Antibiotic Feeding in Food Animals and Its Consequences on the Environment

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Collaborators

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Antibiotic Production and Use

- Institute of Medicine
- 50 M pound produced per year
  - 60% Human medicine
  - 40% Agriculture uses
    - 32% Non-therapeutic
    - 8% Therapeutic

- Union of Concerned Scientists
- 35 M pound produced per year
  - 13% Human medicine
  - 84% Agriculture Uses
    - 78% non-therapeutic
    - 6% Therapeutic
  - 3% Pets

K.M. Shea, 2003

Antimicrobial Approved by FDA for Growth Promotion in Food Animals (Shea 2003)

- Amprolium
- Arsanilic acid
- Bacitracin*
- Bambermycins
- Carbadox
- Chlortetracycline*
- Erythromycin*
- Laidomycin
- Lasalocid
- Limcomycin*
- Monensin
- Oxytetracycline*
- Penicillin*
- Sulfonamides*
- Roxarsone
- Tiamulin
- Tylosin*
- Virginiamycin*

*** Identical to human-drugs**

Non-therapeutic Use of Antibiotics in Animal Production

- Dose: 1-400 g/ton of feed

- Purpose:
  - To increase the ability of animal to absorb nutrients and reach the market weight on time
  - To prevent the outbreak of diseases

- As much as 80% of the antibiotics fed to animals are excreted unaltered in urine and manure.

Major Concerns on Antibiotic Feeding of Food Animals

- Antibiotics appearing in potable waters
- Antibiotics appearing in food supply
- Emergence of Antibiotic resistant bacteria

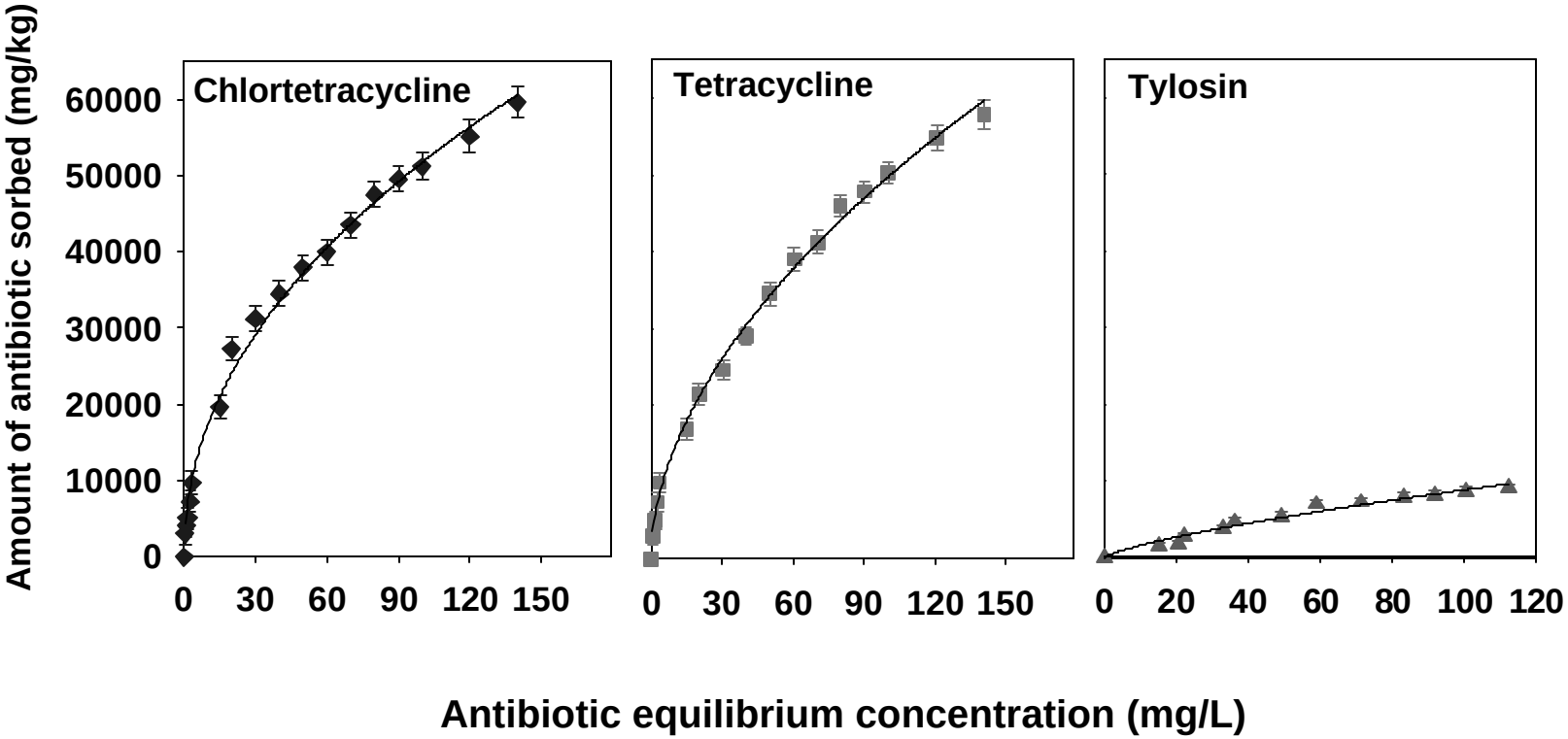
The major pathway is thru the land application of manure.

Laboratory Studies

- Antibiotics
  - Chlortetracycline
  - Tetracycline
  - Tylosin
- Soils
  - Hubbard sandy loam 10% clay
  - Webster clay loam 34% clay

