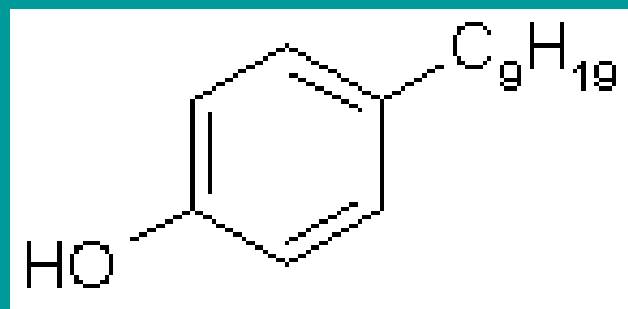


Fate and Degradation of 4-Nonylphenol in Biosolids

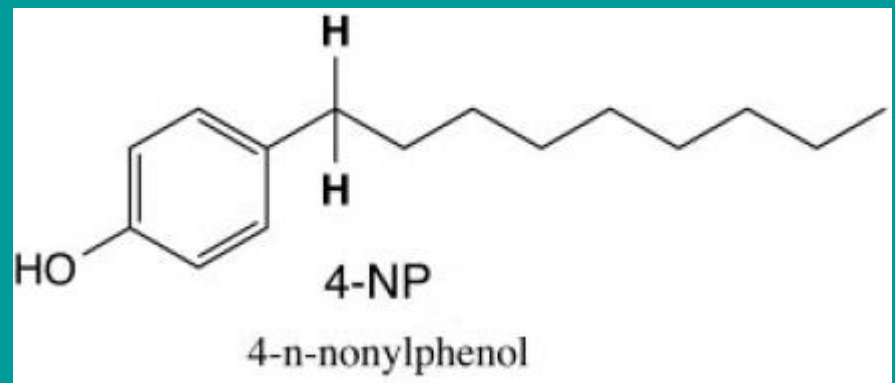


Dana Devin-Clarke, Mike
Doubrava, and Sally Brown

University of Washington and King County
Environmental Lab

What is 4-Nonylphenol?

- Nonylphenol is the anaerobic degradation product of nonylphenol polyethoxylate, a non-ionic surfactant which is used in:
 - Industrial detergents
 - Synthesis of pesticides
 - A plasticizer in PVC
 - Pulp and paper processing



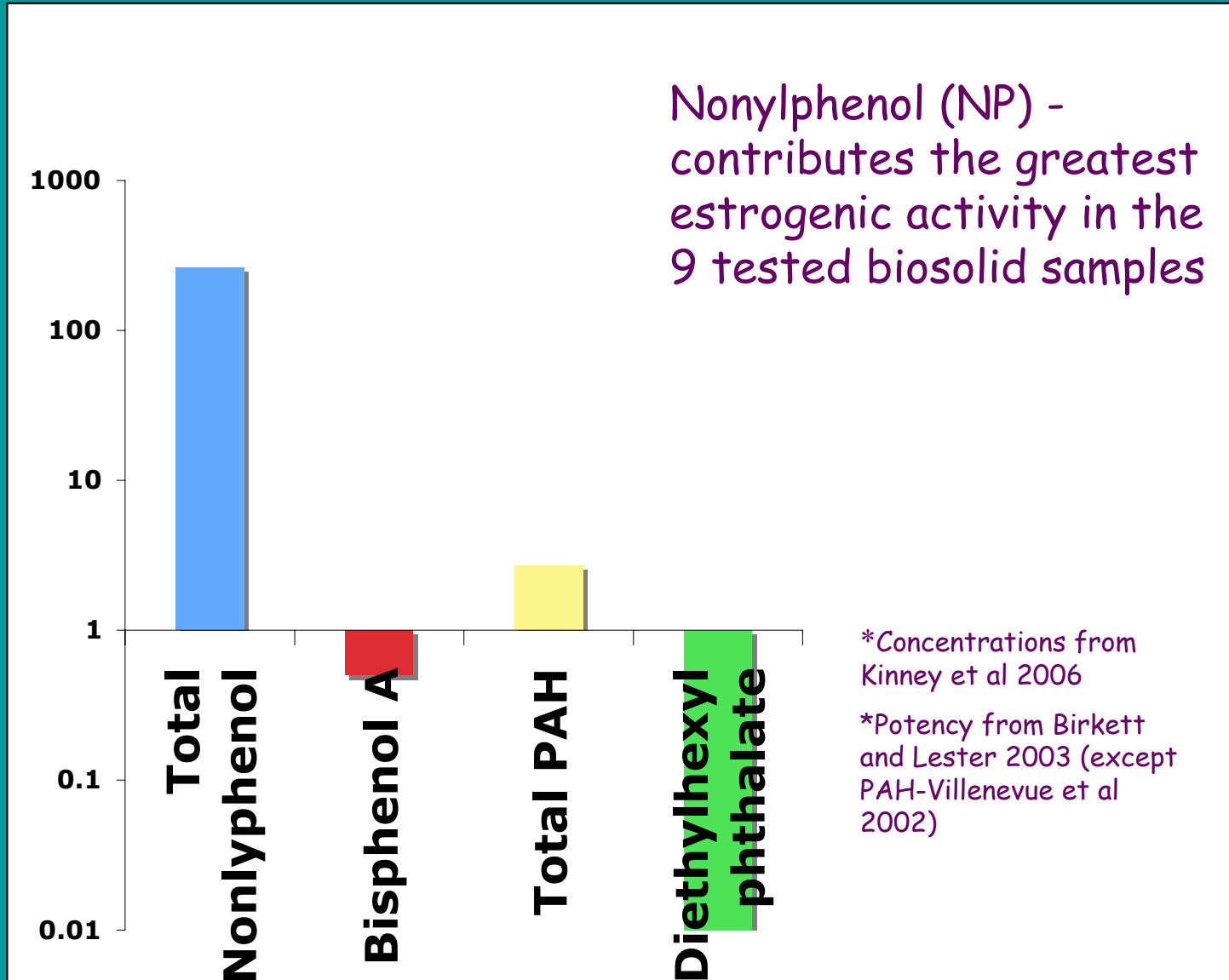
How is NP formed?

