Pig Barn Manure Management with Solid-Liquid Separation Barn

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Manure Management and Utilization Technologies (2) – New Approaches

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Objectives

- Background, common pig manure systems
- Materials and methods, separation barn and monitoring effort
- Separation efficiency, value of manure, constructions, and air quality
- Economic analysis and lessons learned

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Common Pig Manure Storage – Deep-Pit System

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Common Pig Manure Storage – Lagoon System

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Introduction

- Issues with Swine Manure Production/Application
  - Uneven nutrient concentrations
  - Excess moisture increasing manure mass and transport cost
  - Air quality output by swine barns
    - Urea-urease reactions producing ammonia
- Solid/Liquid Separation
  - Removal of significant amounts of liquid from the solids
  - Altered nutrient distributions due to two separate streams

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Manure Solid Separation Options

Solid-liquid separation pig barn and solid manure storage in Missouri

Sloped screen separator

Conveyor screen and a small screw press treating swine manure (Credit: Clemson University Extension)

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Materials & Methods

- 18” pit space, v-shape gutter, 4” rise or 7% slope, 9’4” wide.
- 6” pvc pipe draining liquid, a drop of 8” over 60’ long barn = 1% slope.

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Finishing Barn and Automatic Scrapers

Central Missouri, 80’ x 132’, four individual rooms, 300-hd finishing pigs

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Materials & Methods

- Separation Barn
  - Automated scraper system
  - Gravity draining for liquid
    - Pumps to collection pit
  - Conveyor system for solids
    - Moves to solid storage shed

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Materials and Methods

- Quantity and characteristics of the solid and liquid manure, for > 18 months
- Room Live Mass Monitoring
    - Initial weight, sale weight, sale dates, mortality rate, headcount
    - Barn operated as antibiotic-free
  - Rate of feed consumption also monitored
    - Separated by the 4 rooms

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Materials & Methods

- Manure Production Monitoring
  - Timed camera system for solid storage shed
    - Measure change in pile height
  - Liquid pressure logger placed in collection pit
    - Pressure converted to depth

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Materials and Methods

- Liquid Manure Filtration
  - Looking to further process liquid manure produced
  - Pretreatment options
  - Membrane filtration
    - Microfiltration & Reverse Osmosis

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Materials and Methods

- Air Quality Monitoring
  - Monthly check of output by barn fans
  - Ammonia and hydrogen sulfide levels
  - Wall fans and pit fans

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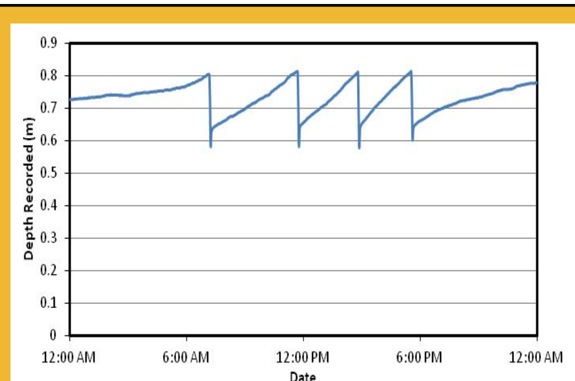
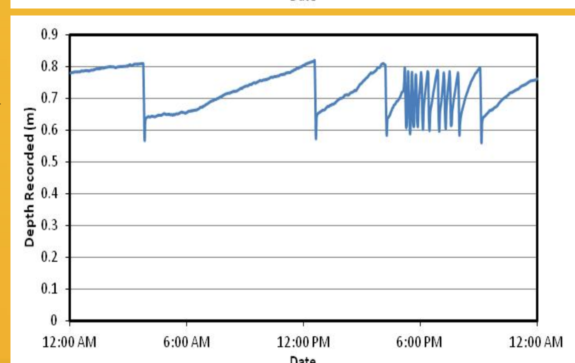
Results

- Liquid Manure Production
  - Normal production vs. abnormal production
  - Abnormal data removed
    - Attributed to rainfall and influx of water from other sources
  - 298 to 1,840 gallons per day, averaged 885 gallons