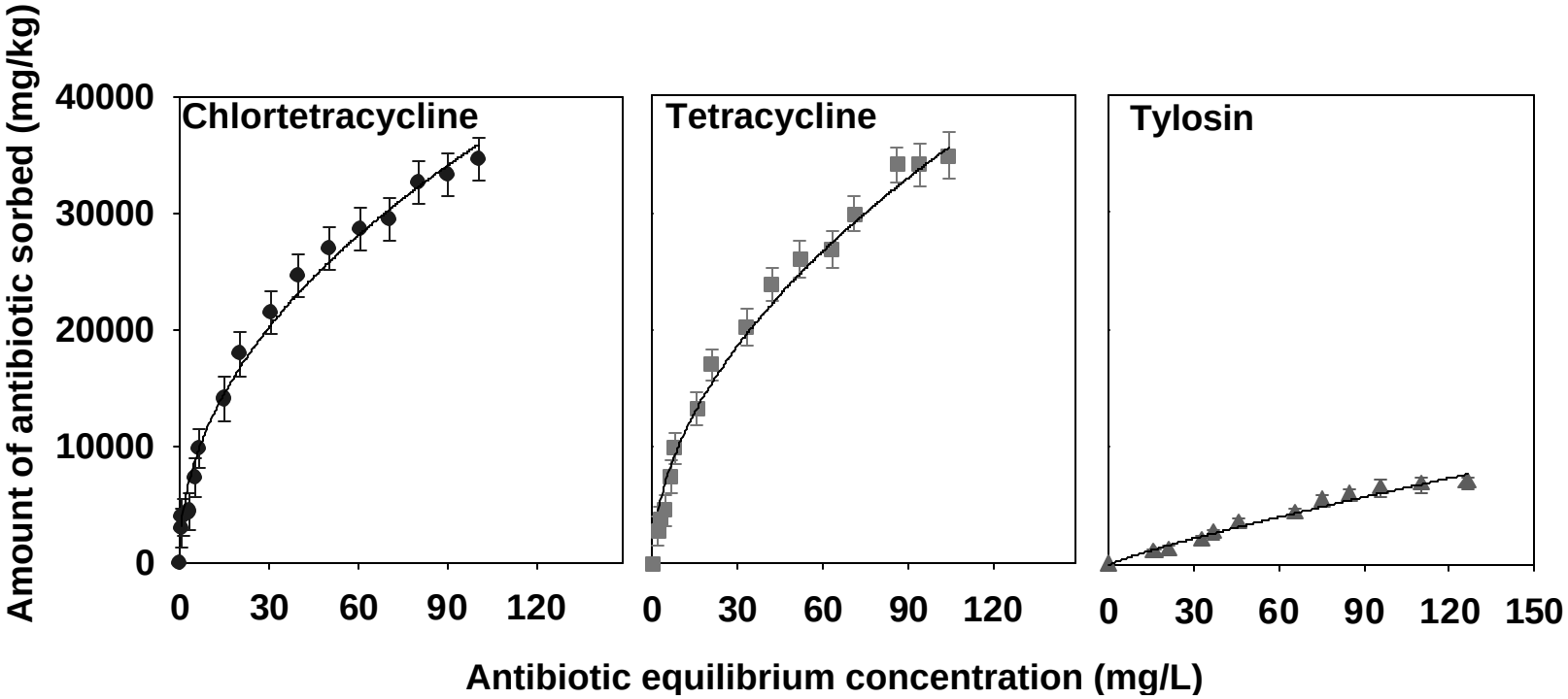
Adsorption isotherm - Batch Studies

Webster clay loam-34% clay

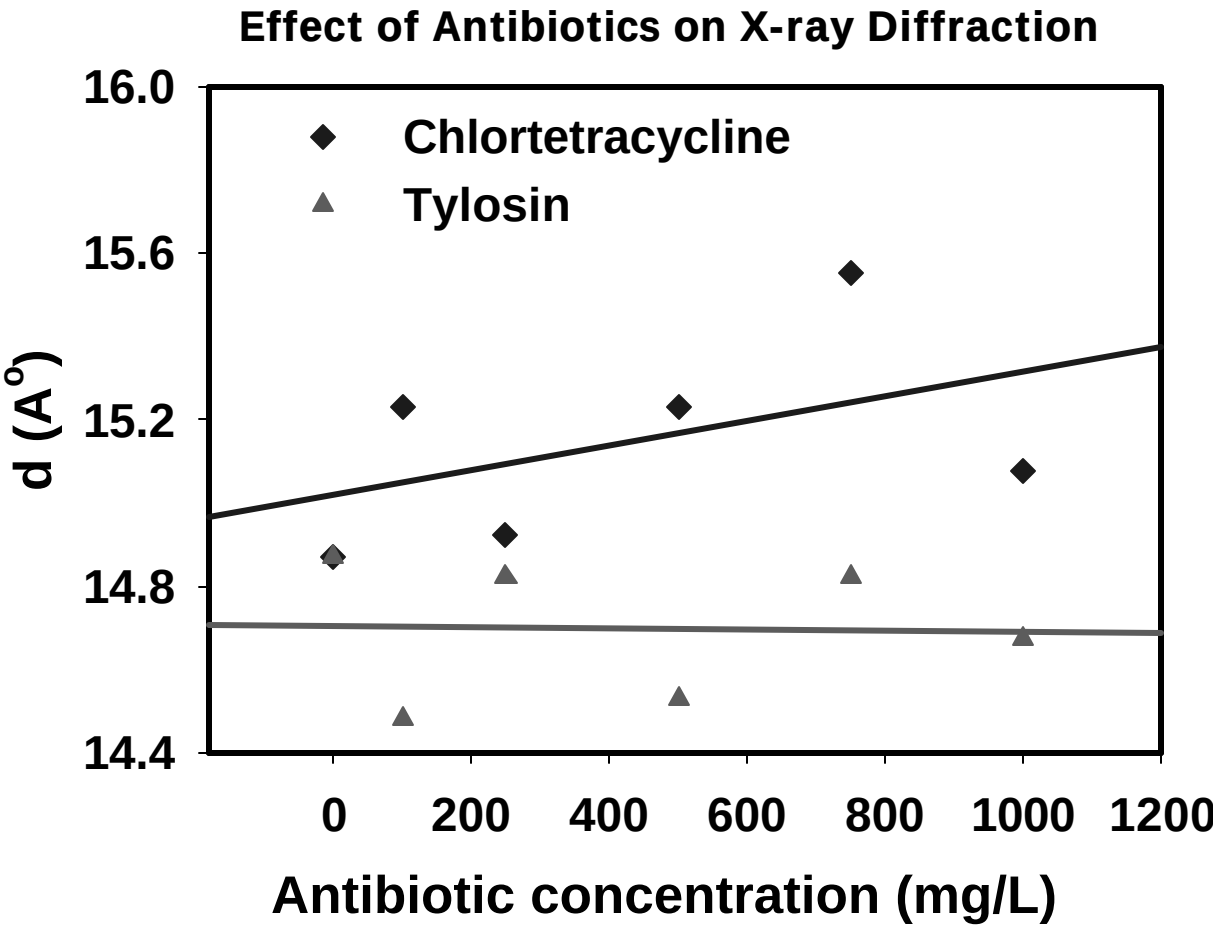


Adsorption Isotherm

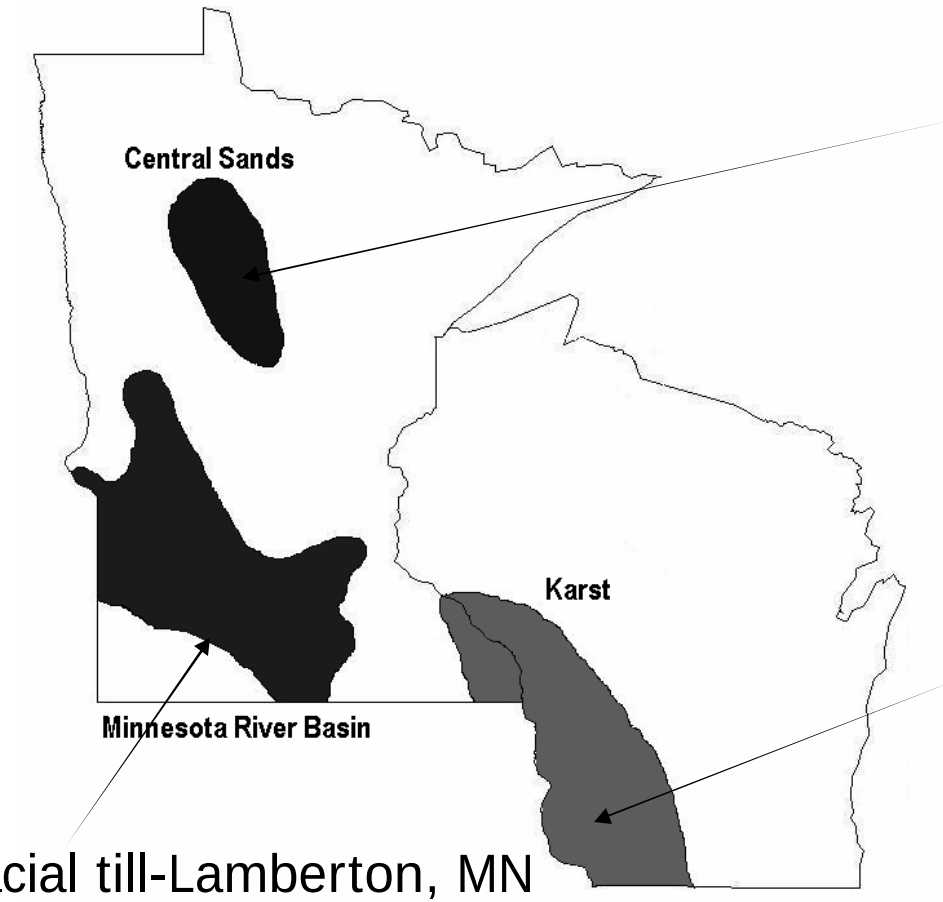
Hubbard loamy sand-10% clay



Question-How are antibiotic adsorbed on the soil?



Manure Application Impacts on Water Quality



Kumar et al.

Central Sands- Staples, MN
Turkey and Hog manure

Dolliver et al.

Karst -Lancaster, WI
Beef and Hog manure

Glacial till-Lamberton, MN
Hog manure

Antibiotic Losses from Glacial Till Soils-Lamberton Study

- Treatments
  - Chisel vs. moldboard plow
  - Injected hog manure vs. commercial fertilizer

- Antibiotic monitored
  - Chlortetracycline
  - Tylosin

Monitoring well

Surface runoff outlet

Surface runoff tipping bucket

Tile line

Tile line tipping bucket

Sump pump

Winter and Snowmelt Scene

Antibiotic Losses from Glacial Till Soils-Lamberton Study Fall 2001

- Swine Manure applied=45.8 m^3/ha
  - (4000 gallons/ac)
- Chlortetracycline=5.0mg/L of manure
  - =229 grams/ha (0.20 lbs/ac)
- Tylosin=5.6 mg/L of manure
  - =256 grams/ha (0.23 lbs/ac)

Antibiotic Losses in 2002

- No losses of dissolved chlortetracycline in surface runoff or through tile drainage
- No losses of dissolved tylosin in tile drainage

Dissolved Tylosin Losses via Surface Runoff in 2002

Event	Manure mg/ha	Urea mg/ha
30 July	46.7	0
4 August	4.2	0.7
9 August	113.8	39.5
22 August	3.7	1.2
Total	168.4	41.4

0.07% of tylosin applied

Antibiotics Applied in Manure Fall 2002

