MIT Clean Water 4 All, Inc.

Final Master of Engineering Group Presentation – Ghana Team

May 30th, 2008

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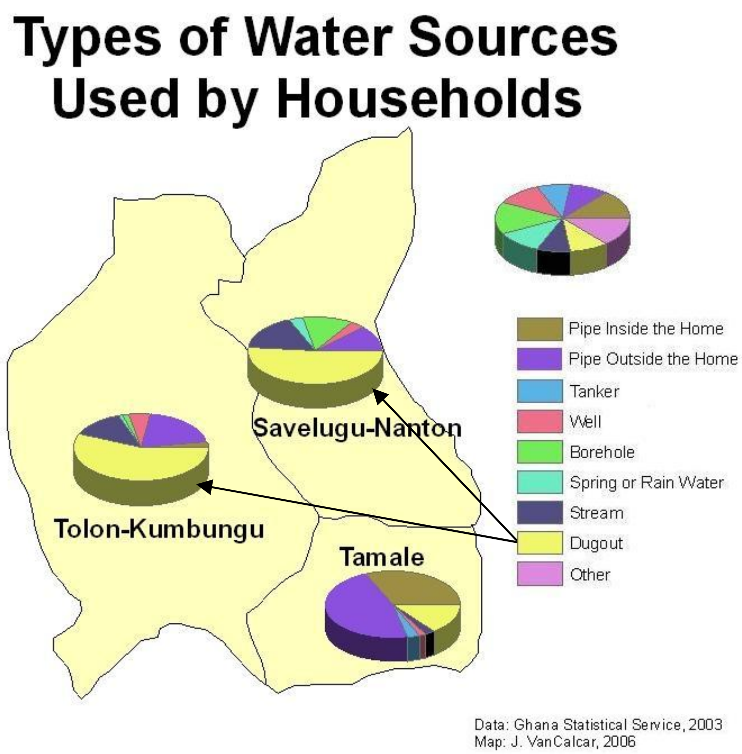
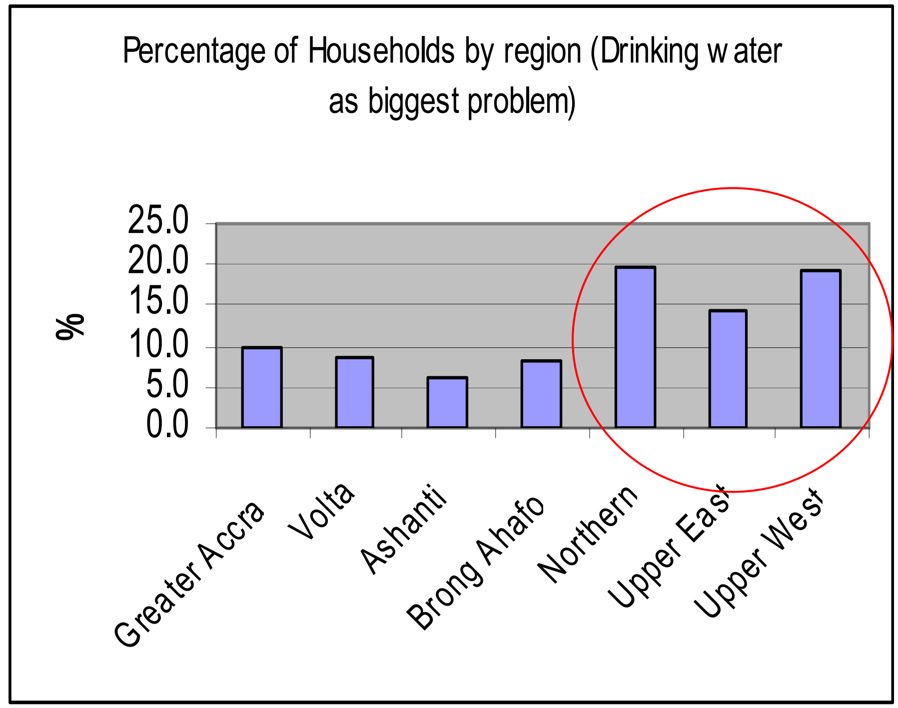
Presentation Outline

- **Ghana: Background and Logistics**
- **Horizontal Roughing Filtration: Tamar Losleben**
- **Household Filtration (Biosand Filter) : Izumi Kikkawa**
- **Chlorine Products: Cash Fitzpatrick**
- **HWTS Consumer Choice Study: Vanessa Green**
- **Ceramic Pot (Kosim) filter + Chlorine Disinfection with Aquatabs: Andrew Swanton**

Background



Large Percentage of Water Source is Dugouts



(National Statistical Services Survey -CWIQ 2003)

Local Perception: Lack of Clean Drinking Water is a Major Problem

Dungu Dam

Dugouts

St. Mary's Dam

E-Coli, Total Coliform, and Turbidity of Raw Water Samples from Selected Dugouts During the Rainy Season in Tamale and Savelugu Districts

Location	Date (2006)	E. coli (CFU per 100 mL)	Total Coliforms (CFU per 100 mL)	Turbidity (TU)
Ghanasco Muali Dam, TD	20-Jun	169	6,621	~1,600
Kaleriga Dam, TD	22-Jun	754	13,475	> 2,000
Bipelar Dam, TD	27-Jun	100	21,667	38
St. Mary's Dam, TD	29-Jun	1,650	52,110	>2,000
Dungu Dam, TD	4-Jul	133	4,540	400
Libga Dam, SD	6-Jul	0	500	75
Bunglung Dam, SD	11-Jul	200	5117	300
Diare Dam, SD	13-Jul	0	3,417	23
Libga Dam, SD	17-Jul	50	1,408	50
Gbanyami Dam, TD	19-Jul	367	19,150	~1,000
Vitting Dam, TD	25-Jul	1,400	12,767	~125
Average		**438**	**12,797**	**690**

Source: Foran, 2007

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Pilot Study of Horizontal Roughing Filtration in Northern Ghana as a Pretreatment Method for Highly Turbid Water

Tamar Rachelle Losleben

Objectives

- Characterize dugout particle sizes and distribution
  - Turbidity, settling stability, filtrability, sequential filtration, solids settleability
- Pilot test horizontal roughing filter (HRF)
  - Particle size characterization, turbidity, flow rate, microbial contamination


Ghanasco Dam
Photo Credit:
Murcott 08


Gbrumani Dam

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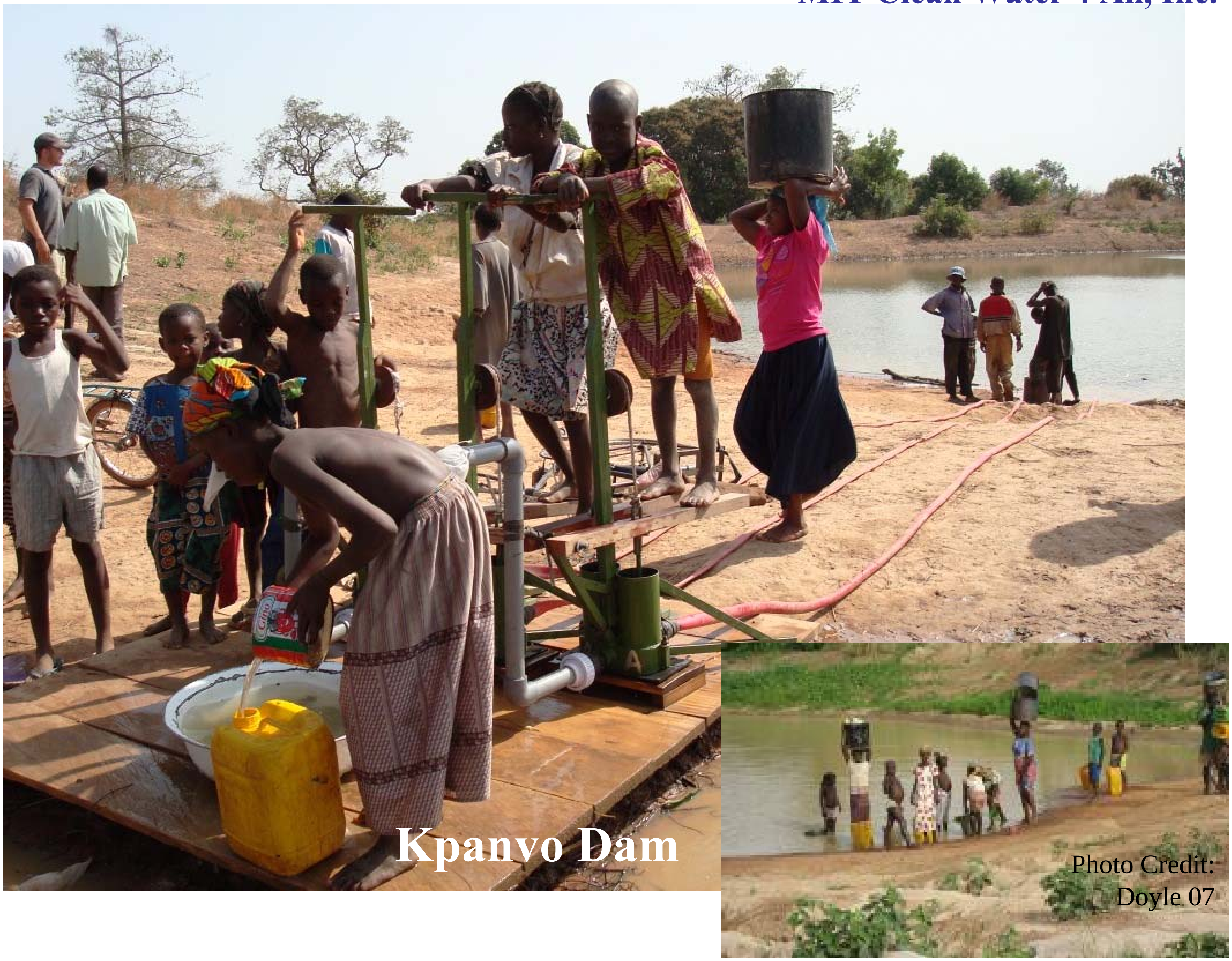
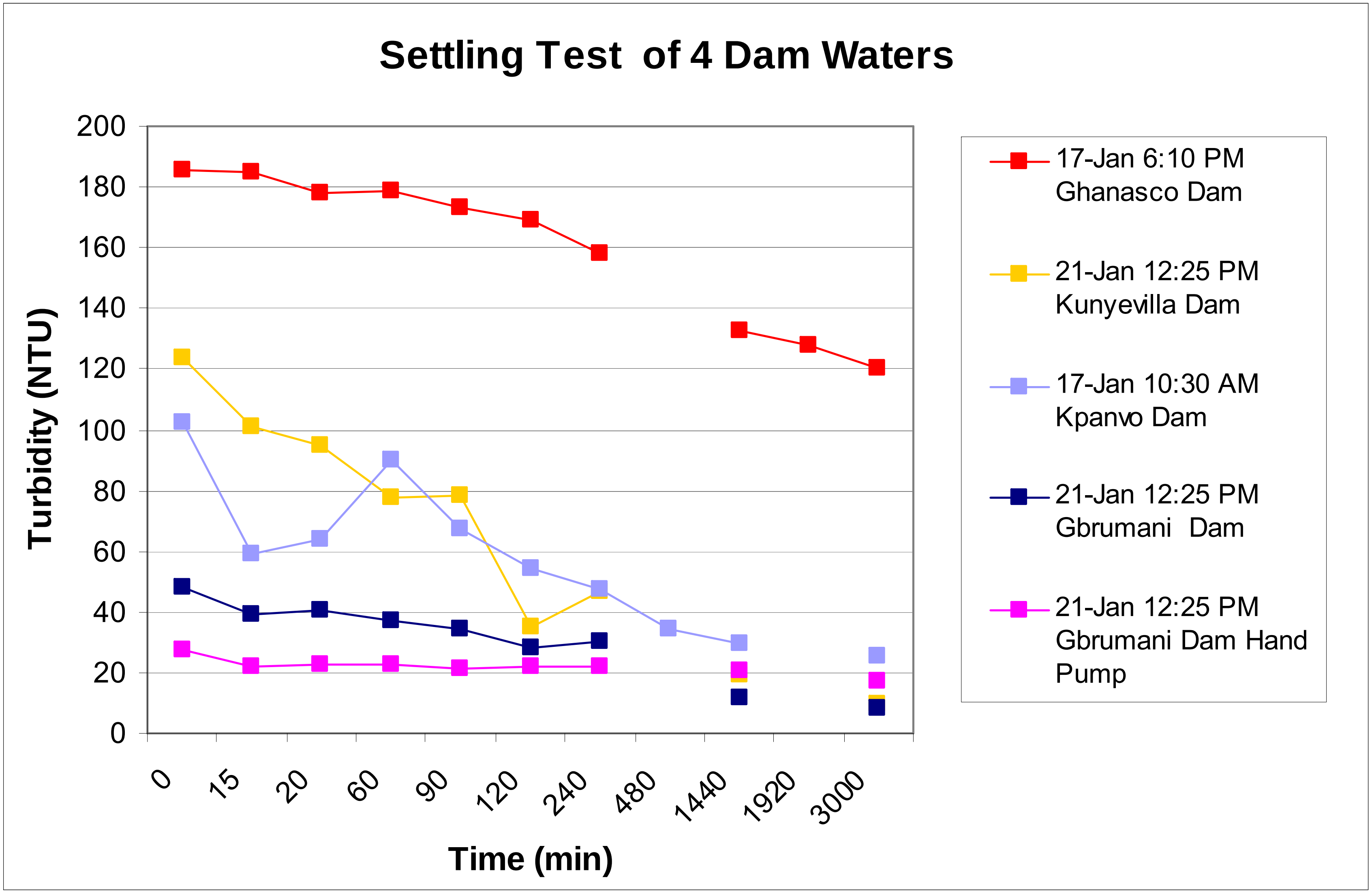


Photo Credit:
Doyle 07

Kunyevilla Dam


Settling Test of 4 Dam Waters
Turbidity (NTU)
200
180
160
140
120
100
80
60
40
20
0
0
15
20
60
90
120
240
480
1440
1920
3000
Time (min)
17-Jan 6:10 PM Ghanasco Dam
21-Jan 12:25 PM Kunyevilla Dam
17-Jan 10:30 AM Kpanvo Dam
21-Jan 12:25 PM Gbrumani Dam
21-Jan 12:25 PM Gbrumani Dam Hand Pump

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Dugout

?

Pretreatment

Slow sand filtration (SSF)

Maximum raw water turbidity:
(Wegelin, 1996; Galvis 1993)

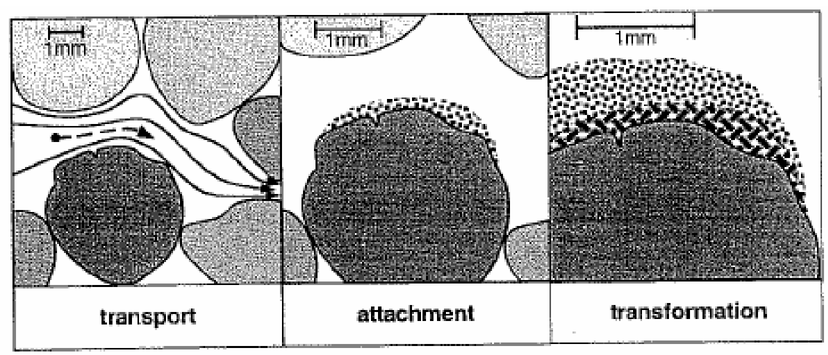
20-50 NTU

99-99.99% removal of microorganisms
(Wegelin, 1996)

Raw Dugout Samples in Tamale and Savelugu Districts (Foran, 2007)

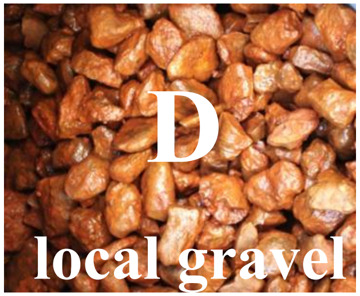
	Dry Season	Rainy Season
Average *E.Coli* (CFU/100 mL)	779	438
Average Total Coliform (CFU/100 mL)	26,357	12,797
Average Turbidity	**248 NTU**	**931 NTU**

Horizontal Roughing Filters (HRF)

