Evaluating Water Remediation Options for Potential Agricultural Water Use

Update for Jimmy Nakatani

Jari Sugano, Jensen Uyeda, Josh Silva and Lynn Nakamura-Tengan
University of Hawaii at Manoa
College of Tropical Agriculture and Human Resources
September 20, 2017
FSMA Water Testing: Method 1603

- Prior to September 2017, Method 1603 was the only method that FDA has formally approved for use (in the text of the Rule)
- FDA was not willing to state whether Colilert or Colilert-18, used with Quantitray/2000 MPN format, would be approved methods for generic E. coli in 40 CFR 136.3, alongside method 1603
- Method 1603 has a 6-hour hold time from collection to delivery to the lab (8 hours to analysis)
- There is one testing lab in Hawaii that can offer this test (Manoa)
- It is possible the Recycled Water Branch also does this membrane testing method. UH CTAHR is currently evaluating this method (2016).
Difference Between Method 1603 & Colilert

- Colilert water test is a reagent based test that detects total coliform and *E. coli*
  - Used for drinking water
  - Presence vs. Absence type of test
  - Results read at 24 hours
- Method 1603
  - Recreational & waste water quality test
  - Membrane filtration method
  - Direct count of *E. Coli* in water based on the development of colonies (CFU/100 ml)
  - Within 6 hours of hold time
Agriculture Water Thresholds

- FSMA: EPA Recreational Water Standards
  - Geometric mean (GM) is **126 CFU or less** of generic *E. coli* / 100 ml of water AND
  - Statistical Threshold Value (STV) is **410 CFU or less** generic *E.coli* in 100 ml/ water

- GAP Previous Audit Standards
  - Geometric mean (GM) is **126 CFU or less** of generic *E. coli* / 100 ml of water
  - No more than **235 CFU** generic E. coli per 100 ml for any single water sample
Water Remediation Options

- If water does not meet FSMA criteria or exceeds thresholds, corrective action is required:
  - **Passive treatments:**
    - Longer harvest time to allow for microbes to die off in the field (die off rate (log))
    - Longer harvest time to allow for microbes to die off between harvest and end of storage
  - **Active Treatment:**
    - Treating the water
2014: To address aquaponic industry request
Remedial Actions may include: chlorine, peracetic acid, UV, aqueous ozone, etc.
### Evaluation of Remedial Water Treatments- Colilert

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Beginning E. coli</th>
<th>Ending E. coli</th>
<th>ORP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine: 200 ppm</td>
<td>130</td>
<td>1</td>
<td>600</td>
</tr>
<tr>
<td>Chlorine: 200 ppm</td>
<td>130</td>
<td>1</td>
<td>661</td>
</tr>
<tr>
<td>Chlorine: 400 ppm</td>
<td>130</td>
<td>1</td>
<td>620</td>
</tr>
<tr>
<td>UV</td>
<td>130</td>
<td>&lt;1</td>
<td>495</td>
</tr>
<tr>
<td>Aqueous ozone: 25% 1 ppm</td>
<td>&lt;200</td>
<td>83</td>
<td>523</td>
</tr>
<tr>
<td>Aqueous ozone: 50% 1 ppm</td>
<td>&lt;200</td>
<td>6</td>
<td>462</td>
</tr>
<tr>
<td>Aqueous ozone: 75% 1 ppm</td>
<td>&lt;200</td>
<td>&lt;1</td>
<td>359</td>
</tr>
<tr>
<td>Aqueous ozone/ UV</td>
<td>130</td>
<td>&lt;1</td>
<td>495</td>
</tr>
<tr>
<td>Peracetic acid: 3 ppm</td>
<td>200</td>
<td>&lt;1</td>
<td>332</td>
</tr>
</tbody>
</table>

J. Sugano, J. Uyeda, S. Fukuda, and J. Odani, August 2014
2017: Can we assist growers in remediating surface water for use in food crop systems and meet FSMA’s definition of agricultural water?
Evaluation of Remedial Water Treatments- Method 1603

