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Optimum Dose of Colloidal Silver (Ag) Coated on Activated Carbon Media to Reduce Coliform Bacteria in Clean Water Supply Ferry Kriswandana* Rizal Bahri Marlik Environmental Of Health, Surabaya Polytechnic of Health Ministry, Indonesia Abstract In line with the raise of population, clean water contamination level also has raised so that clean water treatment is needed to enhance the physical, chemical and biological quality. This research aims to determine the optimum dose of colloidal silver coated on activated carbon media to reduce coliform bacteria in clean water supply. This research is descriptive research in form of quasi experiment using activated carbon media coated by colloidal silver in several dose : 0 mg/g; 2,5 mg/g; 5 mg/g and 10 mg/g. At first, MPN coliform in clean water were examined then it was contacted through the media with constant flow rate of 0,8 l/m then output MPN coliform were examined. The results show the average MPN coliform after column test using colloidal silver coated on activated carbon is smaller than neat activated carbon (0 mg/g) with lowest average MPN coliform is occurred on 10 mg/g media reached 83,4. The highest average percentage of MPN coliform reduction is also occurred on 10 mg/g media reached 81,87%. However, the optimum dose in this research is not determined yet because the results of MPN coliform using three media (2,5 mg/g; 5 mg/g and 10 mg/g) are not appropriate to microbiological clean water standards according to Indonesian Ministry of Health regulation on Permenkes No.

416/Menkes/PER/IX/1990. Further research needs to be conducted using doses above 10 mg/g to determine the optimum dose in reducing coliform bacteria in clean water. Moreover, contact time can be increased to get higher reduction in order to determine the optimum dose. Keywords: Colloidal Silver, Activated Carbon, Coliform, Water Treatment. 1. INTRODUCTION Clean water is used for daily needs and has appropriate quality to fresh water standards according to current regulation. [1] In line with the raise of population, water contamination level has also raised . The using of water that not appropriate to health standards can lead to health damage . Some pathogenic microorganisms usually found in contaminated water such as Enteropathogenic E. coli, Vibrio cholera and Salmonella typhi [2]. Those bacteria can be recognized in water by checking coliform bacteria as indicator of contaminated water [3]. According to Indonesian Ministry of Health regulation on Permenkes No. 416/1999, microbiology standards of clean water is less than 50 MPN coliform in non piping water and less than 10 MPN Coliform in piping water [1]. Silver metal has antibacterial activity [4]. In form of Ag+ ion, it can interact with sulfihydryl (SH) protein group and cell DNA which lead to cell respiration inhibition [5] . Silver nanoparticles are chemically more reactive and easily ionized than larger-sized silver. Therefore it is indicated that silver nanoparticles have stronger antibacterial activity [6]. Moreover, silver in the form of nanoparticles that release silver ions more effectively has a high bactericidal activity due to its high surface-area-to-volume ratio [7]. Silver nanoparticles activity is influenced by the particle size and concentration also number and type of bacteria [8]. According to Environmental Protection Agency silver metal does not fatal cause to the body [9]. Colloidal system is heterogeneous mixture of two or more substances which are dispersed in another substance. Colloidal system contains nano-sized particles ranged in 1 nm – 100 nm . Bredig arc is one of the methods that used to make colloidal metal. This process is done by putting the metals on tip of both electrodes and given strong enough electricity, causing electrical spark. High temperature due to the electrical spark cause metals are dispersed into water forming colloidal metal [10]. Colloidal silver can be deposited in solid material to kill bacteria in water treatment system [6]. Activated carbon is charcoal that can adsorb molecules in the form of organic and inorganic compounds. Activated carbon can be applied in water system because it can adsorb organic substances, suspended solids and reduce bacterial concentration [11]. El Asshar et al had done research using 20 mg/g silver nanoparticles formed by chemical synthesis coated on activated carbon to reduce E. coli concentration in water. The antibacterial susceptibility was investigated using column test. The result showed that output count E. coli was zero [12]. However, the optimum dose of Ag/AC to reduce coliform according to regulation of clean water was not found yet. This research aims to determine optimum dose of colloidal silver coated on activated carbon media to reduce coliform bacteria in clean water supply. 2. RESEARCH METHODS 2.1 Research Type and Design This type of research is quasi experimental research using one group pretest posttest design. 