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Evaluation of the eTulip POU unit at a rural village in the Eastern Cape

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In an effort to gain a better understanding of the factors leading to the successful uptake of point-of-use water treatment units, a twelve-month study was undertaken in a remote rural community in the Eastern Cape in South Africa by a research team from the Department of Chemical Engineering at the Durban University of Technology. The eTulip ceramic siphon candle filter was distributed to 22 participating households. The filter was effective in providing 30-40 litres of filtered water per day of adequate water quality. 64% of the users used and maintained their filters on a daily basis. Participants liked the taste of the filtered water and reported decreased rates of diarrhoea, stomach pains and skin rashes in both children and adults.

Introduction

Approximately five million people in rural South Africa do not have access to piped water. These people obtain their water from springs, small rivers and even puddles after the rain. Drinking untreated water exposes these people to water borne diseases, with diarrhoea in the main. South Africa is one of the few countries in the world where the under-five mortality rate has increased and diarrhoea and dirty water being the cause.

The South African Free Basic Water Policy (DWAF, 2001) essentially stipulates that 6000 L of water are to be provided at no cost to all households in the country every month. This calculates to an average of 25 L per person per day for a household of eight people. South African municipalities, through the Municipal Infrastructure Grant process, have access to resources to finance their responsibility of providing the basic water supply services. The South African Strategic Framework for Water Services (DWAF, 2003) defines a basic water supply as "the infrastructure necessary to supply 25 L of potable water per person per day supplied within 200 m of a household …".

So, although rural communities in South Africa are entitled to 25 L free water, it is envisaged that it will take 5-15 years to get piped water to all the rural communities. The scattered clusters of households, the geographic situate (hilly terrain), lack of infrastructure, lack of water sources, and remoteness makes it relatively expensive to provide piped water. More and more point-of-use (POU) water treatment technologies are emerging as a foreseeable interim solution. These technologies do not require any infrastructure or energy by way of electricity or motor driven devices. In addition they are relatively inexpensive, easy to operate and maintain. There are however paralleling challenges in implementing POU water treatment systems on a large scale.

Internationally several POU water treatment systems have already been implemented in rural communities. Some examples of these units are ceramic pot filter, ceramic candle filter and chlorination. However there have been several factors leading to the poor uptake of these technologies on a large scale. Some of these factors are operational and maintenance issues, social and cultural integration of the units, and economic viability of replacement filters.

Given some of the afore-mentioned points, it follows, that for the successful implementation of the POU systems to be achieved on a large scale the following aspects must be considered:

- The need for POU systems within the rural areas of South Africa;

- The socio-cultural-economic conditions relating to the diverse consumer base in these areas; and
- The value systems, historical socio-political exposure of the past against the introduction of the more modernistic or improved technology in consuming purified water.

In order to gain a better understanding of the factors leading to the successful uptake of POU systems, the research team undertook a twelve-month study in a rural community in Bizana in the Eastern Cape in South Africa. The eTulip ceramic siphon candle filter was identified as a suitable POU unit. The objectives of the pilot study were to evaluate the performance of the filter in the field and to evaluate the acceptability of the filter by this remote rural community.

Materials and methods

Bizana is a rural community made up of approximately 4000 people in the Eastern Cape in South Africa. The households are scattered and the geographic outlay made up of steep hills and valleys. The community obtain their water from small springs and rivers which are at the bottom of very steep valleys. They share their water sources with their live-stock. They do not treat the water used for drinking and cooking purposes.

On having met with community representatives and performing an initial analysis of water samples, twenty two households were recruited to participate in the study. Households were selected from four out of the eight villages originally scanned for the study. There were seven water sources in the four selected villages. Approximately three households per water source were selected. Preference was given to households with young children, elderly persons, widows or single parents. This was to gauge whether vulnerable people could operate the unit effectively.