- Nonylphenol polyethoxylates enter the WWTP and are degraded into NP
- The Log Kow of NP is 4.48
- Almost all NP ends up in the biosolids



NP in Biosolids

$$\text{Activity} = \text{Concentration} * \text{Potency}$$



NP in Biosolids

- USGS survey (2006) of OCs in 9 different biosolids:
 - Median concentration of NP = 261 mg/kg
 - Max: 1,520 mg/kg and a Min: 2.18 mg/kg
- **King County biosolids NP = 700- 900 mg kg**



Biosolids and Feminine Sheep



One study found sheep embryos had smaller testes when ewes grazed in biosolids amended soils (Paul et al., 2005)

Changes in behavior were also observed, suggesting increased female character traits by male sheep (Erhard and Rhind, 2004)



Initial Work

- 1) Develop analytical methods
 - Freeze dry sample
 - Spex Certiprep Mixer Mill
 - Accelerated Solvent Extraction/
known amount of standard added
 - Silica Gel Fractionation
 - Analysis by Gas Chromatograph/Mass Spectrophotometer- results adjusted to match standard recovery
- 2) Determine detection limits (0.5 mg kg)
- 3) Recovery from biosolids and biosolids amended soils



Actual Study

Objectives:

- 1) Determine the degradation rate of NP in land applied biosolids at realistic agronomic rates
- 2) Investigate the effect of plant presence on degradation rate
- 3) Monitor the movement of NP within the soil column and uptake into plant tissue after biosolids application



Experiment

- Soil : Esquatzel silt loam: coarse, silty, superactive, mixed, mesic Torrifuventic Haploxeroll
- Biosolids: Class B anaerobically digested applied at 10 Mg ha
Surface application, mixed top 4 cm
- One spike - tech NP- combination of 22 isomers (8 tested)
- Each treatment- plant (wheat)/no plant
- Harvest at 0, 15, 30, 45
- Additional treatment- biosolids harvested at 0,3,6,9,12- to determine rapid decomposition rate



