Pilot field comparison of traditional alum flocculation, chlorination, and combined flocculation-chlorination point-of-use water treatment on drinking water quality in Western Kenya

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Woman collects drinking water from a turbid pond
Asembo, Western Kenya

Background

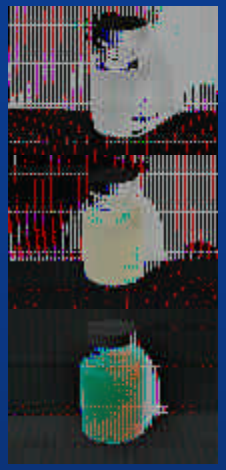
- 1.1 billion persons lack access to improved water
- Diarrheal disease kills >2 million persons annually
- ‘Point-of-use’ approaches to improving drinking water
  - Require little infrastructure
  - Are suited to rural settings
  - Empower individuals to make water safe for their families
- ‘Point-of-use’ disinfectants (e.g., sodium hypochlorite) are likely to perform poorly for highly turbid source water

Aim

- To compare the effect on water quality indicators of traditional alum flocculation, chlorination, and combined flocculation-chlorination (Pur A and Pur B) point-of-use water treatment on drinking water quality in Western Kenya over a range of source water turbidities

Methods and Materials

- 30 water sources



10 low turbidity (<10 NTU)

10 medium turbidity (10-100 NTU)

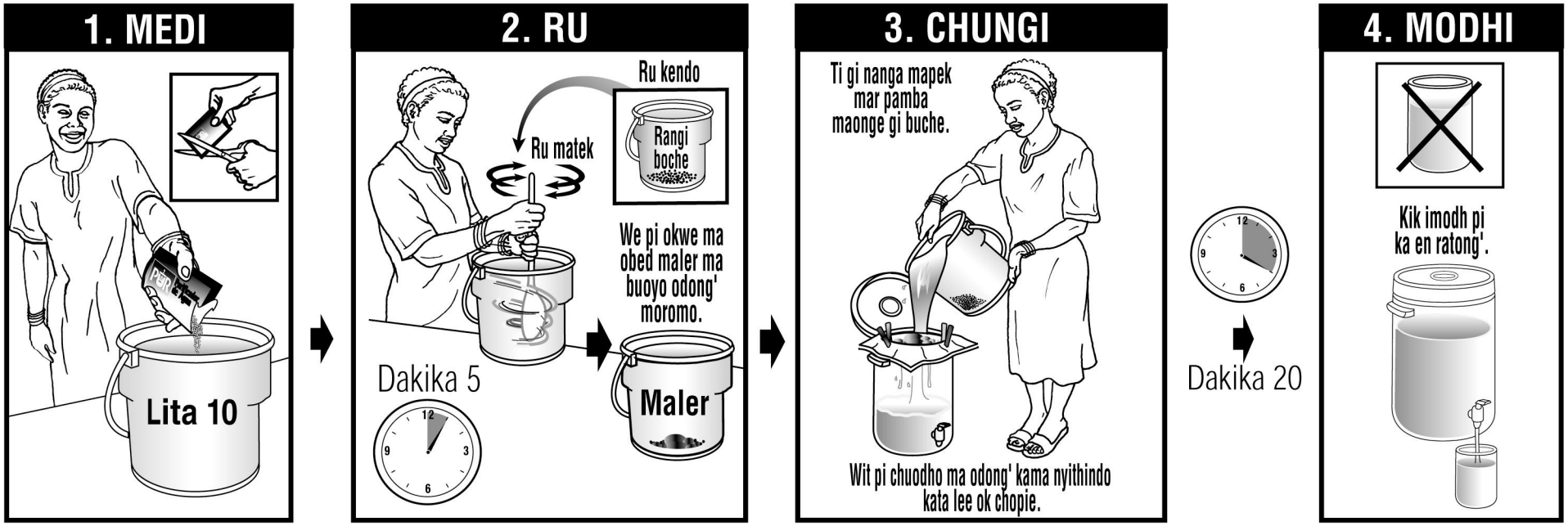
10 high turbidity (>100 NTU)

- Six treatments
  - Combined flocculation-chlorination product yielding ~3.5 mg/L free chlorine (Pur A)
  - Combined flocculation-chlorination product yielding ~2.0 mg/L free chlorine (Pur B)
  - Locally produced water disinfectant yielding ~5.0 mg/L free chlorine (Klorin)
  - Locally available alum flocculant ~100 g for 60 seconds
  - Alum + Klorin
  - Untreated control