The study participants each received an eTulip water filter system. It consisted of an eTulip ceramic candle filter with siphon tubing, a 25-L plastic bucket, a 20-L clear plastic bucket with attached tap and lid and a 70 cm high plastic stand. The source water is placed in the 25-L bucket which sits on the plastic stand (top bucket). The candle filter element is attached to the side of the top bucket at a height of 10 cm from the bottom of the bucket. The siphon bulb has to be squeezed a few times to start the flow of water from the bucket through the ceramic filter. The filtered water goes into the 20-L bucket which sits on the floor (lower bucket).

Study participants were trained and shown various instructions pertaining to the use and maintenance of the POU system. In particular a sound briefing was done by demonstrating the backwashing and scrubbing the filter element with a cotton scrub cloth. This briefing which entailed a practical demonstration was accompanied by in-depth explanations in their language. This combination assisted by interpreters saw a meaningful understanding, acceptance of the POU system and indeed sound co-operation.

Users were advised to perform a day filtration and night filtration each day. Users were instructed to fill the top bucket with 20-L of untreated water for the night filtration and then the same for the day filtration. They were also advised to top-up the water level during the day in order to maintain a high flow rate. Users were also instructed to backwash and scrub the filter with a cloth after the night filtration and again after the day filtration. Backwashing is a method of cleaning the ceramic filter to restore the flow rate.

Two local women who served as study participants were recruited to be on the cleaning and maintenance team. For these duties they were paid a monthly stipend. The training of the cleaning and maintenance team was carried out by the research team. The broad functions for the cleaning and maintenance team were to clean filters once a week in each household, carry out repairs if any and to ensure smooth functioning of the units, to keep a stock of spares for the unit, and to observe and make note of any other challenges or problems during the course of the visits to households relating to the operations of the unit.

Monitoring over twelve months included surveys, focus group meetings, interviews and water quality tests. This planned process was explained to all involved, which resulted in timeous responses, good participation, feedback and enthusiasm to progress further with our endeavours.

Results and discussion

From the various monitoring processes over a twelve-month period the research team was able to establish the field performance of the filter and the acceptability of the filter by the community.

Volume production of filters

When asked how much water do you collect from the night filtration and day filtration, households responded with volumes ranging from 5-20 L, with an average of 17-L for both night and day filtration. Majority of the households (94%) used the filtered water for drinking and cooking purposes only, and 88%

of these households found filtered water to be sufficient for drinking and cooking purposes. All of the households were satisfied with the taste and quality (odour, colour, particles in water) of the filtered water.

Table 1. Filter usage and maintenance

Question	% of households
How much water do you collect from the night filtration? 20-L 15-L 10-L	47% 35% 18%
How much water do you collect from the day filtration? 20-L 15-L 10-L	64% 18% 18%
What are you using the filtered water for? Drinking and cooking drinking only	94% 6%
Is it sufficient for these purposes? Drinking and cooking only: Yes No Drinking only: Yes No	 88% 12% 100% 0%
Are you satisfied with the taste of the filtered water? Yes No	100% 0%
Does the filtered water have any odour, colour or does it have any particles? Yes No	0% 100%
Do you find the filter easy to use? Yes No	100% 0%
How often do you clean the filter? Daily 3-times a week 2-times a week	64% 18% 18%
Is backwashing easy to do? Yes No	100% 0%
Do you find scrubbing the filter with the cloth takes time? Yes No	12% 88%
Do you top-up the top bucket during the day? Yes No	100% 0%
Do you find that sometimes you just did not have time to clean the filter? Yes No If yes, how many times would this happen in a week? 1-2 times a week 3-4 times a week	72% 28% 77% 23%
Are you experiencing any problems with the filter or with cleaning the filter? Yes No	6% 94%
Are you comfortable with the unit? Yes No	94% 6%
Do you like the filter system: buckets, stand and candle filter? Yes No	100% 0%
Do you have any suggestions as to how we could make the system more simple? No changes Include a stand for the lower bucket candle filter with no tubing	 82% 12% 6%
If any part of your filter system breaks, do you think you should pay for a new replacement part? Yes No	20% 80%

Cleaning practices

Nine months after the filter hand-over, 64% of the households were cleaning the filter daily. Users reported that when the source water was fairly clean, only backwashing the filter was sufficient to restore the flow rate. None of the users experienced any problems with backwashing the filter. In a focus group meeting users reported that they noticed “things” come out of the filter when they backwashed and the flow rate improved after backwashing.

