IMPROVEMENT OF CLEAN WATER PRODUCT QUALITY THROUGH DESINFECTION PROCESS

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IMPROVEMENT OF CLEAN WATER PRODUCT QUALITY THROUGH DESINFECTION PROCESS

PENINGKATAN KUALITAS PRODUK AIR BERSIH MELALUI PROSES DESINFEKSI

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ABSTRACT

In the process of treating raw water into clean water, the pathogenic bacteria must be eliminated. The process of eliminating pathogenic bacteria which then cause an unpleasant odor can be carried out by disinfection. The thing that needs to be considered in the context of disinfection is how to prevent the transfer of germs to the human body through clean water by breaking the chain between the two by means of disinfection. This research begins with a laboratory test of the total coliform content in water treated by Biofilter without disinfection. The laboratory test results showed that the content of Fecal Coli was 1880/100 ml and the bacteria in the Coli group were 2060/100 ml. This parameter must be reduced to the limit according to the Environmental Quality Standard (BML) using a disinfection treatment. From the observations made on the coagulation process from raw water it can be informed that in the range of observed variables, with an increase in the dose of Calcium Hypochlorite (Ca (OCl) 2) from 1 mg / lt to 3 mg / l in the disinfection process, the number of E. coli bacteria which is being lowered more and more. At a dose of Calcium Hypochlorite Ca (OCl) 2 2.5 mg in 1 liter of raw water for the Kebon Agung Canal Drainage Channel with a stirring time of 30 minutes was able to reduce the number of E. Coli bacteria by 99, 40%.

INFO ARTIKEL	ABSTRAK

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Kata kunci:
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Dalam proses pengolahan air baku menjadi air bersih, bakteri patogen harus dihilangkan. Proses pemberantasan bakteri patogen yang kemudian menimbulkan bau tidak sedap dapat dilakukan dengan cara disinfeksi. Hal yang perlu diperhatikan dalam rangka disinfeksi adalah bagaimana mencegah perpindahan kuman ke tubuh manusia melalui air bersih dengan memutus mata rantai antara keduanya dengan cara disinfeksi. Penelitian ini diawali dengan uji laboratorium kandungan total *coliform* pada air yang diolah dengan Biofilter tanpa disinfeksi. Hasil uji laboratorium menunjukkan kandungan Fecal Coli 1880/100 ml dan bakteri golongan Coli 2060/100 ml. Parameter ini harus dikurangi hingga batas sesuai dengan Baku Mutu Lingkungan (BML) dengan menggunakan perlakuan disinfeksi. Dari pengamatan yang dilakukan terhadap proses koagulasi dari air baku dapat diketahui bahwa pada rentang variabel yang diamati, dengan peningkatan dosis Kalsium Hipoklorit ($Ca(OCl)_2$) dari 1 mg/lt menjadi 3 mg/l pada proses desinfeksi, jumlah bakteri E. coli yang diturunkan semakin banyak. Pada dosis Kalsium Hipoklorit $Ca(OCl)_2$ 2,5 mg dalam 1 liter air baku untuk Saluran Drainase Kanal Kebon Agung dengan waktu pengadukan 30 menit mampu menurunkan jumlah bakteri E. Coli sebesar 99,40%.

INTRODUCTION

One of the important processing steps to get clean water is to kill bacteria that are unwanted in clean water, such as pathogenic bacteria as the cause of various diseases [1]. Processes that can be carried out to treat raw water are coagulation-flocculation [2], filtration [3], sedimentation [4], aeration [5], and so on [6]. However, these processes do not guarantee the loss of pathogenic bacteria in clean water, but only reduce the turbidity and content of BOD - COD and TSS content in raw water. These processes can still pass bacteria/microorganisms that are not expected in clean water. Pathogenic bacteria will not live long in water that is very acidic or alkaline, such as water with a pH of < 3 or > 11 [7].

In the process of treating raw water into clean water, the pathogenic bacteria must be eliminated.

Clean water for consumption purposes must meet all three factors: microbiological, physical, chemical and radioactive requirements determined by the regulations of the ministry of health [8]. Water that does not meet one of these requirements before being used as drinking water still needs further processing. One of the requirements before being used as drinking water is the microbiological requirement and what needs to be paid attention to is the presence of coliform bacteria in water which is allowed a maximum level of 0 per 100 ml for drinking water and 10 per 100 ml for clean water. The World Health Organization (WHO) has determined that the water requirement per person per day for healthy living needs is 60 liters. These needs must include quantity, quality and continuity [9].