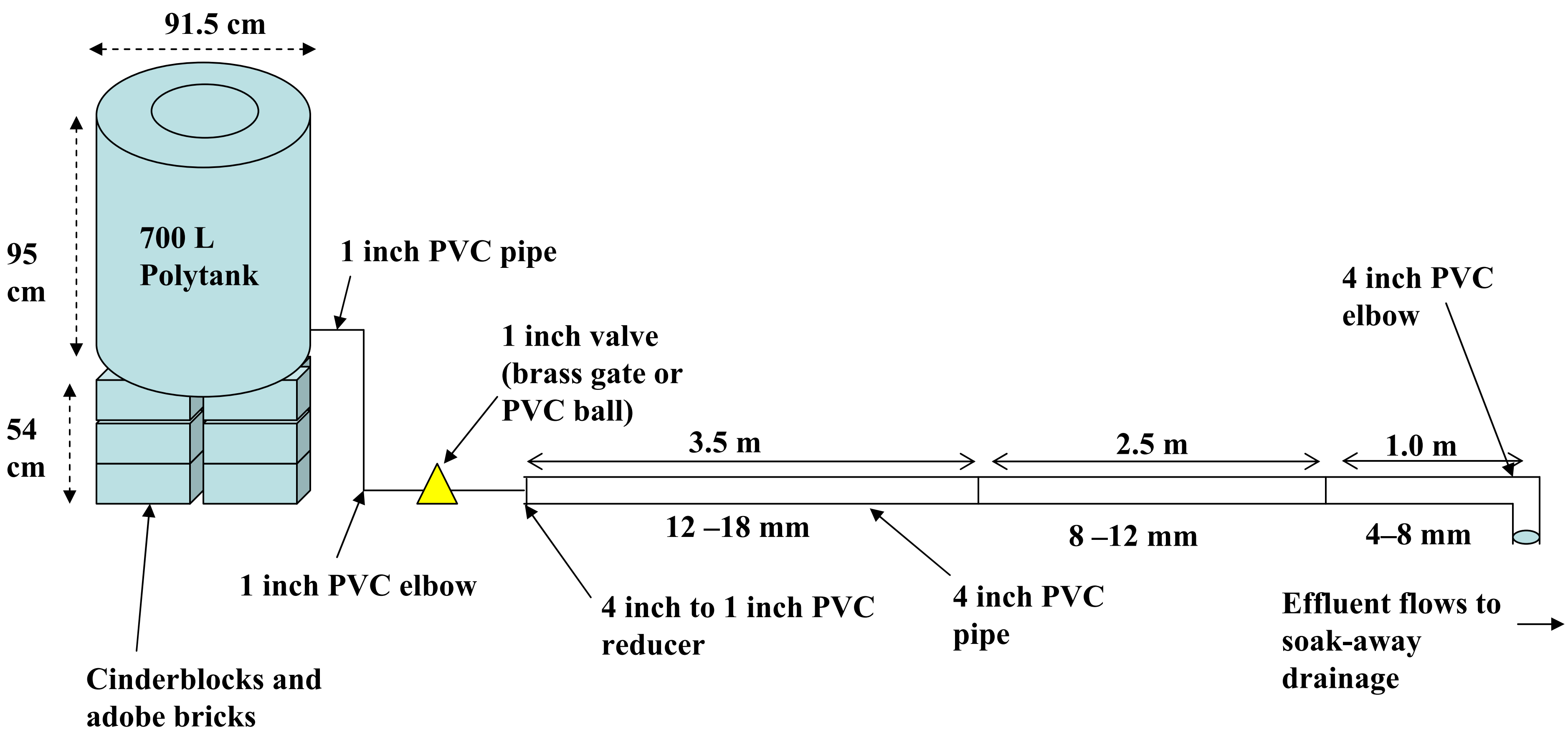


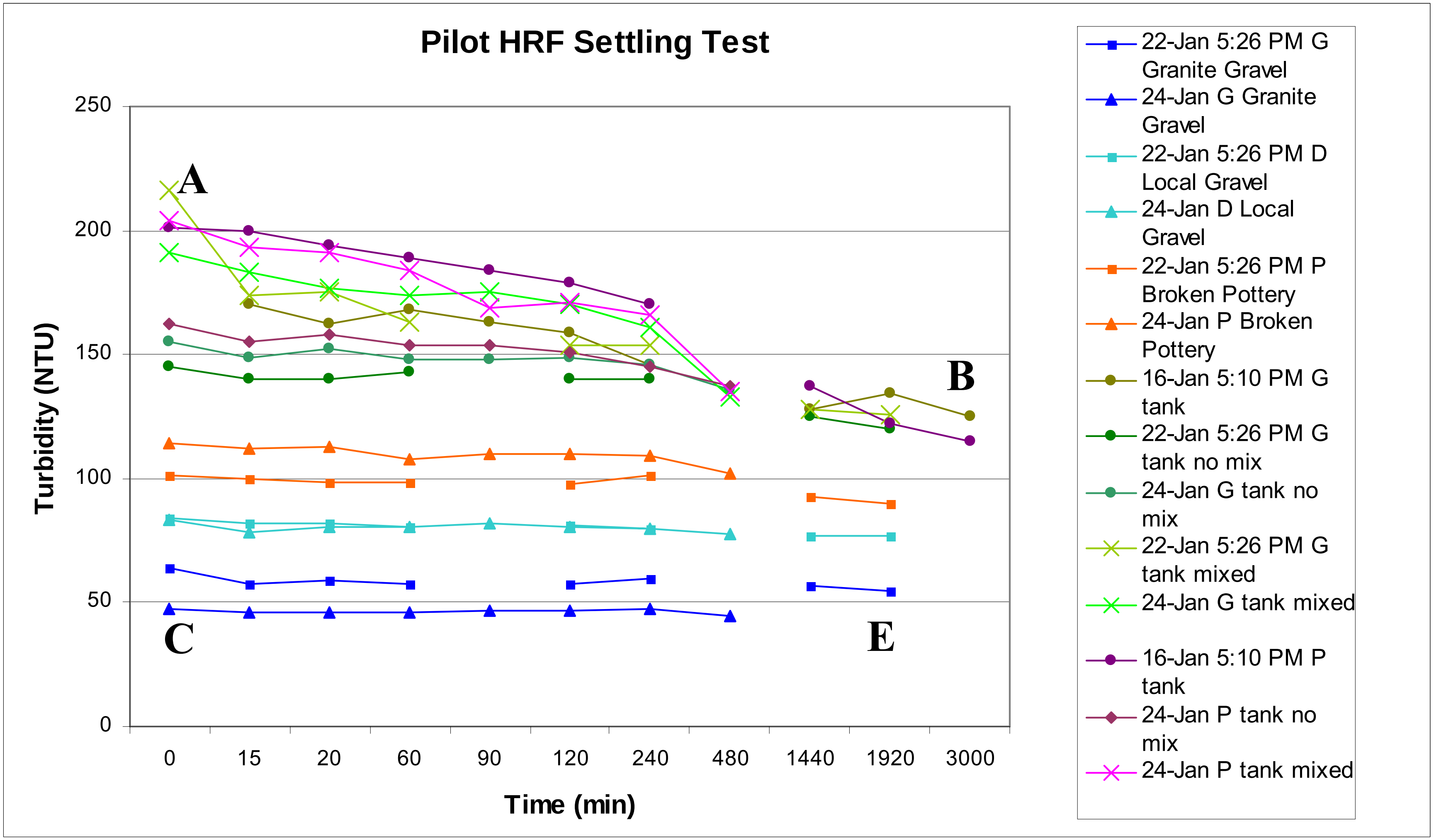
Particle removal mechanisms in HRF (Wegelin, 1996)

Ghanasco Dam Pilot HRF



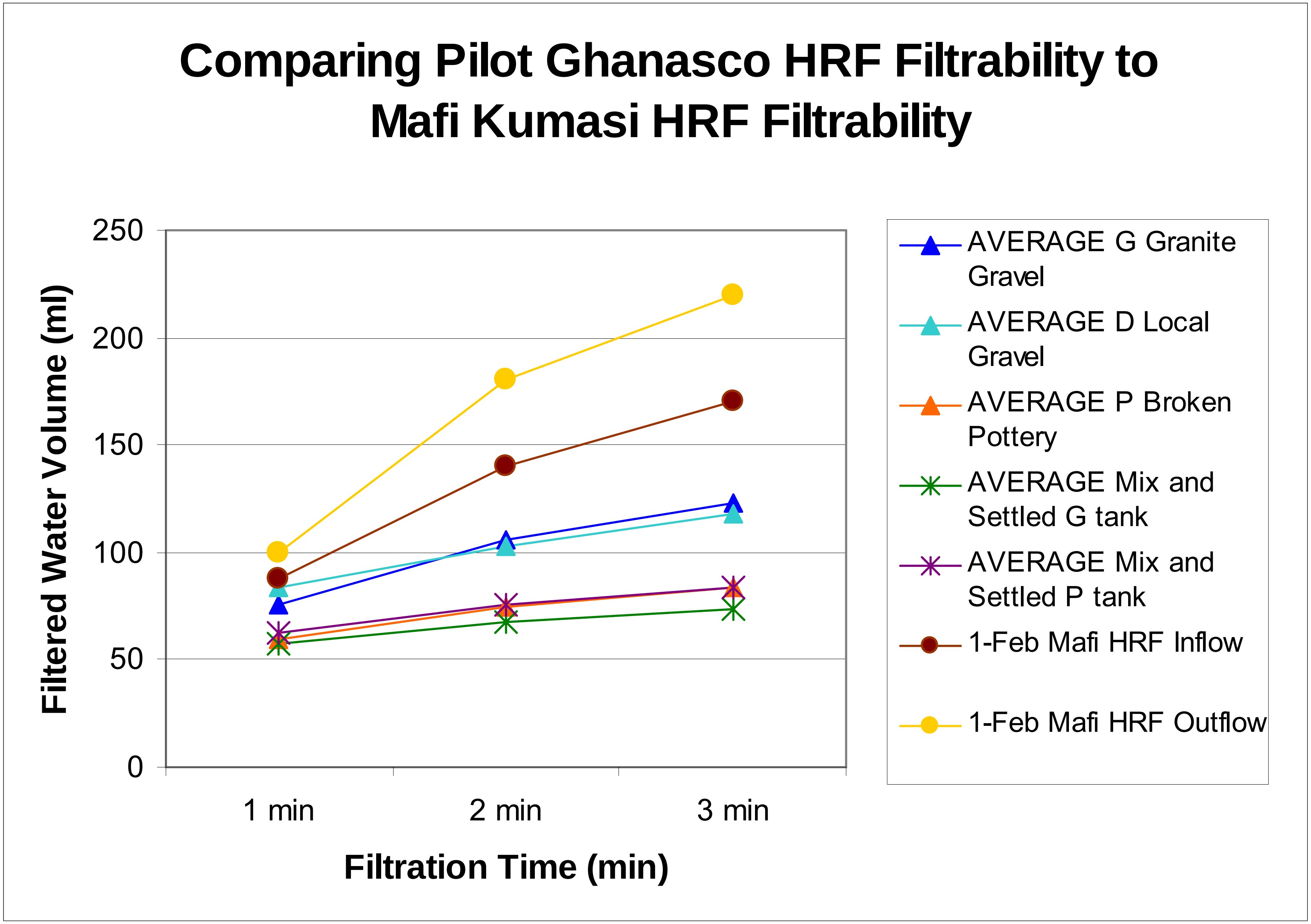
Ghanasco Dam Pilot HRF




Pilot HRF Settling Test
Turbidity (NTU)
0
50
100
150
200
250
0
15
20
60
90
120
240
480
1440
1920
3000
Time (min)
A
B
C
E
22-Jan 5:26 PM G Granite Gravel
24-Jan G Granite Gravel
22-Jan 5:26 PM D Local Gravel
24-Jan D Local Gravel
22-Jan 5:26 PM P Broken Pottery
24-Jan P Broken Pottery
16-Jan 5:10 PM G tank
22-Jan 5:26 PM G tank no mix
24-Jan G tank no mix
22-Jan 5:26 PM G tank mixed
24-Jan G tank mixed
16-Jan 5:10 PM P tank
24-Jan P tank no mix
24-Jan P tank mixed

Comparison of the Turbidity Reduction Performance of HRF Media

	Average HRF effluent turbidity	Average filtration rates (ml/min)	Average additional turbidity removed by HRF after settling	Average % additional turbidity removed by HRF after	Average % total HRF turbidity reduction	Filtration coefficient, λ (min^-1)
G granite gravel	51 NTU	220 (1.6 m/hr)	46 TU	**61 %**	**84 %**	**0.002**
D local gravel	72 NTU	170 (1.3 m/hr)	30 TU	**47 %**	**76 %**	**0.0007**
P broken pottery	61 NTU	200 (1.5 m/hr)	18 TU	**55 %**	**80 %**	**0.0006**
Goal:	< 50 NTU	41-270 (0.3-2.0 m/h)	---	**---**	**---**	**---**


Comparing Pilot Ghanasco HRF Filtrability to Mafi Kumasi HRF Filtrability
Filtered Water Volume (ml)
250
200
150
100
50
0
1 min
2 min
3 min
Filtration Time (min)
AVERAGE G Granite Gravel
AVERAGE D Local Gravel
AVERAGE P Broken Pottery
AVERAGE Mix and Settled G tank
AVERAGE Mix and Settled P tank
1-Feb Mafi HRF Inflow
1-Feb Mafi HRF Outflow

Ouagadougou Pilot HRF

International Institute for Water and Environmental Engineering
Burkina Faso

- **June 5 - July 28, 2006**
- **Loumbila Dam (Sylvain, 2006)**

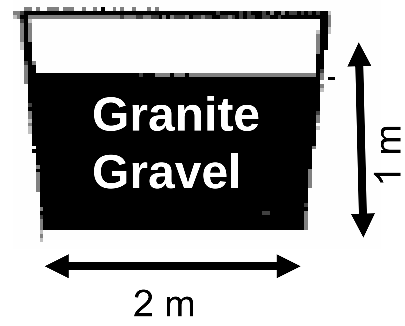
http://aochycos.ird.ne/HTMLF/ETUDES/HYDRO/LOUMBILA.HTM

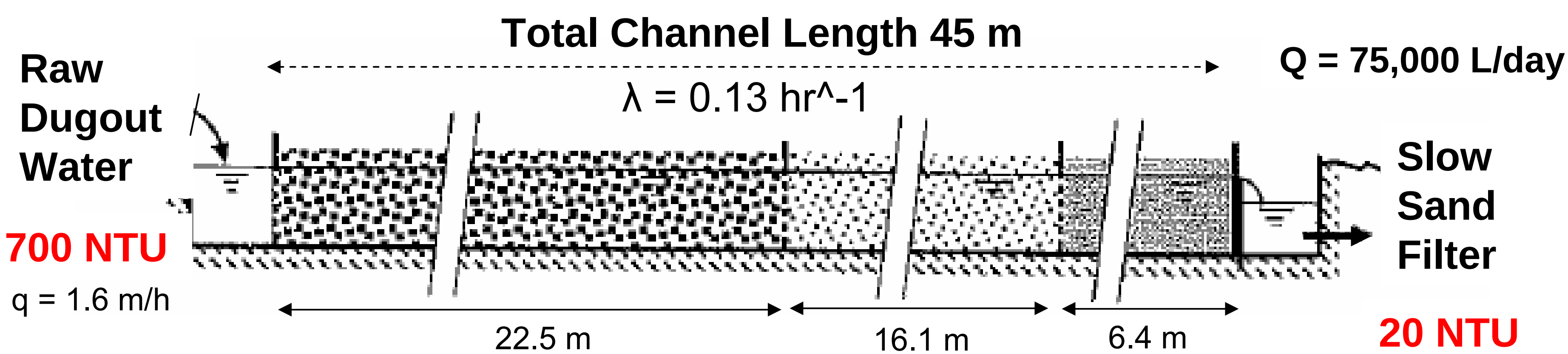
Comparison of Pilot HRF Performance

	Blue Nile Health Project, Sudan (referenced by Wegelin, 1996)		Ghanasco Dam, Tamale, Northern Ghana (Losleben, 2008)			Ouagadougou, Burkina Faso (Sylvain, 1989)
Media	broken burnt bricks	gravel	granite gravel G	local gravel D	broken pottery P	quartz gravel
Average filtration rate (m/h)	0.30		1.6	1.3	1.5	1.0
Filter length and media size (mm)	270 cm, 30-50 85 cm, 15-20 85 cm, 5-10		350 cm, 12-18 250 cm, 8-12 100 cm, 4-8			400 cm, 15-25 150 cm, 5-15
Raw water turbidity	40-500 NTU		313 NTU	301 NTU	301 NTU	5-50 NTU
Prefiltered water turbidity	5-50 NTU		51 NTU	72 NTU	61 NTU	4-19 NTU
Faecal coliforms* (/100ml)						
Raw water	> 300	---	8400	8400	8400	---
Prefiltered water	< 25	---	---	15500	500	---
Mean turbidity reduction	77 %	87 %	84 %	76 %	80 %	32 %

* as *E.coli*

HRF Channel Design





(Wegelin, 1996)

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Background ~Biosand Filter (BSF)~

- Household treatment
- Intermittent slow sand filtration
- Removes:
    - >90 % of *E.coli* bacteria
    - 100 % of protozoa and helminthes (worms)
    - 50-90 % of organic and inorganic toxicants
    - <67 % of iron and manganese
    - most suspended solids
- 270,000 BSFs installed in 25 countries
  - Disadvantages:
    - does not suite treatment of high turbid water
      - » Decline in treatment efficiency, frequent clogging and maintenance requirement

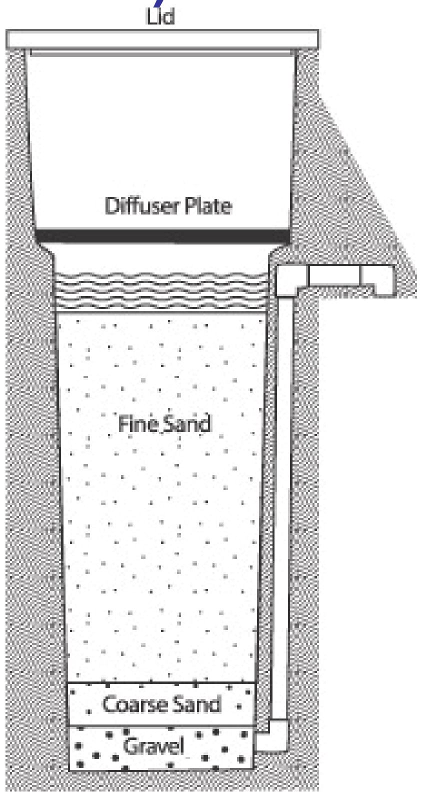


Diagram of Biosand Filter

Turbidity Limit ~50 NTU

Local Plastic Design BSF

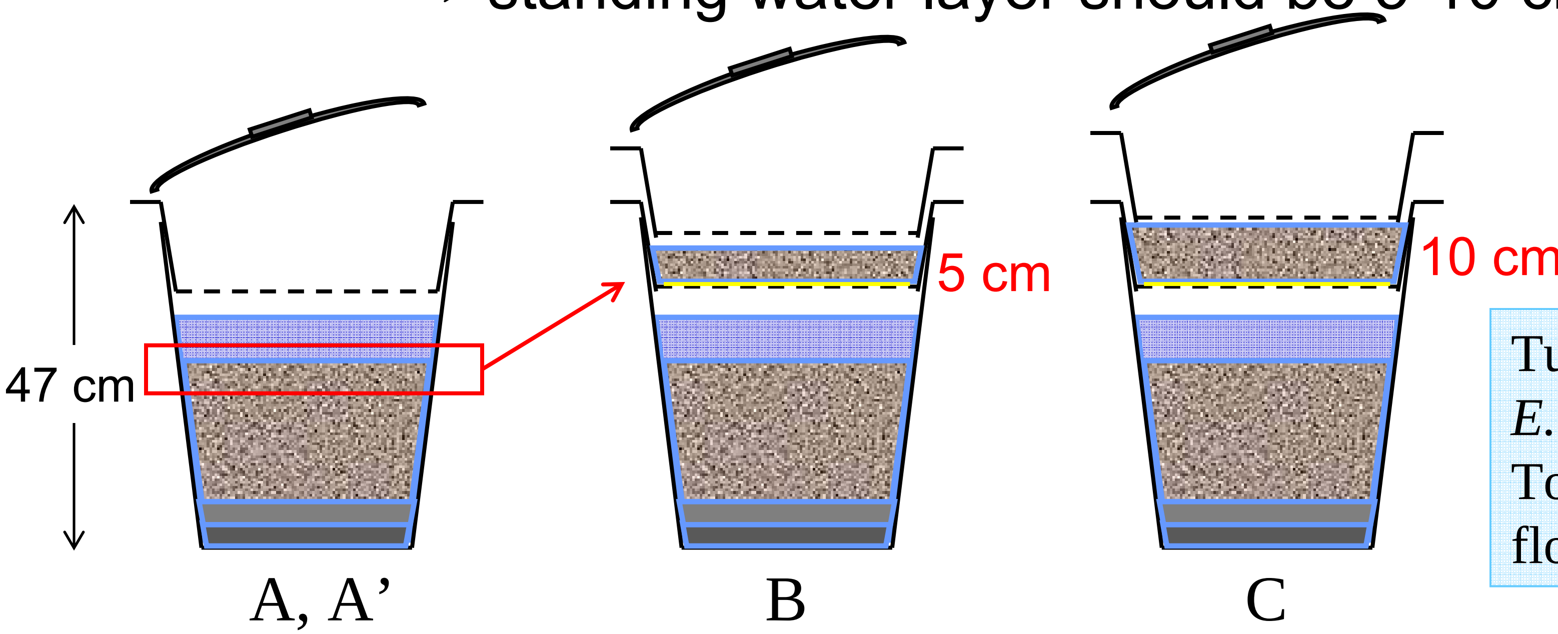
Biolayer: *schumutzdecke*, biofilm

- most purification proceeds here
- estimated to be 5-10 cm in depth[1]