Harvest

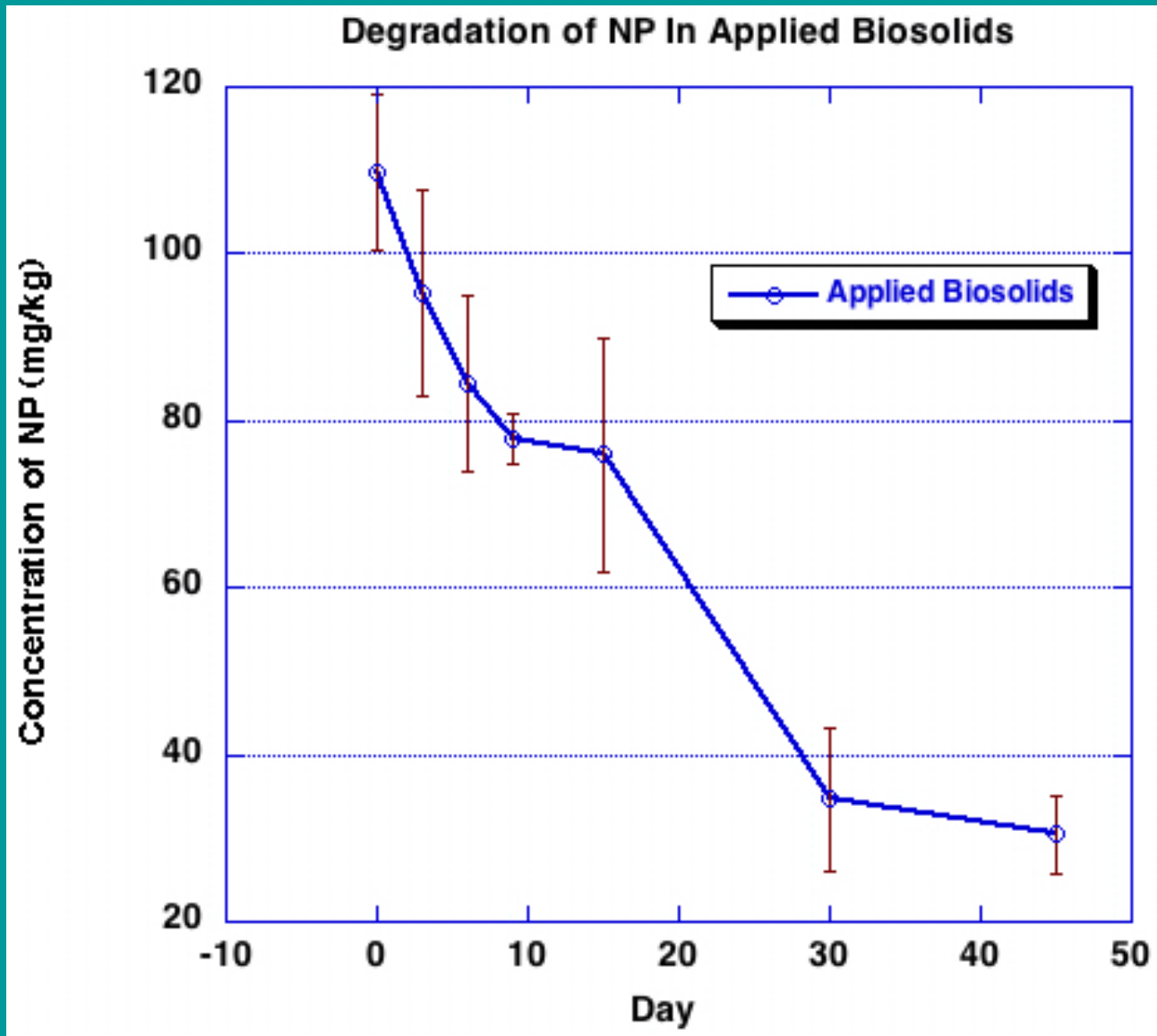


Intact soil column, plant and leachate samples were collected for each harvest

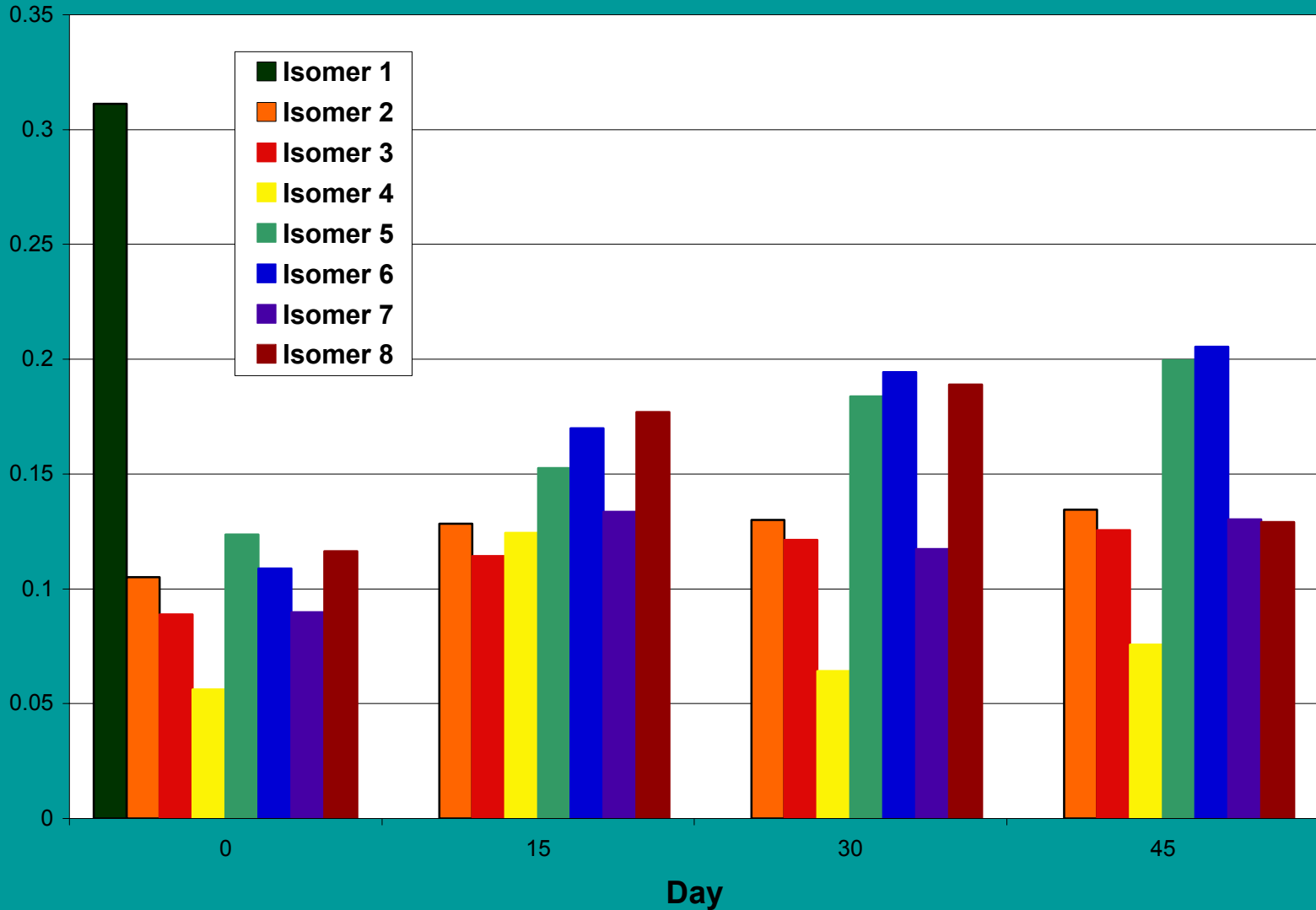