Outcomes

- Turbidity measured by Hach 2100P Portable Turbidimeter (Hach Company, Loveland, CO)
- Free and total chlorine concentration measured by Hach Portable DR/890 Colorimeter (Hach Company, Loveland, CO)
- pH measured by IQ 150 Handheld pH Meter (IQ Scientific Instruments Inc, San Diego, CA)
- *E. coli* concentration measured by Colilert Quantitray 2000 system (IDEXX Laboratories Incorporated, Westbrook, ME)

Point-of-use water treatments evaluated

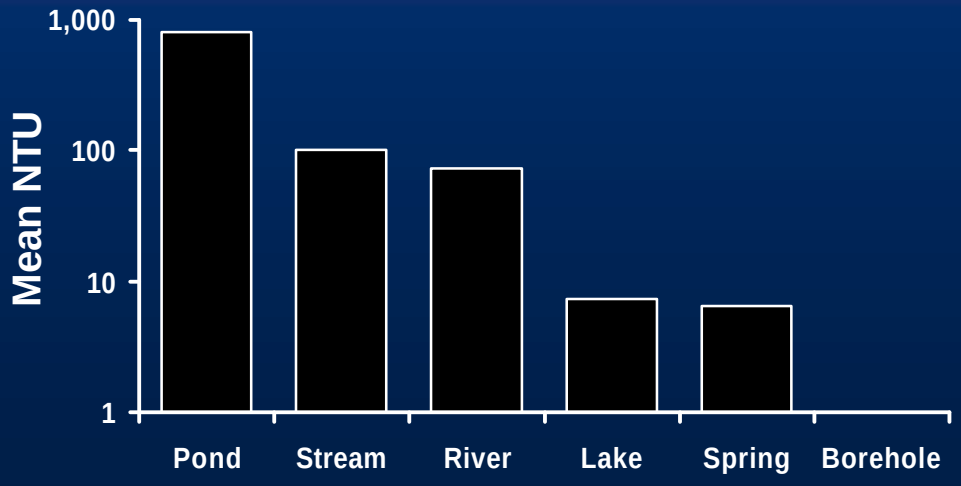


Turbid water after treatment with Pur

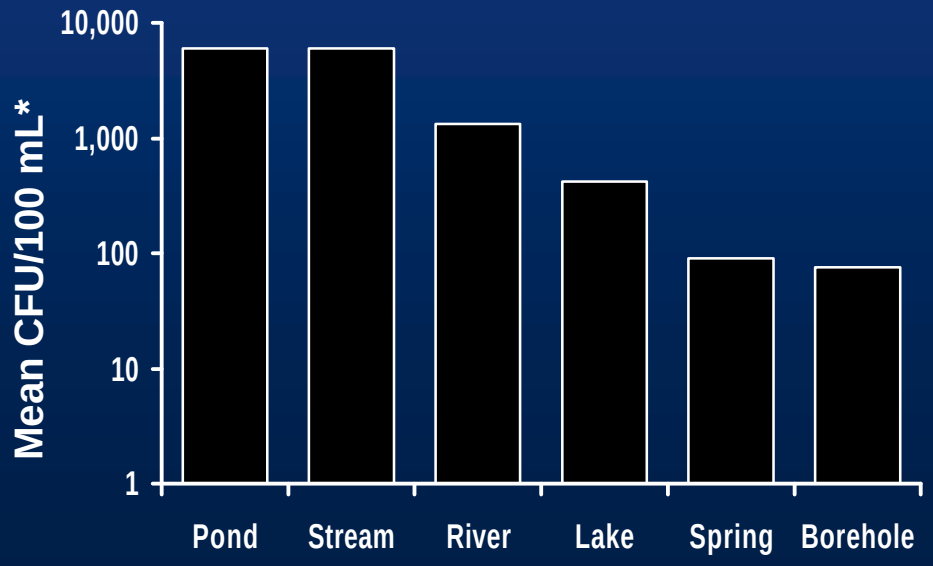
Results

Before treatment, turbidity and *Escherichia coli* concentrations were highest in pond water, followed by stream, river, lake, spring, and borehole water

