RESEARCH REPORT

NPB FINAL RESEARCH GRANT REPORT

Mass Composting of Swine Slurry, NPB PR-005774

Gary A. Flory
G.A. Flory Consulting, LLC
July 28, 2024

Principal investigators

Dale W. Rozeboom, Mark L. Hutchinson, and Gary A. Flory

Industry summary

This project was conducted to increase our knowledge about how we might compost swine slurry in the event of ASFv. Very little information exists on how to compost large amounts of swine slurry in an emergency situation. The objectives of the project were to: 1) determine the retention capabilities (like water-holding capacity) of carbon amendments, 2) evaluate the relationship between depth of carbon amendment base and the amount of slurry retained by that amendment, and 3) describe the management that would be required to compost large amounts of swine slurry in a single event.

Swine slurry was obtained from grow-finish and nursery production units (GF-slurry and N-slurry, respectively). Slurry was applied to carbon amendments contained in lined pails fitted with a grate or strainer in the bottom of the pail effectively separating carbon amendment and leachate (slurry not retained by the carbon amendment). In addressing the first objective, slurry was applied to corn stover, conditioned corn stover, ground mulch, a 50:50 blend of sawdust and large flake pine wood shavings, a 50:50 blend of sawdust and playground wood chips, a 75:25 blend of conditioned corn stover and sawdust, and a 75:25 blend of mulch and sawdust. All blends were done 'by volume.' Retention of slurry by carbon amendments varied, with the sawdust-large flake shaving blend retaining best and corn stover least. The conditioning of corn stover improved slurry retention. Interestingly, the aging of GF-slurry in jugs resulted in physical changes in the slurry such that increased viscosity and increased retention.

The second objective was studied by applying slurry to the surface of ground mulch in pails, with mulch depth varying from 6 to 18 in. As expected, increasing the depth of the carbon amendment increased its ability to retain slurry. Based on this linear relationship and the retentions observed earlier, it could be postulated that a 2-ft. base would completely retain slurry applied at 0.75 gallons per square foot of area (i.e. 33,000 gal./A) if any of the amendments tested were used, except unconditioned corn stover.

Using this depth of carbon amendment and application rate, the composting of 1,000,000 gallons of slurry could be accomplished on 50 to 60 A of cropland, and the use of 45,000 to 50,000 cubic yards of that carbon source. The variability in slurry retention observed in this project however, suggest caution in the immediate application of this model. There was variability in retention among carbon sources and among slurries (two compared herein). The degrees to which characteristics or attributes influence the amount of slurry being retained are not fully understood. Containment of the slurry within the compost is critical for eliminating disease and protecting the environment. Overall, results from this project improve our understanding of the resources needed to practically compost slurry from storage pits of barns where infected swine were being reared.

Key findings

- The composting of swine slurry in the management of a highly consequential disease is feasible.
- The amount of carbon amendment needed to compost swine slurry is predictable.

- The amount of carbon amendment needed differs with different amendments and with varying amendment depth.
- Understanding the ability of the carbon amendment to retain slurry and minimize leaching of slurry to the environment below the composting base is important.
- The impact of slurry attributes (percent moisture and solids, emulsification or foaming post-agitation and withdrawal from pit storage, and others) upon retention by the carbon amendment needs further consideration.
- Slurry retention with different amendment conditions (primarily moisture content and porosity) also needs to be understood better.

Keywords
Swine, slurry, carbon amendment, mass composting feasibility, slurry retention

Scientific abstract

Mass Composting of Swine Slurry

D.W. Rozeboom[a], M.L. Hutchinson[b], and G.A. Flory[c]
[a]Dead Animal Management, LLC
[b]Black Bear Agricultural Services, LLC
[c]G.A. Flory Consulting, LLC

Information is lacking as to how large amounts of swine slurry could be composted in an emergency situation. The objectives of this research were to: 1) determine the retention capabilities of different carbon amendments, 2) evaluate the relationship between depth of carbon amendment base and the amount of slurry retained by that amendment, and 3) describe management necessary to compost large amounts of swine slurry on-farm. Swine slurry was obtained from grow-finish and nursery production units (GF-slurry and N-slurry, respectively).

