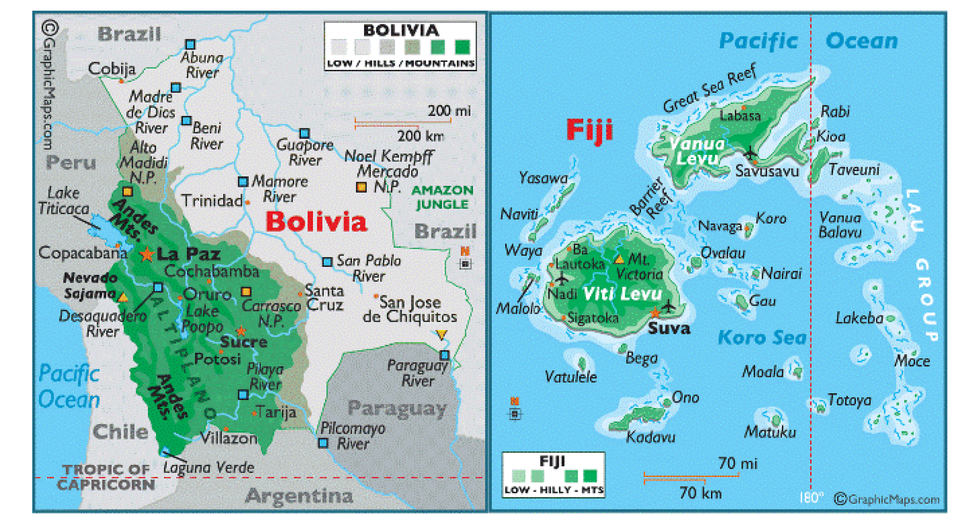
A Study on the Long-Term Performance of the Sawyer PointONE™ Filter in the Developing World

Erik Lindquist[1,3], Thomas Soerens[2,3], Lawrence Mylin[1,3], Holly Ross[1,3], Andrew Nevin[1,3], Daniel Yeisley[2,3]

[1]Department of Biological Sciences, Messiah College, One College Ave Suite 3030, Mechanicsburg, PA 17055
[2]Department of Engineering, Messiah College, One College Avenue Suite 3034, Mechanicsburg, PA 17055
[3]The Collaboratory for Strategic Partnerships and Applied Research, Messiah College, One College Avenue Suite 3034, Mechanicsburg, PA 17055



Abstract

Lack of sustainable access to safe water and sanitation services dramatically impacts the health and productivity of many people living in under-served nations. Infrastructure improvements needed to provide such services are costly and slow to implement. A number of NGOs have sought instead to distribute low-cost household water filtration units in community-focused programs while providing basic training in filter use and health education.

The Sawyer PointONE™ filter, a hollow microfiber biological, filter has been used in both relief and development settings. Some NGOs have been reticent to adopt this product, citing uncertain field longevity, cultural factors, NGO-related training schemes and implementation challenges, and component availability for repair and replacement after breakage. In 2014, Lindquist et al. demonstrated significant reductions in diarrheal prevalence among young children related to short-term use of these filters in peri-urban Bolivia. Yet recently, Murray et al. (2015) reported on serious, negative issues regarding breakage and fouling failures of these filters in the laboratory. This study calls into question the ability of these filters to produce adequately filtered water after two years of household use.

To verify issues in long-term use, we conducted a follow up study involving Sawyer PointONE™ filters that had been in continuous use for five or more years in Cochabamba, Bolivia and Nadi, Fiji. Microbial loading and turbidity in source and effluent water from unmanipulated, water-backwashed, or chlorinated water-backwashed filters were tested in the field and later under controlled laboratory conditions. Field and laboratory results from quantifying total coliforms and *E. coli* loads and turbidity in source are presented.

While relatively few filters were located five or more years following initial distribution, a majority of those collected did reduce bacterial loads in effluent water to comply with WHO guidelines. Based on these and other results, our study will help to answer important questions about longevity for these hollow micro-fiber filters.

