Effect of In-house Windrow Composting on Odors During Land Application

Scott Winkler[1], Daren Harmel[2], Terry Gentry[3], Eddie Caraway[4], Nathan Fuchs[1], and Craig Coufal[1]

[1]Department of Poultry Science, Texas A&M University, College Station, TX

[2]USDA-ARS, Temple, TX

[3]Department of Soil and Crop Sciences, Texas A&M University, College Station, TX

[4]Olfactometry Laboratory, West Texas A&M University, Canyon, TX

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Abstract M33

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Introduction

- The *2010 Texas Integrated Report for Clean Water Act Sections 305(b) and 303(d)* lists 621 impaired water segments in Texas.
  - 303 of the 621 are impaired for bacterial counts (*E. coli*) above acceptable limits for the designated water use.
  - Many water segments on the list are in poultry producing regions of Texas.
  - Implementation of Total Maximum Daily Loads (TMDLs) are a concern for producers and land owners.

Water Quality Concerns

- Much of the bacteria is thought to originate from runoff water from livestock producing areas or lands receiving application of manure.
- Previously published research has shown poultry litter samples from Texas contain 8.8 x 10^{10} *E. coli*/g of litter (Terzich et al. 2000).
- In 2011, Texas produced 630,500,000 broilers.
- Litter production is ~ 1 ton/1000 birds produced (Coufal et al. 2006).
- Therefore, ~ 630, 500 tons of litter are produced in Texas annually, most of which is land applied.

Nuisance Issues

- Recent expansion of the poultry industry and rural development has led to an increase in nuisance odor complaints.
- Senate Bill 1693
  - Passed by the Texas Legislature in 2009.
  - Purpose was to address odor issues from poultry farms and litter application.
    - Siting requirements for new or expanding farms
    - Requires state agencies to respond to odor complaints within 18 hours
    - Requires record keeping to track where poultry litter is transported and applied

In-House Windrow Composting (IWC)

- Therefore, best management practices (BMP) need to be developed to address the potential impacts to runoff water quality and nuisance odors from the land application of poultry litter.

- In-house windrow composting (IWC) is a practice already commonly used by the poultry industry to manage litter between grow-outs.

Previous Research

- When done correctly, IWC of litter can significantly reduce the bacterial load when compared to uncomposted litter (Macklin et al., 2008).
- Trial 1 of a 3-year study was conducted in the fall of 2011, and results were previously reported (Winkler et al., 2012).
- Air samples from litter were analyzed for 13 volatile odorants commonly associated with animal manure using GC/MS.
  - 6 odorants were lower with IWC litter compared to raw litter.
  - The other 7 odorants were greater.
- Results showed that the use of IWC does not eliminate odors at land application, but does have the ability to alter the odor profile.

Trial 1 Odorants (Winkler, et al. 2012)

Compound	Description	Detection Threshold (mg/m^3)	Treatment[1]	Concentration (ng/L)	OAV[2]	Percent Difference	P-Value
Proprionic Acid	Body odor; vomitus	0.350	Raw	5.86	16.76	-26.51	0.57
			IWC	4.31	12.32		
Phenol	Medicinal ; floral	0.734	Raw	41.73	56.85	-56.76	0.38
			IWC	18.05	24.58		
P-cresol	Barnyard	0.010	Raw	15.26	1,573.44	-53.87	0.42
			IWC	7.04	725.89		
4-ethylphenol	Spice; horse manure	13.000	Raw	4.83	0.37	-73.76	0.30
			IWC	1.27	0.10		
2'-aminoaceto phenone	Bat cave; taco shell	0.514	Raw	1.75	3.41	-78.66	0.17
			IWC	0.37	0.73		
Indole	Piggy; musty	0.004	Raw	1.18	307.43	-97.38	0.11
			IWC	0.03	8.05		

[1] n = 3 samples per treatment

[2] OAV = concentration/detection threshold

Trial 1 Odorants (Winkler, et al. 2012)