Turbidity by untreated source water type, Asembo and Gem, 2002

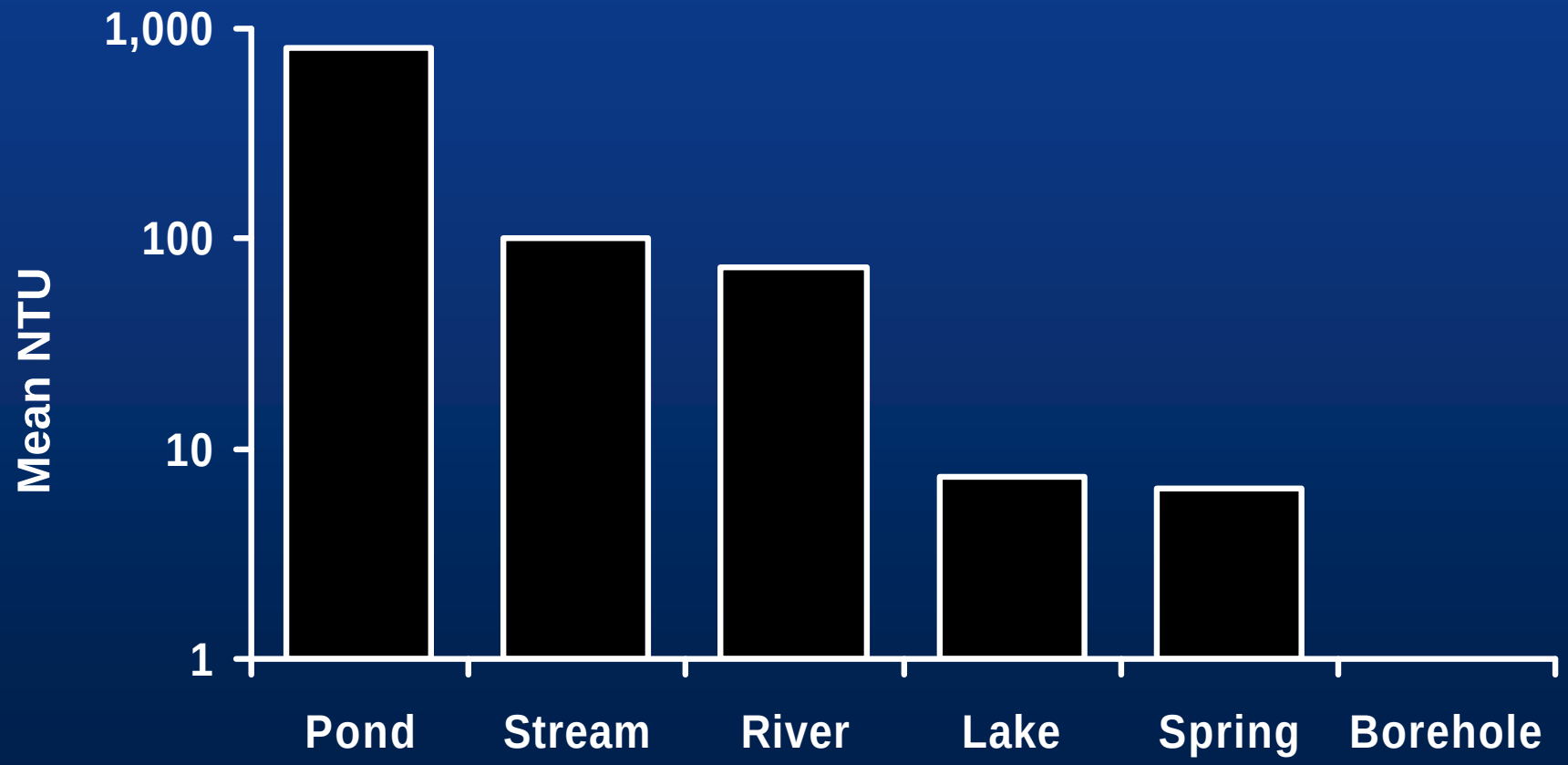


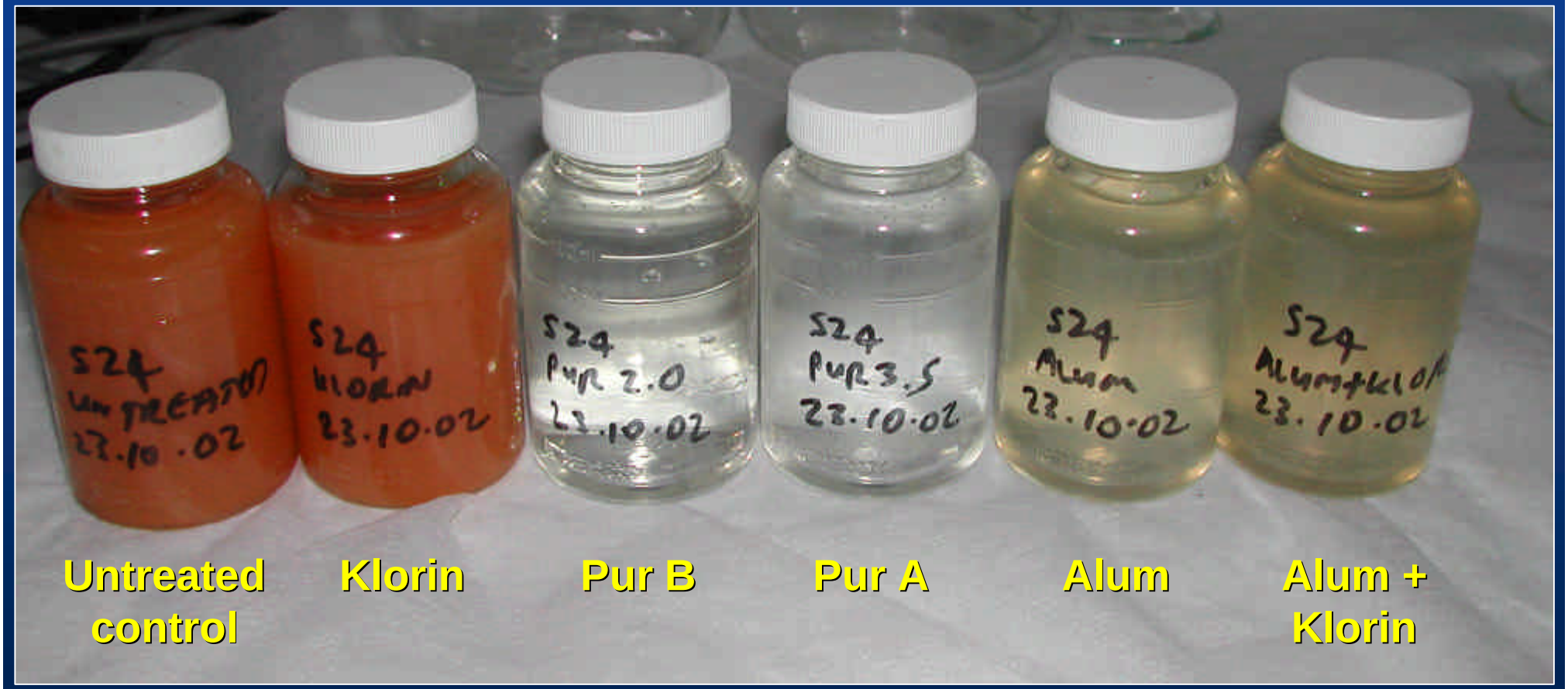
***E. coli* concentration by untreated