The Effect of Water Characteristic on Disinfection Process by Ozone

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1. INTRODUCTION

Today in Indonesia, The numbers of people, which consume bottle water, have increased. One of the reasons why people use bottle water is that it does not produce unique smell that came from chlorine because they use ozone as disinfectant for bottle water. Ozone is a strong disinfectant, stronger than widely used disinfectants such as chlorine. In water, ozone will decompose into OH radicals which are the strongest oxidants in water (von Gunten, 2003).

Since the price of bottle water is expensive, many Indonesian who have limited budget, buy drinking water from small bottle Water Company that called water refill depot. Because the demand of drinking water have increased we can find water refill depot everywhere in Indonesia big city. It is small company that owned individually so that it has inadequate quality control, moreover the supervision of the treated water from the public is limited.

According to the government report, some refill depot product treated water which contain Total Coli and E.Coli. It means disinfection process not optimum. Although Ozone is a strong disinfectant, Ozone is unstable in the water. Stability of ozone in the water is affected by water quality such as pH, turbidity, the type and content of natural organic matter (NOM), inorganic content and alkalinity. The reactions of ozone in water are usually rather complex. In the water, only part of the ozone reacts directly with dissolved solutes, the other part may decompose before reaction (Hoigne, at al., 1983).

Water refill depots have used ground water, spring water, and treated water from water treatment plant as raw material. Those sources of water have different characteristic so that they will show different response to ozonation process.

The aim of this research is to find out the influence water characteristic on disinfection process which used ozone. Furthermore, this research will recommend the appropriate water quality for ozonation process and this research will affect the quality of treated water which is produced by water refill depots.

2. MATERIALS AND METHODS

2.1 Samples

Two water samples were taken. Those samples were groundwater (GW) and spring water (SW). Samples were taken from Bandung City -West Java, Indonesia. Another data, which was from treated water treatment plant (TW), took from previous study. Different samples were taken to evaluate characteristic water effect to the concentration of residual ozone in water and disinfection process.

2.2 Experimental set up

The experimental set-up is presented in Figure *.1. The equipments are air pump which was equipped with air flow meter, ozone generator, and contactor, where sample is put, with capacity of 2 liters for ozone-water reaction. The excess ozone released from the contactor was decomposed by scrubbing it into KI solution.

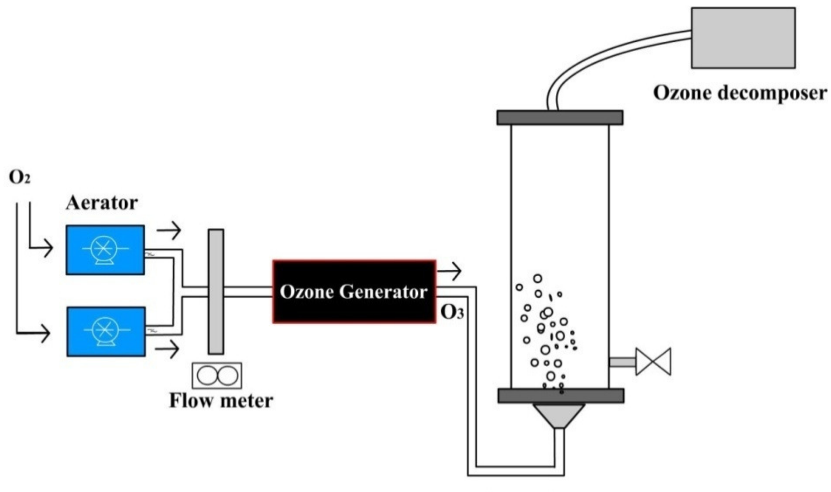

Figure *.1 Experimental set up conventional ozonation process

Air flow in this research was kept constant to a flow at about 2 L/minutes. Aerator is applied to supply oxygen to ozone generator which alters oxygen to ozone. Ozone will be supplied into a contactor where ozone in the form of gas phase will be contacted to the water. The contactor was provided with a filter disc having pore diameter of 16-40µµ, and also a dispenser and a valve for water sampling.