- Swine Manure applied=36.4 m^3/ha
  - (3899 gallons/ac)
- Chlortetracycline=5.47mg/L of manure
  - =199 grams/ha (0.18 lbs/ac)
- Oxytetracycline=1.31mg/L of manure
  - =48 grams/ha (0.04 lbs/ac)
- Tylosin=4.52 mg/L of manure
  - =165 grams/ha (0.15 lbs/ac)

Antibiotic Losses in 2003

- Virtually no loss of dissolved antibiotics
- Chlortetracycline in 3 runoff samples sitting in tipping buckets
  - 0.88 to 1.51 μg/L
- Presence of chlortetracycline in 8 tile line samples
  - 0.4 to 0.76 μg/L (16 μg/ha-0.008% of applied)

Recovery of Antibiotics From Soil

Extraction Agent= 0.2M Na_2 EDTA

Soils	Clay Content,%	Tyl	OCT	TC	CTC
Webster clay loam	34	61	29	43	54
Hubbard sandy loam	10	63	39	43	50

Tyl=Tylosin, OCT=Oxytetracycline, TC=Tetracycline, CTC=Chlortetracycline

Chlortetracycline Remaining in the Soil (Summer 2003)

Treatment	0-15 cm g/ha	15-30 cm g/ha	Total (g/ha) (% of applied)
MP-M	84.1	15.6	99.7 (43.2%)
CH-M	116.5	25.9	142.2 (61.7%)

We found no presence of antibiotics below 30 cm depth.

Tylosin Remaining in the Soil (Summer 2003)

Treatment	0-15 cm g/ha	15-30 cm g/ha	Total (g/ha) (% of applied)
MP-M	76.1	40.5	116.6 (45%)
CH-M	90.6	55.8	146.5 (56.5%)

We found no presence of antibiotics below 30 cm depth.

Antibiotic Losses from Sandy Outwash Soils-Staples Study

Observation at Staples, MN

- As much as 5% of applied CTC leached thru sandy outwash soil to 5 feet depth
- Dissolved antibiotic losses in surface runoff were minimal because most rain and irrigation water percolated due to high permeability

