Waste Technology (WasTech)
Journal homepage: http://ejournal.undip.ac.id/index.php/wastech
An International Journal

Synergy of ozone technology and UV rays in the drinking water supply as a breakthrough prevention of diarrhea diseases in Indonesia

R. Wulansarie[1,*], S. Bismo[2]

[1] Chemical Engineering, State University of Semarang, Kampus Unnes, Kel. Sekaran, Kec. Gunung Pati, Semarang, Central Java 50229, Indonesia. Email: ria.cheui@gmail.com. Tel.:085714421955
[2] Chemical Engineering Department, University of Indonesia, Depok 16424, Indonesia

Abstract - *Escherichia coli bacteria which lead to contamination of drinking water in Indonesia, disinfected using ozone technology and UV rays in this research, particularly for solving the problem of water supply. The research was carried out by the variation of samples (tap water and AMDK) and presence or absence of UV rays on the research. All the results, which are related to the number of colonies of E. coli analyzed by using the method of TPC (Total Plate Count). Based on the results of the research, the number of bacteria after disinfection show a significant decline either using ozone alone, UV rays alone, or both, particularly at the time of disinfection for 3 minutes. The most optimal technology for the disinfection process is a synergy between ozone technology and UV rays, proven by the number of bacteria equal to 0 after the disinfection process for 30 minutes.*

Keywords - *Disinfection, Ozone, UV Rays, Escherichia coli, Diarrhea*

Submission: June 07, 2015 Correction: July 11, 2015 Accepted: July 30, 2015

Doi: http://dx.doi.org/10.12777/wastech.3.2.55-57

[How to cite this article: R. Wulansarie, R. and Bismo, S. 2015. Synergy of ozone technology and UV rays in the drinking water supply as a breakthrough prevention of diarrhea diseases in Indonesia. *Waste Technology*, *3*(2),55-57. doi: http://dx.doi.org/10.12777/wastech.3.2.55-57

1. Introduction

Diarrhea disease is endemic in almost all parts of Indonesia, especially since the 1970s. Incidence of diarrhea disease in Indonesia is increasing from year to year even in 2008 declared the extraordinary events that occurred in Papua. Cases of diarrhea are still haunt Indonesia until 2011, the evidence in some places are still found in cases of diarrhea, for example in the area of Lebak, Banten, the number of patients with diarrhea disease in February 2011 is reached 200 people [1]. The existence of cases of diarrhea that struck Indonesia will certainly drain the budget of foreign exchange. In addition, diarrhea diseases also lead to productivity and quality of life of Indonesia to be reduced. Handling of cases of diarrhea should be done so that diarrhea is not a terrible outbreak of Indonesian.

One of the major causes of diarrhea disease is due to drinking water contaminated by the bacterium Escherichia coli. This bacterium is one of the main species of gram-negative bacteria that can cause a variety of human gastrointestinal diseases such as diarrhea and vomiting. Drinking water containing the bacteria is certainly very dangerous to human health so it needs a technology to disinfect the contaminated water. These studies continue to be developed to disinfect water containing the bacteria. Based on the results of testing on the ground, ozone can be used in the process of inactivation of bacterial contaminants of water. Ozone can act as a disinfectant against pathogens, reduce taste and odor as well as the ability to oxidize compounds [2]. In addition to ozone technology, the process of disinfection of bacteria can also be performed using UV rays. Ozone, UV, microfiltration to effectively eliminate the bacteria E. coli and all coliform [3]. Ozone technology and UV rays to disinfect water shrimp ponds that contain the bacteria Salmonella typhimurium was significantly [4]. In addition, the combination of ozone technology and UV rays can be used for inactivation of spores of Bacillus subtilis [5].

In this research, ozone technology and UV rays will be applied for the disinfection of water samples containing bacteria E. coli, as a synthetic raw water that can be used for the provision of clean water or drinking water. UV rays are used in this study is the UV-C, with a wavelength of 254 nm, as germicides that are effective in killing microorganisms. Water samples used in this research is tap water. The research was conducted at the pump output flow rate variations and the presence or absence of UV applications in the research. Observations made on the number of bacteria E. coli found in water samples, before and after the disinfection process. Effectiveness of the disinfection process, using the power of 15 Watt, were analyzed using the TPC (Total Plate Count). The purpose of this research is the design of water disinfection system that contains the bacterium Escherichia coli to obtain products and clean water or drinking water as well as a per cent degradation of bacteria found in raw water synthesis.

Diarrhea disease is one type of infectious disease caused by the bacterium Escherichia coli is a rod-shaped bacteria, gram-negative, and included in the family Enterobacteriaceae. E. coli has a length of 0.5 to 1.0 micrometers wide and 1.0 to 3.0 micrometers [6].
Disinfection is the mechanism of inactivation or destruction of pathogenic organisms to prevent the spread of disease in users of water and the environment. In general, disinfectants can be classified into two groups [7]:

1. Disinfectants physics, namely ultraviolet radiation (UV) and heat (pasteurization and boiling).
2. Disinfectants with chemicals such as chlorine, chloroamina, chlorine-dioxide, and ozone.

