Identification, evaluation and quantification of VOCs as bio-secure markers of swine carcass degradation

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Ultimate goal

❖ To find biosecure markers of swine carcass degradation
❖ To develop a sampling and quantification method that can be used to test completion of an emergency swine carcass composting process

Animal mortality disposal

❖ On-farm: Burial, incineration
❖ Off farm: Rendering, sanitary landfill

❖ Limitations
❖ Illegal dumping problem

Illegal dumping, Iowa

Illegal dumping, Georgia

Animal mortality composting

❖ Daily and emergency disposal of carcasses
❖ Avian Influenza H7N3 Strain Outbreak, British Columbia, 2004
❖ 1.25 million infected birds
❖ Disposal strategy switched to on-farm composting

Studies to monitor VOCs from composts

Monitoring composting process

❖ Temperature
❖ Moisture
❖ O_2 & CO_2

not necessarily indicate completion of carcass degradation

NEW METHOD!

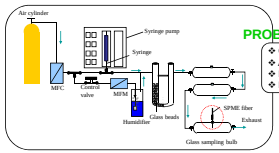
❖ VOC measurements

Originality of the study

❖ To measure swine mortality VOCs
❖ To test completion of the swine carcass degradation
❖ New SPME method developed
❖ Developed method tested for full scale composting operations
❖ Regular sampling during 60 days
❖ 6 different plant (envelope) materials
❖ 3 different sampling locations
❖ Laboratory and field studies
❖ Aerobic and anaerobic conditions
❖ VOC emission rates are reported

1st objective

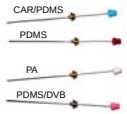
Method development to sample and quantitatively analyze VOCs from field scale swine mortality composting operations



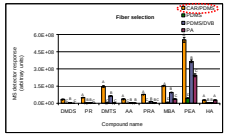
PROBLEMS SOLVED

❖ Condensation
❖ Accuracy of pump
❖ Homogenous mixing
❖ Rxn b/w analytes

Fiber coating selection



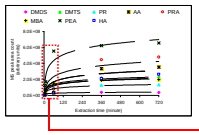
Target compounds: 85 µm CAR/PDMS



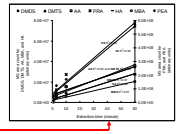
DMDS: dimethyl disulfide, DMTS: dimethyl trisulfide, PR: pyrimidine, AA: acetic, PRA: propanoic, MBA: 3-methyl butanoic, PEA: pentanoic, HA: hexanoic acid

Extraction time selection

Displacement



1 h extraction time



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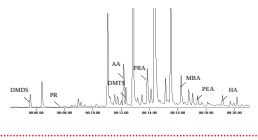
Quantification & method detection limits (MDL)

Compound name	Theory (ppbv)	SPME (ppbv) at dry conditions: Average	SPME (ppbv) at dry conditions: % difference	SPME (ppbv) at humid conditions: Average	SPME (ppbv) at humid conditions: % difference	MDL (ppbv) (dry)	MDL (ppbv) (humid)
DMDS	28	30[A]	7.14	27[A]	3.57	1	1.1
DMTS	23	26[A]	13.04	19[B]	17.39	5.7	5.5
PR	2	2.1[C]	0.5	2[C]	0	0.01	0.011
AA	430	799[A]	9.38	759[A]	12.09	520	551
PRA	618	631[A]	3.44	609[A]	1.47	580	572
MBA	225	251[B]	11.55	232[B]	3.55	120	180
PEA	229	195[C]	14.87	181[C]	20.96	46	36
HA	197	210[B]	6.59	202[B]	8.00	110	120

dry (RH≈0%)
humid (≈97%)

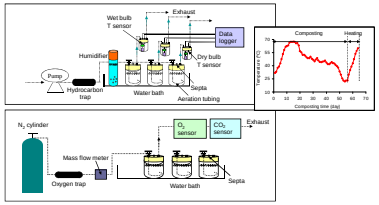
Test of calibration equations for field scale composting