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Beginning E. coli</th>
<th>Ending E. coli</th>
<th>ORP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorine: 200 ppm (MultiChlor)</td>
<td>3200</td>
<td>0</td>
<td>331</td>
</tr>
<tr>
<td>Chlorine: 500 ppm (MultiChlor)</td>
<td>3200</td>
<td>0</td>
<td>558</td>
</tr>
<tr>
<td>Peracetic acid: 4.4 ppm (Bioside HS 15%)</td>
<td>3200</td>
<td>0</td>
<td>315</td>
</tr>
<tr>
<td>Peracetic acid: 19.7 ppm (Bioside HS 15%)</td>
<td>3200</td>
<td>0</td>
<td>398</td>
</tr>
</tbody>
</table>

Zero E.coli does not mean no other pathogens exist such as Cryptosporidium, Leptospirosis, Hepatitis A, Giardia intestinalis, etc. We submitted a duplicate sample set to Food Quality Lab to test for Salmonella kill rates. No Salmonella detected on the starting sample.

**NOTE:** Label does not allow for shock treatment of reservoir water. Wash water rates differ and may require a post treatment rinse with potable water. Experiment was conducted to determine if rates would kill E.coli. Label changes would need to be pursued to explore this further. **Inline treatments are currently acceptable if to be used as irrigation water for algae control, not for pathogens.**

New Equivalent Testing Methodologies Approved (9/2017)

- FDA has determined that the following methods are “scientifically valid” and “at least equivalent to the method of analysis (method 1603) in § 112.151(a) in accuracy, precision, and sensitivity[1]:
  - Method 1103.1
  - Method 1604
  - 9213 D
  - 9222 B
  - D 5392-93.
  - Hach Method 10029 for Coliforms – Total and *E. coli*
  - IDEXX Colilert® Test Kit
  - IDEXX Colilert-18® Test Kit

[1] https://www.fda.gov/Food/FoodScienceResearch/LaboratoryMethods/ucm575251.htm?source=govdelivery&utm_medium=email&utm_source=govdelivery
FDA FACT SHEET

EQUIVALENT TESTING METHODOLOGIES FOR AGRICULTURAL WATER

FDA has determined that the following methods are “scientifically valid” and “at least equivalent to the method of analysis in § 112.151(a) in accuracy, precision, and sensitivity”


6. Hach Method 10029 for Coliforms – Total and *E. coli*, using m-ColiBlue24* Broth PourRite Ampules.

7. IDEXX Colilert® Test Kit, but only if using IDEXX Quanti-Trap/2000 for quantification.

8. IDEXX Colilert-18® Test Kit, but only if using IDEXX Quanti-Trap/2000 for quantification.

For more information:
- FSMA Final Rule on Produce Safety

Have you seen our Blog? FDA Voice

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The FDA, an agency within the U.S. Department of Health and Human Services, protects the public health by ensuring the safety, effectiveness, and security of human and veterinary drugs, vaccines and other biological products for humans, and medical devices. The agency also is responsible for the safety and security of our nation's food supply, cosmetics, dietary supplements, and products that give off electronic radiation. And for regulating tobacco products.
# Wash Water Sanitizer Options for Growers