source water type, Asembo and Gem 2002**



*WHO guideline <1 *E. coli* CFU/100 mL

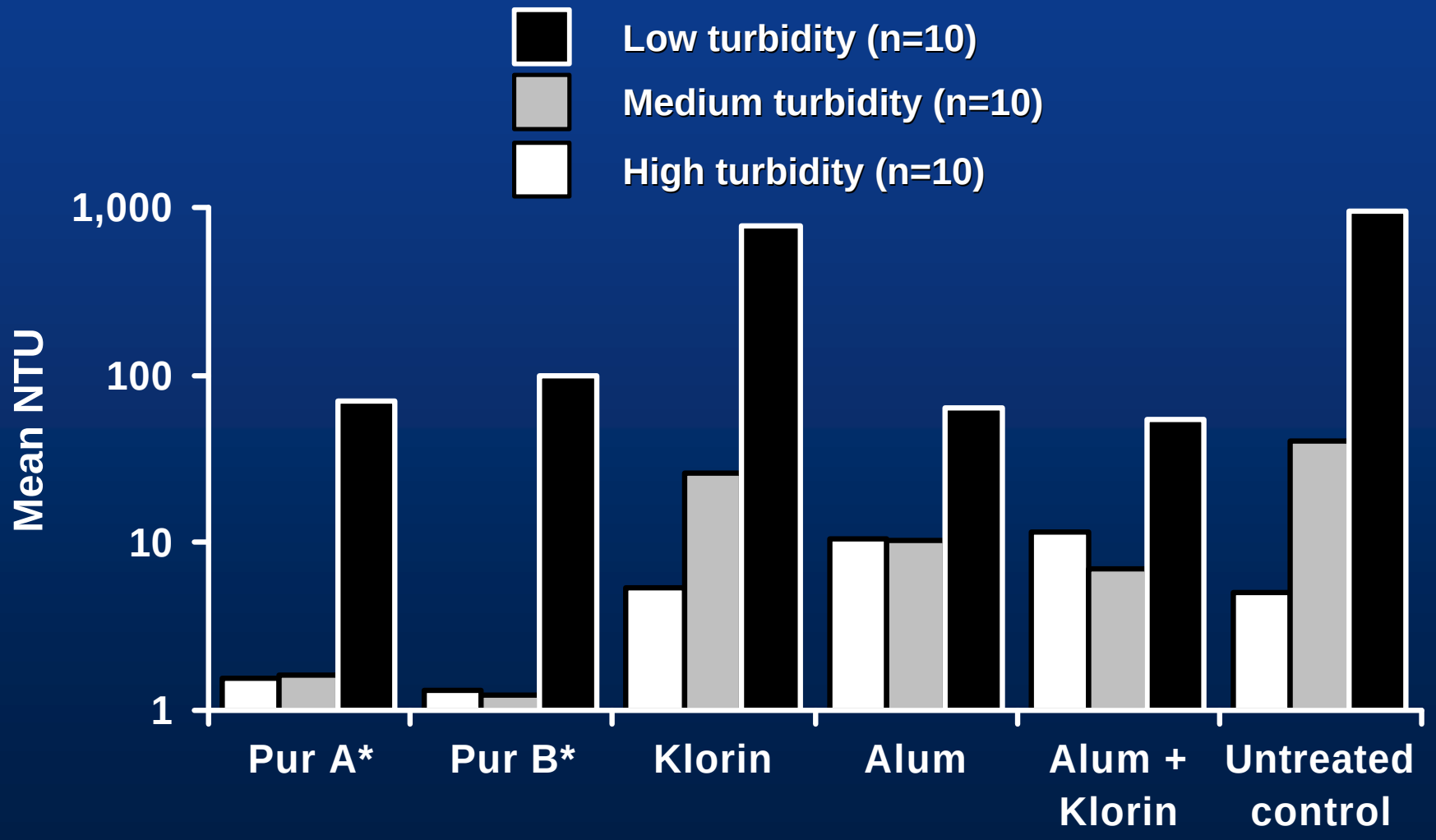
Turbidity by untreated source water type, Asembo and Gem, 2002