*.2.3 Analytical methods

Water quality parameters measured at this research are: Temperature, pH, turbidity, alkalinity, concentration of Fe, Organic Compound (UV_{254}), Coliform and E.Coli content (MPN/100 mL).

During the research concentration of residual ozone was measured according to standard method 4500-O3-B.

3 RESULT AND DISCUSSION

3.1 Water sample characteristic

The important parameters of the Groundwater (GW), Spring water (SW) and Treated water sample (TW) used in the experiment are shown in Table *.1.

Table *.1 Water samples characteristic

Parameter	GW Sample	SW Sample	TW sample[1]
Temperature (^oC)	24.3	23.5	24
pH	5.25	4.87	7.22
Alkalinity (mg/L $CaCO_3$)	167.45	39.4	46.23
UV_{254} (m^{-1})	10.1	1.4	1.2
Turbity (NTU)	12.2	4.15	1.5
Fe^{2+} (mg/L)	0.57	0.28	0
Coliform (MPN/100 ml)	1100	1100	1100
E.Coli (MPN/100 ml)	210	460	460

Table *.1 shows that the temperatures were around the room temperature. The pH from both at GW and at SW sample is acid, while at TW sample is normal. The alkalinity, Turbidity, Fe^{2+}, and UV_{254} at GW sample were highest than both SW and TW. All of the sample contain either coliform or E.Coli.

3.2. Concentration of residual ozone

Figure *.2 shows the measurement of residual ozone at contact time interval in disinfection process at GW, at SW and at TW samples.

[1] Sururi,2008

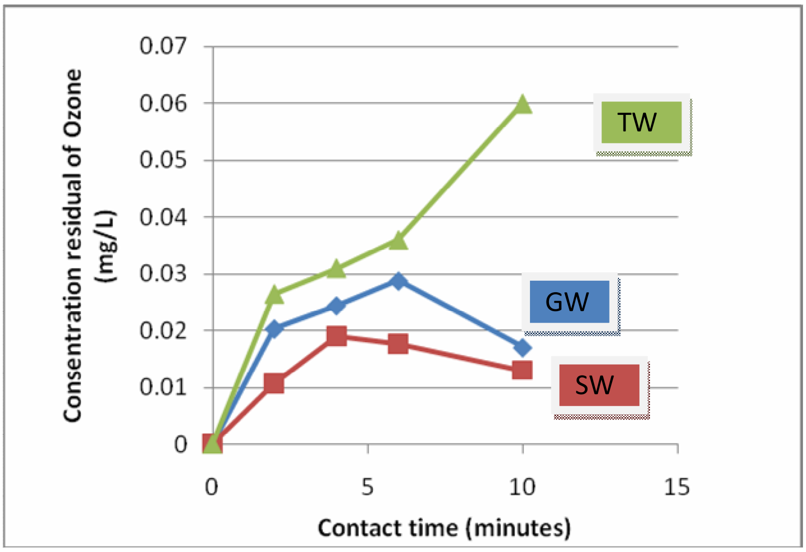

Figure *.2. Concentration of residual ozone at AOP and Conventional ozonation

Figure *.2 shows that concentration residual of ozone at TW is the highest, while concentration residual of ozone at GW higher compare to SW. Those phenomena happened because of the influence of characteristic of the water.

In fact, SW sample has the lowest alkalinity value. Alkalinity can inhibit decomposition of ozone (Hoigne et al, 1994; Acero et al, 2000; von Gunten, 2003). The reactions are (von Gunten, 2003):

$$OH \bullet + CO_3^{2-} \rightarrow CO_3^{2-} \bullet + OH \bullet \qquad (1)$$

$$OH \bullet + HCO^{3-} \rightarrow CO_3^{2-} \bullet + H_2O \qquad (2)$$

According to that reaction, carbonate and bicarbonate radical react with OH radical will result carbonate radical that will not react with ozone (von Gunten, 2003). Figure 2 also shows that the alkalinity of GW is higher compare to TW; however concentration residual of ozone at TW is higher compare to GW. This phenomenon shows there are other parameters which affected the concentration residual of ozone.

