



Antimicrobial Resistance in the Environment

Carrie E. Givens *, Christopher D. Ecker,
Lisa R. Fogarty

U.S. Geological Survey

June 22, 2016

USGS Antibiotics Research

Are antibiotics entering our environment?

Yes! Series of national reconnaissance studies (early 2000s) found antibiotics in streams, groundwater, and drinking water source waters as complex mixtures at ng/L to $\mu\text{g/L}$ concentrations.

What are the sources of antibiotics (signatures)?

Multiple sources; ongoing research in agricultural and urban environments.

What happens to antibiotics in the environment?

Detected in water *and* sediment; ongoing research assessing fate through WWTPs and DWTPs, surface transport, and subsurface transport.

- **Are there adverse effects to ecosystem *and* human health from unintended exposures to antibiotics?**

Development, Maintenance, and Transfer of Antibiotic Resistance?

- What is the distribution of antibiotic resistant bacteria and/or genes in the environment?
- Do microbial resistances detected in the environment reflect antibiotics detections or known antibiotic usage?
- What are the factors that influence gene transfer and maintenance in the environment?
- How do antibiotics in the environment affect the natural microbial community?



Distribution of Antibiotic Resistance in the Environment

Great Lakes beaches

- Detection of methicillin-resistant *Staphylococcus aureus* (MRSA) genes increased with number of bathers
- MRSA appeared to be community-acquired (CA) strains

Fogarty, L.R. and others, 2015. *Staphylococcus aureus* and methicillin-resistant *S. aureus* (MRSA) at ambient freshwater beaches. *J Water Health*, 13(3): 680-692.



National Livestock Study

- Study of 19 small watersheds influenced by single type of animal agriculture
- Assess for resistance genes linked to antibiotics used in AFOs



Livestock Manure as a Source of Antibiotics and Antibiotic Resistance Genes (ARGs)

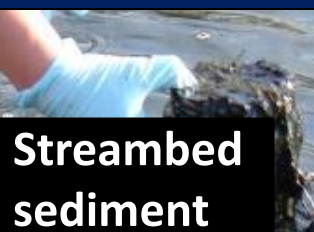
Preliminary Results from the National Livestock Study



- **Antibiotics:** frequently detected (86%)
 - 60% beef, 100% swine, poultry, dairy
- **ARGs:** frequently detected (none in beef manure)



- **Antibiotics:** sporadically detected (14%)
 - 80% in post-manure application/runoff
- **ARGs:** frequently detected (86%)
 - type of ARGs varied by livestock type



- **Antibiotics:** frequently detected (70%)
- **ARGs:** frequently detected (67%)

- Livestock operations contribute more resistance genes to stream waters than rural background sites.

Relation between Resistance and Antibiotics Usage

Antibiotic Resistance in Source Material

- Evaluate enterococci resistance to clinically-significant antibiotics in a variety of human and animal wastes
 - Resistance patterns varied by source type
- Relationship between antibiotics and resistance patterns?
 - No clear relationship to antibiotic detections
 - Linkage of resistance genes uncoupled direct relationships to specific antibiotics



Sulfamethoxazole (SMX) in Groundwater Affects Native Bacteria Functions

Tandem lab / field experiments show that SMX at environmentally relevant levels:

- reduced bacterial growth
- altered bacterial composition
- lowered nitrate reduction potential



Underwood et al., 2011



SMX affects ecosystem functions (e.g. denitrification)

Antibiotic Resistance: Looking Forward

- Active area of USGS research
 - Multi-tiered method approach – culture-based approach using isolates and PCR *and* also qPCR, PCR arrays, and metagenomics
- Antibiotic-resistant bacteria and genes are detected in the environment (surface water, groundwater, sediment, manure)
 - Reservoir of resistant bacteria and source of resistance genes
 - Differences in urban (wastewater, stormwater runoff) and agriculturally-influenced resistance patterns?
- Understanding source and scope of antibiotic resistance
 - Sediment-bound Contaminant Resiliency and Response Strategy (SCoRR)
 - Contaminant mixtures – agriculture, WWTPs

Antibiotic Resistance: Looking Forward

- Influence of exposure to sub-therapeutic levels of antibiotics on the native microbial community, microbial processes, and host microbiome?
- Factors influencing gene transfer and maintenance in the environment?
- Do resistances found in the environment have real human or ecological health implications?
 - Focus on resistances of clinical importance



Questions?

Carrie E. Givens, Ph.D.

Microbiologist

U.S. Geological Survey

Michigan-Ohio Water Science Center

517-887-8933

cgivens@usgs.gov