Agua Peru, MIT Summer 2004

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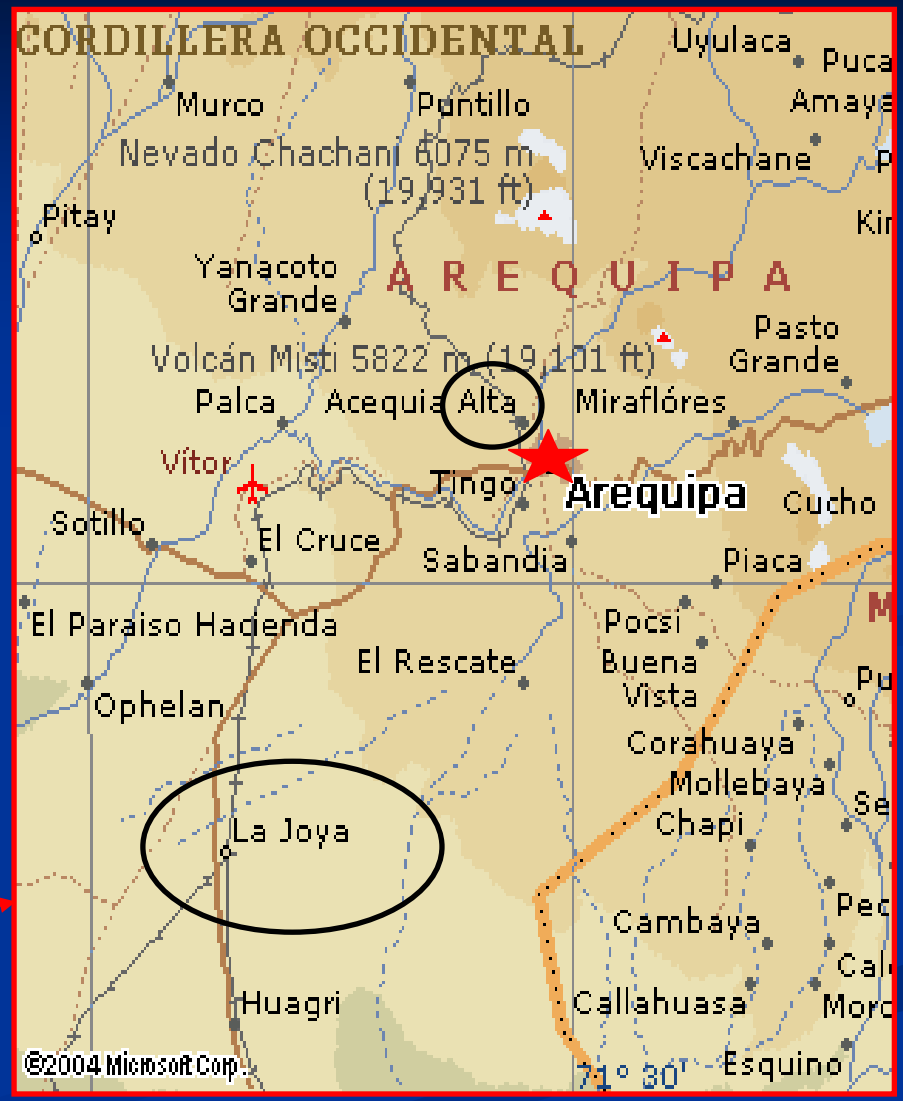
Investigations of Microbial Drinking Water Contamination & Household Filtration Interventions in Rural Peru



In Peru, diarrhea is the second leading cause of death in children under 5. (UNICEF, *The State of the World's Children*, 1998)

Study Location: **La Sociedad Misionera de San Pablo,** in Atlta Cayma and El Pueblo Joven Cerrito Buena Vista in La Joya. Both locales are in the Department of Arequipa, Peru.



Maps of study location: Left map taken from the 2004 CIA online World Factbook, Peru. Right map taken from Microsoft Encarta, 2004.



Part 1: Characterization of TTC Contamination for Cerrito Buena Vista (CBV)

CBV is a *Pueblo Joven*, young town, adjacent to La Joya in the Department of Arequipa Peru.

CBV has a population of approximately 2000 people. Workers earn between $3-$5 USD per day primarily as agricultural workers.

CBV has an ineffective water treatment facility that distributes water to all families through a gravity system. Water is gathered from the mother canal, an offshoot of the Rio Chili.

CBV has a water treatment plant that uses chlorine as a disinfectant and the system allows for settling, but our results indicate that the chlorine amount is insufficient or nonexistent and turbidity remains moderate.

