

Effluent nutrient attributes and water quality risk from storm events on bovine mortality compost piles

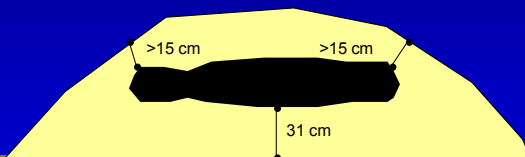
Jerrod Sanders, Michigan State University

Bovine Mortality Composting

- Primary Phase (1-6 months)
 - Whole carcass placed in amendment (carbon source)
 - No turning - soft tissue decay
 - Heterogeneous mixture
- Secondary Phase (3-12 months)
 - Managed similar to typical compost pile
 - Turning/aeration (increasingly homogeneous)
- Curing

Primary Mortality Compost Pile

■ Carcass ■ Amendment ■ Soil



Not to Scale

Not to Scale

Bodies of Dead Animals Act 239 of 1982, amended (BODA)

Objectives

- Protect human and animal health
- Protect environment

Legal Disposal Options

1. Burial
2. Incineration
3. Rendering
4. Land-fill
5. Composting



Steve Bayles, Ohio State University

Study Objectives

1. Compare water quality impacts of potential amendments
2. Determine water quality of effluent from full-scale open piles
 - Determine surface water risk (runoff)
 - Determine groundwater risk
3. Provide context/relativity to results

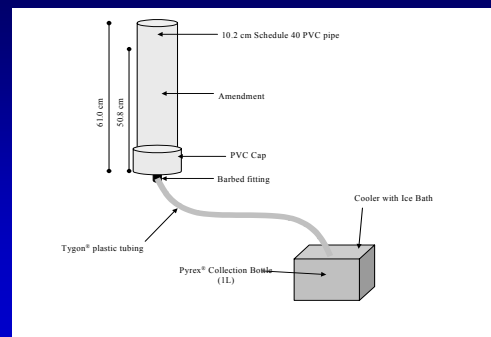
Amendment Water Quality Comparison

Column Study

Potential Amendments

1. Bovine Manure Pack
2. Corn Silage
3. Grass Clippings (Residential Lawn)
4. Hardwood Sawdust (Furniture Factory)
5. Hardwood Sawdust NF (Furniture Factory, no geotextile separator)

Schematic of Column Study



Not to scale

Not to scale

Rainfall Simulation

25 year, 24 hour (10.2 cm)

Parameters:

Volume

TKN: HACH Method 8075 WAH: Nessler Method

NO₂/NO₃: EPA, 1993: Method 353.2

NH₄: Kempers and Zweers, 1986

P: AWWA, 1993: Method 508 C

K: Flannery and Markus, 1980

Ca: Flannery and Markus, 1980

Mg: Flannery and Markus, 1980

COD: HACH Method 8231: Dichromate Method

pH: Calibrated pH electrode

Mean Volume and Concentration Results, ppm (n=3)

	(mL)	TKN	NO ₂ /NO ₃	NH ₄	P	K	COD	pH
Corn Silage	477	975.7 ^a	2.9 ^a	533.8 ^a	960.7 ^a	4329 ^c	19300 ^c	3.9
Bovine Manure	475	526.7 ^{ab}	3.2 ^{ab}	118.1 ^b	80.7 ^b	7460 ^{1b}	15976 ^a	7.7
Grass Clippings	577	166.0 ^{ab}	3.4 ^a	40.6 ^{bc}	81 ^b	11574 ^b	3756 ^b	7.9
Sawdust	355	24.3 ^b	0.4 ^c	0.7 ^c	0.8 ^c	1138 ^b	1124 ^b	5.6
Sawdust NF	375	22.5 ^b	0.2 ^c	0.5 ^c	0.2 ^c	1167 ^c	1199 ^b	5.6
Rainwater	823	2.6 ^c	0.3 ^c	0.3 ^c	0 ^c	0 ^c	1 ^c	6.9

Study of Full-Scale Open Piles

Moveable Rain Shelter (Reese, MI)



Goals

Determine pollution potential for:

- Total Pile
 - Runoff
 - Infiltration
- Severe storm scenario
 - 25 year, 24 hour storm event
 - At the time of greatest risk

Perceived Risk Timing

Carcasses Collapse

- Swelling (3-10 days)
- Release of significant gasses and fluids

Composting tends to stabilize nutrients

- Reduced risk over time

Therefore, time of greatest anticipated risk is immediately after collapse

Storm Simulations

- 25 year, 24 hour storm (10.2 cm)
- Same nutrient parameters as Column Study

Total Pile Pollution Potential

Pile/Soil Interface Platform



Pile/Soil Interface Simulations

One repetition of A through D below:

- A. Hardwood sawdust only
- B. 1 Cow
- C. 2 Cow
- D. Secondary

Runoff Plots



Runoff Plot Simulations

Two repetitions of A through D below:

- A. Bare Soil
- B. 1 Cow
- C. 2 Cow
- D. Secondary

Results

Total Pile Nutrient Load (g)

	<u>Total N</u>	<u>Inorganic N</u>	<u>Total P</u>	<u>Total K</u>	<u>COD</u>
Sawdust	11.3	1.1	0.9	321	924
1 Cow	309	364	25.2	317	3,912
2 Cow	1,878	1,458	86.9	517	16,530
Secondary	383	342	26.4	190	4,841

