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Reduction of Water in Swine Manure Storage

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Problem Statement

Our client manages a three barn 4200 head swine facility with deep pit manure storage. They have noticed at this current site that there is an abnormal weekly rise in deep pit manure storage levels. The manager has narrowed this issue down to excess water usage due to the in-barn flow rate.

Disciplines

Bioresource and Agricultural Engineering | Industrial Technology

IOWA STATE UNIVERSITY

Department of Agricultural and Biosystems Engineering (ABE)

TSM 416 Technology Capstone Project

Reduction of Water in Swine Manure Storage

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1 PROBLEM STATEMENT

Problem Statement

Our client manages a three barn 4200 head swine facility with deep pit manure storage. They have noticed at this current site that there is an abnormal weekly rise in deep pit manure storage levels. The manager has narrowed this issue down to excess water usage due to the in-barn flow rate.

Business Case

By restricting the water flow for drinking in the barns, we will reduce excess water waste collecting in manure storage. Manure storage must be pumped twice a year in the spring and fall at a cost per gallon. By reducing the amount of excess water in the barns, deep pit storage is assumed to reduce pumping costs and increase manure nutrient content.

2 MAIN OBJECTIVE

The problem is that excess water in the swine manure storage reduces the amount of manure storage and increases the amount of product that must be handled. It is assumed that excess water in the manure also decreases its nutrient content.

- **Main Objective(s) and Specific Objectives**
  - The main objective is to:
    - Reduce water usage on a per head basis on a 4200 head swine farm with the use of "Ziggity 101 Water Regulators" shown in manure storage data.
    - Design and document the method to reduce water use in the form of an installation kit for the "Ziggity 101 Water Regulator".
- **Specific objectives include:**
  - Determine the cost savings of water reduction based on pit pumping costs.
  - Create a detailed parts list of an installation kit for the "Ziggity 101 Water Regulator".
  - Develop a working prototype for water reduction.
- **Rationale**
  - Reduce excess water usage on a per pig basis to a goal of 1.2 gallons/day.
  - Assumed increase nutrient content of applied manure by 40%.
  - Estimated decrease manure storage pumping costs by 40%.
  - Increase compliance with water regulation.
- **Project Scope**
  - Reduction of water usage per head basis on a 4200 hd swine farm using "Ziggity 101 Water regulators" shown in manure storage data.
  - Design and document, in the final report, the method to reduce water use. In the form of an installation kit for the "Ziggity 101 water regulator" used.

The project scope objectives listed above were chosen by the client.

3 METHODS/APPROACH

We found a simpler way to solve the excess water problem by monitoring where the water comes from. We found out the cause was the pressure coming into the waterers for the pigs. In most cases, the pressure was 40 psi to 60 psi to the water nipples. This high pressure was causing the drinker nipples to release water at a rate of 6 oz per 5 seconds of the drinker nipple being engaged. This created more water than the animals will drink, causing the excess water in the pan to be wasted.

A. Methods/Approach

- Water pressure to the building is approximately 60 psi; then, it is regulated to 40 psi. The drinker nipple manufacturer suggests a pressure tolerance of 0 psi to 50 psi. The manufacture also claims that each nipple produces 2 qt per minute at 40 psi.

Data collection:

- We began to collect data from 3 different barns comparing water usage before and after the installation of regulators; the installation of the regulators can help lower the excess water in the manure pit.
- We compared the amount of manure pumped from the pit from before the regulators vs. after the regulators were introduced.

Skills:

- The TSM 327 animal production systems class helped with the understanding of swine production systems.

Solutions:

- We decided to lower the water pressure going to the drinker nipples by installing a secondary regulator to lower the pressure from 3 psi to 6 psi producing approximately 6 oz per 10 second of drinker nipple engagement.

4 RESULTS

Results/Deliverables

- To date, a 38% reduction in water usage has been observed after the installation of pressure regulators
- 38% reduction of estimated manure pumping cost (Table 5)
- Estimated 1-inch reduction in the weekly rise of storage levels shown in tables and figures 1-3.

