# Managing Water Quality in the Green Industry

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UF UNIVERSITY of FLORIDA IFAS Extension | Floriculture Research Alliance | Water Education Alliance For Horticulture WaterEducationAlliance.ORG



# Water sources differ in quality

- Municipal treated or wells: "high quality"
- Catchment ponds and tanks or reclaimed water: "lower quality"



# What is the cost of irrigation water?

| Water source | Water volume (gal/year) | Cost ($/ 1000 gal) | | |
|---|---|---|---|---|
| | | Water | Fertilizer | Nutrient solution |
| Well | 20,945,044 | $0.17 | $1.00 | $1.17 |
| Pond | 10,000,000 | $0.35 | $1.00 | $1.35 |
| Municipal | 8,603,600 | $3.75 | $1.00 | $4.75 |
| Recirculated | 32,800,000 | $0.24 | $0.00 | $0.24 |

Can be economic benefits in recirculating water.



# Irrigation Water Quality

- Pathogens, algae, biofilm/microbes, (biological)
- Organic material or suspended solids (physical)
- High alkalinity or EC, specific salts (chemical)

# Biological Water Quality

| Factor | Problem | Treatment |
|---|---|---|
| Pathogens | Presence<br>Can lead to plant disease | Filtration + sanitizer |
| Biofilm<br>(mainly bacteria) | >10,000 cfu/mL<br>Can cause emitter clogging.<br>(Bacteria=Indicator microbial load) | |
| Algae | No clear threshold<br>Hazard, pests, aesthetic | |



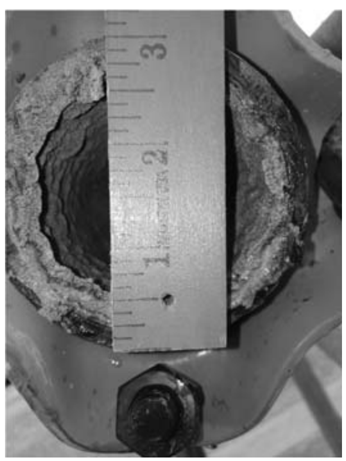
# Plant Pathogens in Water

- Pathogens reported in irrigation water:
  - *Phytophthora* (17 species)
  - *Pythium* (26 species)
  - True fungi (27 genera)
  - Bacteria (8 species)
  - Viruses (10 species)
  - Nematodes (13 species)


(Hong and Moorman, 2005)



# Biofilm



**Cost: $153K/year**



# Algae

- Clog emitters
- Reduce plant growth
- Provide food for shoreflies
- Form impermeable layer on surface

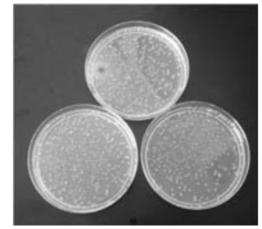
# Physical Water Quality

| Factor | Problem | Treatment |
|---|---|---|
| Total Suspended Solids | >100 ppm<br>*Clogging of emitters*<br>>20 ppm<br>*Sanitizing agents ineffective* | Filtration |



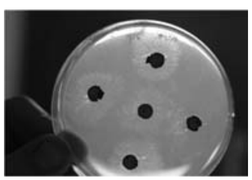

# Outline:

1. Monitoring
2. Filtration
3. Sanitation



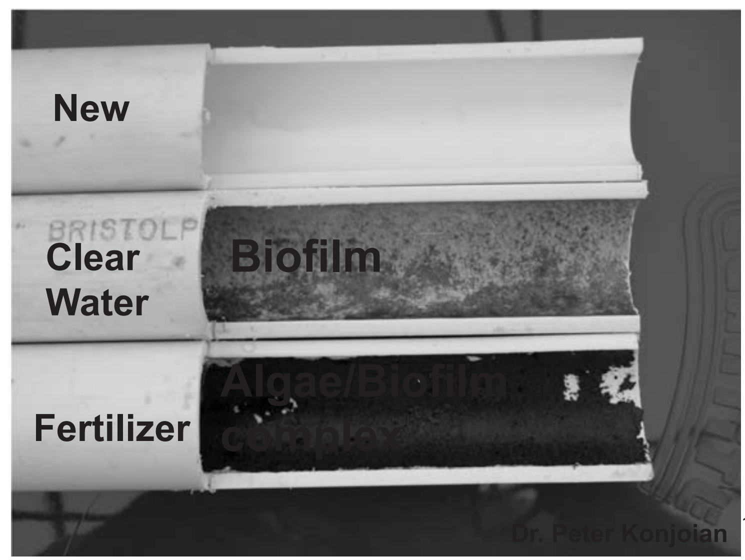


# Monitoring Pathogens

| | | |
|---|---|---|
| Plating  | Genus level<br>*Pythium, Phytophthora* | University of Massachusetts<br>$50<br>2 weeks |
| DNA Scan  | Species level<br>70+ pathogens | University of Guelph<br>$195<br>1 week |