Antibiotic Losses from Loess Soils
Lancaster, WI Study

Fractured Bedrock

Observations at Lancaster, WI

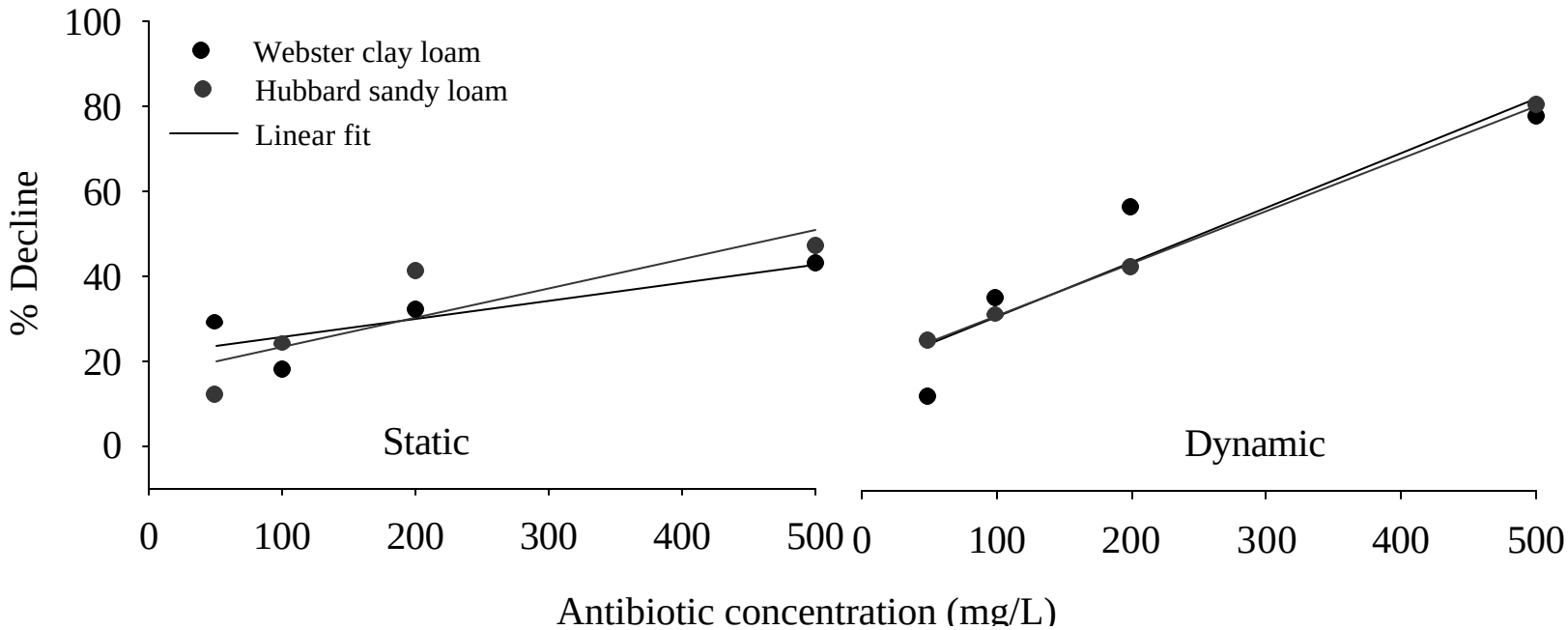
- There are several occurrences of antibiotic transport both through leaching and in surface runoff.
- No chlortetracycline losses through leaching.
- All antibiotic losses in dissolved form are <0.1% of applied.

Next Question?

- Is the soil or sediment adsorbed antibiotics biologically active?

Effect of Adsorbed Tetracycline on Decline in Number of Colony Forming Units

Antibiotic Sensitive *Salmonella* sp.



Chander et al. 2003

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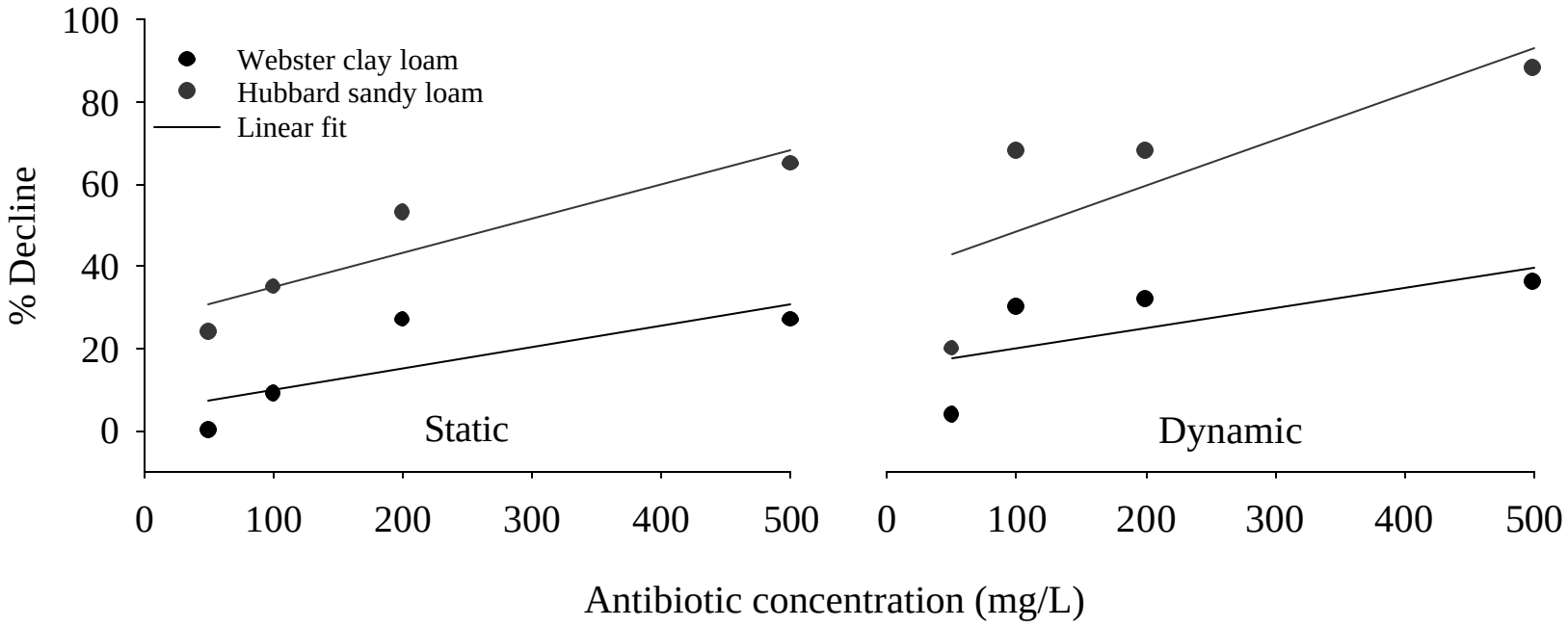


Chander et al. 2003

Emergence and Spread of Antibiotic Resistance Bacteria

- Compare antimicrobial resistance between antibiotic using and non-antibiotic using farms
  - Three animal species (Swine, Turkeys, Cattle)
  - Manure, soil, compost samples
- Spread of antimicrobial resistance to dogs
  - Dog poop samples (Poop collector, pooper scoopers)

Swine Farms w/o Sub-therapeutic Feeding of Antibiotics

With antibiotic feeding

Without antibiotic feeding

Turkey Farms w/o Sub-therapeutic Feeding of Antibiotics

With antibiotic feeding

Without antibiotic feeding

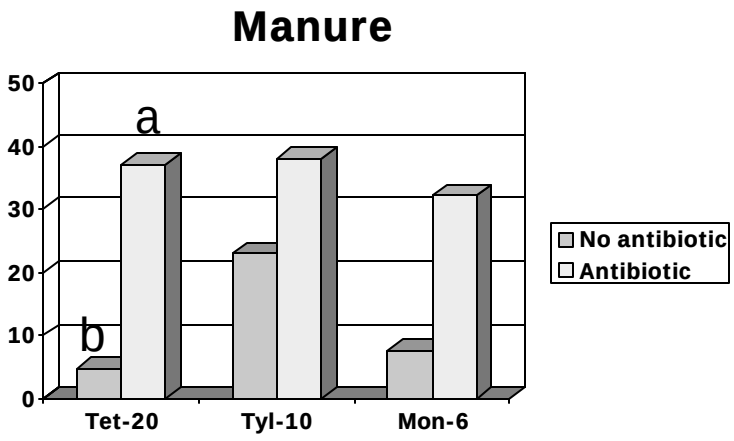
Cattle Farms w/o Sub-therapeutic Feeding of Antibiotics

