Evaluation of the pathogen reduction from plug flow and continuous feed anaerobic digesters.

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ABSTRACT.

Reduction of pathogens from the treatment of animal manure in anaerobic digesters (AD) has implications for policies related to land application of the post AD materials and bio-security implications for "community " digesters. Samples of pre-AD liquid, post AD liquid, and post AD solid were assayed bi-weekly, on two consecutive days, for six sampling events from a continuous feed and plug flow AD. Samples were quantitatively assayed for generic E-coli and enterococci and qualitatively assayed for Mycobacterium avium paratuberculosis (MAP), and bovine enterovirus, and Salmonella spp. E. coli, enterococci, and enterovirus were selected because of their dependable occurrence in bovine feces, their similarity to potential biosecurity agents and their wide thermotolerance range. Mycobacterium avium paratuberculosis and Salmonella were selected due to their importance as biosecurity agents. Anaerobic digestion resulted in declines of 98.8 % and 99.9 % (at the two sites) for generic E. coli and 84.5 % and 95.8 % for enterococci. Four samples of composted solid manure from the plug flow digester indicated a reduction of 100 % for generic E-coli and 99.9 % in enterococci. Bovine enterovirus and MAP were isolated on numerous occasions from both pre- and post-digestion samples and composted material. Salmonella spp. were found in only two samples, both post-digestion. While substantial quantitative reductions occurred for E. coli and enterococci, the low level of survival of these indicator organisms along with the frequent survival of enterovirus and MAP indicates that anaerobic digestion, even followed by composting, would not remove all biosecurity hazard.

Keywords. Anaerobic digester, pathogens, bio-security

Manure is recognized as a means of transmitting some domestic disease agents of biosecurity concern in cattle, including Mycobacterium paratuberculosis (Wells 2000), salmonella (Veiling, 2002; Radke, 2002; Warnick, 2001), protozoa and viruses (Guan, 2003). Manure also represents a mode of transfer of zoonotic agents to crops grown for animal or human consumption (Beuchat, 1997; Natvig, 2002; Solomon, 2002; Guan, 2003). Manure contamination of crops in international commerce has been implicated as a means of transmission of *E. coli* 0157:H7 (Davis, 2003).

While there are numerous claims of the impact that anaerobic digesters (AD) can have on pathogen reduction (http://www.epa.gov/agstar/library and Sobsey et al. 2000), limited detailed studies are available that demonstrate efficacy. Most of these studies result in uncertain pathogen reduction estimates and are based on limited lab studies or pilot field studies with few pathogens (Sobsey et al 2000). Reductions range from 1- 2 $\log_{10}$ for mesophilic AD to >4 $\log_{10}$ for themophilic AD. Gamroth and Krahn (2003) did report a 98 % reduction from 60 million to 1.2 million with a continuous flow AD in Oregon.

Currently there are a number of AD systems being proposed in Washington State, with only one currently being operational (McConnell, 2004 and Sayre, 2004). One system being proposed is a community digester that would collect manure from many dairies at a centralized facility (http://www.quilcedapower.com/). In planning these systems, there has not been a consideration of the implications of pathogens associated with the post AD liquid or solid material. The potential pathogen reduction due to AD treatment is an important consideration since it has been proposed that the post AD solid would be: 1) used in the horticulture and row crop vegetable and fruit industry, 2) recycled back to dairies as bedding material, and the liquid used for fertilizer and irrigation. Movement of post AD liquid or solid has the potential in each case to transfer pathogens amongst agricultural industries or herd-to-herd transmission in the case of the community AD system.

METHODS

Two operating anaerobic digesters in Oregon were the source of pre- and post AD samples. The sampling period was bi-weekly, on two consecutive days, for six sampling events. The samples were

obtained from: manure prior to the AD system, and solids and liquids post AD. The design of the two digesters was different, with one being a plug-flow and the other, a continuous feed.

Specific organisms selected for evaluation were: Salmonella, Generic *E. coli* (including 0157:H7), enterococci, salmonella, m*ycobacterium paratuberculosis* (Johnes), and enterovirus. Generic *E. coli* was selected because high concentrations are dependably present in bovine fecal waste, and, because of its relatively low thermotolerance, survival of this organism in residues would indicate that a wide variety of biosecurity agents could likely survive. Enterococci were selected because they are dependably present in bovine fecal waste, and, because of their relatively high thermotolerance, survival of these organisms in residues would indicate that thermotolerant biosecurity agents could likely survive. Salmonella and *Mycobacterium paratuberculosis* were selected because they are themselves important biosecurity agents, because they occur frequently enough in dairy herds that a good chance exists of finding them (at least in pre-digestion samples), and because they are environmentally resistant to a lesser (Salmonella) or greater (*Mycobacterium*) degree. Enteroviruses were selected because they occur ubiquitously in cattle populations at a high prevalence (Ley et al, 2002) and they have a similar level of environmental resistance as certain viruses with biosecurity implications.

RESULTS AND CONCLUSIONS

A summary of results from pre- and post AD samples collected from the two AD systems are shown in Figures 1-3 and Table 1. The data indicated reductions in pathogen concentration were > 98% (generic E. coli, enterococci, and enterovirus) in most cases. While the detection of Mycobacterium paratuberculosis was reduced in post digested samples, however, greater than 50% of samples had detectable levels. The overall data suggest that AD treatment of dairy manure would not remove all biosecurity hazard.