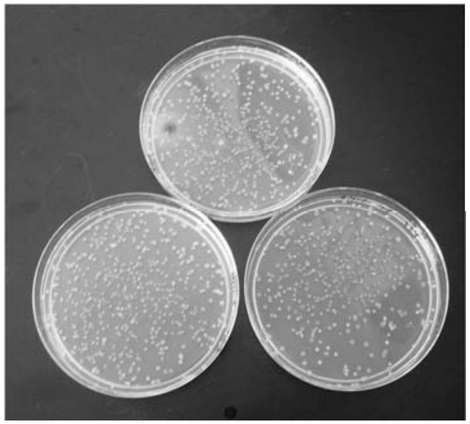


# Monitor biofilm directly



# Or monitor biological load

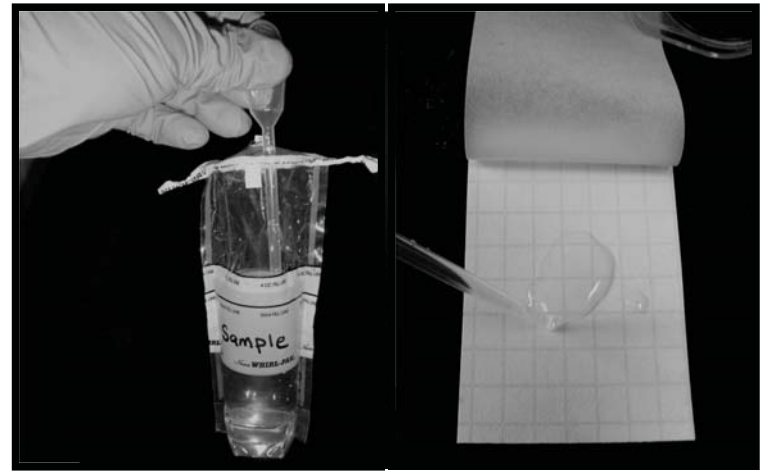
Laboratory agar plating and colony counts





# Petrifilm onsite measurement

Dustin Meador (UF)




>10,000 cfu/mL bacteria = high biofilm risk



# Biological water quality in commercial irrigation systems

| Sample Type | Aerobic Bacteria CFU/mL | |
|---|---|---|
| Source | 557 | a |
| Furthest outlet | **22,771** | **b** |
| Tank | **102,266** | **c** |
| Ebb and Flow | **134,762** | **c** |
| Pond | **322,170** | **d** |
| Recommended | <10,000 | |



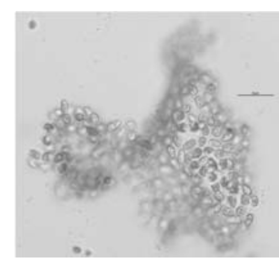
# Algae Lab Test

Specialist labs such as GreenWater Laboratories (Palatka, FL) can provide algae type and quantity.

This sample from a subirrigation tank was dominated by green algae.

$150 per sample

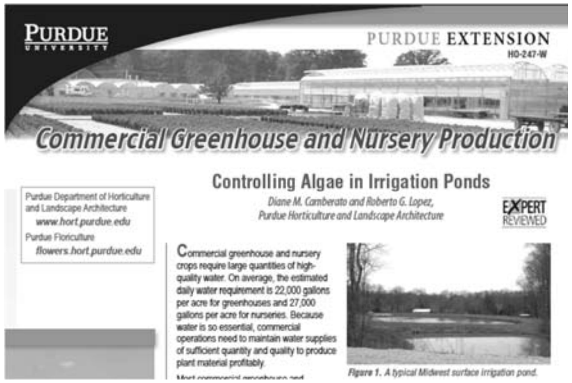
*Chlorococcum* sp. vegetative cells 400X (scale bar = 10 µm)



chlorophyte sp. 1 colony 400X (scale bar = 20 µm)

