

Interactive comment on “Do low-cost ceramic water filters improve water security in rural South Africa?” by Jens Lange et al.

Jens Lange et al.

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Answers to referee #1

General comments: The paper reports on the performance of low-cost ceramic filters (CCFS) for improving water security in rural South Africa. This is an interesting topic considering the challenges faced by rural communities in South Africa and many other developing countries where point of use devices such as CCFS could aid in improving access to potable water in these areas. There is dire need for knowledge of the performance of such point of use devices for informed decision making while promoting the same.

Our answer: We thank the anonymous referee #1 for his thorough check and his helpful comments that greatly improve our manuscript.

Specific comments:

1. Page 2, lines 12-14- what have been the general trends in levels of acceptability of the technology, affordability, reliability in terms of amount water generated per day and willingness to pay for the CCFS in rural communities especially where these have been promoted by Du Preez et al., 2008 and Mwabi et al., 2013?

Our answer: We will add the price of the bucket water filter (ZAR 599) in the filter description and further details on acceptability of this specific filter system. The study of Du Preez et al. (2008) tested CCFS performance in the field and reported their high acceptability, while the laboratory study of Mwabi et al. (2013) does not contain information about acceptability. We will add the following sentence:

“Du Preez et al. (2008) reported about high acceptability of CCFS in rural communities of South Africa.”

We did not include questions on willingness to pay in our questionnaire, but we think that a recent study by Rananga and Gumbo (2015) in another South African municipality may provide useful information. So we will additionally add the following sentence:

“The need for improved drinking water supply in South Africa was recently manifested for two communities in the Municipality of Mutale (Rananga and Gumbo, 2015): 95% of the households were willing to pay for reliable drinking water supply, those with tertiary level education would afford ZAR 150 per month.”

Reference: Rananga, H.T., Gumbo, J.R.: Willingness to Pay for Water Services in Two Communities of Mutale Local Municipality, South Africa: A Case Study, *Journal of Human Ecology*, 49(3), 231-243, 2015.

2. Page 3, line 10 is not clear. Please consider revising.

Our answer: We will revise the sentence as follows:

“We selected a widely used, low-cost (ZAR 599,-) two-bucket CCFS for our laboratory

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and field tests. It is commercially distributed under the brand name DrinC by Headstream Pure Water, Johannesburg, South Africa.”

3. Section 3.1 does not sound like methodology rather a general description of the CCFS. Authors are better off explaining what was actually done with the CCFS.

Our answer: With the two new introductory sentences (see 2. above), we hope that it is now clear what was actually done with the CCFS in section 3.1. Also recommended by reviewer #2, we will also add more information about the filters as follows:

“The ceramic filter candles consist of a 0.2 μm silver-impregnated ceramic shell containing an activated charcoal interior medium. The filters have a diameter of 0.1 m and unlimited shelf life. Once in use, the filter candles have to be replaced once a year (DrinC, 2016). Raw water is filled into the top bucket. The water drips through the candle filter unit into the bottom bucket, where clean water can be drained through the tap. According to the manufacturer CCFS remove >99.9% of harmful bacteria (100% of E. Coli), >98% of particles larger than 0.2 μm , >96% of metals like Fe, Al, Pb, and >80% of various organic pollutants.”

4. Page 3, line 24-Did the authors also use the BiopadesLite[©] software to evaluate the performance of dip slides in detection of the coliforms? This is not coming out very clear here.

Our answer: We did not use this software. We will add the following sentence:

“The BiopadesLite[©] software had not been available to be used in the present study.”

5. Page 4, lines 18-which type of bacteria were analysed to evaluate the performance of the NUT/AMC Dip slides in the field?

Our answer: We analysed aerobic coliform bacteria. So we added the following sentence:

“Our dip slides detected aerobic coliform bacteria as dots of a red-colored dye.”

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What can you say about issues of bacterial regrowth in relation to issues of maintenance and performance of the CCFS?

Our answer: Also recommended by reviewer #2, we will add the following sentences about the recommended cleaning procedure in the method section:

“Users are advised to clean the filter every time the water flow becomes too slow. Then the bottom bucket should be cleaned by a bleach solution and the filter candle by a non-metal scrubbing pad.”

In addition we updated figure 7 to also include the cleaning method. There was no influence on using the recommended bleach solution, the filters even deteriorated when bleaching was applied. We will add the following sentence:

“Also recommended bleaching did not improve CCFS performance.”

6. Page 5, lines 2-3-which statistical test was performed to test the significance differences between the filling scenarios or immediate effects of different loading concentrations? At what significance level?

Our answer: Due to your comment we noticed that the formulation regarding the significance of the filling scenarios is unclear. Strictly speaking, the filling scenarios could not be tested, because they were influenced by the repeated loading. We also provide information about the used test procedure. We will re-formulate as follows:

“We fitted regressions to our data using the Generalized Linear Model with significance level $p < 0.05$ for hypothesis testing. Those revealed no significant difference of different loading concentrations. The filling scenarios were influenced by repeated loading that had a significant influence on CCFS performance.”

