RuFaS: Manure Module

Nutrient Recycling and Greenhouse Gas Emissions from dairy housing and manure management

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Outline – Manure Module

Animal Module

Manure Module

Manure characteristics:

- Total manure
- Total solids (TS)
- Degradable and non-degradable volatile solids (VS_d and VS_{nd})
- Nitrogen (N) and TAN
- Urea
- P2O5 and K2O

Manure handlers

1. Cleaning:
Flushing and scrape methods

2. Bedding:
Organic and Sand

3. Manure distribution:
Lac cow (Time allocation)
Milking center
Holding pen

Reception pit

Manure separators

1. Rotary drum screen
2. Screw press
3. Inclined slope screen
4. Roller press

Storage/Treatment

1. Slurry storage
2. Anaerobic lagoon
3. Anaerobic digestion
4. Compost bedded pack

Output

Crop and Soil module

Animal module

Pen Management

Pen Information by animal type	
id	0
animals	CALF, HEIFERS
housing type	open air barn
pen type	freestall
Manure management scenario	**1**
id	1
animals	LAC COW
housing type	open air barn
pen type	freestall
Manure management scenario	**2**
id	1
animals	DRY COW
housing type	open air barn
pen type	freestall
Manure management scenario	**2**

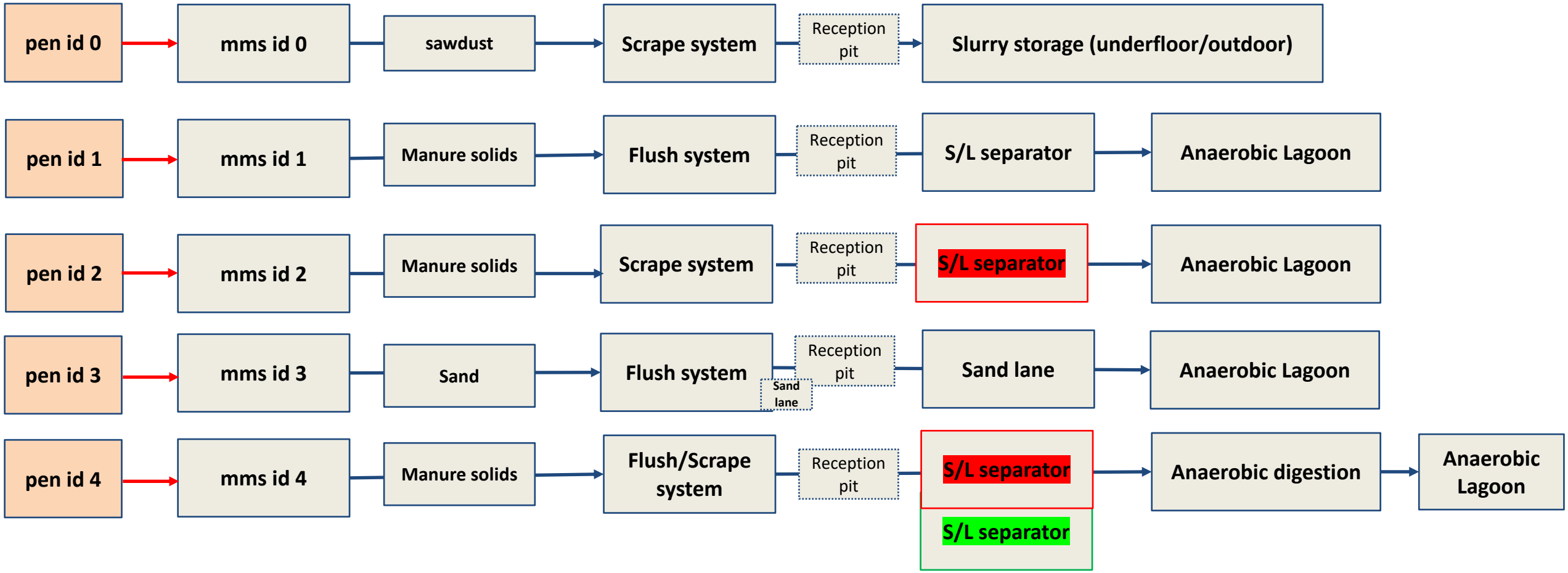
Flexibility for users to customize the MMS.
Configurations can be reused by different pens.