Compound name	MS area count (arbitrary units)	Concentrations (ppm): Dry cond.	Humid cond.
DMDS	1.1E+07	0.003	0.00
PR	4.7E+06	0.006	0.06
AA	3.3E+07	5.84	7.39
DMTS	9.9E+06	0.432	0.49
PRA	2.3E+07	2.76	3.62
MBA	1.9E+07	0.68	1.06
PEA	8.5E+06	0.35	0.41
HA	1.2E+07	0.64	0.66

2nd objective

Laboratory scale composting studies to find biosecure marker VOCs of decaying swine carcass tissues

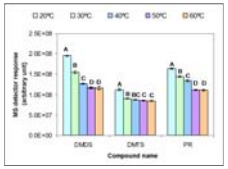


43/43 compounds identified

Compound name	CAS #	Aerobic: Plant: Corn silage	Aerobic: Plant: Oat straw	Aerobic: Plant: Alfalfa hay	Aerobic: Animal: Pig tissue	Aerobic: Mix (1:15 w/w): Pig + silage	Anaerobic: Plant: Corn silage	Anaerobic: Plant: Oat straw	Anaerobic: Plant: Alfalfa hay	Anaerobic: Animal: Pig tissue	Anaerobic: Mix (1:15 w/w): Pig + silage
Pyrimidine*	289-95-2	-	-	-	+	+	-	-	-	+	+
Dimethyl disulfide*	624-92-0	-	-	-	+	+	-	-	-	+	+
Dimethyl trisulfide*	3658-80-8	-	-	-	+	+	-	-	-	+	+

Pyrimidine, dimethyl disulfide, dimethyl trisulfide are biosecure marker compounds

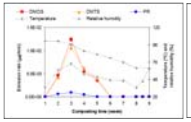
Effect of temperature on SPME



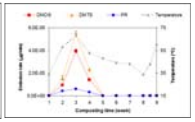
Calibration curves
R^2≈94-99%
RSD≈0.22-6.15%

Emission rates

Aerobic



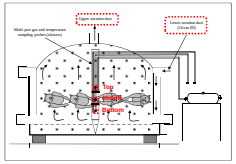
Anaerobic

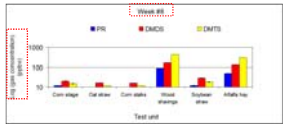


Respiration rate:
3.25±0.12 mg CO_2-C/g VS*d (stable compost)

3rd objective

Field scale composting studies to test completion of swine carcass degradation using biosecure marker VOCs





Test units	Carcass decomposition (%)	Respiration rate (mg CO_2-C / g VS^{-1} d^{-1})	
Corn silage	64.4 ±0.1	6.40 ±0.42[D]	moderately unstable
Oat straw	71.8 ±0.6	5.52 ±0.3[E]	
Corn stalks	74.8 ±0.9	5.21 ±0.82[E]	
Wood shavings	63.6 ±5.1	9.25 ±0.85[A]	unstable raw compost
Soybean straw	71.0 ±1.9	7.85 ±0.65[C]	
Alfalfa hay	64.3 ±3.3	8.56 ±0.38[B]	

Corn stalks ≈ Oat straw>Corn silage ≈ Soybean straw>Alfalfa hay> Wood shavings

General conclusions

❖ Dimethyl disulfide, dimethyl trisulfide, and pyrimidine were found to be produced during degradation of swine carcass tissues but not produced from decaying plant (envelope) materials (marker compounds)
❖ 85 µm CAR/PDMS was shown to extract the highest amount of marker compounds at 1 h sampling
❖ It was possible to detect analytes at low concentrations. Method detection limits were ranging from 0.01 to 580 ppbv
❖ Laboratory studies showed that marker compounds could not be detected when the respiration rates of the carcasses decreased to 3.25 mg CO_2-C/ g VS*d
❖ Field studies showed that when carcass degradation was incomplete, detection of marker compounds was still possible in the 8th week
❖ In the 8th week, the highest concentrations of marker VOCs were detected from test units with the lowest carcass decomposition and highest respiration rate
❖ Marker compounds were produced from all composting units regardless of the plant material used, moisture content, porosity and temperature

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