Modification: Create additional biolayer

oxygen diffusion is essential

⟶ standing water layer should be 5-10 cm



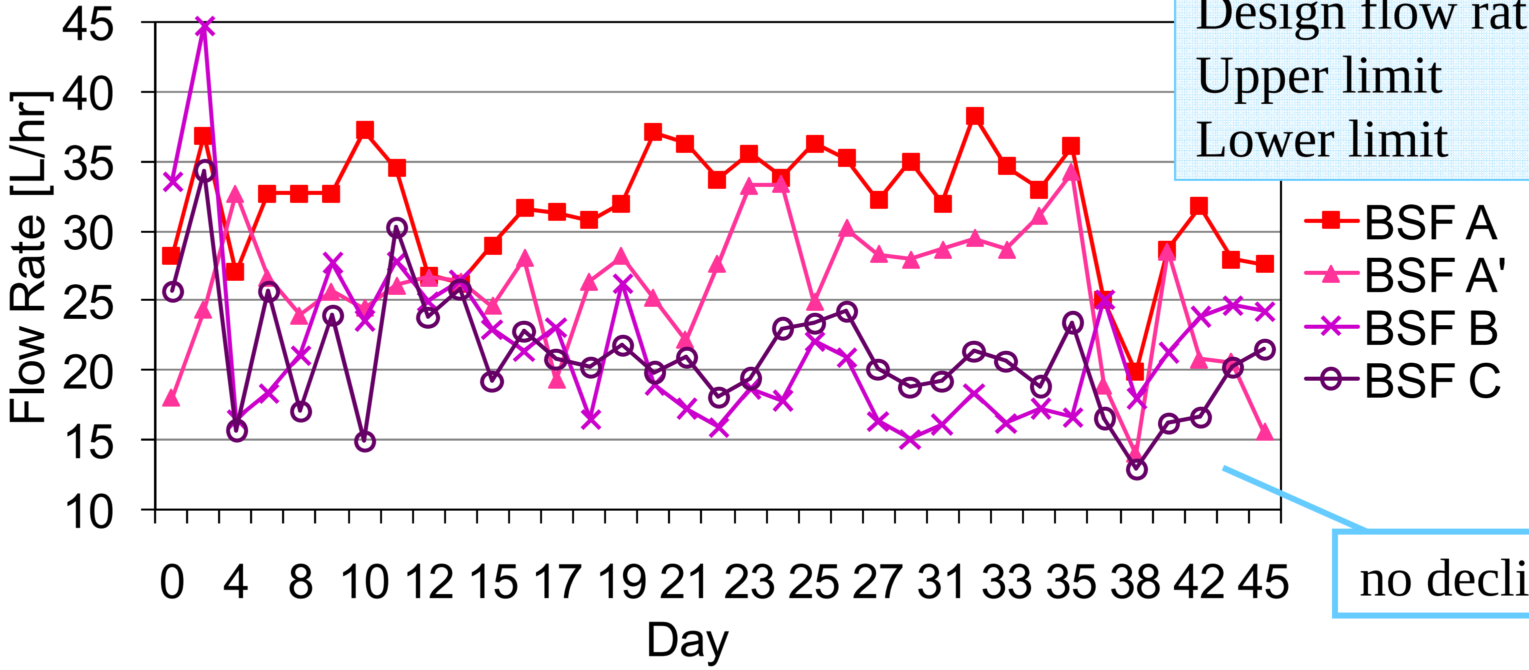
Evaluation:

- Turbidity
- *E.Coli*
- Total Coliform
- flow rate

1) B.J.Buzunis, *Intermittently Operated Slow Sand Filtration: A New Water Treatment Process*, March **1995**

Results & Discussion -Flow Rate-

Design flow rate	~ 20 L/hr
Upper limit	30 L/hr
Lower limit	5 L/hr

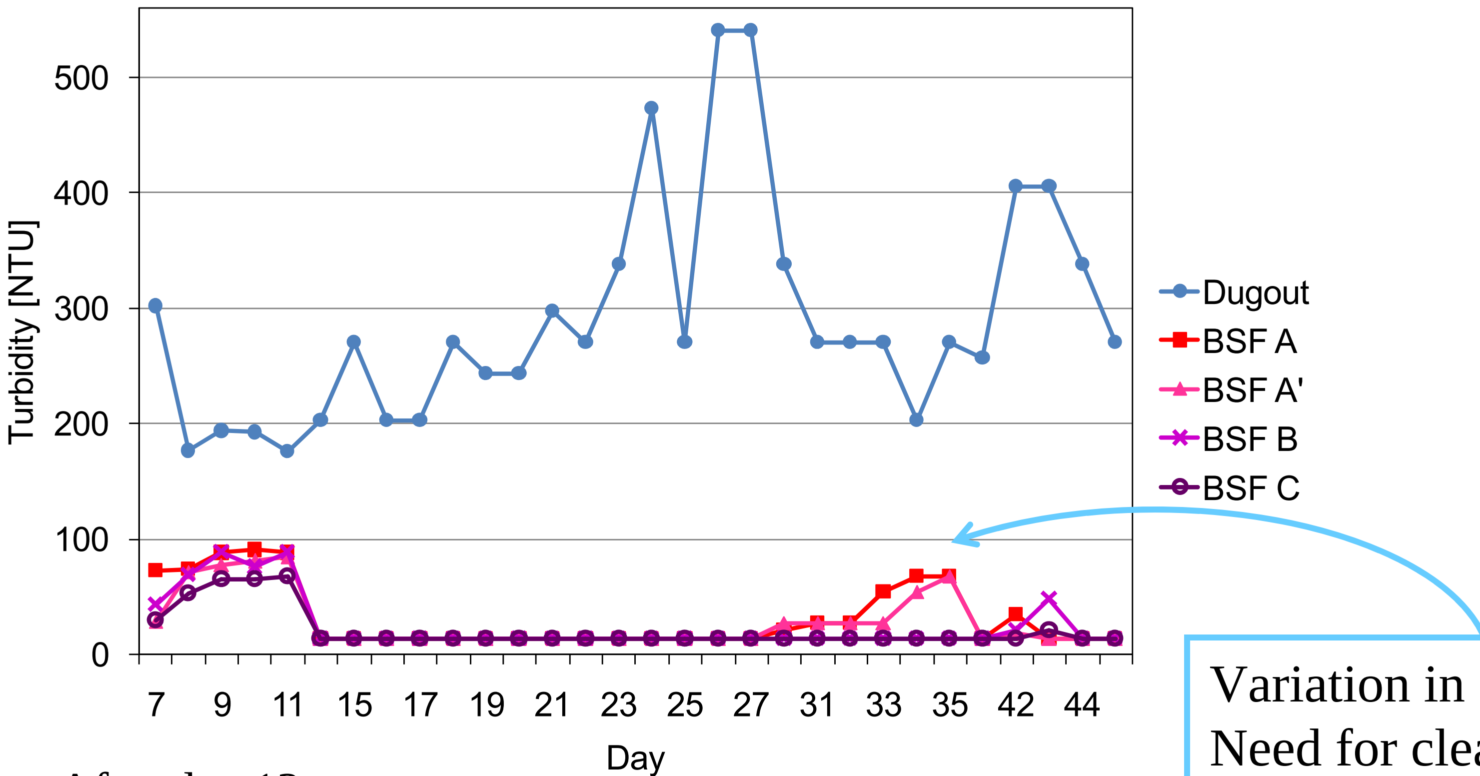


no decline in flow rate

LPD BSF	average flow rate [L/hr] (standard deviation)
A (without modification)	32.0 (4.1)
A' (without modification)	25.9 (4.9)
B (additional 5 cm sand layer)	21.8 (6.0)
C (additional 10 cm sand layer)	21.1 (4.3)

lower flow rates for BSF B & C No clogging

Results & Discussion -Turbidity-



Variation in operation?
Need for cleaning?

After day 13

Dugout and BSF	Average turbidity [NTU] (standard deviation)
Dugout	306 (97)
A (without modification)	22 (17)
A' (without modification)	20 (14)
B (additional 5 cm sand layer)	15 (6.8)
C (additional 10 cm sand layer)	14 (1.4)

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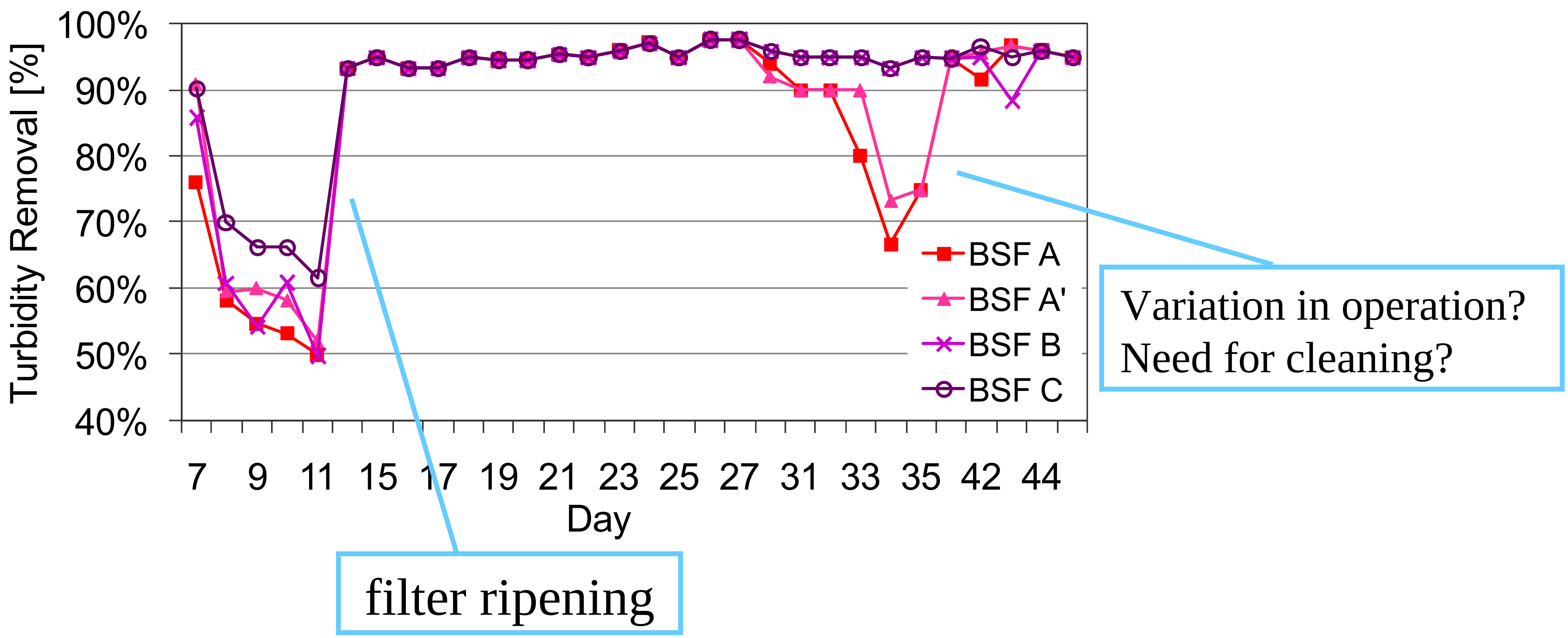
Results & Discussion -Turbidity-

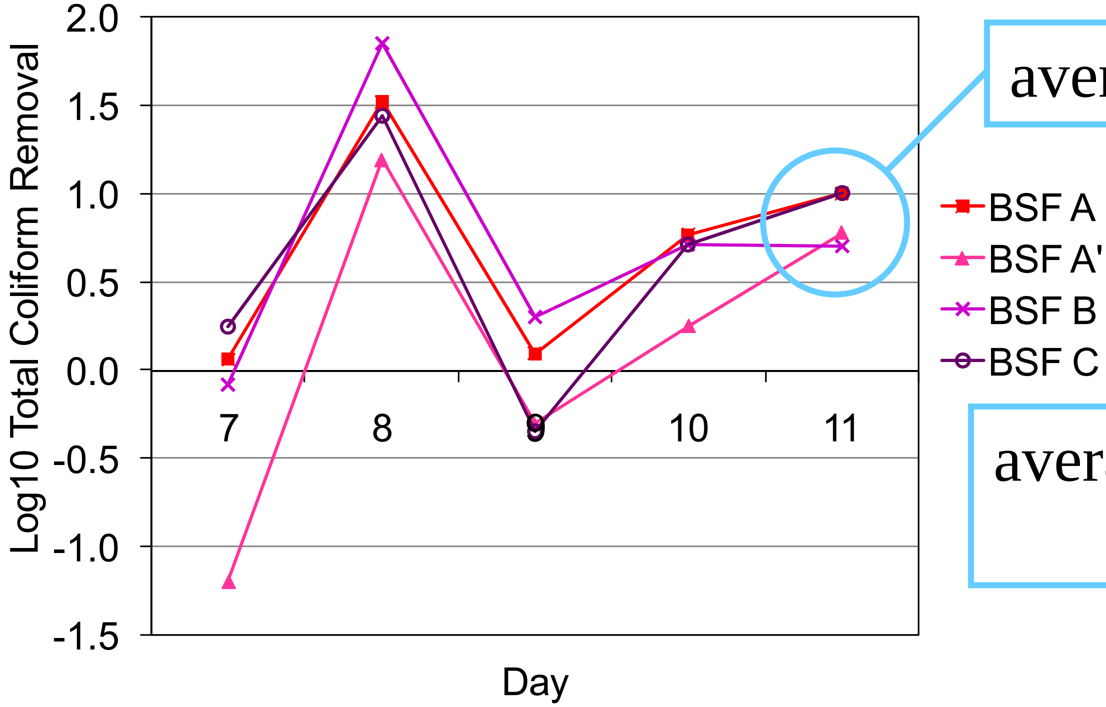


After day 13

BSF	average turbidity removal (standard deviation)
A (without modification)	92 % (7 %)
A' (without modification)	93 % (6 %)
B (additional 5 cm sand layer)	95 % (2 %)
C (additional 10 cm sand layer)	95 % (1 %)

Results & Discussion -Microbial-

Total Coliform



average 86 % removal

average influent:
12,000 cfu/100ml

Hydrogen Sulfide Bacteria; Presence/Absence

Day	30	38	43	46
Dugout	30000	Present	Present	Present
BSF A	0		Present	Absent
BSF A'	300	Absent	Absent	Present
BSF B	200		Absent	Absent
BSF C	0		Present	Absent

E. Coli mostly not detected in influent/effluent

Discussion -LPD BSF-

Flow Rate

- Modified BSFs had slower flow rates

  Due to additional basin with sand

- All BSFs had not clogged after 46 days of operation

Turbidity

- Dugout: wide variation
- Filter ripening: after 13 days
- Modified BSFs showed slightly higher turbidity removal
  - Decline in BSF A & A': operation conditions ? cleaning?
  - No decline in BSF B & C: could be benefit of modification

    Able to withstand more operational variation, or less frequent cleaning

Total Coliform Removal

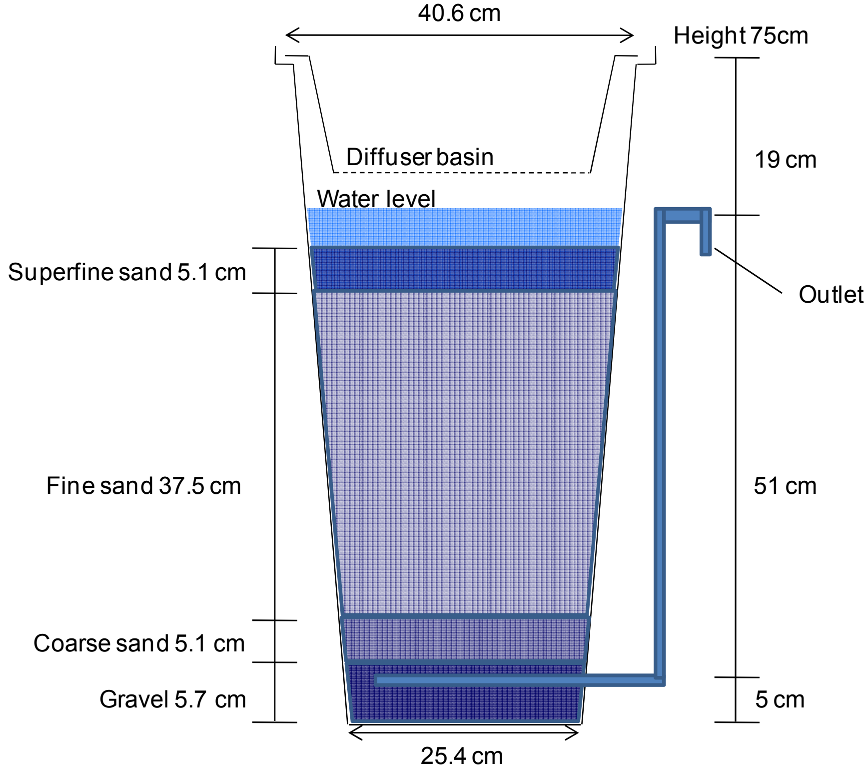
- No quantitative data after filter ripening (Day 13)
- 86 % removal with average effluent of 430 cfu/100 ml (on Day 11)

E. Coli

- Mostly was not detected in influent/effluent

HydrAid™ BioSand Filter

- Approximately 200 HydrAid BSFs installed (December, 2007) in Kpanvo Village
- By International Aid
- Additional layer of superfine sand



Tests conducted at 30 households:

- Turbidity
- *E.Coli*
- Total Coliform
- flow rate

**Average turbidity not high

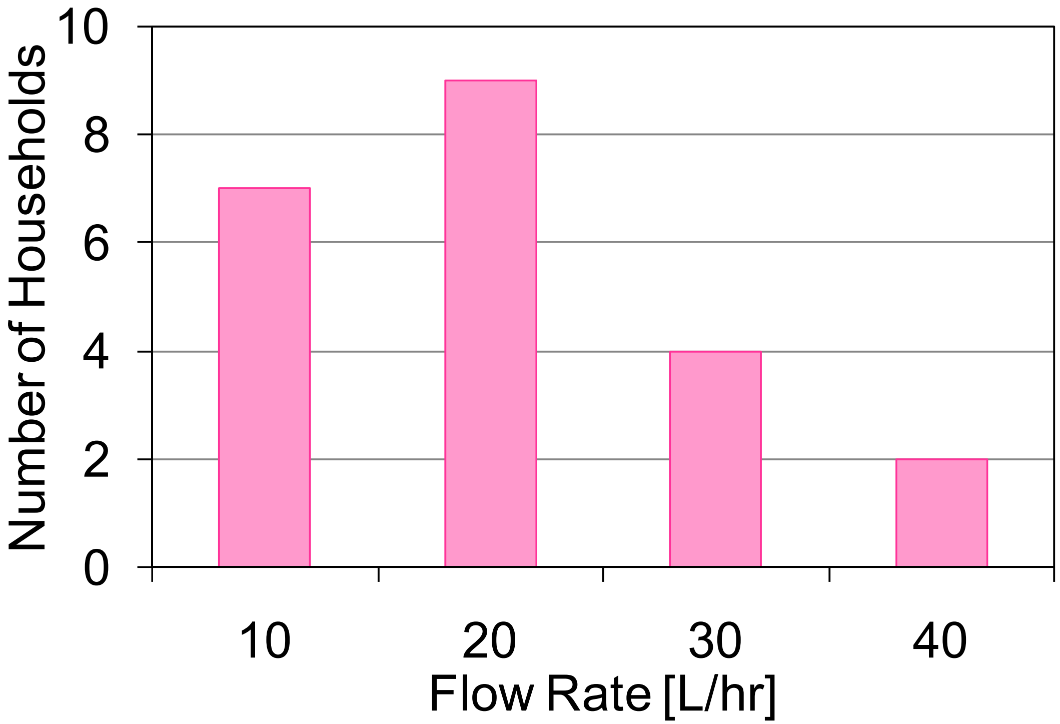
Dugout ~85 NTU

Influent ~ 32 NTU

Results & Discussion -Flow Rate-

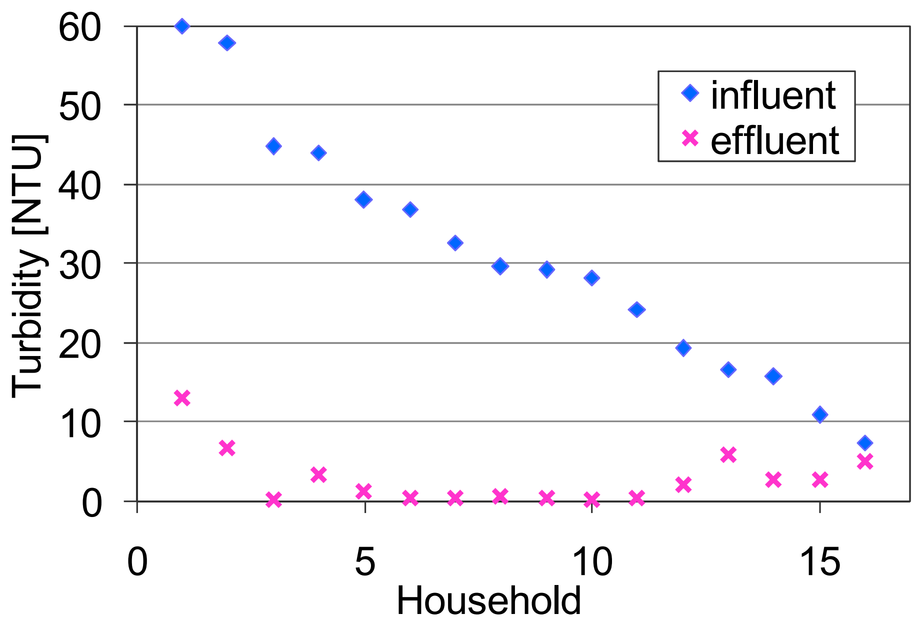
Design Flow Rate 47 L/hr

- measurements not taken at maximum head thus slower than design flow rate
- cleaning every 3 days
- clogging was not problematic



average flow rate:
17 L/hr

Results & Discussion -Turbidity-

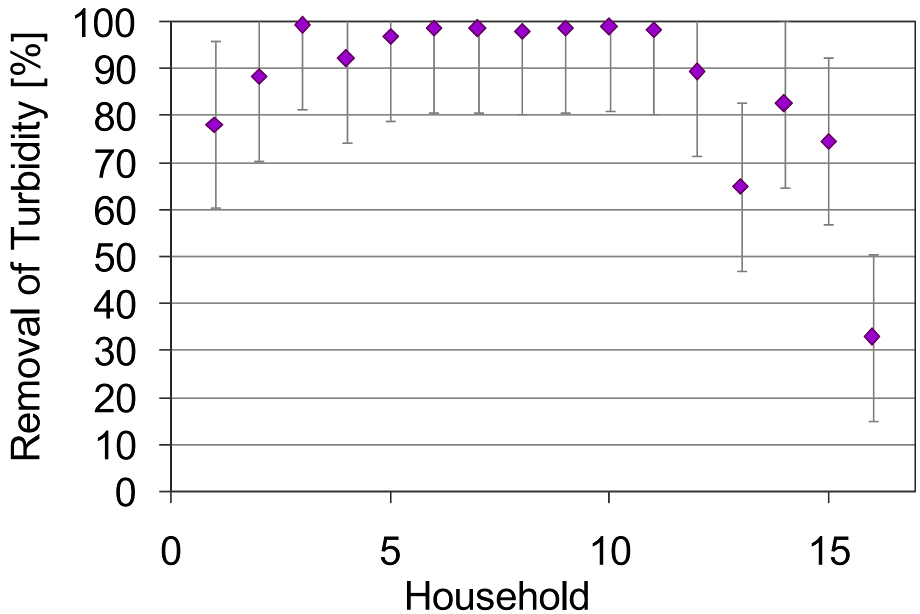


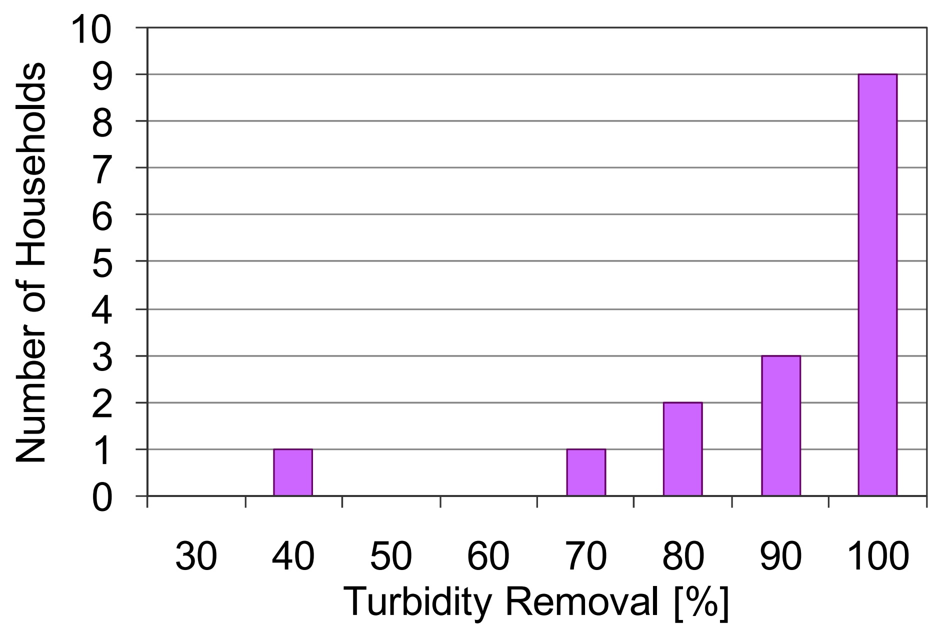
Average

Influent : 32 NTU

Effluent : 2.9 NTU

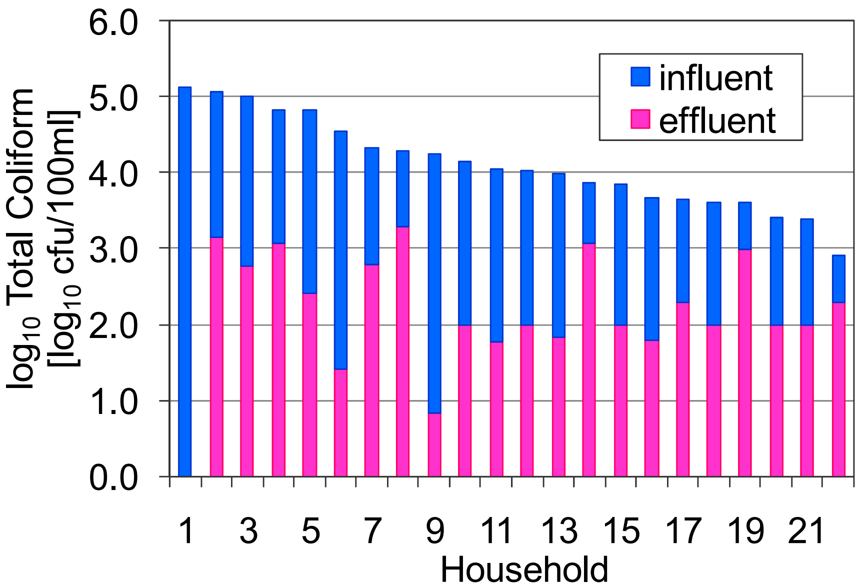
Removal : 87 %

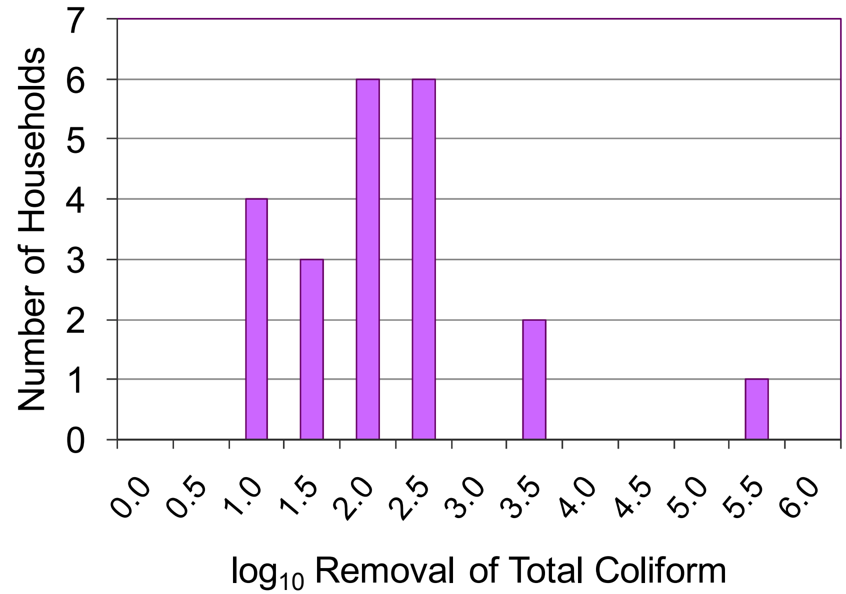


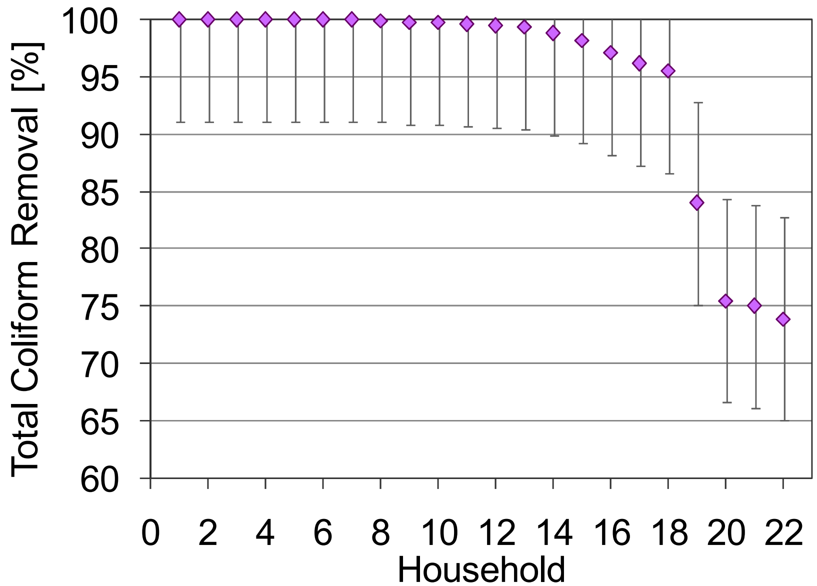


Results -Microbial-

Total Coliform







Average Removal 1.9 Log_{10} units, 95 %

Average Effluent 710 cfu/100 ml

E. coli:

detected in 9/22 samples (influent)

average influent 960 cfu/100 ml (9 samples)

55 % removal

Discussion -HydrAid BSF-

Flow Rate

- Slower than design flow rate, but not problematic

Turbidity

- Influent: relatively low turbidity
- Effective in turbidity removal

  average removal 87 %, average effluent 2.9 NTU

Total Coliform

- Effective in total coliform removal

  average removal:1.9 log10 units, 95 %

- Effluent concentration is high: 710 cfu/100ml

E. Coli

- Only detected in limited # of samples

Summary

		Locally Plastic Design BSFs unmodified; modified	HydrAid BSFs
Design Flow Rate		15-20 L/hr	47 L/hr
Measured Flow Rate		29 L/hr; 21 L/hr	17 L/hr *
Turbidity	influent	227 TU	32 NTU
	effluent	16 TU; 11 TU	2.9 NTU
	removal	93 %; 95 %	87%
Total Coliform	influent	15,000 cfu/100ml	20,000 cfu/100ml
	effluent	430 cfu/100 ml **	710 cfu/100ml
	removal	87 % **	95%
Cost		$ 16 - $ 25	$ 50 - $ 65

* Not measured at maximum head
** Average values on Day 11
*** Average value after 30+ days of operation

Local Plastic Design Biosand Filter Summary:

- Slower design flow rate
- Higher influent turbidity, higher percent removal
- Lower percent total coliform removal, lower effluent concentration
- Much less expensive

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Overall Goal: To Compare HTH Chlorine Dosing System with Aquatabs

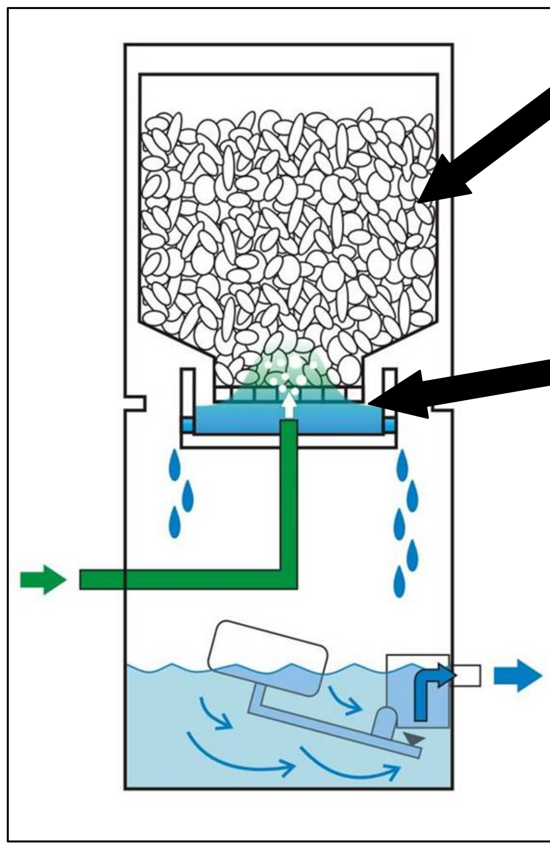
- Thesis Title: "*Efficacy of Gravity-Fed Chlorination System for Community-Scale Water Disinfection in Northern Ghana*"
- Specific Objectives
  - To take Pulsar 1 System* and convert it for drinking water usage for community scale chlorination
  - Based on current capacity, need to significantly lower output residual chlorine concentrations
    - CDC: <2mg/L after 30 mins and >0.2mg/L after 24 hours
  - Compare different chlorine options (community scale versus household scale)

Pulsar 1 Unit

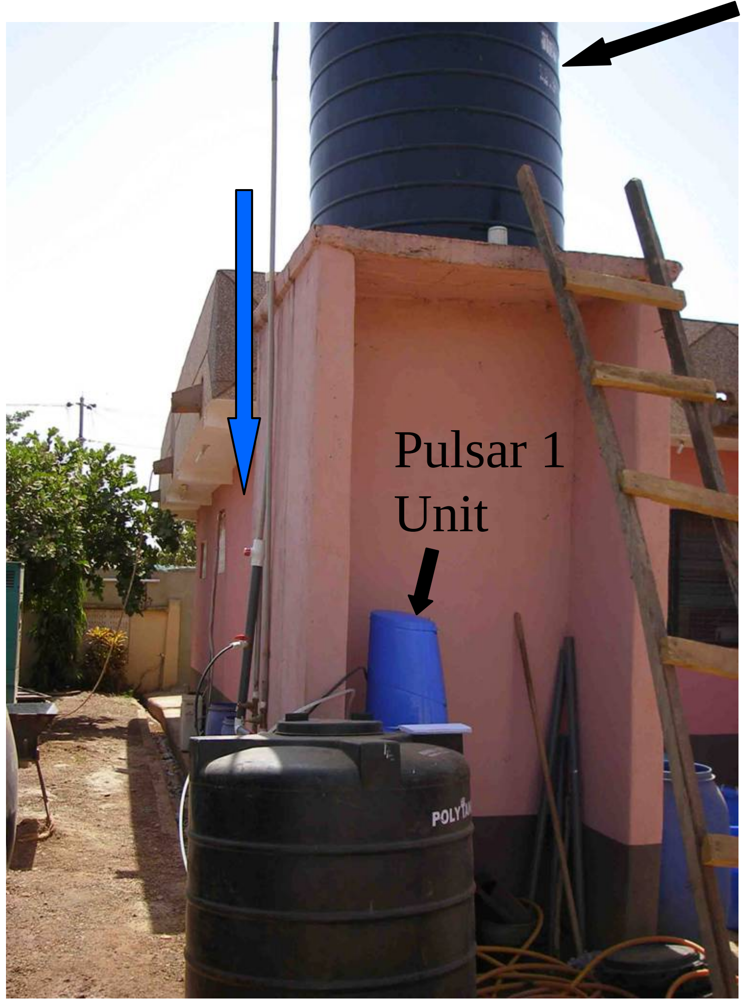
* Pulsar 1 system is unique in being a highly accurate chlorine dosing system <u>that does not require electricity</u> (gravity feed). It was designed for large-scale swimming pools, but we hypothesized that it might be appropriate to adapt for developing country contexts such as schools, hospitals, and rural communities.