Manure module

Scenario	Pen Manure Management	
SC 0	**pen**	**0**
	bedding	organic manure solids
	manure handler	flush system
	manure separator	rotary drum screen
	Treatment 1	anaerobic lagoon
	Treatment 2	none
Sc1	pen	1
	bedding	organic manure solids
	manure handler	manual scraping
	manure separator	none
	Treatment 1	anaerobic digestion
	Treatment 2	anaerobic lagoon
Sc2	pen	2
	bedding	sand
	manure handler	flush system
	manure separator	sand lane
	Treatment 1	anaerobic lagoon
	Treatment 2	none
Sc3	pen	3
	bedding	organic manure solids
	manure handler	manual scraping
	manure separator	none
	Treatment 1	Slurry storage
	Treatment 2	none

How it works?

Assigning MMS id to the pen animal management:



With the object-oriented interface, it is more flexible and dynamic in tracking the manure properties through each stage of the manure treatment life cycle.

Housing manure collection and distribution

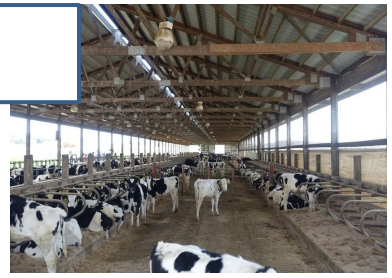
- Animals in each pen will be simulated based on the animal class, housing type, and the number of animals.
- The milking time, no. of milkings per day and the water consumption will be calculated from the milking center and holding pen.
- Allows estimation of housing gas emissions based on the manure characteristics (total or reduced), soiled area (m^2), and time allocation - defaults are assigned to each animal class and housing type with based on the pen designation.

Time spent each location is accounted

Pen lac cow

Subsequent manure collection and processing

Pen calf + heifers

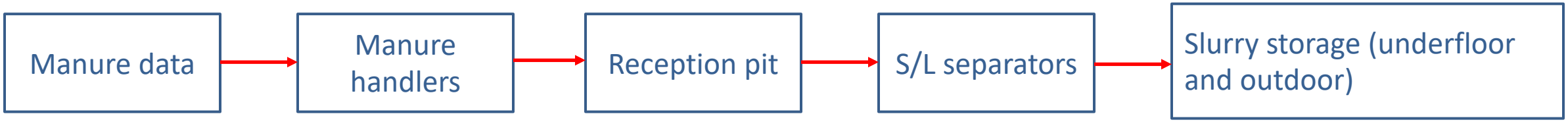


none

none

Subsequent manure collection and processing

MMS processes with functional code



- ✓ Manure volume
- ✓ TS
- ✓ VS
- ✓ N
- ✓ P
- ✓ K
- ✓ WIP
- ✓ WOP
- ✓ P frac
- ✓ TAN
- ✓ UREA

- ✓ Includes the bedding, wash water during cleaning.

- ✓ Mass and volume conversions as needed

- ✓ Fibrous solids and liquid effluent

- ✓ Treatment output to Crop and Soil team

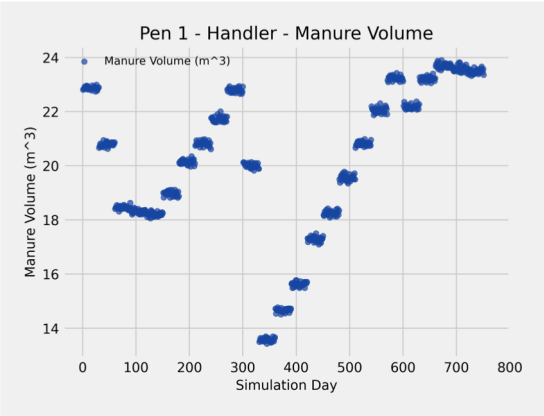
Simulation output

Some results:

- Manure collection and cleaning methods.
- Solid/Liquid separation method.
- Overall manure module simulation (Collection thru treatment/storage).
- Gas emissions and manure removal for field application.