The process of eliminating pathogenic bacteria which then cause an unpleasant odor can be done through disinfection [10]. Disinfection is a method to kill unwanted bacteria in drinking water, such as pathogenic bacteria that cause various diseases. In contrast to sterilization, which means killing all living microorganisms. The targets of sterilization are for research, medical and pharmaceutical use. Drinking water does not require sterilization. Disinfection itself can be defined as inactivation (killing) pathogenic microorganisms present in water. Initially, this process aims to kill disease-causing microorganisms (pathogens), either from processing plants or those that enter through the distribution network. These microorganisms can be viruses (causing poliomyelitis), bacteria (causing cholera, dysentery, typhoid fever and so on), and other microorganisms.

In subsequent developments, the objectives of the disinfection process were developing for the oxidation of organic and inorganic matter (Fe, Mn), destruction of smell and taste, control of the growth of microorganisms. From the purpose of disinfection, there are several types of disinfection that can be applied to safety in drinking water, including: physically, namely by heating (boiling) [11], irradiation with ultraviolet [12], metal ions using Cu^{2+} and Ag^{2+}, alkalis and acids [13], and with chemicals oxidizers [14] namely bromine [15], chlorine, iodine [16] and ozone [17].

In the process of disinfect using chlorine, it can be reacted with water, ammonia (NH3) and inorganic materials such as carbon (C), cyanide (CN), H_2S and iron (Fe). The types of chlorine that are often used as disinfectants are chlorine gas, sodium hypoclorite (NaOCl), and Calcium Hypoclorite ($Ca(OCl)_2$) or also known as chlorine. Chlorine has the disadvantage of causing an unpleasant odor, and is easily changed by changes in temperature and temperature. In addition, it also causes breathing disruption at highconcentrations [18].

In this disinfection process, chlorine is used as a disinfectant. The water resulting from the coagulation process is then disinfected with chlorine. Chlorine is used as a disinfectant because it is cheaper, more stable and more soluble in water [19]. The parameter measured was the number of E. Coli bacteria. Because the E. Coli bacteria is an indicator of pollution. These bacteria also cause many infections in the digestive tract (enteric) of humans and animals, as well as cause disease in some plants. Meanwhile, the variables carried out were the type of disinfectant, namely chlorine ($Ca(OCl)_2$) and stirring time.

The thing that needs to be considered in the context of disinfection is how to prevent the transfer of germs to the human body through drinking water by breaking the chain between the two with disinfection. There are 3 categories of pathogenic microorganisms in the human intestine, namely bacteria, viruses and amoebic cysts [20]. For practical considerations, disinfection must meet requirements such as: it can kill various types and all populations of pathogens present in drinking water at a certain time and temperature, disinfectants are not toxic to humans / animals or their existence is rejected because of taste or smell, low procurement costs, methods storage and administration is safe, levels in water are easy to analyze and know, and still leaves a certain amount before analysis.

The ability of disinfection is influenced by several factors, namely disinfectant concentration, contact time, type and number of microorganisms and temperature [21]. The greater the disinfectant concentration the greater the disinfection rate, while the type of disinfectant will determine the specific destruction coefficient value. Therefore, it is necessary to calculate the number of microorganisms in the water. Microorganisms counting can be done in various ways, including: Dilution Method, Filter Membrane Method, MPN Method (Most Probable Number) [22]. The first method is through dilution method. The dilution method is a series of dilutions of the sample, which is then embedded in the media. After incubation, the number of colonies that grow can be calculated by assuming that 1 growing colony comes from one cell, then the number of cells in the original sample can be calculated by multiplying the number of colonies with the dilution factor. Dilutions are usually expressed in negative powers, for example 10-3 for a 1: 1000 dilution. From this method we will calculate the number of microorganisms from existing samples. The second is filter membrane method. This method uses the principle of filtration using a filter membrane with a porosity of 0.45 µm. For testing drinking water required 100-150 ml, the sample that is passed on a sterile filter membrane (the ideal sample is a sample that produces 50-200 colonies). The filter containing the bacteria is then placed aseotically on a suitable sterile medium in a Petri dish. For the determination of total coliform, M - FC media was used. For the determination of total coliform, an incubation temperature of 35 ± 0.5 ° C was required for 22-24 hours, while for the determination of fecal coli, an incubation time of 24 ± 2 hours at a temperature of 44.5 ± 0.5 ° C was required. (TIM, 2013). The last is MPN (Most Probable Number) method.