People in CBV perform household disinfectant measures, primarily boiling. However, our results indicate that the residents continue to drink contaminated water.

Tap-Drinking Water Quality Characteristics (prior to additional household treatment) from samples taken in CBV, Arequipa. June 2004.

House Sampled	Field Tests		Laboratory Tests			
	pH	Free Chlorine [mg/L]	Turbidity NTU	Chlorine [mg/L]		TTC
				Free	Total	Colonies/100 ml
1	7.2	0	9.2	0	0	0.00E+00
2	8.2	0	2.91	--	--	2.00E+02
3	7.3	0	9.22	--	--	8.00E+02
4	7.1	0	6.36	--	--	3.05E+04
5	7.4	0	6.46	--	--	1.13E+04
6	7.4	0	7.56	0	0	8.75E+03
7	7.3	0	7.81	0	0	5.63E+04
8	7.2	0	3.09	--	--	1.20E+04
9	8.2	0	3.08	0	0	1.00E+02
10	7.4	0	5.59	--	--	1.21E+04
11	7.4	0	5.59	--	--	1.53E+04
12	7.4	0	11.8	0	0	1.31E+04
Average	**7.46**	**0**	**6.56**	**0**	**0**	1.34E+04
Variability	**0.36**	**0**	**2.75**	**0**	**0**	1.61E+04

Post-Household Treatment Water Quality Data from samples taken in CBV, Arequipa. June 2004.

House Sampled	Field Tests		Laboratory Tests			
	pH	Free Chlorine [mg/L]	Turbidity NTU	Chlorine [mg/L]		TTC
				Free	Total	Colonies/ 100 ml
1	8.2	0	5.3	--	--	0.00E+00
2	7.4	0	5.51	0	0	1.70E+03
3	8.2	0	9.39	0	0	0.00E+00
4	7.3	0	7.89	--	--	3.00E+04
Average	**7.77**	**0**	**7.03**	**0**	**0**	**7.93E+03**
Varia-bility	**0.49**	**0**	**1.97**	**0**	**0**	**1.47E+04**

Part 2: The Investigation of Household Filter Performance Removing Thermotolerant Coliform (TTC), also known as Fecal Coliform.

Filter materials primarily procured in Arequipa, Peru and evaluated in the Lab in Alta Cayma:

*Household Slow Sand Filter (HSSF)

*Katadyn Ceramic Candle Filter

*Pozzani Ceramic Candle Filter

*Table Filter, known locally as Filtro de Mesa

***For this Presentation, TTC results were evaluated using results within 0-200 Coliform Forming Units (CFUs) per 100 mL. Standard Methods uses 20-60. The report containing the material used in this presentation compares results for both ranges; this presentation does not. For comparison of turbidity removal or flow rate please see the report INVESTIGATING THE EFFECTIVENESS OF A VARIETY OF HOUSEHOLD WATER SYSTEMS ON MICROBIALLY CONTAMINATED WATER IN AREQUIPA, PERU 2004.




For tests, the team assembled the filters primarily using locally procured materials.

TTC tests and filter construction were performed in a homemade laboratory at the Sociedad Misionera de San Pablo, Enace, Alto Cayma

Cost Comparison of Filter Construction:

Filter System	Components	Cost	Total
Pozzani	2 HDPE Pails	$12.00	**$15.00**
	2 Ceramic Candles	$3.00	
Katadyn	2 HDPE Pails	$12.00	**$30.00**
	2 Ceramic Candles	$18.00	
Filtro de Mesa	Sand**	$0.00-$1.00	**$17.00-$22.00**
	2 HDPE Pails	$12.00	
	Geotextile*	$1.00-$3.00	
	Rubber Ring*	$1.00-$3.00	
	2 Ceramic Candles	$3.00	
HSSF	Gravel**	$0.00-$1.00	**$10.00-$13.50**
	Course Sand**	$0.00-$0.50	
	Fine Sand**	$0.00-$1.00	
	PVC	$1.00	
	Diffuser Pail	$3.00	
	Fabric/Textile**	$0.00-$1.00	
	1 HDPE Pail	$6.00	