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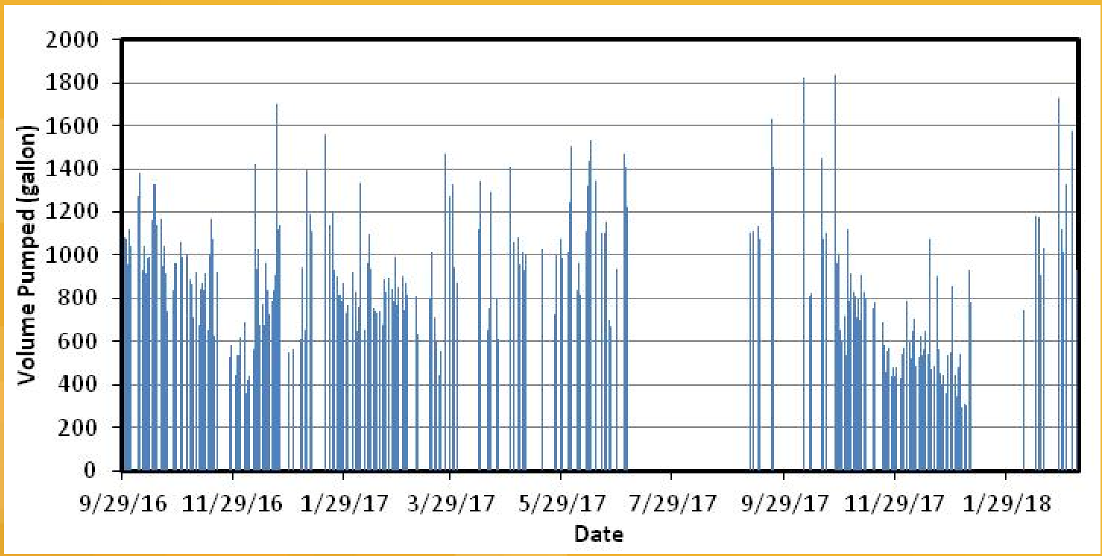
Liquid Manure Production



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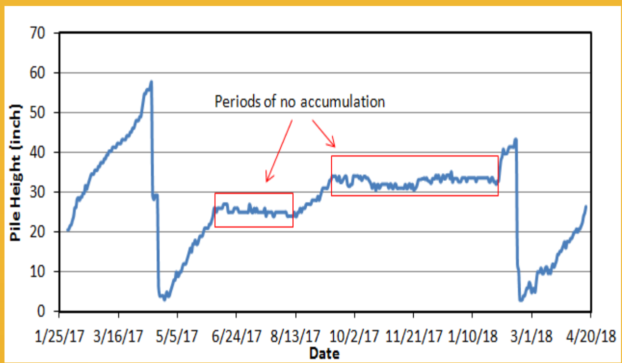
Results

- Solid Manure Production
  - Scope of information collected limited by technical issues
  - Less variation in daily production compared to liquid
  - Averaged 299 gallons daily



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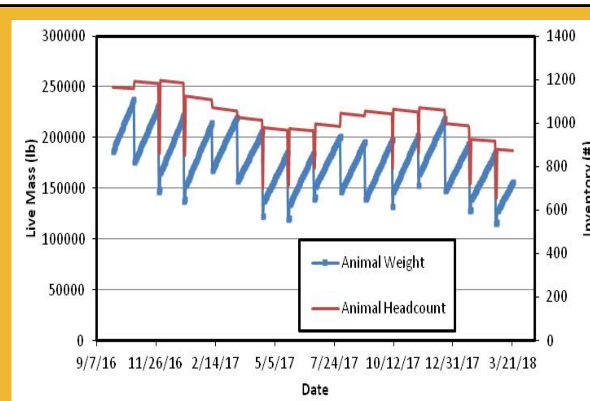
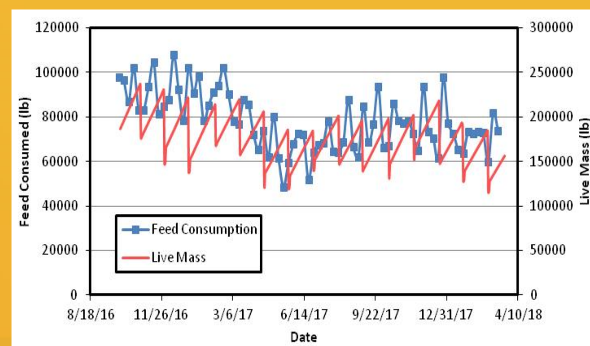
Results

- Live Mass and Feed
  - Combined live mass curve for all four groups followed linear trend
  - Feed calculated biweekly to reduce variance due to recording method





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Results: Solid vs. Liquid Manure!