Visual impact of water treatments on highly turbid source water

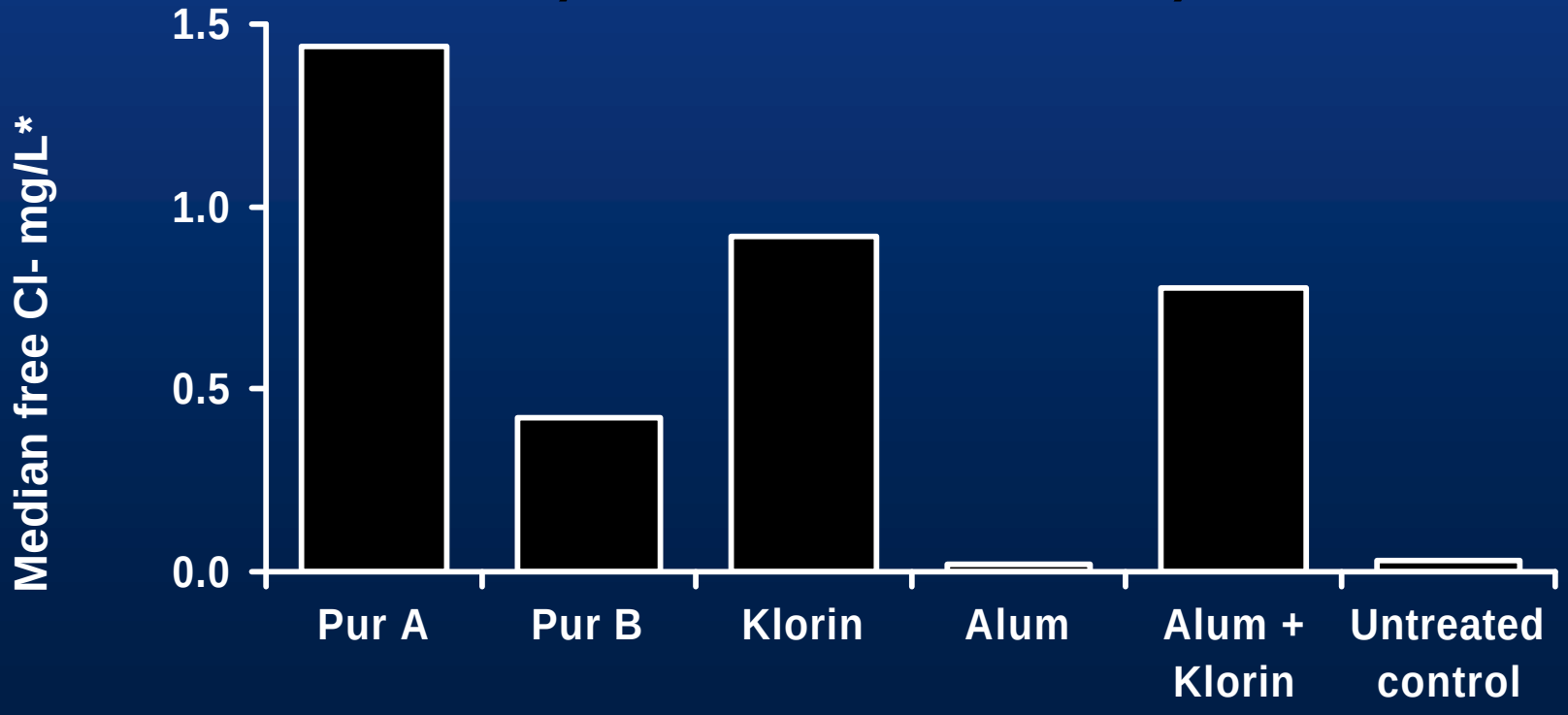
Effect of water treatments on turbidity by turbidity, Asembo and Gem, 2002