Water testing for the number of bacteria in the e-coli group is carried out in several levels, namely: estimation testing, confirmation testing and complete testing. Estimation testing is a preliminary test to predict whether coli bacteria are present in the water. The forecast test is positive if gas forms in the fermentation cylinder. But what is positive in this test is not necessarily that the water contains coli bacteria, because many other bacteria can share lactose by producing gas. This is called quasi-forecast testing, and therefore requires further testing.

Confirmation testing is carried out by continuing to test positive predictions into the Brillian Green Lactose Bile Broth (BGLBB) media. If a gas forms in this liquid medium, it means that the test is positive. The complete test aims to ensure the results of the affirmation test. To control water quality, it is sufficient to carry out an affirmative test analysis, however for case studies it may be continued until the testing is complete.

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The thing that needs to be considered in the context of disinfection is how to prevent the transfer of germs to the human body through clean water by breaking the chain between the two by means of disinfection. For practical considerations, disinfection must meet requirements such as: it can kill various types and all populations of pathogens present in clean water at a certain time and temperature, besides disinfection is not toxic to humans and also its levels in water are easy to analyze and know.

The need for water for sanitation is needed in a large enough amount, while the water from coagulation - flocculation cannot be used for sanitation. The content of E. Coli bacteria in raw water exceeds the quality standard of clean water set by the Minister of Health of the Republic of Indonesia, this causes water to not be used for sanitation purposes. In this study, the quality of clean water will be improved by using a disinfection process using calcium chlorite.

METHOD

This research begins with a laboratory test of the total coliform content in water treated by Biofilter without disinfection. The laboratory test results showed that the content of Fecal Coli was 1880/100 ml and the bacteria in the Coli group were 2060/100 ml. This parameter must be reduced to the limit according to the Environmental Quality Standard (BML) using a disinfection treatment. The variables in this study consisted of:

1. The independent variable; namely liquid chlorine (liquid chlorine), hypochlorite compounds, chloride of lime ($CaOCl_2$) and chlorine dioxide (ClO_2) respectively: 100 ppm, 150 ppm, 200 ppm, 250 ppm. 300 ppm, 350 ppm, and 400 ppm.
2. The dependent variable: namely the quality of processed water physically, chemically and biologically in the form of Esherecia Coli bacteria

Population and sampling in this research are:

1. The population in this study is treated wastewater in the reactor
   The biofilter in the Clarifier tub was continued with filtration and disinfection media with a discharge capacity of 6 M2/day.
2. The sample for each experiment running the addition of chlorine continuously through the filtration reactor in this study is 1 M2 of treated water in a Clarifier bath. From the last processed water, after going through complete processing, 1,500 ml each is taken every time you run the experiment for a complete quality analysis for physical, chemical and microbiological parameters in the laboratory.

Tools and material used in this research are: Biofilter reactor, faucet O. ", Pipe O.", PVC pipe O 4 ", O 6", O 8 ", PVC pipe, Jirigen, PVC glue, Tandon, waste water, pumps, and equipment for analysis of clean water parameters -the materials used in this research are as follows: cation and anion resin, BOD analysis reagent, aquadest, silica sand, Manganeese Greensand, activated carbon, and chlorine.

The research procedure are:

1. Weigh the ingredients consisting of 3 g of meat extract, 5 g of peptone and 5 g of lactose for 10 ml of media. Whereas for 5 ml media weigh the material 3 times the weight of 10 ml media. Enter into erlenmeyer, mix with 100 ml of aquadest.
2. Heat on an electric stove, stirring until all solid ingredients dissolve. Adjust the pH so that you get a neutral pH.