<table>
<thead>
<tr>
<th>Brand Name</th>
<th>Active Ingredients</th>
<th>Company Contact</th>
<th>Where to Buy</th>
<th>Label Instructions</th>
<th>Desired ppm Active Ingredient</th>
<th>Amount per 100 gal. Tank</th>
<th>Standard Operating Procedure</th>
</tr>
</thead>
</table>
| Tsunami 100      | 11.2% Hydrogen peroxide, 15.2% Peroxyacetic acid | Ecolab Inc. Institutional Division 370 N. Wabasha St. St. Paul, MN 55102 1-800-352-5326 | contact - Ecolab 4 gal ~ $110 | 36-575 ppm total product (5-80 ppm PAA) | 80 ppm PAA (FDA regulation) | 6.7 oz $1.45/ use | 1. Remove soil  
2. Prepare 80 ppm solution  
3. Submerge produce  
4. Monitor PAA level with strips, adjust as needed  
5. Contact time ~ 90 s  
6. Drain and dry |
| Sanidate 5.0     | 23% Hydrogen peroxide, 5.3% Peroxyacetic acid | BioSafe Systems, LLC 22 Meadow St. East Hartford, CT 06108 1-888-272-3089 | Johnny's.com 2.5 gal ~ $159 Helena Chemical Co. 5 gal ~ $80 Crop Prod. Serv. 5 gal ~ $218 | 462-1636 ppm total product (24-85 ppm PAA) | 80 ppm PAA (FDA regulation) | 19.3 oz $9.59/ use | |
| Vigor Ox 15 F&V  | 15% Peroxyacetic acid, 10% Hydrogen peroxide | FMC Corporation - Peroxogens Division 1735 Market Street Philadelphia Pennsylvania 19103 | online - amazon.com 4.5 gal ~ $39.95 | 30-45 ppm PAA | 80 ppm PAA (FDA regulation) | 6.83 oz $1.48/ use | 1. Remove soil  
2. Prepare 25 ppm  
3. Submerge produce  
4. Monitor pH levels  
5. Monitor turbidity  
6. Rinse required |
| Chlorox Regular | 6% Sodium Hypochlorite       | The Chlorox Company P.O. Box 493 Pleasanton, CA 94566 | online - walmart.com 5.35 | 25 ppm available chlorine | 25 ppm free chlorine (label) | 5.33 oz $0.55/ use | |
| Bleach EPA# 5917-50 |                 |                                                     |                               |                    |                               |                          |                             |
| Chlorox Germicidal Bleach EPA# 5913-100 | 8.25% Sodium Hypochlorite | The Chlorox Company P.O. Box 493 Pleasanton, CA 94566 | online - amazon.com 4.5 gal ~ $27.95 -walmart.com $32 | 25 ppm available chlorine | 25 ppm free chlorine (label) | 3.88 oz $1.02/ use | 1. Remove soil  
2. Prepare 25 ppm  
3. Submerge produce  
4. Monitor pH levels  
5. Monitor turbidity  
6. Rinse required |

*Suggestion based on recommendations for chlorine, see publication by Trevor Suslow for various commodities [http://ucce.ucdavis.edu/files/26414.pdf](http://ucce.ucdavis.edu/files/26414.pdf)  
*Sample standard operating procedure  
Authors: Marie Lawton and Amanda Kinchla

UMass Food Science Extension, Kinchla, Issued 9.2015.
Ran Multi-dose at UH Microbiology Lab (9/14/17)

Ran under controlled environment at UH Microbiology Lab (Dr. Yong Li)

Starting E. Coli Colony | 3137 CFU
---|---
(251 CFU / 10 ml)
251 + 12.5

Ending E. Coli after 15 minutes

Method 1603

<table>
<thead>
<tr>
<th>Treated with</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1) 50 ppm Chlorine</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2) 100 ppm Chlorine</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3) 200 ppm Chlorine</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>4) 3 ppm PAA</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>5) 20 ppm PAA</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>6) Control</td>
<td>3137 CFU</td>
<td></td>
</tr>
</tbody>
</table>
Inoculation of E. Coli to Different Treatments
Method 1603: Membrane Filtration Method
Counting Coliform Fecal Units (CFU) Indicates Presence of Fecal Material
For More Information

Jari S.K. Sugano
University of Hawaii at Manoa
College of Tropical Agriculture and Human Resources
Department of Plant and Environmental Protection Sciences
Wahiawa Extension Office
suganoj@ctahr.hawaii.edu
622-4185
Proposal: Drop surface water E.coli levels to zero

Hypothesis #1: 200 ppm is not suffice to eliminate E.coli in surface water to 0

Hypothesis #2: 3 ppm of peracetic acid is not suffice to reduce E. Coli to 0

Collection: 8/9/17, Method 1603

Start Time: 9:05 am, end time: 10:48 am

**Note: current label does not allow for shock treatment of reservoir water. Wash water rates differ.

Experiment was conducted to determine if rates would kill E.coli. Label changes would need to be pursued to explore this further.

