The Use of Ultraviolet Light to Disinfect Drinking Water: An Alternative to Chlorination

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Introduction

- UV radiation is a potential water disinfection alternative
- The germicidal effect of UV light on microorganisms
  - Biochemical changes induced within the DNA and RNA molecules
  - The nature of biochemical changes depends on UV dosage

Introduction

- UV light disinfection mechanism
  - Formation of pyrimidine dimers in DNA molecule
  - Interruption of transcription and replication of DNA
- UV light classification
  - UV-C: 100 to 280 nm
  - UV-B: 280 to 315 nm
  - UV-A: 315 to 400nm
- Limitations of UV light disinfection
  - No residual disinfection dose
  - Photoreactivation

Objectives

- To determine the efficiency of UV light to inactivate waterborne pathogens namely, *Escherichia coli, Streptococcus faecalis, Salmonella typhi, and Shigella flexneri.*
- To determine the influence of turbidity on the effect of UV light.
- To determine photoreactivation of microbes irradiated with UV light.

Materials and Methods

- Bacterial
  - Liphilization
- Activation and culture of bacteria
  - *E. coli*: Eosine Methylene Blue agar
  - *S. faecalis*: m-Enterococcus agar
  - *S. typhi*: Xylose Lysine Desoxycholate agar
  - *S. flexneri*: Salmonella-Shigella agar
- Bacterial growth measurement
  - Serial dilution
  - Spread plate method
  - Membrane filter method

Materials and Methods

- Isolation of bacteria (The Standard Methods of Examination of Water and Wastewater, 1989)
  - Membrane filter method used to isolate *S. faecalis*.
  - Spread plate method used to isolate *E. coli, S. typhi and S. flexneri*
- UV light disinfection
  - UV Waterworks standard unit, model UVW 2.3NC
  - UV-C bulb: 12 W of UV-c at 254 nm.
  - Bacteria count $1x10^5$ to $1x10^6$ CFU mL^{-1}
  - Exposure time: 5, 10 and 20 seconds

Materials and Methods

- A cocktail of bacterial suspension studied
- Turbidity
  - Sterile clay colloids used
  - Turbidity concentrations ranging from 0 to 160 NTUs
  - Bacterial count: $1x10^5$ to $1x10^6$ CFU mL^{-1}
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  - Exposure time: 5, 10 and 20 seconds
  - Depth: 5 cm.
  - Treatments carried out in duplicate

Materials and Methods

- Visible light irradiation (Photoreactivation)
  - UV treated samples at 5 cm depth
  - Growing chamber set at 16 h daylight and 8 h nigh time
  - Four lamps at 17 W fluorescent bulbs suspended horizontally 15 cm above liquid surface
  - Samples incubated at 22 ^{o}C for 24 h.
  - Treatment carried in duplicate
  - Samples were plated out after 24 h
- Bacterial count determined by counting visible colonies.

Results

- Disinfection efficiency
- A total inactivation of E. coli ater20, 10 and 5 sec. UV exposure

Introduction

- Disinfection efficiency
  - A total inactivation of *S. typhi* after 20, 10 and 5 sec. UV exposure

Results

- Disinfection efficiency
  - A total inactivation of *S. flexneri* after 20, 10 and 5 sec. UV exposure

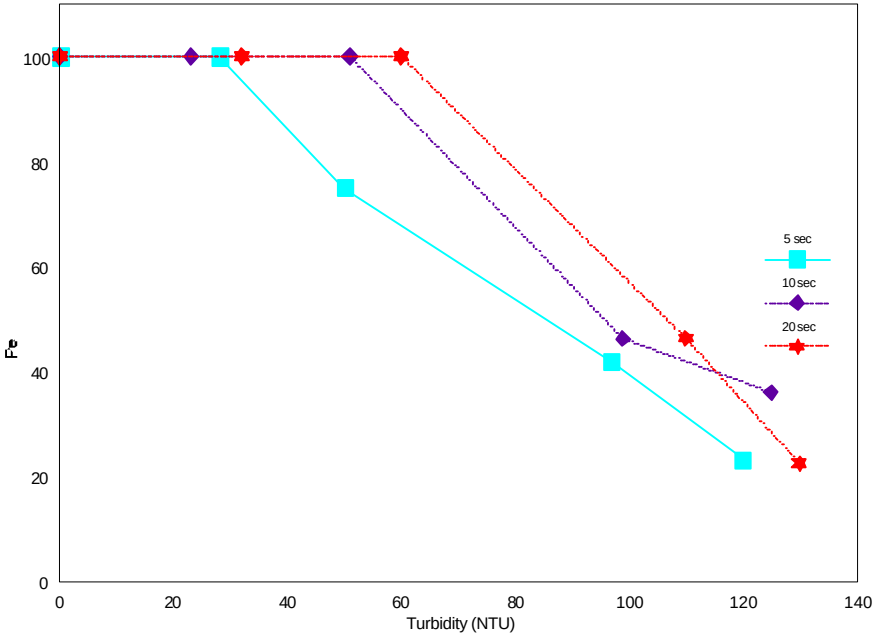
Results

- Disinfection efficiency
  - A total inactivation of *S. faecalis* after 20, 10 and 5 sec. UV exposure