Knowing the algae types may help in selecting algaecides.

http://www.extension.purdue.edu/extmedia/HO/HO-247-W.pdf



PURDUE UNIVERSITY

PURDUE EXTENSION
HO-247-W

Commercial Greenhouse and Nursery Production

Controlling Algae in Irrigation Ponds

Diane M. Camberato and Roberto G. Lopez,
Purdue Horticulture and Landscape Architecture

EXPERT REVIEWED

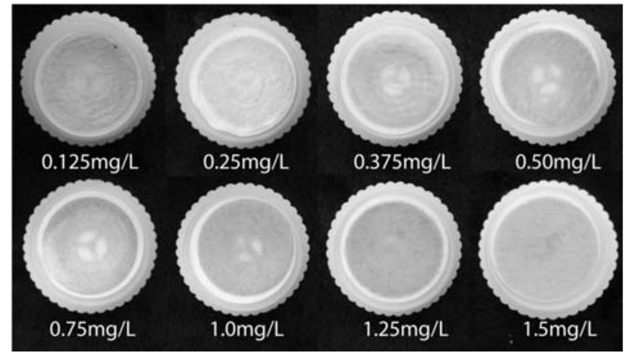
Purdue Department of Horticulture and Landscape Architecture
www.hort.purdue.edu
Purdue Floriculture
flowers.hort.purdue.edu

Commercial greenhouse and nursery crops require large quantities of high-quality water. On average, the estimated daily water requirement is 22,000 gallons per acre for greenhouses and 27,000 gallons per acre for nurseries. Because water is so essential, commercial operations need to maintain water supplies of sufficient quantity and quality to produce plant material profitably.

Figure 1. A typical Midwest surface irrigation pond.



# Onsite testing




Qualitative assessment with Lamotte® Algae Test Kit:
www.lamotte.com



# Monitoring Physical Water Quality

| Measurements | Target range | Significance |
|---|---|---|
| Total Suspended Solids | <100 ppm to prevent clogging<br><br><20 ppm for reuse on non-edible crops | Indicates need for additional filtration. High TSS clogs emitters and reduces efficacy of sanitizing agents. |
| Particle size distribution | | Indicates filter pore size required to remove suspended solids |



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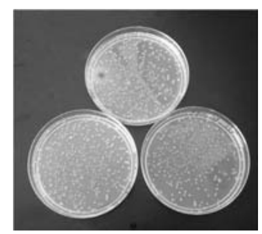


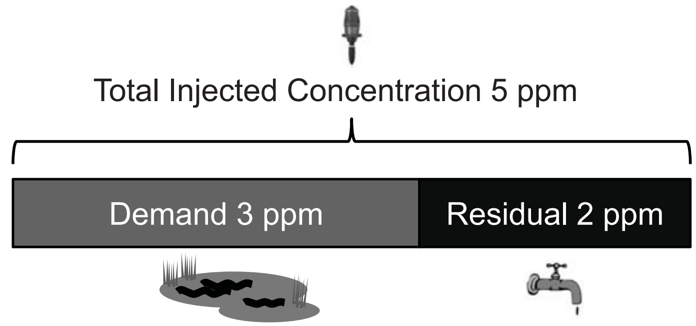
# Filtration of recirculated water






# Filter first to reduce "demand"

- Reduces chemical cost
- Increases sanitizing efficacy






# Are filters removing suspended solids?


| Sample | Total Suspended Solids (mg/L or ppm) |
|---|---|
| Return Before Paper Filter | 11.7 |
| Return After Paper Filter | 5.9 |
| | -50% |