In line treatments are acceptable for algae not pathogen control

<table>
<thead>
<tr>
<th>Method</th>
<th>PH</th>
<th>ORP</th>
<th>E.coli</th>
<th>Total Coli</th>
<th>E.coli</th>
</tr>
</thead>
<tbody>
<tr>
<td>1603</td>
<td>7.5</td>
<td>331</td>
<td>3200</td>
<td>&gt;2,419.6</td>
<td>&gt;2,419.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>SPIKED</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temp: 30.9 °C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Extracted water into a trash can and spiked with 2 bird droppings

1) Lake Wilson Water (spiked)
   Collect 30 gallons (Lake Wilson Water)
   Test starting E.coli levels
   125 ml

2) Treated with 200 ppm Multichlor
   24 hours later chlorine reading
   8/30/17: Chlorine reading
   Rate: 1 ounce into 5 gallon water: Temp: 28.7 °C

3) Treat with 500 ppm Multichlor (take 2 samples)
   24 hours later chlorine reading
   8/30/17: Chlorine reading
   Rate 2.5 oz into 5 gallons: Temp: 28.4 °C

4) Treat with 4.4 ppm Peracetic acid
   Temp: 28.5 °C

5) Treat Peracetic acid at 20 PPM
   Temp: 28.5 °C

*re-did tested at UH

**Lake Wilson Water**

125 ml

**200 PPM (CL)**

24 hours later chlorine reading
8/30/17: Chlorine reading
Rate: 1 ounce into 5 gallon water: Temp: 28.7 °C

**500 ppm**

24 hours later chlorine reading
8/30/17: Chlorine reading
Rate 2.5 oz into 5 gallons: Temp: 28.4 °C

**4.4 ppm (PAA)**

Temp: 28.5 °C

**20 ppm (PAA)**

Temp: 28.5 °C
*** Zero E.coli does not mean no other pathogens exist such as Cryptosporidium, Leptospirosis, Hepatitis A, Giardia intestinalis, etc. We submitted same sample set to Food Quality Lab to test for Salmonella kill rates. No salmonella was present at the start from Lake Wilson Water.

We conclude 200 PPM (or less) of Multichlor or 20 PPM of PAA (or less) maybe ample to reduce E. coli levels in surface water to zero, depending on H2O turbidity. Under FSMA, ag water only has to meet the criteria below. We wanted to evaluate the potential of water sanitation treatment options for growers.

Geometric mean (GM) is **126 CFU or less** of generic *E. coli* / 100 ml of water **AND**

Statistical Threshold Value (STV) is **410 CFU or less** generic *E.coli* in 100 ml/ water

We conducted a multi dose trial in a controlled lab environment to test this theory further.

Additional funding is needed to replicate this work and evaluate new label changes.

9/14/2017
Ran under controlled environment at UH Microbiology Lab (Dr. Yong Li)

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<thead>
<tr>
<th>Starting E. Coli Colony</th>
<th>3137 CFU</th>
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<tr>
<td>(251 CFU / 10 ml)</td>
<td></td>
</tr>
<tr>
<td>251 + 12.5</td>
<td></td>
</tr>
</tbody>
</table>

Method 1603

1) Treated with 50 ppm Chlorine
2) Treated with 100 ppm Chlorine
3) Treated with 200 ppm Chlorine
4) Treated with 3 ppm PAA
5) Treated with 20 ppm Chlorine
6) Control

<table>
<thead>
<tr>
<th>Ending E. Coli after 15 minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
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<tr>
<td>0</td>
</tr>
</tbody>
</table>