How the Pulsar Works

- Operates in parallel with water line (diverts some flow and re-injects downstream)



Field Work Site



Modifications Made in Ghana

Modifications

- Added ¼" Spiked Grid
- Enlarged "Emergency Shutoff Valve"
- Added a dilution nozzle
- Reduced the inlet/outlet flows

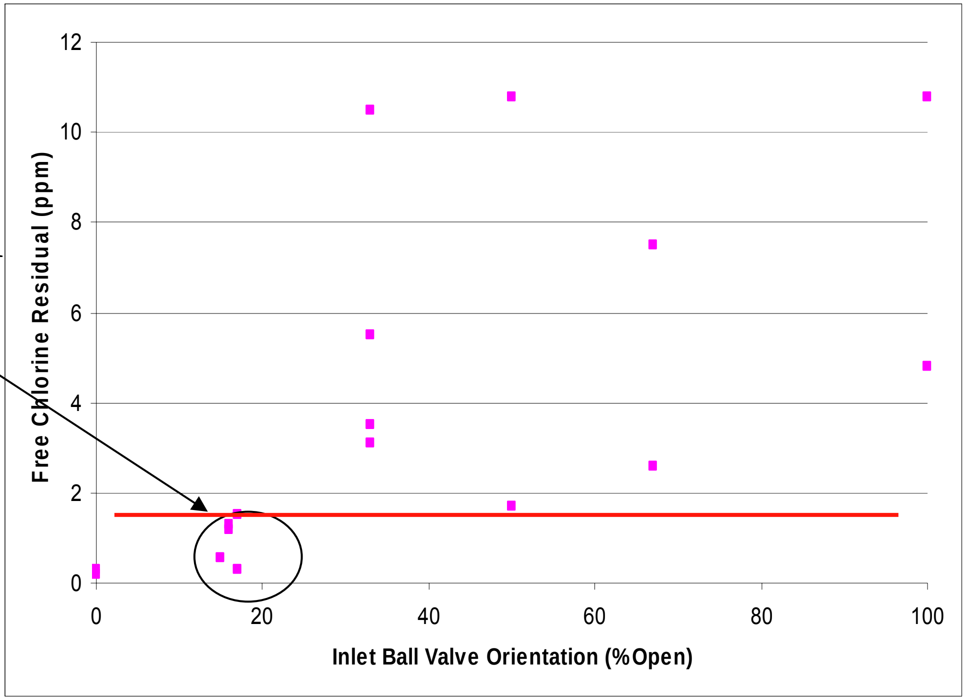
Results

- Less contact with chlorine tablets in dissolving cup
- Divert more influent water away from the chlorine tablets
- Decreased total flow in and out of Pulsar unit

Field Work Results

- Successfully lowered concentrations to drinking water levels in Ghana

0.6-1.6 mg/L chlorine residual



But There's a Problem…

- This final modification causes frequent O&M problems
  - Low internal flow rates leads to chlorine buildup of tubes & parts
  - Is therefore *unsustainable*

Further Research at MIT Lab

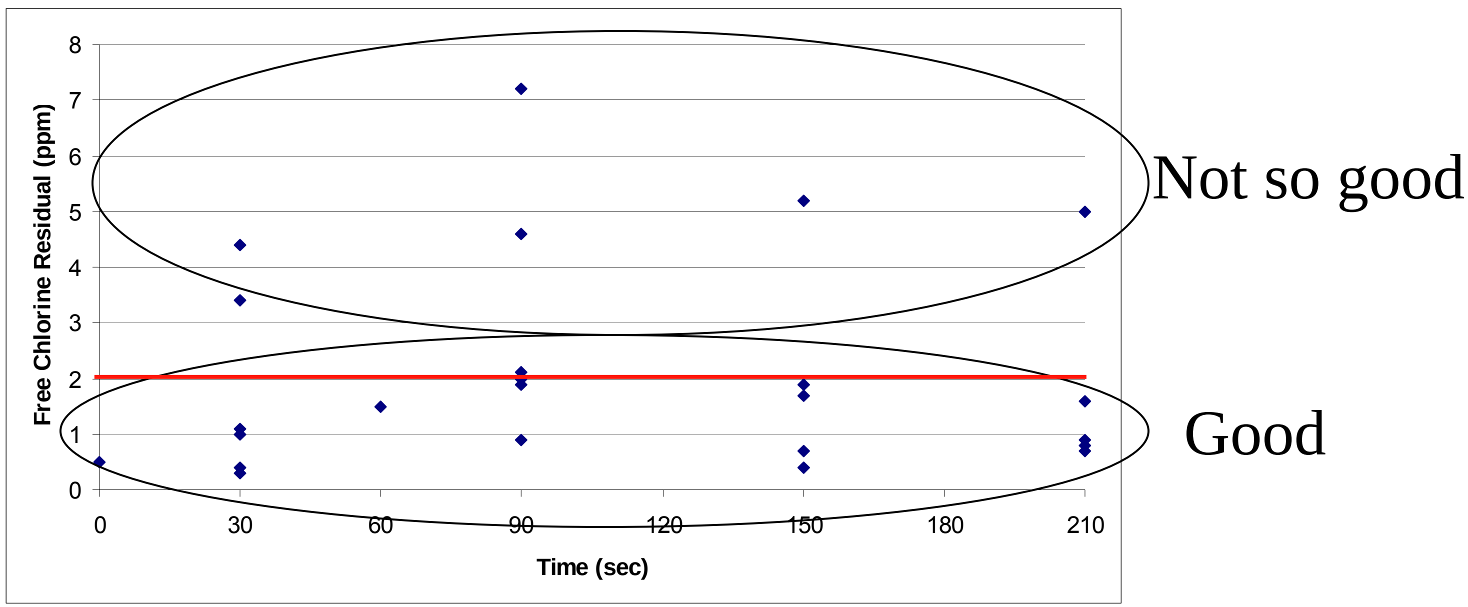
- Installed new parts to increase Pulsar's internal dilution capacity

  - Emergency Shutoff Valve – Pulls more water into the Pulsar unit

  - Dilution Nozzle Assembly – Diverts more of this water away from the dissolving cup

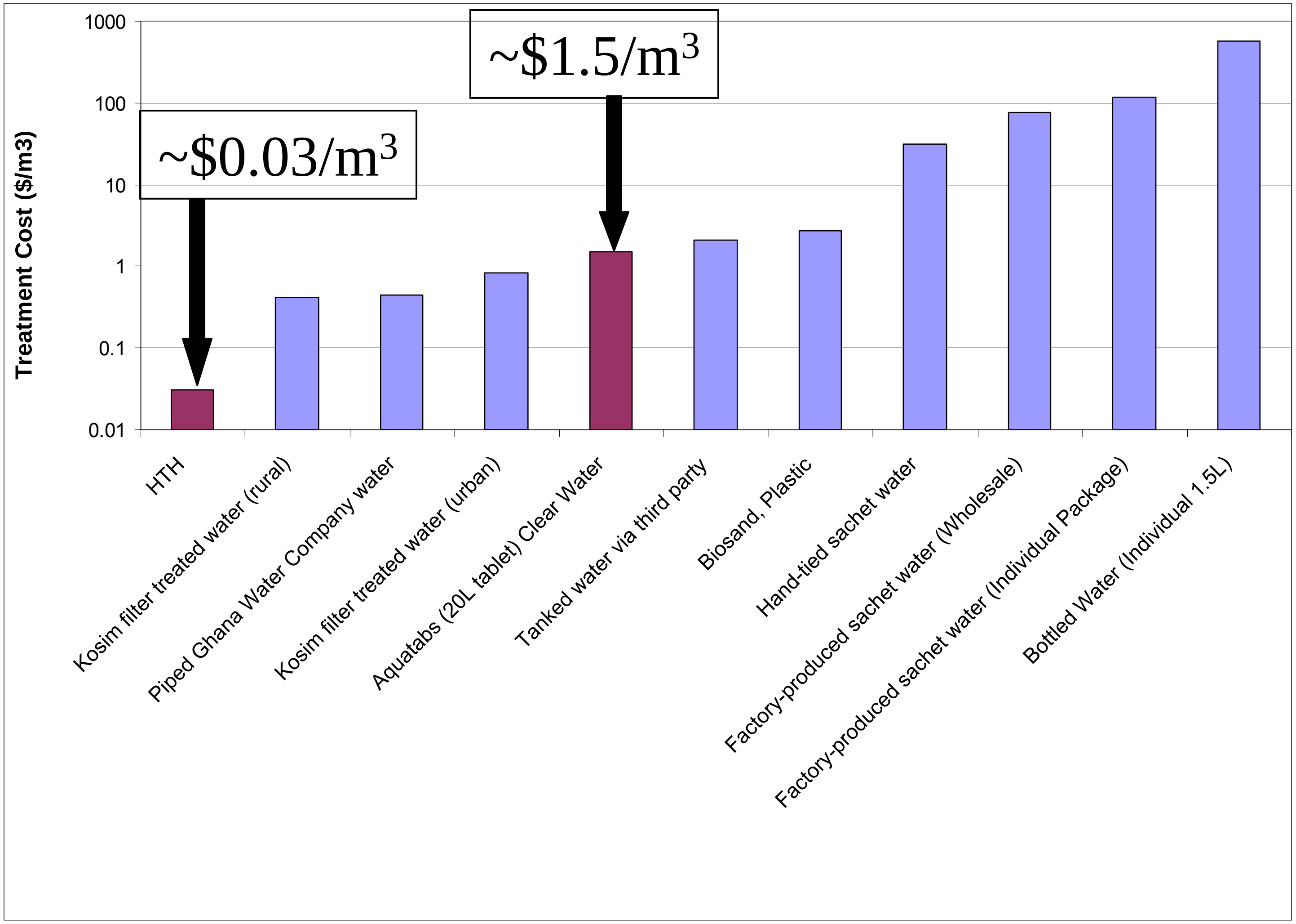
Cambridge Lab Work Results

- Partially successful in lowering chlorine concentrations to drinking water levels



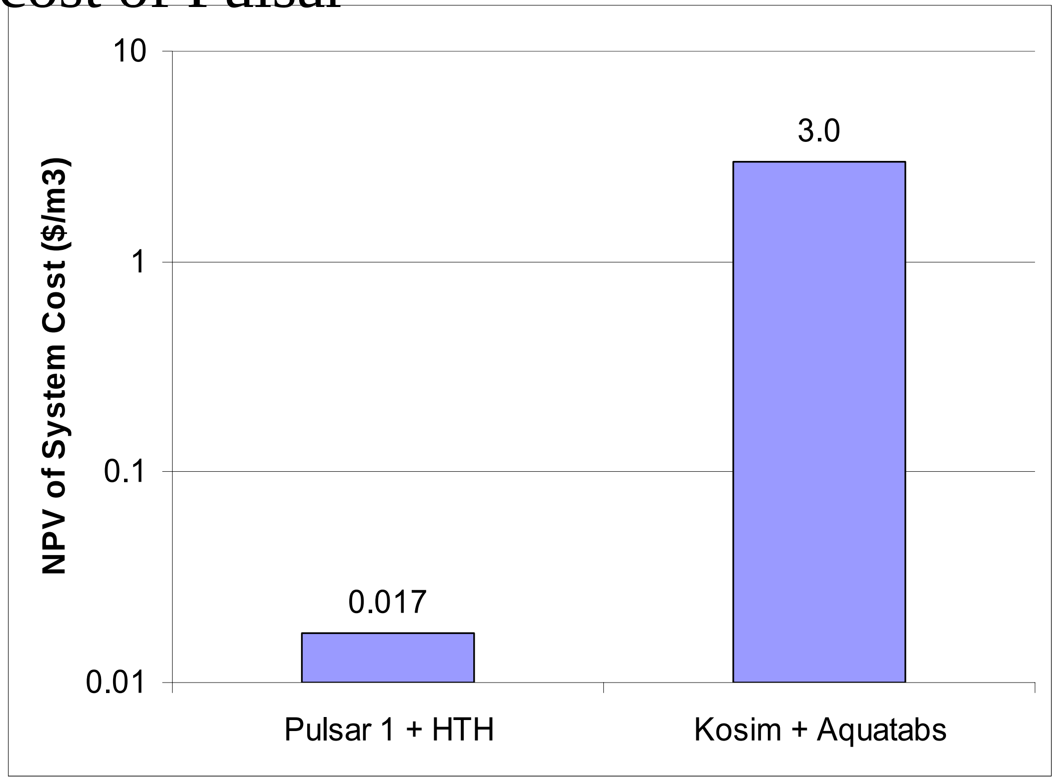
Results: HTH vs. Aquatabs on Supplies Cost

HTH is *48X* Times Cheaper!



Results: HTH vs. Aquatabs on Treatment Cost (cont)

Includes: Price of chlorine, Pulsar 1 & Kosim filter, and operational cost of Pulsar



Pulsar 1 + HTH is ***much*** more economic on a volumetric ($/m3) basis!

Overall HTH vs. Aquatabs Comparison

	Kosim Filter with Aquatabs	Pulsar 1 Unit with HTH
Maximum Flow Rate	Low (1-7 L/day)	High (>100,000 L/day)
Can Serve Many People	✸	✸ ✸ ✸
Cost of Treatment ($/m^3)	✸ ✸	✸ ✸ ✸
System Lifetime	~2 years*	~10 years*
Low Initial Cost ($)	✸ ✸	✸
Low Running Cost ($/yr)	✸ ✸ ✸	✸ ✸
Simple O&M	✸ ✸ ✸	✸ ✸
Materials Availability	✸ ✸	✸ ✸

*Value Assumed by Author

✸ =Poor ✸ ✸ = Moderate ✸ ✸ ✸ =Good

There is no "single best option", so site-specific circumstances will dictate the appropriate technology

Presentation Outline

- **Ghana: Background and Logistics**
- **Horizontal Roughing Filtration: Tamar Losleben**
- **Household Filtration (Biosand Filter) : Izumi Kikkawa**
- **Chlorine Products: Cash Fitzpatrick**
- **HWTS Consumer Choice Study: Vanessa Green**
- **Ceramic Pot (Kosim) filter + Chlorine Disinfection with Aquatabs: Andrew Swanton**

Consumer Choice Research Objectives

- Assess the relative value and cost of HWTS options in Northern Region, Ghana
- Make recommendations about which products are likely to have the greatest impact on local drinking water quality based on product effectiveness, adoption and sustained use

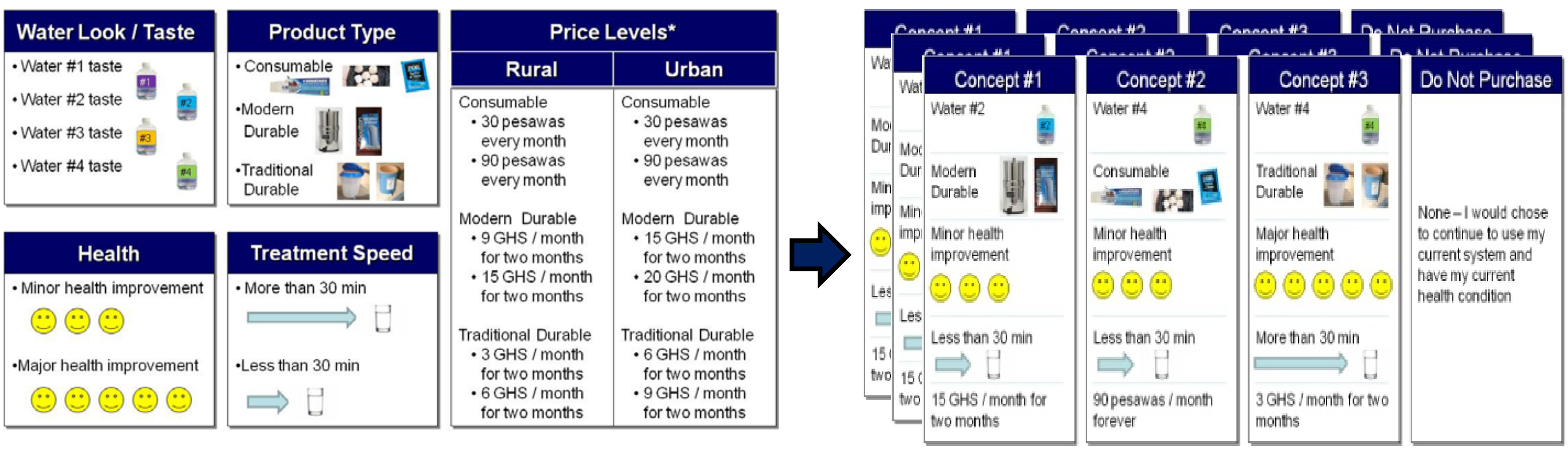
Team included: Vanessa Green, Gaetan Bonhomme, Avani Kadakia, Gabriel Shapiro, Matt Thomson, Musah Abdul-Wahab, Jaafar Pelpo, Ibrahim Mohammed Ali, Alhassan Tahiru Senini & Susan Murcott

Field Research: Study Design

Final survey instrument included three elements:

1. Baseline survey: water management and ability to pay
2. Water quality testing (microbial and turbidity)
3. Conjoint (choice task) to assess product feature preference

Tested New Pictorial Conjoint Methodology:



Results: Household Demographics

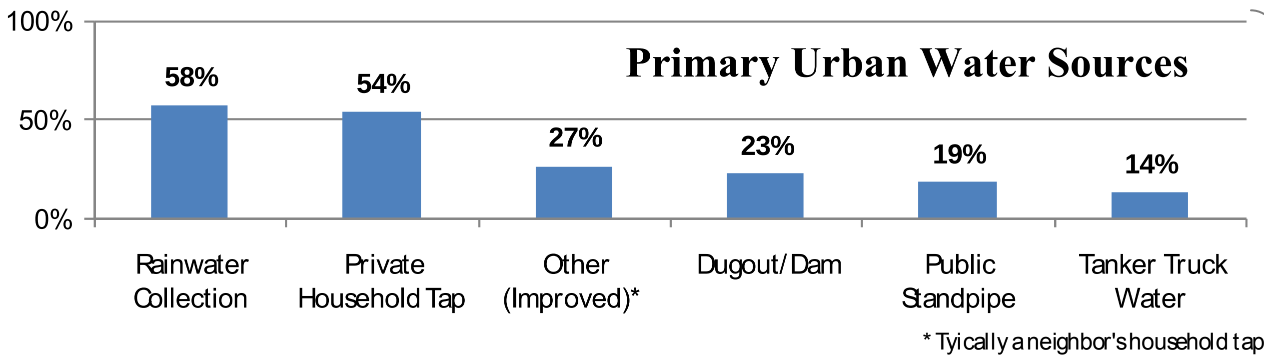
Type	Gender (% Female)	Religion (% Muslim)	House Type (Roof)		Education		Average Household Size
			% Tin	% Thatch	Primary	Secondary	
Urban (n=118)	77%	94%	100%	5%	51%	31%	12
Rural (n=119)	70%	86%	15%	97%	19%	3%	13

