Monitoring Aerosol Drift from Spray Irrigated Manure Liquids

May 17, 2013

Mark Borchardt, Ph.D.
Research Microbiologist, USDA-ARS

Becky Larson, Ph.D.
Assistant Professor & Extension Specialist, UW – Madison

Susan Spencer, Ana Rule, John Panuska, Zach Zopp, Jordan Gonnering

Funding

- *Study funded completely by the WDNR*
- *In July 2012 granted $75,000 for one year*
- *In April 2013 an additional $60,000 awarded following first runs to do additional runs*
- *In July 2013 an additional $200,000 awarded for additional study year*
- *Total funding ~ $335,000*

Objectives

- *Collect pathogen samples for pathogen drift from:*
  - *Traveling gun*
  - *Center pivot*
- *Assess impacts of:*
  - *Wind velocity*
  - *Solar intensity*
  - *Temperature*
  - *Relative humidity*
- *Develop transport models*
- *Develop QMRA*
- *Make recommendations for setback distances*

Where to start . . . . . .

What we soon discovered

- *Existing literature on manure spray application is limited*
- *Our research team had limited experience with air sampling*
- *Climate variables (ex. wind direction/speed, air temp, etc.) are important*

Where to start . . . . . .

What we soon discovered

- *Existing literature on manure spray application was limited*
- *Our research team had limited experience with air sampling*
- *Climate variables (ex. wind direction/speed, air temp, etc.) are important*

Where to start . . . . . .

What we soon discovered

- *Existing literature on manure spray application was limited*
- *Our research team had limited experience with air sampling*
- *Climate variables (ex. wind direction/speed, air temp, etc.) are important*

Where to start . . . . . .

What we soon discovered

- *We needed specialized equipment we didn't have*
- *We needed proper test and sample handling protocols*
- *We had more questions than answers . . . . .*

Where to start . . . . . .

What we soon discovered

- *We needed specialized equipment we didn't have*
- *We needed proper test and sample handling protocols*
- *We had more questions than answers . . . . .*

Where to start . . . . . .

What we soon discovered

- *We needed specialized equipment we didn't have*
- *We needed proper test and sample handling protocols*
- *We had more questions than answers . . . . .*

In summary what is it going to take to do this right ?

Our Approach . . . . . .

The research team had limited experience with air sampling

We added an air sampling expert to the research team Dr. Anna Rule from Johns Hopkins School of Public Health

We needed specialized equipment we didn't have

Dr. Rule loaned us equipment. We also obtained equipment from the UW – Madison Civil & Environmental Engineering Department

We needed proper test and sample handling protocols

Dr. Rule and Dr. Borchardt's lab developed sampling handling and testing protocols

Our Approach . . . . . .

The research team had limited experience with air sampling

We added an air sampling expert to the research team Dr. Anna Rule from Johns Hopkins School of Public Health

We needed specialized equipment we didn't have

Dr. Rule loaned us equipment. We also borrowed equipment from the UW – Madison Civil & Environmental Engineering Department

We needed proper test and sample handling protocols

Dr. Rule and Dr. Borchardt's lab developed sampling handling and testing protocols

Our Approach . . . . . .

The research team had limited experience with air sampling

We added an air sampling expert to the research team Dr. Anna Rule from Johns Hopkins School of Public Health

We needed specialized equipment we didn't have

Dr. Rule loaned us equipment. We also obtained equipment from the UW – Madison Civil & Environmental Engineering Department

We needed proper test and sample handling protocols

Dr. Rule and Dr. Borchardt's lab developed sampling handling and test protocols

Our Approach . . . . . .

