Introduction

Approximately 350 million tons of manure is produced every year by agriculture in the U.S.; manure disposal at large concentrated animal feeding operations (CAFO) represents a significant challenge.

For operations seeking to reuse dry digested solids as bedding materials, reduction of the causative agents of mastitis, a pathogenic infection in dairy cattle causing decrease in milk production, is of prime importance.

Although, at present, pathogen reduction is not required for manure application to land as is the case for wastewater biosolids, similar regulations for manure biosolids are a possibility in the near future. Therefore, the reduction of populations of zoonotic pathogens such as Salmonella spp., Campylobacter spp., Enterococcus spp. and fecal bacteroides in manure treatments need to be quantified.

Pathogen reduction in agricultural waste has been shown to depend upon operational parameters on the farm including storage, treatment processes (anaerobic digestion, solids separation, composting etc.) temperature, pH, influent substrate composition, but thorough analysis to establish correlations between these different parameters has not been conducted.

Identification of process and operational parameters that yield greater pathogen reduction and thus allow for better recycling of solid waste residuals may increase economic benefits to U.S. dairy operations that choose to use a particular technology for manure treatment.

Hypothesis

Reduction of pathogens may occur through treatment of biosolids which may be dependent on processes involved (anaerobic digestion, solids separation, composting etc.)

Pathogen concentration is directly proportional to the moisture content, volatile solids content and chemical oxygen demand of the sample in which the pathogens are being tested.

Pathogen concentration in inorganic bedding materials is statistically lower than organic bedding.

Methods

Samples were collected from Sheland farms (Adams, NY), North Harbor Dairy (Sackets Harbor, NY) and Mark’s farm (Lowville, NY) (shown below)

Collected samples were analyzed for total solids (TS) and volatile solids (VS) content and Chemical Oxygen Demand (COD) according to Standard Methods.

Statistical analysis was done to determine the significant effects of various parameters on pathogen populations using Minitab-15 software.

The detection and quantification of pathogens was done by real-time qPCR analysis of extracted DNA from the collected samples using methods described in research literature.

Results

Reduction of pathogen populations during anaerobic digestion, Sheland farms

• In general a 1.5 to 2.5 log reduction in pathogen populations was observed in Sheland farm digester, which is in agreement with literature;

• Solids composting at elevated temperatures (~60 °C) also achieves a 1 to 2 log reduction of pathogens

\[ P > 0.05 \] Strong effect on pathogen concentrations (shown in blue)

\[ 0.001 < P < 0.005 \] Weak/no effect on pathogen concentrations (shown in red)

• Moisture and volatile solids content and sample type (manure, sand or organic bedding) have significant effects on concentration of pathogens; temperature and sample location had little or no effect on pathogen concentration.

• Taking affecting parameters one at a time as a predictor/independent variable, linear regression analysis was done for the response (log values of pathogens).

• Residuals on the normal probability plot form a nearly linear pattern indicating that the normal distribution is a good model for the given data set.

Conclusions

• Anaerobic digestion is an effective way of reducing pathogen concentrations in agricultural waste streams.

• Pathogen reduction is also achieved by composting dairy waste at high temperature (~60 °C)

• Pathogen concentration in samples is dependent upon moisture and volatile solids content but not on ambient temperature or sample location.

• Inorganic media like sand harbor less pathogens than carbon-rich media like organic bedding.

• Using factorial design we would like to find the joint effect of two or more factors that influence pathogen concentrations. This would help to identify the pathogen outcomes more precisely.

Acknowledgements

NYSERDA, NY Ag and Markets & USDA for funding the research Yunhui Deng, Madhuri Grandhi, Kaushik Venkiteshwaran and Ying Zhang for their help in sample analysis