Compound	Description	Detection Threshold (mg/m^3)	Treatment[1]	Concentration (ng/L)	OAV[2]	Percent Difference	P-Value
Acetic Acid	Sour; vinegar	2.030	Raw	2.14	1.05	41.9	0.65
			IWC	3.04	1.50		
Butyric Acid	Body odor; vomitus	0.034	Raw	2.47	72.77	324.6	0.13
			IWC	10.48	308.99		
Isobutyric Acid	Rancid; butter	0.123	Raw	5.55	45.32	1,163.9	0.00
			IWC	70.16	572.77		
Valeric Acid	Foul	0.036	Raw	1.93	53.19	11.8	0.86
			IWC	2.16	59.49		
Isovaleric Acid	Foul/sweat; buttery	0.007	Raw	3.61	555.36	57.8	0.69
			IWC	5.70	876.88		
Hexanoic acid	Foul	0.180	Raw	7.14	39.57	81.5	0.30
			IWC	12.96	71.82		
Skatole	Outhouse; fecal	0.002	Raw	0.33	146.66	18.8	0.76
			IWC	0.39	174.27		

[1] n = 3 samples per treatment

[2] OAV = concentration/detection threshold

Objective

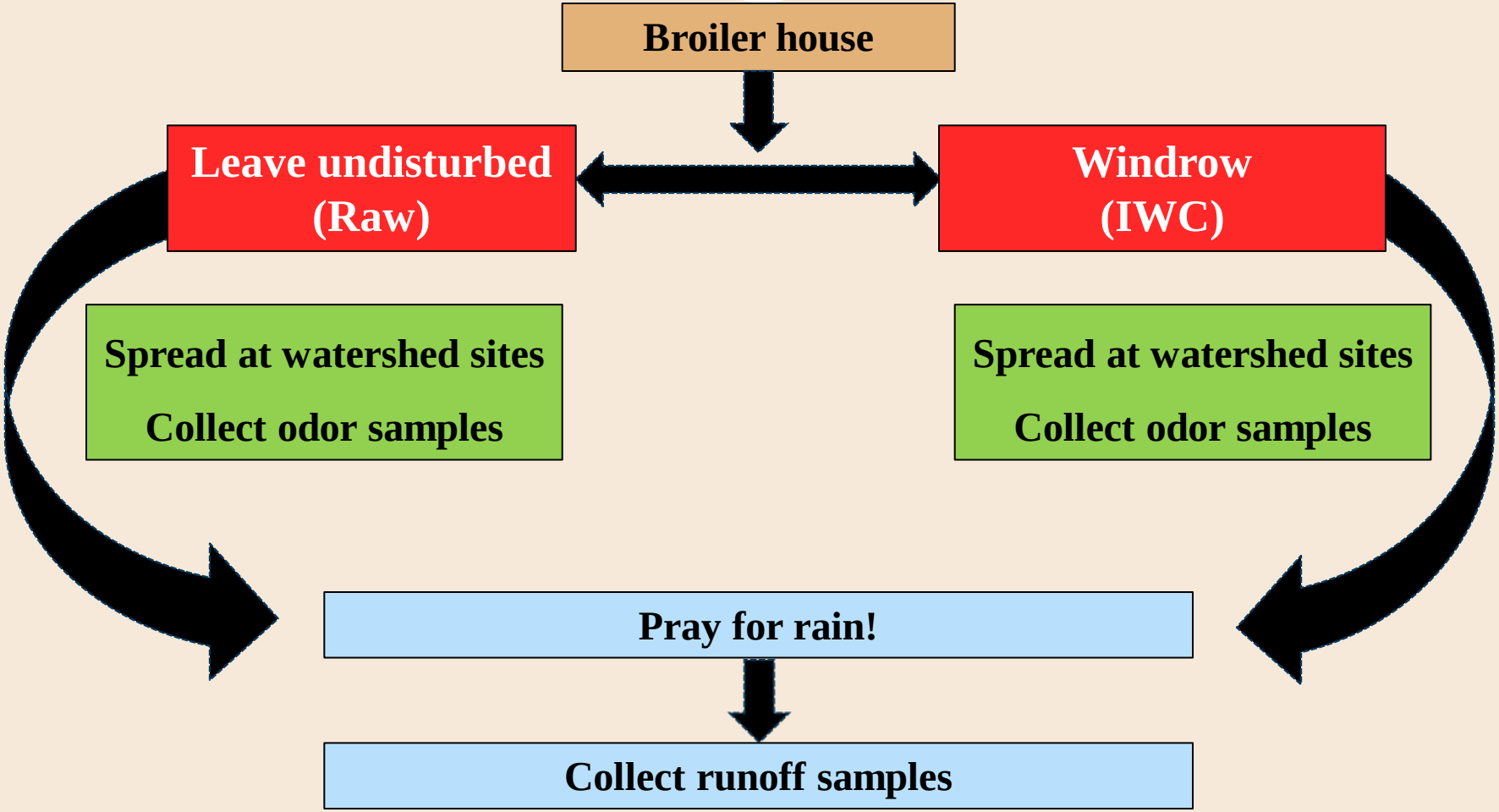
- Evaluate the effectiveness of in-house windrow composting of poultry litter prior to land application as a BMP to reduce bacteria in runoff and influence volatile odorants.
  - Enumerate *E. coli* in litter and runoff water samples from land application sites.
  - Determine the influence of IWC on volatile odorants.