Recommendations

- Regulate the water into the barn to 40 psi following secondary regulator specifications
- Regulate water using a secondary "Ziggity 101" water regulator to 3 to 6 psi to the water nipple with a flow rate of 6 oz per 10 s.
- Check and repair all components for water leaks, including but not limited to:
    - Nipples, water pans, connections

5 BROADER OPPORTUNITY STATEMENT

- Assumed increase in manure nutrient value per gallon
- Reduced pumping frequency and urgency
- Eliminate the need/urgency for spring manure pump-out

6 GRAPHICAL ABSTRACT

→ By finding the source of the excess water in the deep pit storage,
→ It can be regulated with a Secondary regulator,
→ And reduce pump-out urgency, cost, and manure nutrient dilution.

7 APPENDIXES

Figure 1 – Graph Showing the weekly manure storage measurement weekly in barn 1 2020 for the 1st quarter of the year. When this data was collected, the site had filled with 60 lbs feeder pigs on 1/1/2020. The regulators were not in use, and the incoming water psi was approximately 40 psi.

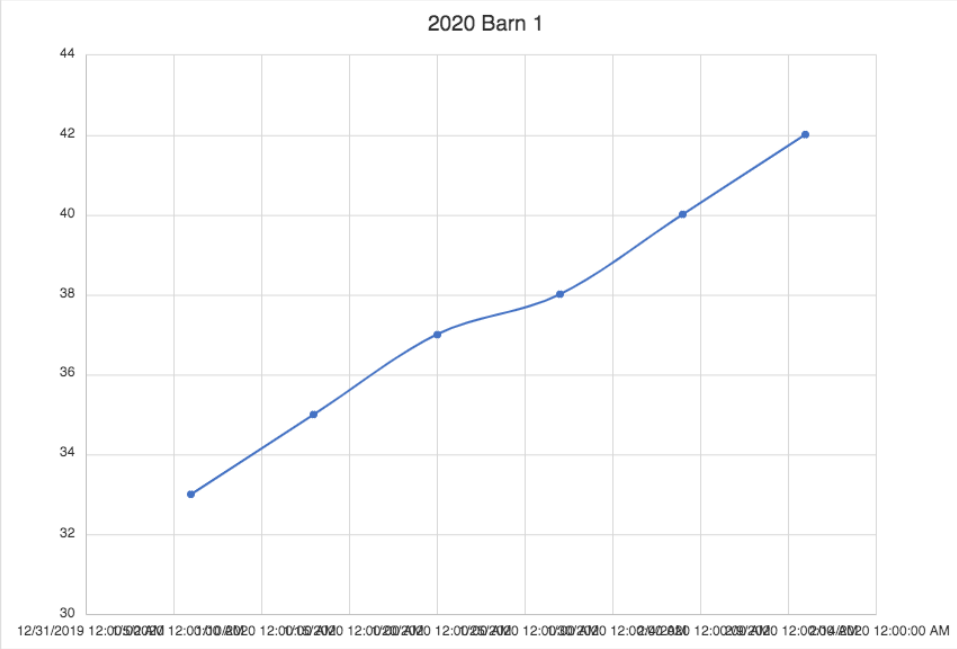
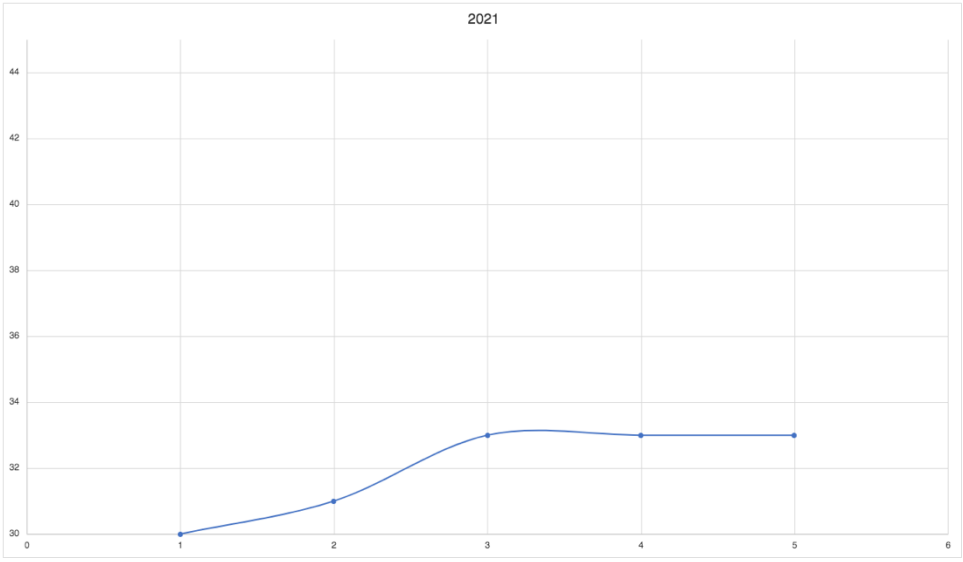


