
# MICROBIOLOGICAL EFFECTIVENESS OF MINERAL POT FILTERS

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# Outline

- Introduction to mineral pot filters (MPFs)
- Purpose of our evaluation
- Methods
- Results and discussion
- WaterSHED-Cambodia Laboratory

# Mineral Pot Filter Device

- Widespread Use: Common in Cambodia & across Asia.
- Countertop Ceramic Candle Filter
- 80% of 440 retail outlets surveyed by PATH sold MPFs. This demonstrates that market penetration of MPFs greatly exceeded other HWTS options in the market (B. McLaughlin, PATH)
- Product retail cost: China & Vietnam ($15-$50), Cambodia ($21-$45).

# Mineral Pot Filter


# Background

**1. Dubious marketing claims:**

- Effectiveness against arsenic, pesticides, other chemicals
- Prevents cancer
- Boost sex drive and have other supernatural advantages

**2. Unknown treatment effectiveness**

- However, they are widely used across Cambodia
- No systematic testing, data or scientific characterization of performance available

**3. Protect human health and consumers**

# Purpose of Evaluation

- Ability to remove microbes from water over long-term use, under realistic conditions and microbial performance testing by the WHO recommendation (WHO 2011)

- As necessary first step in a broader assessment of the potential current and future role of these uncharacterized devices

- To demonstrate and pilot our laboratory's capacity for microbiological testing according to the new WHO testing recommendations.
    - Brown, J. and Sobsey, M. 2011. ***Evaluating household water treatment options: health-based targets and performance specifications*.** Geneva: World Health Organization. ISBN: 978 92 4 154822 9. Available at www.who.int

# Testing set up

- Used WHO (2011) performance testing recommendation in developing laboratory method (bacteria, virus, protozoa).
- 3 common MPFs in PP market in 2010 were tested in duplicate with 2 challenge waters
  - Dechlorinated Phnom Penh tap water (DTW): High quality sources with low dissolved matter.
  - Dechlorinated tap water + 1% sterile wastewater (DTWW)
- Approximately 10 liters of test waters/filter/day
- Monitoring performance over ~1500 liters total throughput per test filter.
- Reporting reductions as $\log_{10}$ reductions