Site specific climate data are important

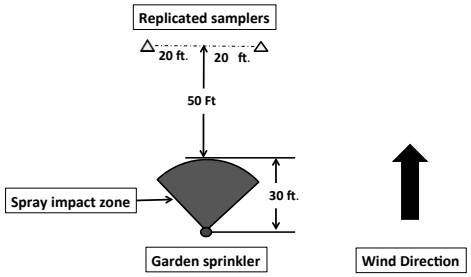
We set up an on-site portable weather station

The following weather data were collected every 30 seconds during all test runs:

- Wind direction and speed
- Air temperature
- Solar radiation
- Relative humidity
- Precipitation (always = 0)

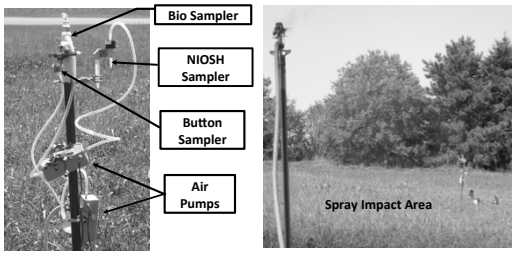
Our Approach . . . . . .

Pilot study - Layout configuration



Our Approach . . . . . .

Prior to testing, we evaluated the various types of air sampling equipment in a pilot study at the Dairy Forage Research Center

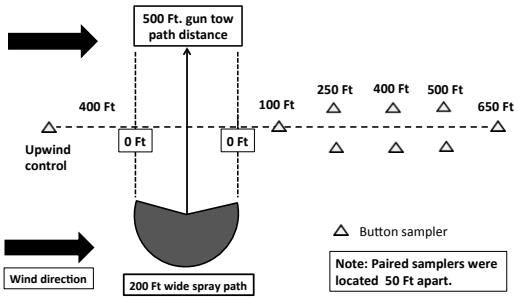


Our Approach . . . . . .

Full scale testing on a <u>traveling gun</u> was done at the Marshfield Agriculture Research Station

Our Approach . . . . . .

Typical full scale spray / sampler configuration



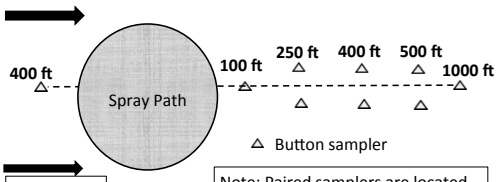
Our Approach . . . . . .

Full scale testing on a <u>center pivot</u> system is to be conducted at Two Private Producers

1. **Dairy - mechanical separation followed by a three stage lagoon**
2. **Dairy - digester and separation**

Our Approach . . . . . .

Typical full scale spray / sampler configuration



Note: Paired samplers are located 50 feet apart. Additional Bio Samplers will be added to assess viable pathogens.

Our Approach . . . . . .

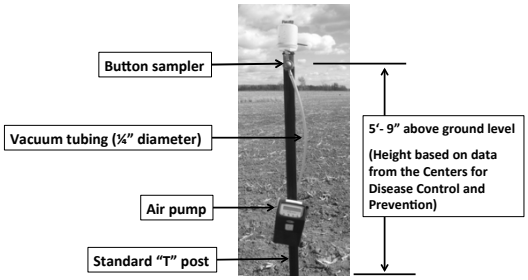
Based on the results of the pilot testing, the button sampler was selected for use in the full scale study.

Air Pump Tubing = 1/4 in D
Air Flow = 4 L / min optimum
Sampler ≈ 1 in D

Field air flow calibration

Our Approach . . . . . .

Full scale sampler field installation



Our Approach . . . . . .

Full scale manure application using traveling gun

- Typical run time 70 – 85 min -

1½" D oscillating nozzle

Manure application rate = 10,000 gal / acre

Our Approach . . . . . .

The source material was sampled and analyzed for microorganisms

The air samples were then analyzed for those microorganisms found in the source manure

In the future we are focusing on pathogens related to human health

Our Approach . . . . . .