Soil column divided into three depths



Results- Degradation in Biosolids amended

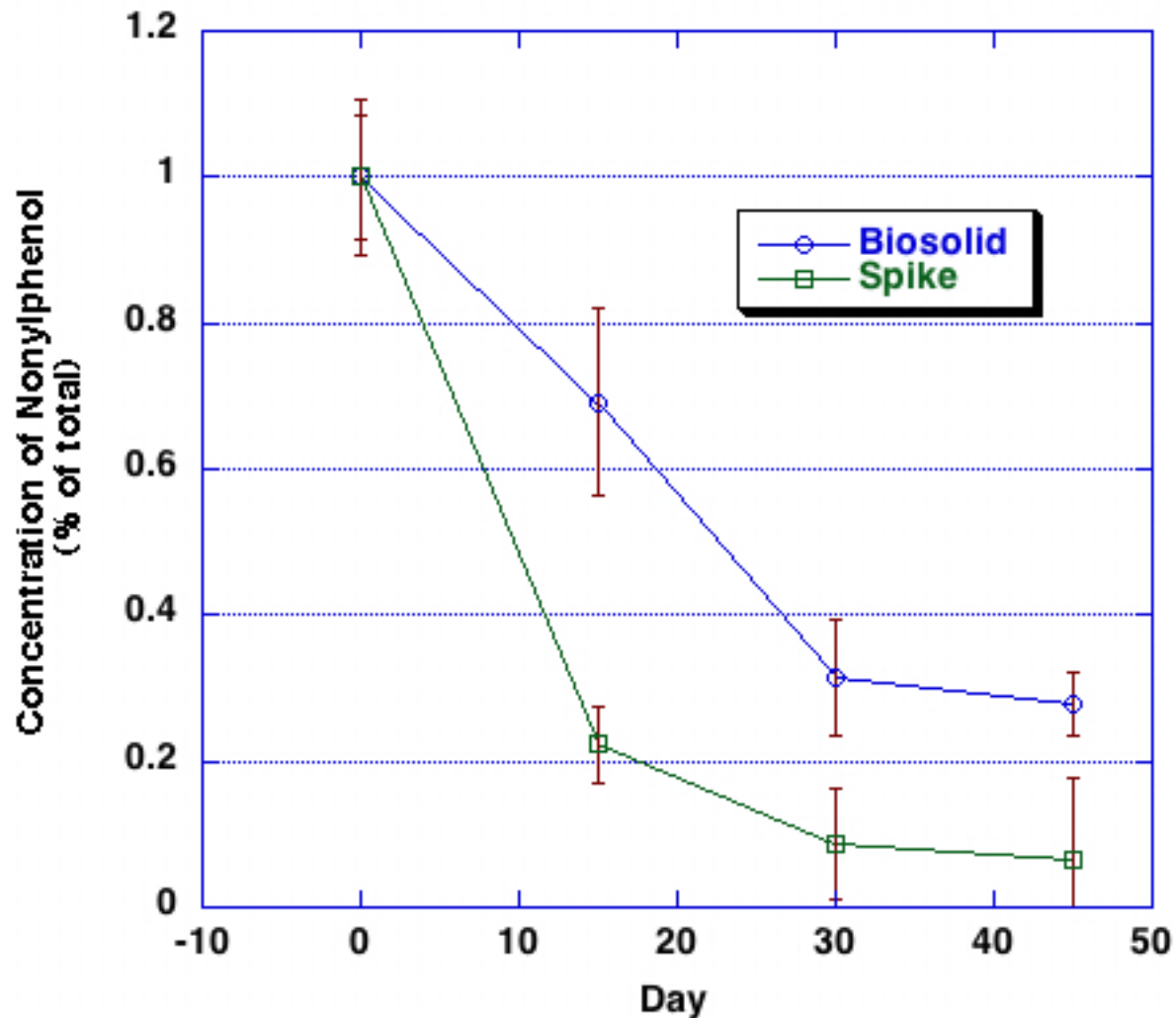


Prevalence of Isomers (Biosolids treatment)