*Includes two water sources where one sachet of Pur failed to form floc

Although Klorin delivers a higher chlorine dose compared to Pur A, free chlorine levels measured 30 minutes after water treatment were higher for Pur A compared to Klorin alone

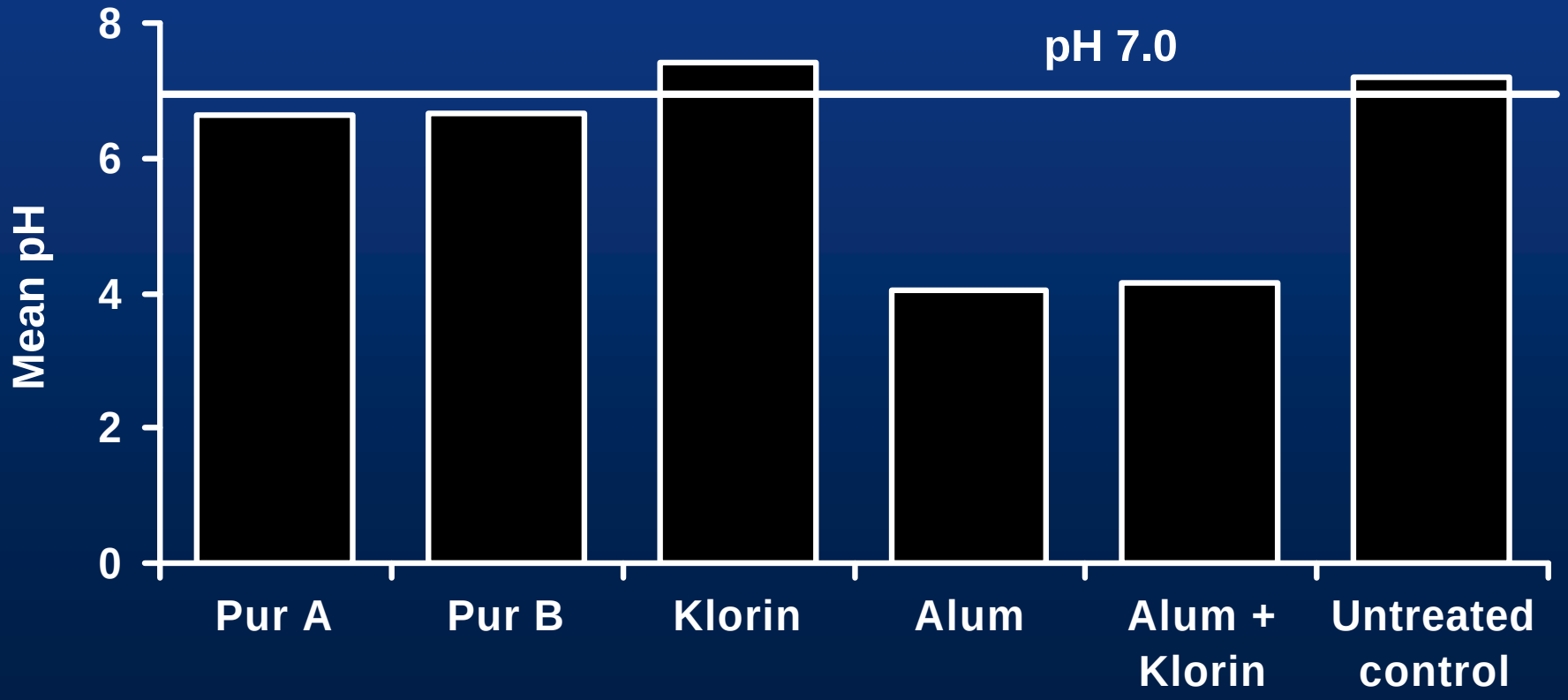
Effect of water treatments on free chlorine, Asembo and Gem, 2002