Notes: * cost is uncertain; ** item could be free

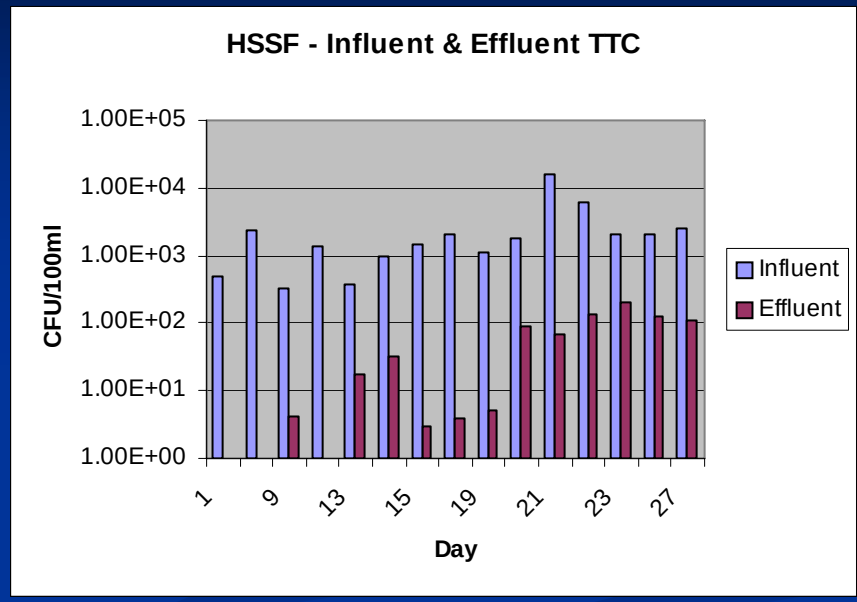
Categorization of Source Water Contamination for Filter Experiments:

Sample water gathered from 3 locations during June and July 2004.

	Location	Average Turbidity (NTU)	Average CFU /100ml	Average Free Chlorine mg/liter
1	Canal, Cerrito Buena Vista	15.19	1.3×10^3	0
2	Rio Chili, Arequipa	4.76	1.25×10^3	0
3	Canal, Alta Cayma (near clinic)	4.26	7.27×10^3	0

Household Slow Sand Filter

HSSF TTC Presence in Influent and Effluent of the Household Slow Sand Filter, June and July 2004. Based upon "Total Range" (0-200 CFU/100mL) data set.



For the majority of the study the LRV is between 1.2 - 3.

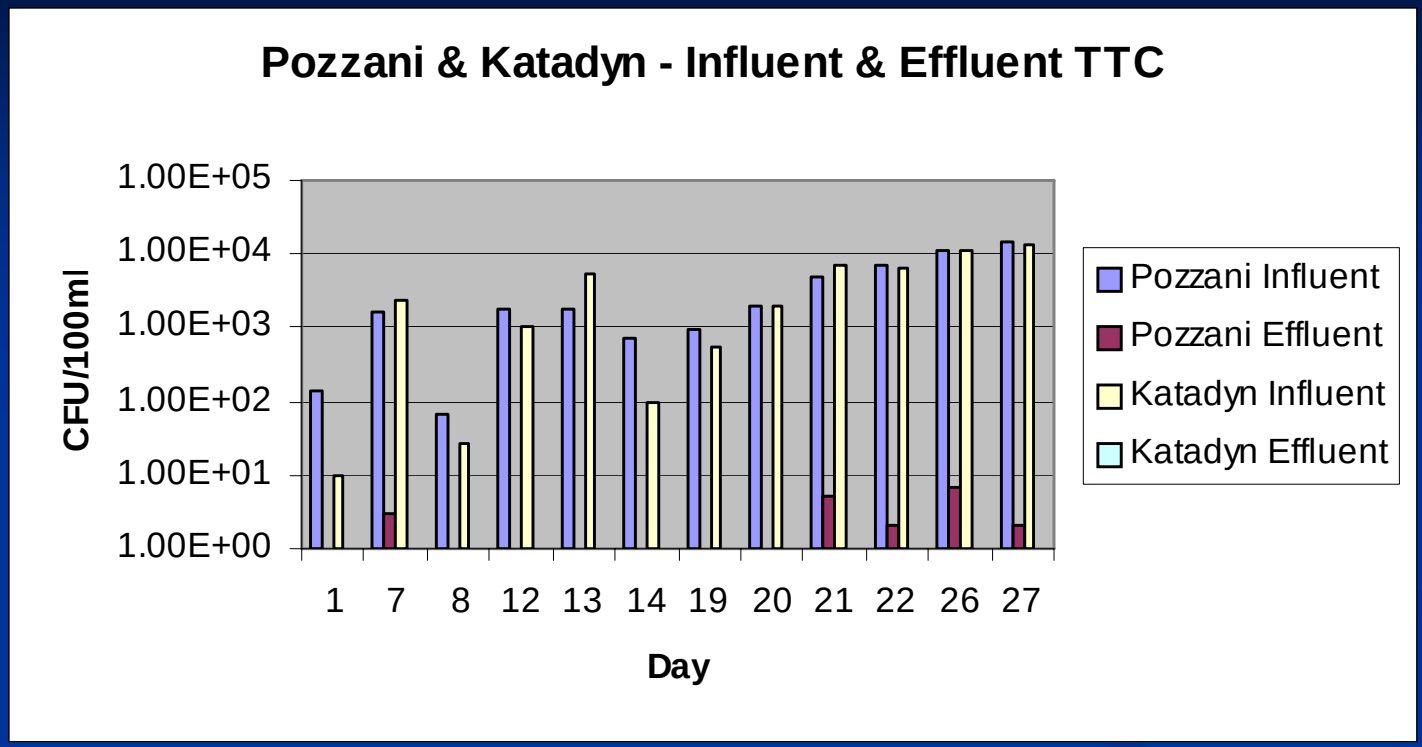
Filter performed best at the beginning of the study where multiple zero values are seen. The initial loading of clean influent delayed the appearance of TTC contaminated effluent until approximately the fourth day.

