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Effectiveness of Ceramics Water Filter Pots with Addition of Silver Nitrate to Reduce of *Escherichia Coli* Contents

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***Abstract*— Efforts to create a filter alternative in an emergency is very necessary in order to meet the drinking water needs. Filter pottery is one alternative screening models are cheap and mobility, so it can be applied, however, the ability of pottery on filtering raw water into drinking water needs to explored.. This study tested the ability to pottery from a mixture of clay and fine rice husk with 0.001 mole added of silver nitrate and 0.0005 mole within the period of use. This study conducted in soil and water engineering laboratory, Universitas Padjadjaran, Environmental Laboratory Institute of Ecology Universitas Padjadjaran and Energy and Mineral Resources Laboratory, West Java Province. This study also conducted pore size analysis using Scanning electron microscope (SEM) in order to know the pore diameter and pore distribution formed from the ceramic pot filter. The faucal-coli analysis is performed as an indicator of filter quality generated from the ceramic pot filter. The results showed that added of silver nitrate to lower the flow rate of 0:35 l/h. The Increasing added of silver nitrate also showed an increase in water resulting residue 0:02. Increasing the number of used periods to decrease of silver nitrate residue 0001. The results show that ceramic pot filter can reduce the number of e-coli with significant amount. The size of the pores of ceramic pots formed shows a diameter smaller than the diameter of e-coli. There are still some cracks in the process of making ceramic pots, thereby reducing the ability of ceramic pot filters to reduce e-coli.**

***Keywords*— ceramic water filter pot; e-coli residue; silver nitrate residue; number of applied.**

I. INTRODUCTION

Contamination in water sources can be a result of many different factors, both natural and artificial. Although small amounts of contamination can occur from natural processes such as earthquakes and rainfall, it often stems from human activity[1]. Lack of clean water for use by rural communities in developing countries is of great concern globally. Contaminated water causes water-borne diseases such as diarrhea, which often lead to deaths, children being the most vulnerable. Therefore, the need to intensify research on point-of-use water purification techniques cannot be overemphasized [2]. The water contain E. coli bacteria to drinking water use can cause diarrhea and gastrointestinal infections. In general effort to reduce e-coli content in the raw water is done by boiling water to boiling (100 ° C) for at least 1 minute. The water treatment is simple so that the content of E. coli bacteria in the raw water through a colander pottery from a mixture of clay and rice husk or fine material which is coated by a solution of silver nitrate is an alternative model of water filtration is easy to carry and cheap, so interesting to study[3][4][5][6]. Ceramic Water Filter Pots (CWFPs) consist of porous clay that acts as a filter, which is coated with silver nanoparticles creating a system capable of removing 99.995% of bacterial pathogens from drinking water [7].

Utilization of ceramic pot filters has been widely applied to communities in various countries; Southeast Asia, Africa and Central America. Ceramic pot filters are applied in various places to obtain clean water and reduce diarrheal diseases for rural and poor communities [8][7][9], so that this filter is very potential to be developed in Indonesia which has a high level of flood and drought.

The ceramic filter with 15 % saw dust, 80 % clay and 5 % grog that was fired at temperature of 950 °C or 1000 °C showed the best removal efficiency. Statistical ANOVA

tests showed a significant difference between ceramic filters with various compositions in their removal efficiencies[10].

Ceramics filter pots formed from mixing ingredients in addition to the main ingredient forming pottery. Pottery can be used as a water filter to reduce the content of E. coli and improving the quality of raw water [8][11]. A mixture of the most effective and stable is a pottery strainer rice husk mixture with the composition of the main ingredients of clay and rice husk 80% and 20% [12]. The ceramic filter with 15 % saw dust, 80 % clay and 5 % grog that was fired at temperature of 950 °C or 1000 °C showed the best removal efficiency[10]. Tests showed that copper is a suitable antibacterial agent to combat coliforms in contaminated water. Copper mesh made of thin wire of 0.65 mm porous diameter was placed inside the receptacles of the filters [2] . Ceramic pot water filter model used in several location are given in Fig. 1.

