

Mobility of Arsenic and Trace Contaminant Metals in Poultry Litter Amended Agricultural Soils

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Roxarsone Use in the Poultry Industry

- Dose: 45 g roxarsone per ton of feed
- 2000, 70% of chickens (5.8 billion animals)
- 150 mg arsenic excreted in 42 days
- Litter: 30-50 mg/kg As

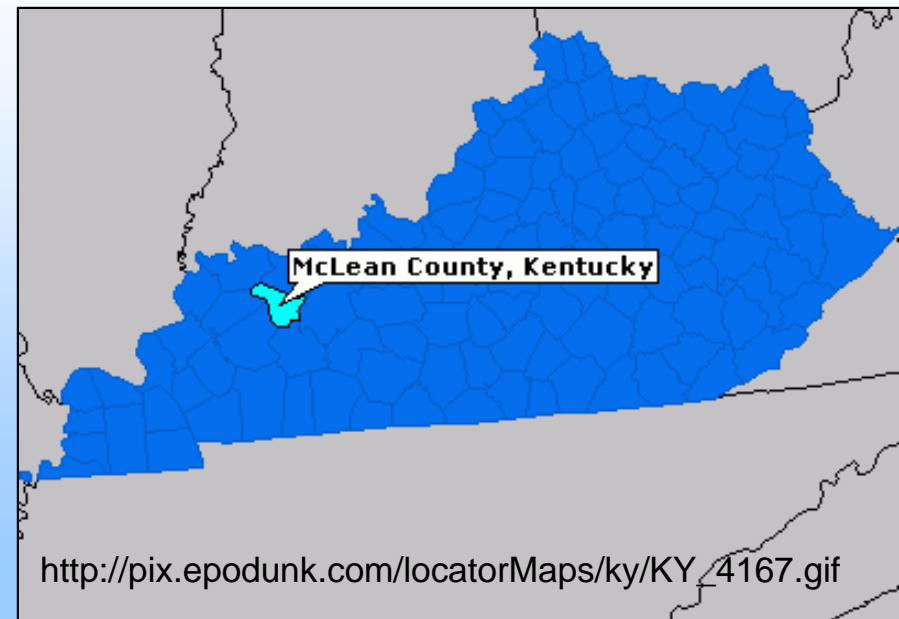


Poultry Litter Use in Agriculture

- Chicken litter as inexpensive N fertilizer
 - Application: 1-2 tons/hectare
 - Ex: 100 hectare, 2 tons/hectare = 10 kg As
- McLean County: 400 chicken houses
 - 150 tons poultry litter/yr each
- Arsenic loosely bound
 - 76% mobile, 1 extraction