Introduction

- Diarrheal disease accounts for the second largest cause of death for children under five years old around the globe.[1]
  - ★ These preventable diseases are often caused by infection of the intestinal track due to the consumption of contaminated drinking water.
  - ★ 780 million people around the world lack access to potable drinking water, a simple method of prevention.
- The Sawyer PointOne Filter™ is a gravity-fed point-of-use filter with a bundle of hollow filter membranes with 0.1 micron pores.[2]
  - ★ Similar technology is used in kidney dialysis, except these filters are even more effective.
  - ★ New filters have been shown to decrease bacterial loads (*Raoultella terrigena, Micrococcus luteus,* and *Bacillis subtilis*) by at least an 8 log reduction, exceeding EPA recommendations.[3]
  - ★ Clogging can inhibit flow rate, but a syringe is provided for backwashing.[2]
- Disease rates have been shown to decrease in households using these filters in a developing context.
  - ★ A longitudinal study conducted in Cochabamba, Bolivia found a 73% and 79% reduction in childhood disease for household groups provided with filters.[4]
  - ★ Filter usage has also been correlated to a reduction in disease in Nadi, Fiji.[5]
- Study by Murray et al. (2015) reports filters merely remove 54% of *E. coli* after 23 months of household use due to fouling of the membrane.[6]
  - ★ However, this study only utilized a sample size of 6 filters.
- This study sought to more accurately quantify the effect of five years of use on the efficacy of these filters.

Field Analysis

Methods

- 24 filters collected in Cochabamba, Bolivia, but only 13 of 347 original households encountered (3.75%) still had filters after 5 years of use and were eligible for this study
- 24 filters collected in Ba, Fiji, but the source water was chlorinated to the extent that bacterial growth was insignificant (results are not shown to the right)
- Protocol at household:
  - ★ 500 mL source water collected
  - ★ 500 mL filter effluent collected (unrinsed)
  - ★ 1 L backwash with syringe and distilled water
  - ★ 500 mL "backwashed" sample collected
  - ★ 1 L backwash with syringe and 1% chlorinated solution
  - ★ 600 mL "chlorinated" sample collected in thiosulfate Whirl-Pak
  - ★ Filter collected and stored on ice for transport to laboratory
  - ★ Warm mark used to guarantee temperature <8° C
- Membrane filtration of all samples, at three dilutions: 1 ml, 10 ml, and 100 ml
  - ★ Plated in duplicate on m-ColiBlue24 differential media to quantify total coliform (red colonies) and *E. coli* (blue colonies)