Output: manure cleaning and collection

- Pen 1 (Heifer_II, Heifer_I) - Scrape system
- Pen 3 (Lactating cow) – Flush system
- Number of animals varies each day and data represents (head/day)
- Simulation days = 751



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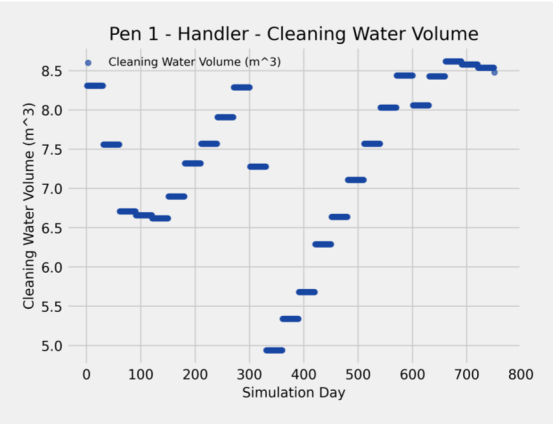

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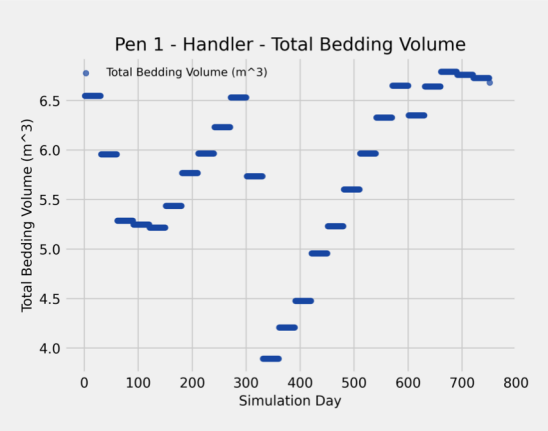

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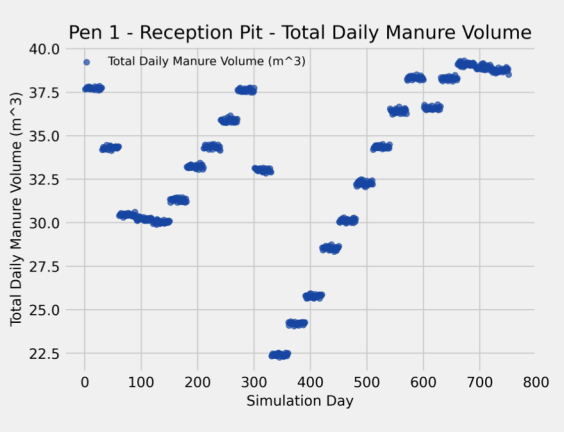

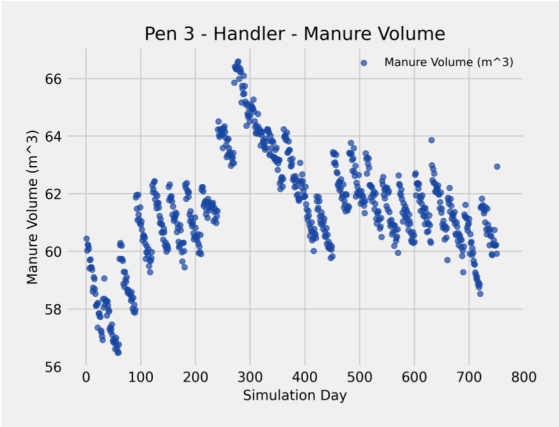

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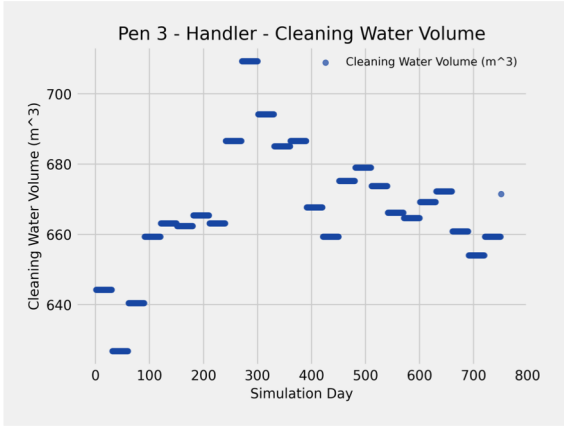