3. Pour the lactose medium into the test tube. Five tubes contain 5 ml of media and five tubes contain 10 ml of media.
4. Test tube, Durham tube, goiter pipette and dropper pipette sterilize in autoclave at 121 ° C for 1 hour.
5. Remove it from the autoclave, put it in the incase in a sterile manner, five tubes, each containing 5 ml of media, are planted with 10 ml of water sample, five tubes of which each contains 10 ml of media are planted with 1 ml of water sample, five tubes each contains 10 ml of medium planted with 0.1 ml of water sample.
6. Put it in an incubator with a temperature of 45 ° C for 24 hours. After that, observe whether the Durham tube contains gas, if it contains gas it means positive and if it does not contain gas it means negative.
7. The positive tube is proceeded to an affirmation tes

RESULT AND DISCUSSION

Research on the disinfection process in raw water to be used as clean water, namely observation with an emphasis on the factors: stirring time, type of microorganism, temperature, type of disinfectant, and pH. Observation by carrying out the coagulation-flocculation process. Coagulation results with a turbidity value of 0.76 NTU. From the measurement, it was found that the content of E. Coli bacteria was very high, namely ≥ 1600, while the measured pH was 7.71

1. Effect of Stirring Time (minutes) on the Number of Microorganisms (MPN)

The results of the analysis that have been carried out show that the results of the number of E. Coli bacteria can be seen in Table 1.

Table 1. Effect of Stirring Time with Calcium Dose Hypochlorite (Ca (Ocl2)) In Mg/ Lt Against Amount (MPN)

Stirring Time (minutes)	**Chlorine dosage (mg / lt) / number of E. Coli bacteria**				
	1	**1,5**	**2**	**2,5**	**3**
10	220	190	170	140	110
15	170	140	130	110	90
20	130	110	70	60	50
25	110	70	40	34	22
30	70	34	21	9	< 2

Research on the disinfection process in raw water to be used as clean water, namely observation with an emphasis on the factors: stirring time, type of microorganism, temperature, type of disinfectant, and pH. Observation by carrying out the coagulation-flocculation process. Coagulation results with a turbidity value of 0.76 NTU. From the measurement, it was found that the content of E. Coli bacteria was very high, namely ≥ 1600, while the measured pH was 7.71

2. Effect of Stirring Time (minutes) on the Number of Microorganisms (MPN)

The results of the analysis that have been carried out show that the results of the number of E. Coli bacteria can be seen in Table 2.

Table 2 Effect of Stirring Time with Calcium Dose Hypochlorite (Ca (Ocl2)) in Mg / Lt Against Amount Microorganisms (MPN)

Stirring Time (minutes)	Chlorine dosage (mg / lt) / number of E. Coli bacteria				
	1	1,5	2	2,5	3
10	220	190	170	140	110
15	170	140	130	110	90
20	130	110	70	60	50
25	110	70	40	34	22
30	70	34	21	9	< 2

The effect of stirring time in the analysis process of decreasing the number of E. Coli bacteria is an important factor. The longer the stirring time, the more the number of dead microorganisms. Based on the table above, it can be seen that the stirring time is 10 minutes with a dose of chlorine 1; 1, 5; 2; 2, 5 and 3 mg / lt obtained the ability to reduce the number of E. Coli bacteria, namely 220, 190, 170, 140, and 110 per 100 ml. At the stirring time of 15 minutes with the same dose, the E. coli bacteria decreased, namely 170, 140, 130, 110, and 90 per 100 ml.

At the stirring time of 20 minutes with the same dose, the E. coli bacteria decreased, namely 130, 110, 70, 60, and 50 per 100 ml. Likewise, at the stirring time of 25 minutes with the same dose, the E. coli bacteria decreased, namely 110, 70, 40, 34, and 22 per 100 ml. And if the stirring time was extended to 30 minutes at the same dose, the decrease in the number of E. Coli bacteria was getting smaller, namely 70, 34, 21, 9, and < 2 per 100 ml.

Based on the observations, it can be seen that with the addition of a dose of Calcium Hypochlorite (Ca (OCl) 2) of 2.5 mg /l with a stirring time of 30 minutes, the number of E. Coli bacteria has met the requirements for clean water quality, namely 9 per 100 ml. The number of E. Coli bacteria based on clean water quality requirements is 10 per 100 ml.

Temperature also affects the disinfection process this time. E. Coli grows well at temperatures between 8 ° to 45 ° C. While the maximum temperature for E. coli growth is 37 ° C (Dwidjoseputro, 1980). Therefore, the overall decrease in the number of microorganisms which is influenced by the stirring time is shown in Figure 1.

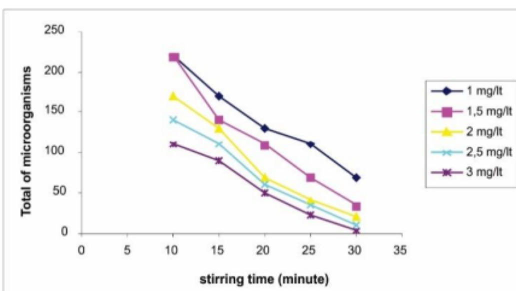

Figure 1. The Relationship Between Stirring Time and the Number of Microorganisms.