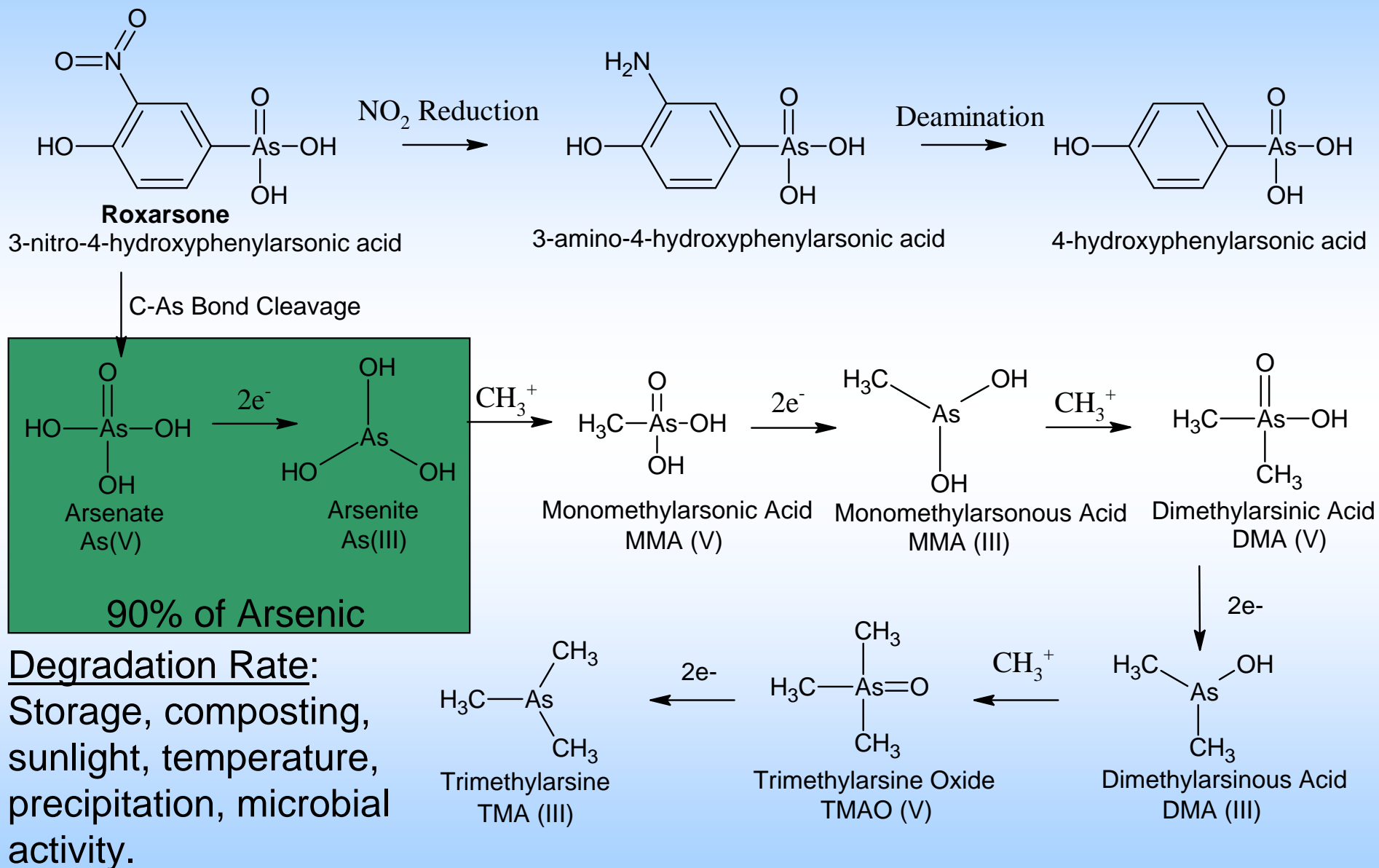


Rutherford, D.W.; Bednar, A.J.; Garbarino, J.R.; Needham, R.; Staver, K.W.; Wershaw, R.L.; *Environ. Sci. Technol.* **2003**, 37, 1515-1520.



http://pix.epodunk.com/locatorMaps/ky/KY_4167.gif

Roxarsone in the Environment



Degradation Rate:
 Storage, composting,
 sunlight, temperature,
 precipitation, microbial
 activity.

Soil Physicochemical Properties

Properties:

- Organic Matter
- pH
- Metal Content
 - Fe, Mn oxides
 - Ca, Mg
- Clay Minerals
- Competing Anions
 - PO_4^{-3} vs. AsO_4^{-3}
 - NO_3^{-1} vs. AsO_3^{-1}

Main Questions:

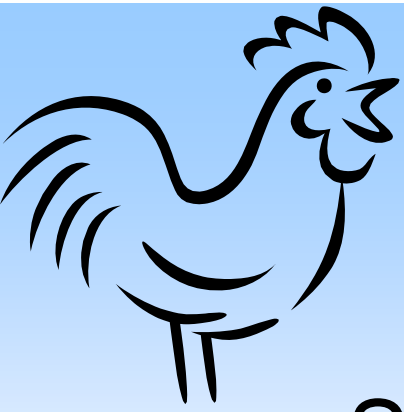
- Arsenic present?
- Arsenic mobile?
- Correlation:
 - Contaminant mobility and
 - Soil physicochemical properties?



Soils Examined in McLean Co., KY

- General
 - W. KY Coal Field Region
 - Wetness a severe limitation
 - Difficult to overcome
 - Soils poorly drained
- Karnak Soil
 - Silty clay (montmorillonite)
 - Neutral pH
 - Low organic content
 - 16% of soils
- Belknap Soil
 - Silty loam (organics, sand)
 - Strongly acidic
 - 50% of soils





Sampling

- Sample Sets for Each Soil Type:
 - 3 Amended Fields
 - 1 Unamended Field
- Samples Collected:
 - Soil
 - Tile Drain Effluent
 - Un-spread, Weathered Poultry Litter



Procedures

- Soil and Litter
 - Moisture, pH
 - EPA Method 3050B “Total” Digestion
 - Leaching Studies: As, Metal Mobility
- Tile Drain Water Samples (simple digestion)
- All Samples:
 - IC: Cl^- , F^- , NO_3^{-1} , PO_4^{-3} , SO_4^{-2}
 - GFAAS: As, Pb, Cd
 - ICP-OES: Ca, Cu, Fe, Hg, Mg, Mn, Ni, Zn

(Arsenic Mobility, Feed Additives, Mining)

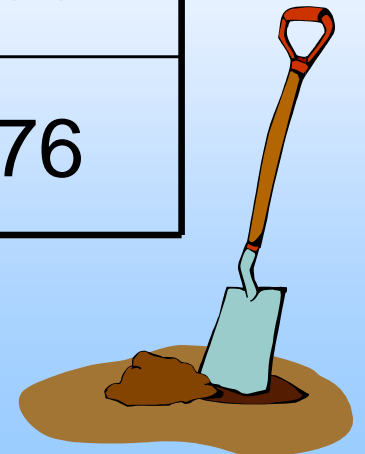


Total Digestion Results: Arsenic

Field	Karnak (ppb As)	Belknap (ppb As)
1	37.85 ± 1.81	76.36 ± 45.31
2	41.73 ± 6.09	117.28 ± 37.56
3	90.37 ± 12.68	42.42 ± 1.30
4†	43.86 ± 8.83	41.22 ± 6.76

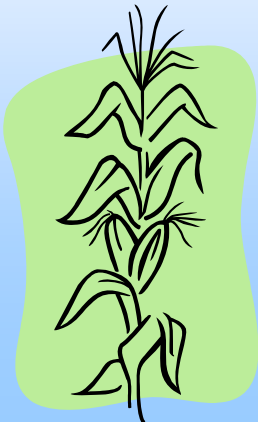
†Control: unamended fields.

