Pushing the Limits: Challenges of Compliance with Ohio EPAs TDS Regulations

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Columbus, OH

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Presentation Summary

• Introduction

• Current Regulations in Ohio
  • Residue, Total Filterable (i.e. Total Dissolved Solids (TDS))
  • Acute Toxicity $TU_a$
  • Chronic Toxicity $TU_c$

• Other States
  • Ion Specific Limits

• Case Studies / Compliance Strategies
Ohio EPA Permit Limits (NPDES Permits)

- TDS limits are intended to keep the receiving stream TDS concentration less than 1,500 mg/l based on 7Q\textsubscript{10} (seven day, ten year low flow)

- The larger the stream, the less stringent the concentration limit is:
  - For zero flow or intermittent streams (where 7Q\textsubscript{10} is zero), then permit limit is 1,500 mg/l (based on chronic toxicity)
  - For very large streams / rivers, TDS impacts will be small and practically not limited
Recent Ohio EPA Permit Actions

• Some Recent WWTP NPDES permit renewals have been given new compliance and/or monitoring parameters:
  • Residue, Total Filterable (TDS)
  • Acute Toxicity
  • Chronic Toxicity
  • Stream Mussel Study Requirements
# Example of New NPDES Permit

<table>
<thead>
<tr>
<th>Effluent Characteristic</th>
<th>Discharge Limitations</th>
<th>Monitoring Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Concentration</td>
<td>Loading* kg/day</td>
</tr>
<tr>
<td></td>
<td>Maximum Minimum Weekly Monthly Daily Weekly Monthly</td>
<td>Frequency</td>
</tr>
<tr>
<td>39100 - Bis(2-ethylhexyl) Phthalate - ug/l</td>
<td>1112</td>
<td>8.4</td>
</tr>
<tr>
<td>50050 - Flow Rate - MGD</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>50092 - Mercury, Total (Low Level) - mg/l</td>
<td>1700</td>
<td>-</td>
</tr>
<tr>
<td>61425 - Acute Toxicity, Ceriodaphnia dubia - TUa</td>
<td>1.0</td>
<td>-</td>
</tr>
<tr>
<td>61426 - Chronic Toxicity, Ceriodaphnia dubia - TUs</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>61427 - Acute Toxicity, Pimephales promelas - TUa</td>
<td>1.0</td>
<td>-</td>
</tr>
<tr>
<td>61428 - Chronic Toxicity, Pimephales promelas - TUs</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>61941 - pH, Maximum - S.U.</td>
<td>9.0</td>
<td>-</td>
</tr>
<tr>
<td>61942 - pH, Minimum - S.U.</td>
<td>-</td>
<td>6.5</td>
</tr>
<tr>
<td>70300 - Residue, Total Filterable - mg/l</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>80082 - CBOD 5 day - mg/l</td>
<td>-</td>
<td>15</td>
</tr>
<tr>
<td>80082 - CBOD 5 day - mg/l</td>
<td>-</td>
<td>40</td>
</tr>
</tbody>
</table>

This is clearly discharging into a small ditch/stream (1,504 mg/l TDS limit)
Typical Testing for TDS

• Acute / Chronic toxicity testing for TDS typically involves testing with:
  • Ceriodaphnia dubia (water flea)
  • Pimephales promelas (fathead minnows)
Ceriodaphnia dubia (C.dubia) “Water Flea”

• Acute Toxicity
  • Observations – mortality rates are recorded with % effluent concentrations.
  • Some Test Features:
    • Duration < 48 hours
    • Age: < 24 hours old
    • Minimum of 20 organisms per sample concentration in 4 replicates of 5 organisms per sample.

• Chronic Toxicity
  • Observations:
    • mortality rates are recorded with % effluent concentrations.
    • Reproduction are recorded.
  • Some Test Features:
    • Up to 7 days.
    • Age < 24 hours and all neonates must have been released within 8 hours of each other.
    • Three samples sets and solutions renewed using those every 24-hours.
    • Minimum of 10 organisms per sample concentration in 10 replicates with 1 organism per sample.