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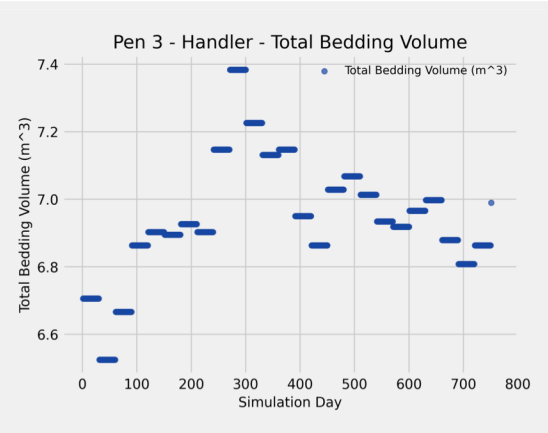

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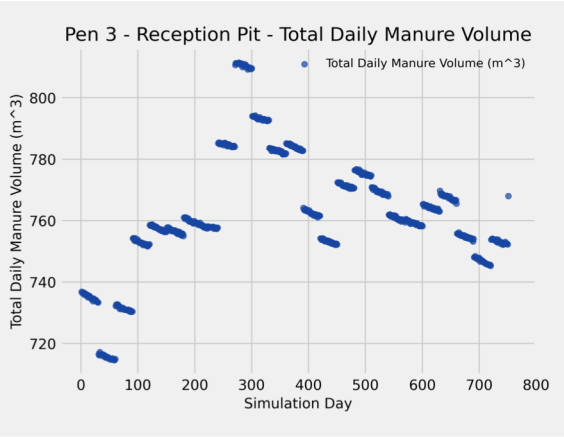
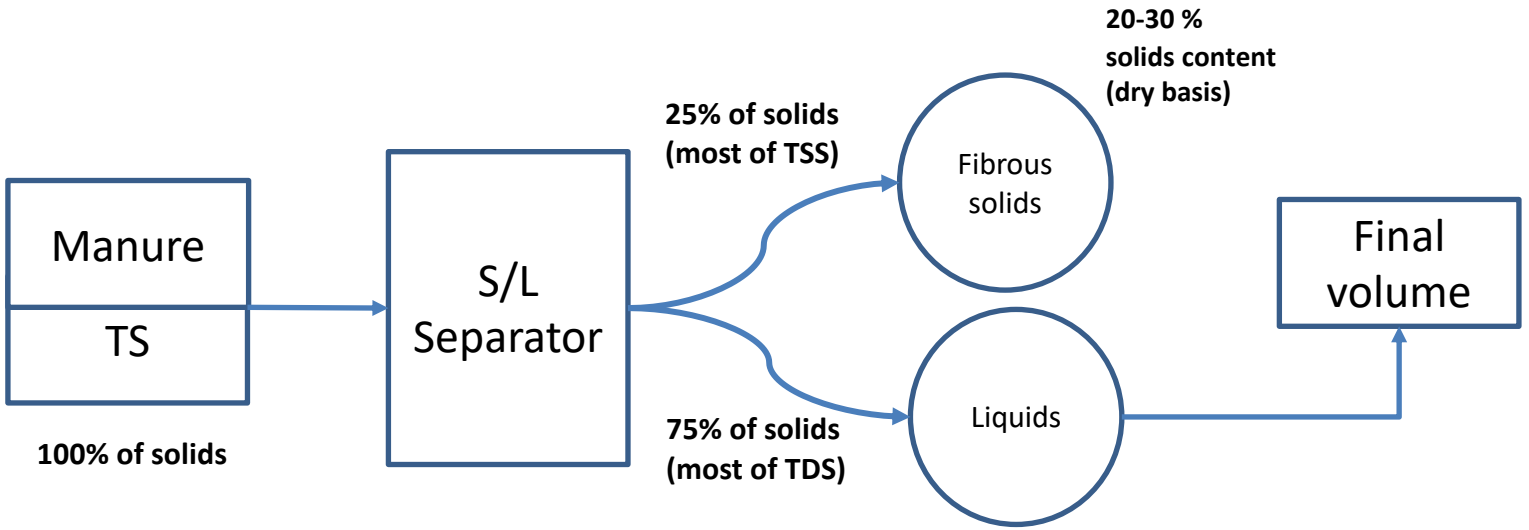