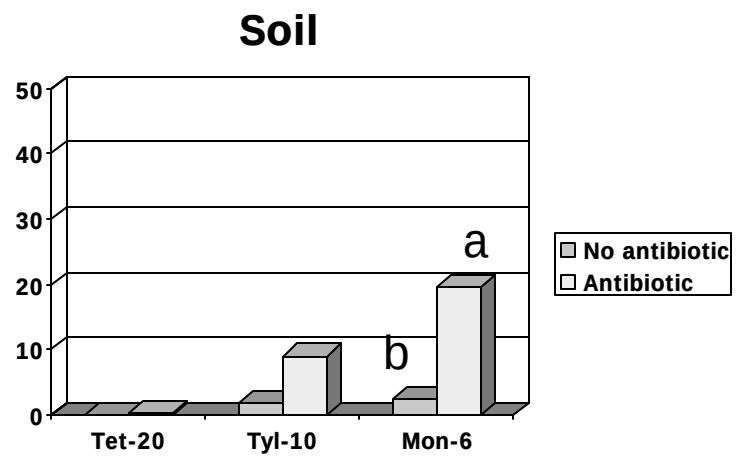
With antibiotic feeding

Without antibiotic feeding

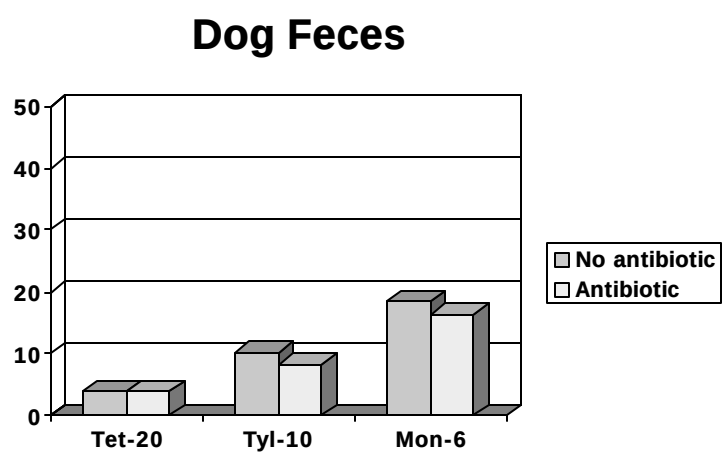
Compost Pile and Dog Fecal Samples

Percent Antibiotic Resistant-Bacteria (ARB) at Swine Farms

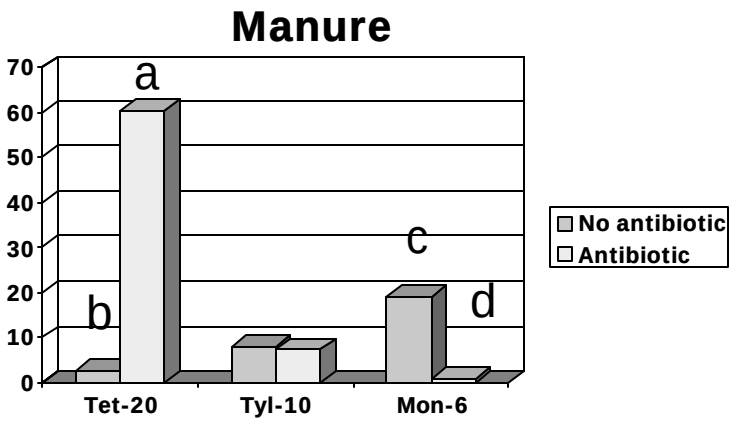


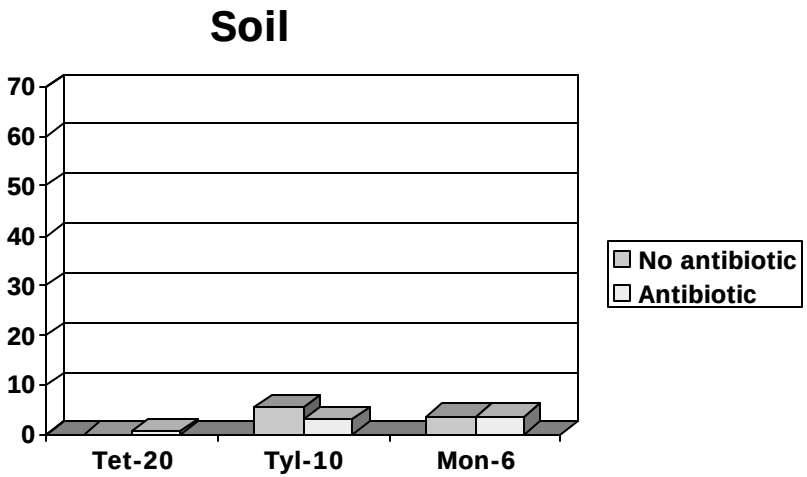


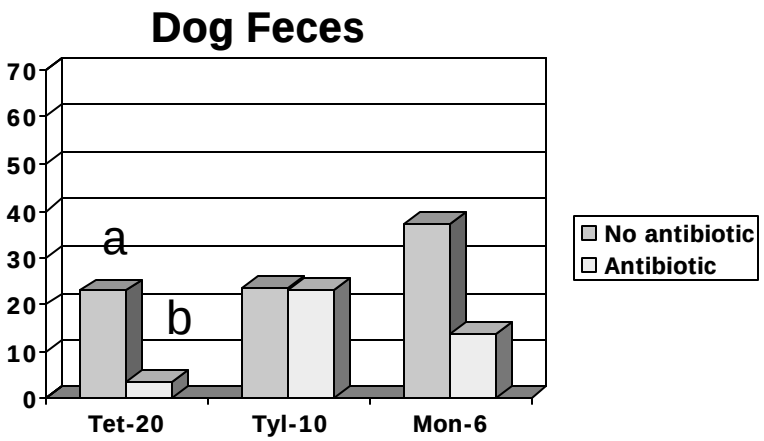
Tet-Tetracycline
Tyl-Tylosin
Mon-Monensin