Slurry was applied to the surface of carbon amendments (listed in Table) contained in lined pails fitted with a grate or strainer in the bottom of the pail to separate carbon amendment and leachate. Retention of slurry by carbon amendments varied, with the sawdust-large flake shaving blend retaining all of the slurry applied upon it and corn stover the least (see Table). The conditioning of corn stover improved slurry retention. Storing GF-slurry in jugs for 7-9 d resulted in physical changes (foam, viscosity) which increased retention. The second objective was studied by applying slurry to the surface of ground mulch in five pails, with mulch depths of 6, 9, 12, 15, and 18 in. Linear regression described the relationship between depth and slurry retention (%) as $Y = 2.744*X + 39.35$ ($R^2 = 0.92$). With this data, we can approximate resources needed and be better prepared to compost large amounts of slurry on an infected farm going through the decontamination process.

Carbon amendment	Average slurry retention, %
Corn stover[a]	58.0
Conditioned corn stover[a]	76.4
Ground mulch[a]	75.8
50:50 blend sawdust and large flake pine wood shavings[ab]	100.0
50:50 blend sawdust and playground wood chips[ab]	95.4
75:25 blend conditioned corn stover and sawdust[bc]	76.1
75:25 blend mulch and sawdust[bc]	84.5
[a]3 observations per carbon source [b]blending done on a volume basis [c]2 observations per carbon source	

Introduction

African swine fever virus is a major disease concern for the United States swine industry. The current USDA recommendation for controlling the virus is stamping out. Composting is an acceptable method to inactivate the virus in whole hogs. However, composting slurry/manure has not been researched. This project will address several concerns related to composting slurry/manure.

Swine slurry is the feces, urine, wasted drinking water, wasted feed, inter-group wash water with detergents/disinfectants, dander, insects, and microorganisms (normal and infectious) accumulated in a storage pit located under the slatted floor of a swine production building. It may be called liquid swine manure.

The composting of swine slurry has been studied and proven effective as a treatment prior to use as a soil amendment (Eiland et al., 2001). Previous studies have been completed in a lab or controlled field setting with objectives focused on normal swine farm management. To our knowledge, there are no reports about the mass emergency composting of swine slurry. The significant water content in swine slurry, in the range of 85 to 95%, makes the composting of swine slurry both a decontamination and environmental challenge.

In the Midwest U.S., corn stalks and corn stover are plentiful composting amendments to be used in emergency response plans for poultry. It will be used if a swine HCD response is undertaken. With water contents of swine slurry as mentioned above and a book value of 12% water in ground corn stalks, we estimate that it would take 5,792 yd^3 to compost a full pit (538,610 gallons) of a 1200 swine facility. Absorption of water and nutrients from swine slurry poured over the top of an amendment will be dependent on several factors, including the amendment used, the depth of the amendment, ambient temperature, humidity, and the amount of conditioning (mixing with the physical effects of increasing amendment surface area and opening the hard waxy surface of stalks and stems). Researchers in China studied the absorption of swine slurry into mechanically treated corn stalks and observed that water absorption by conditioned stalks was about 500% of its weight in about 4 hr. It took 12 hr. for complete absorption (1000% of stalk initial weight; Jiao et al., 2022).

If composted on-farm, we do not know how much slurry we can apply to various available amendments. Probably, many farms would not have equipment to condition or mix the slurry and amendment prior to laying down windrows. The degree of absorption and how much will run through a ‘bed’ of amendment is not known. Because composting in a highly consequential disease emergency response will result in pathogen inactivation, we have planned this study to gain practical experience with composting swine slurry.

Stated objectives from the original proposal

The overall goal of this project was to gain practical experience with composting swine slurry. The specific objectives were to: 1a) make a preliminary determination of the compostable slurry water-holding capacity of three commonly available carbon amendments, ground (conditioned) corn stover, ground mulch, and a 50:50 blend of sawdust and shavings (medium-to-large flakes), and 1b) accurately determine the compostable water-holding capacity of three commonly available carbon amendments, ground (conditioned) corn stover, ground mulch, and a 50:50 blend of sawdust and shavings (medium-to-large flakes), 1c) determine the relationship of amendment bed or base thickness to the amount of slurry retained, and 2a) describe the management that would be required to compost all the swine slurry present in storage in a single event.