Results

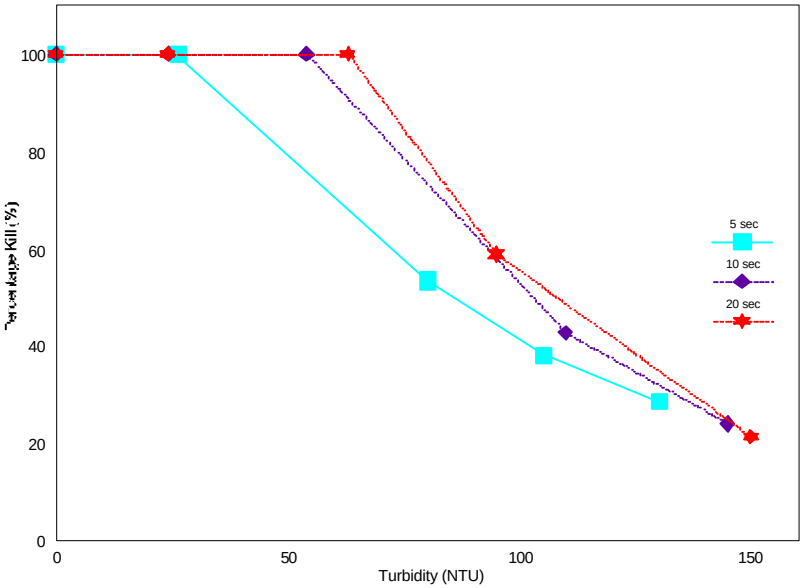
- 100% inactivation on cocktail bacterial suspension
- No effect of visible light exposure on disinfected water after 24 h4 (Photoreactivation was not evident)
- Turbidity
  - Increased levels of turbidity had a negative effect on UV light efficiency
  - Percentage survival=(the number of bacteri survived/the number of bacteria without UV treatment) x 100
  - Percentage kill = 100% - % survival

Results



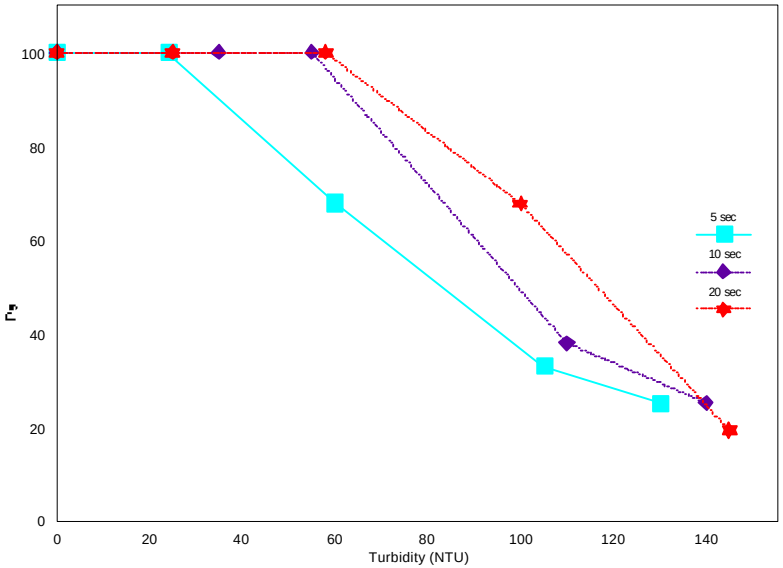
The relationship between turbidity and inactivation of *S. faecalis*

Results



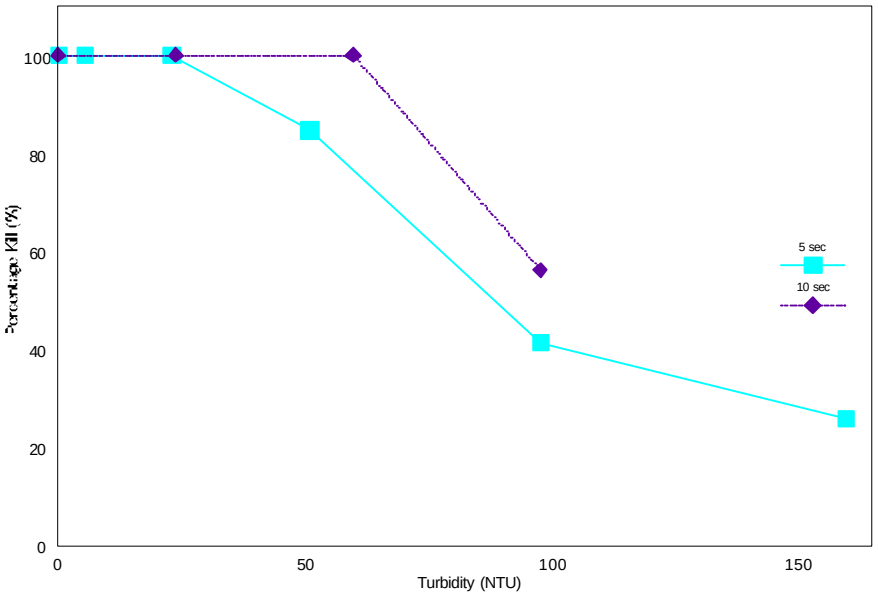
The relationship between turbidity and inactivation of *S. flexneri*

Results



The relationship between turbidity and inactivation of *S. typhi*

Results



The relationship between turbidity and inactivation of *E.coli*

Conclusion

- UV-C light effectively inactivated *E. coli, S. daecalis, S. Typhi and S. flexneri*
- UV disinfected water had bacterial growth below detectable limits after 16 h of exposure to visible light
- Increased levels of turbidity reduced the efficiency of UV light disinfection

Recommendations

- UV light disinfection appropriate for point-of-use systems
- UV treated water not appropriate for long-term storage
- Information on resistance of microorganisms and inactivation of coliphages
- Comprehensive evaluation on process reliability of UV light disinfection systems
- UV light systems for use in rural communities
- UV light systems for use in developing countries