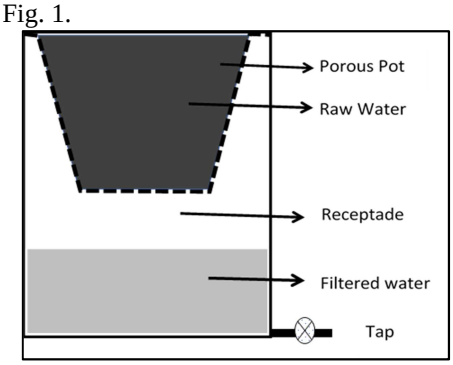


Fig 1. Schematic Diagram of a Ceramic Pot water Filter

Silver nitrate solution as a disinfectant can kill and inhibit the proliferation of the bacteria E. coli to meet the requirements of clean water in accordance with drinking water standards. Silver nitrate has the effect of essentially killing and disabling the reproduction of the smallest bacteria that are able to pass through the pores. The silver also helps to prevent moles from growing on the filter surface [8]. The mechanism of the silver nitrate solution in a deadly bacterial silver nitrate solution is sticking to the walls of bacterial cell membranes, causing enlargement of the cell wall. This happens because silver nitrate replacing the compound in the cell membrane of bacteria needed for the membrane remain stable so as to prevent the proliferation of bacteria. The use of silver nitrate solution on a filter earthenware able to reduce the bacterial content to 99.73% [12].

Another ceramics system filters was two ceramic filter discs as a medium for water filtration. These filters were made from two different ceramic mixtures of local red clay, sawdust, and water filtration system can be operated continuously with a constant flow rate and the filtration process was controlled by a skin thin layer of rejected materials. The ceramic water filters of both filtration modules have high removal efficiency of total suspended solids up to 100% and of turbidity up to 99.94%.[13]
Scanning Electron Microscope (SEM) is capable of visually displaying corrosion damage with micro size in motor vehicle exhaust [14]. thus potentially being used to visually analysed the characteristics of pore distribution in ceramic pot filter [15].

Research on ceramic pot water filters with the addition of silver nitrate and some clay and fine rice husk ratio showed that the pottery filter with clay and bran composition: 80%: 20% and coated with silver nitrate can reduce the content of e-coli up to 100% [16], but it has not been known to screen for long periods of time.

The purpose of research is to know the effectiveness of the addition to silver nitrate to the Ceramic water filter pots to decrease raw water contain E. coli bacteria. This study also examines the quality of filtration after a number of uses, this refers to Halem 2017 research [5] which states that one of the problems using ceramic filters is the occurrence of clocking which inhibits the flow of water in the filter so that the productivity of ceramic filters decreases.

II. Material and Methods

The research conducted at Soil and Water Engineering Laboratory, analysis samples at Ecology Institute Laboratory Padjadjaran University. Scanning Electron Microscopes analysis conducted at Energy and Mineral Resources Laboratory, West Java Province.

This research uses descriptive analysis approach to water quality ceramic water filter pot filtering results with the addition of silver nitrate through several stages of research namely:

A. Pre Research

This phase includes a literature review, surveys the availability of materials and equipment used in the study, than making pottery with the activities of collecting materials and manufacturing process. Ceramics water filter pot strainer made from a mixture of clay, fine rice husk and water. In the process of making ceramic pot strainer required multiple tools including starcher machine, mixing machine, printer machine and the furnace.
This study uses ceramic water filter pot strainer of three units with higher levels of silver nitrate solution different. The basic ingredients of the three pots of earthenware sieve has a composition of 80:20 to clay and fine rice husk.
The process of making pottery includes crushing materials, mixing materials, molding pots, drying and burning continued with earthenware pots with controlled temperature. Two ceramic pots strainer given additional silver nitrate solution with each concentration 0,0005M (GB) and 0,001M (GC), the pot marks added silver nitrate solution (GA).Ceramic pot water filter used in this study are given in Fig 2.

Fig 2. Ceramic Water Filter Pot Models

B. Filtering Process

The sampling and measurement of flow rate in litter/hour screening results used first, fifth, tenth and fifteenth of each pottery. Data flow rate in ceramic water filter pot type and flow rate after several uses are used for ceramic water filter quality analysis.

C. Data Analysis

The data analysis is done by testing samples of raw water filtered ocean pottery additional premises silver nitrate with the parameters of E. coli bacteria content, nitrate (NO_3), and the content of silver ($AgNO_3$).