7. Page 5, line 11-what were the remaining 74% households without toilets using? Were they practicing open defecation? This might definitely have been contributed to the high levels of fecal contamination in water sources in the area. Are there any behavioral change interventions being done in the community?

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Our answer: The rest of the households were indeed practicing open defecation at that time, which definitely can increase the fecal contamination of the water sources. We are not aware of behavioural change interventions in the area but will recommend those, also following referee #3. Open defecation was one reason, why we started our project and distributed CCFS in the area. We will add the following sentences:

“The remaining 74% of the households were practicing open defecation, which must be considered as a serious threat for hygienic drinking water quality. This was one of the reasons why CCFS were distributed in Hobeni.”

8. Page 6, line 21-what platform is used for silver impregnation to improve strength and avoid silver being washed out during repeated loading of CCFS? The silver washed out could have a pollution effect as well.

Our answer: Also recommended by reviewer #2, we will add more details of the filter candle, also on the platform where the silver impregnation is attached. In addition we will add a reference on silver-ceramic composites and a short discussion on silver wash-out and environmental and human toxicity of silver nanoparticles:

“The ceramic filter candles consist of a 0.2 μm silver-impregnated ceramic shell containing an activated charcoal interior medium. Lv et al. (2009) showed that silver nanoparticle–porous ceramic composites show efficient antibacterial effects without a measurable loss of nanoparticles. However, incorporated into water filters, Bielefeld et al (2009) documented a significant wash-out of silver with decreasing filter efficiency. This process has to be taken into account for this type of water filter and per se causes a limited life time. Silver nanoparticles are widely used in various biomedical applications, although it is difficult to draw definite conclusions about their human and environmental toxicity (Wei et al. 2015).”

References: Bielefeldt, A.R., Kowalski, K., and Summers, R.S.: Bacterial treatment effectiveness of point-of-use ceramic water filters, *Water Res.* 43, 3559-3565, doi:10.1016/j.watres.2009.04.047, 2009. Lv, Y., Liu, H., Wang, Z., Liu, S., Hao, L.,

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Sang, Y., Liu, D., Wang, J., Boughton, R.I.: Silver nanoparticle-decorated porous ceramic composite for water treatment, *Journal of Membrane Science* 331, 50–56, 2009.
Wei, L, Lu, J., Xu, H., Patel, A., Chen, Z-S., Chen, G.: Silver nanoparticles: synthesis, properties, and therapeutic applications, *Drug Discovery Today* 20 (5), 595-601, 2015.

9. Page 6, line 26-what is the shelf life of the CCFS?

Our answer: According to the manufacturer the shelf life is unlimited and during use, the candles have to be replaced once a year. This will be written into section 3.1:

“The filter candles have a diameter of 0.1 m and unlimited shelf life (JustWater 2016). Once in use, the candles have to be replaced once a year (DrinC, 2016).”

References DrinC: Instructions DrinC Water Bucket,
<http://drinc.co.za/instructions/water-bucket>, last access: 16 September 2016. JustWater: 4"X4" Ceramic Filter, <http://www.justwater.me/products/4x4-ceramic-filter>, last access: 16 September 2016.

How do you explain the aging with respect to shelf life and problems arising from the maintenance of CCFS?

Our answer: Also requested by referee #2 we will add the following sentences about the recommended cleaning/maintenance procedure in the method section:

“Users are advised to clean the filter every time the water flow becomes too slow. Then the bottom bucket should be cleaned by a bleach solution and the filter candle by a non-metal scrubbing pad.”

In addition we will update figure 7 to also include the cleaning method. There it will be shown that there was no influence using the recommended bleach solution. We will add the following sentence:

“Also recommended bleaching did not improve CCFS performance.”

10. Figure 5-please label the y-axis and extend the axis so that even the value for the

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'spring only' is easier to read from the axis.

Our answer: Figure 5 will be modified with extended axis. It is attached

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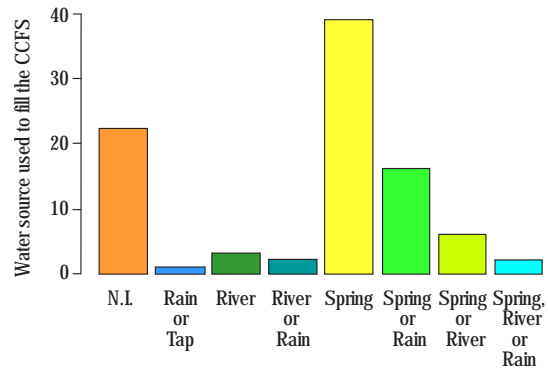


Fig. 1. Updated figure 5