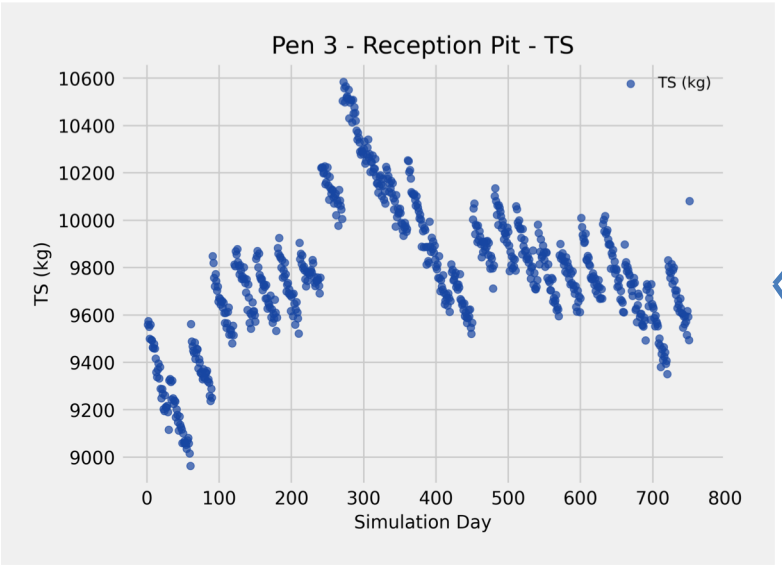
Output: Solid-liquid separation

- Pen 3 (Lactating cow) – Flush system
- Number of animals varies each day and data represents (head/day)
- Simulation days = 751
- S/L Separators - Rotary drum screen, screw press, inclined slope screen, etc.,
- Vendor survey provided TS, VS, TKN, P, and K removal efficiencies.