Source: http://mblaquaculture.com/content/organisms/daphnids.php
**Pimephales promelas (P.promelas) “Fathead Minnow”**

- **Acute Toxicity**
  - Observations – mortality rates are recorded with % effluent concentrations.
  - Some Test Features:
    - Duration 48 - 96 hours
    - Age: 1 – 14 days old (e.g. 8 days)
    - Minimum of 10 organisms per sample concentration in 2 replicates of 10 organisms per sample.

- **Chronic Toxicity**
  - Observations:
    - mortality rates are recorded with % effluent concentrations.
    - Survival and weight to larvae also recorded.
  - Some Test Features:
    - Up to 7 days.
    - Age 24 - 48 hours fish larvae.
    - Three samples sets and solutions renewed using those every 24-hours.
    - Minimum of 40 organisms per sample concentration in 4 replicates with 10 organism per sample.

Source:
http://mblaquaculture.com/content/organisms/pimephales_promelas.php
Acute Toxicity - Example

- TUa = 100 / LC50
- LC50 = Lethal Concentration to 50% of the population (50% dead).

Control 0% Eff.  | Sample 6.25%  | Sample 12.5%  | Sample 25%  | Sample 50%  | Sample 100%
---|---|---|---|---|---
0% dead  | 0% dead  | 0% dead  | 10% dead  | 20% dead  | 50% dead

- Above, the LC50 = 100% effluent; TUa = 100/100 = 1.0
Acute Toxicity - Example

- TUa = 100 / LC50
- LC50 = Lethal Concentration to 50% of the population (50% dead).

<table>
<thead>
<tr>
<th>Sample</th>
<th>0% Eff.</th>
<th>6.25%</th>
<th>12.5%</th>
<th>25%</th>
<th>50%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>40%</td>
<td>60%</td>
<td>75%</td>
</tr>
<tr>
<td>0% dead</td>
<td>0% dead</td>
<td>0% dead</td>
<td>40% dead</td>
<td>60% dead</td>
<td>75% dead</td>
<td></td>
</tr>
</tbody>
</table>

- If LC50 realized between test sample concentrations, then interpolation. Above, the LC50 ~ 37.5%, TUa = 100/37.5 = 2.67

- If LC50 not realized with 100% effluent, then reported as fractional value estimated. If 100% effluent = 30% dead, then TUa = 0.60.
**Chronic Toxicity - Example**

- \( TUc = 100 / IC25 \).

- \( TUc = \frac{100}{\sqrt{NOEC \times LOEC}} \) for *C. dubia* ("water flea").

- **NOEC** = No Observed Effect Concentration – highest concentration without observed effects.

- **LOEC** = Lowest Observed Effect Concentration – lowest concentration with observed effects.

- **IC25** = Inhibition Concentration of 25% of reproduction or growth

- As in acute toxicity, the dilution series of 0% (control), 6.25%, 12.5%, 25%, 50%, and 100% effluent are also used for chronic toxicity.  [Example: If IC25 = 85%, then TUc = 100/85 = 1.18]
OAC 3745-1-04: Criteria applicable to all waters

The following general water quality criteria shall apply to all surface waters of the state including mixing zones… shall be:

A. Free from suspended solids …. that will settle to form putrescent or otherwise objectionable sludge deposits, or that will adversely affect aquatic life;

B. Free from floating debris, oil, scum and other floating materials …. to be unsightly or cause degradation;

C. Free from materials entering the waters … producing color, odor or other conditions in such a degree as to create a nuisance;

D. **Free from substances** entering the waters … in concentrations that are **toxic or harmful** to human, animal or **aquatic life** and/or are rapidly lethal in the mixing zone;

E. Free from nutrients entering the waters … that create nuisance growths of aquatic weeds and algae…

F. Free from public health nuisances associated with raw or poorly treated sewage…
Federal Requirements (adopted by the state)

• 40 CFR Sections 124.8 and 124.56 Require a Fact Sheet be prepared for receiving stream with pertinent data
  • Fact Sheet must contain data used in determining permit limits (flows, toxicity test data, background concentrations, etc.)
## Typical Creek – Background Data (from Fact Sheet)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Units</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Dissolved Solids</td>
<td>mg/L</td>
<td>430</td>
</tr>
<tr>
<td>Hardness</td>
<td>mg/L as CaCO₃</td>
<td>370</td>
</tr>
<tr>
<td>pH</td>
<td>SU</td>
<td>8.0</td>
</tr>
<tr>
<td>Annual 7Q10</td>
<td>cfs</td>
<td>0.61</td>
</tr>
<tr>
<td>Summer 30Q10</td>
<td>cfs</td>
<td>0.71</td>
</tr>
<tr>
<td>Winter 30Q10</td>
<td>cfs</td>
<td>1.71</td>
</tr>
</tbody>
</table>
Background Levels of TDS