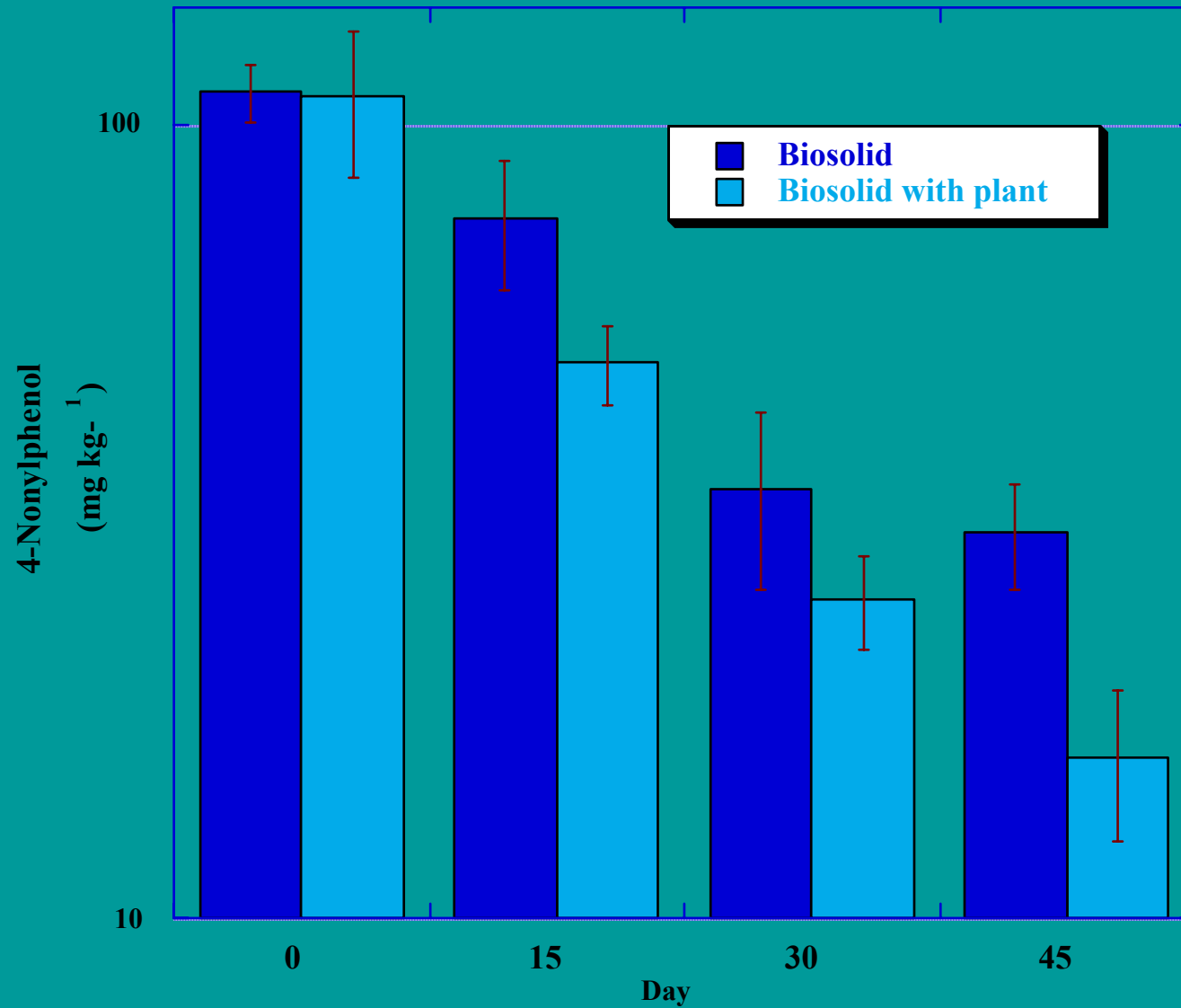


Degradation in Spike versus Biosolids