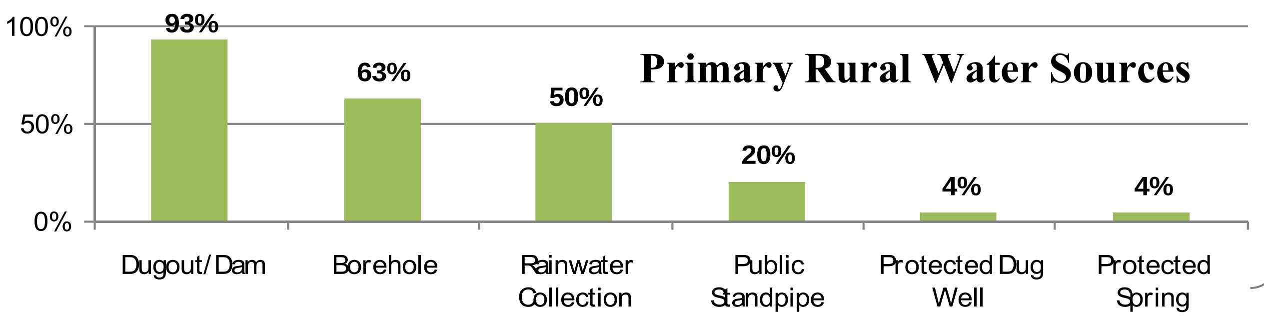
Low rural education

Significant **difference in house type** between rural and rural communities

Similar household size, urban result different from previous work in middle income areas

Results: Water Source Access & Challenges





- Majority of urban and rural respondents **collect rainwater**
- Urban respondents get water from a **private tap or a neighbor** (infrequent flow, taps open 2-4x / month)
- Rural respondents **use a dugout,** some access boreholes / standpipes

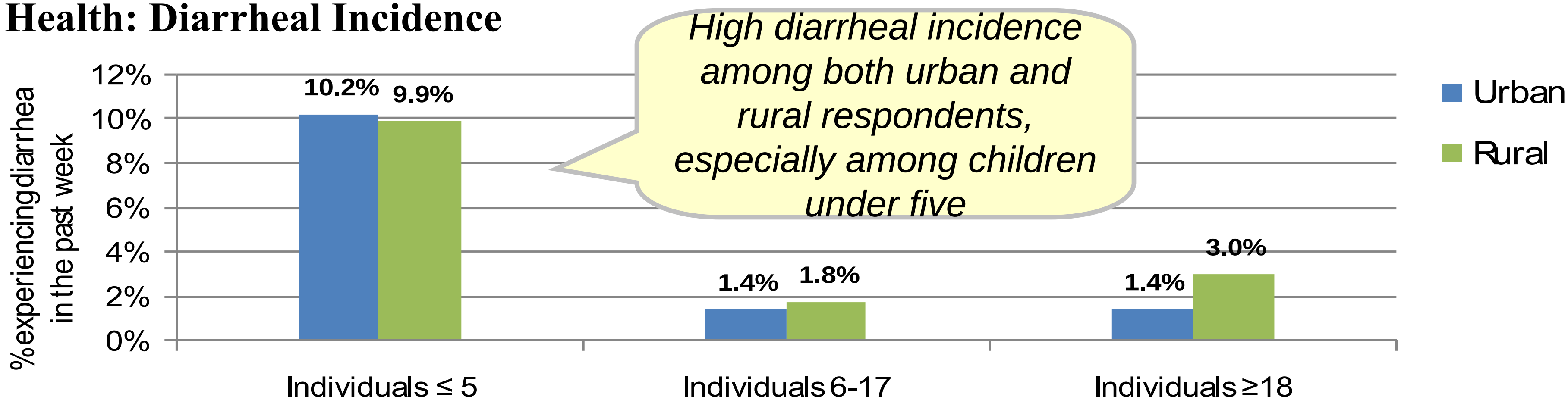
Key Challenges:

Urban: Water Quantity & Recontamination

Rural: Source Distance & Water Quality

Results: Needs Assessment

Health: Diarrheal Incidence



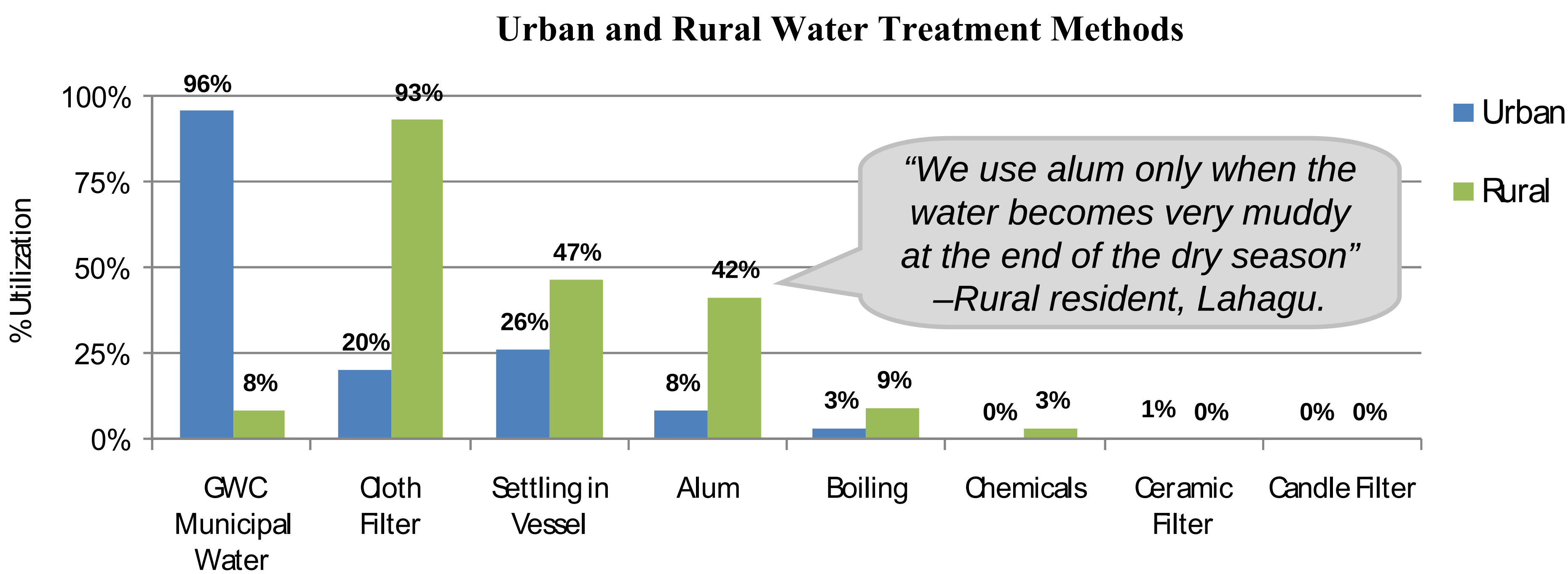
Household Drinking Water Quality

Type	Turbidity		Total Coliform (TC)			*E. Coli*	
	Ave. (TU)	Max. (TU)	% with CFU	% >1000 (CFU / 100ml)	Ave. (CFU/ 100ml)	% With *E.Coli*	Ave. (CFU/ 100 ml)
Urban (n=118)	<5	<5	59%	26%	2,500	8%	47
Rural (n=119)	238	1000	89%	82%	18,800	26%	172

Recontamination remains a challenge

Highly turbid source water, and significant contamination

Results: Current Water Management Practice



Significant **adoption of cloth filter** in rural areas where distributed

Limited use of other treatment products, with the notable exception of **alum in rural** areas

Results: Ability to Pay

Urban Households:

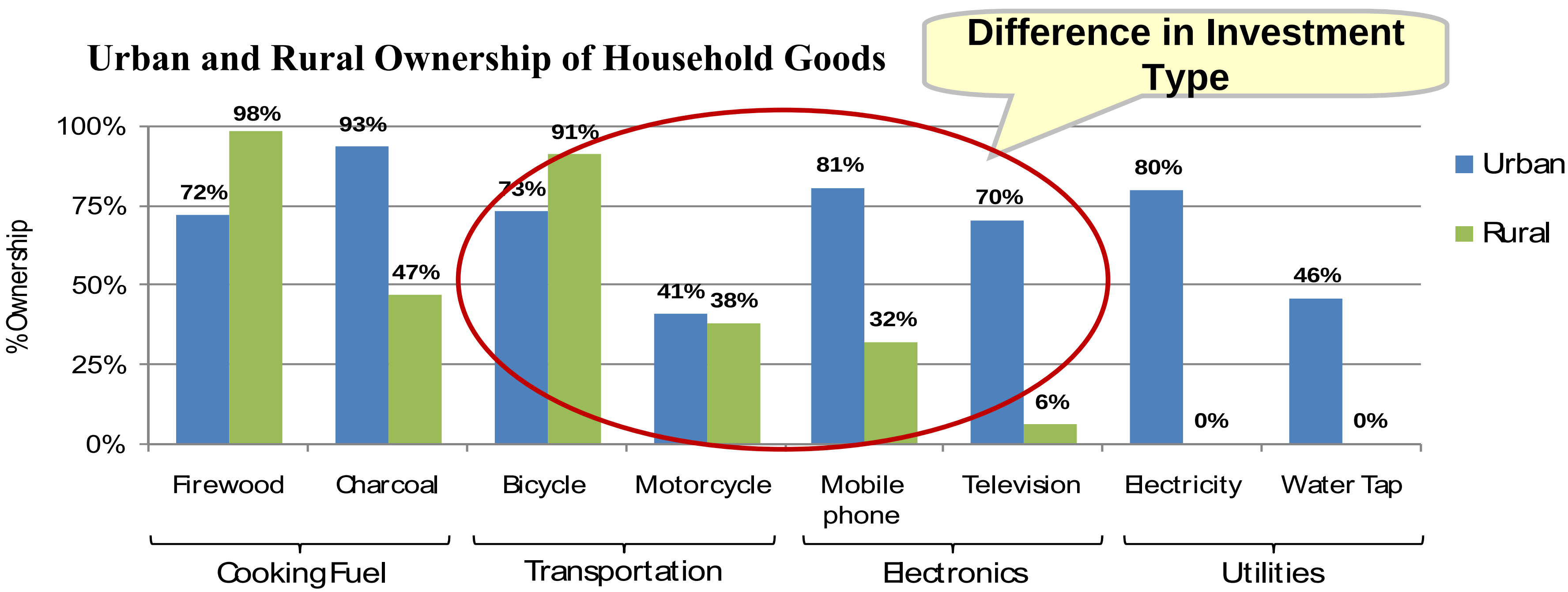
- Average income of GHS 1,530 / yr
- Ability to pay for water GHS **0.21 / day***

Rural Households:

- Average income of $619 / yr
- Ability to pay for water GHS **0.08 / day***

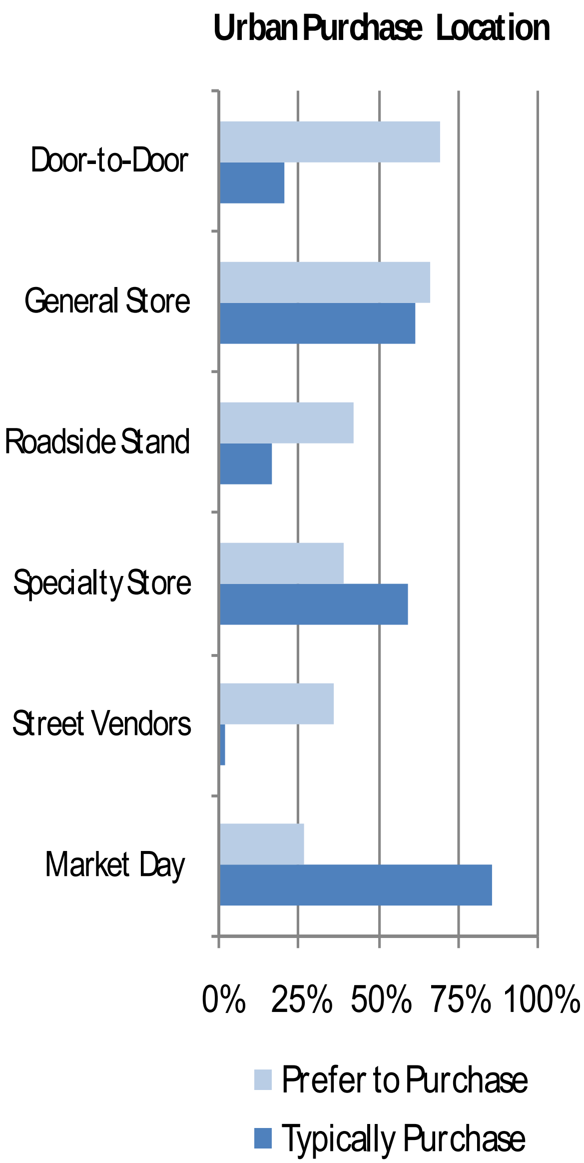
"If you are going to bring an expensive filter to this village you need to bring it at the time of year that we have just finished farming" – Rural respondent, Golinga.

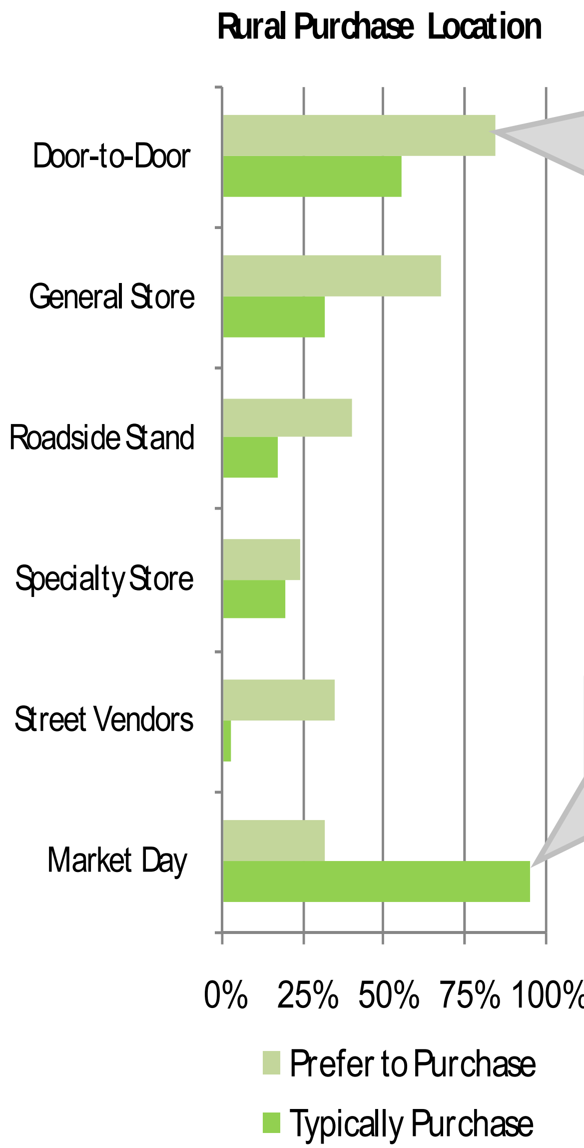
Urban and Rural Ownership of Household Goods



Note: Ability to pay calculation assumes that 5% of daily income allocated to water

Results: Purchasing Location

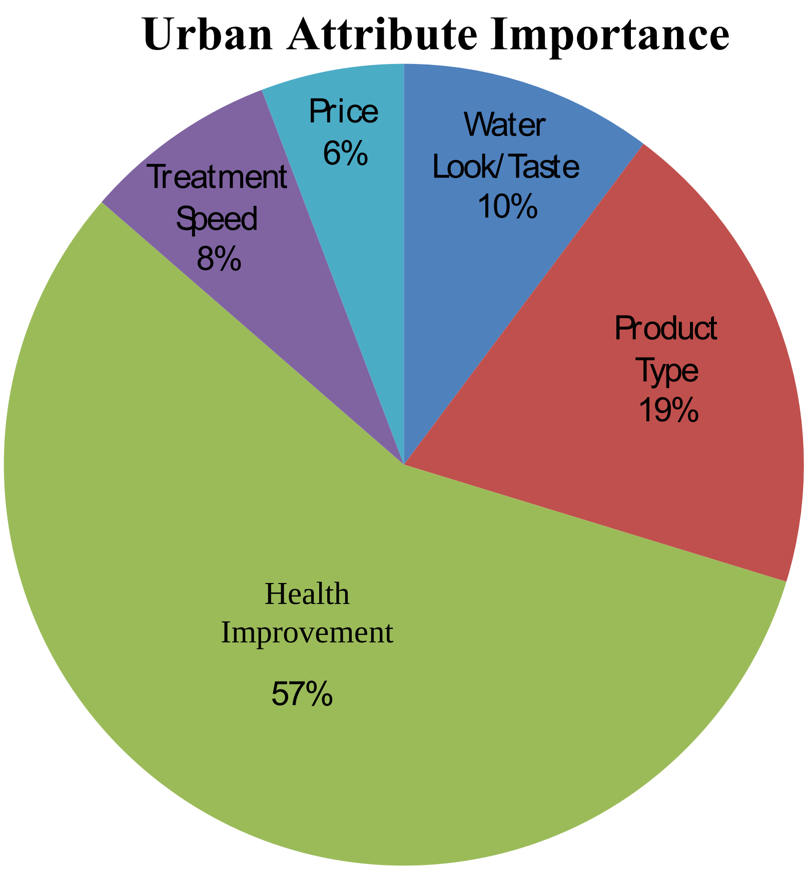


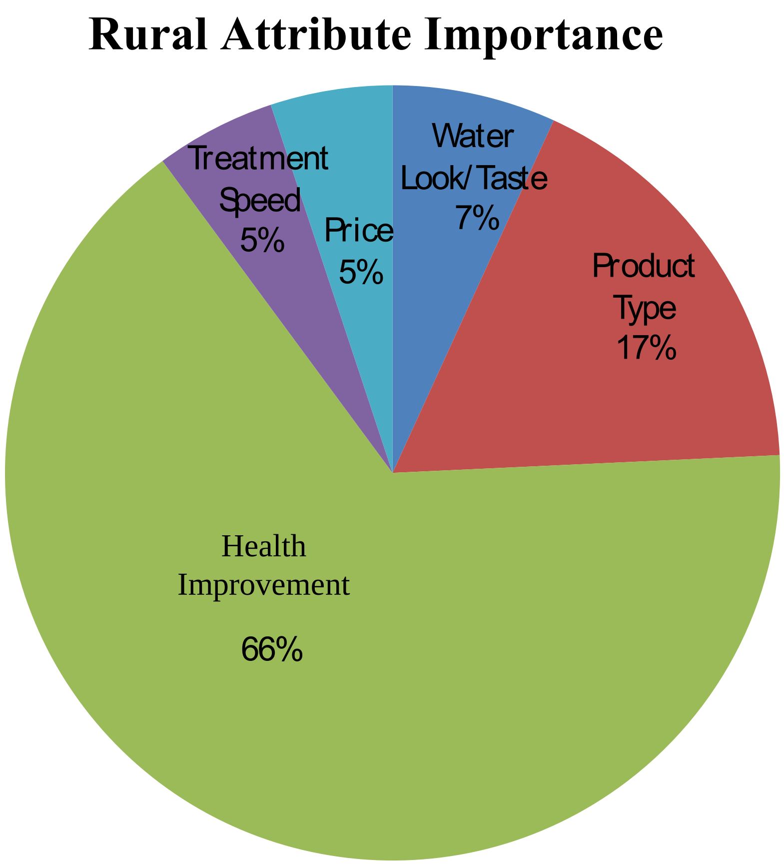


"For items that I buy often I would like door-to-door or a store in the community." – Rural respondent, Golinga.