36% of the users, it would appear, were not sufficiently “in the know” or knowledgeable to effectively maintain and service the filter. Some reasons given for this were: (a) source water is fairly clean, so no need to clean (b) flow rate is sufficient (c) no time to clean the filter – they have many household chores to do as well as gardening (d) they rely on the cleaning and maintenance team to clean the filter. In addition 72% of users reported that sometimes they just did not have time to clean the filter. Of these users 77% said that this happened 1-2 times a week.

After 4 months of filter usage, users complained that flow rate was low even after the filter was cleaned. The cleaning and maintenance team were then advised to gently scrub the ceramic filter with the scrub pad during their weekly visits to households. The scrub pad removes 2-3 mm of the ceramic filter. After

scrubbing with the scrub pad an improvement in flow rate was noted. During the last three-months of the study, the cleaning and maintenance team reported signs of over-scrubbing of the filters. They reported that some users purchased their own scrub pad from the local supermarket and scrubbed their filters with it. For this particular reason, users were not told about cleaning the filter with the scrub pad during the training session, neither was scrub pads given to them. In hindsight maybe this ought to have been done.

Physical structure of filter system

The majority of the households (94%) are comfortable with the filter system. One user reported problems with children tampering with the filter tubing when she was not at home. All the users found the filter system easy to use. When asked if they have any suggestions as to how the system could be made simpler, 82% wanted no changes, 12% would like a stand for the lower storage bucket as the tap on the bucket is close to the floor, and 6% would like candle filter with no siphon tubing.

Table 2. Water quality results

	Before filtration		After filtration	
	Total coliform	E.coli	Total coliform	E.coli
Present	16	12	3	1
Absent	0	4	13	15

Water quality

Water quality samples were collected both before and after filtration at 16 households in the 10th-month of the pilot study. The before filtration sample was taken from the top bucket containing the source water. The after filtration sample was taken from the tap on the lower storage bucket containing the filtered water. Ten of the source water samples were river or spring water, the remaining six were rain water. Total coliform bacteria were present in all 16 source water samples. E.coli was present in 12 of the 16 source water samples. Sources without E.coli included 4 of the rain water samples.

Thirteen out of 16 filters were able to remove total coliform. Thus 81% of the filters removed total coliform. Of the 12 households that had E.coli in the source water, 11 had no E.coli in the filtered water. Hence 92% of the source water contaminated with E.coli was not contaminated after filtration. The absence of E.coli in the filtered water is also an indication that there is no contamination of the lower bucket.

Table 3. Breakages

Study month	Number of breakages
Months 1-6	12
Months 7-12	3

Breakages

Fifteen filters had to be replaced during the 12-month study period. Filters had to be replaced due to filter outlet pipe breaking, cracked filters and faulty siphon tubing. In the first six months of the study, 12 filters had to be replaced; in the last six months of the study 3 filters had to be replaced. As users got used to the filter, the number of breakages decreased. Thirteen households (59%) did not experience any breakages throughout the study period; nine households (41%) experienced filter breakages of which five households had to have their filters replaced more than once. Only 20% of users think they should pay for replacement parts. These users are willing to pay between 20-50 South African rand (2-3 US$) for replacement parts.

Perceived benefits of filters

Do you think your family has benefitted from the filter? How?
Some responses:

Filter 1: Before filter, children had skin rashes and diarrhoea. Now they don't.