2.2 Population and Samples The population of this research are fresh water well in Manyar Sabrangan VIII area, Surabaya – East Java. Coliform concentrations in the population are 460 MPN coliform per 100 ml. The volume of sample for intervention is 1 liter with 5 times replication in each media. 2.3 Materials The form of silver used in this research was two of 5 g pure silver wire with length of each wire is 30 cm. The form of activated carbon media was granule made from coconut shell with sized of 1 mm. 2.4 Preparation of Colloidal Silver Two silver wires were connected to the anode and cathode of 9 volt battery using alligator cable in 250 ml distilled water placed inside a bottle. The bredig arc process was undergo for several hours. It signed that silver nanoparticles were dispersed into distilled water. Colloidal silver dosage was calculated using the difference weight of silver wires before and after bredig arc process. This process was performed three times to gain three different doses. The doses then was diluted using dilution equation V1 . N1 = V2 . N2 to gain 500 mg/l; 1000 mg/l and 2000 mg/l. 2.5 Coating of Colloidal Silver on Activated Carbon A total of 50 g of activated carbon granules were soaked into 250 ml of colloidal silver with different concentrations (500 mg/l; 1000 mg/l; 2000 mg/l) within 24 hours. Then it were dried into oven with temperature of 110OC for 2 hours. Thus, Ag/AC with different dose (2,5 mg/g; 5 mg/g and 10 mg/g, respectively) were prepared. Confirmation of dose was done by weighing the activated carbon granules before and after coating process. 2.6 Column Test The antibacterial susceptibility of colloidal silver coated on activated carbon media was tested using column test as a small lab scale water treatment. An amount of media to be tested was packed into a plactic column with diameter 2,5 cm and length of 12 cm. (Fig.1). Fig. 2. Interpolation Graphic of Average MPN Coliform ————————————————— • Kriswandana, Ferry is currently a lecturer of Environmental Health Department, Polytechnic of Health Surabaya, Indonesia. • Bahri, Rizal is currently pursuing diploma degree program in Environmental Health, Polytechnic of Health Surabaya, Indonesia. The tested column was washed using pumped distilled water before any run. Flow rate of this column was maintained by flow controller in 0,8 l/m. The efficiency of tested media was performed by contacting contaminated water samples. 3. RESULTS AND DISCUSSION 3.1 Preparation of Colloidal Silver The principle of bredig arc process is the high temperature can cause metals to be dispersed into water [10]. During the process, golden yellowish smoke was appeared on cathode silver wire. This smoke was actually silver nanoparticles and formed colloidal system. The dose of silver colloidal was calculated by weighing the cathode-silver wires before and after the process. Thus the results of weighing of silver wire are described in table 1 : Table 1 The Weight Of Silver Wire According to table 1 the weight of silver wire after bredig arc process was decreased in every process. Silver particles put off of the silver wire causing weight loss of silver wire. The biggest weight loss of silver wire was occurred in the third process with loss of 540 mg. Three colloidal silver had been made with doses of 680 mg/l, 1520 mg/l, 2160 mg/l. Those colloidal silver then was diluted into 500 mg/l, 1000 mg/l and 2000 mg/l. 3.2 Coating of Colloidal Silver on Activated Carbon A total of 50 g activated carbon were soaked into colloidal silver (500 mg/l, 1000 mg/l and 2000 mg/l) that have been made for 24 hour. Activated carbon that had been soaked into colloidal silver then dried in oven with temperature of 110OC for 2 hours. The doses of silver colloidal coated on activated carbon media was measured by weighing the activated carbon granules before and after the coating process. Thus the results of weighing of activated carbon granules are described in table 2 : Table 2 The Weight Of Activated Carbon Activated carbon can adsorb molecules in organic and inorganic compounds [11]. Silver nanoparticles were adsorbed by activated carbon granules during soaking process. Thus make activated carbon have silver nanoparticles coat in the surface. According to table 2 the weight of activated carbon granules after coating process was increased. The highest weight increment was on activated carbon that were soaked into 2000 mg/l of colloidal silver with weight increment of 0,5 g. Three activated carbon media coated by colloidal (Ag/AC) with doses of 2,5 mg/g (2,5 gram silver particle coated onto every one gram activated carbon granules) ; 5 mg/g and 10 mg/g. The three media then were tested the antibacterial susceptibility using lab scale packed column. 