

Jean E. McLain, Associate Director University of Arizona Water Resources Research Center Arizona WateReuse 2016 Symposium, Flagstaff, Arizona July 25, 2016

Outline

What is antibiotic resistance? Antibiotic resistance in the news Current studies examining effects of water-borne emerging contaminants on environmental resistance







Outline

What is antibiotic resistance? Antibiotic resistance in the news

Current studies examining effects of water-borne emerging contaminants on environmental resistance

What to look for in analysis of resistance studies







Antibiotic Resistant Bacteria



The ability of a bacterium to prevent an antibiotic from adversely affecting that isolate, strain, or group.



Antibiotic Resistant Bacteria



The ability of a bacterium to prevent an antibiotic from adversely affecting that isolate, strain, or group. Horizontal Gene Transfer confers antibiotic resistance in response to selective pressure **Clinical settings** High antibiotic dosages



Environmental Antibiotic Resistance

Agricultural and clinical use of antibiotics

Up to 75% excreted unaltered or as metabolites







Environmental Antibiotic Resistance

Agricultural and clinical use of antibiotics

Up to 75% excreted unaltered or as metabolites

Nanofiltration, UV/O₃ enhance removal of these chemicals Recycled wastewater Biosolids







Environmental Antibiotic Resistance

Agricultural and clinical use of antibiotics

Up to 75% excreted unaltered or as metabolites

Nanofiltration, UV/O₃ enhance removal of these chemicals Recycled wastewater Biosolids

Proposed that this is a "key source of resistance to the environment"







Antibiotic Resistant Bacteria



Earliest antibiotics: naturally produced (e.g., Penicillin)

Resistant bacteria isolated from deep terrestrial subsurface (>250 m deep caves) and prehistoric (120,000+ YBP) ice cores



Antibiotic Resistant Bacteria





Earliest antibiotics: naturally produced (e.g., Penicillin)

Resistant bacteria isolated from deep terrestrial subsurface (>250 m deep caves) and prehistoric (120,000+ YBP) ice cores

Resistance evolved in absence of selective pressure Detoxification Signal trafficking Competition for scarce resources

Resistance Analysis: Culturing vs. Molecular Methods

PROS:

Highly reproducible, robust Can assess at clinical levels

CONS:

Analyze a single isolate in each plate





Resistance Analysis: Culturing vs. Molecular Methods

Polymerase Chain Reaction (PCR), Quantitative PCR

PROS:

With great sensitivity, can identify/quantify resistance genes in entire DNA sample







Resistance Analysis: Culturing vs. Molecular Methods

Polymerase Chain Reaction (PCR), Quantitative PCR

PROS:

With great sensitivity, can identify/quantify resistance genes in entire DNA sample

CONS:

No discrimination between live and dead bacteria







Aug 13: Antibiotic resistance genes in pipe outflows of recycled water distribution system





Aug 13: Antibiotic resistance genes in pipe outflows of recycled water distribution system

Sept 26: "New Study Finds Antibiotic-Resistant Bacteria Genes in Flagstaff's Reclaimed Water"





Aug 13: Antibiotic resistance genes in pipe outflows of recycled water distribution system

Sept 26: "New Study Finds Antibiotic-Resistant Bacteria Genes in Flagstaff's Reclaimed Water"

Oct 11: "Wastewater Snow-Making Could Breed Super-Bacteria"





- Aug 13: Antibiotic resistance genes in pipe outflows of recycled water distribution system
- Sept 26: "New Study Finds Antibiotic-Resistant Bacteria Genes in Flagstaff's Reclaimed Water"
- Oct 11: "Wastewater Snow-Making Could Breed Super-Bacteria"
- Oct 15: "Manmade Snow From Recycled Water May Contain Antibiotic Resistant Bacteria"





- Aug 13: Antibiotic resistance genes in pipe outflows of recycled water distribution system
- Sept 26: "New Study Finds Antibiotic-Resistant Bacteria Genes in Flagstaff's Reclaimed Water"
- Oct 11: "Wastewater Snow-Making Could Breed Super-Bacteria"
- Oct 15: "Manmade Snow From Recycled Water May Contain Antibiotic Resistant Bacteria"
- Oct 17: "Antibiotic Resistance Racing Downriver"



The Washington Post



The Facts: "Antibiotic resistance genes in pipe outflows of recycled water distribution system"







The Facts: "Antibiotic resistance genes in pipe outflows of recycled water distribution system"

Antibiotic resistance genes
 ≠ resistant bacteria (DNA can indicate living or dead)







The Facts: "Antibiotic resistance genes in pipe outflows of recycled water distribution system"

- Antibiotic resistance genes
 ≠ resistant bacteria (DNA can indicate living or dead)
- Recycled water pipe only: what about drinking/potable water pipes?







