The Use of Ceramic Water Filters in Improving the Microbial Quality of Drinking Water

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***Abstract*—**Water borne infections are the number killer of children under five years in developing countries. The main reason is the consumption of untreated drinking water. Here we report on the use of ceramic water filters in reducing *Escherichia coli*, a surrogate for pathogens in drinking water and can be applied in a rural household. For microbiological analysis, the two ceramic water filters, one from Mukondeni and the other one from Sese in Zimbabwe reduced the high microbial load of the raw water. The result showed that the counts as colony form units, of coliform in the purified water was zero and in raw water was too many to count; these colonies were probably removed by the ceramic water filter. The microbial counts in the purified water were zero colony forming units per 100 ml and within the SANS 241 guidelines values. The ceramic water filters from Mukondeni and Sese were able to improve the microbial quality of the raw water. The Sese ceramic water filter was slow and thus further improvements are required in the composition of materials by increasing the saw dust component and reducing the clay component. Thus, ceramic water filters are suitable for use at household level.

***Keywords*—** Ceramic water filters; rural communities; drinking water; microbial load

I. INTRODUCTION

South Africa and Zimbabwe are a water-scarce country and the demand on this resource is increasing due to population growth and increased industrialization [1]. Associated with this industrialization is overburdening of municipal sewage plants that discharge partially treated sewage effluent that contributes to river base flows and contamination of surface water sources [2]. The quality of drinking water is powerful environment determinant of health.

Drinking water quality management has been the foundation for the prevention and control of water borne diseases. In rural areas due to lack of awareness and maintenance, most of the families carry out the routine activities such as clothes washing, utensil washing, bathing cattle's, washing near to the ground and river water sources which is one of the reasons for contamination [3]. Close to 2 billion people over the world lack access to safe drinking water and estimated 2 million fatalities are linked to water borne infections [4]. Safe drinking water is very important in controlling and preventing many diseases. This is particularly well established for diseases such as diarrhoea, cholera, typhoid and paratyphoid fever, hepatitis and others. Ceramic water filters are affordable water purifications systems that are easily deployed at household level in order to provide safe drinking water. Recently in Harare, Zimbabwe there was an outbreak of typhoid fever and was attributed to contamination of groundwater source as a result of the recent rains [5-6]. The purpose of the study is to evaluate the microbial quality of filtered water using traditional ceramic water and a modern ceramic water filter.

II. MATERIALS AND METHODS

A. Ceramic Water Filters and Water Sampling

The modern ceramic water filter has been manufactured in a factory environment (Mukondeni, South Africa) and has silver nanoparticles incorporated in the clay matrix. Whereas the traditional ceramic water filter (Sese, Zimbabwe) was manufactured using traditional techniques of making ordinary clays pots but has the added advantage of having saw dust incorporated (no silver was added). The river water samples (raw) were then filtered through the ceramic water filters, hereby named, Mukondeni (CWF1), and Sese (CWF2) ceramic water filters. The raw and filtered water was then subjected to further microbial analysis. Turbidity was measured using turbidity meter, it was also measured in triplicate and the mean value was calculated.

This was done by investigating the presence of indicator organism *E. coli*. Membrane filtration method was used for *E. coli* pathogen indicators in the samples [8]. All agar plates used in this study were prepared according to the manufacture's specification (Heyns Lab Supplies), after preparation the samples were allowed to disperse into petri dishes and allowed to cool. All tests were performed in triplicates on 100 ml volumes of samples were passed through 0.45 µm pore size, 47mm diameter Microsep filter paper.

The number of bacterial colonies on each of the specific plates were determined and expressed as colony forming units per 100 ml (cfu/100 ml). Violet Red Bile Agar (VRBA) (Merck) was used for the enumeration. The colonies that turned red or surrounded by reddish precipitation zones were counted as *E. coli*.

B. Data Analysis

The results obtained were analysed comparing it to DWAF and SANS 241 [7] recommended water quality standards. The one-way ANOVA was used to determine the statistical

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differences between the raw and filtered water samples for each of the ceramic water filters at a significant level of $p<0.05$.