# Testing Procedures:

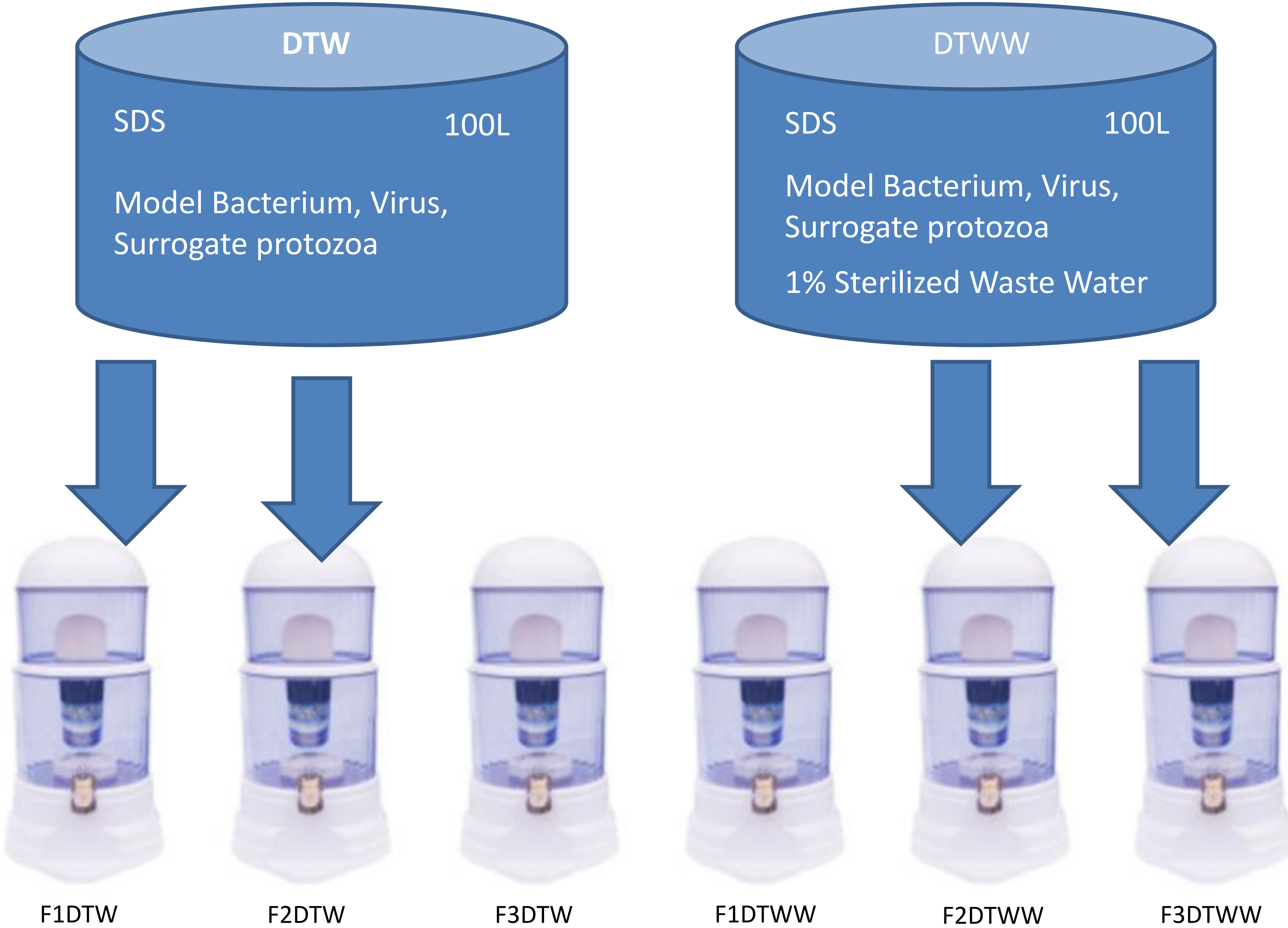
1. Daily Dosing for each filter

1. Periodic Testing of influent and effluent water

3. Weekly cleaning of filters

4. Following Treatment: daily spiking of influent water

4. Collected samples from effluent (Tues., Weds, Thurs.)


DTW
SDS
100L
Model Bacterium, Virus,
Surrogate protozoa
DTWW
SDS
100L
Model Bacterium, Virus,
Surrogate protozoa
1% Sterilized Waste Water
F1DTW
F2DTW
F3DTW
F1DTWW
F2DTWW
F3DTWW

# Experiment Design


# Methods

***All methods as recommended by the WHO guidelines:***

## Membrane filtration  (USEPA 2002)

- ***E. coli*** : bacterial pathogens ( *Salmonella* spp, *Shigella* spp, *Vibrio Cholera, Campylobacter* spp).
- **Bacillus Atrophaeus** : Surrogate for protozoa (*Cryptosporidium* oocysts)

## Plaque Assay ( Adams 1959, USEPA2001)

- **MS2** : Coliphage Bacteriophage which size, shape and other properties are similar to human enteric viruses  (Noroviruses, infectious hepatitis and enteroviruses)

## Data Analysis

- Descriptive Statistics determined by a Shapiro-Wilk normality test.
- Interpretive Statistics: Using a *priori* significance level ἀ= 0.05
- Stata Version 8.1 (Stata Corporation, College Station, TX, USA)