Los Angeles and CRE (March 2016)

CRE thrives in soil and water AND in the human gut; mortality rate of 50%



- Los Angeles and CRE (March 2016)
- CRE thrives in soil and water AND in the human gut; mortality rate of 50%

Los Angeles Times

- "Deadly Superbugs Get Stronger in the Sewers..."
- WWTPs serve as a "luxury hotel" for superbugs
- "Chlorine is just not doing it"

Los Angeles Times





- Los Angeles and CRE (March 2016)
- CRE thrives in soil and water AND in the human gut; mortality rate of 50%

Los Angeles Times

- "Deadly Superbugs Get Stronger in the Sewers..."
- WWTPs serve as a "luxury hotel" for superbugs
- "Chlorine is just not doing it"
- The Facts
- Sampled "partially treated wastewater" and "hospital effluent"

Los Angeles Times





Antibiotic-resistant bacteria thriving in Galway's sewers

Chicken coops, wastewater plants serve as breeding grounds for antibiotic resistance

Wastewater a source of antibiotic-resistant bacteria: study

1. Headlines can be inflammatory



Antibiotic-resistant bacteria thriving in Galway's sewers

Chicken coops, wastewater plants serve as breeding grounds for antibiotic resistance

Wastewater a source of antibiotic-resistant bacteria: study

Headlines can be inflammatory
 Look for the facts:

 Where were samples collected?
 DNA or living bacteria?
 Control site?



Control Sites Can Change Results!



Gilbert Riparian Preserve

Created in 1986, seven recharge basins receive tertiary-treated recycled water







Gilbert Riparian Preserve

Created in 1986, seven recharge basins receive tertiary-treated recycled water

Control site: irrigation retention pond at Maricopa Agricultural Center









High Level Antibiotic Resistance

Antimicrobial	% Isolates with High-Level Resistance	
	Groundwater	Wastewater
Tigecycline	14.3 🗧	→ 6.1
Erythromycin	42.8	21.2
Tetracycline	21.4	0.0
Ciprofloxacin	57.1	24.2
Chloramphenicol	7.1	0.0
Penicillin	14.3 🔶	→ 6.1
Daptomycin	57.1 🗲	51.5
Vancomycin	7.1 ←	→ 3.0
Streptomycin	0.0	0.0
Nitrofurantoin	28.6 <	21.2
Tylosin Tartrate	25.0	3.0
Gentamycin	0.0	0.0
Quinupristin/Dalfopristin	3.6	27.3
Lincomycin	57.1	48.5
Linezolid	21.4 🗲	→ 24.2
Kanamycin	0.0	12.1



High Level Antibiotic Resistance

Antimicrobial	% Isolates with High-Level Resistance	
	Groundwater	Wastewater
Tigecycline	14.3	6.1
Erythromycin	42.8 🔶	→ 21.2
Tetracycline	21.4 🗲 🗕	→ 0.0
Ciprofloxacin	57.1 🔶	→ 24.2
Chloramphenicol	7.1 🗧	→ 0.0
Penicillin	14.3	6.1
Daptomycin	57.1	51.5
Vancomycin	7.1	3.0
Streptomycin	0.0	0.0
Nitrofurantoin	28.6	21.2
Tylosin Tartrate	25.0 ←	→ 3.0
Gentamycin	0.0	0.0
Quinupristin/Dalfopristin	3.6	27.3
Lincomycin	57.1	48.5
Linezolid	21.4	24.2
Kanamycin	0.0	12.1



Multi-Resistant Bacteria





Multi-Resistant Bacteria





Control Sites Can Change Results!

Antibiotic Resistance is NATURAL and MUST be considered in design of research studies













World Health Organization: "one of the most critical human health challenges of the next century"







World Health Organization: "one of the most critical human health challenges of the next century"

Recycled water use is growing; increasing need for accurate assessments of public health

Informed decision-making, driven by risk assessment rather than public sentiment







Questions? Jean McLain University of Arizona Water Resources Research Center mclainj@email.arizona.edu **Channah Rock** University of Arizona Extension Specialist crock@email.arizona.edu