UV $_{254}$ can predict the organic aromatic content (Beltrand, J Fernando, 1995; APHA, 1999). UV $_{254}$ content and inorganic content of the water will influence the concentration residual of ozone (Hoigne et al,1994; von Gunten, 2003, Harth et al,1983 in Sallanko, 2006).

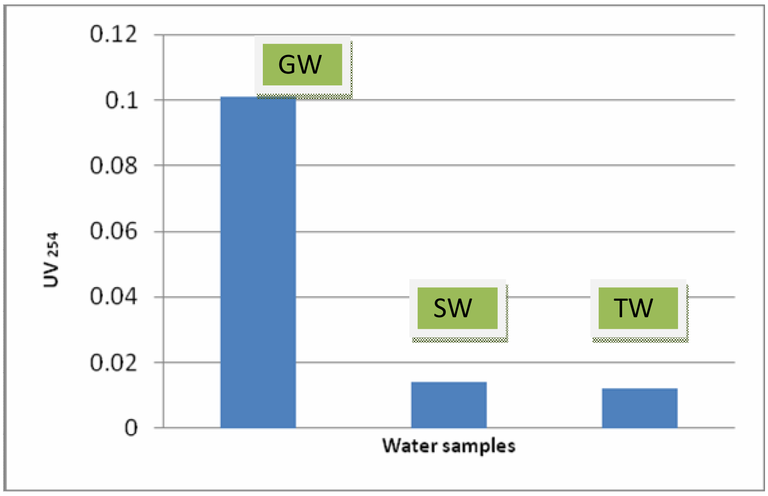

Figure .3. Organic Content of the samples

Figure 3 inform us that UV 254 content at TW (1.2 m^{-1}) is the lowest compare to SW and GW which account for 1.4 m^{-1} and 10.2 m^{-1} respectively. UV 254 was known as promoter of decomposition of ozone which involved two mechanisms: direct reaction; and OH radical reaction. The direct reactions are (von Gunten, 2003):

$$O_3 + NOM\ 1 \rightarrow NOM\ 1\ ox \quad (3)$$

$$O_3 + NOM\ 2 \rightarrow NOM2^{+}* + O_3*^{-} \quad (4)$$

Meanwhile, the NOM and OH radical reactions are (von Gunten, 2003):

$$OH* + NOM3 \rightarrow NOM3\ * + H_2O \text{ or } NOM3 + OH^{-} \quad (5)$$

$$NOM3* + O_2 \rightarrow NOM\text{-}O_2* \rightarrow NOM3 + O_2*\text{-} \quad (6)$$

Superoxide radical (reaction 6) will react with ozone to produce OH radical. Those reactions are explain why the concentration residual of ozone at GW are lower, even though the alkalinity value at GW is the highest among the samples. Furthermore, concentration of Fe at GW is the highest compare to SW and TW. Fe will faster decomposition of ozone in the water, according to following reactions(Harth et al,1983 in Sallanko, 2006):

$$Fe^{2+} + O_3 \rightarrow Fe^{3+} + O^{-} \quad (7)$$

$$O_3^{-} \Leftrightarrow O^{-} + O_2 \quad (8)$$

$O^- + H_2O \rightarrow OH + OH^-$ (9)
$OH + Fe^{2+} \rightarrow OH^- + Fe^{3+}$ (10)
$OH + O_3 \rightarrow HO_2 + O_2$ (11)

In order to prove the effect of ozonation process on Fe^{2+} , the Fe^{2+} content was measured. Figure 4 shows the gradual decrease of Fe^{2+} in samples, while this happened, the concentration residual of ozone will decrease gradually.