Results

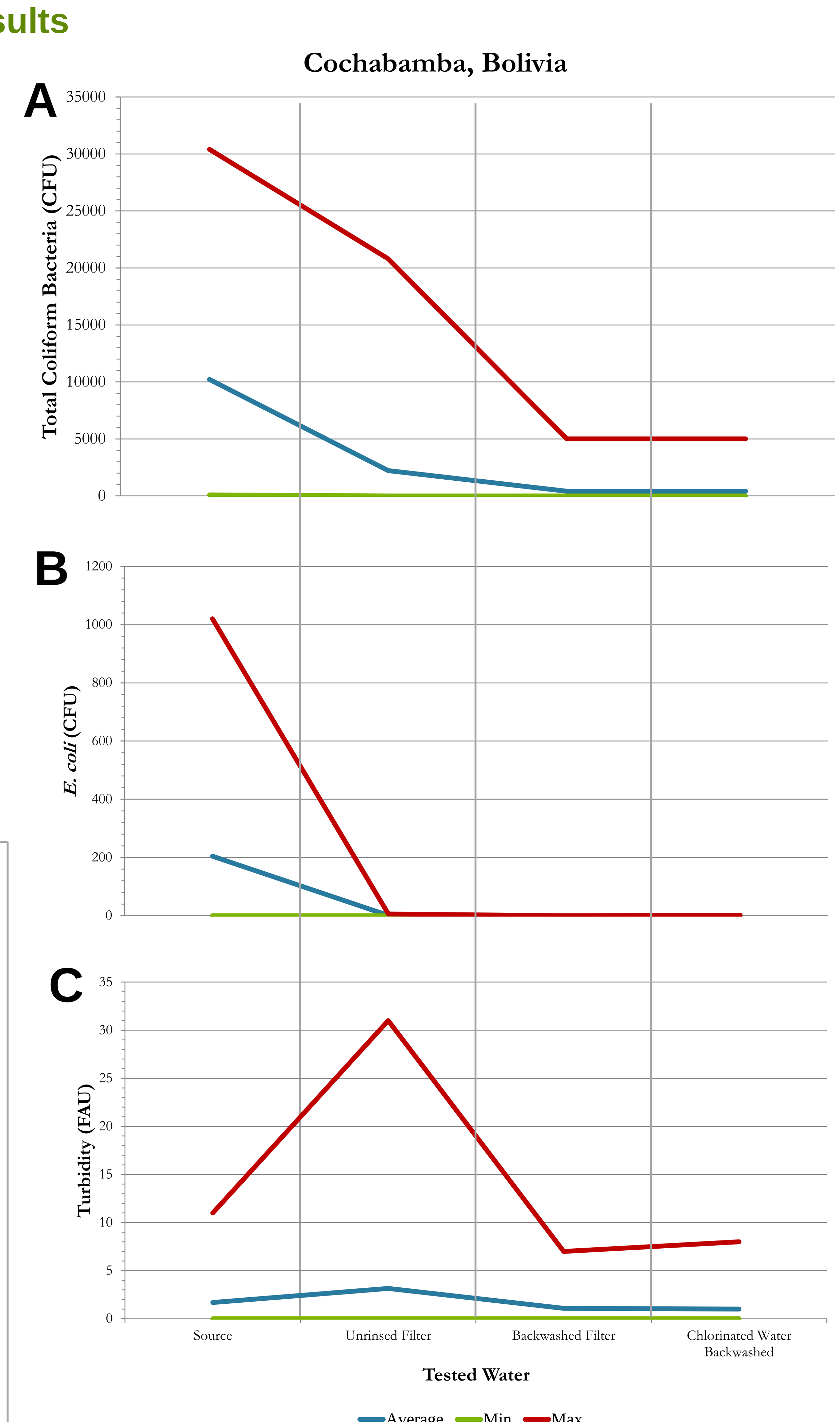


Figure 1 (above): Samples were collected at each phase of the cleaning process and membrane filtered onto petri plates so that bacterial load could be quantified. **A** and **B)** The greatest reduction in bacterial content generally occurred moving from the source to filter effluent, providing evidence of filter efficacy. The most effective cleaning stage was chlorination, which displayed the highest reduction from the original source count. **C)** Turbidity generally increased with use of the filter, until backwashing with distilled and chlorinated distilled water.