Table 1 – Table Showing the weekly manure storage measurement weekly in barn 1 2020 for the 1st quarter of the year, which is highlighted in yellow. When this data was collected, the site had filled with 60 lbs feeder pigs on 1/1/2020. The regulators were not in use, and the incoming water psi was approximately 40 psi.

Storage Type	Max Capacity	Manure Level	Foam Level	Total Level	Source	Read Date	Inserted Date
PIT	628080	33	0	33	Islat	1/6/2020 12:00:00 AM	1/6/2020 11:04:13 AM
PIT	628080	35	0	35	Islat	1/13/2020 12:00:00 AM	1/13/2020 10:17:26 AM
PIT	628080	37	0	37	Islat	1/20/2020 12:00:00 AM	1/20/2020 5:54:10 PM
PIT	628080	38	0	38	Islat	1/27/2020 12:00:00 AM	1/27/2020 11:07:00 AM
PIT	628080	40	0	40	Islat	2/3/2020 12:00:00 AM	2/3/2020 10:29:03 AM
PIT	628080	42	0	42	Islat	2/10/2020 12:00:00 AM	2/10/2020 11:48:48 AM
PIT	628080	43	0	43	Islat	2/17/2020 12:00:00 AM	2/17/2020 11:10:45 AM
PIT	628080	44	0	44	Islat	2/24/2020 12:00:00 AM	2/24/2020 9:31:10 AM

Figure 2– Graph Showing the weekly manure storage measurement weekly in barn 1 2021 for the 1st quarter of the year. When this data was collected, the site had filled with 60 lbs feeder pigs 1/3/2021. The regulators had been in use since the first pit measurement. The incoming pressure to the barn was 40 psi, and the pressure to the pigs was 6 psi.



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2020-53	2021-1	2021-2	2021-3	2021-4	2021-5	2021-6
30	31	28	33		33	33

Table 3 – This is a table that categorizes what supplies and tools are needed to install one regulator. The list has three categories: Part Name, Size, Part material, and the needed quantity.

Part Name	Size	Material	Quantity2
Tee	3/4"	Sch 40 PVC	2
"Ziggity" Regulator	101	-	1
Ball valve	3/4"	Sch 40 PVC	3
90 angle	3/4"	Sch 40 PVC	2
Female hose end	3/4" hose thread	-	2
hose clamps	1.5"	-	2
Hose	3/4"		2 ft
NPT x hose thread adaptor	3/4"	nylon	1
Teflon Tape	1/2"	-	1
Pipe	3/4"	Sch 40 PVC	1 ft
pvc glue	1 pint		1

PVC primer	1 pint	1

Recommended Tools	Size
PVC/hose cutter	1"-1.5"
Pliers	6"
nut driver	5/16"

Table 4 - Table Showing the weekly manure storage measurement weekly in barn 2 2020 for the 1st quarter of the year highlighted in yellow. When this data was collected, the site had filled with 60 lbs feeder pigs on 1/1/2020. The regulators were not in use, and the incoming water psi was approximately 40 psi.

Storage Type	Max Capacity	Manure Level	Foam Level	Total Level	Source	Read Date	Inserted Date
PIT	628080	35	0	35	Islat	1/6/2020 12:00:00 AM	1/6/2020 11:04:13 AM
PIT	628080	37	0	37	Islat	1/13/2020 12:00:00 AM	1/13/2020 10:17:26 AM
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PIT	628080	43	0	43	Islat	2/10/2020 12:00:00 AM	2/10/2020 11:48:48 AM
PIT	628080	45	0	45	Islat	2/17/2020 12:00:00 AM	2/17/2020 11:10:45 AM
PIT	628080	47	0	47	Islat	2/24/2020 12:00:00 AM	2/24/2020 9:31:10 AM

Table 5 - Table Showing the weekly manure storage measurement on a weekly basis in barn 3 2020 for the 1st quarter of the year, which is highlighted in yellow. When this data was collected, the site had filled with 60lbs feeder pigs on 1/1/2020. The regulators were not in use, and the incoming water psi was approximately 40 psi.

