATION OF WASTEWATER CONTAINING AMOXICILLIN ANTIBIOTIC USING GREEN TECHNOLOGY “OZONATION”

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Abstract. In this research, wastewater containing amoxicillin antibiotic was treated using green technology “ozonation”. The research was carried out with allowance for time variation (15, 30, 45, and 60 minutes), pH of wastewater (acidic, neutral, and alkaline), and ozone generator voltage (75, 150, and 225 Volt). The amoxicillin wastewater in this research was artificial. The concentration of amoxicillin was 50 ppm. Based on experimental result, the best condition of wastewater (containing amoxicillin antibiotic) ozonation was alkaline conditions with pH ≈ 10. The best percent degradation of amoxicillin antibiotic was 86.78% with a final concentration of 6.61 ppm. The ozone generator voltage variations affect the amoxicillin removal in wastewater. The higher of ozone generator voltage, the percentage of amoxicillin removal was also increase.

1. Introduction
Hospital activities are closely related to waste production. Waste generated by hospitals can cause environmental pollution and can endanger living things including humans. Waste generated by hospitals can be grouped into three parts, namely solid waste, liquid waste, and clinical waste. The penicillin waste belongs to the liquid waste group. Penicillin was the first antibiotic discovered from Alexander Fleming in 1928 in London. Penicillin is included in the β lactam class of antibiotics because it has a built-in formula with a structure like the β lactam ring which is an absolute requirement to show its efficacy. The use of penicillin antibiotics can cause several dangers such as: symptoms of resistance, allergies and supra infection. Amoxicillin is one of penicillin antibiotics. Penicillin antibiotic waste can cause environmental pollution. The antibiotic waste can cause bacteria that are resistant to antibiotics. This is certainly very dangerous for living things, especially humans if the resistant bacteria infect humans. Therefore, penicillin antibiotic waste needs to be set aside so as not to endanger living things and the surrounding environment. Research on penicillin waste removal has been done before. In 2004 Arslan-Alaton et.al eliminated penicillin by ozonation [1]. In that study the percentage of waste removal reached 56%. Then in 2004 Arslan-Alaton and Dogruel eliminated penicillin by ozonation, direct and indirect photolysis, phentone and phenone-like, photo-fenton and photo-fenton-like [1]. In that study the percentage of waste removal when using ozonation reached 49%. In 2005, kinetic of amoxicillin ozonation was also studied [2]. Ozone was also used for penicillin removal from wastewater [3]. Then in 2006 Cokgor et. al. eliminating penicillin by ozonation [1]. In this study the percentage of waste removal reached 34%. Pharmaceuticals was also treated using ozone and advance oxidation processes [4]. Then in 2009
Yang excluded penicillin by microwave enhanced fenton-like [1]. The removal of amoxicillin was also studied using plasma treatment [5]. Amoxicillin removal in water also studied using medium-high frequency ultrasound and ozone based advanced oxidation [6]. Ozone technology was also used for tofu wastewater treatment [7]. In this study the percentage of waste removal reached 57.53%.

In this research, amoxicillin antibiotic wastewater was treated using ozonation with different ozone generator. The results of this study will be analyzed using a spectrophotometer to determine the concentration of amoxicillin.

2. Methodology/Experimental
Amoxicillin used in this research was artificial wastewater. In this research, ozonation was carried out with time variation of 15, 30, 45, and 30 minutes. The concentration of amoxicillin was 50 ppm. The pH variation used in this research were acid, neutral, and base (pH=3,4,7,9,10). Ozone generator used in this research was Resun type RSO-9805 made in Hong Kong. Voltage of ozone generator was varied into 75, 150, and 225 V. PH of wastewater was varied into acid, neutral, and base. The schematic design of ozonation process could be seen in Figure 1.

![Schematic design of ozonation process](image)

Figure 1. Schematic design of ozonation process

3. Results and Discussion
The ozonator used in this research was Resun type RSO-9805 made in Hong Kong. Measurement of ozonator products includes measurements of flow rate and ozonator productivity. The ozone productivity of the Resun RSO-9805 ozonator used in this study was 41,088 mg / hour. While the ozonator gas flow rate is 9 L / min. Ozone productivity of 41,088 mg / hour based on literature is sufficient to set aside antibiotic waste by 50 ppm [8].

The ozonation of wastewater containing amoxicillin was carried out under three conditions of pH: acidic, neutral and base (pH=3,4,7,9,10). The concentration of amoxicillin was 50 ppm. The results of ozonation wastewater containing amoxicillin could be seen in Figure 2.