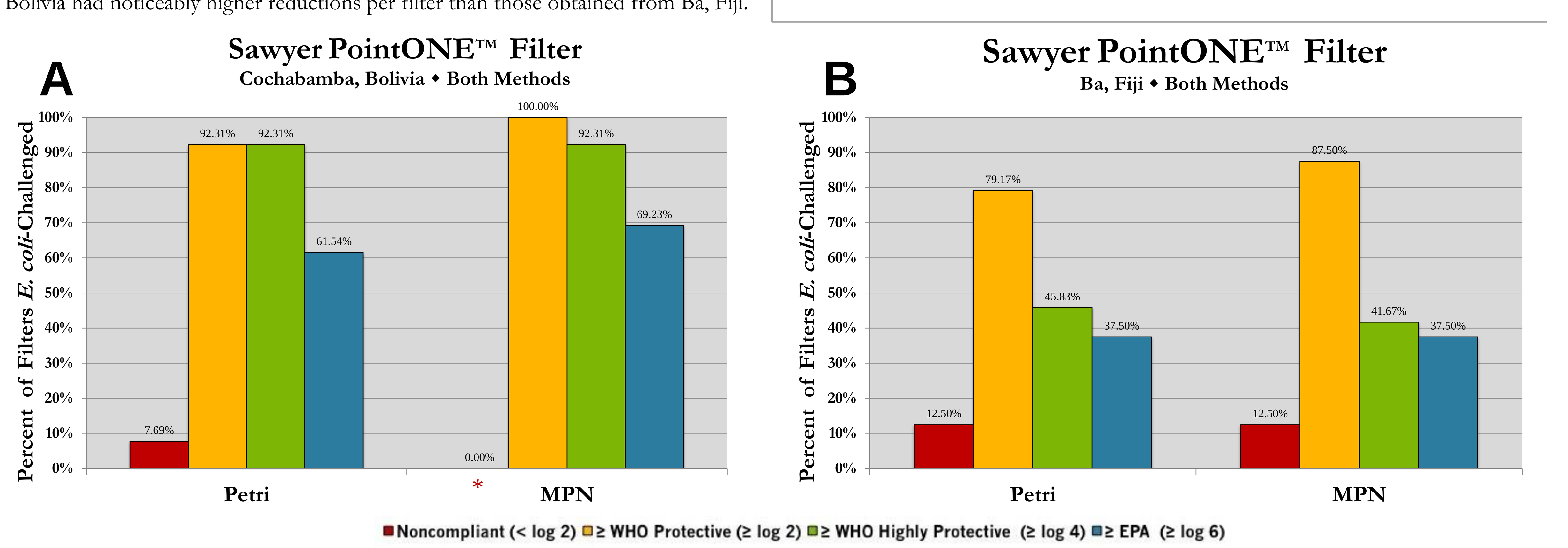
Laboratory Analysis

Methods

- Each filter backwashed with 1 L of 1% bleach solution
- 10 minutes reprieve to increase the chlorine penetration
- Filters washed with 1.5 L of sterile water with a 10 minute reprieve after the first 750 mL
- 500 mL of water with 10^6 CFUs per mL *E. coli* was allowed to flow through the filter before 300 mL was collected and mixed with thiosulfate to neutralize residual chlorine
- Plates (Petri) and Quantitrays (MPN) of effluent were made at concentrations of 1 ml, 10 ml, and 100 ml
- To confirm concentration of bacteria, the spiked source water was analyzed in duplicate at various dilutions between 10^{-4}-10^{-7}

Results

Figure 2 (below): Results of the laboratory study for filters from Cochabamba, Bolivia (**A**) and Ba, Fiji (**B**). The reduction by each filter from a solution of 10^8 CFUs per 100 mL is shown. Both petri plate count (CFU) and Colilert™ (Quantitray, MPN) data were used in the calculation of the log reduction averages. Blue bars represent all filters that meet EPA standards of at least a 6 log reduction. Yellow represents all filters that meet WHO "highly protective" compliance (≥ log 4). Yellow corresponds to WHO "protective" compliance (≥ log 2). Red bars represent filters that were noncompliant. Filters obtained from Cochabamba, Bolivia had noticeably higher reductions per filter than those obtained from Ba, Fiji.



Conclusions

- 37 filters used continuously, maintained near-manufacturer grade standards of cleaning: 8 filters showed an 8 log reduction (or better) removal of bacteria, and 17 or 18 filter (depending on method) showed a 6 log reduction meeting Environmental Protection Agency standards.
- 16 filters performed within the WHO "protective or "highly protective" standards (2-4 log reduction).
- 3 or 4 filters (depending on method) performed at less than a 2 log reduction.
- Our ultimate cleaning protocols involved chlorination of filters during the testing, a process now recommended by Sawyer Products Inc., that was not recommended at the time of distribution and implementation). We recommend that chlorination become a standard cleaning protocol for use in communities served by NGOs.
- Future studies should seek to examine the durability of the membrane on filters that have been in use for shorter periods of time in order to better understand the lifespan of these filters in developing contexts.

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