Percent Antibiotic Resistant-Bacteria (ARB) at Turkey Farms







Tet-Tetracycline
Tyl-Tylosin
Mon-Monensin

Antimicrobial Resistance in Surf-N-Sub Plots, April 2004

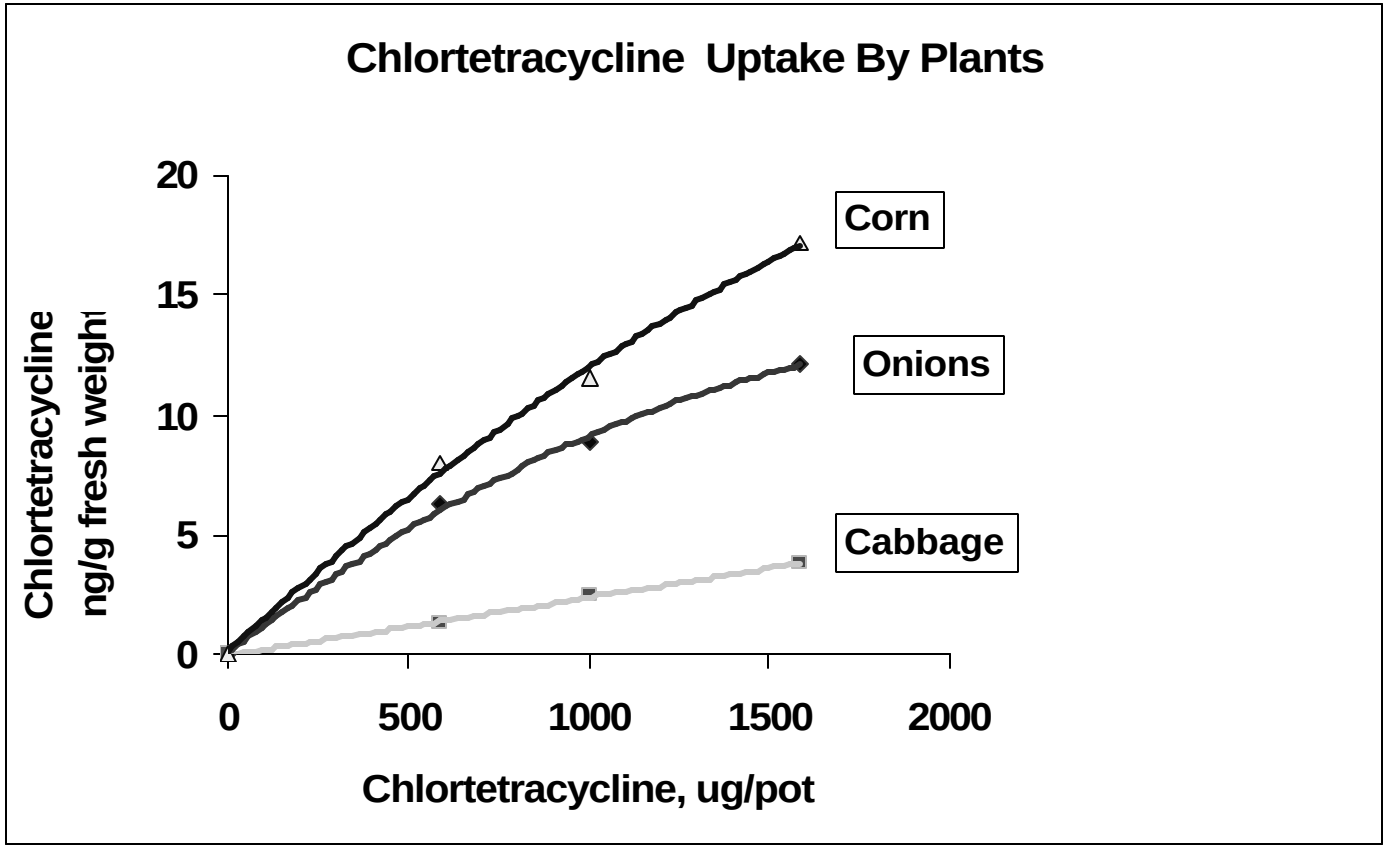
	% Increase in Resistant Bacteria		
Treatment	Tetracycline	Tylosin	Monensin
Manure	0	34.8	27.0
Urea	0	7.0	6.0
Manure never applied	0	0.3	0.7

Plants Uptake of Antibiotics

Corn
Lettuce
Potato

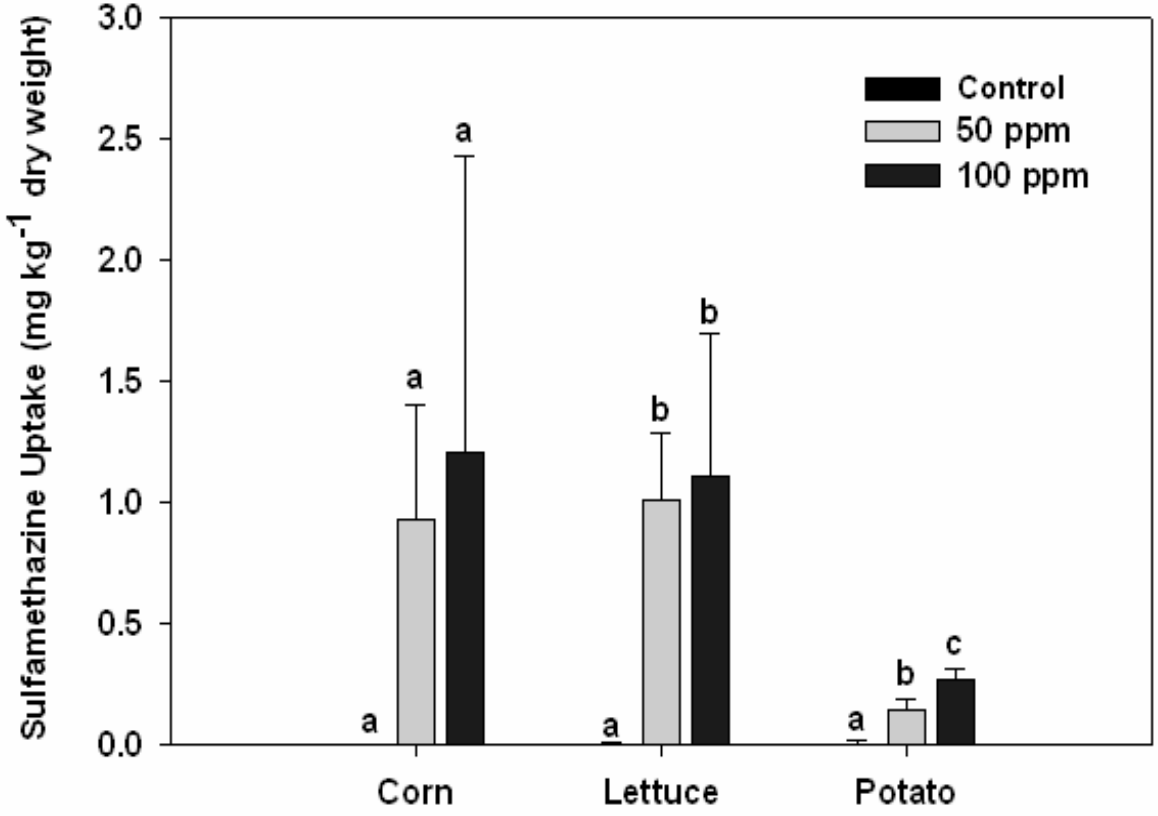
(Holly Dolliver's Experiment)

Chlortetracycline Uptake by Plants (Kumar et al. 2005)



No uptake of tylosin by plants

Sulfamethazine Uptake by Vegetable Plants (Dolliver et al.)