Analysis of pore size and distribution using SEM was done in order to know the distribution and size of the pore formed visually compared with micro size of e-coli. Visual analysis of SEM results was performed to see the pore and cracks of ceramic water filter samples pieces.

Determination of the quality of the filter made is done by comparing the filtration results of several types of pot filters through descriptive analysis.

III. Result and Discussion

A. Initial testing of Raw Water

Water used in testing sieve pottery is raw water obtained in Faculty of Agricultural Industrial Engineering, Universitas Padjadjaran (UNPAD) at Jatinangor, West Java Indonesia. The content of the test sample used for comparison at the beginning of the major testing are presented in Table 1.

TABLE I
THE CONTENT OF THE INITIAL SAMPLE OF RAW WATER

Parameter	Unit	Quality standards	Methods of analysis	Results
E. Coli	/100 ml	0	SMEWW-9221 - E	150
Nitrate	mg/L	50	SMEWW-4500-NO3-b	6.72

The quality of water sources used in this study has an e-coli content above the threshold for quality requirements for drinking water, which is above the threshold for e-coli content, so that it can be seen the decrease in e-coli content resulting from filtration of several types of ceramic water filters after several uses.

B. Flow Rate Ceramic Water Filter Pot

The flow velocity is measured as an indicator of the rate of water which shows it easy for bacteria to escape sized particles of porous ceramic pot [15]. The measurement results of the ceramic pot filter speed indicates that there has been an increase in water flow rate over the time of use. Ceramic pot filter with the addition of nitrate silver 0.001 M has the lowest water flow rate. In detail the distribution of the flow velocity versus time of use is shown in Fig. 3.

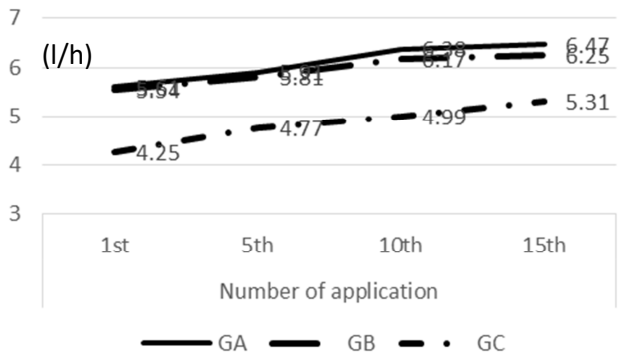


Fig 3. The flow velocity of ceramic pot water filter

Figure 3 shows the flow rate characteristics of each type of ceramics filter in several uses. Flow rate and average flow rate measurements have shown that ceramic pot filter with the addition of 0.001 M silver nitrate (GC) has the lowest flow rate compared another ceramic wate filter. Flow rate tends to increase after several times of use, this is probably due to a decrease in the amount of blockage of organic matter, the remainder of the process of combustion of ceramics in the pores that drift with water filtration when the filtration process takes place. The test results ceramic filter pot flow rate is presented Table 2.

TABLE II
FLOW VELOCITY FILTER OF CERAMIC WATER FILTER

Sample	**Velocity l/h**	**Flow rate (l/h)**	**Increase in flow rate (l/h)**	**Average flow rate (l/h**
GA 1 (1st)	5.61		0.86	6.09
GA 5 (5th)	5.91	0.3		
GA 10 (10th)	6.38	0.47		
GA 15	6.47	0.09		
GB 1 (1st)	5.54		0.71	5.94
GB 5 (5th)	5.81	0.27		
GB 10 (10th)	6.17	0.36		
GB 15 (15th)	6.25	0.08		
GC 1 (1st)	4.25		1.06	4.83
GC 5 (5th)	4.77	0.52		
GC 10 (10th)	4.99	0.22		
GC 15 (15th)	5.31	0.32		

A flow velocity on pottery (no added silver nitrate) has an average value of the flow rate of 6.09 l/h. The flow velocity increases according to the number of applications with increased flow rate of 0.28 l/h. Pottery B (added silver nitrate 0.0005 M) has the average value of the measured flow rate is equal to 5.94 l/h. Increased speed according to the amount of usage with an average increase of 0.24 l/h. Ceramics water filters C (added silver nitrate 0.001 M) has an average value lower flow rate that is equal to 4.83 l/h. Increasing the flow rate according to the amount of use to an increased flow of 0:35 l/h.