Output: Rotary drum screen

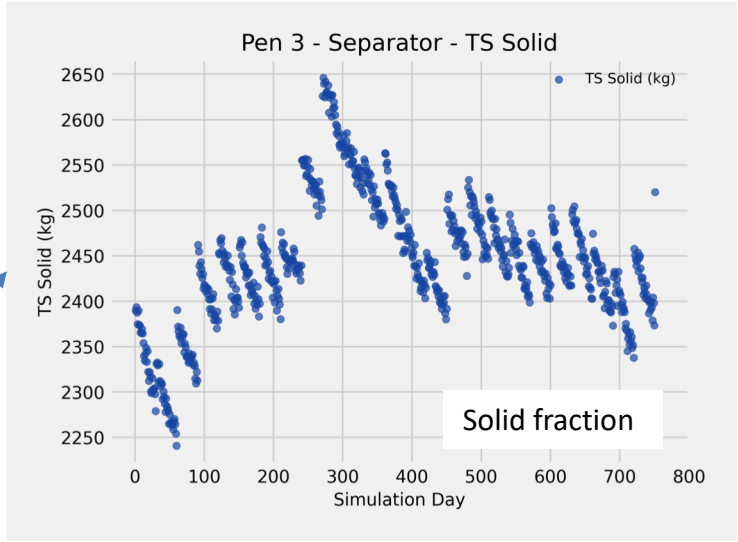
100%

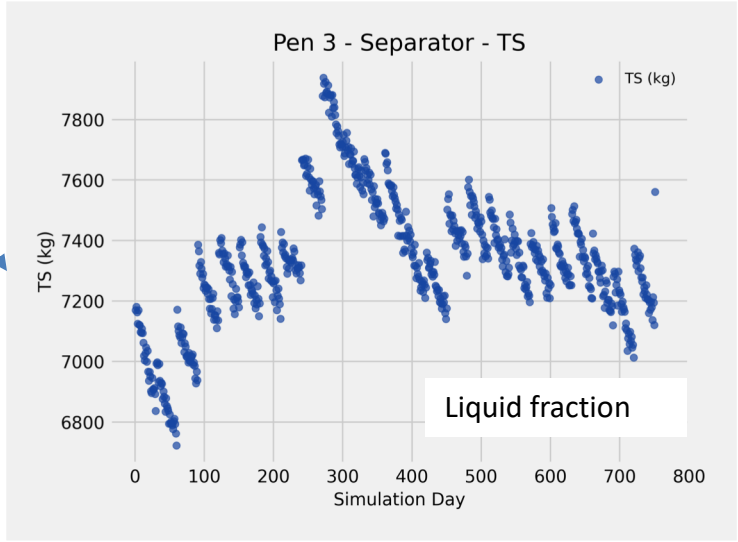


25%

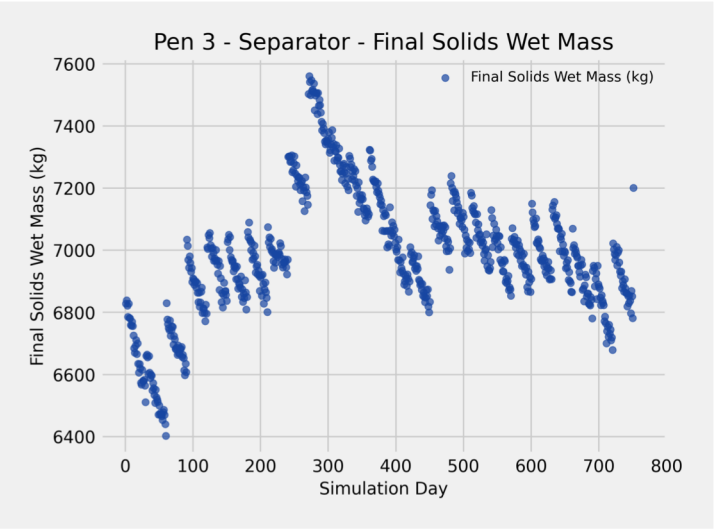
75%

Dry weight

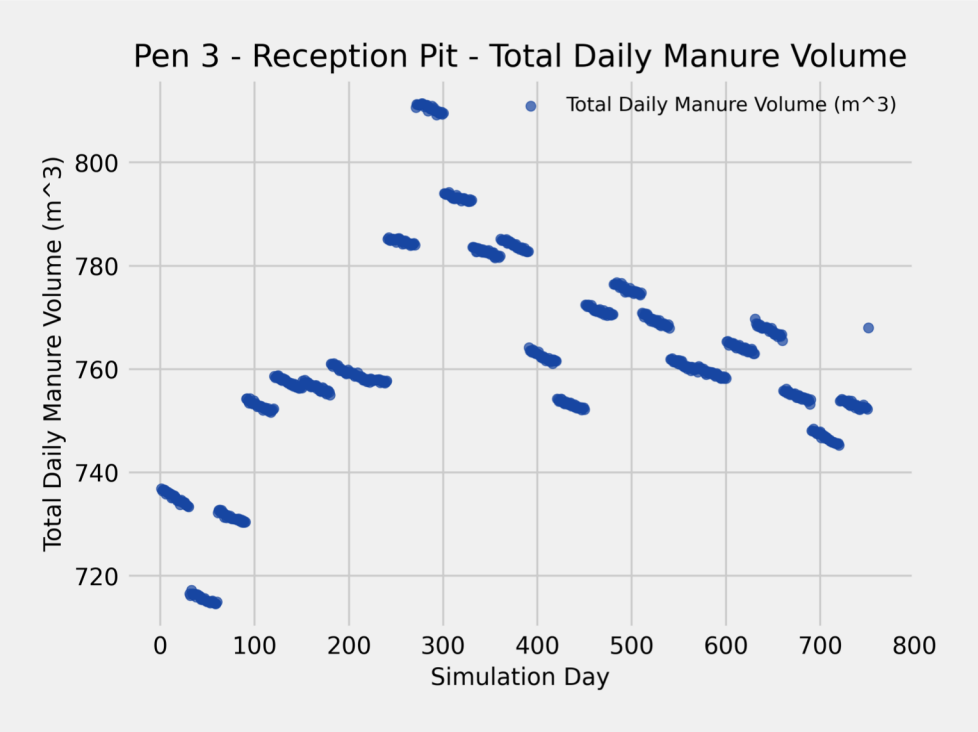




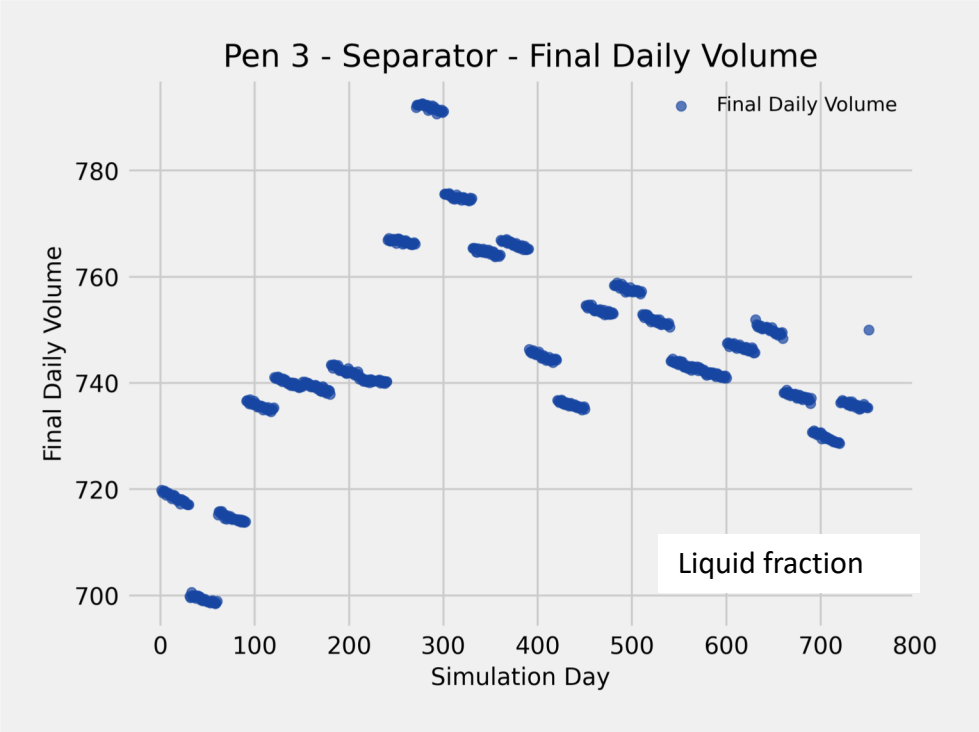
Separated solids wet weight (assuming 35% dry matter)



Final manure volume after solids are separated

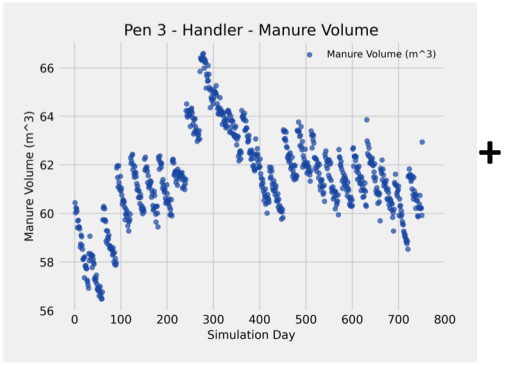


~ 20 m^3 reduction



Output: Total Simulation

- Pen 3 (Lactating cow) – Flush system; Number of animals varies each day-which is fully accounted in the calculations
- Sim days = 751
- Manure + wash water total volume across all methods.
  - ✓ Manure collection activities:
    - Manure from barns
    - Wash water in all housing components
  - ✓ Reception pit:
    - Manure + Wash water + Bedding
  - ✓ Separator:
    - Fibrous solids and Liquid effluent
  - ✓ Treatment: Slurry storage
    - Final total volume (includes the loss of total and volatile solids that happens during the storage time period)



Manure from all animal pens

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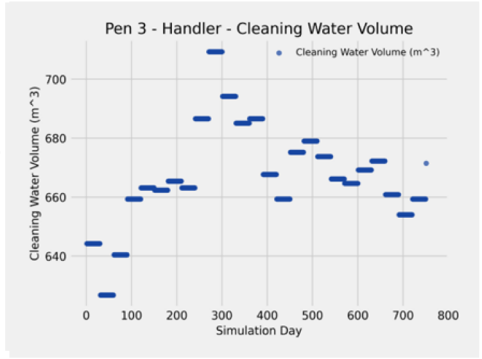