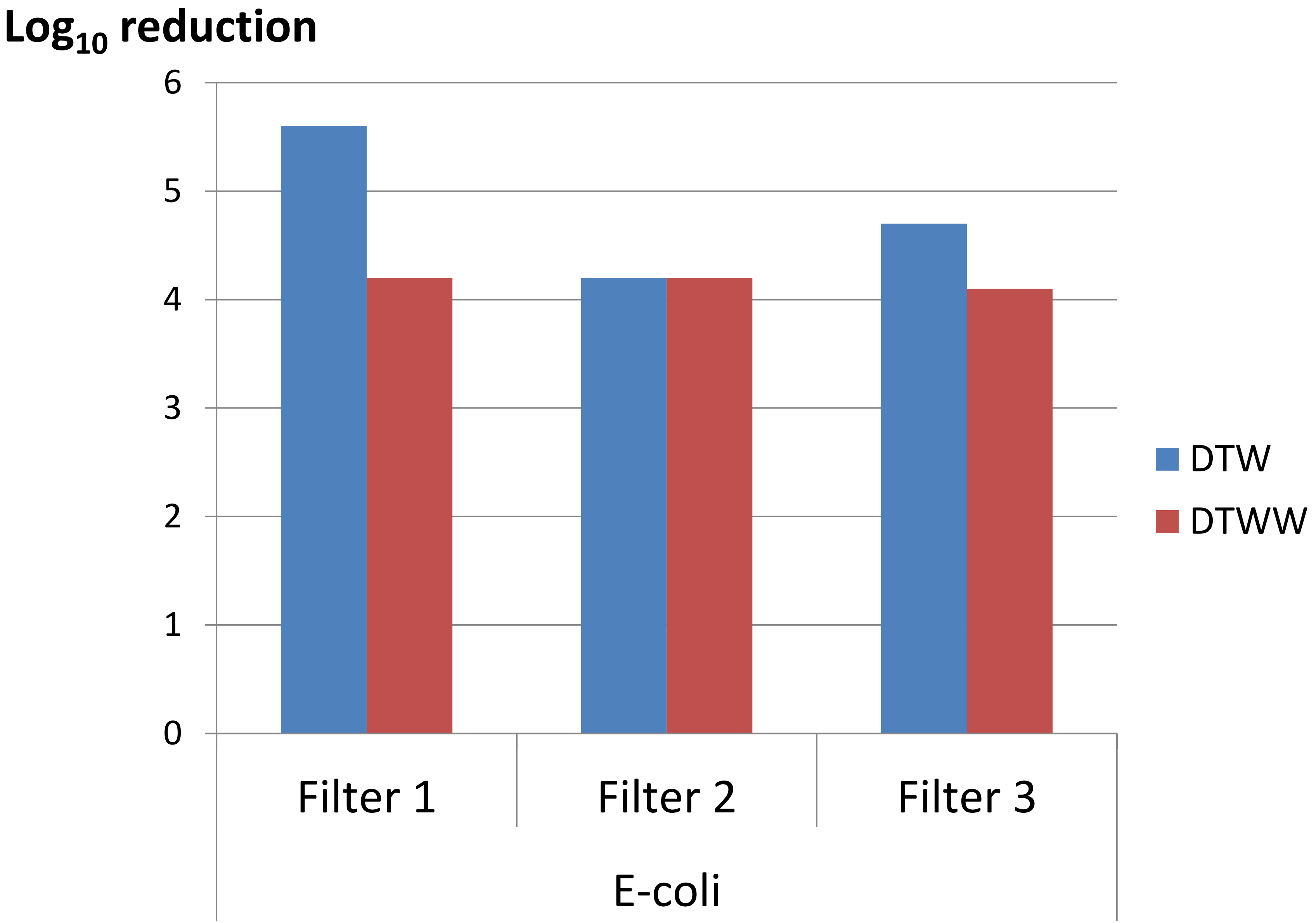
# What are $\log_{10}$ reductions?

- 1 $\log_{10}$ = 90%
- 2 $\log_{10}$ = 99%
- 3 $\log_{10}$ = 99.9%
- 4 $\log_{10}$ = 99.99%
- 5 $\log_{10}$ = 99.999%
- And so on