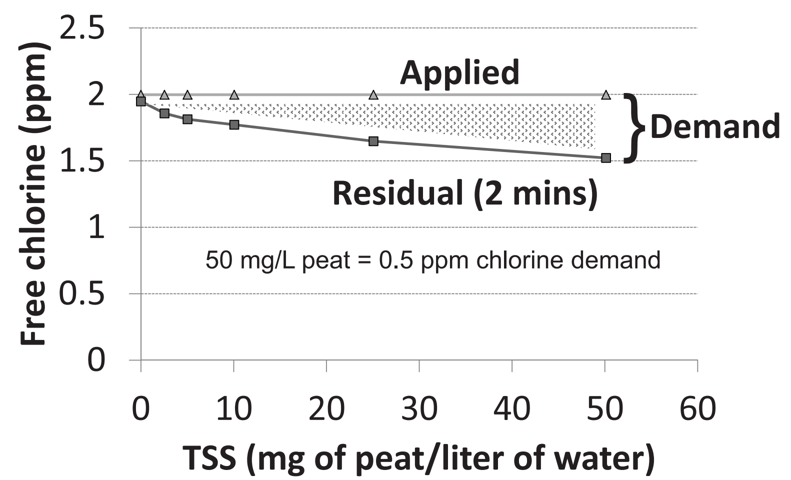
# Mesh Size and Microns

| Mesh size | Microns | Notes |
|---|---|---|
| 60 | 250 | Fine sand |
| 100 | 149 | Median suspended solids we saw in irrigation |
| 200 | 74 | |
| 400 | 37 | Silt |
| (625) | 20 | Too small for screen |
| | 7 to 10 | *Phytophthora* zoospores |

Membrane filtration 0.1 to 0.5 microns

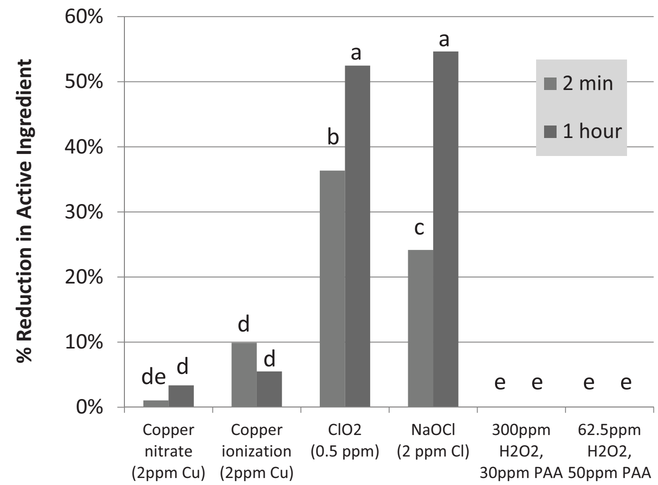
McPherson et al. (1995)
Ohtani et al. (2000)
Tu and Harwood (2005)

# Total Suspended Solids (TSS) and sanitizing agent demand

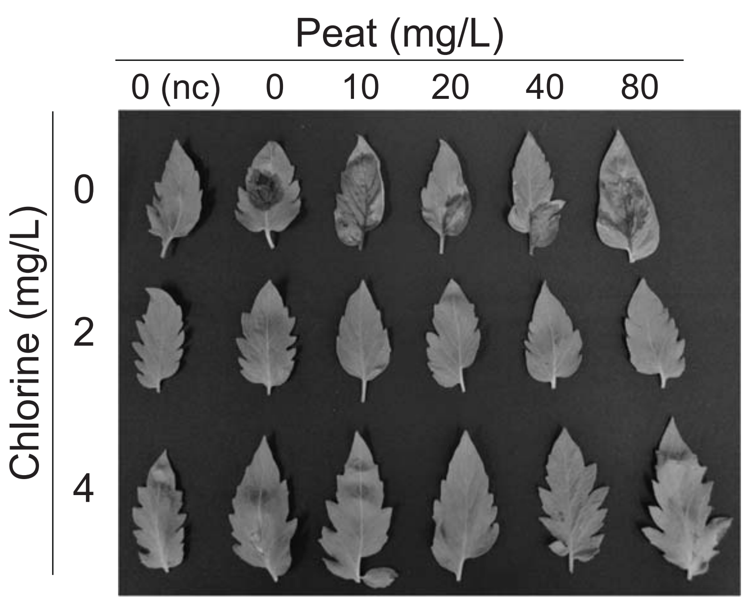





# Total Suspended Solids and Demand:
## 50 mg/L screened peat with several sanitizers








# Filter costs: Kason vibrating screen

| | Per Year | Per 1000 gal |
|---|---|---|
| <u>Capital</u> | | |
| Purchase & installation (total $17,000) | $1,700 | $0.112 |
| <u>Consumables</u> | | |
| Electrical cost | $608 | $0.040 |
| <u>Labor</u> | | |
| Maintenance cost/year | $191 | $0.013 |
| **Total cost** | **$2,499** | **$0.164** |

For an operation that uses 15,200,000 gal/ year in flood floors and recycles 83%.