The effectiveness of the filter decreases with time. This is likely due to the clogging of the filter by particulates as more contaminated water was added.

There appears to be a rise in quality during the first week (between days 1 and 8) but since both the effluent CFU values for these days were zero it is impossible to tell the actual improvement in quality.

Pozzani and Katadyn Ceramic Candle Filters

Pozzani and Katadyn TTC Presence. Where there is no bar the CFU count was zero.

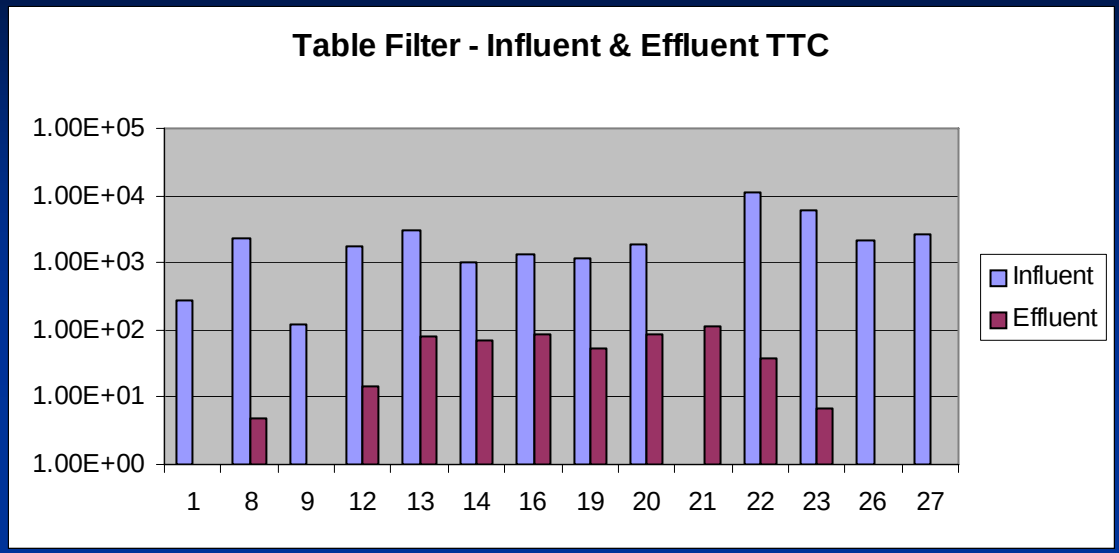


Katadyn: a positive CFU TTC effluent result was never seen.

The Pozzani, a cheaper model, still performs well, with all effluent results below 10 CFU/100ml. It should be noted that the MIT research team suspects the TTC presence in the Pozzani effluent during days 7, 21, 22, 26, and 27 was a result of contamination. The negative results from day 8 support the hypothesis that contamination resulted from filter operation or construction rather than a defect in the Pozzani ceramic candle. The team did not clean out the bottom bucket for the next set of positive TTC results from Pozzani during days 21, 22, 26 and 27.

Table Filter

Where there is no bar the CFU count was zero. Table Filter TTC Presence in Influent and Effluent.



