Effect of Anaerobic Digestion of Dairy Manure on Fate of Bacteria

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LPELC AD Webcast

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May 20, 2011
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Partnership for a Sustainable Future

- Qualco Energy:
  - Tulalip Tribes of NW Washington
  - Northwest Chinook Recovery
  - Snohomish-Skykomish Agricultural Alliance
- Support environmental projects that maintain agricultural river corridors.
  - Shellfish business
  - Fisheries
  - Culture

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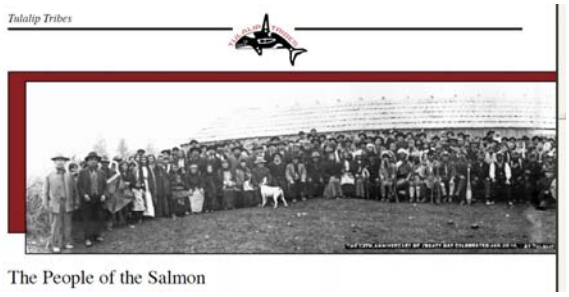

" I have a responsibility to look out 7 to 10 generations"

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Qualco Anaerobic Digester (AD)

- Renewable Energy Production
  - Methane to Electricity
- Waste Management
  - Decreased Odor
- Pathogen Reduction
- Nutrient Management
  - Nutrient transformation
  - Cycle nutrients back to farm
- Value Added Products
  - Composted solids
  - Struvite

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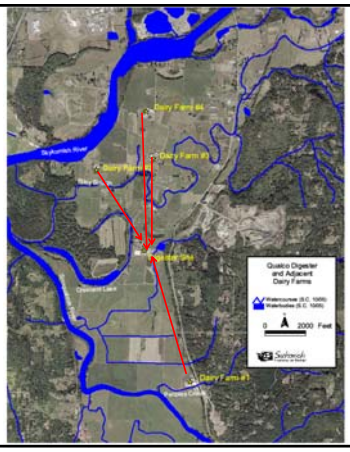

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Use of Pre-consumer Foodwastes for Anaerobic Digestion in Washington State

Guidelines for 30% limit of pre-consumer foodwastes can be found at:

http://www.ecy.wa.gov/programs/swfa/ad/2009Leg.html

Trap grease, ruminant blood, expired beverages and liquids, fish stick waste, paper pulp byproduct, whey, and biodiesel byproduct

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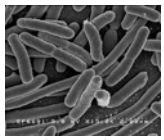
Financial support for the projects was provided by the USDA Natural Resources Conservation Service via their Conservation Innovation Grant Program

USDA NRCS
United States Department of Agriculture
Natural Resources Conservation Service

What are the benefits of AD from the microbiological perspective?



- What about bio-security?
  - Are herds at risk due to comingling manure from other herds?
  - Is infection transmission reduced within a herd?
- Is the environmental impact of dairy manure reduced?
  - Can ADs reduce the load of bacteria applied to land?
  - Provide protection of surface water quality?!

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Dairy manure may contain many microorganism species, some in high numbers

- > 150 are pathogens (disease-causing microorganisms) and some are zoonotic, meaning that if present they are risks to exposed humans
- Some, such as *E. coli* O157:H7 and certain *Campylobacter* spp., are not pathogenic for the infected cow producing the contaminated manure but are for other species exposed to the manure
- Manure application may pose risks to humans and grazing animals because some manure pathogens survive well in vegetation, soil, and water if present at application

For general microorganism and disease information, see the CFSPH information sheets at http://www.cfsph.iastate.edu/DiseaseInfo/

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Bacteria selected for monitoring represent several characteristics

- Risk to human health
- Environmental survivability
- Frequent occurrence in the dairy environment

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Four cause significant human disease

Bacteria	Infections per 100,000 people	Proportion Hospitalized	Case Fatality Rate (CFR)
Salmonella spp.	342.5 (1:300)	27.2%	2.0%
Campylobacter spp.	281.7 (1:350)	17.1%	0.9%
E. coli O157:h7	21.1 (1:5,000)	46.2%	0.9%
Listeria monocytogenes	0.5	94.0%	17.5%

For further information, see:
Foodborne illness acquired in the United States – Major pathogens. *Emerging Infectious Diseases* 17(1)7:15, 2011. DOI: 10.3201/eid1701.P11101
http://www.cdc.gov/eid/content/17/1/7.htm

Ranking the risks: The 10 pathogen-food combinations with the greatest burden on pubic health. MB Batz, S Hoffman, JG Morris, UF Emerging Pathogens Institute, 2011
http://www.epi.ufl.edu/sites/www.epi.ufl.edu/files/RankingTheRisksREPORT.pdf

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Survival times depend on the response of that pathogen species to specific environmental conditions