III. Results and discussion

The water sample for microbial analysis was obtained from a stream close to the University of Venda and was then passed through the Mukondeni ceramic water filter (CWF1) and the Sese ceramic water filter (CWF2) (Figure 1).

Fig 1: The ceramic water filters from (A) Mukondeni, Limpopo province of South Africa and (B) Sese, Masvingo province of Zimbabwe

Turbidity is the degree of cloudiness or clarity of water and this may be due to suspended and or colloidal material. WHO establishes that the turbidity of drinking water shouldn't be more than 5 NTU (Nephelometric Turbidity Units) and should ideally be below 1 NTU. To test turbidity, all that is needed to do is to collect the water sample and put it inside a vial that is inserted to a turbidity meter which measures the corresponding value of turbidity. The ceramic water filters, CWF1 & CWF2, were able to reduce the turbidity <1 NTU in the filtered water as shown by the single factor ANOVA which showed that the raw and filtered water was significant different ($p<0.05$). The ceramic water filters were found to be more effective and was able to reduce the turbidity of the river water. The study of Brown et al. [9] also confirmed the effective ability of ceramic water filters in reducing turbidity in raw water. However, the continuous use of the ceramic water filter results in blockages of the pores the trap pathogens during the filtration process and necessitates the cleaning of the ceramic water filters to remove the trapped contaminates [10]. Also, the suspended materials (turbid) in raw water supply may indicate the presence of pathogens and it is important in reducing turbidity.

The Mukondeni and Sese ceramic water filters were evaluated for the ability to remove and or reduce the microbial load of untreated drinking water (Figure 2). This was carried out by passing raw and contaminated water separately through the ceramic water filters and determining the levels of *Escherichia coliform*.

Fig 2: The microbiological evaluation of ceramic water filters: (A) raw contaminated water from a stream at the University of Venda; (B) purified water after passing through the Mukondeni ceramic water filter, Limpopo province of South Africa and (C)) purified water after passing through the Sese ceramic water filter, Masvingo province of Zimbabwe

The results of microbiological organisms showed that there was a different between the raw water and filtered water (Table 1) as shown by the single factor ANOVA which showed that the raw and filtered water was significant different ($p<0.05$). The filtered water contained zero *E-coli* and this indicates that the ceramic water filter was able to remove all the microorganisms that were present in water.

Ceramic water filter	**BEFORE FILTRATION**	**AFTER FILTRATION**	**SANS 241 GUIDELINE VALUES (cfu)**
Mukondeni	>300	Zero	1-10
Sese	>300	Zero	1-10

Data is average of triplicates

Escherichia coli are an indicator of faecal pollution. *E. coli* provides conclusive evidence of recent faecal pollution and should not be present in drinking-water [11](WHO, 2005). Thus, the presence of high *Escherichia coli* levels in water may indicate a higher risk of contracting waterborne disease, even if small amounts of water are consumed [12]. Thus, the ceramic water filters were able to reduce to zero the microbial load of the untreated raw water. The absence of *E. coli* in the purified water would translate to safe water that is suitable for human consumption. The Sese ceramic water filter was not impregnated with anti-microbial agents such as copper and or silver.

These anti-microbial agents are able to add value of improving the killing efficacy of the ceramic water filter [4]. A study by van der Laan et al. [13] showed that there was no difference in removing pathogens in ceramic water filters with silver and without silver nanoparticles. Thus, this implies that the ceramic water filters are effective in reducing pathogens but the presence silver is desirable. Though the presence of silver is desirable in the ceramic water filter the issue of cost becomes prohibitive since silver is expensive and would result in an expensive ceramic water filter beyond the reach of rural communities [14]. Also the silver leaches out in the ceramic water filter after two to three water filtration cycles resulting in no residual silver presence [15]. In this particular study the silver was analysed by was below detectable limits implying that the silver had leached out, below the 100 ppb WHO guideline for drinking water [10].

IV. Conclusion

The ceramic water filters, Mukondeni and Sese, were able to improve the turbidity and microbial quality of drinking water. It was recommended that further research be carried out to improve the filtration rate of the ceramic water filter, since the Sese was very slow.

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