"I always buy at the market because I assume that is where I can get the best price" – Rural respondent, Golinga..

Results: Conjoint Attribute Importance



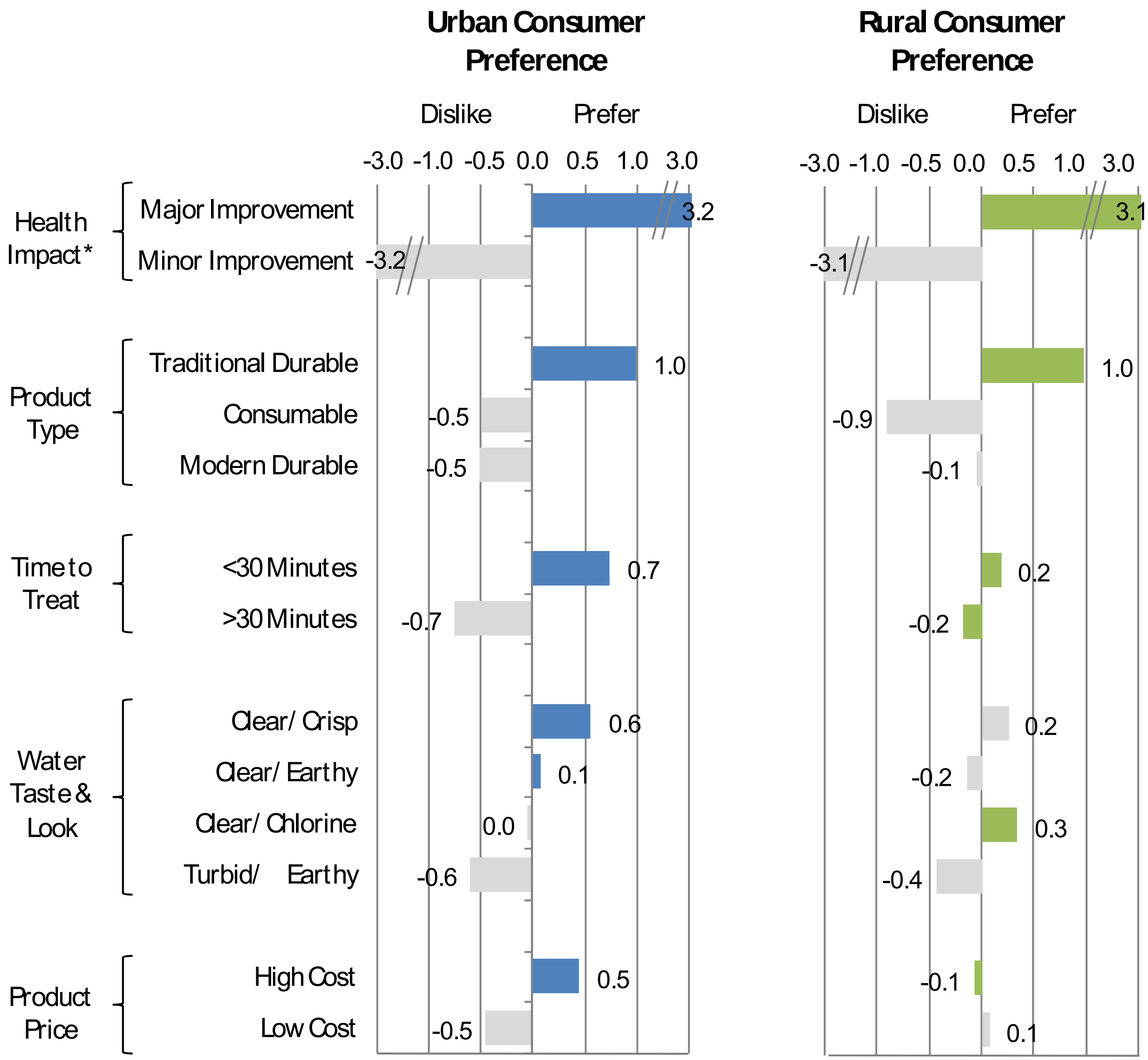


- Attribute importance quantifies the effect that each of the HWTS product attributes selected had on a respondent's overall product preferences; Urban and rural communities had similar attribute importance rankings

Source: G-lab Final Report, February 2008

MIT Clean Water 4 All, Inc.

Results: Consumer Preference



- **Health impact** was most important to both urban and rural respondents
- **Durable products** favored (respondents want something that will last)
- **Short treatment time** more important in urban
- Slight preference for **clear/crisp** (urban) and **clear/ chlorine** (rural)
- **Higher prices** preferred in urban areas, limited price sensitivity in rural

MIT Clean Water 4 All, Inc.

HWTS Product Options Assessment

Type	Household Water Product		Turbidity Efficacy	Microbial Efficacy	Local Availability	Annual cost (GHC) / family*
Particle Removal	Cloth Filter		Low	Low	High	0.0
	Alum		High	Low-Moderate	High	2.2
	BioSand Filter	Local LDP	High	Moderate	Low	10
		Int. Aid	High	Moderate	Low-Moderate	22
Particle Removal & Safe Storage	Pot Filter (*Kosim*)		High	Moderate	High	10
	Candle Filter	OK	High	Moderate	Moderate	14
		Mission	High	Moderate	Low	50
		Berkefeld	High	Moderate	Moderate	136
Disinfection	SODIS (UV)		Low	Low-Moderate	Moderate	8
	HTH Chlorine		Low	High	Low	0.3
	Liquid Chlorine		Low	High	Low	2 – 5
	Aquatabs (20l)		Low	High	Low-Moderate	13
Coagulation & Disinfection	PuR™ (P&G)		High	High	N /A	45 - 80
Safe Storage	Locally Manufactured		N / A	N / A	Low	1.2
	CDC (SWS)		N / A	N / A	Low	2.4
Sachet Water	Hand-tied (single)		N / A	N / A	High	275
	Factory (wholesale)		N / A	N / A	High	657

Note: Annual cost per family was estimated by calculating using an anticipated average household size of 12 individuals and 2 liters of drinking water per individual per day.

HWTS Product Assessment Description

- Particle removal: **Alum and the *Kosim* ceramic pot filter** have the most potential in the short term as they are low-cost, they effectively reduce turbidity (and microbial contamination), and are available in northern Ghana.
  - The **OK candle filter and biosand filters** (locally manufactured and International Aid) have longer term potential
- Disinfection: UV has not been shown to be highly effective given high atmospheric dust seen in northern Ghana, and thus **chlorine disinfection** emerges as the priority option.
  - Chlorine disinfection is less effective in water with turbidities >30 NTU, thus in rural areas with turbid source water chlorination should be used in conjunction with particle removal
  - **PuR™** offers a simple solution as it combines both particle removal and disinfection in a single sachet; however, the relatively high-cost and lack of availability in the region reduces the attractiveness of this option
- Safe storage: **Low-cost safe storage** options have the potential to enhance protection from recontamination, particularly if used in conjunction with chlorine disinfection.
- High end products: The more expensive **Mission and Berkefeld candle filters as well as sachet water** product should be targeted to upper and middle class

Market Segmentation

- **Objective:** Describe the household water treatment landscape in terms of observable differences between sample populations
  - To facilitate the development of targeted HWTS interventions
  - To promote product adoption and sustained use
- **Market Landscape:**
  - The vertical axis is source water, defined by community location and water quality
  - The horizontal axis is profession which serves as proxy for both income and daily activity

SOURCE WATER	RESPONDENT PROFESSION	Housewife	Agricultural	Production Worker	Sales & Other	Trader	Profess-ional
Urban							
Rural	Clear Water						
	Turbid Water						

- **Segmentation:** Based on observed HWTS preference the eighteen respondent types were combined into five segments, and priority HWTS products were matched to each segment

HWTS Market Landscape, N. Ghana

SOURCE WATER / RESPONDENT PROFESSION		Housewife	Agriculture	Produc-tion	Sales & Other	Trader	Profess-ional
Urban		2b Agricultural / Clear Water (<10 TU) Chlorine & <u>safe storage</u> N = 58		2a Urban Workers <u>Chlorine</u> & safe storage N = 42		1 Urban High-Income Opportunity for high cost products (e.g., <u>modern durable</u> and sachet) N = 46	
Rural	Clear Water				3a Rural Traders / Salespeople Alum, <u>chlorine</u> & safe storage N = 25		
	Turbid Water	3b Agricultural / Turbid Water (>10 TU) Alum, chlorine & <u>safe storage</u> Ceramic pot (or biosand) with chlorine & <u>safe storage</u> N = 66					

Priority HWTS products were matched with each segment based on observed differences in: 1) source water quality, 2) ability to pay and 3) consumer preferences

HWTS Recommendations by Target Segment

Priority Options: Product Effectiveness, Adoption and Sustained Use	Target Population
• Develop a **safe storage product** – strong preference for traditional durable, significant recontamination challenge	1, 2a, 2b, 3a, 3b
• Consider **local manufacturing of a low-cost HWTS chlorine** product (e.g., HTH or Liquid Chlorine)	1, 2a, 2b, 3a, 3b
• Develop a **chlorine treatment protocol** for communities with non-turbid water – specifically dosing within 24h of consumption to combat recontamination due to long storage	1, 2a, 2b
• Opportunity for a **targeted sachet water business** that focuses on the urban upper and middle class	1
• Opportunity for **low-cost combined treatment products** in communities with turbid source water (e.g., Alum / Biosand / Kosim + Chlorine Disinfection (Aquatabs)	3a, 3b
• **Focus Kosim sales / distribution** on rural areas with turbid water, and continue to develop the biosand for this market	3a, 3b

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Overview

3-Week Pilot Study: Combined *Kosim* Filter and Aquatabs System

•59 Households: 24 lower-class, 35 lower middle-class

•Baseline: Survey, WQ Testing, Distribution of Jerry Cans, Aquatabs

•Follow-up (1 Week Later): Survey, WQ Testing

Baseline Survey Results

16 Questions to Gauge User Acceptability, Appropriate Cleaning, Perception

Key Questions and Results:

•From where do you collect your water?	95% dugout
•How many times per week do you add water to the *Kosim* filter?	2.9
•Can you act out for me how to clean the filter?	100% yes
•Do you like the taste of the filtered water?	100% yes

Follow-Up Survey Results

8 Questions to Gauge User Acceptability, Perception with Addition of Aquatabs

Key Questions and Results:

•Do the Aquatabs improve the taste of the water? 100% yes

•Would you recommend the use of Aquatabs

to others? 100% yes

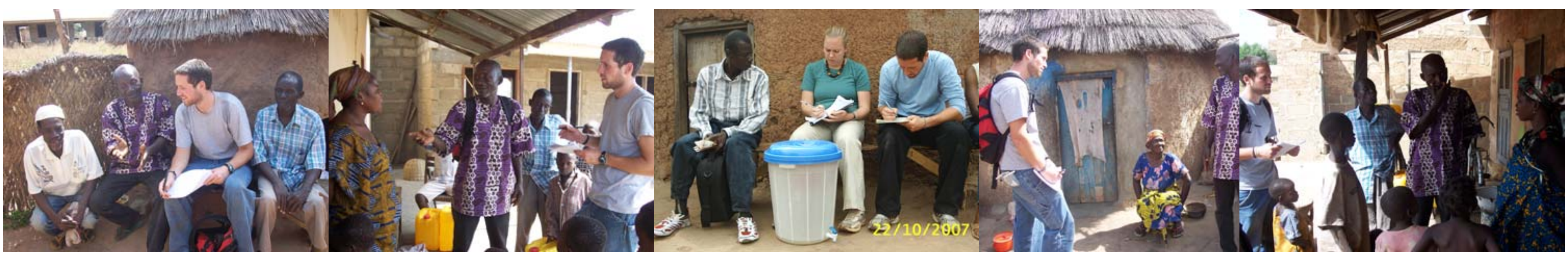
•Have you had any problems using Aquatabs? 100% no

•Specific Problems: "not comfortable", hernia/urine more yellow, stomach aches

Cost Results

Aquatabs cost 3 pesaws (=3 cents) per tablet, 3 GHC (=$3 US dollars) for 100

- Question: "Would you spend 3 GHC for 100 Aquatabs?"
- If no: "What do you think a fair price is for 100 Aquatabs?"
- Kalariga (lower-class): 25% willing to pay 3 GHC, 1.8 GHC average
- Kakpagyili (lower middle-class): 94% willing to pay 3 GHC, others 1,2 GHC



Water Quality Data

Dugout

	n	Turbidity (NU)	TC (CFU/100mL)	EC (CFU/100mL)
Kalariga	1	400	6,200	67
KakDam1	1	400	11,000	<100
KakDam2	1	1200	23,000	1,000

Pre-Treatment, Stored Water

	n	Turbidity (NU)	TC (CFU/100mL)	EC (CFU/100mL)
Kalariga	1	150	5,000	100
Kakpagyili	2	200	6,000	<100
Total	3	180	5700	67

Post-Filtered

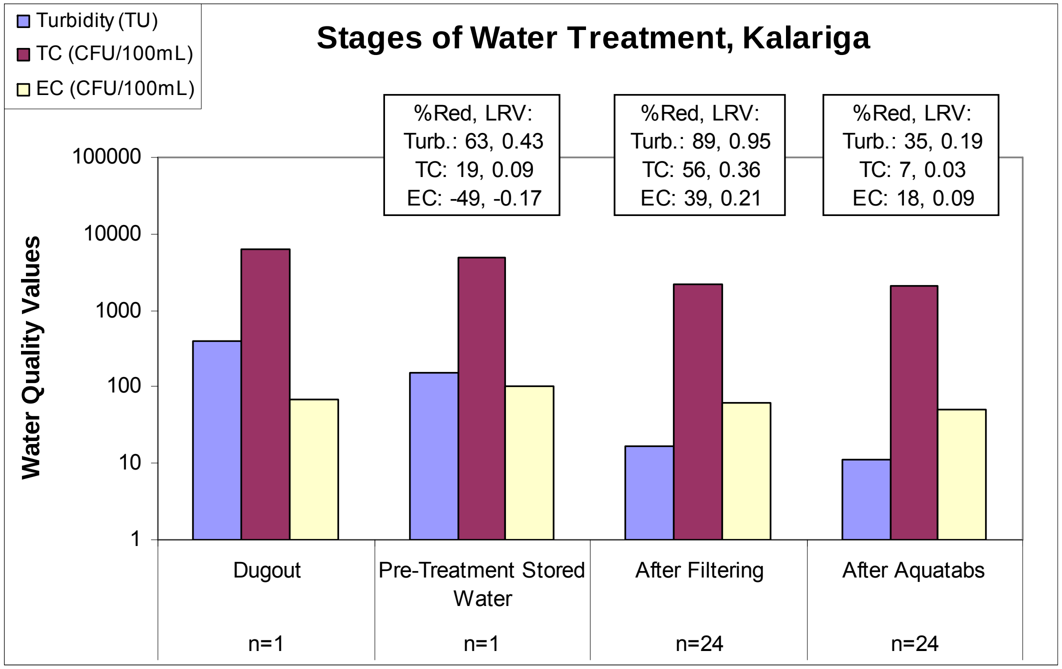
	n	Turbidity (NU)	TC (CFU/100mL)	EC (CFU/100mL)
Kalariga	24	16	2,200	61
Kakpagyili	35	17	2,900	60
Total	59	16	2,600	60

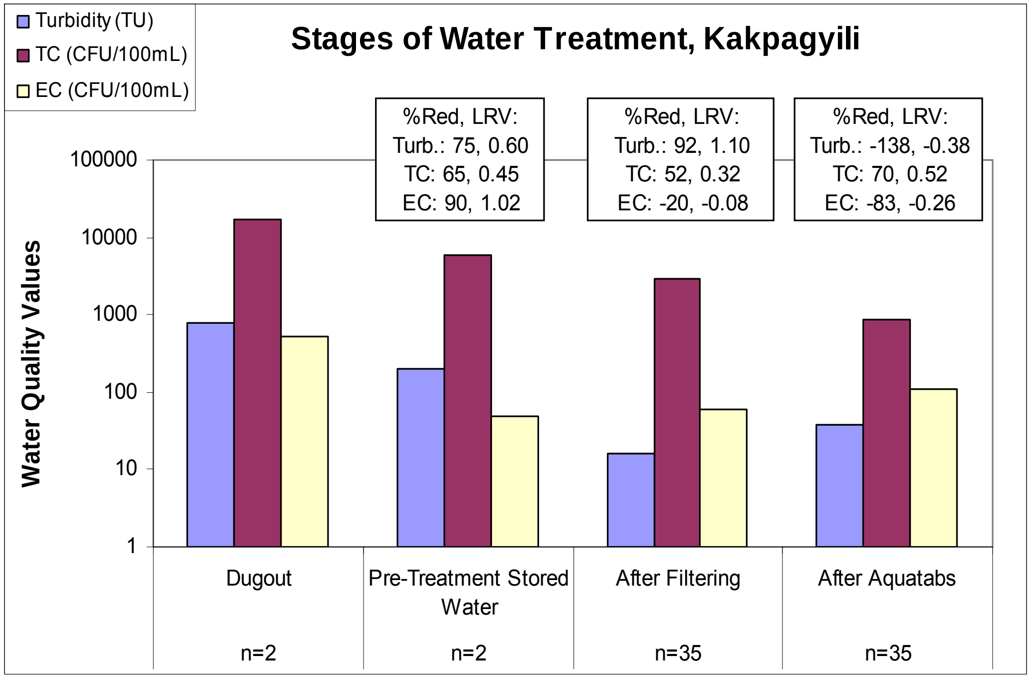
Post-Aquatabs

	n	Turbidity (NU)	TC (CFU/100mL)	EC (CFU/100mL)
Kalariga	24	11	2,000	<100
Kakpagyili	35	38	900	110
Total	59	27	1,300	86

