Turbidity and *E.coli* Removal with Novel Portable Paper Water Filters for Developing Countries

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ABSTRACT & BACKGROUND

CHALLENGE & IMPORTANCE: Clean drinking water remains a global issue, especially in low-resource communities that rely on cost-effective household water treatment methods like filtration[1].
RESEARCH FOCUS: The study evaluates the efficacy of a proprietary silver ion-coated paper filter at improving drinking water quality by assessing turbidity reduction, bacterial removal, and structural integrity.
KEY RESEARCH QUESTIONS: Is the filter more efficacious when glued or folded into a cone? What is the maximum volume of water that can be treated before replacement is necessary? Do the metal ions significantly reduce bacterial concentrations to appropriate levels when applied to the filter paper?
BASIS OF TESTING: Use *Escherichia coli* (ATCC 11229) and Phi6 bacteriophage as test organisms, analyzing water quality before and after filtration to measure bacterial and turbidity reduction.
IMPACT & CONTRIBUTION: Provides practical insights into filter performance and longevity, supporting the development of affordable, effective water purification solutions for communities in need.

METHODOLOGY

EXPERIMENTAL SETUP

Three filtering stations were assembled, each with a filtration cone, dedicated influent and effluent buckets to prevent cross-contamination, and a solenoid pump system to regulate flow. Scales and timers monitor flow rates. Turbid water was prepared using ISO 12103-1 powder.

FILTRATION & MONITORING

Filters were tested with 20L influent tanks. Effluent samples were analyzed for turbidity, bacteria, and metal residues, with CFU/100mL measurements determining bacterial removal. Filter longevity was measured by total volume filtered.

TEST MATRIX FOR WATER FILTER LAB PROCEDURE

FILTER TYPE		FILTER COAT		TURBIDITY		PHAGE SPIKE		BACTERIA SPIKE
Glued	X	**No Additive**	X	**0 NTU**	X	Phi6	X	***E.coli* (ATCC 11229)**
				5 NTU				
Folded		**Silver**		10 NTU		MS2		

** Bolded typeface indicates conditions tested in experiments presented herein*

E. coli (ATCC 11229) REMOVAL

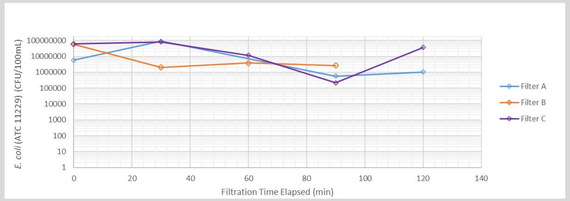

FIG 1: Geomean *E. coli* (CFU/100mL) concentration through uncoated filter paper.

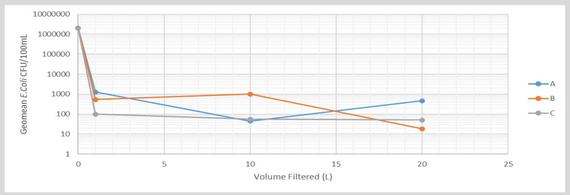

FIG 2: Geomean *E. coli* (CFU/100mL) concentration through coated filter paper.

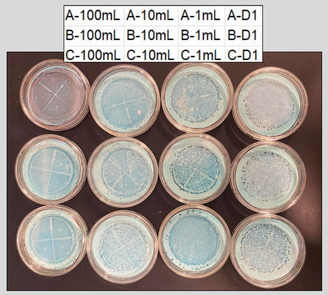

FIG 3: *E. coli* growth from effluent post silver-coating filtration.

EFFLUENT *E. coli* Concentration

- No effluent plates were "Too Numerous To Count" (TNTC) from silver-coated paper.
- The effluent silver-coated filter reduced *E. coli* by ≥ 4 $\log_{10}$ CFU/100 mL
- Achieved WHO standard[1]

FILTER FLOW RATES

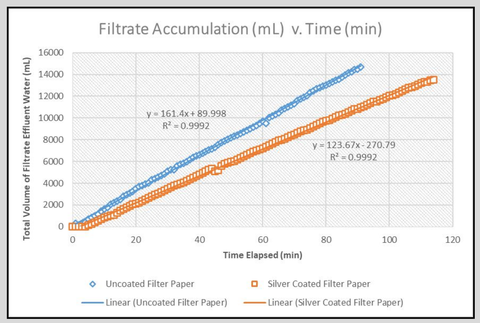

FIG 4: Flow Rate Determination Based on Gravimetric Approach (Converted to Volume)

FIG 5: Filtration apparati during testing of the silver-coated filters

- **Uncoated filter paper**: 161.4 mL/min
- **Silver coated filter paper:** 123.67 mL/min

RESIDUAL SILVER TESTING

Sampling Time	Sample Code	Silver Detected	Filtrate Silver Content (mg/L)
Initial Effluent	A-0	☑	0.04
	B-0	☑	0.04
	C-0	☑	0.04
Final Effluent	A-N	☑	0.03
	B-N	☑	0.03
	C-N	☑	0.03
Mixed Effluent	A-M	☑	0.03
	B-M	☑	0.04
	C-M	☑	0.04

FIG 6: Residual Silver Testing Results from HACH Tests[3]

- Colorimetric HACH[3] test kits detected residual silver in all effluent samples
- Samples collected from:
  - Initial effluent through filter
  - Final effluent (After 20L of filtrate passed)
  - Effluent after thorough mixing in reservoir

KEY TAKEAWAYS

DISCUSSION

- Silver ion-coated filtration paper exhibited promising results in the removal of *E. coli*
- Residual silver leachate from the filter paper may decrease over time, especially with repeated use
- Filtration flow rate reduced by coating application

NEXT STEPS

- Investigate repeated use of silver-coated filters
- Filter a bacteriophage such as Phi6 through the influent
- Combine turbidity, and bacterial removal into one experiment

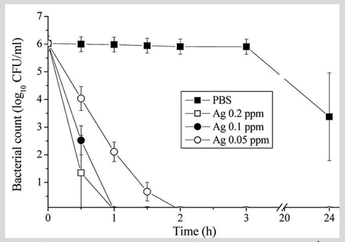

FIG 7: *E. coli* vs. silver from Jung *et al.*[4]

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[1] WHO. 2018. "International Scheme to Evaluate Household Water Treatment Technologies."
[2] String & Gallandat. 2017. "E. coli Spiking Procedure for Filters Testing." *Tufts School of Engineering*.
[3] HACH. 2018. "Method 8021: Silver Colorimetric Testing." HACH. Accessed March 23, 2025.
[4] Jung WK, Koo HC, Kim KW, Shin S, Kim SH, Park YH. Antibacterial activity and mechanism of action of the silver ion in *Staphylococcus aureus* and *Escherichia coli*. Appl Environ Microbiol. 2008 Apr;74(7):2171-8.