*Global average: 2 – 20 ppb As



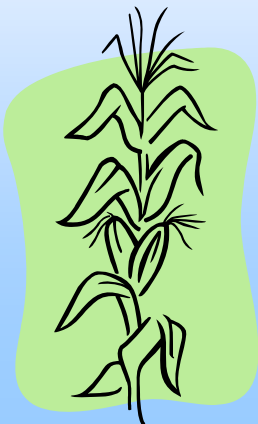
Karnak Leachings: Colloidal Arsenic

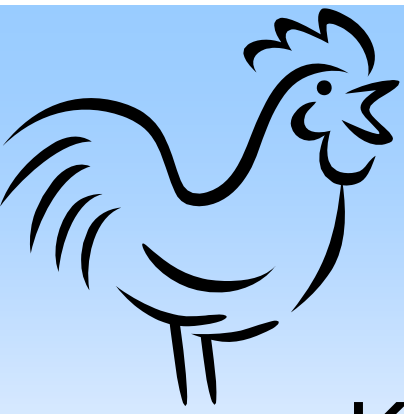
- Preliminary Column Elution Study
 - Metals: Typical 0.45 μm filtration
 - Range of 8-30 ppb As
 - Large background interferences
- Better, 0.20 μm filtration
 - “Jar” tests
 - 24, 48, and 72-hour leach times
 - Majority of samples < 5 ppb
- Arsenic associated with colloidal matter



More Arsenic Leaching Results

- Belknap Soil: Arsenic Strongly Bound
- Poultry Litter: 141.63 ± 4.43 ppb As
 - 24, 48 hour leachings comparable
 - 0.20 μm filtration; *not* associated w/ colloids
 - Litter derived arsenic highly mobile

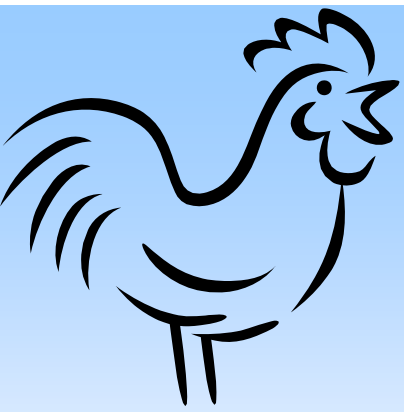




Summary: As Correlations

- Karnak Soil:
 - As vs. Mn, direct ($R^2 = 0.9355$)
 - Ultimately, Fe controls As mobility
 - As vs. SO_4^{-2} , weakly direct ($R^2 = 0.6641$)
- Belknap Soil:
 - As vs. F^- , inverse ($R^2 = 0.9986$)
 - As vs. Cl^- , direct ($R^2 = 0.9648$)

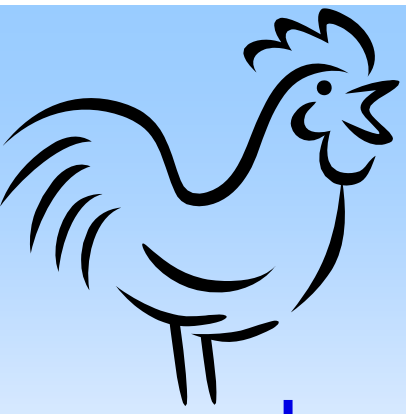




Summary: Anion Analysis

Anions	Soils (mg/kg)	Litter (mg/kg)
Chloride	2 - 14	1,210 - 28,190
Fluoride	1 - 4	BDL, < 1
Nitrate	< 0.8 - 33	6 - 4,783
Phosphate	< 6.5 - 11	716 - 2,720
Sulfate	4 - 24	3,140 - 35,720





Summary:

Contaminant Metals

- **Lead and Nickel**

- Soil: 3-6 mg/kg Pb, 8-27 mg/kg Ni
- Litter: 2-3 mg/kg Pb, 11-12 mg/kg Ni

- **Copper**

- Very high levels in litter (859 mg/kg)
- None (< 30 mg/kg) present in soil

- **Cadmium and Zinc**

- Soil: 37-201 mg/kg Cd, 39-82 mg/kg Zn
- Litter: 312-317 mg/kg Cd, 740-1250 mg/kg Zn



(Arsenic Mobility, Feed Additives, Mining)





Future Work

- Aluminum Correlation Calculations
- Colloid Characterization
- Phosphate Displacement of Bound Arsenate?
- Potential Poultry Litter “Tracers” Where Arsenic *is* a Problem?
 - Cadmium, Copper, Zinc
 - Chloride, Sulfate



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