![Percentage of](image)

Figure 2. Percentage of
amoxicillin removal by ozonation

The removal of amoxicillin contained in the wastewater increases with increasing processing time, as shown at Figure 2. This indicates that the longer the removal time, the active species contact with amoxicillin compounds is also getting longer so that the amoxicillin that is set aside is also more. In this acidic condition, the dominant elimination reaction is direct ozonation [9]. In this direct ozonation, ozone will react exclusively with compounds that have specific groups through selective reactions such as electrophilic, nucleophilic, or dipolar additional reactions. At the allowance at pH = 3 the percentage of amoxicillin removal reached 16.11% and the concentration at the end of the allowance was 41.95 ppm. While the amoxicillin removal yield at pH = 4 reached 19.22% with amoxicillin concentration at the end of the allowance was 40.39 ppm. The results of ozone removal in acidic conditions tend to be small because the ozonation reaction that occurs is direct ozonation so that the dominant one to set aside the amoxicillin is ozone. Under acid conditions, the OH radical that are formed are lower than in neutral and basic conditions.

Next discussion was the treatment of wastewater containing 50 ppm amoxicillin in neutral. The intended neutral condition is the condition of liquid waste without treatment but the pH has been neutral, 7. In this neutral condition the allowance reaction that occurs is direct ozonation and indirect ozonation [9]. In direct and indirect ozonation, species that play a role in the removal process are not only ozone, but also OH radical which plays a role in the removal process. At this allowance at neutral pH the percentage of amoxicillin removal reached 44.08% and the concentration at the end of the allowance was 27.96 ppm. The yield of removal with ozone under neutral conditions is greater than the allowance under acidic conditions. That was because the ozonation reaction occurs in direct and indirect ozonation so that the species that play a role in removing amoxicillin are ozone and OH radical. In addition, in neutral conditions, the OH radical formed was greater than in acidic conditions.

Next, the treatment of liquid waste containing 50 ppm amoxicillin under alkaline conditions was also studied. The intended base condition is the condition of the waste which was regulated in such a way that the pH is 9 and 10 by adding NaOH. In these base conditions, the dominant allowance reaction is indirect ozonation [9]. In the indirect ozonation, the dominant species that plays a role in the removal process is OH radical, where the species is very strong in removing amoxicillin compounds. In the allowance at pH = 9 the percentage of amoxicillin removal reached 82.81% with a concentration at the end of the allowance of 8.60 ppm. Whereas at the allowance at pH = 10 the percentage of amoxicillin removal reached 86.78% with the concentration at the end of the allowance was 6.61 ppm. The yield of ozone removal under these basic conditions is greater than the allowance under acidic and neutral conditions. That is because the ozonation reaction that occurs is indirect ozonation so that the dominant species that play a role in removing the amoxicillin is OH radical which is a strong species, greater than ozone [10]. This is evidenced by the OH radical which formed under alkaline conditions tends to be greater than under acidic and neutral conditions.

The effect of pH on removal using ozone also studied in this research. Based on Figure 2., the percentage of amoxicillin removal was increase linearly with pH. The lowest percentage of amoxicillin removal occured at acidic condition while the highest percentage of amoxicillin removal occured under alkaline conditions, at pH = 10, which was capable of removing moxicillin from 50 ppm into 6.61 ppm. That was because the hydroxyl radical at base conditions formed more than the acidic and neutral conditions. The hydroxyl radical has a higher oxidation potential than ozone so that the removal of waste by ozonation is better in alkaline conditions. Based on literature, concentration of hydroxyl radical at 50 ppm can be used for remove amoxicillin and ampicillin [11].

The effect of variation in generator ozone voltage was also studied in this research. The result could be shown in Figure 3.
Figure 3. Effect of generator ozone voltage on the removal of 50 ppm of amoxicillin with ozone

Figure 3. shows that ozone generator voltage variations affect the amoxicillin removal in wastewater. On the graph it can be seen that the higher the voltage of the ozone generator, the better the yield. This is caused by the higher of ozone generator voltage, the more ozone is produced, so that the compounds that can be set aside are also large and the percentage of removal will increase.

4. Conclusion
According to this research, the percentage of 50 ppm amoxicillin removal using ozonation can achieve 86.78% at pH 10. The ozone generator voltage variations affects also the amoxicillin removal in wastewater. The higher of ozone generator voltage, the percentage of amoxicillin removal was also increase.

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