Overview

• Background Information
• Analytical Methods
• Experimental Design
• Results
• Conclusions & Recommendations
• Acknowledgments
• Questions?
Soil-Aquifer Treatment (SAT)

- Secondary treatment
- Multi-media filtration (tertiary treatment)
- Disinfection
- Surface Spreading Basins

Steroids

- **What are steroids?**
  - Endocrine Disrupting Compounds (EDCs)
- **What effects do they cause?**
  - Feminization, vitellogenin induction
- **What concentrations cause adverse effects?**
  - As low as 1 ng/L
- **What concentrations are steroids present at in wastewater?**
  - 1 to 10 ng/L
Mechanisms of Removal

- Study wastewater mechanisms
  - Adsorption to biosolids
  - Biodegradation
  - Photolytic Degradation

- Removal of bulk & nutrients during SAT

<table>
<thead>
<tr>
<th>Compound</th>
<th>Molecular Weight</th>
<th>Water Solubility (mg/L)</th>
<th>Log $K_{ow}$ (octanol-water partition coefficient)</th>
<th>Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>17β Estradiol</td>
<td>272.39</td>
<td>3.6</td>
<td>4.01</td>
<td></td>
</tr>
<tr>
<td>Estradiol</td>
<td>288.39</td>
<td>441</td>
<td>2.45</td>
<td></td>
</tr>
<tr>
<td>Estriol</td>
<td>288.43</td>
<td>23.4</td>
<td>3.32</td>
<td></td>
</tr>
<tr>
<td>Testosterone</td>
<td>288.43</td>
<td>23.4</td>
<td>3.32</td>
<td></td>
</tr>
</tbody>
</table>
Analytical Methods

- C-18 Solid Phase Extraction

- HPLC Clean-Up
  - Size Exclusion Chromatography Column
  - Reverse Phase Column

- Enzyme-Linked Immunosorbent Assay (ELISA) for quantification of sample concentrations

ELISA

- Free hormone binds antibodies
- AChE linked tracer binds antibodies
- Tracer binds substrate to AChE
- Color development inversely proportional to hormone concentration

- Method detection limits:
  - 17β-estradiol: 0.4 ng/L
  - Estriol: 0.6 ng/L
  - Testosterone: 0.5 ng/L
Experimental Design

• Field Scale
  - Water reuse field sites employing soil-aquifer treatment (Tucson, Mesa AZ)

• Laboratory Scale
  - Verification of Field Scale
    • Anoxic, saturated flow
    • Aerobic, saturated flow
Experimental Design

• Photolytic Degradation
• Adsorption Experiments
  – Adsorption isotherm (sand)
  – Abiotic soil column
• Biodegradation Experiments
  – Aerobic, unsaturated flow soil columns

Soil-column experiments

– 30 cm-Soil Columns
  • Flow-through, aerobic
  • Recycle, aerobic
  • Recycle, abiotic

• Bulk water & 3 fractions of bulk water
  (hydrophobic acids; hydrophilic carbon; colloids)
Water Reuse Field Sites

- 2 Water Reuse – Soil-aquifer treatment sites in Arizona
  - Wastewater, Groundwater

Tucson Sweetwater Recharge and Storage Facility, Arizona

Map Based on Graphic Provided by Tucson Water
Tucson Sweetwater Basin No. 1 Profile

- Infiltration Basin
- Monitor Well (WR-199A)
- Shallow Well
- Perching Layer
- Vadose zone
- Saturated zone (mixing zone)

Quanrud, 2001

Tucson Sweetwater Recharge Facility

DOC = 13.9 mg/L
E2 = 7.2 ng/L
E3 = 21.3 ng/L
T = 11.5 ng/L

C/Co

Depth (ft)
Mesa Northwest Water Reclamation Plant, AZ

Mesa Northwest Water Reclamation Plant, AZ
Mesa Northwest Water Reclamation Plant, AZ

DOC=6.74 mg/L
E2=4.2 ng/L
E3=4.9 ng/L
T=3.0 ng/L

Anoxic Soil Columns

E2=300ng/L
E3=300ng/L
T=250ng/L

E2=1±0.4ng/L
E3=n.d.
T=n.d.

E2=n.d.
E3=n.d.
T=n.d.
Aerobic Soil-Columns

Photolytic Degradation

- Secondary Effluent
- 3 target compound solution
- Exposed to direct sunlight for ~8 hours
Photolytic Degradation

![Graph showing Photolytic Degradation](image)

Adsorption Isotherms

- Three target compound solutions; 
  \( c_0 = 10-500 \text{ ng/L}; \) 800 mL volume
- 200 g sand;
Adsorption Kinetics

![Graph showing adsorption kinetics with concentration over time for 17b-Estradiol, Estriol, and Testosterone.]

Abiotic Column

![Graph showing effective bed contact time with concentrations for 17b-Estradiol, Estriol, and Testosterone.]
Conclusions

- Soil-Aquifer Treatment is effective at removing target compounds
- SAT is capable of handling high concentrations
- Adsorption is the primary mechanism of removal for steroids studied
- Biodegradation is also occurring
Disclaimer 😊

Statements of fact and opinion expressed are those of the author and presenter. AZ Water Association, AZAWWA and AZWEA assume no responsibility for the content, nor do they represent official policy of the Association.

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Questions???