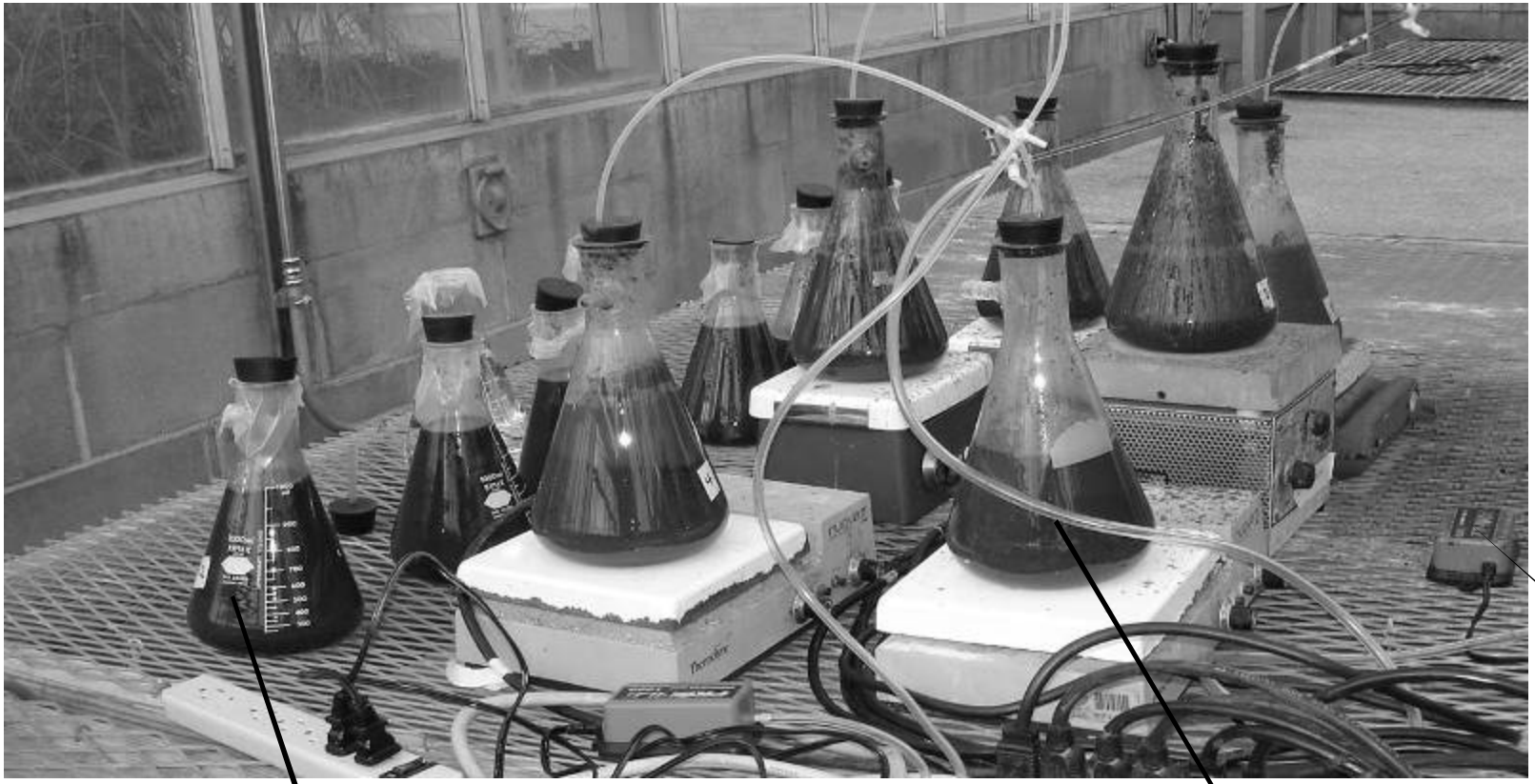
Effect of Cooking on Vet. Drug in Food Animal Tissue

Drug	Water 100 °C	Cooking Oil 260 °C	Bo, Ro, Gr, Br, Fr
Clenbuterol	Stable	1/2 life 5 minutes	No change except frying
Levamisole	Stable	Unstable ½ life 5 mts	No change, some loss in roasting
Sulfamethazine	Stable	½ life 5 mts 180 °C ½ life 2 hrs	No change. Stable for 3 mo when frozen
Oxytetracycline	Unstable ½ life 2 mts	180 °C ½ life 8 mts	35-94% reduction

Bo=Boiling; Ro=Roasting; Gr=Grilling; Br=Braising; Fr=Frying

Rose et al. (1995, 1996)

Degradation of Antibiotics in Swine Manure (Kumar & Dolliver)

