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Discussions

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

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Answers to referee #2

General comment: This study evaluates the performance of 51 ceramic candle filters (CCFS) for the production of safe drinking water in rural South Africa. The authors evaluated different factors which affect the performance of CCFS and propose the use of dip slides as cost-efficient alternative to standard laboratory tests for detection of microbial contaminants. The authors have successfully shown that the performance of the filters is affected by various factors which reduce the filters' life span. Overall the manuscript is well written. Having said that, I have the following comments for the authors:

Our answer: We also thank the anonymous referee #2 for his thorough check. Also his

comments helped us to improve our manuscript.

Specific comments

a) Page 2, line 12: Please acknowledge recent literature publications which have looked into ceramic and biosand filters.

Our answer: We will add the following paragraph including recent literature on ceramic and biosand filters:

"Murphy et al. (2010) monitored the microbiological and chemical quality of treated water from BSF and CWF in rural Cambodia. During a six month period both technologies improved water quality for various parameters but failed to consistently meet the WHO drinking water guidelines for nitrite and for E. coli. BSF can be improved by using iron oxide coated sand (Ahammed and Davra, 2011) or by adding a layer of bark biomass (Ali Baig et al., 2011). Also continuous operation resulted in better BSF performance (Young-Rojanschi and Madramootoo, 2014). Other studies concentrated on cost-efficient POU water treatment techniques. BSF with plastic housing were found to be as efficient as their concrete counterparts (Fabiszewski de Aceituno et al., 2012) and various researchers reported the success of locally produced, low-cost CWF (Brown et al. 2008, Simonis and Basson, 2011, Mwabi et al. 2013). Recent reviews about reduction of diarrhoea by different POU interventions found filtration techniques superior to solar or chemical water disinfection (Wolf et al., 2014, Clasen et al., 2015). However, comparisons were blurred by a high risk of bias, since the data relied on self-reported diarrhea and placebo POU interventions were missing."

References: Ahammed, M.N., Davra, K.: Performance evaluation of biosand filter modified with iron oxide-coated sand for household treatment of drinking water, Desalination 276, 287–293, 2011, doi:10.1016/j.desal.2011.03.065.

Ali Baig, S., Mahmood,Q., Nawab, B., Nawaz, B., Shafqat, M.N., Pervez, A. (2011): Improvement of drinking water quality by using plant biomass through household

biosand filter – A decentralized approach, Ecological Engineering 37, 1842– 1848, 2011, doi:10.1016/j.ecoleng.2011.06.011.

Brown, J., Sobsey, M.D., Loomis, D.: Local drinking water filters reduce diarrheal disease in Cambodia: a randomized, controlled trial of the ceramic water purifier, American Journal of Tropical Medicine and Hygiene, 79(3), 394–400, 2008.

Clasen, T.F., Alexander, K.T., Sinclair, D., Boisson, S., Peletz, R., Chang, H.H, Majorin, F., Cairncross, S.: Interventions to improve water quality for preventing diarrhoea, Cochrane Database of Systematic Reviews 2015, Issue 10. Art. No.: CD004794, 2015, DOI: 10.1002/14651858.CD004794.pub3.

Fabiszewski de Aceituno, A.M., Stauber, C.E., Walters, A.R., Meza Sanchez, R.E., Sobsey, M.D.: A randomized controlled trial of the plastic-housing BioSand filter and its impact on diarrheal disease in Copan, Honduras. American Journal of Tropical Medicine and Hygiene, 86 (6), 913–21, 2012.

Murphy, H.M., McBean, E.A., Farahbakhsh, K.: A critical evaluation of two point-of-use water treatment technologies: can they provide water that meets WHO drinking water guidelines?, Journal of Water and Health 8 (4), 611-630, 2010, doi: 10.2166/wh.2010.156.

Mwabi, J. K., Mamba, B. B., and Momba M. N. B.: Removal of waterborne bacteria from surface water and groundwater by cost-effective household water treatment systems (HWTS): A sustainable solution for improving water quality in rural communities of Africa, Water SA, 39 (4), 445-456, 2013.

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Simonis, J.J., Basson, A.K.: Evaluation of a low-cost ceramic micro-porous filter for elimination of common disease microorganisms, Physics and Chemistry of the Earth,

36, 1129–1134, 2011, doi:10.1016/j.pce.2011.07.064.

Wolf, J., Prüss-Ustün, A., Cumming, O., Bartram, J., Bonjour, S., Cairncross, S., Clasen, T., Colford, J. M., Curtis, V., De France, J., Fewtrell, L., Freeman, M.C., Gordon, B., Hunter, P.R., Jeandron, A., Johnston, R.B., Mäusezahl, D., Mathers, C., Neira, M., Higgins, J.P.T.: Assessing the impact of drinking water and sanitation on diarrhoeal disease in low- and middle-income settings: systematic review and meta-regression, Tropical Medicine and International Health 19 (8), 928–942, 2014, doi:10.1111/tmi.12331.

Young-Rojanschi, C., Madramootoo, C.: Intermittent versus continuous operation of biosand filters, Water Research 49, 1-10, 2014, doi.:10.1016/j.watres.2013.11.011.

b) Page 2, line 25: What is the accuracy of dip slides?