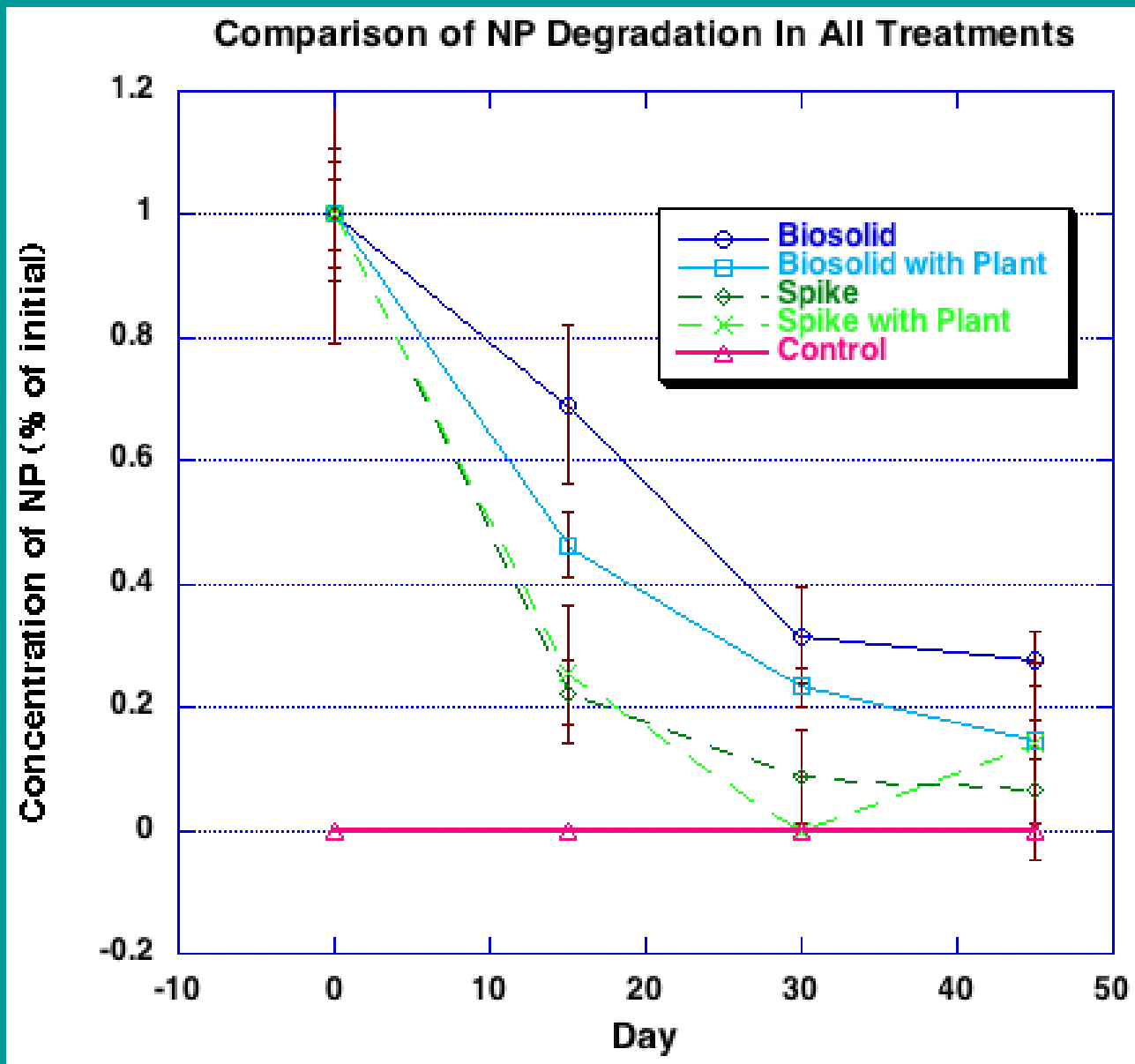
Comparison of 4-Nonylphenol and Technical Nonylphenol Degradation