Hypothesis

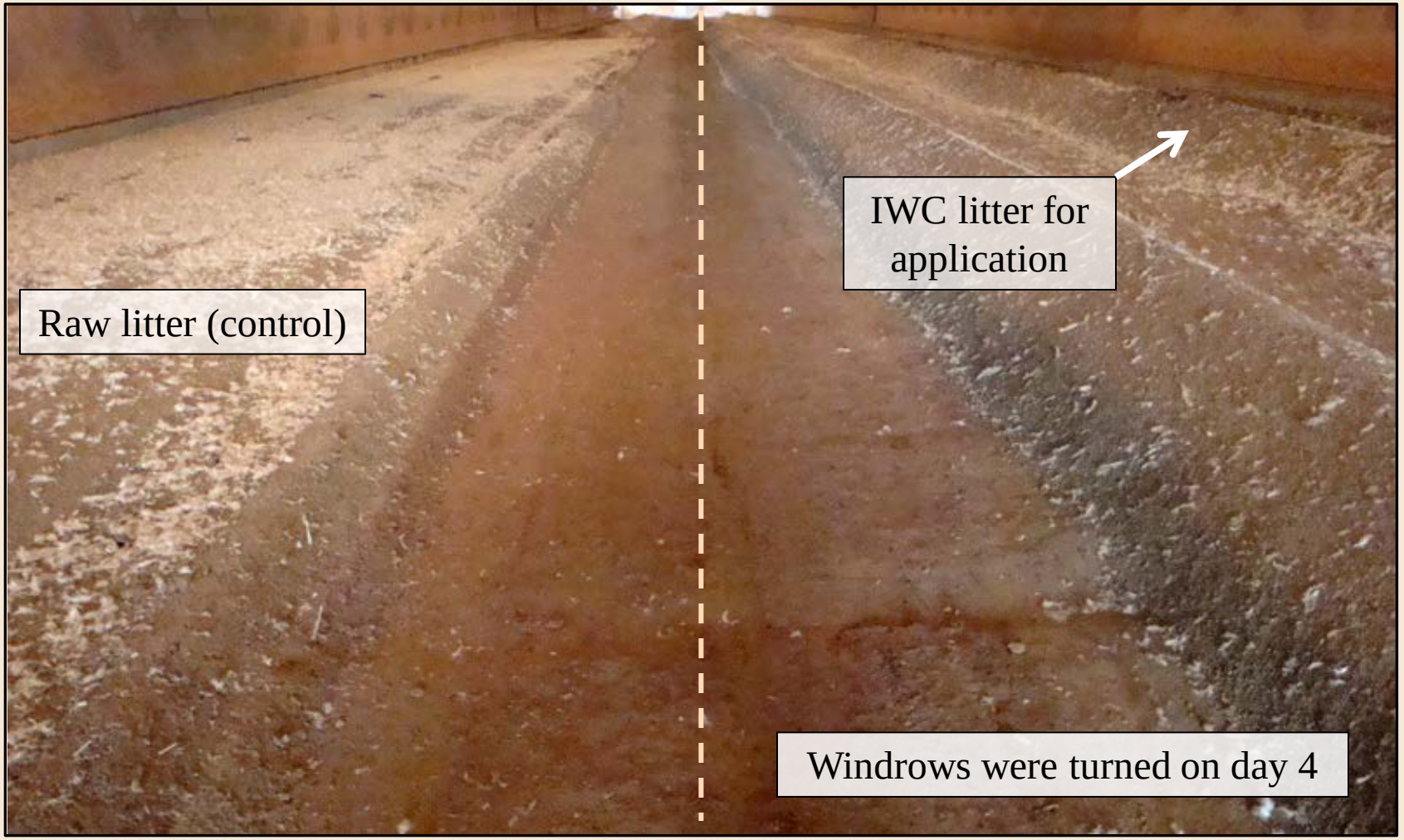
- The process of in-house windrow composting of poultry litter prior to land application can be used as a best management practice to help mitigate *E. coli* counts in litter prior to land application and reduce the potential for nuisance odor complaints.