Microorganism	Typical Survival Times					Multiply Outside Host?
	Slurry	Fecal Pats	Soil	Water	Dried (no UV)	
Campylobacter spp.		2 mth	3 wk	1 mth		No
Salmonella enterica	3 mth	5 mth	1 mth	2-4 wk	years	Yes
E. coli	3 mth		1 mth	2-4 wk		Yes
Listeria spp.	6 mth		2 mth	6 mth		Yes
Enterococcus spp.		1 yr				No
M. paratuberculosis	6 mth		1 yr	2 yrs		No
Viruses			1 yr			No
Cryptosporidia	2 yrs			6 mth	<1 hr	No
Helminth ova			7 yrs			No

- Summarized in NRAES -147 – Waterborne Pathogens in Agricultural Watersheds

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Subjective ranking of bacteria for hardiness, high to low resistance

Mycobacterium avium subspecies *paratuberculosis*

Enterococcus spp.

Listeria spp.

Salmonella enterica

Escherichia coli

Campylobacter jejuni

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Pathogens are not constantly present in high numbers so indicator organisms are monitored

- Pathogens are commonly present at low levels in the environment, water, and foods
  - Present risk to susceptible hosts at low infectious doses (ID), typically 1 to 100 cells
    - *E. coli* O157:H7 – ID of 1 – 10 cells
    - *M. paratuberculosis* – ID of 100 cells
    - *Salmonella enterica* – ID of 1 – 100 cells
  - Difficult to detect when present in such low numbers
- Indicator organisms are commensal bacterial commonly present in high numbers, can carry antibiotic resistance elements, and are similarly affected by the environment
  - Generic *E. coli* – 21,500 cells per ml on-farm
  - *Enterococci* spp. – 4,800 cells per ml on-farm

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Several pathogens are common in dairy herd manure

Organism	Between Herd Prevalence	Within Herd Prevalence
Campylobacter spp.	93%	34%
E. coli O157:H7	53%	4%
Salmonella enterica	61%	14%
Listeria spp.	32%	
M. paratuberculosis	68%	

For further information, see USDA National Animal Health Monitoring System reports:

- USDA. 2011. *Salmonella*, *Listeria*, and *Campylobacter* on U.S. Dairy Operations, 1996–2007. USDA–APHIS–VS, CEAH. Fort Collins, CO
- USDA. 2008. Johne's Disease on U.S. Dairies, 1991-2007. USDA–APHIS–VS, CEAH. Fort Collins, CO
- USDA. 2003. *Escherichia coli* O157 on U.S. Dairy Operations. USDA–APHIS–VS, CEAH. Fort Collins, CO

http://www.aphis.usda.gov/animal_health/nahms/dairy/index.shtml

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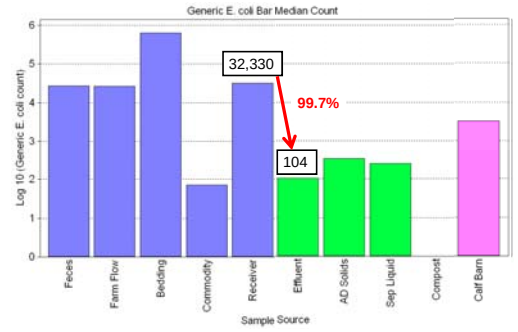
Generic *E. coli* counts dropped passing through the AD



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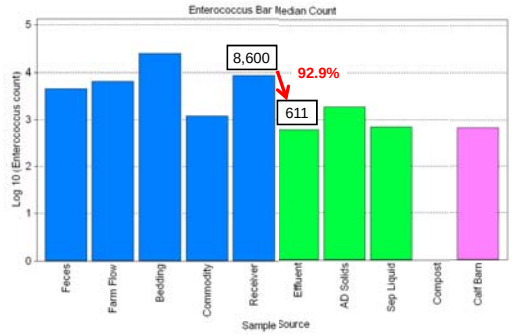
Enterococcus spp. counts dropped passing through the AD



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The AD process reduced two of the other bacteria

Sampling Location	*Campylobacter* spp.*	*Listeria* spp. ***	*Mycobacterium paratuberculosis**	*Salmonella enterica*
On-farm Feces	56% (14/25)	12% (3/25)	84% (21/25)	44% (11/25)
Farm Flow	35% (9/26)	4% (1/26)	78% (21/27)	77% (20/26)
Bedding	0% (0/22)	0% (0/22)	10% (2/21)	27% (6/22)
Feedstocks	0% (0/4)	0% (0/4)	0% (0/6)	17% (1/6)*
Receiving Tank	28% (7/25)	0% (0/25)	63% (17/27)	89% (24/27)
AD Effluent	28% (8/29)	7% (2/29)	71% (22/31)	90% (28/31)
AD Solids	0% (0/23)	9% (2/23)	32% (8/25)	84% (21/25)
SepLiquid	7% (3/43)	5% (2/43)	55% (24/44)	95% (42/44)
Compost	0% (0/20)	0% (0/20)	0% (0/19)	10% (2/20)