# Filter costs: Clearstream "paper"

| | Per Year | Per 1000 gal |
|---|---|---|
| Capital | | |
| Purchase & installation (total $24,000) | $2,400 | $0.136 |
| Consumables | | |
| Fabric | $2,679 | $0.152 |
| Labor | | |
| Maintenance cost/year | $429 | $0.024 |
| **Total cost** | **$5,508** | **$0.313** |
| (compared with Kason vibrating screen) | | |
| **Total cost** | **$2,499** | **$0.164** |



# Key points on filtration

- Targets:
  - <20 mg/L suspended solids to reduce demand
  - Filter to particles smaller than emitter orifices
- 2-stage filtration ideal for recirculated water
  - Screen typically first stage
  - Small pores or high consumable cost last stage
- Media filters remove pathogens embedded in peat or plant parts, and reduce sanitizing agent demand
- Free living pathogens are only removed by membrane filters



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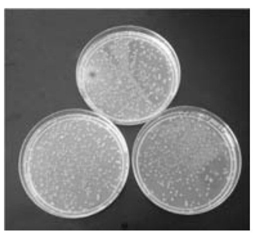


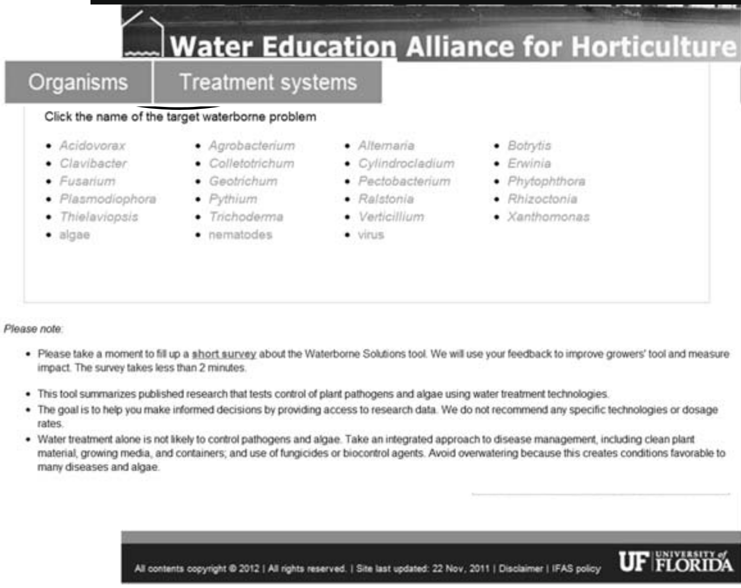


# Water Sanitizers

Chlorination, chlorine dioxide, copper ionization, copper sulfate, hydrogen peroxide, ozone, slow sand filtration, constructed wetlands, UV

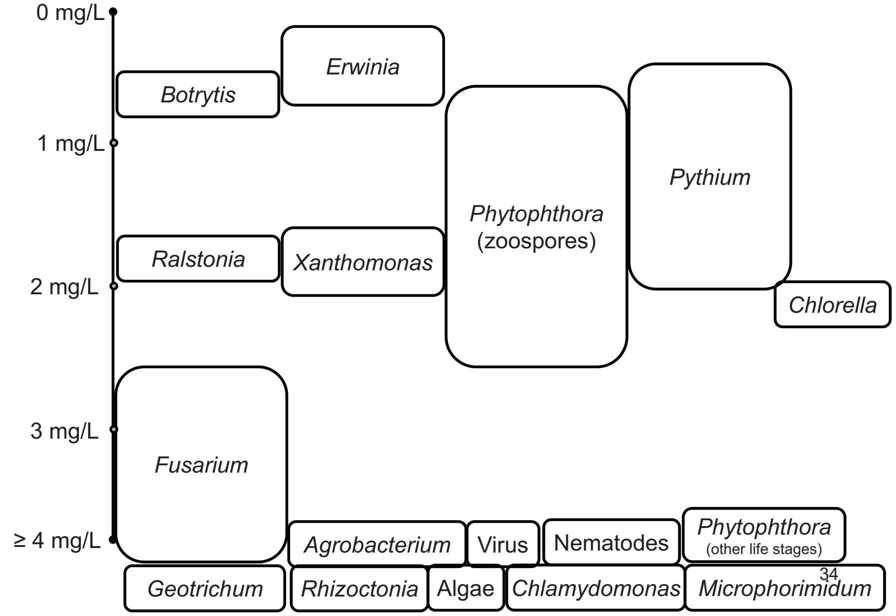

(Stewart-Wade, 2011)