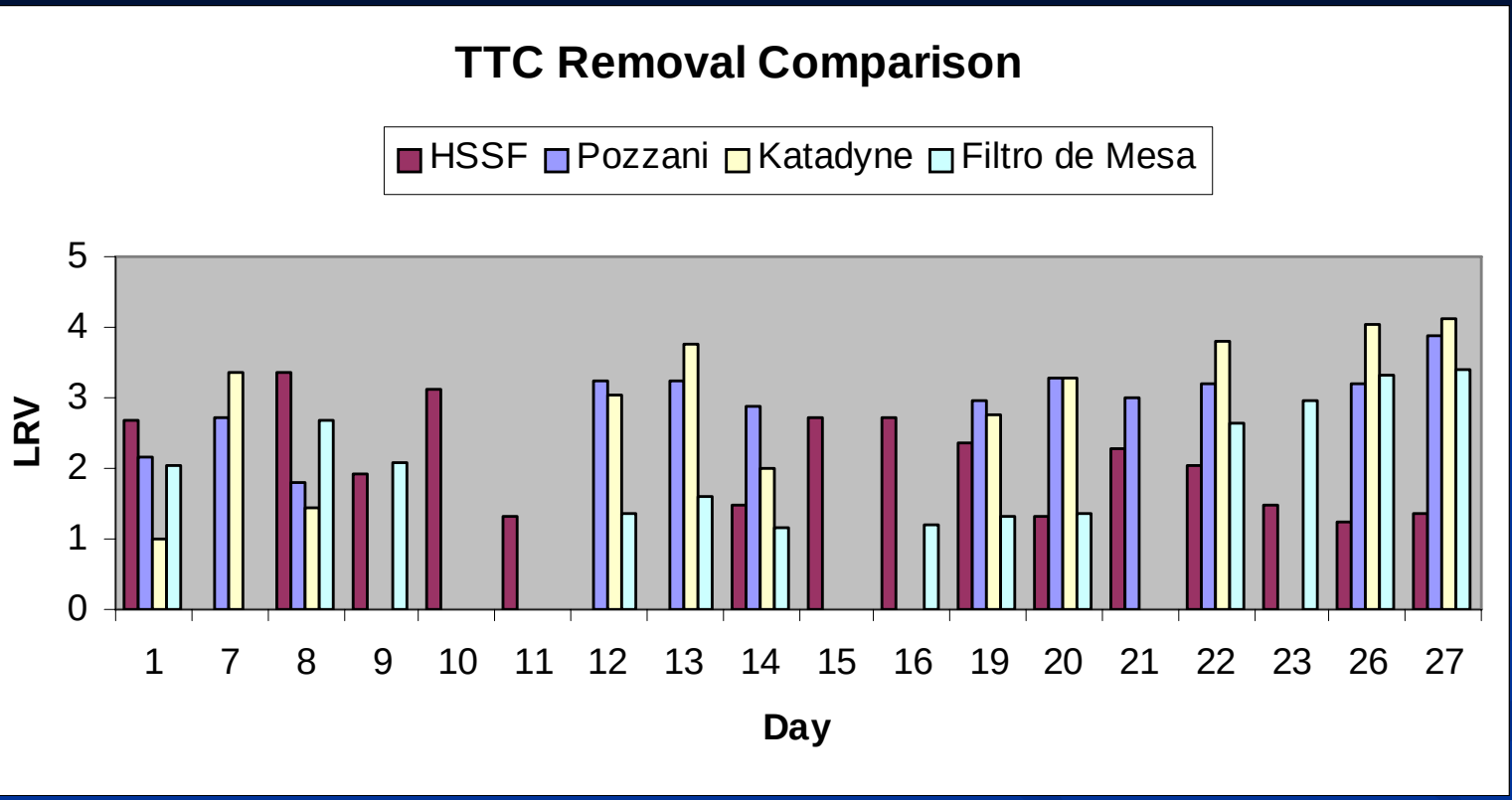
All influent results are between 0 and 1.57x104 CFU/100ml.

All effluent results are between 0 and 102 CFU/100ml.

Since the table filter was composed of Pozzani candles, it was expected to act more or less equally to that of the Pozzani filter system. The addition of sand and geotextile is expected to have some effects on flow, turbidity removal and microbial removal.

However, the Table Filter had poorer TTC removal efficiency than just the Pozzani. This could be due to improper filter construction and thus, contamination of the post-filtered effluent.

Comparison of All Four Filters



Katadyn performs the best in terms of TTC removal

Followed by, Pozzani, Table Filter, and HSSF

We hypothesize that experimental error and contamination associated with improper filter construction and operation by the MIT team affected results for Pozzani and the Table Filter. We expect performance to be better if repeating the experiment.