Storage Type	Max Capacity	Manure Level	Foam Level	Total Level	Source	Read Date	Inserted Date
PIT	628080	25	0	25	Islat	1/6/2020 12:00:00 AM	1/6/2020 11:04:13 AM
PIT	628080	27	0	27	Islat	1/13/2020 12:00:00 AM	1/13/2020 10:17:26 AM
PIT	628080	29	0	29	Islat	1/20/2020 12:00:00 AM	1/20/2020 5:54:10 PM
PIT	628080	30	0	30	Islat	1/27/2020 12:00:00 AM	1/27/2020 11:07:00 AM
PIT	628080	32	0	32	Islat	2/3/2020 12:00:00 AM	2/3/2020 10:29:03 AM
PIT	628080	34	0	34	Islat	2/10/2020 12:00:00 AM	2/10/2020 11:48:48 AM
PIT	628080	35	0	35	Islat	2/17/2020 12:00:00 AM	2/17/2020 11:10:45 AM

PIT	628080	37	0	37	Islat	2/24/2020 12:00:00 AM	2/24/2020 9:31:10 AM

Table 6 – Table showing barns 1-3 storage level percentage from the 1st quarter of 2021. This the first section of table 7.

System Storage Levels

Site No	Site	Storage Name	Site Inventor	% Full Older ---> Newer	% Full Low	% Full High	% Full Last
F069	Henderson	Barn 1	3975		25.0%	87.5%	34.4%
F069	Henderson	Barn 2	3975		33.3%	90.6%	52.1%
F069	Henderson	Barn 3	3975		15.6%	60.4%	26.0%

Site fill: 1/2/21 wk 53 2021

Table 7 – Table showing each barn's storage levels from top to bottom starting with barn 1 on the top and barn 3 on the bottom by week, which progresses through time from left to right. This table is where table 2a is derived from. On the right, it also displays a ventilation depth in inches, total depth, And the number of total gallons in the storage underneath the barns.

2020-53	2021-1	2021-2	2021-3	2021-4	2021-5	2021-6	Days since last report	Treat Foa	Vent Warnir	Vent Depth (	Free Board Depth (	Total Depth (	Manure Level Gallo
30	31	28	33		33	33	3			84	96	96	215,902
44	32	46	48		49	50	3			84	96	96	327,125
19	19	19	20		23	25	3			84	96	96	163,562

Table 8 – Table showing the max capacity of storage for the barn in gallons. Starting with barn 1 at the top and barn 3 at the bottom.

Max Capac
628,080
628,080
628,080

Table 9 – Conversion table shows water waste reduction in deep pit storage, reduction in storage pumping costs per day and annually, and calculation assumptions for per pig, barn, and per-site basis.

	Per Head Space	**1400 head/One Barn**	**Per 4200 head Site**
Estimated Gallons/Week Before Regulator Installation	**7.477**	10468.000	31404.000

Estimated Gallons/Week after Regulator Installation	4.673	6542.500	19627.500
% Reduction of Gallons of Waste/Week	38%	38%	38%
Estimated Reduction Gallons/Day	0.668	934.643	2803.929
Estimated % of 628,000 Gallon total storage/Day	0.0001%	0.149%	
Cost/Day @ $0.01 per Gallon before Regulator use	$0.07	$9.35	$28.04
Estimated Total Annual Pumping Costs for Every Gallon of Manure in Storage before Regulator Use	$3.89	$5,443.36	$16,330.08
Estimated Total Annual Pumping Costs for Every Gallon of Manure in Storege After Regulator Use	$2.43	$3,402.10	$10,206.30
Estimated Total Annual % of Reduction in Pumping Costs	38%	38%	38%

Assumptions	
Gallons/inch	6,542.5
Days downtime/year	28
Reduction/week/inch	1
The average amount of weekly rise 1st quarter 2020	1.6 to 2 inches
Pumping cost/$	0.01