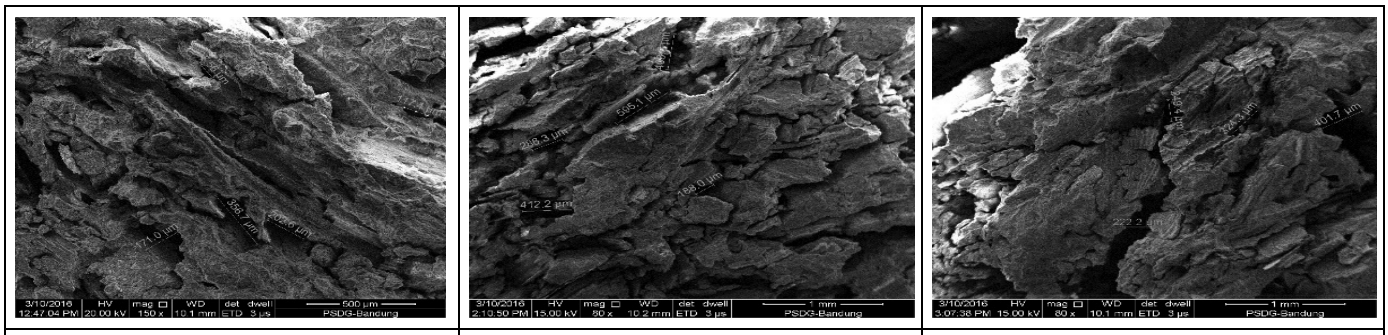
The flow rates of the research are more rapid than the ceramic water filters was Nnaji's built. The Flow rates ceramic water filters that ranged between 0.0005 l/h for the filter with 5% sawdust and 0.8 l/h for the filter with 50% saw dust[13]. Rapid filtration process is needed in the provision of clean water for the community, but still needs to pay attention to the quality of water produced.

Sieve pottery used in the test had an average flow rate of the different pottery A has the highest flow rate (6.09 l/hr) followed by pottery B (5.94 l/h) and ceramic water filter C showed the lowest flow rate (4,83 l/h). This results showed that silver nitrate coating inhibits the speed of the water filtration process into clean water.

The flow velocity is strongly influenced by the manufacture of pottery and pottery-making process material that is not perfectly mixed flow will increase the speed and reduce the ability of earthenware sieve to reduce the content of E. coli [3].

C. Pores Earthenware Pottery with Flow Rate Filtering

Pores ceramic water filter pottery produced from mixing ingredients. Variations in the mixture of clay and pore-producing materials determine the amount of pore and pore size, the greater the mixture of pore filling material will produce larger and more pore size and size. The ceramics water filter has pores formed from mixing ingredients in addition to the main ingredient forming pottery. Pottery mixed material will be mixed with the main ingredient pottery makers, mixing ingredients that will burn when done burning. The combustion residue from the mixing ingredients generate pores in the earthenware. Pores formed pottery that will stop the flow of water to be filtered to show a negative correlation higher pore size, pore size small will increase the effectiveness decrease in Total Coliforms[3]



Ceramics Water Filter Pot A	Ceramics Water Filter Pot B	Ceramics Water Filter Pot C

Fig. 4 Results of Scanning Electron Microscopes

Scanning Electron Microscopes (SEM) results showed that all ceramics water filter pots have a smaller pore size than the size of the e-coli bacteria, but not uniformly so that there is still a possibility of pore size larger than the diameter of E-coli bacteria. Non-uniformity occurs because of the process of making and drying the pottery filter, so that cracks appear and pores form too large because the mixture of materials is not homogeneous. Pottery quality also depend on the quality of the printing process of silver nitrate. The result Scanning Electron Microscopes of ceramics water filter are presented in Fig.4.

1) Contents of E-Coli Bacteria: The result of measurement of e-coli decrease after cultivation has shown that ceramic C (ceramic pot with the addition of nitrate silver 0001 Moles) has the highest efficiency level in decreasing e-coli, this shows that silver nitrate is very effective in reducing e-coli levels, so that it can prove that silver nitrate is one of the disinfectants The result of measurement of e-coli decrease after cultivation are showed in Fig 5.

