Diagnostic Tools to Evaluate Impacts of Trace Organic Compounds on Aquatic Populations and Communities
Tt Project Team

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WERF Research Challenge

- Understand, manage, and communicate perceived and potential risks of trace organic compounds (TOrCs)
- Focus on TOrCs in surface waters from point and non-point sources
- Coordinate with other organizations
Trace Organic Compounds - TOrCs

✓ Organic compounds known or suspected to be released to the aquatic environment

✓ Not commonly regulated or monitored

✓ Potential risk to ecological health relatively unknown
Research Objectives

- Develop and apply a procedure to prioritize TOrCs
- Develop and test diagnostic tools to identify TOrCs by source type
- Develop a relational database of TOrC exposure data
- Develop a Collaboration Plan for fostering partnerships among stakeholders in Phase 2
Project Focus

- Organic contaminants of emerging concern
- Surface water only
- Ecological, not human health
- Wastewater-influenced sites
- Effects on aquatic populations and communities
TOrC Prioritization Approach

Compile:

- TOrC occurrence data
- TOrC fate information (ECOSAR, PBT Profiler)
- Predicted toxicity and endocrine activity thresholds (ECOSAR, PBT Profiler, EU, FDA)
Prioritized TOrCs based on either:

1) Maximum observed concentration vs. conservative effect thresholds

2) Max vs. thresholds + persistence and bioaccumulation potential

3) PBT – not occurrence-based
Occurrence Data

- > 100 studies examined; 70 studies used
- Information from > 700 sites
- Over 500 TOrCs, including 48 high risk, high production volume TOrCs (Muir, et al 2009) with no occurrence information
- > 30 monitoring organizations represented
Types of High Priority TOrCs by Approach

- **Risk**
  - Deodorizer/Fragrance: 17%
  - Flame Retardant: 37%
  - Industrial Chemical: 5%
  - Natural Hormone/Steroid: 8%
  - PAH: 6%
  - Personal Care Product: 8%
  - Pharmaceutical: 10%
  - Plasticizer: 15%
  - Pesticide: 2%
  - Surfactant: 7%

- **Risk + P + B**
  - Deodorizer/Fragrance: 39%
  - Flame Retardant: 13%
  - Industrial Chemical: 2%
  - Natural Hormone/Steroid: 5%
  - PAH: 3%
  - Personal Care Product: 10%
  - Pharmaceutical: 2%
  - Plasticizer: 8%
  - Pesticide: 13%
  - Surfactant: 5%

- **P + B + T**
  - Deodorizer/Fragrance: 8%
  - Flame Retardant: 13%
  - Industrial Chemical: 3%
  - Natural Hormone/Steroid: 6%
  - PAH: 2%
  - Personal Care Product: 6%
  - Pharmaceutical: 8%
  - Plasticizer: 24%
  - Pesticide: 15%
  - Surfactant: 13%
## High priority TOrCs that are monitored infrequently

<table>
<thead>
<tr>
<th>Substance</th>
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<tbody>
<tr>
<td>3-methylcholanthrene</td>
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<tr>
<td>4-nonylphenol diethoxycarboxylate</td>
</tr>
<tr>
<td>4-nonylphenol monoethoxycarboxylate</td>
</tr>
<tr>
<td>Acetyl cedrene</td>
</tr>
<tr>
<td>Benfluralin</td>
</tr>
<tr>
<td>Celestolide (ADBI)</td>
</tr>
<tr>
<td>Clotrimazole</td>
</tr>
<tr>
<td>Di-N-octyl phthalate</td>
</tr>
<tr>
<td>Musk xylene</td>
</tr>
<tr>
<td>Novobiocin</td>
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<tr>
<td>Oryzalin</td>
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<td>OTNE</td>
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Results: Risk-based Prioritization Approach

- Few pharmaceuticals ranked as high priority based on either predicted toxicity or endocrine activity thresholds
  - Exceptions are steroids and hormones
Results: Risk-based Prioritization Approach

Most sensitive endpoint is predicted chronic toxicity rather than estrogenic activity for most high priority TOrCs.

- Exceptions are the few hormones.
Lists of high priority TOrcs should **not** be taken as monitoring requirements or chemicals for regulation.

Prioritization approaches should help utilities and others organize and manage screening of TOrcs.
DIAGNOSTIC SCREENING TOOL DEVELOPMENT
Challenges

- TOrCs often co-occur with less subtle stressors (e.g., habitat modification, nutrients)
- Link between EDC effects on individual organisms and population / community level effects not clear
- Mode of action unknown for many TOrCs
Under what types of site conditions do TOrCs pose a risk to aquatic populations and communities?
Do TOرCs measured in effluent pose a risk to aquatic populations and communities?

Predictive/risk assessment
Do we find effects when TOرCs are elevated?
Two General Approaches

- **Screening assessment:**
  - Develop relationships between certain types of sources (e.g., POTW effluent) and biological effects
  - Infer TOrC effect using exposure models

- **Diagnostic risk assessment:**
  - Evaluate high priority TOrCs first
  - Use causal analysis tools (e.g., CADDIS)

- **Both approaches work together.**
Screening Approach

**Influent factors:**
- population size and age distribution;
- types of inputs (e.g., hospital contribution)

**Treatment factors:**
- Type of treatment;
- treatment performance;
- effluent consistency;
- frequency of upsets

**Site factors:**
- barriers to organism movement;
- refugia present;
- sensitive species;
- pH, temp;
- effluent dilution

**Site observations:**
- fish intersex frequency;
- tissue hormone concentrations;
- TOrC data;
- population/community impairment

**TOrCs predicted to pose risk to aquatic life?**
DIAGNOSTIC RISK ASSESSMENT
EXPOSURE

Predicted concentration of TOrCs

Measured concentration of TOrCs

Group TOrCs by MOA or class

Calculate toxicity or EDC effect

Priority TOrC exposure

Habitat impairment*
Legacy toxics*
Inorganic toxics*
Invasive species*
Excess Nutrients

Sources
Fate
Treatability

Prospective
Retrospective

Other stressors

* Not readily predicted – usually must be measured at site
EFFECTS

Measured biological condition

Community & Assemblage Indicators

Causal analysis: Determine if TOrCs pose risk

Organism Indicators

Sub-organism Indicators

Priorit TOrC exposure regime

Predict biological risk

SSDs ecosystem models

Population models Ecotox Ecosar

EDC/biomarker thresholds

Detemine if TOrCs pose risk

Prospective Retrospective
Coordination and Collaboration are Key

- California water re-use CEC prioritization
- Int’l Joint Commission of Great Lakes Survey
- Florida micro-constituent evaluations
- USGS-NAWQA 3rd decade CEC prioritization
- Canadian Water Network CEC prioritization
- EPA – POTW surveys; fish tissue surveys
- EU EDC prioritization
Next Steps

- Evaluate example case studies using screening and diagnostic framework
- Develop hypotheses that should be tested in Phase 2
- Build collaborations & partnerships for Phase 2