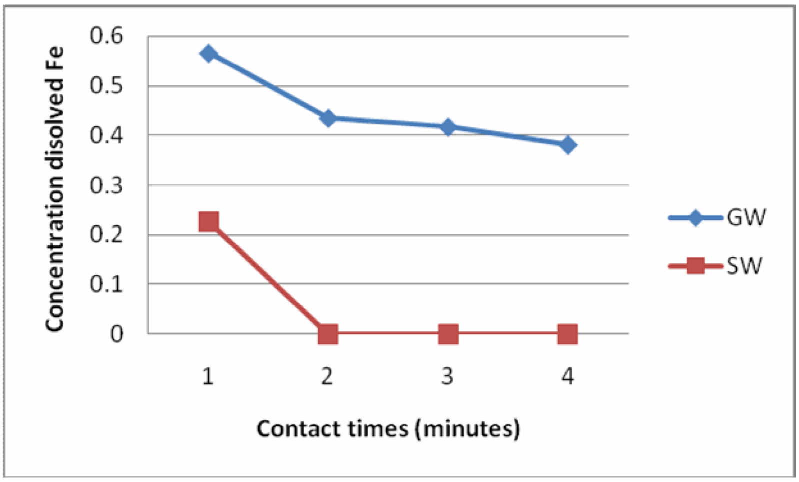

Figure.4. Degradation of Fe^{2+} on samples

3.3.The affect of concentration of residual ozone on disinfection process

Coliform was measured to known the effectivity of ozonation process. Figure 5 shows, The higher level of concentration ozone, the higher level of efficiency of disinfection process.

According to the figure, The highest percentage of efficiency at SW was 58.18% with concentration of residual ozone at 0.0176 mg/L, it then follow by GW (78.18%) and TW (96.46%) with concentration residual of ozone 0.028 mg/L and 0.036 mg/L respectively. Moreover, it was found that to gain 100%, we need 0.0365 mg/L of concentration residual of ozone.

Water matrix at TW is less complex than two other samples. This mean ozone will more focus to react with micro-organisms than in both SW and GW sampels. According to K. Bancrof (1984), those happen because there are competitions between micro-organism, organic and inorganic content to react with ozone.

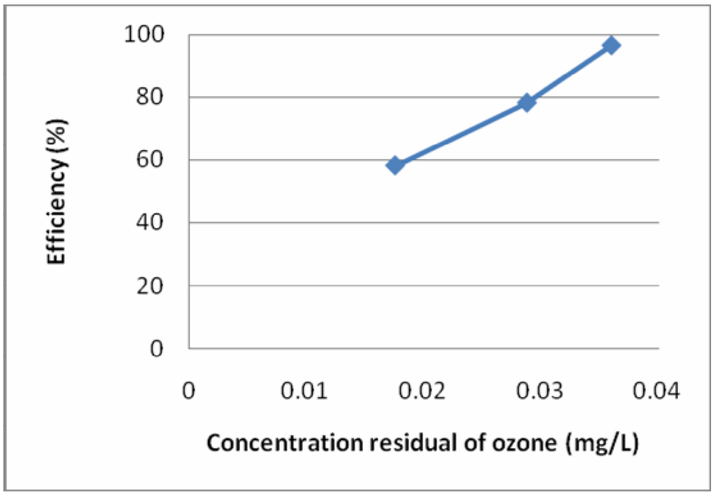

Figure.5. The effect of concentration residual of ozone on efficieny

That condition were illustrated to following reaction (K.Bancroft et al, 1984):

Gas transfer :

$$O3\ (g) \rightarrow O3\ (aq) \quad (12)$$

The competition :

$$O3 + TOC \rightarrow Product \quad (13)$$

$$O3 + \text{micro-organism} \rightarrow \text{disinfection} \quad (14)$$

5. CONCLUSION

The efficiency of disinfection process by ozone is influenced by concentration residual of ozone which is affected by characteristic of water. The result shows that the higher level of concentration of ozone, the higher level of efficiency of disinfection process.

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