2020 RMP ANNUAL MEETING

Quaternary Ammonium Disinfectant Chemicals in Wastewater and the Bay

Miguel Mendez
About Me

- MS in Environmental Engineering
  - Studied saltwater intrusion effects on wastewater treatment at SEP
- Joined SFEI in January 2020
Outline

❖ Quaternary Ammonium Compounds?
  ➢ QACs and COVID-19
❖ Environmental Pathways and Fate
  ➢ Sediment
❖ Current and Future Directions
  ➢ Wastewater
  ➢ Stormwater
Outline

❖ Quaternary Ammonium Compounds?
  ➢ QACs and COVID-19

❖ Environmental Pathways and Fate
  ➢ Sediment

❖ Current and Future Directions
  ➢ Wastewater
  ➢ Stormwater
QACs are all around us
QACs are all around us
QACs are all around us
➢ Benzalkonium chloride
➢ End in “ammonium chloride”
Benzalkyl Dimethylammonium Compounds (BACs)

Dialkyl Dimethylammonium Compounds (DADMACs)

\[
\begin{align*}
\text{N}^+ & - \text{C}_n\text{H}_{(2n+1)} \\
\end{align*}
\]

\[
\begin{align*}
\text{N}^+ & - \text{C}_n\text{H}_{(2n+1)} \\
\end{align*}
\]

\(n = 12, 14, 16, 18, 20\)
QACs used against COVID-19

100% contain BAC and/or DADMAC

- Chlorine: 216 (50.2%)
- H2O2: 68 (15.8%)
- Other: 60 (14.0%)
- Other: 86 (20.0%)

List N: Disinfectants for Use Against SARS-CoV-2 (COVID-19)
Toxicity

❖ Aquatic Life
➢ Plants and invertebrates - most sensitive
➢ Limited toxicity to benthic organisms
➢ Persistent

❖ Human Health
➢ Antibiotic resistance

❖ More studies needed!
Outline

❖ Quaternary Ammonium Compounds?
  ➢ QACs and COVID-19

❖ Environmental Pathways and Fate
  ➢ Sediment

❖ Current and Future Directions
  ➢ Wastewater
  ➢ Stormwater
QACs in Bay Surface Sediment

Recent pro-bono study by Dr. Bill Arnold (U of Minnesota)

- 7 QACs detected at 11 sites
- Greatest sum of QACs detected in Grizzly Bay, then Lower South Bay
QACs in Bay Surface Sediment

- BAC-C18 was most detected (9 sites)
- DADMAC-C18 had highest concentrations (830 ng/g)
  - Low recovery rates

\[ \text{Chemical Structures} \]

\[ n = 12, 14, 16, 18, 20 \]
QACs in Sediment Cores

➢ Collected in 2011 from Central Bay
➢ Spans roughly 60 years (1951-2009)
➢ Same 7 QACs detected
➢ DADMAC-C18 had the highest concentration
  – Nearly 50x greater than BAC-C18
Sediment Core Data

<table>
<thead>
<tr>
<th>Sediment Layer (top to bottom; cm)</th>
<th>Concentration of BAC-C18 (ng/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-4</td>
<td>2009</td>
</tr>
<tr>
<td>8-10</td>
<td>1994</td>
</tr>
<tr>
<td>12-14</td>
<td>1971</td>
</tr>
<tr>
<td>16-18</td>
<td>1971</td>
</tr>
<tr>
<td>20-22</td>
<td>61</td>
</tr>
<tr>
<td>24-26</td>
<td>1951</td>
</tr>
</tbody>
</table>
### CECs in San Francisco Bay

<table>
<thead>
<tr>
<th>High Concern</th>
<th>Moderate Concern</th>
<th>Low Concern</th>
<th>Possible Concern</th>
</tr>
</thead>
<tbody>
<tr>
<td>moderate or</td>
<td>low</td>
<td>limited</td>
<td>uncertainty as to</td>
</tr>
<tr>
<td>high impact</td>
<td></td>
<td></td>
<td>impact</td>
</tr>
<tr>
<td>None currently</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PFAS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alkylphenols, Alkylphenol Ethoxylates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fipronil, Imidacloprid, Bisphenols</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organophosphate Esters, Microplastics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBDEs and HBCD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pharmaceuticals, Pyrethroids*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal Care &amp; Cleaning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBDDs / PBDFs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative Flame Retardants</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pesticides, Plastic Additives, QACs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Siloxanes, SDPAs, UV-BZTs, others</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Outline

❖ Quaternary Ammonium Compounds?
  ➢ QACs and COVID-19
❖ Environmental Pathways and Fate
  ➢ Sediment
❖ Current and Future Directions
  ➢ Wastewater
  ➢ Stormwater
Inhibition of Activated Sludge Processes
QACs in Wastewater

➢ Study on influent, effluent, and biosolids
  ○ EBMUD, SJSC, and Palo Alto

➢ Tracking temporal trends related to COVID-19
  ○ Samples archived from early 2020

➢ Sediment samples from Grizzly Bay also included
Stormwater

➢ Understanding as a pathway
➢ Screening a few samples
Future Directions

➢ Periodic monitoring of QACs
➢ Understanding of sources and pathways
Summary

➢ QACs are present all around us
➢ Further studies needed to determine presence and negative effects
➢ Consider alternatives
   – Check for “-ammonium chlorides”

Safer COVID-19 cleaning products and disinfectants
Thank you for listening!

Any Questions?