Filter 3: Before filter, children and adults had skin rashes and diarrhoea. Now they don't. They also like the taste of water, it is nice.

Filter 5: Before filter, children used to get skin rashes, now they do not. Before filter they were drinking dirty water, water that had things in it. Filtered water is clean.

Filter 6: Before filter, children and adults had diarrhoea. Now they are better.

Filter 14: Before filter, children and adults had skin rashes and diarrhoea. Now they don't.

Filter 15: Yes. Before filter adults and children used to have running stomach, stomach pains and skin rashes. Now they do not.

Filter 21: Yes. Children used to have skin rashes and runny stomach but now they don't. Adults used to have runny stomach but now they don't.

Perceived benefits of filter

The central objective of the filter system is to produce an acceptable quality of clean water for consumption. The water quality of the filtered water was found to be satisfactory. When study participants were asked how their families have benefitted from the filter, there were some very positive feedback from the study participants such as decreased rates of diarrhoea, stomach pains and skin rashes. Although the study sample size is small and no health study was done, there appears to the users to be some health benefits of the filter.

Summary of field performance of filters and community acceptance

Table 4 provides a summary of the extent to which filters meet field performance and community acceptance criteria. The major concern regarding field performance is the relatively high number of breakages in the first six months. So as to ensure that there would be minimal amount of breakages, it is evidently clear that in further interaction with the community adequate training and supervision as regards the handling of the filter system would have to be provided. In addition alternate options of operating the filter such as allowing the filter to hang in the bucket instead of being attached to the bucket would have to be explored.

Table 4. Criteria for field performance and acceptability

Criteria for field performance	**Extent to which filters meet criteria**
Volume production is sufficient	Yes. Average 17 L filtered water for day filtration as well as for night filtration. Volume of filtered water is sufficient for cooking and drinking purposes.
Water quality is acceptable	Yes. 92% of the source water contaminated with E.coli was not contaminated after filtration.
Number of breakages	Relatively high. There were a relatively high number of breakages in the first six months. This is a concern for sustained use of the filter.
Criteria for community acceptance	**Extent to which filters meet criteria**
Filter is easy to use	Yes
Filter is easy to clean	Yes. Users found backwashing to be easy and scrubbing the filter with the cloth did not take time.
Users are comfortable with filter	Yes
Users willing to clean filters daily	Somewhat. Only 64% of users are cleaning filters daily.
Users like taste and quality of filtered water	Yes
Users see filter as beneficial	Yes

The major concern regarding community acceptance is users' lack of cooperation to clean the filter on a daily basis. With this in mind and taking into account the importance of the filter's function, it is evidently clear that in further interaction with the community tremendous emphasis would have to be placed on cleaning and maintenance which would then elicit greater cooperation in understanding the importance of the filter and therefore demand keeping the filter system clean.

Conclusions

Users were by and large satisfied with volume production of the filter, the taste and quality of the filtered water and the physical structure of the filter system. They also found the filter system easy to use.

During the course of monitoring it was established that 36% of users did not clean the filter on a daily basis. If users do not clean the filter at least once a day, it will result in slow flow rate and consequently insufficient clean water for the household for drinking and cooking purposes. The slow flow rate could hinder the sustained acceptability of the filter. Therefore it is important to impress upon users the necessity to clean the filter at least once a day.

Microbiological data showed that 81% of the filters removed total coliform and 92% of the filters removed E.coli. Samples of filtered water were taken from the tap on the lower storage bucket. With this in mind it is advisable that when future tests are conducted samples should also be taken from the filter outlet tubing as a basis for comparison with the lower storage bucket water. This would then provide an accurate reflection of the testing process.

A further observation was the number of breakages during the first six months was relatively high which necessitated providing further filters at no cost. So as to ensure that there is a minimal amount of breakages, it is evidently clear that there would have to be further training, interaction, communication and a bit more supervision as regards the filter system. This process would then ensure a better understanding which would allow for careful handling and give maximum output of filtered water.

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