*Passing through the AD reduced the proportion of positive cultures
*** Too infrequently isolated to detect a reduction

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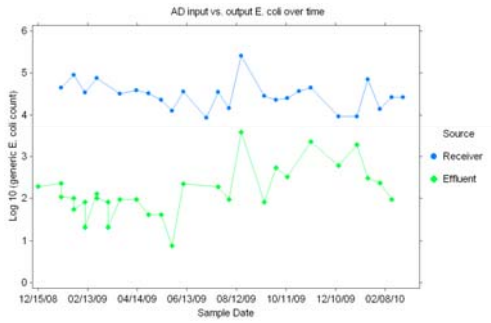
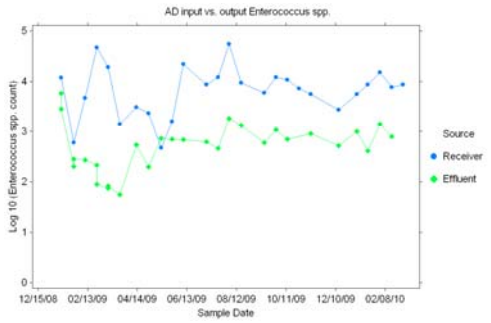
AD effect on generic *E. coli* counts was consistent over time



AD effect on *Enterococcus* spp. counts was less consistent over time



AD effect on a bacterial species is randomly selective rather than differentially selective

- Antibiotic resistance profiles of *Salmonella* spp. and generic *E. coli* were not changed by passing through the AD
- Biofermentation profile of generic *E. coli* was not changed by passing through the AD
- Rep-PCR of generic *E. coli* isolates did not identify a difference due to passing through the AD

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AD reduces the hardier bacterial species less than the more fragile

- Effluents from mesophilic AD are not sterile
- Unless processed further, such as by aerobic composting, the materials must be handled with the same precautions as unprocessed manure
  - Minimize exposure of susceptible animals, such as transition cows, neonates, and sick animals
  - For Johne's control, youngstock should not be exposed to AD effluents before a year of age
  - Observe manure recommendations when applying AD effluents to crops

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To increase environmental benefit, design AD systems to operate at higher temperatures

- Higher operating temperature increases bacterial reduction, particularly of the more resistant species
  - Opportunity to significantly reduce dairy contribution of bacteria to the environment
- More sophisticated control technology with remote monitoring would likely improve thermophilic system feasibility
  - Goal is increased reduction, not necessarily pasteurization

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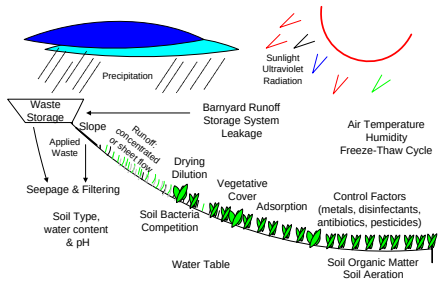
Factors affecting the viability of pathogens along transport pathways.
In general, cool temperatures, moist conditions, and lack of direct-sunlight promotes the survival of microorganisms; while UV light, drying conditions, and limited crop canopy promote die-off of microorganisms



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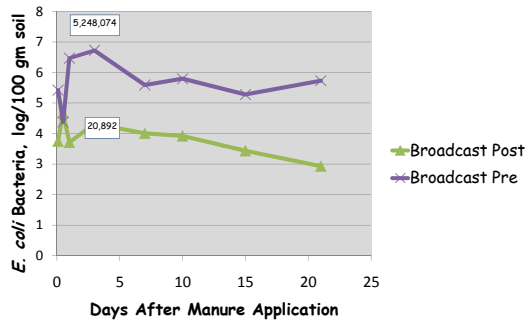

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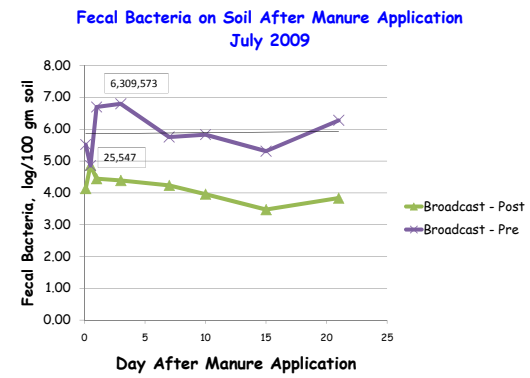

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Take Home Messages

Anaerobic digestion of manure reduces common pathogens in manure by at least 90%

When land applied, anaerobically digested manure has significantly fewer bacteria, both initially and for weeks thereafter

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