Status of the project in regards to stated timeline

The proposed timeline was to have addressed 1a by fall 2023, 1b and 1c by winter/spring 2024, 2a in spring 2024 and submit a Final Report in summer 2024. Experimentation in the study of objectives 1a and 1b were completed in March 2024 using grow-finish slurry and in May 2024 using nursery slurry. Experimentation to test objective 1c was completed in May 2024. Based on results from these experiments, modeling was completed to address objective 2a from May to July 2024. The project has been completed as planned, without adjustment to the original proposal timeline.

Modifications of the project from original proposal

To learn more about other possible carbon amendments, unconditioned corn stover, a 50:50 blend (by volume) of sawdust and playground wood chips, a 75:25 blend (by volume) of conditioned corn stover and sawdust and a 75:25 blend (by volume) of mulch and sawdust were evaluated for their slurry retention capacities. To learn more about characteristics of slurry that may impact its retention by carbon amendments, slurry from a shallow-pit nursery room was procured and applied to carbon materials.

Methods

Objectives 1a and 1b: Swine slurry was obtained from a commercial grow-finish producer as the pit was being pumped and slurry applied to cropland in spring (GF-slurry), and from the MSU Swine Farm as the shallow pit of a nursery room was being emptied (N-slurry). Slurry was put into 20-L F-Style jugs for transport and temporary storage.

Moisture content was determined on subsamples of GF slurry poured out of each jug after 30 sec. of agitation 3 d after it was received. Moisture content was determined similarly on subsamples of N-slurry collected on the same day the jugs were filled. This was when the slurry left the building and was flowing through a transfer tank to permanent storage. GF-slurry samples averaged 94.1% water or 5.9% solids (Table 1). Subsamples from each jug varied little. However, moisture content was more variable between jugs. N-slurry averaged 95.9% water or 4.1% solids.

Table 1. Moisture content of grow-finish and nursery slurries applied to carbon amendments to assess their retention capacity.

Slurry Container	**Sample Aluminum Pan ID**	**% H_2O**
GF GF-slurry, jug 1	1	92.5
GF GF-slurry, jug 1	2	92.5
GF GF-slurry, jug 1	'blank'	92.6
GF GF-slurry, jug 2	3	96.6
GF GF-slurry, jug 2	4	96.6
GF GF-slurry, jug 2	5	96.1
GF GF-slurry, jug 3	19	96.6
GF GF-slurry, jug 3	20	96.5
GF GF-slurry, jug 3	21	96.6
GF GF-slurry, jug 4	16	91.1
GF GF-slurry, jug 4	17	91.0
GF GF-slurry, jug 4	18	90.9
N-slurry, jugs 1 and 2	1	96.3
N-slurry, jugs 1 and 2	2	95.9
N-slurry, jugs 1 and 2	3	95.7
N-slurry, jugs 1 and 2	4	95.9
N-slurry, jugs 1 and 2	5	95.7
N-slurry, jugs 1 and 2	6	95.8

As planned, conditioned corn stover, ground mulch, and a sawdust-shavings blend (50:50 by volume) were carbon amendments evaluated as windrow base materials. Additionally, unconditioned corn stover and a 50:50 blend (by volume) of sawdust and playground wood chips were evaluated.

Corn stover was conditioned using a single pass through a Portland, 14 Amp, 1-1/2-in. capacity, electric chipper shredder (Model 61714, Camarillo, CA). Conditioning corn stover reduced volume and increased bulk density by 31.6%. The depth of material decreased from 14.25" to 9.75" in the 5-gal. pail.

In repetitions 4 and 5, the sawdust-shaving blend and the sawdust-chips blend were not further evaluated and were replaced by two other blends which may be more likely (less costly and more available) used by farms in emergency response, conditioned corn stover-sawdust (75:25 by volume) and mulch-sawdust (75:25 by volume). Individual carbon amendments were analyzed (in triplicate) for moisture content (drying oven at 80º C) and bulk density (weight per volume), and are described in Table 2 below. The moisture content and bulk densities of blends were determined mathematically. Dryness and the amount of surface area are characteristics of materials that may affect slurry retention during windrow construction.

Table 2. Moisture content and bulk density of carbon amendments evaluated for slurry retention.

