WASTEWATER CHARACTERIZATION IN TOMATO PACKINGHOUSES

GURPAL TOOR
MANINDER CHAHAL
BIELINSKI SANTOS
OUTLINE

- Background: Water Use and Wastewater Generation
- Study Objective
- Methods
- Results:
  - Chemical constituents of concern in wastewater
  - Evolution of metals in wastewater
  - Likely sources of metals in wastewater
- Summary/concluding thoughts
TOMATO PACKING: JOURNEY FROM FIELD TO PACKINGHOUSE

Harvested → Sanitized → Packed

**Dump Tank Water:**
Water usage for round tomato: 3,000 to 22,000 gallons/day.
Water usage for roma and grape tomato: 70 to 25,000 gallons/day.

**Other Water (Washing/Cleaning operations):**
Water requiring disposal: 50 to 4,800 gallons/day.

*Source: Steve Sargent* Options for Utilization of Tomato Packinghouse Solid Waste and Water.
WASTEWATER GENERATION

- Clean water (and Chlorine) is added in dump tanks
- Tomatoes are washed with this water all day
- Wastewater is generated
### AMOUNTS OF WASTEWATER

Total amount of water requiring disposal: **31.3 million gallons per season.**

**Source:** Steve Sargent

Options for Utilization of Tomato Packinghouse Solid Waste and Water.

<table>
<thead>
<tr>
<th>District</th>
<th>Total water/season (gal)</th>
<th>Use</th>
<th>Disposal cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3,068,968</td>
<td>50% sewage &amp; 50% sewage/ filtration</td>
<td>no report</td>
</tr>
<tr>
<td>2</td>
<td>597,800</td>
<td>100% sewer</td>
<td>no report</td>
</tr>
<tr>
<td>3</td>
<td>8,624,000</td>
<td>50% spray field &amp; 50% spray field /sewage</td>
<td>$9,000 season</td>
</tr>
<tr>
<td>4</td>
<td>18,981,200</td>
<td>83% spray field &amp; 17% septic service</td>
<td>$144,400 season</td>
</tr>
<tr>
<td>TOTAL</td>
<td>31,271,968</td>
<td></td>
<td>$154,600</td>
</tr>
</tbody>
</table>
Greatest Reported Concerns:

- Need approved locations for all discharge items
- Disposal cost
- Pending regulations will change business.
- EPA’s New Rules [Numeric Nutrient Criteria]

What is present in wastewater?

Can wastewater be discharged in surface water/municipal systems?
WASTEWATER SAMPLE COLLECTION:

- Two tomato packinghouses; Four sampling events in each packinghouse.
- Samples collected from dump tanks before beginning of packing operations and then continuously after the start of packing operation at 30-minute intervals for about 6–8 hours.

ANALYSES:

- Samples analyzed for pH, EC (salinity), chloride
- 19 metals
  - 11 metals not present (Al, As, B, Cd, Co, Cr, Mo, Mn, Ni, Pb, and Se)
  - Only 8 metals were present (P, Ca, Mg, K, Na, Cu, Zn, Fe)
PKG 1: Packing rate (Roma): 38 tons/hour. Rate of tomato addition: **55-72 seconds** per 1000 lbs (~0.5 ton). Tomato stayed in dump tanks longer.

PKG 2: Packing rate (round): 48 tons/hour. Rate of tomato addition: **29-40 seconds** for 1000 lbs (~0.5 ton). Tomato stayed in dump tanks for less time.
## WASTEWATER CHARACTERISTICS

Properties of municipal water used in the dump tanks before packing (time = 0 hours).

<table>
<thead>
<tr>
<th>PKG</th>
<th>pH</th>
<th>EC</th>
<th>Chloride</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>dS m⁻¹</td>
<td>mg L⁻¹</td>
</tr>
<tr>
<td>1</td>
<td>7.2</td>
<td>0.43</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>7.1</td>
<td>0.38</td>
<td>27</td>
</tr>
</tbody>
</table>

Properties of wastewater generated in the dump tanks at end of packing (time = 6-8 hours).

- Greater chloride in wastewater was due to the use of sanitizers (chlorine gas, chlorine dioxide) to kill pathogens
- Chloride and EC were significantly correlated (r=0.95)
- Lower chloride in PKG2 was because of automated control than PKG1 where it was manually maintained
<table>
<thead>
<tr>
<th>Parameters</th>
<th>Packinghouse 1</th>
<th></th>
<th>Packinghouse 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
<td>Wastewater</td>
<td>Water</td>
<td>Wastewater</td>
</tr>
<tr>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>0.27</td>
<td>5.7</td>
<td>0.21</td>
<td>2.8</td>
</tr>
<tr>
<td>Cu</td>
<td>0.01</td>
<td>2.2</td>
<td>0.01</td>
<td>1.9</td>
</tr>
<tr>
<td>Zn</td>
<td>0.13</td>
<td>0.3</td>
<td>0.11</td>
<td>0.1</td>
</tr>
<tr>
<td>Ca</td>
<td>34</td>
<td>59</td>
<td>34</td>
<td>55</td>
</tr>
<tr>
<td>Mg</td>
<td>16</td>
<td>25</td>
<td>15</td>
<td>21</td>
</tr>
<tr>
<td>K</td>
<td>6</td>
<td>49</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>Fe</td>
<td>0.02</td>
<td>0.8</td>
<td>0.02</td>
<td>0.1</td>
</tr>
</tbody>
</table>

