CERAMIC WATER FILTER FOR DRINKING WATER TREATMENT

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Abstract – *One of the greatest threats to human health in developing countries is the drinking water contamination. Ceramic water filters (CWFs), manufactured from naturally sourced materials and manufactured by local labor are one of the most socially acceptable for drinking water treatment technologies because of their effectiveness, low-cost and ease of use. Ceramic water filtration has been greatly improved to remove most of the microbial contamination in water. In past, the developed ceramic filters are not able to treat chemical contaminants in water. Therefore, aim of this project is to develop a ceramic water filter that could remove certain chemical contamination in water at the household level. This review also summarizes the critical factors that influence the performance of CWFs, including CWF manufacturing process (raw material selection, silver impregnation), and initial water quality before treatment.*

Key Words*: Ceramic water filter; *silver coated calcium hydroxyapatite; Burn out materials

1. INTRODUCTION

In the early 2022, the world population has reached 7.9 billion. It is estimated that 884 million people, that is 1 in 9 do not have access to clean drinking water sources. The World Health Organization reported that 80% of gastrointestinal disease is caused by the use of contaminated drinking water. Vibrio cholera, Escherichia coli, and Shigella dysenteriae are some of the pathogens that are commonly found in drinking water in developing communities and can cause diseases such as diarrhoea, that could lead to dehydration, malnutrition or even death. Nearly, 99.8% child deaths resulting from gastrointestinal infections is happening in developing countries. The major causes of these infections and the resulting deaths are lack of access to drinking water and exposure to waterborne diseases from unsafe drinking water. Finally, all water related diseases are caused due to the lack of provision of sufficiently pure water for the basic needs of the community.

1.1 Development of Ceramic Water Filter

A filter is defined as a device, which removes something from whatever passes through it. Therefore, ceramic water filtration is defined as the process in which a porous ceramic (fired clay) medium is used to filter microbes or other contaminants from water. Ceramic water filters (CWFs) are simple and effective devices made from naturally available materials for providing safe drinking water. This technology is currently used in more than 50 countries as a cheap and effective point-of-use water treatment option. The size of pores in the ceramic medium is small enough to trap anything bigger than a water molecule. From the ancient times to the present, water filters have developed of necessity, initially to remove materials that affect appearance, then to improve unacceptable tastes and then to remove contaminants that can cause disease and illness.

1.2 Ceramic Filtration System

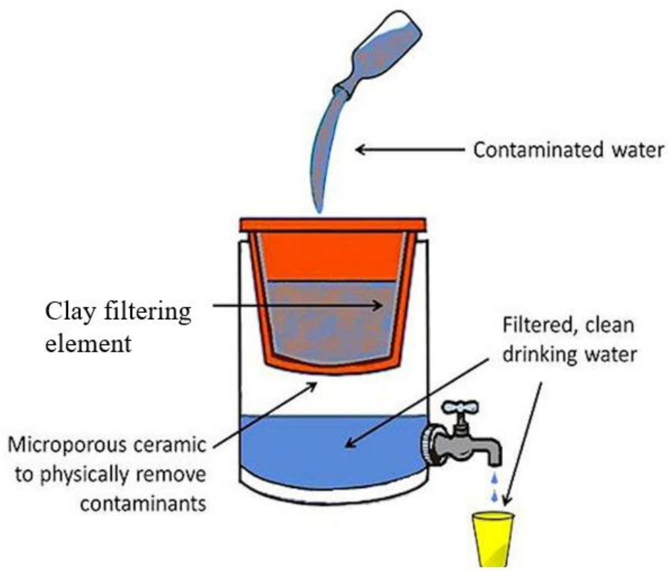

Fig -1: Ceramic water filtration system

Usually, ceramic pot filters are made which is kept above a plastic or clay receptacle. Water to be filtered is poured into the ceramic filter. A lid is provided at top to prevent further contamination of water. The water will flow through the minute pores of the filter into the receptacle placed below. During this path of flow contaminants gets trapped in these nano-micro pores and thus removing bacterial and chemical contaminants. And finally filtered water will reach the receptacle which can be taken out using a plastic faucet placed outside the bottom of the receptacle.

2. METHODOLOGY

CWFs are fabricated from a mixture of clay and organic combustible materials (e.g., rice husks or sawdust) also known as burn-out materials. Porous structure of ceramic filter is created as a result of the burn-out during the firing process. Manufacturing of conventional ceramic filter includes raw material selection and processing, mixing and pressing, drying and firing, as well as quality testing. The clay that was used in this study was obtained from potters. The combustible materials used are sawdust and activated carbon. The sawdust is collected from Sawmill. Activated carbon is prepared from wood charcoal using lime. Both sawdust and activated carbon subjected to a 500-µm sieving. Silver coated calcium hydroxyapatite were used as obtained from the suppliers. It consists of a white powder (average particle size of 5µm) of $Ca_3(PO_4)_2$ having silver coating.

