Antibiotics and Antibiotic Resistance: Perspectives from Environmental Soil Chemistry

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Pathways for Pharmaceuticals into the Environment

- Antibiotics
  - Livestock feeding and treatments
  - Human treatments
  - Inappropriate disposal of unused medicines
  - Municipal wastewater treatment
  - Receiving water
  - Soil

- Aquaculture
  - Manure and slurry spreading
  - Storage of manure and slurry

Pharmaceuticals enter the environment through various pathways, including human treatments and agricultural practices.
• Using LC-MS/MS techniques, we have developed analytical protocols to quantify many types of antibiotics present in water (at ng/L level), in soils and biosolids (at µg/kg level) as well as in vegetable produce (at µg/kg level).

**Research question:** How widespread are antibiotics in our food chain?

• Provide collaboration with projects which need analytical chemistry components for screening and quantification of chemicals of emerging concern (CECs).
Relation between Tetracycline Speciation and Expression of Antibiotic Resistance Genes

Tetracycline speciation at pH 4-10 with different forms and their proportions:
- $H_3TC^+$
- $H_2TC^0$
- $HTC^-$
- $TC^{2-}$

M = Ca$^{2+}$ or Mg$^{2+}$

Tetracycline: 100 µg/L, Ca$^{2+}$: 0.005 M
Uptake of tetracycline (100 µg/L) by *E. Coli* bioreporter in the presence of (A) Ca\(^{2+}\) and (C) Mg\(^{2+}\), and the corresponding expression of antibiotic resistance genes (B and D).
Bacterial uptake of tetracycline (and expression of antibiotic resistance genes) is strongly correlated with its zwitterionic form.
Hypothesis:
The neutral (zwitterionic) species of tetracycline (L) is more bioavailable to *E. coli*

Research questions:
1) Given that manure contains many metals as well as many complexing ligands to compete with the antibiotic, how might management conditions be manipulated to minimize bioavailability?
2) Do other antibiotics and bacteria follow similar patterns?
3) How bioavailable are sorbed antibiotics, and could in-situ geosorbent amendments be used to reduce antibiotic uptake and selective pressure?
Bacteria could acquire antibiotic resistance genes via horizontal gene transfer. Environmental chemistry research questions:

1. How stable (persistent) are these antibiotic resistance genes in soils?
2. Effects of sorbent?
3. Are the soil-sorbed genes still bioactive, and available for transfer into bacterial cells to develop antibiotic resistance?