From Figure 1, it can be seen that the number of bacteria decreased very rapidly at the beginning of the experiment. This is due to the effect of disinfectants, this disinfectant affects several vital cell parts. The part of the cell that is most susceptible to disinfectants is the cytoplasmic membrane, certain enzymes, and proteins such as those contained in the cell wall. It can be seen that the best result is when the stirring time is 30 minutes with a chlorine dose of 2.5 mg / lt, the number of E. Coli bacteria is 9 per 100 ml. This is due to the length of time it takes for disinfectants to kill microorganisms. The longer the contact time, the more microorganisms will die.

3. Effect of Stirring Time on the Percentage of the Number of Microorganisms (%)

Based on the data in Table 3 above, the percentage reduction in the number of E. Coli bacteria can also be calculated as in Table 3.

Table 3. The Effect of Stirring Time on the Percentage of E. Coli Bacteria (%)

Stirring Time (minutes)	Chlorine dose (mg / lt) / Percentage Decrease				
	1	1,5	2	2,5	3
10	86,25 %	88,13 %	89,40 %	91,25 %	93,10 %
15	89,40 %	91,25 %	91,90 %	93,10 %	94,40 %
20	91,90 %	93,10 %	95,70 %	96,25 %	96,90 %
25	93,10 %	95,70 %	97,50 %	97,80 %	98,70 %
30	95,70 %	97,80 %	98,70 %	99,40 %	99,80 %

Based on Table 3, it can be seen that the stirring time is 10 minutes with a dose of chlorine 1; 1.5; 2; 2.5 and 3 mg /lt obtained a percentage reduction of 86.25%; 88.13%; 89.40%; 91.25% and 93.10%. At the time of stirring 15 minutes with the same dose the percentage decrease was 89.40%; 91.25%; 91.90%; 93.10% and 94.40%. At the stirring time of 20 minutes with the same dose, the percentage decrease was 91.90%; 93.10%; 95.70%; 96.35% and 96.90%.

Likewise, at the stirring time of 25 minutes, the percentage of reduction was 93.10%; 95.70%; 97.50%; 97.80% and 98.70%. And if the stirring time is continued for 30 minutes and with the same dose, the percentage decrease is 95.70%; 97.80%; 98.70%; 99.40% and 99.80%. Overall, the percentage reduction in E. Coli bacteria is shown in Figure 2.

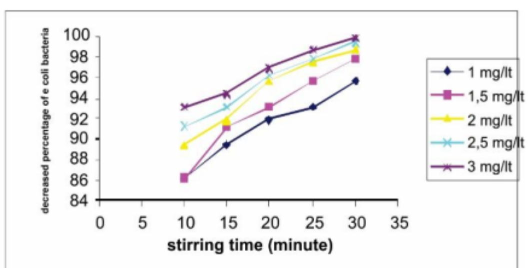

Figure 2. The Relationship Between the Percentage of E. Coli Bacteria Decrease with Dose Variations (Mg /Lt) and Stirring Time.

In Figure 2, it can be seen that there is an increase in the percentage decrease in E. Coli bacteria at each additional dose of disinfectant. This is due to the smaller number of E. Coli bacteria that are obtained. It can be seen in the addition of a chlorine dose of 3 mg/l with a stirring time of 30 minutes, the percentage reduction in E. coli bacteria lasts a maximum of 99.80%, but at the time of adding a chlorine dose of 2.5 mg/l with a stirring time of 30 minutes and the percentage of bacterial decline. E. Coli 99.40% can meet the requirements of clean water. The smaller the number of E. Coli bacteria, the higher the percentage of decline.

The maximum chlorine dose used is 3 mg/lt because more than 3 mg/lt can cause health problems (Mursid, 2011). While the stirring time used is between 10 and 30 minutes, the number of bacteria has met the requirements for clean water quality. Based on the results of the research that has been done, further research is still needed with the addition of a dose of Calcium Hypochlorite of more than 3 mg/lt in order to obtain a graph of the reduction in the number of E. Coli bacteria such as the shape of the growth curve of microorganisms.