Our answer: We will include two references on the accuracy of dip slides (for contact methods and for water):

“Dip slides had similar precision as swapping or contact agar plates during detection of contamination on artificially soiled stainless-steel surfaces (Salo et al., 2000). For drinking water, dip slides had considerably less accuracy than membrane filter methods but were recommended for the detection of massive contamination of drinking water sources (Vanderzwaag et al., 2009).”

References:

Salo, S., Laine, A., Alanko, T., Sjöberg, A.-M., Wirtanen, G.: Journal of AOAC International, 83(6), 1357-1366, 2000.

Vanderzwaag, J.C., Bartlett, K.H., Atwater, J.W., Baker, D.: Evaluation of Field Testing Techniques Used in a Household Water Treatment Study in Posoltega, Nicaragua, Water Quality Research Journal of Canada, 44, 122-131, 2009.

c) Page 3, section 3.1: Please add more information about the CCFS e.g. pore size, shelf life, dimensions etc. What type of contaminants do they remove?

Our answer: We will add more information about the filters as follows:

“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). 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.”

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.

d) Page 4, line 5: Please clarify on the filtration procedure and filtrate collection. Was the filtrate discarded after 7 h of filtration or filtration was allowed to run for 48 h with filtrate collected after 7 h, 24 h, and 48 h?

Our answer: We will modify the sentence to clarify the filtration procedure:

“The top bucket of the CCFS was filled once, allowed to run for 48 h with 100 ml of filtrate collected from the bottom bucket after 7 h, 24 h, and 48 h. During this 48 h the top bucket was not filled up again.”

e) Page 5, line 26: The filters may be damaged during cleaning resulting in poor performance. Please explain how the filters were cleaned in the field. Is this the recommended cleaning procedure?

Our answer: Also requested by referee #1, 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 will update figure 7 (attached) 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.”

f) Page 5, line 27: The water quality for the water sources (in terms of microbial contamination and turbidity) may differ due to seasonal variations in rainfall. How did the water quality change for the different water sources (during rainy and dry seasons) and how did this affect the performance of CCFS?

Our answer: We will include a graph on average climate into figure 1. We cannot exclude seasonal differences in water quality of the different water sources. Moreover, we assume that people in the area collect their drinking water from different sources in different seasons, which may also affect CCFS performance. To study these effects, measurements on a regular basis would be necessary that we recommend in the discussion: We will add the following sentence:

"Monitoring of CCFS performance should be carried out on a monthly basis to also include seasonal changes in water quality“

g) Page 6, line 24: Did the flow rate of the filters change over time? How does this correlate with filter performance?

Our answer: We do not have continuous data about flow rates, but at the end of our test, only 1 % of the households complained about slow filtering. So in most households the original flow rates could be re-established by cleaning as recommended. We will add the recommended cleaning procedure that should avoid blocking of the filters (see e) above) and will add a sentence on the results of the field survey showing the fact that

most users were satisfied with the flow rate:

“Only 4.4 % of the households complained about the intensive maintenance of the CCFS, 3.3 % about the long distances to the water sources and only 1.1% about a slow filtering time.

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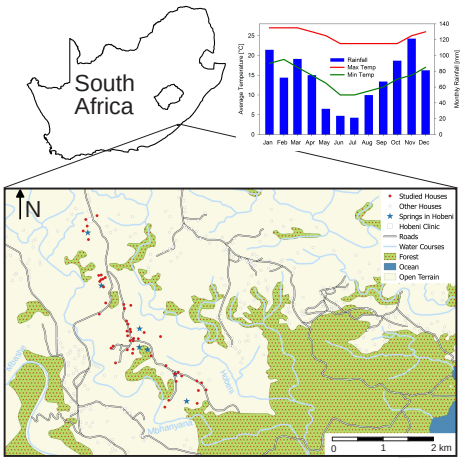

Fig. 1. Modified Figure 1

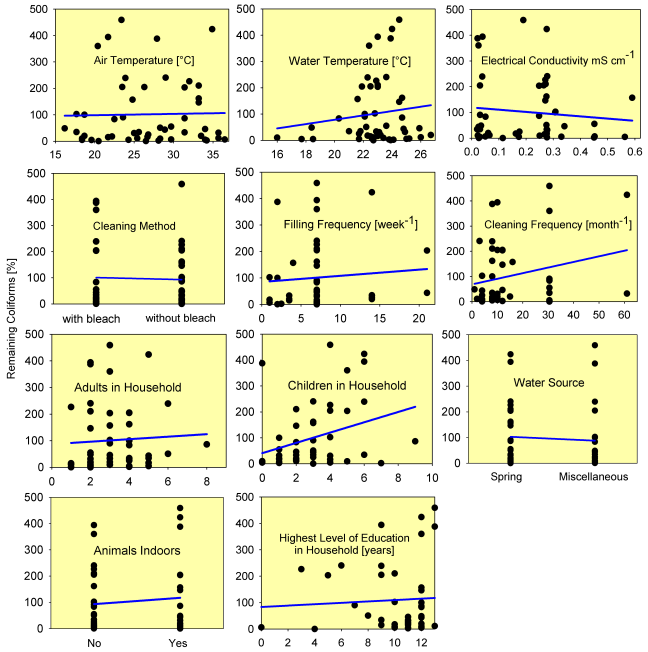

Fig. 2. Updated Figure 7