	Nitrogen (ppm)	Ammonium (ppm)	Phosphorous (ppm)	Potassium (ppm)	Carbon (%)	Moisture (%)
Liquid Manure	3,334	3,199	669	2,762	1.18	97.7
Solid Manure	15,864	6,763	5,890	7,020	13.2	72.5

	Nitrogen	Ammonium	Phosphorous	Potassium	Carbon	Total Solids
Liquid Manure (gal/day)	2.95	2.83	0.59	2.44	10.4	20.3
Solid Manure (gal/day)	4.74	2.02	1.76	2.10	39.5	82.2
Total Manure (gal/day)	7.69	4.85	2.35	4.54	49.9	102
Percent Removal by Solid Separation (%)	61.7%	41.7%	74.8%	46.2%	79.1%	80.2%

Liquid manure averaged 885 gallons, solid averaged 299 gallons, daily

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Results

- Economic
  - Average deep-pit barn was $175-$230/pig
  - Electrical cost - daily operation time for scraper/conveyor, motor horsepower, and average electrical cost
    - Annually- 3.32 MWh used

Construction Needs	Total Cost	Cost per Pig (1,200 head)
Finishing Barn (80 x 132 feet)	$280,000	$233.33
Building	$188,000	$156.67
Concrete	$60,000	$50.00
Equipment	$32,000	$26.67
Conveyor System	$11,000	$9.17
Manure Storage Shed (25 x 75 feet)	$32,000	$26.67
Total Cost	**$323,000**	**$269**

Maintenance Items	Yearly Cost	Cost per Pig (1,200 head)
Motor Replacements	$228.14	$0.19
Link Chain for Conveyor	$457.14	$0.38
Cable Replacements, 1000ft/year	$600.00	$0.50
Pulley Replacements, 2 sets/year	$57.14	$0.05
Electricity for Scraper and Conveyor Systems	$330.73	$0.28
Total Cost	**$1,673**	**$1.39**

Economic Analysis for Separated Manure Nutrients to Payback the Separation Barn

- Baseline: 476,000 gallons slurry manure hauled 5 miles to corn fields. Included wash water. Value of the manure = $12,798/year; $115.62/acre; $26.89/1000 gallons. All N was valued ($42.86/acre), while P&K were applied in excess of crop removal. Only crop removal value of phosphorus ($40.42/acre) and potassium ($32.34/acre) was considered.
- Hours to load 6000-gallon tanker, transport 5 miles to apply the manure = 92.3 hours/year. Assuming a custom application rate of $120/hour, the total application rate was $11,076. The baseline scenario manure value exceeded its cost by $1,722/year.

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Swine Manure Application Management

- Manure is applied to corn and soybean fields to meet the nutrient needs of the crops grown.
- Manure is transported to the nearest available field that will be growing corn (corn-soybean rotation).
- Manure is injected or incorporated into the soil to conserve N and avoid runoff.
- Nutrients are valued as fertilizer if needed by the cropping system.
- Nutrients in excess of cropping system need are valued at $0.

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Management	Unseparated Manure	Liquid Fraction	Solid Fraction
Storage	Under hog barn	Outside tank (collecting rainwater)	Under roof (outside of hog barn)
Application method	Aerway injector	Aerway injector	Side discharge spreader, incorporated within 24 hours.
Nutrient limit rule	100 % corn N need	100 % corn N need	100 % corn N need
Phosphorus application	140% corn-soybean P_2O_5 need	80% corn-soybean P_2O_5 need	90% corn-soybean P_2O_5 need
Years between application to the same field	Two	Two	Four

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Economic Analysis for Separated Manure Nutrients to Payback the Separation Barn

- Baseline: a deep pit was $45,000, amortized to $2,250/year.
- A solid/liquid manure facility: $11,000 for a conveyor system, $32,000 for storage shed, and $62,000 for uncovered liquid pit. Amortized to $5,800/year. Additional maintenance and operating expenses was $1,673 annually.
- The liquid/solid system is $60,000 more than the deep pit.
- The payback period was the additional investment ($60,000) divided by $4,408, the difference of the marginal benefit of the manure ($6081 yr^{-1}) minus the additional annual maintenance ($1,673 yr^{-1}).
- The payback period was estimated to be **13.6 years**.