Weather conditions during testing – Fall 2012

Date of Spray	Spray No.	% Time Directly Down Range (± 33 Degrees)	Avg. Wind Speed (mph) (± St D)	Avg. Wind Gust (mph) (± St D)	Avg. Solar Intensity (W/m^2) (± St D)
Aug 29	Pilot	71.3	4.1 (± 1.5)	6.9 (± 1.7)	*673 (± 40.7)
Sep 26	1	70.4	2.7 (± 1.5)	4.2 (± 1.8)	172(± 57.1)
Sep 27	2	42	2.3 (± 1.6)	4.5 (± 2.2)	637 (± 8.40)
Oct 10	3	*100	*12.9 (± 2.5)	*16.3 (± 2.9)	403 (± 212)
Oct 11	4	97.0	11.2 (± 2.0)	14.1 (± 2.6)	447 (± 159)

Note: (*) indicates the highest recorded value within category

Sample Collection

1. Complete post sampling air flow check.
2. After post sampling air flow check: remove gel membrane filter using aseptic techniques (ex. alcohol cleaned tweezers, clean gloves).
3. Place gel membrane filter directly into vial containing Qiagen's Buffer AVL with carrier RNA. (liquefies and preserves filter).
4. Deliver samples to the Marshfield Lab.

Conclusions – Study Design

- ❑ A small scale manure liquid irrigation pilot study allowed us to select an air sampler for the study.
- ❑ The aerosol pathogen recovery rate from the Button Sampler was adequate for use in the study.
- ❑ An on-site weather station is needed to collect sufficient site-specific weather data for the study.

Conclusions - Operation

- ❑ The traveling gun irrigation system provided sufficient manure liquid to monitor pathogen drift.
- ❑ A full scale sampler configuration with 5 down-wind distance from the spray impact area provided adequate concentration vs. distance data.
- ❑ Field-scale monitoring of pathogen aerosol drift can be done successfully however, **significantly** more data are needed to adequately understand manure liquid pathogen transport and fate.

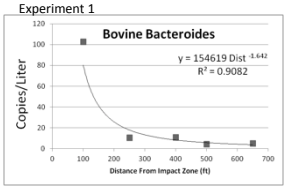
Timeline

- *Sample collection methods were completed in Summer 2012*
- *Traveling gun runs (6 total) were completed in May 2013*
- *Center pivot runs begin June 2013 and continue for one year*
- *Modeling and QMRA to be conducted from July 2013 to June 2014*

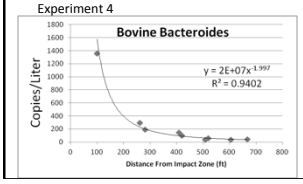
Travelling Gun Irrigation with Liquid Dairy Manure, September 26, 2012

Airborne Transport – Bovine Bacteroides

Experiment 1



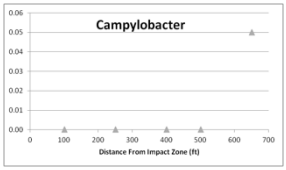
Experiment 4



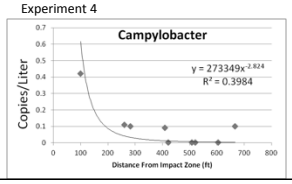
	Expt 1 9/26/12	Expt 4 10/11/12
Bacteroides manure concentration (gc/L)	4.8×10^7	3.3×10^8
Average wind speed (mph) ± SD	2.7 ± 1.5	11.2± 2.0
% time samplers in target wind direction	70%	97%
Average solar intensity (W/ m^2)	172	447

Airborne Transport – *Campylobacter jejuni*

Experiment 1



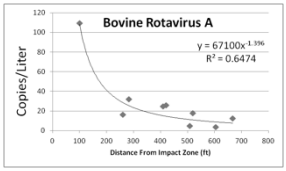
Experiment 4



	Expt 1 9/26/12	Expt 4 10/11/12
C. jejuni manure concentration (gc/L)	3.5×10^3	6.1×10^4
Average wind speed (mph) ± SD	2.7 ± 1.5	11.2± 2.0
% time samplers in target wind direction	70%	97%
Average solar intensity (W/ m^2)	172	447

Airborne Transport – Bovine Rotavirus A

Experiment 4



Distance to reach 1 rotavirus/liter air = 2,868 feet

	Expt 1 9/26/12	Expt 4 10/11/12
Rotavirus A manure concentration (gc/L)	Not detected	5.9×10^5
Average wind speed (mph) ± SD	2.7 ± 1.5	11.2± 2.0
% time samplers in target wind direction	70%	97%
Average solar intensity (W/ m^2)	172	447

Questions ? ?