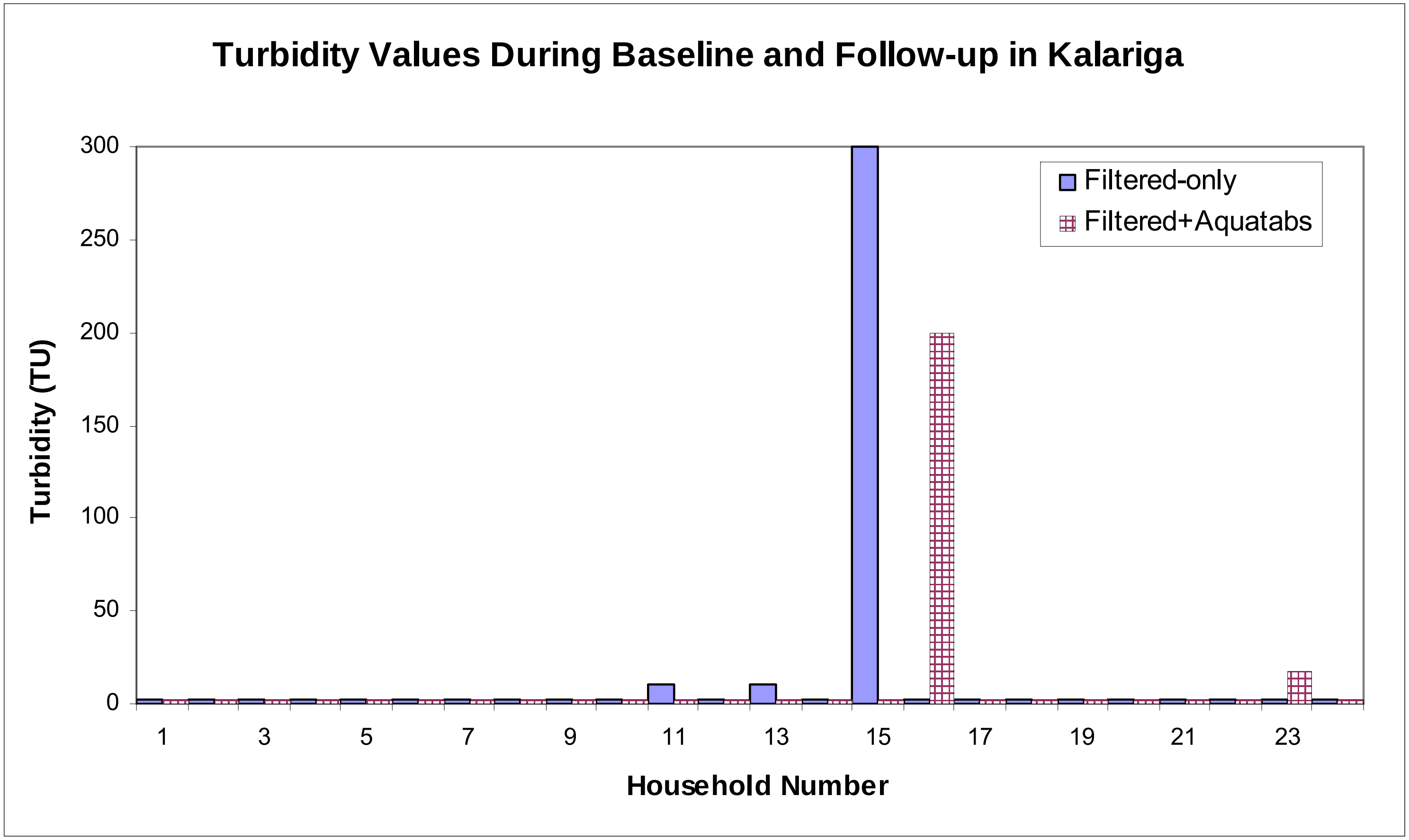
% Reductions

•(-)ve % reductions, indicate % increase





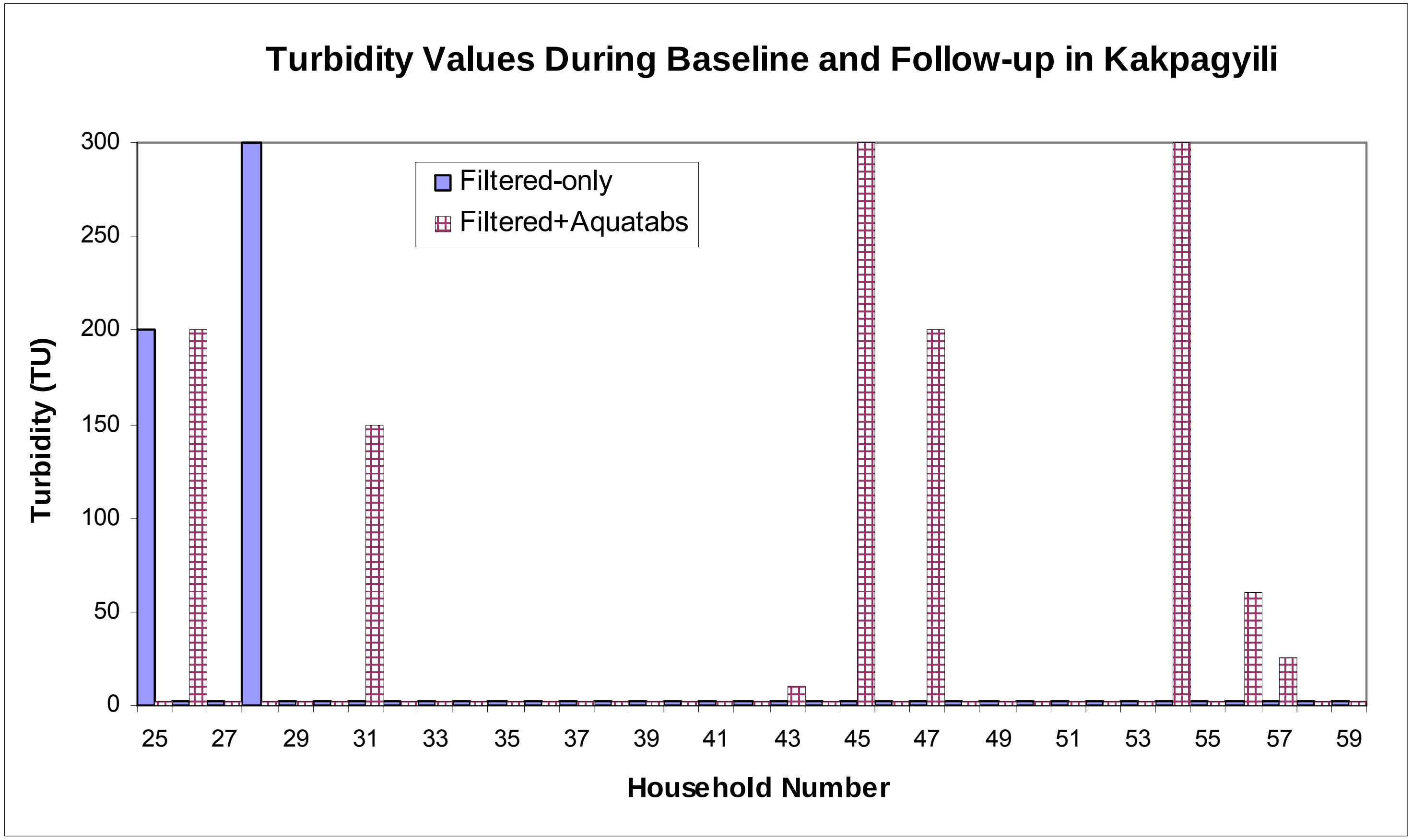
Turbidity Test Results-Kalariga



Limit of Detection: <5 TU, Displayed as 2.5 TU

Turbidity Detected, Baseline: 3/24, Post-intervention: 2/24

Turbidity Test Results-Kakpagyili

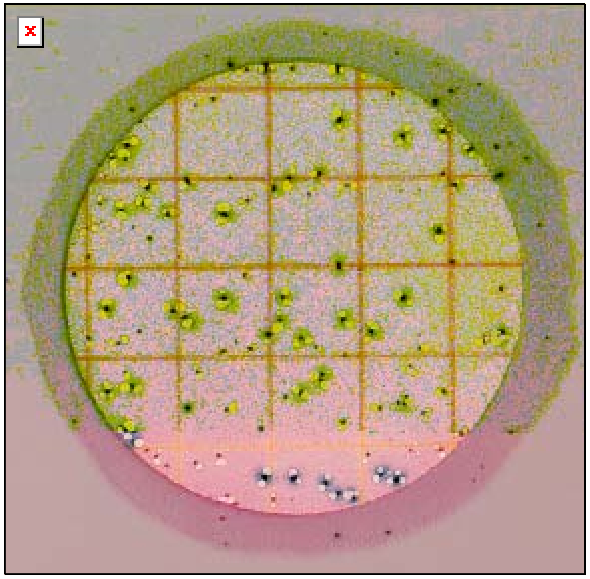


Limit of Detection: <5 TU, Displayed as 2.5 TU

Turbidity Detected, Baseline: 2/35, Post-intervention: 8/35

Total Coliform Test Results

3M Petrifilm Test



Community	Households with No TC Detected	
	Baseline	Post-Intervention
Kalariga	5/24=21%	12/24=50%
Kakpagyili	21/35=60%	26/35=74%
Both	26/59=44%	38/59=64%

Community	TC Count Decreased	TC Count Increased	TC Count Remained the Same
Kalariga	15/24=63%	3/24=13%	6/24=25%
Kakpagyili	12/35=34%	7/35=20%	16/35=46%
Both	27/59=46%	10/59=17%	22/59=37%

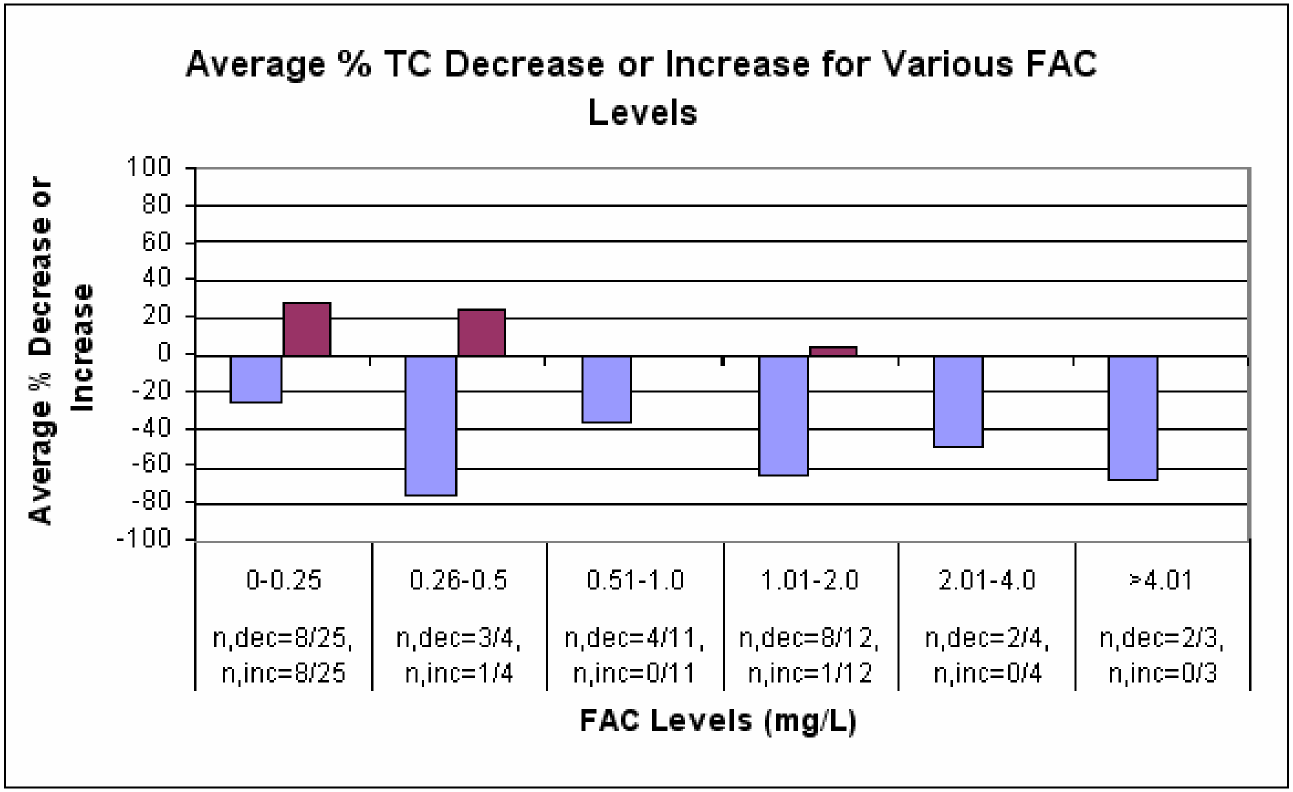
E.Coli Test Results

Community	Households with No EC Detected	
	Baseline	Post-Intervention
Kalariga	21/24=88%	24/24=100%
Kakpagyili	31/35=89%	34/35=97%
Both	52/59=88%	58/59=98%

Average EC concentrations higher in follow-up?

- 1 household during follow-up with *E.Coli*: 2,200 CFU/100mL
- 7 households during baseline with *E.Coli*: 50-200 CFU/100mL

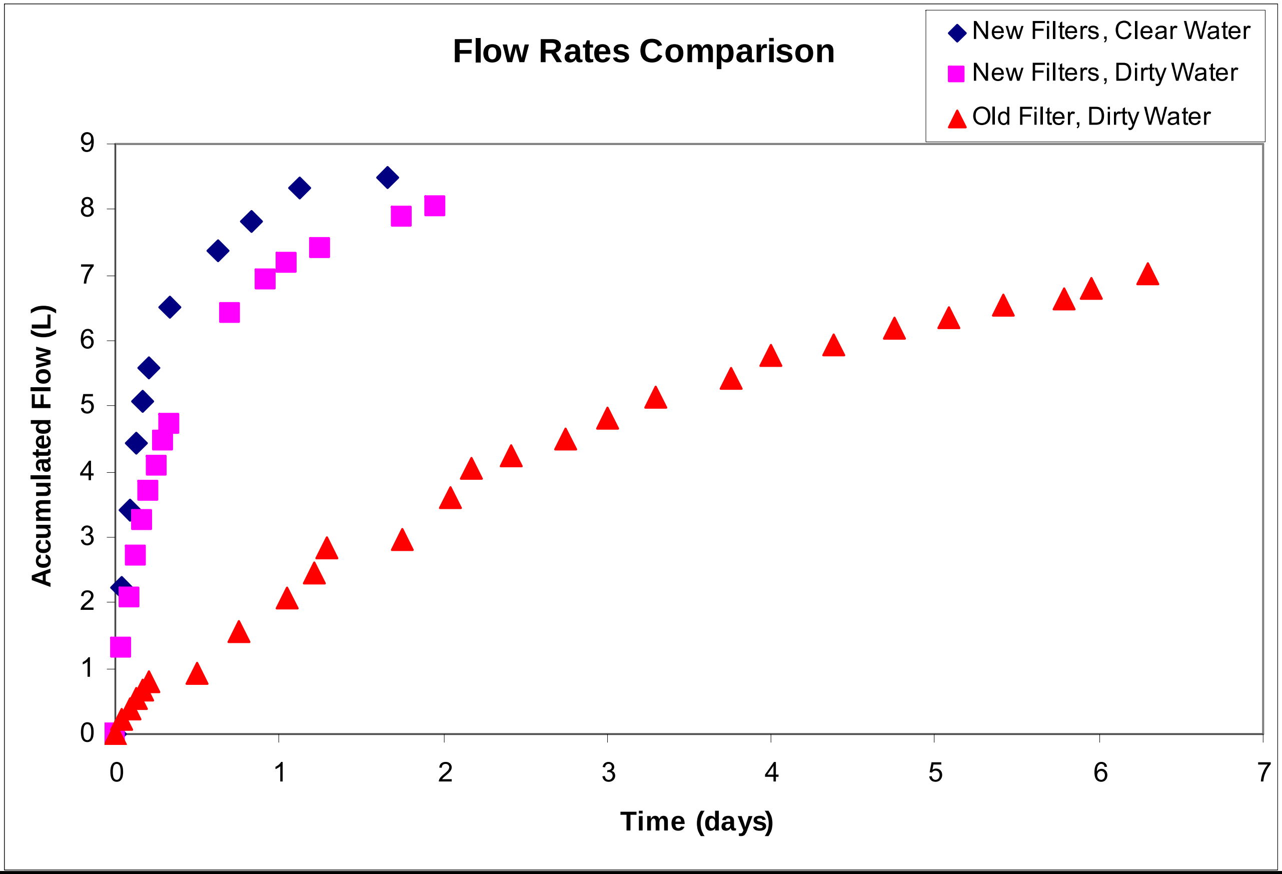
Free Available Chlorine Test Results



% of Households with FAC level > 0.1 mg/L at follow-up

Kalariga: 63%, Kakpagyili: 66%

Flow Rate Test Results



Description	Age	Turbidity (TU)	TC (CFU/100mL)
New, Filters, Clear Water	0	0	0
New Filters, Dirty Water	0	200-300	2,150-100,000
Old Filter, Dirty Water	1 year	400	6,200

Summary

- Average TC Conc. Reduced by 50%
- TC: 46% reduced, 37% same, 17% increased from baseline to post-intervention
- No TC: 44% to 64%, No EC: 88% to 98%
- 64% Households had FAC > 0.1 mg/L at follow-up
- FAC b/t 0-0.25 mg/L: 32% increased, 32% decreased (TC conc)
- FAC b/t 1.01-2.00 mg/L: 67% increased, 8% decreased (TC conc)
- All survey respondents: “improved taste of water” “would recommend to others”