TAMU POSC Litter Windrowing Implement

Experimental Design



Materials and Methods



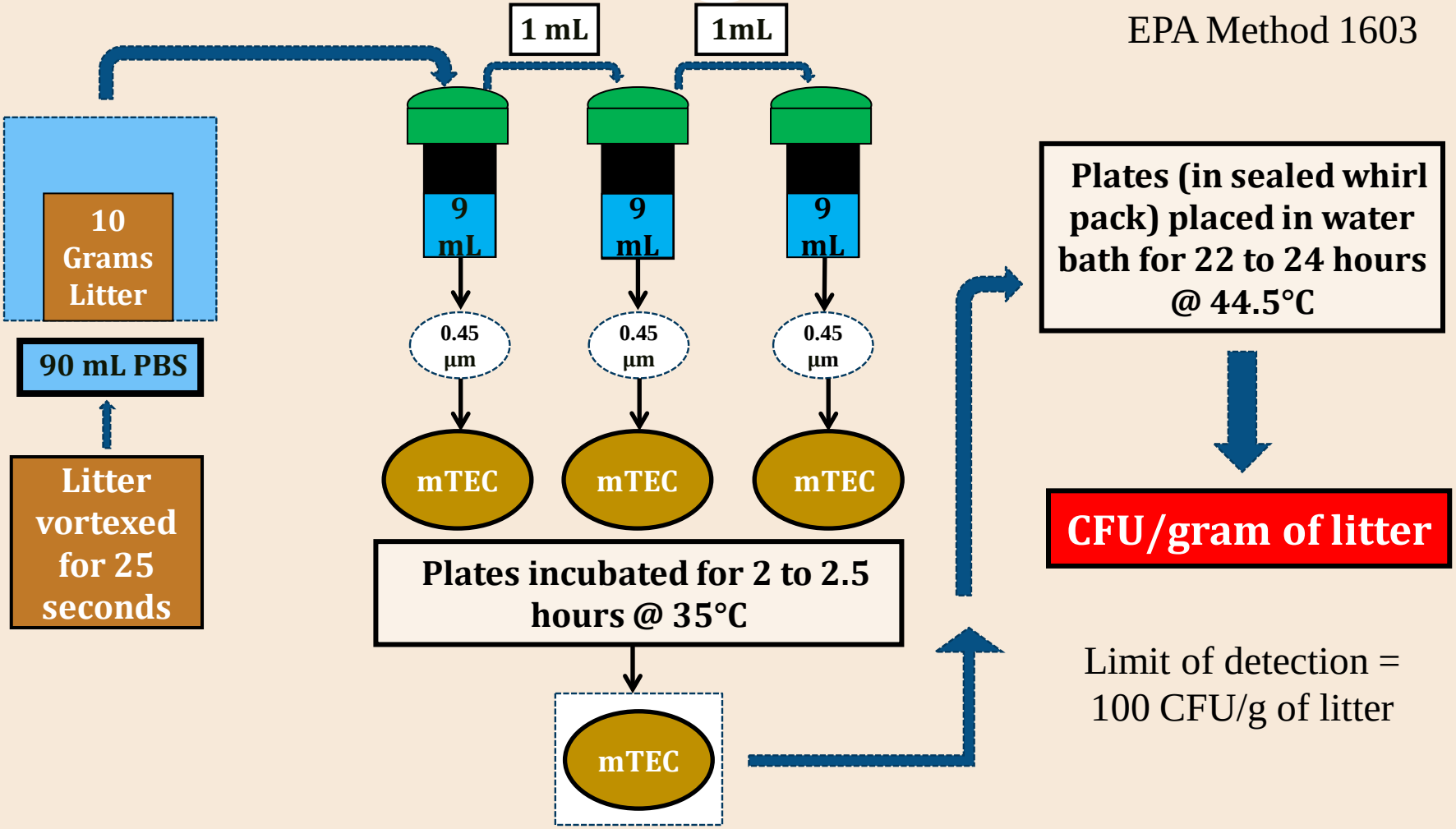
Materials and Methods

- On the 9th day after the windrows were formed, 20 tons of each type of litter were transferred on separate loads to the USDA-ARS watershed site in Riesel, Texas.

Materials and Methods

- Litter samples were collected prior to windrowing at the farm and just prior to land application.
  - Samples were delivered to the TAMU Dept. of Soil and Crop Sciences – Soil and Aquatic Microbiology Lab for bacterial analysis (n = 6).
    - *E. coli* was enumerated using EPA method 1603 and results were provided as CFU/gram of litter.
  - Samples were then transferred to the TAMU Soil, Water and Forage Testing Lab for nutrient analysis (n = 6).

Litter *E. Coli* Enumeration Process



Materials and Methods

- Volatile odorants were collected on sorbent tubes using wind tunnel flux chambers placed directly on litter piles.
  - Concentrations of 13 odorants were assessed using GC/MS.
- 2 types of air samples were collected into Tedlar bags for olfactometry analysis by human panelists.
  - Directly from litter piles using the wind tunnel flux chambers
  - Ambient air from the middle of each application field
    - GC/MS and olfactometry analysis conducted at West TAMU Olfactometry Laboratory.

Materials and Methods

- Litter was land applied at 3 tons/acre to separate, non-adjacent fields.