## www.watereducationalliance.org





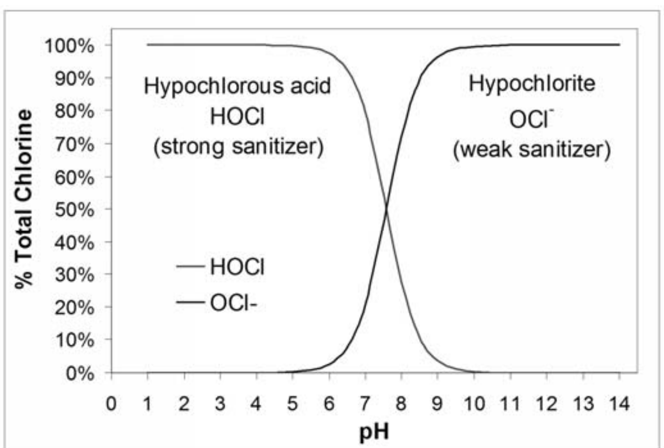

## Published efficacy of chlorine





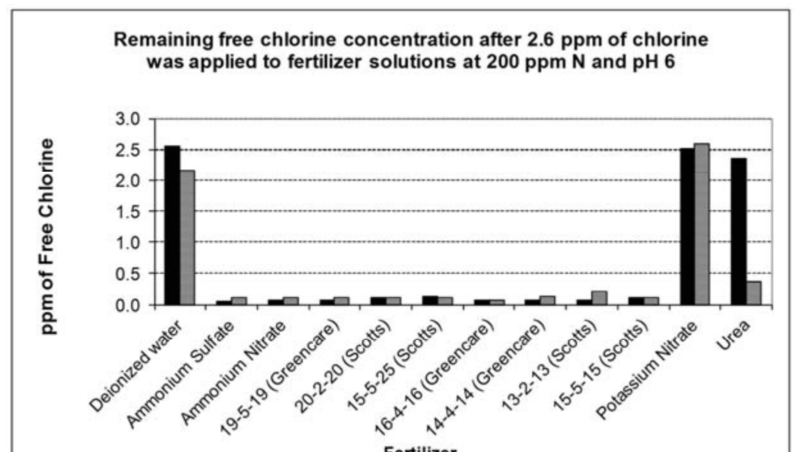

## Water chemistry interacts with sanitizers.

For example, high pH makes chlorination less effective






## Chlorine quickly reacts with ammonium nitrogen to form combined chlorine




Meador et al., 2013

# Cost of chlorination

Operation: 20 million gallons /year
Dose rate: 2 ppm

| Chlorine form | Capital ($) | Cost ($/1000gal) | | | |
|---|---|---|---|---|---|
| | | Capital | Consumable | Labor | Total |
| Calcium hypochlorite | $3,000 | $0.02 | $0.04 | $0.03 | $0.09 |
| Chlorine gas | $7,000 | $0.04 | $0.03 | $0.03 | $0.10 |
| Sodium hypochlorite | $4,580 | $0.03 | $0.03 | $0.03 | $0.09 |



# Comparing some other options

| | Capital $ | Operation $/1000 gal | Total $/1000 gal |
|---|---|---|---|
| Activated peroxygen | ● | ●●● | ●●● |
| Calcium hypochlorite | ● | ● | ● |
| Chlorine gas | ●● | ● | ● |
| Copper ionization | ●● | ●●● | ●● |
| Chlorine dioxide (single tank) | ● | ●●● | ●●● |
| Chlorine dioxide (double tank) | ● | ●●● | ●● |
| Sodium hypochlorite | ● | ● | ● |
| Key | ● < $5K<br>●● $5-10K<br>●●● > 30K | ● < $0.10<br>●● $10-$0.50<br>●●● >=$0.50 | ● < $0.10<br>●● $0.10-$0.99<br>●●● >=$1 |



# Key points on sanitizers

- Match the sanitizer to:
  - The problem (known efficacy)
  - Other factors such as water chemistry.
  - Size of the operation (reduces costs)
- Trade-off between capital cost and operation costs.



# Questions or comments

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