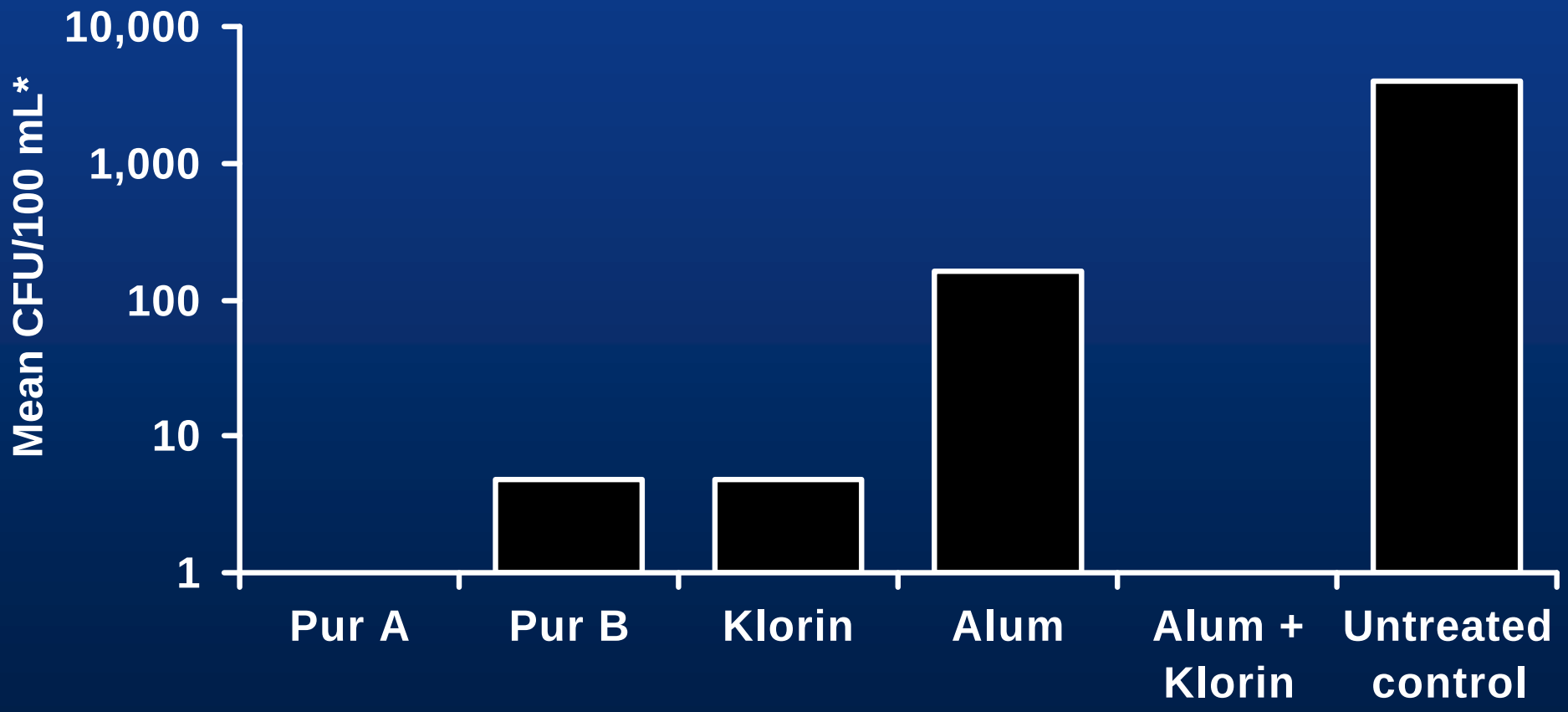
*Measured 30 minutes after treatment

Alum-based treatments lower pH substantially

Effect of water treatments on pH
Asembo and Gem, 2002



Effect water treatments on *E. coli* concentration, Asembo and Gem, 2002

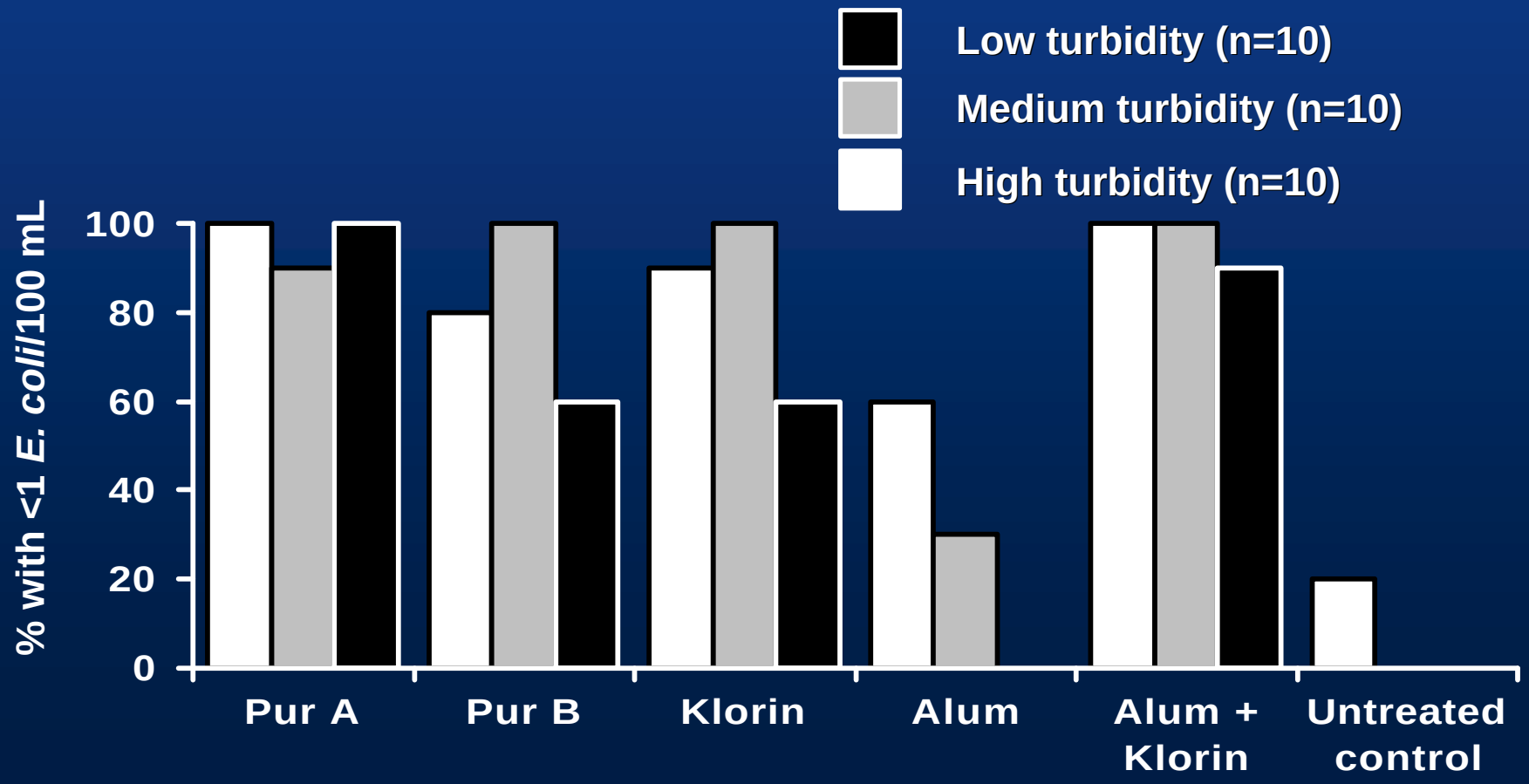


*WHO guideline <1 *E. coli* CFU/100 mL

Only treatments that combined flocculation and chlorination performed well in high-turbidity waters

Treatments that included disinfectant performed well in low- and medium-turbidity waters

Proportion waters with <1 *E. coli*/100 mL after treatment, Asembo and Gem, 2002



Conclusions

- Pur A
  - Mitigates turbidity
  - Achieves <1 *E. coli*/100 mL in even high-turbidity water
  - Maintains neutral pH
- Pur B
  - Mitigates turbidity
  - Achieves <1 *E. coli*/100 mL in low- and medium-turbidity water
  - Maintains neutral pH
- Alum alone
  - Mitigates turbidity
  - Lowers *E. coli* concentration, but not to <1/100 mL
  - Lowers pH
- Klorin alone
  - No impact on turbidity
  - Achieves <1 *E. coli*/100 mL in low- and medium-turbidity water
  - Does not render high-turbidity water potable
- Alum + Klorin
  - Mitigates turbidity
  - Achieves <1 *E. coli*/100 mL in high-turbidity water
  - Lowers pH

Ongoing health outcome study

- Launched in Asembo and Gem, Western Kenya, 2003
- 600 homes (>6,500 persons) randomly assigned to use
  - Pur A , or
  - Klorin, or
  - Traditional practices
- 20 week duration
  - Main outcomes
  - Diarrhea prevalence (especially of children <2 years)
  - Intervention acceptability
  - Water quality