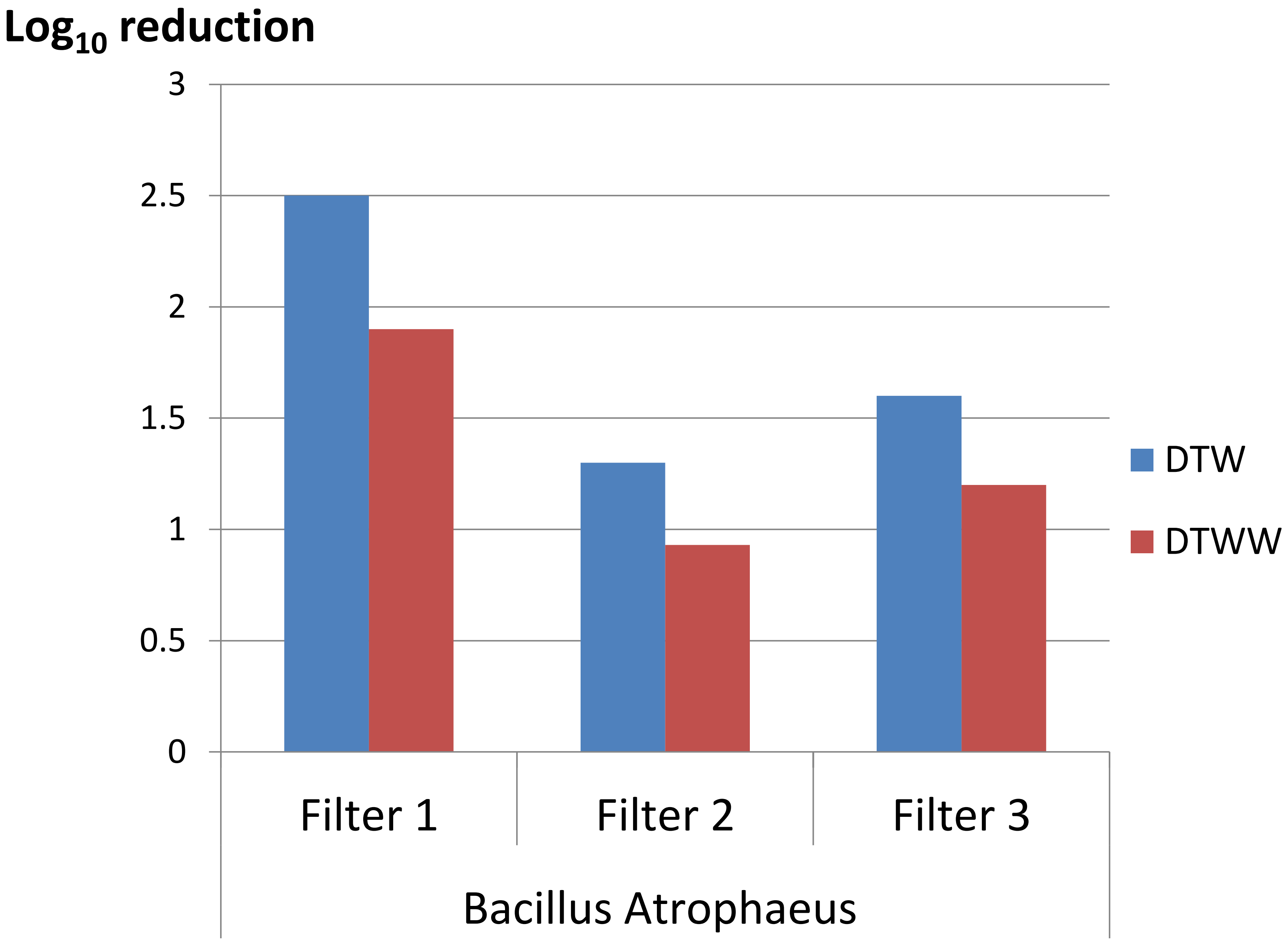
**WHO recommended reduction levels considered as “protective” are:**

