Environmental Compartments of AMR and Antibiotic Metabolites: Wastewater

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22 June 2016

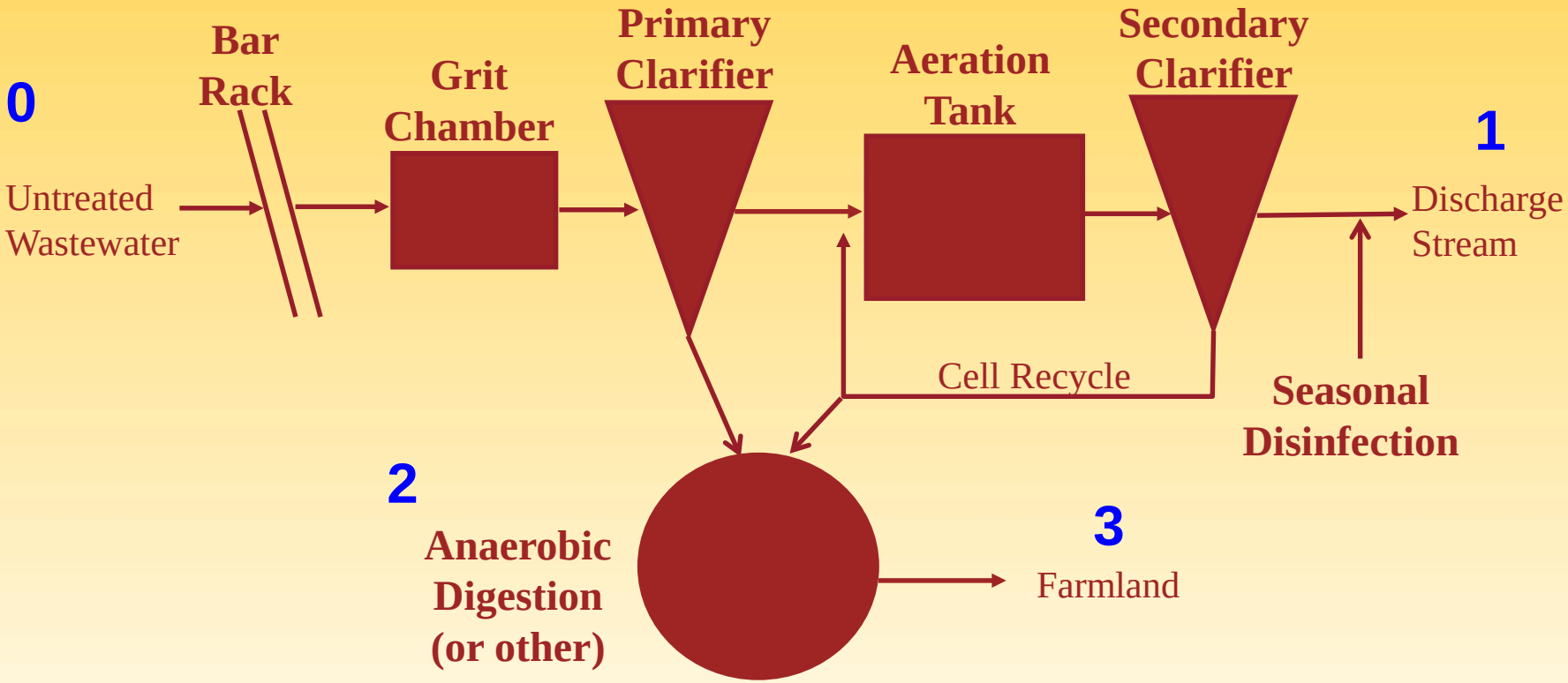
Municipal Wastewater Treatment

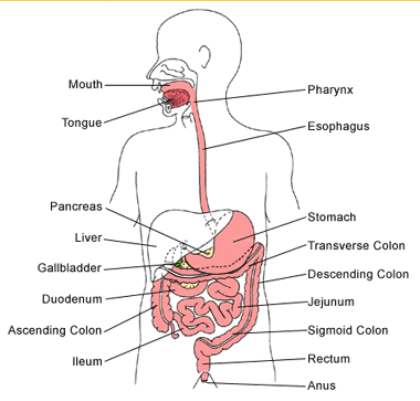
- **US Annual operating costs**: ~$15-20 Billion/year
- **US Capital Value**: ~$50-200 billion
- **Current Goals**: Remove nutrients (carbon, nitrogen?, phosphorus?) and reduce pathogen levels so that water can be returned to the environment without harm
- **Future**: Resource recovery, energy neutrality, and water re-use

The Molecular Ecology of Antimicrobial Resistance Genes

- Hundreds of clinically relevant genes that encode antimicrobial resistance can be tracked
- Tracking genes is useful because genes can be shared among different bacterial taxa, including pathogens, commensals, and environmental/innocuous bacteria
- The approach has limitations, however, because we do not know the host, whether the gene is functional within the host, whether the host is viable, or whether the gene is fully intact.

How does Municipal Wastewater Treatment Work?