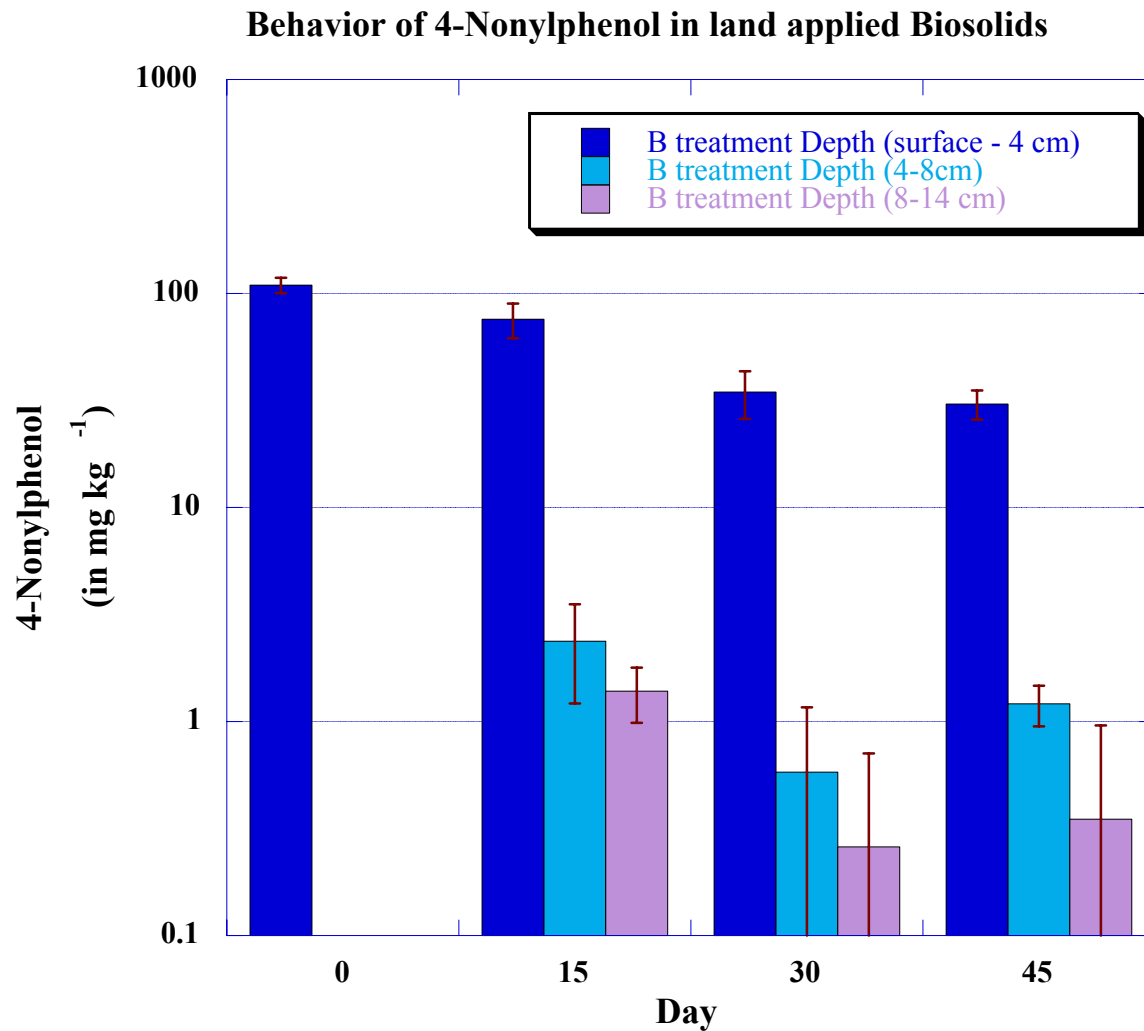
Effect of Plant- Biosolids Treatment



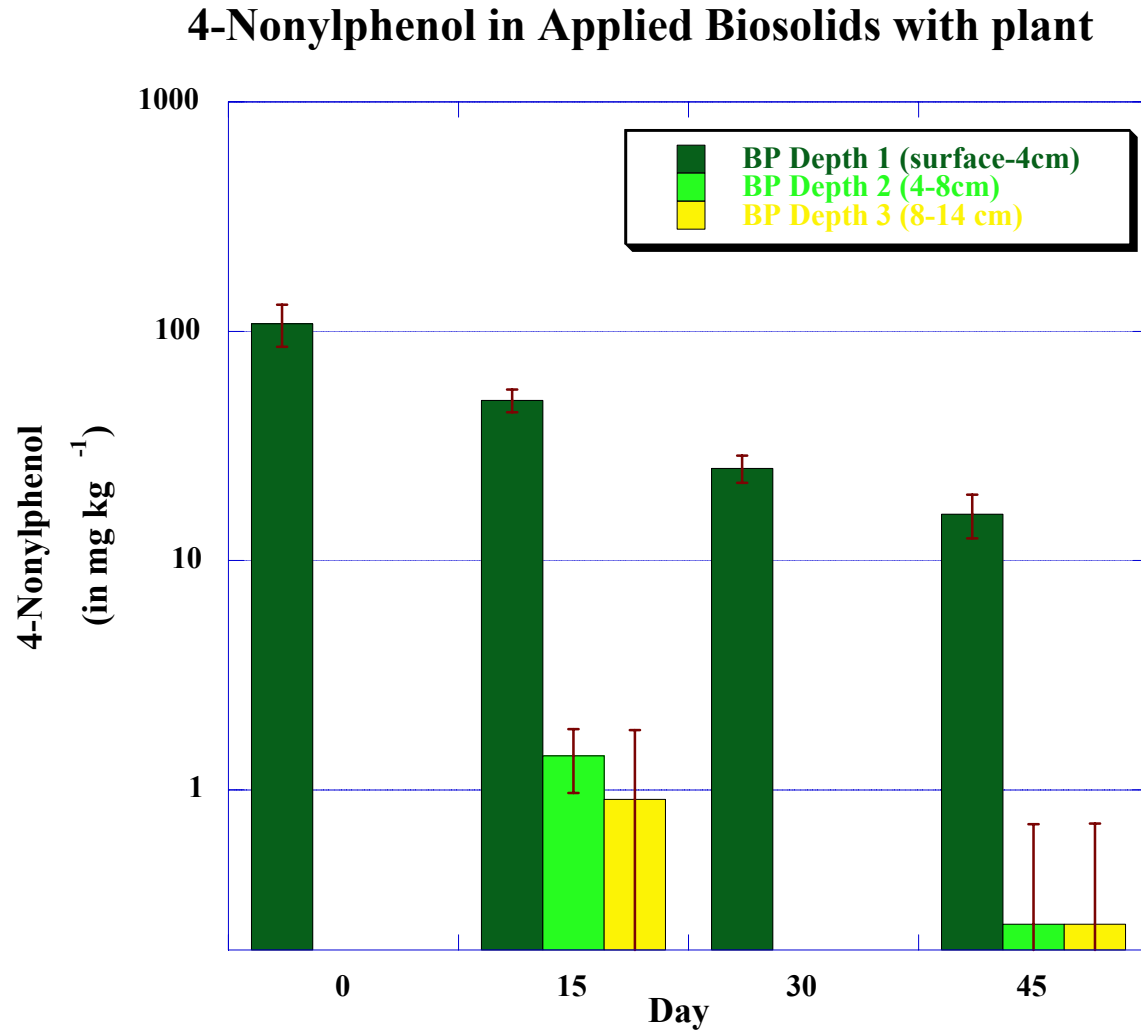
NP Degradation in all Treatments



Movement within the soil column



Plant and Movement (Biosolids amended)



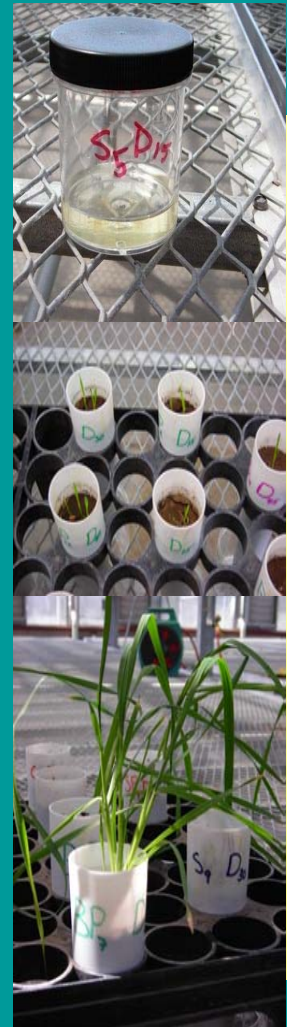


No NP in Plant or Water

- NP below detection for plants in all treatments at all sampling times
- NP below detection for water collected from all treatments at all sampling times

Summary Results

- 4-Nonylphenol remained static within the replicated soil systems and degraded to 15% within 45 days
- Degradation appears to follow 2 phases
- Degradation may be accelerated in presence of plants
- No indication of plant uptake or movement via soil water



Conclusions

With the recent report that 8% of male sheep exhibit homosexual tendencies (NYT 1/24/07) without a whiff of biosolids.....