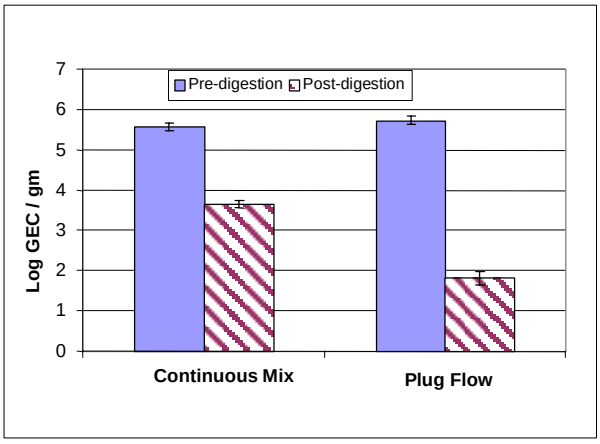

Figure 1. Generic E.Coli concentration in anaerobic digester samples.

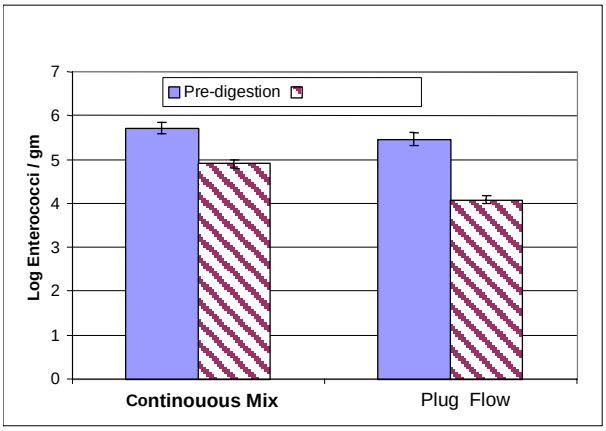

Figure 2. Enterococci concentration in anaerobic digester samples.

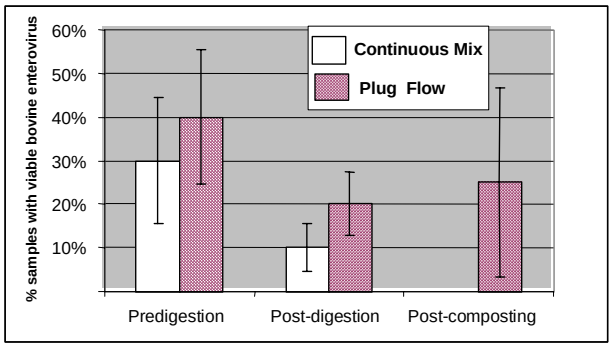

Figure 3. Enterovirus concentration in anaerobic digester samples.

Table 1. Summary of anaerobic digester samples for *Mycobacterium paratuberculosis.*

		Pre-digestion	Post-digestion	Post-composted solids
Continuous Mix	Number of samples	10	30	NA
	% Samples with *Mycobacterium paratuberculosis*	80	40	NA
Plug Flow	Number of samples	10	30	4
	% Samples with *Mycobacterium paratuberculosis*	90	63.3	0

REFERENCES

http://www.epa.gov/agstar/library

Beuchat LR, Ryu JH. Produce handling and processing practices. Emerg Infect Dis. 1997 Oct-Dec;3(4):459-65.

Davis MA, Hancock DD, Besser TE, Rice DH, Hovde CJ, Digiacomo R, Samadpour M, Call DR. Correlation between geographic distance and genetic similarity in an international collection of bovine faecal Escherichia coli O157:H7 isolates. Epidemiol Infect. 2003 Oct;131(2):923-30.

Gamroth M and J Krahn. 2003. Development and monitoring of anaerobic digestion of dairy manure for power generation and better manure management. Report to Portland General Electric.

Guan TY, Holley RA.Pathogen survival in swine manure environments and transmission of human enteric illness--a review. J Environ Qual. 2003 Mar-Apr;32(2):383-92.

Ley, V, J Higgins, and R Fayer. 2002. Bovine enteroviruses as indicator of fecal contamination. Appl. and Env. Micro. 68:3455-3461.

McConnell, C. 2004. Personal communication.

Natvig EE, Ingham SC, Ingham BH, Cooperband LR, Roper TR.Salmonella enterica serovar Typhimurium and Escherichia coli contamination of root and leaf vegetables grown in soils with incorporated bovine manure. Appl Environ Microbiol. 2002 Jun;68(6):2737-44.

Radke BR, McFall M, Radostits SM.Salmonella Muenster infection in a dairy herd. Can Vet J. 2002 Jun;43(6):443-53.

Sayre, J. 2004. Personal communication.

Sobsey MD, LA Khati, VR Hill, E Alocilja, and S Pillai. 2002. Pathogens in animal wastes and the impacts of waste management practices on their survival, transport and fate. White Papers on Animal Agriculture and the Environment. National Center for Manure & Animal Waste Management.

Solomon EB, Yaron S, Matthews KR. Transmission of Escherichia coli O157:H7 from contaminated manure and irrigation water to lettuce plant tissue and its subsequent internalization. Appl Environ Microbiol. 2002 Jan;68(1):397-400.

Veling J, Wilpshaar H, Frankena K, Bartels C, Barkema HW.Risk factors for clinical Salmonella enterica subsp. enterica serovar Typhimurium infection on Dutch dairy farms. Prev Vet Med. 2002 Jun 25;54(2):157-68.

Warnick LD, Crofton LM, Pelzer KD, Hawkins MJ. Risk factors for clinical salmonellosis in Virginia, USA cattle herds. Prev Vet Med. 2001 May 1;49(3-4):259-75.

Wells S J. 2000. Biosecurity on Dairy Operations: Hazards and Risks. J Dairy Sci. 83:2380-2386.