• Vary by location within the state – but tend to be higher in NW Ohio and Central Ohio

• Previous work has defined the Aquatic Life Water Quality Standard at 1,500 mg/l outside of the mixing zone
## TDS Variations By Region

### 50th percentile reference site stream data for all size streams in Ohio

<table>
<thead>
<tr>
<th>Ecoregion</th>
<th>TDS (mg/l)</th>
<th>% of TDS that is:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Sulfate</td>
</tr>
<tr>
<td>IP</td>
<td>306</td>
<td>12%</td>
</tr>
<tr>
<td>WAP</td>
<td>344</td>
<td>27%</td>
</tr>
<tr>
<td>EOLP</td>
<td>408</td>
<td>15%</td>
</tr>
<tr>
<td>ECBP</td>
<td>439</td>
<td>15%</td>
</tr>
<tr>
<td>HELP</td>
<td>478</td>
<td>17%</td>
</tr>
<tr>
<td><strong>All</strong></td>
<td><strong>420</strong></td>
<td><strong>16%</strong></td>
</tr>
</tbody>
</table>

### Ecoregions:
- **IP** – Interior Plateau
- **WAP** – Western Alleghany Plateau
- **EOLP** – Erie/Ontario Lake Plain
- **ECBP** – Eastern Corn Belt Plain
- **HELP** – Huron/Erie Lake Plain

*Data Source: Ohio EPA, Miltner, 10/2011*
Toxicity Limitations by District

- List of Ohio NPDES Permits that have Chronic and/or Acute Monitoring OR Limits were obtained from Ohio EPA.
- Total List of Direct Permits were estimated from Ohio EPA website.
- Approximately 20% of all NPDES permits now have TUₐ or TUₐ “action”.

<table>
<thead>
<tr>
<th>District</th>
<th>Total Permits</th>
<th>Acute Monitoring</th>
<th>Chronic Monitoring</th>
<th>Acute Limits</th>
<th>Chronic Limits</th>
<th>% with TUₐ Or TUₐ</th>
</tr>
</thead>
<tbody>
<tr>
<td>SE</td>
<td>520</td>
<td>69</td>
<td>11</td>
<td>19</td>
<td>0</td>
<td>19.0%</td>
</tr>
<tr>
<td>SW</td>
<td>526</td>
<td>64</td>
<td>47</td>
<td>4</td>
<td>1</td>
<td>22.1%</td>
</tr>
<tr>
<td>NW</td>
<td>782</td>
<td>80</td>
<td>54</td>
<td>16</td>
<td>14</td>
<td>21.0%</td>
</tr>
<tr>
<td>NE</td>
<td>1034</td>
<td>85</td>
<td>71</td>
<td>22</td>
<td>18</td>
<td>19.0%</td>
</tr>
<tr>
<td>C</td>
<td>332</td>
<td>34</td>
<td>29</td>
<td>5</td>
<td>1</td>
<td>20.8%</td>
</tr>
<tr>
<td>Totals</td>
<td>3194</td>
<td>332</td>
<td>212</td>
<td>66</td>
<td>34</td>
<td>20.2%</td>
</tr>
</tbody>
</table>
NPDES Permits by District*

* Approximate
Ohio’s Future TDS criteria

• Future TDS criteria for Ohio might be:
  • Ion specific
  • Ecoregion specific
  • A function of alkalinity

• Equations have been developed by Ohio EPA and are currently under internal and USEPA review

  (while not official, the equations do seem to “allow” higher TDS concentrations than recent discussions of 600-800 mg/l)
Other States – Revised Approach

Sulfate Limits
Indiana and Illinois

Chloride
- <5
- 5
- 10
- 15
- 20
- 25
- 50
- 100
- 150
- 200
- 230

Sulfate Limit (mg/l)