- Bacteria: 2 $\log_{10}$
- Viruses: 3 $\log_{10}$
- Protozoa: 2 $\log_{10}$

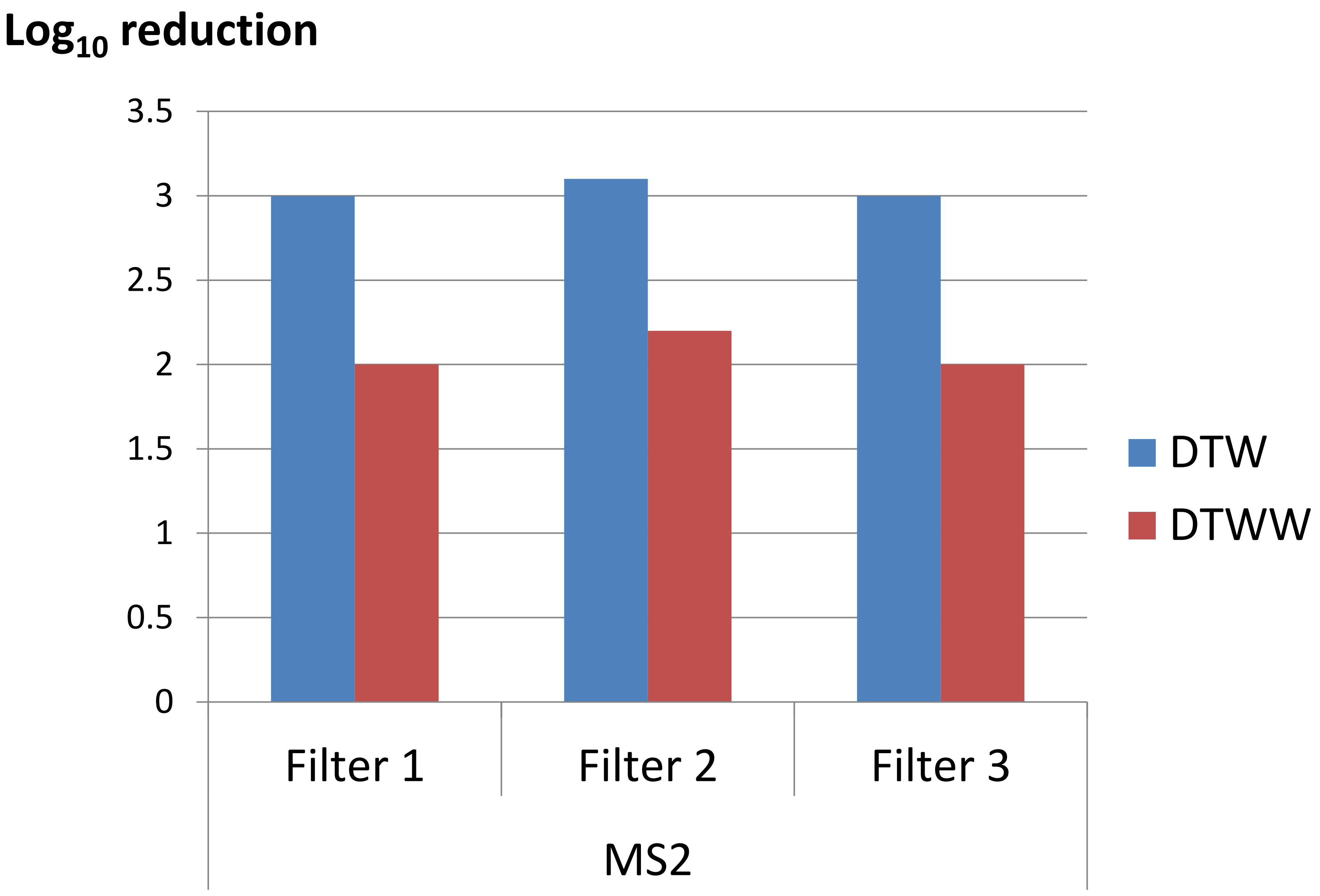
| | | Log$_{10}$ reduction over 1500 liters throughput, arithmetic means (95% CI) | | | | | |
|---|---|---|---|---|---|---|---|
| | | Filter 1 | | Filter 2 | | Filter 3 | |
| **Parameter** | n | Dechlor tap water | Dechlor tap water +1% ww | Dechlor tap water | Dechlor tap water +1% ww | Dechlor tap water | Dechlor tap water +1% ww |
| **E. coli** | 49 | 5.6 (5.0 – 6.1) | 4.2 (3.6 – 4.9) | 4.2 (3.6 – 4.9) | 4.2 (3.6 – 4.7) | 4.7 (4.1 – 5.3) | 4.1 (3.5 – 4.7) |
| **MS2** | 28 | 3.0 (2.7 – 3.3) | 2.0 (1.6 – 2.3) | 3.1 (2.9 – 3.4) | 2.2 (1.9 – 2.6) | 3.0 (2.7 – 3.2) | 2.0 (1.8 – 2.3) |
| **B. atrophaeus** | 52 | 2.5 (1.9 – 3.1) | 1.9 (1.4 – 2.4) | 1.3 (1.0 – 1.6) | 0.93 (0.76 – 1.1) | 1.6 (1.3 – 2.0) | 1.2 (0.86 – 1.5) |
| **Turbidity** | 224 | 0.74 (0.67 – 0.80) | 0.67 (0.61 – 0.74) | 0.64 (0.58 – 0.69) | 0.74 (0.69 – 0.80) | 0.58 (0.49 – 0.66) | 0.62 (0.57 – 0.68) |