Compostable Organic Material	% Water	Density, lb./yd^3
Corn Stover (CS)	17.2	53.8
Conditioned Corn Stover (ConCS)	17.2	74.1
Sawdust (SD), sawmill kiln dried hardwoods, stored piled outdoors	55.3	397.8
Mulch, ground wood bark stored piled outdoors	40.3	438.4
Large Flake Shavings (LFS), commercial bagged bedding	22.6	156.8
Playground Wood Chips (PWC), clean stored piled outdoors	38.8	565.0
50:50 Blend SD and LFS, by volume	46.1	277.3
50:50 Blend SD and PWC, by volume	45.6	481.4

75:25 Blend ConCS and SD, by volume	41.7	155.0
75:25 Blend Mulch and SD, by volume	48.8	428.2

The retention of slurry by the potential compost carbon amendment was measured in 5-gal. pails. To collect leachate passing through the materials, a grit guard washboard insert was placed in the bottom of each pail, and each pail lined with polyester pet-door screening fabricated to fit into pails (Figure 1). Lining the pails prevented the movement of fine particulate with the leachate. Material depth in the lined pail was 1ft. in repetitions 1 through 5. Corn stover was packed by hand and all others were 'tap' packed.

Figure 1. Pail, lining, and grit guard.

The retention of slurry by different materials was tested in three repetitions with GF-slurry (repetitions 1 through 3) and using N-slurry in repetitions 4, 5, and 6. Two different slurries were evaluated to learn more about slurry characteristics which may impact retention by carbon materials. Different jugs of GF-slurry were used in each of the first three repetitions. To avoid preferential flow along the side of the pail, slurry was not poured or applied within 1 in. of the lining/pail side. This resulted in a circular-shaped (10.25-in. diameter) application area of 82.5 in.^{2}. About 2000 mL was poured as quickly as possible onto the material surface. This amount was selected based on the outcomes of two preliminary applications using a similar amount of water, where leachate resulted. Pail management in repetitions with N-slurry was identical to that followed in the first repetitions with GF-slurry.

Figure 2. Carbon amendments evaluated in repetition 1, prior to slurry application. Shown are (top to bottom) are CS, ConCS, SD-PWC, Mulch, SD-LFS.

Figure 3. Rep 1 SD-LFS material 24-hr post GF-slurry application.

The GF-slurry was received from the farm on March 18. The assessment of the moisture content of the GF-slurry began on March 20. Retention repetitions 1, 2 and 3 were conducted on March 25, 26, and 27, respectively. Jugs containing the GF-slurry were agitated and vented every 2 to 3 d. The N-slurry was received on May 27, the same day the assessment of its moisture content began. Retention repetitions 4, 5 and 6 were conducted on May 27, 28, and 29, respectively. Jugs containing the N-slurry were agitated and vented daily, as slurry used for the retention experimentation was taken from both jugs for each repetition.

Objective 1c: In repetition 6, five depths of mulch (only mulch) were 6, 9, 12, 15, and 18 in. were placed in pails as described above. A 7-gal pail with a 20-in. tall lining was used for the 18-in. mulch depth. Mulch was selected for this evaluation as insufficient amounts of the other materials and of the N-slurry was available in order to complete other experimental repetitions evaluating the relationship of depth and retention in other materials. The GraphPad linear regression calculator was used (Dotmatics, 2024 GraphPad Software, https://www.graphpad.com/quickcalcs/linear1/).

Objective 2a: Knowing the 82.5 in.^{2} application area windrow surface area was estimated. Windrow surface area for slurry application was calculated as ft.^{2}, number of 1 x 17 x 800 ft. windrows, miles of 800 ft. windows if laid end-to-end, and A of windrows if a 16-ft. working space were put between each windrow. Knowing grams of slurry retained by the carbon amendment in 2 hr. application rate in gallons per ft.^{2} and gal per A were estimated using data from repetitions 1 through 5 of the retention experiment. In using grams of slurry retained, the assumption was made that no leachate would occur.

Results

Objectives 1a and 1b: In Table 3 below experimental data are shown, including the source of slurry, the amount of slurry applied to each pail of amendment, the leachate not retained and accumulated at the bottom of the pail, the slurry retained (by difference), and the percent of slurry applied which was retained by the carbon amendment.