Statistical Analysis

- *E. coli* litter counts
  - No statistical analysis conducted due to very low counts.
- Nutrient values and odorant concentrations
  - One-way Analysis of Variance using the General Linear Model (GLM) procedure in SPSS.
  - Means were considered significantly different at $P \leq 0.05$.

E. Coli Results

Year	Treatment	*E. coli* prior to windrowing (day 0)	*E. coli* post windrowing (day 9)
Trial 1 (2011)	Raw	<100	<100
	IWC	<100	<100
Trial 2 (2012)	Raw	<100	185
	IWC	<100	<100

Results recorded in CFU/gram of litter

Litter Nutrient Analysis

Year	Treatment	Nitrogen	Phosphorus	Potassium	Calcium
Trial 1 (2011)	Raw	3.51	1.93	3.20	4.21
	IWC	3.55	1.74	3.15	3.59
Trial 2 (2012)	Raw	3.44	1.78	3.42	3.60
	IWC	3.58	1.83	3.40	3.53

All data is calculated on dry matter basis
No statistical differences observed

Sorbent Tube GC/MS Results Trial 2

Compound	Description	Detection Threshold (mg/m^3)	Treatment[1]	Concentration (ng/L)	OAV[2]	Percent Difference	P-Value
Hexanoic acid	Foul	0.180	Raw	0.59	3.26	3,533.46	0.021
			IWC	21.29	118.30		
Phenol	Medicinal; floral	0.734	Raw	6.49	8.84	45.80	0.006
			IWC	9.45	12.88		
P-cresol	Barnyard	0.010	Raw	0.14	13.63	2,752.68	0.069
			IWC	3.89	388.95		
2'-aminoacetophenone	Bat cave; taco shell	0.514	Raw	3.60	7.01	71.82	0.144
			IWC	6.19	12.04		
Skatole	Outhouse; fecal	0.002	Raw	0.31	153.94	980.42	0.000
			IWC	3.33	1,663.18		