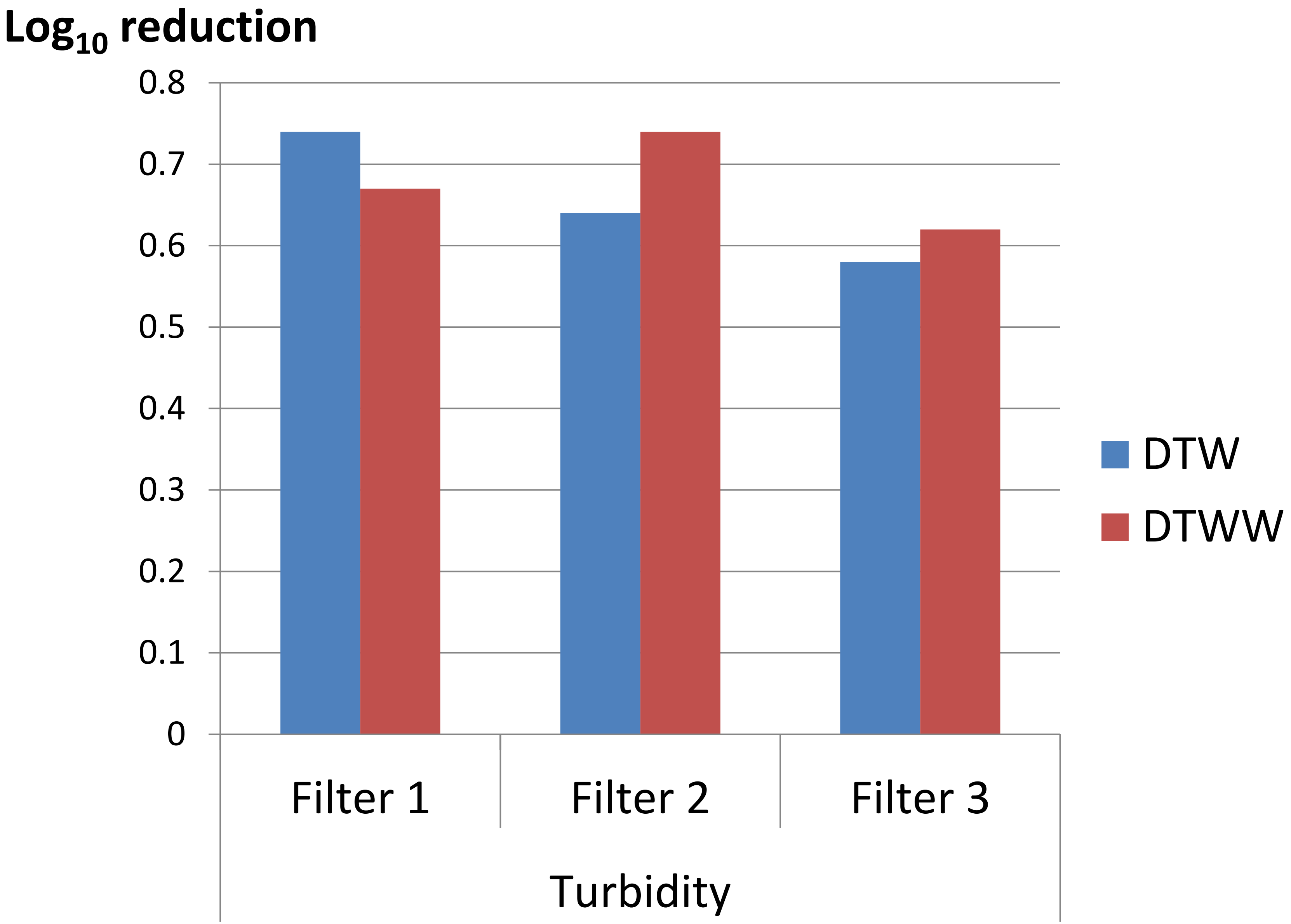


Log10 reduction
6
5
4
3
2
1
0
Filter 1
Filter 2
Filter 3
E-coli
DTW
DTWW



Log$_{10}$ reduction
3
2.5
2
1.5
1
0.5
0
DTW
DTWW
Filter 1
Filter 2
Filter 3
Bacillus Atrophaeus