All of the GF slurry applied to the SD-LFS carbon amendment mixture was retained in the material. The SD-PWC carbon amendment mixture also retained all the slurry applied in in repetitions 2 and 3, but in repetition 1 less (86.3%) of the applied slurry was retained in the 1 ft. of this material. Leachate from the slurry application passed through the CS, ConCS, and Mulch materials in all repetitions, more in the first repetition than in the following repetitions.

Table 3. Retention of slurry by carbon amendment one-foot deep. Shown are individual observations.

Rep	Material	Pail ID	Slurry jug	Slurry applied, g	Leachate at 2 hr., g	Slurry retained, g	Slurry retained, %
1	CS	A	GF3	1980	1310	670	33.8
2	CS	D	GF1	1818	464	1354	74.5
3	CS	C	GF2	2118	332	1786	84.3
4	CS	A	N1	2046	1136	910	44.5
5	CS	B	N2	2122	996	1126	53.1
1	ConCS	E	GF3	2002	1044	958	47.9
2	ConCS	E	GF1	2298	174	2124	92.4
3	ConCS	D	GF2	2138	84	2054	96.1
4	ConCS	E	N1	2056	722	1334	64.9
5	ConCS	E	N2	2228	428	1800	80.8
1	Mulch	D	GF3	1872	1148	724	38.7
2	Mulch	B	GF1	1966	92	1874	95.3
3	Mulch	E	GF2	1986	170	1816	91.4
4	Mulch	D	N1	2004	708	1296	64.7
5	Mulch	A	N2	2216	248	1968	88.8
1	SD-LFS	C	GF3	2550	0	2550	100.0
2	SD-LFS	A	GF1	1812	2	1810	99.9
3	SD-LFS	B	GF2	1768	0	1768	100.0
1	SD-PWC	B	GF3	1904	260	1644	86.3

2	SD-PWC	C	GF1	1912	0	1912	100.0
3	SD-PWC	A	GF2	1844	2	1842	99.9
4	ConCS-SD	C	N1	2106	520	1586	75.3
5	ConCS-SD	C	N2	2158	498	1660	76.9
4	Mulch-SD	B	N1	2048	438	1610	78.6
5	Mulch-SD	D	N2	2142	206	1936	90.4

Objective 1c: Interpretation of the relationship between depth and percent of slurry retained was considered using various statistical models and parameters (Figure 4 and Table 5). Ninety-two percent of the variation in the percent retained was explained by the depth of the mulch ($R^2 = 0.92$). The prediction equation modeled a 2.74 change in percent of slurry retained for every 1-in. change in mulch depth.

Table 4. Assessment of slurry retention by mulch as impacted by depth of mulch. Shown are individual observations.

Mulch depth, in.	**Pail ID**	**N slurry applied, g**	**Leachate at 2 hr., g**	**N slurry retained, g**	**N slurry retained, %**
6	D	2154	1028	1126	52.3
9	B	2130	660	1470	69.0
12	C	2158	560	1598	74.1
15	A	2126	506	1620	76.2
18	F	2182	222	1960	89.8

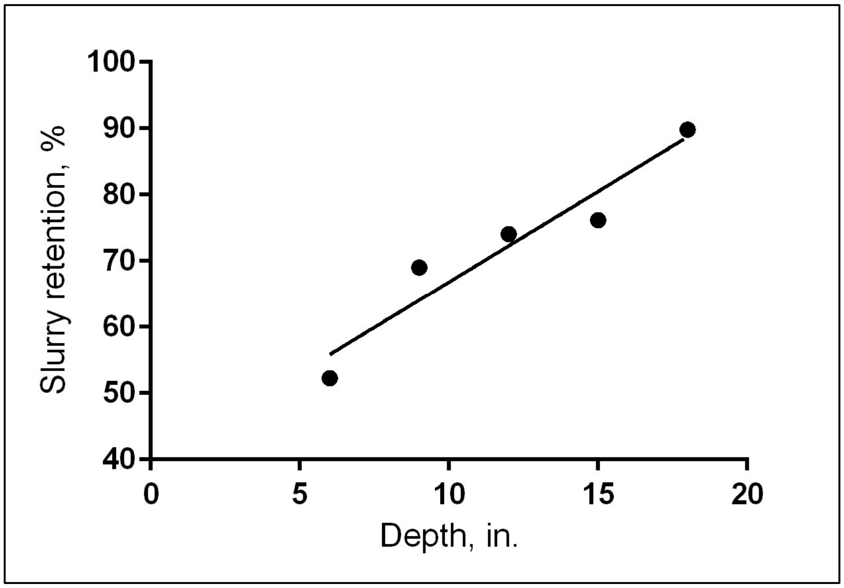

Figure 4. Linear regression describing the relationship between mulch depth (in.) and percent of slurry applied which was retained within the mulch in 2 hr.