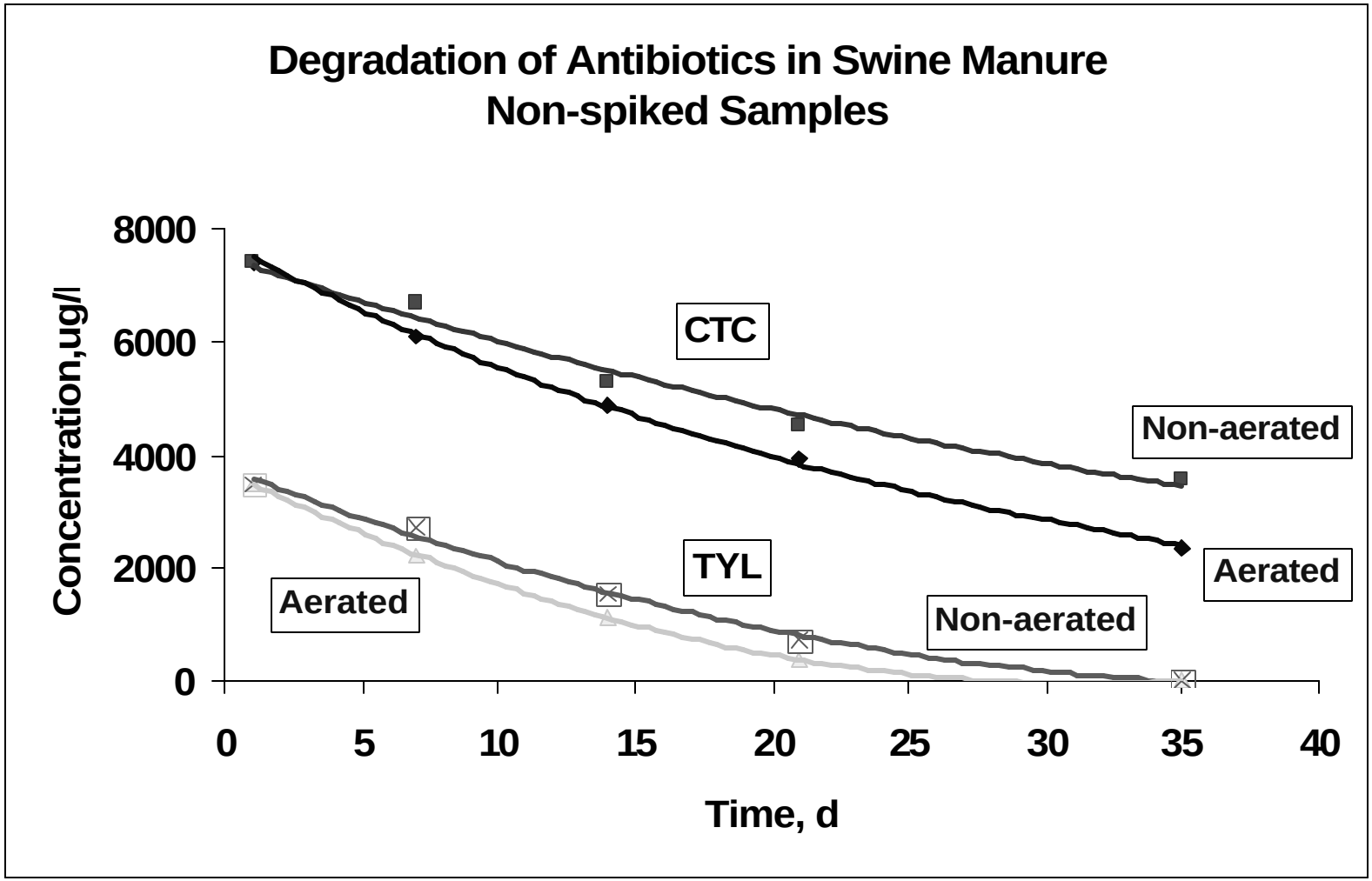


Pump

Non-aerated

Aerated

Antibiotic Degradation in swine Manure



Kumar et al., 2006

Half-life (Days) of Chlortetracycline and Tylosin

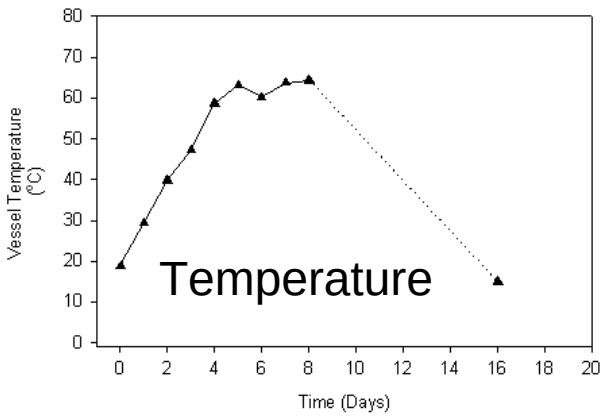
Samples	CTC		TYL	
	Non-aerated	**Aerated**	**Non-aerated**	**Aerated**
	----------Days----------			
Non-spiked	30	22	10	8
Spiked	28	16	6	10

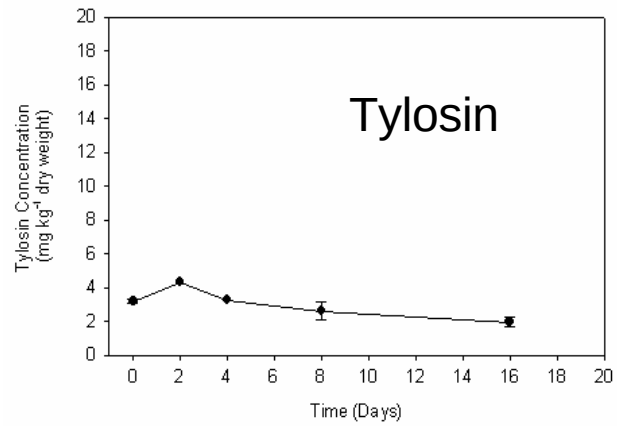
Non-spiked CTC=7.4 mg/L; TYL=3.5 mg/L
Spiked CTC=151 mg/L; TYL= 83.5 mg/L

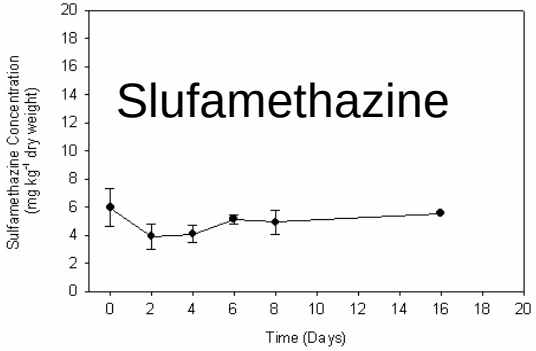
Composting in a Vessel

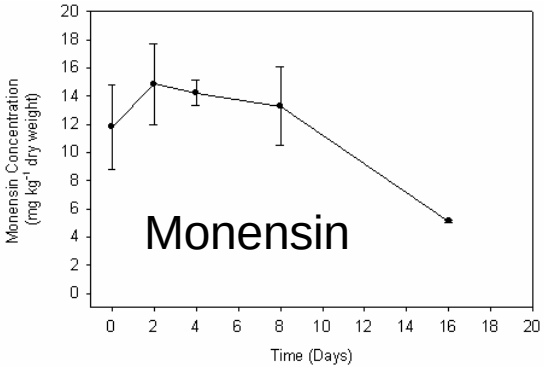
Dolliver et al. 2007

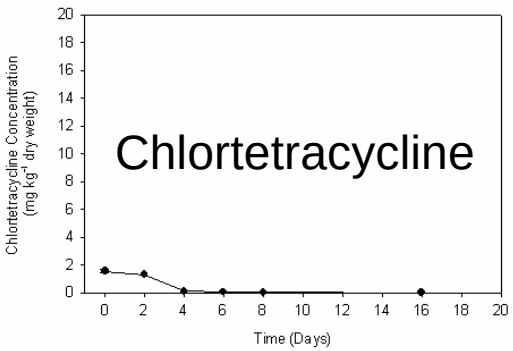
Antibiotic Degradation during Vessel Composting











Dolliver et al. 2007

Composting in Manure Piles

Dolliver et al. 2007

Conclusions

- Chlortetracycline, tetracycline and tylosin are generally tightly held by soils.
- Higher the clay content greater is the adsorption.
- Soil adsorbed antibiotics are microbially active and probably contribute to antibiotic resistance.

Conclusions

- There is some potential for antibiotics to leach into groundwater from sandy outwash and karst soils.
- Most of the antibiotic losses from manure applied lands are with sediment losses in runoff.
- Plants take up antibiotics from manure applied soils. It has some implications on organic farming.

Conclusions

- Antibiotic resistance is higher in manure from antibiotic user farms.
- However, this resistance does not seem to spread to bacteria in soil (mixed results) and dog fecal samples. Sample size is too small.
- Half-life of antibiotics in manure is about 20-30 days for CTC and 6-10 days for tylosin. Aeration has minimal impact on antibiotic degradation.

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Thank you