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Economic Analysis - Considerations

- The payback period can be affected by many other factors.
- When the distance to transport the manure was increased from 5 miles to 10 miles, the pay back periods became 7.8 years.
- Transportation cost can be affected by using larger solid manure spreader or use of truck to reduce time on the road.
- If the liquid manure storage has a roof to prevent rainfall accumulation.
- Scale of the operation of these calculations is small, for larger amount of liquid manure to transport, nutrient/transportation more significant.
- Every farm is unique, a case-by-case analysis is needed.

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Sensitivity Analysis on the Net Benefit of Manure and Payback

	Size of facility (head)				
	1200	1200	4800	4800	4800
	Distance manure hauled (Mile)				
Economic Measure	5	10	5	10	10
P_2O_5 price ($ kg^{-1})	.95	.95	.95	.95	1.06
Marginal fertilizer value ($ yr^{-1})	4905	4,905	19,619	19,619	20,857
Marginal application savings ($ yr^{-1})	1,177	5,603	7,266	2,2182	22,182
Marginal net value ($ yr^{-1})	6,082	10,508	26,885	41,801	43,039
Maintenance of S-L system ($ yr^{-1})	1,673	1,673	6,023	6,023	6,023
Benefit available to repay investment ($ yr^{-1})	4,409	8,835	20,862	35,778	37,016
Additional investment ($)	60,000	60,000	217,637	217,637	217,637
Payback period (yr)	13.6	6.8	10.4	6.1	5.9

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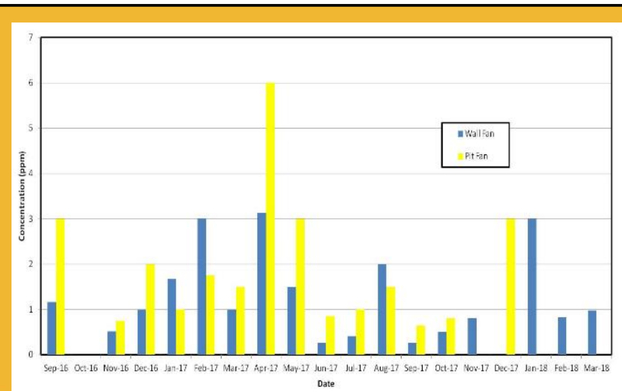
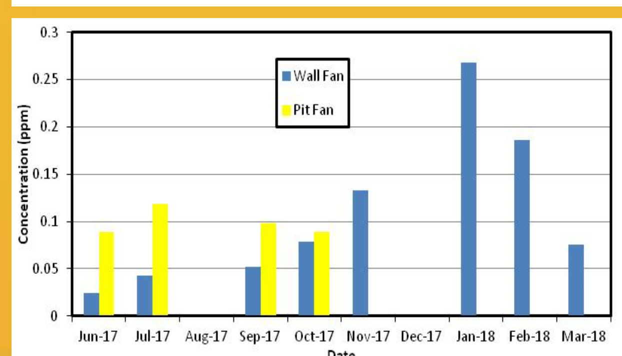
Air Quality Indicators

- NH_3 Concentrations
  - 1.3 ppm for wall fan
  - 1.9 ppm for pit fan
- H_2S Concentrations
  - Below minimum detection by Dragers
  - 0.1 ppm for wall and pit fan
  - Potentially lower than actual, definitely below 0.5 ppm





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Conclusions

- Solid-liquid barn has great potential for separation of certain nutrients (phosphorous)
- Payback period is marginal
- Air quality very good in comparison to deep-pit barns
- Consider nutrient management needs and land application field distances and workload

References
Brown, J., T. Lim, J. Zulovich, and C. Costello. 2018. Sustainability Evaluation of a Solid-Liquid Manure Separation Operation. National Pork Board Research Report NPB#16-094.
Massey, R. E., T.-T. Lim, and J. A. Zulovich. 2019. Economic conditions for implementing solid-liquid separation barn. In International Symposium on Animal Environment and Welfare. Rongchang, Chongqing, China

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