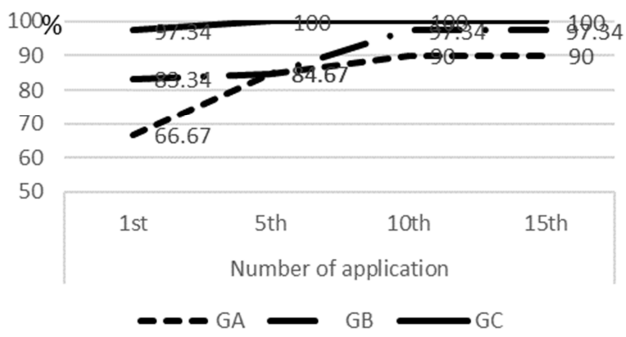


Fig 5. Efficiency of ceramic water filter pots to e-coli decreasing

Ceramics pottery filters without the addition of silver nitrate also showed a decrease in the number of filtered e-coli after several times of use this is possible because of the substrate that narrows the filter pores, so that the e-coli cannot pass through the filter. This condition also shows an increase in blockage of filter pores which can have an impact on clocking. Decrease in filtration quality can also be caused by the process of making earthenware filters that are not hardened so that cracking and pores are too large [17], so that in the manufacture of ceramics need careful supervision so that the quality of the ceramic produced is uniform and does not occur cracks

Based results test, the reduction of E. coli in an ceramic water filter A with the lowest efficiency (82.84%). On pottery and decrease the efficiency of E. coli is higher than the ceramic water filter pot A. Ceramic water filter pot B has an average efficiency of 90.67%. Ceramics water filters C has the highest efficiency among other pots with an average efficiency of 99.34%. addition of silver nitrate was able to improve the quality of filtration against e-coli contamination, however, it is necessary to consider the quality standard of silver nitrate dissolved in clean water so as not to have an adverse effect on users. Efficiency decrease in e-coli are presented in Table 3.

TABLE III
EFFICIENCY DECREASE IN E. COLI

Sample	E. Coli decrease in efficiency (%)	Average decrease in efficiency of E. Coli (%)
GA1 (1st)	66.67	82.84
GA5 (5th)	84.67	
GA10 (10th)	90	
GA15 (15th)	90	
GB 1 (1st)	83.34	90.67
GB 5 (5th)	84.67	
GB 10 (10th)	97.34	
GB 15 (15th)	97.34	
GC 1 (1st)	97.34	99.34
GC 5 (5th)	100	
GC 10 (10th)	100	
GC 15 (15th)	100	

Differences in application of silver nitrate levels indicate different pottery removal efficiency of e. coli filtered water significantly, the more often ceramic water filters are used, the lower the quality of filtering e-coli. The mechanism of action of silver nitrate compounds that silver will penetrate and damage the wall of the bacteria and cause the bacteria to lose its structure. Silver nitrate can also directly bind to DNA, causing the DNA will be thickened and lose their ability to replicate [11].

2) Nitrate contents of water filtration results: Research conducted using silver nitrate solution as a disinfectant on pottery, then in the filtered water samples of pottery B and C need to be tested the nitrate levels in the water to ensure nitrate levels are still within safe limits for consumption, this shows that the use of silver nitrate is still safe for users of filtration water. The results of analysis of concentrations of dissolved silver nitrate levels have not shown the minimum point of concentration of silver nitrate in filtration water in relation to the amount of filter use, therefore it is necessary to examine the extent to which the number of filters used to function properly. The content of nitrate test results are presented in Table 4

TABLE IV
CONTENT OF NITRATE WATER FILTRATION RESULTS

Sample	NO_3 (mg/L)
GB 1 (1st)	0.891
GB 5 (5th)	0.883
GB 10 (10th)	0.572
GB 15 (15th)	0.558
GC 1 (1st)	0.834
GC 5 (5th)	0.770
GC 10 (10th)	0.707
GC 15 (15th)	0.284

Table 4 shows that some silver nitrate dissolves with filtered water, so the more often the ceramics water filter is used, the lower the concentration of silver nitrate dissolved. Decreasing the layer of silver nitrate will have an impact on the quality of ceramics in filtering water.