2.1 Processing of Ceramic Water Filters

Four ceramic water filters were made from a mixture of clay, combustible material as sawdust, without silver coated calcium Hydroxyapatite and one filter is made with the addition of silver coated calcium Hydroxyapatite. The sawdust was used as a pore forming agent to trap some contaminants, while hydroxyapatite was used for the substitution of chemical contaminants. Collected clay was crushed into powdered form, which is then mixed with the sawdust in four proportions. Initially, Sieved clay powder and combustible materials were mixed dry and then wetted by adding water, then wedged and rolled into a smooth homogenous mixture. The resulting paste were molded into shape of a pot in a plastic cup. They had an internal base diameter of 90 mm, internal lid diameter of 110 mm, and internal height of 110 mm, with a thickness of 15 mm for the base and 10 mm for the sides. After pressing, the filters were air-dried for 8 days and fired for 3-4 hours. The percentage of sawdust which give optimum filtration and mechanical performance is found.

2.2 Characterization of Structure

The porosity of the filters was measured by water absorption. Compute the weight of dry filter, W_d. Immerse the filter completely in water for 24 hours. In air after wet-wiping take the wet weight of the filter, W_w. Finally, the mass of the samples was measured under water (i.e., hydrostatic weighing) W_h. Porosity can be calculated as follows:

$$\text{Porosity} = \frac{W_w - W_d}{W_w - W_h}$$

Compare the porosities of filters having different percentage of sawdust and filter having optimum porosity was found.

2.3 Collection of Contaminated Water

Three sampling points having contaminated open well water is traced. Collection of water samples were done from each of these sites. Water samples were collected from these open wells using sterile plastic bottles. Containers are filled with water, transported to the laboratory and refrigerated.

2.4 Determination of Hydraulic Performance

The hydraulic performance of the samples was determined by water discharge. Usually a receptacle was placed under the ceramic water filters. The mass of water discharged from the filters to the receptacle was recorded as a function of time. The water discharge was then obtained by dividing the mass of water discharged by the density (1 g/cm3). Finally, the flow rate was regarded as equal to the slope of the curve water discharge as a function of time. The filter having optimum flowrate is found and flowrate of 2 to 3 litre per hour is considered as optimum.

2.5 Determination of Filtration Performance

The effectiveness of the developed filters was determined by carrying out physio-chemical and microbial analysis on raw and the filter-treated water samples. Three localities having contaminated open well drinking water were traced. Water samples were collected from each of these sites. Physiochemical and bacterial analysis before and after filtration were done. The contaminant removal efficiency of the filter was calculated.

3. RESULTS AND DISCUSSION

The results show that the developed filters are effective in the treatment of physio-chemical as well as bacterial contaminants detected in the water samples. It can be seen that the removal efficiency increases with increase in percentage of clay content in the filter composition.

3.1 Estimation of porosity and flowrate

Table 1 shows the estimated porosity and flowrate of various filters having different sawdust concentration. Filter C 70 has High porosity (58.3%). This is the resultant of high clay to sawdust ratio. Porosity increases with increase in sawdust content. Filter C 85 has the lowest porosity (38.7%). The flowrate testing result shows a similar pattern as that of porosity. Filter C 70 has the highest flowrate (2000ml/h) and C 85 has the lowest flowrate (250ml/h).

Table -1: Estimated porosity and Flowrate of filters

Filter code	Clay Sawdust ratio	Porosity (%)	Flowrate (ml/h)
C 70	70 : 30	58.3	2000
C 75	75 : 25	52.5	1200
C 80	80 : 20	46.8	400
C 85	85 : 15	38.7	250
CS 75	75 : 25	54.7	1300

3.2 Filtration Performance

In the microbiological analysis, three different raw water samples based on their sources were used. The analysis involved testing for bacterial counts, total coliform and fecal coliform counts.