Log$_{10}$ reduction
3.5
3
2.5
2
1.5
1
0.5
0
Filter 1
Filter 2
Filter 3
MS2
DTW
DTWW



Log10 reduction
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Filter 1
Filter 2
Filter 3
Turbidity
DTW
DTWW

# Data Results

- All filters reduced turbidity significantly from pre-treatment levels although mean turbidity did not exceed 5 NTU even in DTWW. Pre-treatment water pH did not change significantly following treatment.
- No large differences in performance between the three filters: they all provided microbiologically safer water, consistently.
- The three filters were **as effective or more effective than other locally available drinking water treatment options**, including ceramic filters (Brown and Sobsey 2010; Brown et al. 2008) and boiling (Brown and Sobsey 2012).
- In brief, at least one filter (Filter 1) could meet WHO recommended performance levels for the "Protective" level, but not across all potential water sources.

# Remaining questions

- Effectiveness against chemicals?
  - RDI/RUPP bridge students have produced a report on this: MPFs NOT effective against arsenic or fluoride
- Toxicity of mineral stone elements?
  - The filtration media remain uncharacterized
- Is regulation appropriate to limit manufacturers claims about effectiveness?
- Quality control of MPFs?
- New models on the market all the time, so cannot extend these results to ALL MPFs – continuous testing should be done

# Conclusions

- MPFs are important because they demonstrate that the private sector can deliver effective water treatment products without subsidy
- The filters we tested (in the $21 - $45 range) were at least as effective as CWPs
- More research is needed to answer remaining questions

# WaterSHED-Cambodia laboratory

- Lab Supervisor: Chai Ratana
- Support from USAID, The University of North Carolina – Chapel Hill and London School of Hygiene and Tropical Medicine
- In operation since April, 2009
- Services provided:
  - Comprehensive testing of household water treatment according to WHO standards
  - Microbiological testing services for water and food safety to private sector, NGO, and individual clients on a fee-for-service basis
  - Support to the water sector of Cambodia for health and well-being of the Cambodian people