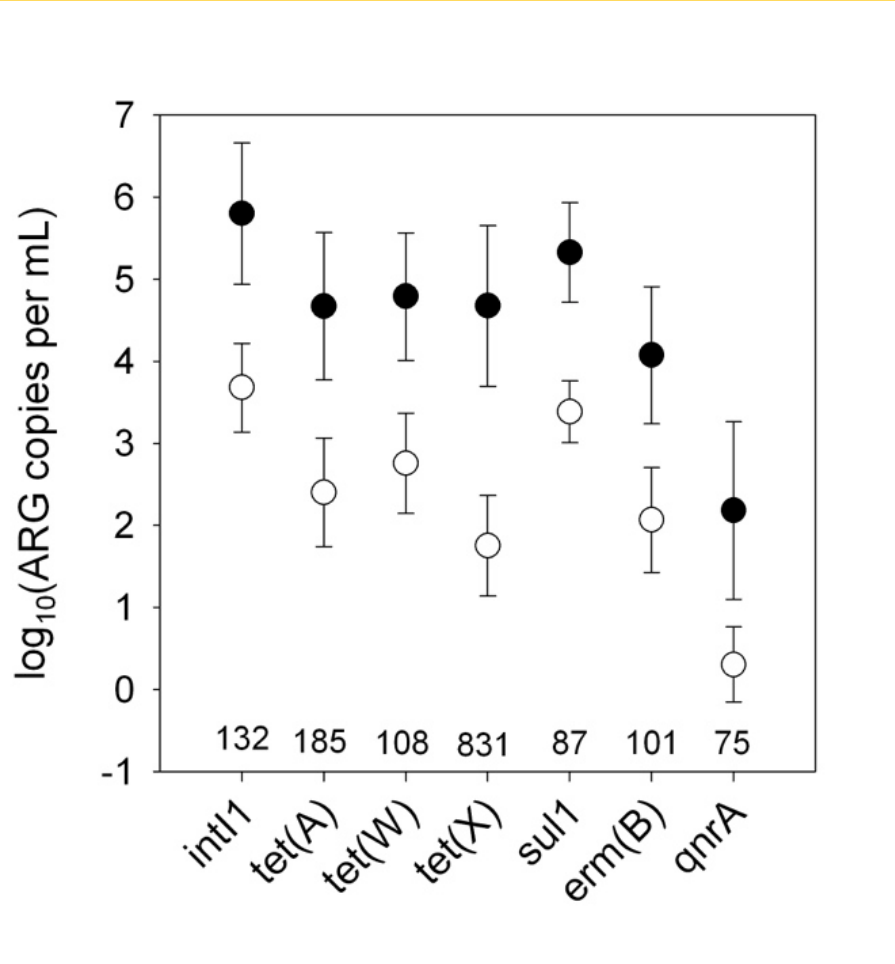
10^{17} copies/day

10^{19} copies/day

10^{18} copies/day

Auerbach et al. 2007. *Water Research* 41:1143 1151; Smith et al. 2004. *Applied and Environmental Microbiology* 70:7372 7377.

Wastewater effluents contain very high levels of ARGs compared to surface water



Source: LaPara *et al.* 2015. Multiple discharges of treated municipal wastewater have a small effect on the quantities of numerous antibiotic resistance determinants in the Upper Mississippi River. *Environmental Science and Technology* **49:**11509 11515.

Different Sludge Treatment Technologies have Different Impacts on ARGs in Sewage Sludge (Half-lives; units = Days)

Gene	Thermophilic Anaerobic Digestion	Aerobic Digestion	Air Drying
erm(B)		3.6	6.4
intI1	0.28	6.3	31.7
sul1		4.6	35.5
tet(A)	1.6	4.4	8.8
tet(W)	0.96	2.8	7.3
tet(X)	0.5	5.7	17.2

The Decay of ARGs is SLOW after Sewage Sludge is Applied to Agricultural Soil (Half-lives; units = Days)

Gene	Sandy Soil	Loamy Soil
erm(B)	13	32
intI1	81	440
sul1	53	63
tet(A)	25	n.a.
tet(W)	21	31
tet(X)	38	n.a.

Source: Burch, Sadowsky, and LaPara.2014. Fate of antibiotic resistance genes and class 1 integrons in soil microcosms following the application of treated residual municipal wastewater solids. *Environmental Science and Technology* **48:**5620 5627.

Final Comments/Summary

- Municipal wastewater is a **VERY LARGE** reservoir of clinically-relevant antibiotic resistance genes
- Wastewater treatment plants could achieve **SUBSTANTIALLY IMPROVED** destruction of antibiotic resistance genes if designed to do so, particularly with the correct selection of sludge treatment technologies.
- Wastewater treatment bioreactors are designed, albeit unintentionally, to be **IDEAL** locales for the exchange of antibiotic resistance genes

Antimicrobial resistance is a complex problem driven by many interconnected factors; single, isolated interventions have little impact.

Pruden et al. 2013 *Environ. Health Persp. 121:878 885. WHO. 2012. www.who.int/mediacentre/factsheets/fs194/en/*41