   Ozone is a gas molecule consisting of three oxygen atoms. Ozone can be produced or formed from UV rays and corona discharge. Based on the results of field testing, ozone can be used in the process of inactivation of bacterial contaminants of water [3].

   UV rays is effective to kill bacteria Escherichia coli and all coliform [3]. UV rays can be divided into four kinds of spectra, namely [8]:
   1.VUV (100-200 nm)
   2.UV-C (200-280 nm)
   3.UV-B (280-315 nm)
   4.UV-A (315-400 nm)

   UV rays are commonly used to disinfect water that is UV-C wavelength of 254 nm because these wavelengths tend to be safe [8]. UV-C rays with a wavelength of 254 nm found in the upper atmosphere. UV rays can be created artificially by converting the electrical energy in a quartz lamp "hard glass" which contains a low-pressure mercury vapor. Electrons will flow through the mercury vapor lamp has ionized between the electrode and then forming the UV rays [4].

   UV rays kills microorganisms by UV rays will penetrate through the cell wall and cytoplasmic membrane of microorganisms, and UV rays will cause molecular rearrangements of the DNA of microorganisms so that they will stop microorganisms reproduction, and then they will die [4].

2. Materials and Methods

2.1. Materials

This research using synthetic samples. Samples used in this research were tap water from Chemical Engineering Department, Engineering Faculty, University of Indonesia and "Air Minum Dalam Kemasan" (AMDK). Those two samples were infected by bacteria of E. coli.

2.2. Disinfection Process

This research was carried out disinfection in tap water and AMDK samples which are disinfected by E. coli in the circulation flow. In this research, technology for disinfection will be varied, using ozone, UV rays, and a combination of both. And then, disinfection time also will be varied for 0, 3, 5, 10, 15.20, 25, and 30 minutes. Flowchart of research can be found in Figure 1 below.

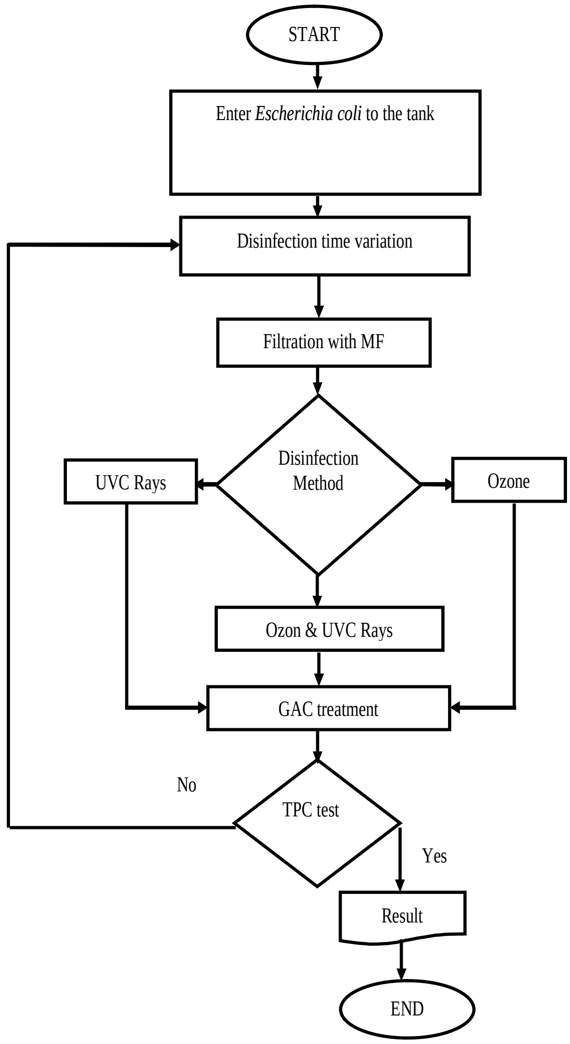

Figure 1. Flowchart of research for the circulation flow

2.3. Sample Analysis

All samples in the disinfection process was analyzed using Total Plate Count (TPC) laboratory of Environmental Engineering, Department of Civil Engineering, Faculty of Engineering, University of Indonesia.

3. Results and Discussions

The results of this research are presented in the table form for comparing efficiency of ozone technology, UV rays, and combination of both technology. Disinfection process using the tap water and AMDK samples were carried out at the circulation flow. Disinfectants used are ozone, UV rays, and the combination of both.

Process disinfection in tap water was discussed first. The comparison of ozone, UV rays, and combination of both technology could be seen in the Table 1 below.

Table 1. Efficiency (% degradation of bacteria) of ozone, UV rays, and combination of both in disinfecting E. coli bacteria in tap water sample (pump flow rate is 1.5 LPM and ozone concentration is 0.0325 g/jam, at pH=7.66) with initial bacteria is 1x10^6 CFU/ml

Technology	Efficiency			
	3 minutes	10 minutes	20 minutes	30 minutes
Ozone	97,95 %	97,74 %	98,29%	98,63%
UV rays	98,91%	99,87%	99,99%	99,99%
Ozone and UV rays	98,42%	99,98%	99,97%	100%

Disinfection processes occurred in tap water was directly and indirectly ozonation because the tap water pH is 7.66 which is in the range of pH 4-9. It is based on the literature that states that the behavior of ozone is affected by pH, in which at pH 4-9 there was a trend of ozone to form OH radicals and also remain in the ozone molecule [9]. At disinfection processes in the tap water, which play a role in inactivates the bacteria of E. coli are ozone and OH radicals. From Table 1 we can see that at disinfection process using ozone, the optimum time disinfection is 3 minutes, appropriate with literature which say that the effective time disinfection in disinfection using ozone is 2 – 10 minutes [10].