- Greatest increase in P and Cu concentrations in wastewater; these were above the surface water quality standards.
EFFECT OF AMOUNT OF TOMATOES WASHED ON WASTEWATER QUALITY

Tomatoes washed (tons)
0 50 100 150 200 250 300 350
EC (dS/m)
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
Chloride (mg/L)
0
200
400
600
800
1000
1200
1400
1600

Packinghouse 1

Packinghouse 2

• EC and chloride increased linearly with washing of tomatoes with higher magnitude in PKG 1 than PKG 2.
Concentrations of bacteria were very low in all dump tank samples. None of the samples were positive for *Salmonella* spp. or *E. coli O157:H7*. Data from Bonilla and Toor (2009). Tomato Institute Proceedings.
P and cations increased linearly with the washing of tomatoes.

Concentrations of all elements were higher in PKG 1 than PKG 2.
Copper increased linearly with the washing of tomatoes.

Zinc increased more in PKG 1 than PKG 2.
### IMPORTANCE OF CONTACT TIME OF TOMATOES WITH DUMP TANK WATER

<table>
<thead>
<tr>
<th></th>
<th>Packing rate</th>
<th>Rate of tomato addition</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>PKG 1</td>
<td>38 tons/hour</td>
<td>55-72 seconds/1000 lbs</td>
<td>More interaction of tomatoes with dump tank water</td>
</tr>
<tr>
<td>PKG 2</td>
<td>48 tons/hour</td>
<td>29-40 seconds/1000 lbs</td>
<td>Less interaction of tomatoes with dump tank water</td>
</tr>
</tbody>
</table>


## LIKELY SOURCES OF P AND CU IN WASTEWATER?

### External factors: residues on tomatoes, plant debris?

<table>
<thead>
<tr>
<th>Source</th>
<th>Purpose</th>
<th>Days to harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organo-P insecticides-</td>
<td>Control insects like aphids, drosophila, mites, earthworms, leaf miners, whiteflies</td>
<td>1–7</td>
</tr>
<tr>
<td>a) Dimethoate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Malathion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Methadiphos</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicides</td>
<td>Powdery mildew, Phytophthora, Pythium species</td>
<td>1</td>
</tr>
<tr>
<td>Mono and di-K salts of</td>
<td></td>
<td></td>
</tr>
<tr>
<td>phosphorus acid</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cu</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fungicides; Copper hydroxide</td>
<td>Anthracnose, early blight, late blight</td>
<td>1–2</td>
</tr>
<tr>
<td>Micronutrients-foliar spray;</td>
<td>Cu deficiency in plant tissue (&lt;5 mg kg(^{-1})) on dry wt. basis</td>
<td>-</td>
</tr>
<tr>
<td>Copper sulfate</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Internal factors: wastewater chemistry, especially high chloride may scour damaged culls and release soluble P from tomatoes?
In addition to tomatoes, chloride can affect the concentration of P.
SUMMARY

- Chloride, P, and Cu elevated in wastewater.
- High chloride in wastewater due to reaction of chlorine sanitizers with water (hydrolysis). Increase in chloride increased EC in wastewater.
- Dechlorination may be needed if Chloride levels are higher in wastewater (~>160-200 mg/L).
- P and Cu much greater in wastewater and will impose restrictions on wastewater disposal.
- Likely sources of P in wastewater are (1) residues of pesticides containing P on tomatoes and (2) dump tank chloride level.
- Residues of Cu fungicides on tomatoes may be the likely source of Cu in wastewater.
TAKE HOME MESSAGE

- Wastewater needs to be treated to remove P and Cu before discharging to surface waters/municipal systems.
- Potential treatment options to remove P and Cu may include use of chemical amendments such as alum (aluminum sulfate), ferrous chloride.
- Future research should:
  - Identify sources of P and Cu in wastewater and ways to decrease there levels (Field BMPs?).
  - Evaluate ways to decrease chlorine use (automation?).
  - Develop/test a cost-effective small scale pilot treatment system using Fe and Al amendments to remove metals from wastewater.
ACKNOWLEDGEMENTS

- Co-operation from Tomato Packinghouse Personnel and Florida Tomato Committee (Reggie Brown).
- Funding support from U.S. Environmental Protection Agency (Contract # X9-95400608-0).