Table 5. Interpretation of the relationship between depth and percent of slurry retained by mulch.

Best-fit values	
Slope	2.744 ± 0.4718
Y-intercept	39.35 ± 6.005
X-intercept	-14.34
1/Slope	0.365
95% Confidence intervals	

Slope	1.242 to 4.245
Y-intercept	20.24 to 58.46
X-intercept	-46.36 to -4.839
Goodness of fit	
R square	0.919
Sy.x	4.476
Is slope significantly non-zero?	
F	33.82
DFn, DFd	1, 3
P-value	0.01
Deviation from horizontal?	Significant
Data	
Number of XY pairs	5
Equation	Y = 2.744*X + 39.35

Objective 2a: If we had 1,000,000 gals of slurry in storage, and if the amount of slurry retained and the material surface area in our experimentation (Table 3) were used in the construction of windrows 1 x 17 x 800 ft., then the number of windrows of this size, the total mi. of windrows if laid end-to-end, and the estimated A of cropland for composting the slurry would be large (Table 5). Acreage ranges from 38 to 144 A. Acreage estimations in the table include a 16 ft. working space between windrows. From 31,000 to 111,000 yd^3 of carbon amendment would need to be sourced for this composting approach, slurry application one-time on the surface of windrows 1 ft. deep and 17 ft. wide.

In our experiment, slurry was applied to the 10.25 in^2 surface area. If the amount retained was applied to that area, then this extrapolates to gal. per ft.^{2} and gal. per A of windrow surface area as shown in Table 5.

Table 5. Extrapolation of carbon amendment slurry retention experimental data (Table 3) to field scale. Shown are predicted slurry application rates and windrow areas if 1,000,000 gal. of stored slurry needed composting.

		Application rate		**Windrow number and dimension**		
Rep	**Material**	**Gal/ft.^{2}**	**Gal/A**	**Total (1 x 17 x 800 ft.)**	**Mi., if end-to-end**	**A, w/ 16’ work space b/w**
1	CS	0.31	13,455	238	36.1	144
2	CS	0.62	27,191	118	17.8	71
3	CS	0.82	35,866	89	13.5	54
4	CS	0.42	18,274	175	26.6	106
5	CS	0.52	22,612	142	21.5	86
1	ConCS	0.44	19,238	166	25.2	101
2	ConCS	0.98	42,654	75	11.4	46
3	ConCS	0.95	41,248	78	11.8	47
4	ConCS	0.61	26,789	120	18.1	72
5	ConCS	0.83	36,147	89	13.4	54
1	Mulch	0.33	14,539	220	33.4	134
2	Mulch	0.86	37,633	85	12.9	52
3	Mulch	0.84	36,468	88	13.3	53
4	Mulch	0.60	26,026	123	18.6	75
5	Mulch	0.91	39,521	81	12.3	49
1	SD-LFS	1.18	51,208	63	9.5	38
2	SD-LFS	0.83	36,348	88	13.4	53

3	SD-LFS	0.82	35,504	90	13.7	55
1	SD-PWC	0.76	33,014	97	14.7	59
2	SD-PWC	0.88	38,396	83	12.6	51
3	SD-PWC	0.85	36,990	87	13.1	52
4	ConCS-SD	0.73	31,850	101	15.2	61
5	ConCS-SD	0.77	33,336	96	14.6	58
4	Mulch-SD	0.74	32,332	99	15.0	60
5	Mulch-SD	0.89	38,878	82	12.5	50

Discussion

Slurry: GF-slurry variation among jugs, we are not sure how they were collected at farm relative to amount of slurry remaining in the pit when jug was filled. Jugs filled earlier may contain fewer solids. This variation is a concern as it could lead to more land and carbon amendment necessary for composting, and alternatively it could result in more leachate flowing downward beneath the compost windrows.