From Table 1, we can also see that the most effective technology for disinfecting bacteria E. coli is synergy of ozone technology and UV rays. For disinfection processes using ozone, the least number of remaining bacteria occurred in the 30th minute which amounted to 1.37 x 10^4 CFU/ml.

At disinfection process using UV rays, the effective wavelength in inactivation of bacteria is 220 – 280 nm [11].That statement appropriate with this research which using UV wavelength 254 nm. If UV rays radiation contact with deoxyribonucleic acid (DNA) of bacteria can cause DNA destruction and stop bacteria cell reproduction, so the bacteria will die [12]. For disinfection process using UV rays, the least number of remaining bacteria occurred in the 30th minute which amounted to 60 CFU/ml. And then the percent degradation of bacteria in this disinfection process reach 99.99%. This suggests that the use of UV light to disinfect tap water sample containing E. coli is more significant in the degradation of the bacteria when compared with using ozone. From this it can be said that the UV light disinfection is more effective rather than ozone.

For disinfection process using synergy of ozone and UV rays, bacteria occurred in the 30 minutes which amounted to 0 CFU/ml. And then the degradation of Escherichia coli bacteria when disinfection using ozone and UV rays until the 30 minutes to 100%. The synergy between ozone technology and UV rays occurred in the disinfection of tap water containing Escherichia coli. This shows that the synergy of ozone and UV rays can be used in the supply of drinking water base on the regulation of Minister of Health of the Republic of Indonesia Number 492 Year 2010.

Disinfection processes also taking place in the sample of AMDK. Comparison between disinfection process using tap water and AMDK sample could be seen in Table 2.

Table 2. Comparison efficiency (% degradation of bacteria) between process disinfection in tap water and AMDK samples at 30 minutes (pump flow rate is 1.5 LPM and ozone concentration is 0.0325 g/jam) with initial bacteria is 1x10^6 CFU/ml

Technology	Efficiency	
	Tap water	**AMDK**
Ozone	98,63%	99,39%
UV rays	99,99%	99,99%
Ozone and UV rays	100%	99,99%

From the Table 2 above we can see that process disinfection is more effective in the tap water sample because in AMDK there are mineral that can inhibit ozone for contacting bacteria E.coli so the number of E.coli which was disinfected will decrease too.

4. Conclusion

Based on this research, the optimum of disinfection time for decreasing Escherichia coli is 3 minute and then the optimum process is disinfection process tap water sample using synergy of ozone technology and UV rays.

References

1. Metrotvnews.com, in *http://soccerclub0162.blogspot.com/2011/02/lebak-klb-diare.html*. 2011.
2. Suslow, T.V., *Ozone Applications for Postharest Disinfection of Edible Horticultural Crops*, ed. 8133. 2004: ANR Publication.
3. Graham, P.P.N., *Treatment of a secondary municipal effluent by ozone, UV and microfiltration: microbial reduction and effect on effluent quality.* Journal of Desalination 186, 2005. **47-56**.
4. Halim, W., *Disinfeksi Salmonella Typhimurium pada Air Tambak Udang dengan Menggunakan Ozon dan Sinar UV*, in *Teknik Kimia*. 2006, Universitas Indonesia Depok.
5. Jung, Y.J.B.S.O., Joon-Wun Kang. *Synergistic effect of sequential or combined use of ozone and UV radiation for the disinfection of Bacillus subtilis spores.* Journal of Water Research 42, 2007. **1613–1621.**
6. Ahira, A. *Mengenal Bakteri Escherechia coli.* 2011
7. Long, B.W., Hlsey, R.A, and Neeman, J.J., *Mixing it up: Integrated Disinfection Scenarios in Drinking Water Treatment.* Journal AWWA, 2005.
8. Yonkyu Choi, Y.-j.C., *The effects of UV disinfection on drinking water quality in distribution systems* Journal of Water Research 44, 2009. **115-122**: p. www.elsevier.com/locate/watres.
9. Peratitus, ed. *Ozone Reaction Kinetics for Water and Wastewater System*. 2003, A CRC-Press: London.
10. Broadwater, W.T., Hoehn, R.C, and King, P.h., *Sensitivity of Three Selected Bacterial Sepecies to Ozone, Virginia, American Society for Microbiology.* 1973. **26**.
11. Laroussi, M. and F. Leipold, *Evaluation of the roles of reactive species, heat, and UV radiation in the inactivation of bacterial cells by air plasmas at atmospheric pressure.* International Journal of Mass Spectrometry 233 2003: p. 81–86.
12. Drew, D., *Modelling UV-Damage to E. coli* Bacteria*.* 1996.