Hardness (mg/l)
<100 100 150 200 250 300 350 400 450 500 500+

One Water Conference – August 2014 – Columbus, Ohio
Other States – Revised Approach

Chloride Limits
Indiana and Iowa

Chloride Limit (mg/l)

Hardness (mg/l)

Sulfate
- 50
- 100
- 150
- 200
- 250
- 300
- 400
- 500
- 600
- 700
- 800
- 900
- 1000
Case Study - Pickerington, Ohio

• **Water Treatment Plant:**
  - 3.5 MGD – Iron / Mn Removal
  - Oxidation, Filtration, Ion Exchange Softening

• **Wastewater Treatment Plant:**
  - 3.2 MGD – Activated Sludge

**WWTP TDS Compliance Issues**
TDS Reduction Alternatives

A total of 13 alternatives were identified to reduce the TDS concentration at the WWTP (8 were considered feasible)

1. Adjustment of Softener Operation
2. Replacement or cleaning of Softener Media
3. Replace Ion Exchange Softeners with Reverse Osmosis
4. Reduce Level of Softening (to 195 mg/l)
5. Dilution Well at WWTP (flow augmentation)
6. Public Relations Strategies (Reduce In-home Softening)
7. Alt. Water Supply for Unsewered Customers
8. Purchasing Water during Peak Months
TDS Alternatives Ruled Out

The following alternatives were ruled out due to cost, technical, or political reasons:

9. Deep Well Injection
10. Evaporation Ponds (not feasible in Ohio)
11. Land Application of Ion Exchange Residuals
12. Relocation of WWTP Effluent
13. Bypassing Softening During Peak Months
Pickerington WTP

New Reverse Osmosis Treatment Installed in place of some existing filter/softening equipment – in 5 months!
Pickerington WTP

Immediate WWTP TDS Compliance

City of Pickerington
WWTP Effluent TDS
Case Study - Delaware, Ohio WTP

- Proposed Integrated Membrane Plant (Bin 2 classification)
- Olentangy River, USGS Gauge

Magnitude and frequency of low flow for indicated periods

<table>
<thead>
<tr>
<th>Period</th>
<th>Number of consecutive days</th>
<th>Streamflow (ft³/s) for indicated recurrence interval (years)</th>
<th>Period</th>
<th>Number of consecutive days</th>
<th>Streamflow (ft³/s) for indicated recurrence interval (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2</td>
<td>5</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>Apr.-Mar.</td>
<td>1</td>
<td>9.2</td>
<td>5.0</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>13</td>
<td>7.6</td>
<td>5.7</td>
<td>4.4</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>19</td>
<td>12</td>
<td>10</td>
<td>8.9</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>35</td>
<td>19</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>May-Nov.</td>
<td>1</td>
<td>12</td>
<td>7.1</td>
<td>5.2</td>
<td>3.9</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>15</td>
<td>9.4</td>
<td>7.2</td>
<td>5.7</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>19</td>
<td>13</td>
<td>11</td>
<td>9.3</td>
</tr>
<tr>
<td></td>
<td>90</td>
<td>36</td>
<td>20</td>
<td>16</td>
<td>14</td>
</tr>
</tbody>
</table>

- $7Q_{10}$ is 5.7 ft³/sec in this case in critical quarter
Case Study: Delaware WTP
RO Discharge Control Strategy

- Obtained approval for a Hydrograph-Controlled discharge permit (rarely approved by Ohio EPA).
- The in-stream concentrations could only be met when the river flow was > 24 cfs ($7Q_{10} = 5.7$ cfs).
- If river is < 24 cfs:
  - Divert concentrate to old lagoons (19 days of storage).
  - Then, pump to sanitary sewer via an existing unused 16” waterline saving the City $\$. 
  - Finally, reduce or stop softening of GW.
- Used USGS gauging station, inline conductivity meters and custom SCADA programming to optimize discharge flow to river at all times.
Case Study - Delaware WTP

Delaware WTP
NPDES Permit (17 Tiers - based on River Flow)
TDS (kg/day) vs. CFS

Olentangy River Flow (CFS)
Case Study – Industrial WWTP (NE)

• WWTP discharged to a tributary to a small creek ($7Q_{10} = 0$). Therefore, TDS “limit” is 1,500 mg/l (unattainable for this WWTP)