Runoff Load¹ as a Percent of Total Pile Load

<u>Volume</u>	<u>Total N</u>	<u>Inorganic N</u>	<u>Total P</u>	<u>Total K</u>	<u>COD</u>
25.9%	5.4%	5.0%	3.8%	6.9%	4.9%

¹Mean volume-weighted load of nutrient leaving pile in runoff over full study as a percentage of the load from the Pile/soil interface platform

Information Collected

- ✓ Water quality data from potential amendments
- ✓ Water quality data during different stages of management
- ✓ Surface water quality data

Estimating On-Farm Water Quality Impacts

Objectives:

1. Compile results to model water quality in a “real-world” situation
2. Provide relativity to results by comparing various amendment options with other common sources of pollution

Hypothetical Farm

1,000 head adult milking herd (5% mortality) = 50 carcasses/year

Assumptions:

- All nutrients not in runoff infiltrate the soil surface
- Mature cows only
- Primary Phase = 3 months (25%) = 13 piles
- Secondary/Curing Phase = 9 months (75%) = 37 piles

Runoff Context Factor

• SE = Soil Equivalency

hectares of fallow soil* that would contribute equal pollutant as the compost site into runoff from a 25 year, 24 hour storm event

*fallow soil runoff load estimate extrapolated from data collected during bare soil simulation on the runoff plots

Estimated Total Runoff Load (TROL), g

	<u>Fresh Hardwood Sawdust</u>		<u>Reused H. Sawdust (2nd Gen.)</u>		<u>Grass Clippings</u>	
	TROL	SE	TROL	SE	TROL	SE
Total N	4,051	0.9	4,323	1.0	4,747	1.1
Inorganic N	3,516	1.7	3,650	1.7	2,388	1.1
Total P	171	2.2	179	2.3	1,116	14.5
COD	34,094	1	36,133	1.1	69,595	2.1
	<u>Corn Silage</u>		<u>Bovine Manure Pack</u>		<u>75% FHS 25% BMP</u>	
	TROL	SE	TROL	SE	TROL	SE
Total N	16,842	3.8	9,680	2.2	4,443	1.0
Inorganic N	9,039	4.3	3,179	1.5	1,531	0.7
Total P	10,744	139	944	12.3	279	3.6
COD	281,126	8.3	232,676	6.9	75,518	2.2

Infiltration Context Factor

• SFHE = Single Family Home Equivalency

In [SFHE] years a four resident single family home septic field would be expected to produce a load of infiltrating nutrient X equal to the compost site.

Estimated Total Infiltration Load (TIL), g

	Fresh Hardwood Sawdust		Reused H. Sawdust (2nd Gen.)		Grass Clippings	
	TIL	SFHE	TIL	SFHE	TIL	SFHE
Total N	17,170	0.8	36,495	1.6	70,154	3.1
Inorganic N	16,492	1.1	30,026	2	30,455	2
Total P	1,254	0.4	2,025	0.6	27,898	8.9
COD	218,740	1.7	374,781	3	1,357,144	10.7

	Corn Silage		Bovine Manure Pack		75% FHS	25% BMP
	TIL	SFHE	TIL	SFHE	TIL	SFHE
Total N	289,785	12.7	161,120	7.1	56,899	2.5
Inorganic N	163,555	10.8	48,965	3.2	24,736	1.6
Total P	268,644	86.2	23,595	7.6	6,984	2.2
COD	5,482,113	43.4	4,537,313	35.9	1,472,635	11.7

On-Farm Modeling Conclusions

Lowest risk

- 100% fresh hardwood sawdust
- Reusing hardwood sawdust compost
- 25% manure 75% fresh sawdust mixture

Highest risk

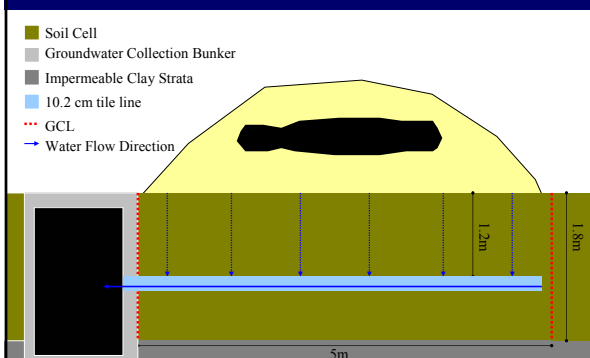
- Corn silage (N, P, and COD)

Overall Conclusions

- Amendment selection will affect the water quality risk associated with mortality compost sites
- More than 90% of the nutrients released from a pile during severe storm events infiltrate the soil surface
- Open mortality compost piles on large farms are sources of pollutants during storm events and preventative measures should be implemented

Groundwater Cells

Profile of a Groundwater Cell



Groundwater Simulations

Four repetitions of A through D below.

- Bare Soil
- 1 Cow
- 2 Cow
- Secondary

Mean Groundwater Pollutant Concentration (ppm)

	<u>Total N</u>	<u>Inorganic N</u>	<u>P</u>	<u>COD</u>
Total Pile	817	688	44.1	8,042
Beneath Pile (1.2 m)	37.5	22.4	0.3	249

Conclusion

- Soil treatment was effective in reducing the pollutant concentrations from direct pile effluent by >95% at 1.2 m depth