[1] n = 3 samples per treatment

[2] OAV = concentration/detection threshold

Sorbent Tube GC/MS Results Trial 2

Compound	Description	Detection Threshold (mg/m^3)	Treatment	Concentration (ng/L)	OAV	Percent Difference	P-Value
Acetic acid	Sour; vinegar	2.030	Raw	7.63	3.76	-77.15	0.013
			IWC	1.75	0.86		
Proprionic acid	Body odor; vomitus	0.350	Raw	33.63	96.09	-38.83	0.065
			IWC	20.57	58.78		
Butyric acid	Body odor; vomitus	0.034	Raw	1.11	32.60	-96.87	0.065
			IWC	0.03	1.02		
Isobutyric acid	Rancid; butter	0.123	Raw	0.97	7.90	-82.84	0.001
			IWC	0.17	1.36		
Valeric acid	Foul	0.036	Raw	71.09	1,974.87	-85.11	0.000
			IWC	10.59	294.03		
Isovaleric acid	Foul/sweat; buttery	0.007	Raw	1.56	222.57	-59.09	0.018
			IWC	0.64	91.06		
4-ethylphenol	Spice; horse manure	13.000	Raw	3.25	0.25	-2.41	0.934
			IWC	3.12	0.24		
Indole	Piggy; musty	0.004	Raw	12.07	3,017.29	-13.99	0.276
			IWC	10.38	2,595.14		

Trial 1 vs Trial 2

Compound	Treatment	Trial 1 (OAV)	Trial 2 (OAV)
Hexanoic acid	Raw	7.1	3.2
	IWC	12.9	118.3
Skatole	Raw	146.6	153.9
	IWC	174.27	1,663.2
Proprionic Acid	Raw	16.8	96.1
	IWC	12.3	58.8
4-ethylphenol	Raw	0.3	0.3
	IWC	0.1	0.2
Indole	Raw	307.4	3,017.3
	IWC	8.0	2,595.1

OAV = concentration/detection threshold

Olfactometry Samples Trial 2

Wind tunnel samples from litter piles		
Treatment[1]	Detection Threshold Value (OU/m^3)	Average
Raw	4,082	4,082
	sample error	
IWC	2,030	1,731
	1,432	
Air samples in field		
Raw	1,011	1,220
	1,429	
IWC	602	428
	254	

[1] n = 2 samples per treatment

Summary and Conclusions

- *E. coli* numbers in IWC litter were lower compared to raw litter in Trial 2 at the time of litter application.
  - Thus, IWC has the potential to be a BMP to reduce *E. coli* counts in litter prior to land application.
- Odor data:
  - Differences in concentration of certain compounds were noted.
  - Olfactometry data indicated that IWC of litter resulted in lower odor concentration as perceived by human panelists.
  - Thus, IWC has the potential to be a BMP to reduce odors from litter during land application.

Future Research

- Sample and test litter from various locations to determine presence of *E. coli*.
- Conduct additional windrowing trials to gather more data on effects on odors.

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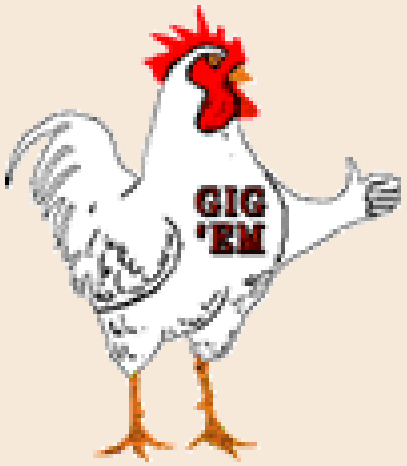
THANK YOU!

http://windrowlitter.tamu.edu



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