The test results indicate that the ceramic water filter pots B (added silver nitrate 0.0005 Mole) and C (added Silver nitrate 0.001 Mole) produces water with silver nitrate levels below 1 mg/L. The amount of use of ceramic filters affects the decrease in nitrate levels in ceramic walls and filtration results, the more often ceramic filters are used the lower the level of silver nitrate in ceramic walls and the level of silver nitrate contained in filtered water. Content water filtered with silver nitrate showed on Fig. 6.

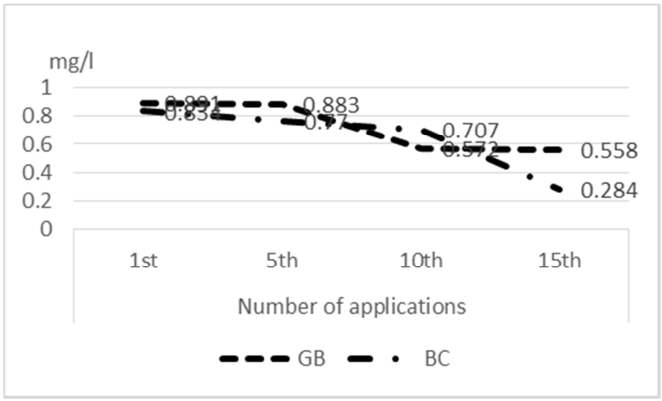


Fig 6. Nitrate (NO_3) content on water filtered

Figure 3 shows that the ceramic pot filter indicates that the silver nitrate gives impact to the water produced with the residual nitrate still contained in the filtration product. The residual dissolved Nitrate into the filtration results indicate a decrease in the duration of use, indicating that the longer the silver nitrate content will decrease, thereby decreasing the ability of e-coli to decrease.

Decrease in filtration quality especially in filtering e-coli and decreasing nitrate content is in line with Laan research, 2014. Laan said that the influence of silver on microbial removal efficiencies during ceramic pot filtration and storage was investigated. It was found that the storage time in the receptacle is the dominant parameter to reach E. coli inactivation, and not the contact time during the filtration phase[3]. Silver nitrate filters provided consistent removal with lower silver levels in the effluent and effective bacterial disinfection[18]. Other research also showed that the

addition of titanium oxide to ceramics water filter pots can reduce e-coli content [19], so it is very interesting to compare with the addition of silver nitrate with the addition of silver nitrate which is effective and efficient considering the quality standards of filtration silver nitrate.

The filters developed in this study are good enough in reducing e-coli, but are still prone to clocking, so cleaning needs to be done when it has been used for a certain time, however, this ceramic filter is very useful in meeting the needs of clean water in areas experiencing floods in flood-prone areas in Indonesia.

The quality of drinking water, especially in developing countries can be enormously improved by the use of clay-rice bran composite filter. Well water, harvested rainwater as well as surface runoff can be converted to ceramic water filter pot by subjecting them to filtration using. Besides the water source (springs were preferable compared to river or rain water) our data suggest that a high water throughput was the dominant reason for a ceramics filter pots performance[20], because the quality of water sources can accelerate the process of decreasing the quality of ceramic filters such as clogged filters.

The use of water filters with high content of total suspended solids (TSS) accelerates the occurrence of blockages, this is in accordance with the Al-hawaji study which states that at the beginning of the use of pores there have been blockages, especially small pores [13]

Ceramic water filter processing from the combustion process of organic matter into pores when burned (straw, husk rice, rice bran, starch, saw dust) so that further research is needed to determine the carbon content in filtered water resulting from the combustion process. This is done to determine the optimum use time so that the carbon content in clean water can be ignored

IV. CONCLUSIONS

The use of silver nitrate solution with a concentration of 0,001M in ceramic water filter has the highest effectiveness in reducing E. coli bacteria content of 99.34% in the raw water.

Filtered water with silver nitrate content of 0,001M in filters pottery yet not worth drinking, if drinking water quality standards is the content of the e-coli 0/100ml. SEM observations showed that all filters have pores smaller than the e-coli diameter, but there are still pores larger than the diameter of e-coli due to cracks.

The quality of the filtration results is determined by the process of making ceramic water filters, so that supervision and accuracy are needed in the process of making and drying the ceramics water filter so that no filter wall cracks occur.

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