# Contact us!

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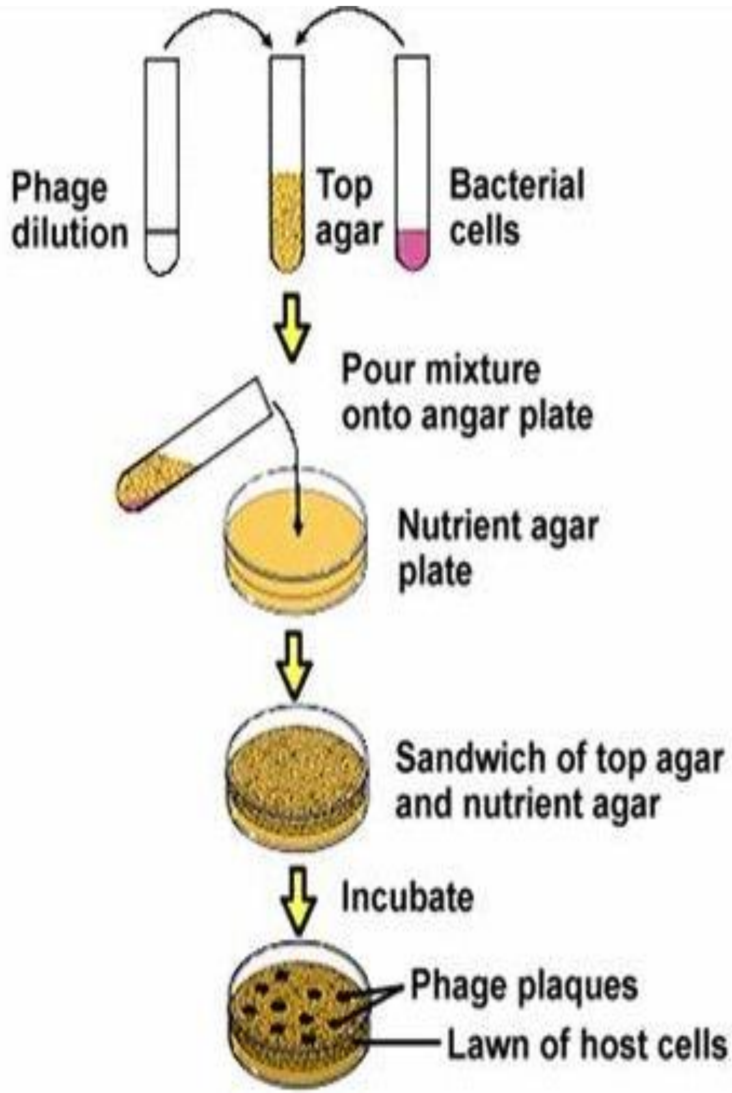
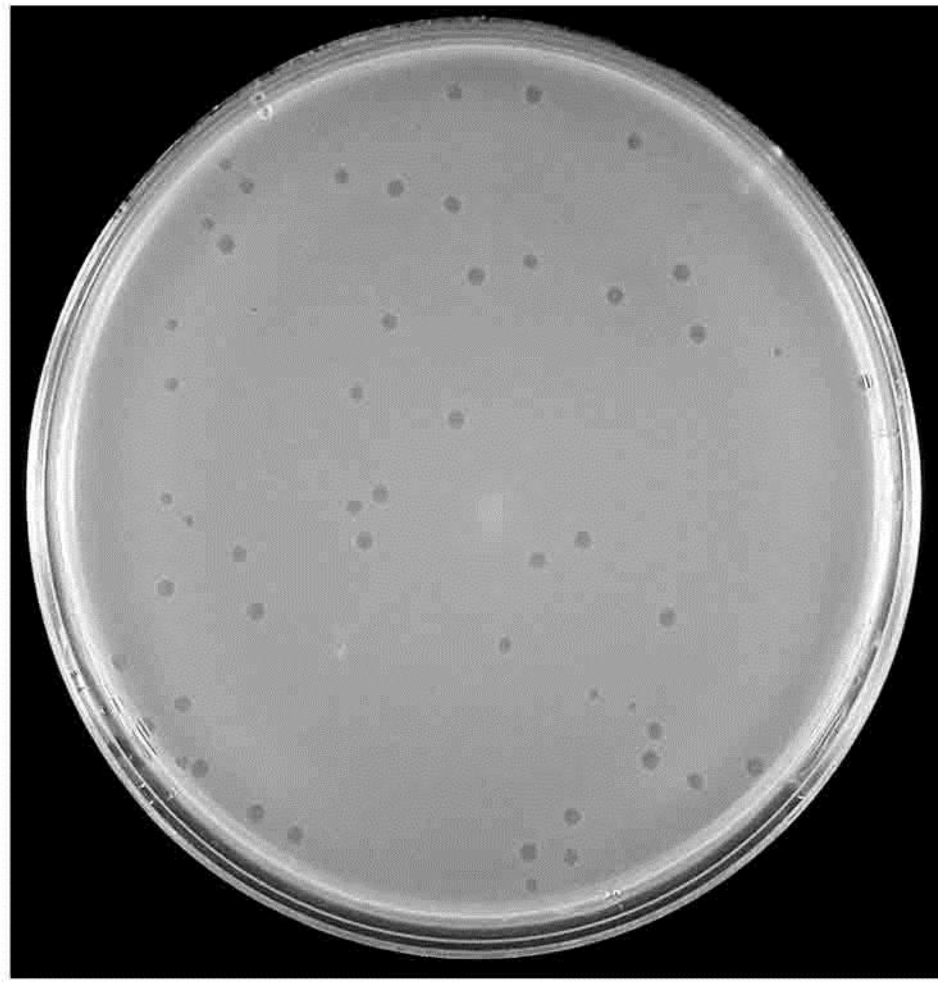
- PATH: market research on MPFs

# Thank You!

# Q&A

# Plaque Assay



# Membrane filtration