4. Effect of Stirring Time (minutes) on Degree of Acidity (pH)

The degree of acidity (pH) is an important factor in the disinfection process. E. Coli bacteria are pathogenic bacteria that cause various diseases. Pathogenic bacteria will not live long in water that is very acidic or alkaline, such as water with a pH < 3, or > 11. Based on the results of the analysis, the pH value can be seen in Table 4.

Table 4. The Effect of Stirring Time (Minutes) on the Degree of Acidity (pH)

Stirring Time (minutes)	Dosis Kaporit (mg/lt)/pH				
	1	1,5	2	2,5	3
10	7,81	7,81	7,84	7,86	7,89
15	7,81	7,82	7,84	7,87	7,89
20	7,83	7,85	7,87	7,88	7,90
25	7,83	7,87	7,89	7,91	7,91
30	7,85	7,88	7,90	7,93	7,93

From Table 4, it can be seen that the stirring time is 10 minutes with a dose of chlorine 1; 1.5; 2; 2.5 and 3 mg/lt got 7.81; 7.81; 7.84; 7.86 and 7.89. At the stirring time of 15 minutes with the same dose obtained a pH of 7.81; 7.82; 7.84; 7.87 and 7.89. At the stirring time of 20 minutes with the same dose obtained a pH of 7.83; 7.85; 7.87; 7.88 and 7.90. Likewise, at the stirring time of 25 minutes, the pH was 7.83; 7.87; 7,89; 7.91 and 7.91. And when successively the stirring time was extended up to 30 minutes with the same dose, a pH of 7.85 was obtained; 7.88; 7,90; 7.93 and 7.93. The overall pH value can be seen in Figure 3:

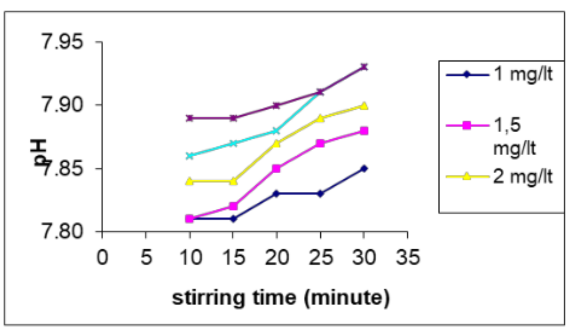

Figure 3. The Relationship Between Stirring Time and pH Raw Water After Addition of Calcium Hypochlorite Ca(Ocl)$_2$

When chlorine gas (Cl_2) is put into water, a reaction will occur which results in atoms (HOCl) and hypochlorite ions (OCl) such as the following reaction:

$$Cl_2 + H_2O \rightarrow HOCl + H^+ + Cl^-$$

(as. hipochlorite) (chlorida)

$$HOCl \rightarrow H^+ + OCl^-$$

(hipochlorite)

In the first reaction, if the pH of the solute is more than 4, the reaction balance shifts to the right so that the Cl2 in the solution decreases to form HOCl. HOCl is what can kill bacteria if it reacts with enzymes under the cell Enzymes have an important role in cell metabolism, if the enzymes are damaged, the metabolism is inactive so that the cells will die.

In the disinfection process with well water samples, the pH value is also influenced by the stirring time. From this research, the optimum pH value was 7.26 at the time of stirring 45 minutes and with a dose of Calcium Hypochlorite 2.5 mg/l.

From Figure 3, it can be seen that the pH value is increasing, this is due to the decrease in Cl2 in the solution and the more HOCl is formed. From Graph 4.3, it can be seen that the minimum pH is 7.80 with a stirring time of 10 minutes. While the maximum pH is 7.93 and occurs at the stirring time of 30 minutes, this is because if the pH exceeds 7.80 HOCl will form hypochlorite ions as in the reaction (4.3). So the longer the stirring time the more HOCl is formed, the more acidic atoms are released, this causes the pH to increase.

CONCLUSION

From the observations made on the coagulation process from raw water it can be informed that in the range of observed variables, with an increase in the dose of Calcium Hypochlorite (Ca (OCl) 2) from 1 mg/lt to 3 mg/l in the disinfection process, the number of E. coli bacteria which is being lowered more and more. At a dose of Calcium Hypochlorite Ca (OCl) 2 2.5 mg in 1 liter of raw water for the Kebon Agung Canal Drainage Channel with a stirring time of 30 minutes was able to reduce the number of E. Coli bacteria by 99,40%.

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