• Solution: Relocate the outfall to larger stream (4,500 lf force main)

• Complication: $7Q_{10}$ was available from Ohio EPA for a location upstream of proposed discharge [0.38 cfs based on 5.6 mi² area]
  • Measured new drainage area and got new $7Q_{10}$ (i.e. twice the area is twice the base minimum flow (say 11.2 mi² ~ 0.76 cfs)
Case Study – Industrial WWTP

• More compliance strategies used for TDS compliance (same WWTP as previous slide):
  1. Flow augmentation:
     a) Well was constructed to dilute TDS discharge
     b) Compliance for TDS (and Temperature)
  2. In-Stream Conductivity Monitoring
  3. Reduction of TDS in Process
  4. Replacing ion exchange with reverse osmosis (for water supply)
Case Study – Marysville, OH WTP

- New RO WTP Proposed
- Low Flows in Mill Creek ($7Q_{10}$: 0.26 CFS)

**Integrated Solutions**

- Dilute RO Concentrate with Raw Reservoir Water
- Dilute RO Concentrate with Well Water (but high hardness)
- Alternative RO System Design (treat most SW water, minimize RO treatment of high TDS (1,200 mg/l) GW)
- Site Specific Criteria: OAC 3745-1-35 allows site specific limits
- Other alternatives (perhaps future)
  1. Treatment of RO Concentrate (Lime softening, etc)
  2. Match Production when stream flow can handle (ASR)
Case Study – Marysville, OH WTP

If only could make most of the water when the stream could handle the RO concentrate……

Aquifer Storage and Recovery (ASR) could be a viable solution..
Case Study – Marysville, OH WTP

Site Specific Criteria: OAC 3745-1-35 allows site specific limits.

• URS Estimated Proposed RO concentrate using “worst case” cocktail (using higher sulfate water)

• GLEC, with assistance from University of Illinois (Dr. David Riecks-Soucek) showed that IC$_{25}$ of the lab-produced concentrate was toxic above 1,412 mg/l (approximately what the current law mandates)

• Further testing using actual RO concentrate expected to yield IC$_{25}$ above 1,800 mg/l or higher
Other Test Results - Inconsistent

• RO concentrates with TDS > 3,000 mg/l have passed the acute toxicity standards in cases

• RO concentrates with lower TDS (<1800 mg/l) have “failed” acute toxicity testing (i.e. TUₐ > 1.0)

Table 5. Percent cumulative mortality, LC₅₀, EC₅₀, and 95% confidence intervals for acute toxicity tests using Ceriodaphnia dubia and Pimephales promelas using effluent collected from Outfall 001.

<table>
<thead>
<tr>
<th>Concentration</th>
<th>C. dubia (water flea)</th>
<th>P. promelas (fathead minnow)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24-hours mortality (% affected)</td>
<td>48-hours mortality (% affected)</td>
</tr>
<tr>
<td>MHRW, effluent</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>DMW</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>0.25% effluent</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>12.5% effluent</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>25% effluent</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>50% effluent</td>
<td>0 (0)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>100% effluent</td>
<td>0 (0)</td>
<td>95 (95)</td>
</tr>
<tr>
<td>LC₅₀</td>
<td>&gt;100% effluent</td>
<td>72.01% effluent</td>
</tr>
<tr>
<td>EC₅₀</td>
<td>&gt;100% effluent</td>
<td>72.01% effluent</td>
</tr>
<tr>
<td>95% C.I.</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>TUs (100-LC₅₀)</td>
<td>1.39</td>
<td>AA</td>
</tr>
</tbody>
</table>

Methods: CT-TOX, Spearman-Karber.
Summary

• Some states (Iowa, Illinois, Indiana) have rescinded TDS regulations for ion specific limits
• Ohio’s current “TDS” limits are still 1,500 mg/l (in-stream)
• Acute and Chronic toxicity will likely end up in future permits for certain dischargers
• Mayfly (*Centroptilum triangulifer*) toxicity may be utilized in future
• University of Illinois, US EPA Region V and others still studying toxicity with GREAT interest
• There are still many techniques to maintain compliance with TDS regulations (in Ohio)
Any Questions?

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