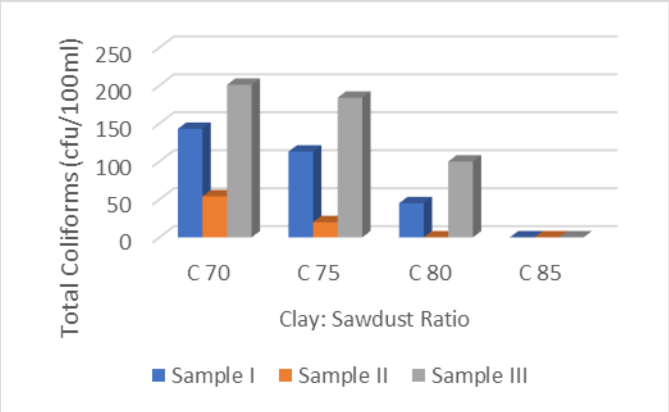

Fig – 2: Total Coliform variation for different sawdust content

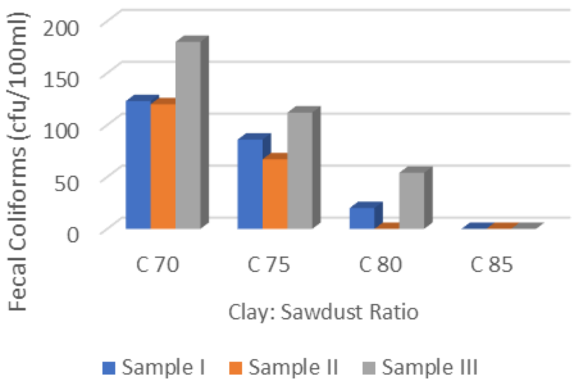

Fig – 3: Fecal Coliform variation for different sawdust content

The results of the open well and borehole samples indicated recontamination in the treated water samples. But based on the initial results, filter C 75 was observed to have given the best treatment with percentage reductions in bacterial counts of up to 70% in the well samples and 80% reduction in the borehole samples. Filter sample C 85 gave a 100% reduction of coliform in the well water samples. For the physio-chemical analysis, three different raw water samples based on their sources were used. They were the open well and borehole raw water sources. The results show that all the filtered samples improved iron and nitrate upto 90%. While the filtered samples increased TDS and electrical conductivity. This is due to the leaching of some clay minerals into the sample water.

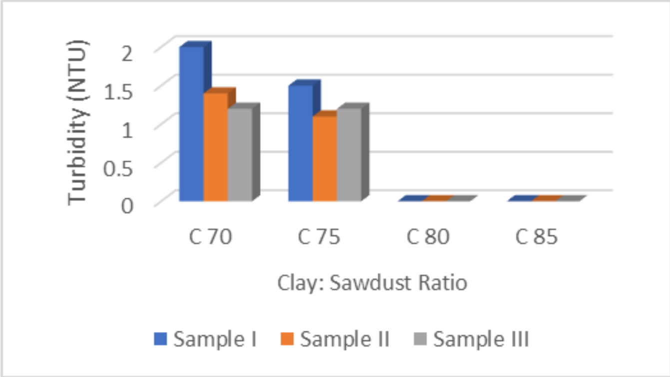

Fig – 3: Turbidity variation for different sawdust content

The results show that there is no sufficient variation in the pH value of the samples. While there is 99% reduction in the turbidity content. The turbidity values are less than one for all samples filtered using C 80 and C 85 filters.

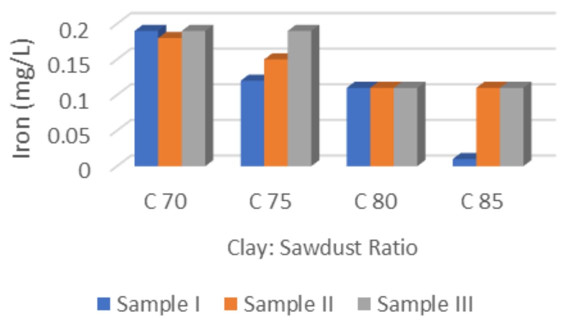

Fig – 4: Iron variation for different sawdust content

The samples preliminary analysis results show that iron content is beyond permissible limit (0.3mg/l). After filtration, the iron content has reduced to a lower value far less than permissible limit. Greater removal of iron has been seen in filters C 80 and C 85.

4. CONCLUSIONS

Ceramic water filtration is one of the recent low-cost water treatment methods made from locally available materials, is an affordable, effective, low-maintenance and sustainable technology appropriate for POU household water treatment in developing areas. According to this study the developed ceramic filters have the ability to treat both chemical and microbial contaminants in water. This study is expected to extend the use of ceramic filters in the household by reducing the existing limitations of the ceramic filters to cover the treatment of chemical impurities in water as well as the microbial and thus making it a complete solution to household water treatment needs.

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