Antibiotics and Antibiotic Resistance in the Environment:

A One Health Perspective

One Health One Planet Symposium
One Health and the Future of Food
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Pharmaceuticals
Personal Care Products
Human Hormones
Nanomaterials
Microplastics
Antibiotics (and resistance genes)
Industrial Chemicals
Agricultural Chemicals
Pesticides
Two main types of contaminant sources for Antibiotics reaching the Environment

Point vs. Non-point
Runoffs carrying bacteria from humans, animals, soil, plants, premise plumbing... including potential antimicrobial resistant bacteria, antimicrobial resistance genes, and/or antibiotics or co-pollutant molecules like antimicrobial drugs, petroleum by-products, heavy metals, pesticides...

Hot spots of antimicrobial resistance emergence and dissemination
Water is Cyclical:
Concentrations of antibiotics in environment (ng/L - μg/L)

Antibiotic Sources

Drinking Water
Low ng/L

WWTP Influent
ng/L - μg/L

Manure
mg/kg

Ground Water
0.1 ng/L – 100 ng/L

Soil
ng/kg - mg/kg

Point and Non-Point Sources

Drinking Water Treatment

Surface Water
1 ng/L – 1 μg/L

Plant Uptake
ng/kg - ug/kg

WWTP Effluent
ng/L – ug/L

Manure
mg/kg
What happens once treated wastewater, biosolids, and untreated manure are released into the Environment?
Movement and fate of pollutants in the aquatic environment
Antibiotics and Antibiotic Resistance in Aquatic Environments

**Antibiotic Contamination**

<table>
<thead>
<tr>
<th>Site Location</th>
<th>Tetracyclines (ng L⁻¹)</th>
<th>Sulfonamides (ng L⁻¹)</th>
<th>Quinolones (ng L⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWTP influent</td>
<td>1615.8</td>
<td>2263.0</td>
<td>3664.0</td>
</tr>
<tr>
<td>WWTP effluent</td>
<td>195.0</td>
<td>2001.0</td>
<td>3866.0</td>
</tr>
<tr>
<td>Upstream</td>
<td>265.2</td>
<td>648.1</td>
<td>728.8</td>
</tr>
<tr>
<td>Downstream</td>
<td>345.1</td>
<td>1111.0</td>
<td>2769.0</td>
</tr>
</tbody>
</table>

Removal efficiency: 87.9% Tetracyclines, 11.6% Sulfonamides, Increased³ Barancheshme & Munir, 2018

**Presence of Antibiotic Resistance**

**WWTP & Fecal Contamination**

- Natural
- Fecal

**Agricultural Runoff Impacts**

- April
- June
- Aug.
- Sep./Oct.

**Urban Runoff**

- Equivalent background period
- Storm water period

Garner et al., 2017

Dungan, et al., 2017

Zhang, 2016
Antibiotics in the Soil

Carter et al., 2014; Franklin et al., 2018; Li et al., 2017; Kumar et al., 2005.

Table 2. The residual levels of antibiotics from undiluted dairy cattle- and chicken-manured soils (DM and CCM) at different depths.

<table>
<thead>
<tr>
<th>Antibiotic</th>
<th>CHK (µg/kg)</th>
<th>DM (µg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CTC</td>
<td>23.33 ± 4.03a</td>
<td>69.54 ± 8.59b</td>
</tr>
<tr>
<td>OTC</td>
<td>23.56 ± 2.22a</td>
<td>64.62 ± 2.38b</td>
</tr>
<tr>
<td>NOR</td>
<td>10.55 ± 1.43a</td>
<td>23.28 ± 1.85b</td>
</tr>
<tr>
<td>ETM</td>
<td>56.38 ± 3.96a</td>
<td>112.27 ± 8.33b</td>
</tr>
<tr>
<td>CPM</td>
<td>5.29 ± 0.08a</td>
<td>130.49 ± 5.08b</td>
</tr>
<tr>
<td>CUM</td>
<td>8.49 ± 1.05a</td>
<td>59.36 ± 3.11b</td>
</tr>
</tbody>
</table>

One Effluent Application

![Graph showing antibiotic concentration against depth and time](image)
Effects in Soil Organisms

Munir & Xagoraraki, 2010
<table>
<thead>
<tr>
<th>Compound</th>
<th>Groundwater at Living Filter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Min.</td>
</tr>
<tr>
<td>SMX</td>
<td>2.8 ± 2.4</td>
</tr>
<tr>
<td>TMP‡</td>
<td>&lt;LOD$\S$</td>
</tr>
<tr>
<td>OFL</td>
<td>0.14 ± 0.11</td>
</tr>
</tbody>
</table>
Effects in Humans and Mammals

- Resistant bacteria in food animals
- Antibiotic resistance influenced by antibiotic use
  - A) Resistant bacteria not adapted for H2H transmission
  - B) Resistant bacteria capable of H2H transmission
  - C) Transfer of resistance genes
  - Sporadic disease in humans; limited onward transmission
    - Sustained transmission in humans; prevalence influenced by antibiotic use

Beyene, 2018 (Figure adapted from Chang et al., 2015)
THANK YOU!

And I’ll answer questions during the panel discussion.
Soil Water Quality Laboratory at Penn State

- Emerging contaminants in soil and water
  - Carbamazepine
  - Estrogens
  - Antibiotics
  - Antibiotic Resistance Genes
  - Toxicological Impacts

- People:
  - Jack Watson – PI
    - Professor of Soil Physics
  - Alison Franklin
    - PhD Student, Soil Science & Biogeochemistry
    - MS – Soil Science
    - BS - Toxicology

- Research Site: The Living Filter
  - Long term irrigation site
Most antibiotics (and pharmaceuticals) make their way into wastewater, biosolids, and manure via human and animal ingestion.