As time passed and the GF-slurry was stored temporarily, and managed with agitation and venting, the slurry became more viscous, foamy, increasing the amount retained by CS, ConCS and Mulch materials in repetitions 2 and 3. The slurry ponded on the surface of the carbon amendment. The application had to be completed more slowly to avoid having the slurry move to the pail edges, leading to preferential flow. In the case of N-slurry, there were fewer solids to begin with, and the increase in retention over the 3 d, may have been due to difficulty in keeping the solids uniformly and consistently suspended in the jugs during pouring into the 2500-mL beaker used for applications. The N-slurry did not become as foamy as did the GF-slurry, but it was not kept in jugs as long. The experiences with the two slurries used in this project, suggest that slurries will differ by stage of production from which slurry is accumulated in pit storage, the amount of agitation, the success in keeping solids suspended, and potential emulsification and (or) aeration responses occurring in the slurry during the entire time, sequence of processes involved in its removal from the pit to when it is applied to the surface of a carbon amendment.

Carbon amendments: Dryness and porosity and depth were confirmed as factors that affect the amount of slurry retained in the amendment after application. This project was not designed to quantify the effects of amendment moisture or bulk density. The impact of depth was studied and is described in Objective 1c.

Objective 1a and 1b: Amendments differ in their capacity to retain slurry. Of those amendments studied, sawdust and shavings were the most effective in retaining slurry. Availability, cost, and the time and equipment needed to blend amendments are considerations when deciding which to use. Mulch and conditioned corn stover have been most commonly used by farms accomplishing mass mortality composting. On-farm, tub grinders are used to reduce the coarseness of bales of hay, straw, corn stover, and other crop residues for cattle feed, and in in conditioning similar residues for use as a carbon source in composting HPAI mortality.

Application rate used in this project exceeded (13,000 to 51,000 gal./A depending on amendment used as base material) those generally applied by liquid tank spreaders on swine farms (5,000 to 10,000 gal./A). To practically apply swine slurry onto compost materials in the field using equipment routinely used by swine producers, the modification of slurry discharge would be needed. Multiple applications over time onto the same compost windrows could be another approach taken to minimize resources (the amount of carbon amendment and land area) needed to compost large amounts of slurry.

Objective 1c: Simple logic, that the use of a deeper base of carbon amendment would retain greater amounts of slurry was proven true. The experiment tested depths of 6 to 18 in. using only mulch, and different outcomes would be anticipated if other materials, which experience leachate at 12 in. would include pails of 18 in. or more. Indeed, the use of depths of 21 and 24 in. would provide greater confidence in the prediction equation. A prediction equation should statistically not be used outside of the test range, in this case, 6 to 18 in. But sometimes this is done as it is insightful, and when done with the equation modeled in this project, a 2.74 change in percent of slurry retained for every 1-in. change in mulch depth suggests that at about 22-in. of mulch as a mulch base, about 0.75 gal./ft^2 or 33,00 gal./A. could be retained fully when applied in a slurry composting event.

Objective 2a: A typical grow-finish double room barn 2,500 head and accumulates in the pit a total manure production of 810,000 gal./yr. (Brumm, 2016, http://forum.mnpork.com/?p=757). Each room is 50 x 192 ft. with a fully slatted floor over a pit. Typically, pits have 6-18" of heavy sludge that remains in the pit year-to-year. In this report the 1,000,000 gal. scenario was presented in Table 5 as it would be an amount removed and applied to compost when completely cleaning the two pits of a double room facility. If the material was 1 ft. deep, then area needed to compost all of the slurry (single application, windrows 1 x 17 x 800 ft., with a 16 ft. working space between them), depending on carbon amendment used, would be large, ranging from 38 to 144 A. If greater depths were used, the size of the composting site could near the smallest end of this range. The 38 A estimation resulted when using SD-LFS and slurry applied at 1.18 gal./ft.^{2} or 51,208 gal./A. How this could be done practically remains to be explored.

Only 100% retention was modeled in this project, so to avoid the environmental risks of leachate leaving the compost base and moving into the soils below. However, it is well accepted that soils receiving direct slurry application routinely, do serve as a treatment of the nutrients in slurry. The potential of allowing a small proportion of slurry applied to safely leach through would decrease the amount of amendment and land required to compost slurry.