3.3 Column Test A lab scale packed column (2,5 cm diameter and 12 cm high) disinfection system of 50 g Ag/AC with doses of 0 mg/g (neat activated carbon); 2,5 mg/g ; 5 mg/g and 10 mg/g was applied in order to investigated antibacterial susceptibility in reducing coliform bacteria. The system was operated with continous and constant flow rate of 0,8 l/m. Volume of sample in every run was one liter with five times replication. Thus the results of MPN coliform bacteria. MPN coliform in clean water before and after column test were examined in order to discover the antibacterial susceptibility and determine the optimum dose to reduce MPN coliform. Thus the results of MPN coliform before and after column test are described in table 3 : Table 3 MPN Coliform Before and After Column Test Antimicrobial activity of silver depends on the size of the particle. Silver nanoparticles has higher antibacterial than larger particle [6]. Moreover, the concentration of silver nanoparticles influences the antibacterial activity [8]. Table 3 shows that output MPN coliform after column test using 0 mg/g; 2,5 mg/g; 5 mg/g and 10 mg/g are less than MPN coliform before any treatment (input MPN coliform). It indicates that activated carbon also has antibacterial activity. However, average output MPN coliform using 0 mg/g or neat activated carbon is higher than average output MPN coliform using activated carbon coated by silver colloidal. Silver colloidal coated on activated had proven has higher antibacterial activity than neat activated carbon. The smallest output MPN coliform was on 10 mg/g media reached 83,4. Although output MPN coliform of 10 mg/g was the smallest, but 10 mg/g media is not optimum dose yet because it cannot reduce MPN coliform under 50 according to clean water regulation on Permenkes No. 416/Menkes/PER/IX/1990. It is because 10 mg/g releases silver ion that’s not enough to kill bacteria. Thus the trend and straight-line equation of average MPN coliform after column test are described in figure 2 : Fig. 2. Interpolation Graphic of Average MPN Coliform After Column Test In figure 2 can be seen that average MPN coliform are significantly declining from point of 0 mg/g media to point 2,5 mg/g media. Average MPN coliform from 2,5 mg/g to 5 mg/g and 10 mg/g points is almost straight-line. The straight-line equation of average coliform after column test is y = -29,433 + 340,12 with R2 = 0,8229. To understand the how much effectiveness of silver colloidal coated on activated carbon media, average percentage of MPN coliform reduction was calculated. Thus the results of percentage of MPN coliform before and after column test are described in table 4 : Table 4 Percentage of MPN Coliform Reduction According to tabel 4 the highest average percentage of coliform reduction was occurred on 10 mg/g media with average percentage of 81,87 %. Thus the trend and straight-line equation of average percentage of MPN coliform reduction after column test are described in figure 3 : Fig. 3. Interpolation Graphic of Average Percentage of MPN Coliform Reduction After Column Test According to figure 3, the straight-line equation of average percaentage of coliform reduction after column test is y = -29,433 + 340,12 with R2 = 0,8229. Silver content in clean water before and after column test were also examined to understand the relation of silver coating on activated carbon media with silver content in clean water. Moreover, the examination of silver content aims to measure if the clean water are want to use as drinking water. Thus the results of silver content in clean water are described in table 5 : Table 4 Silver Content in Clean Water The mechanism of silver nanoparticles kill bacteria is by release Ag+ ion [5]. It can interact with sulfihydryl (SH) protein group and cell DNA which lead to cell respiration inhibition. Table 4 shows that the average silver content in output clean water using neat activated carbon or 0 mg/g is constant. The average silver content in output clean water using activated carbon coated by silver colloidal is higher than using neat activated carbon. The highest silver content output is on 10 mg/g media with amount of 1,62 mg/g. According to Environmental Protection Agency silver metal does not cause fatal effects to the body. However, EPA has silver metal as a secondary standard of drinking water which the minimum concentration in drinking water is 0,1 mg/g. The secondary standards of drinking water are not mandatory standard [9]. 4. CONCLUSION

Silver colloidal was made by bredig arc using silver wires and distilled water as dispersion substance. Activated carbon granules then was coated by silver colloidal. The silver colloidal coated on activated carbon granules with doses of 2,5 mg/g; 5 mg/g and 10 mg/g were made. To investigate the antimicrobial activity the three media then put in column system. The results shows that colloidal silver coated on activated carbon has higher antibacterial activity than neat activated carbon with the highest antibacterial activity was on 10 mg/g. However, 10 mg/g is not optimum dose yet because it cannot reduce MPN coliform until less than 50 according to Permenkes No. 416/1999. Further research is need to be conducted with dose above 10 mg/g to determine the optimum dose.

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