Milking parlor manure +cleaning water
Flush water volume

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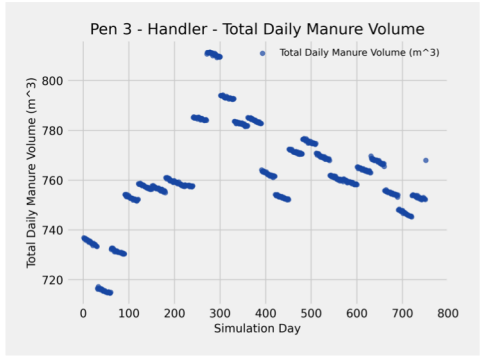

Manure + cleaning water (Milking center + Holding pen + Main barn)

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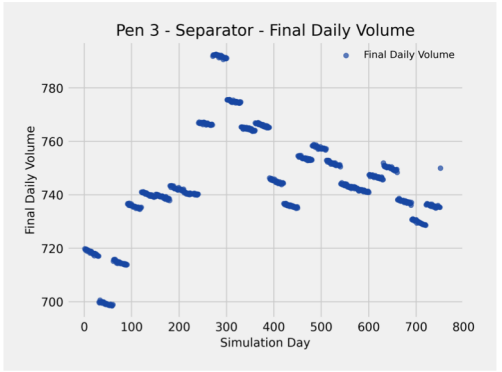

Manure volume (after S/L separator)

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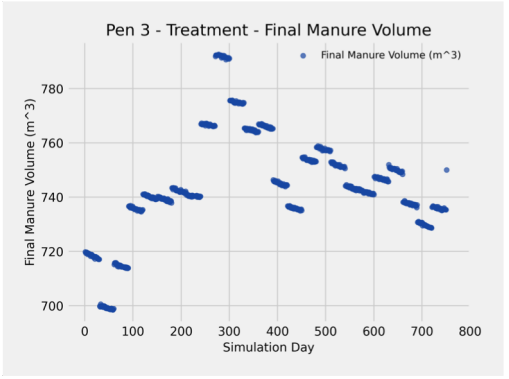
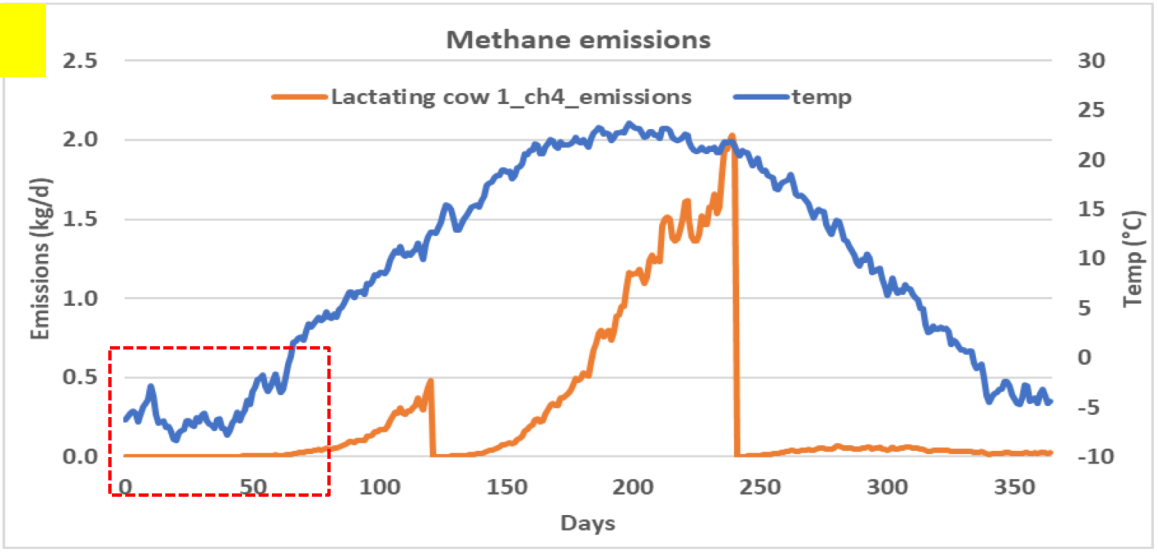


Final Manure volume (after accounting the treatment losses)

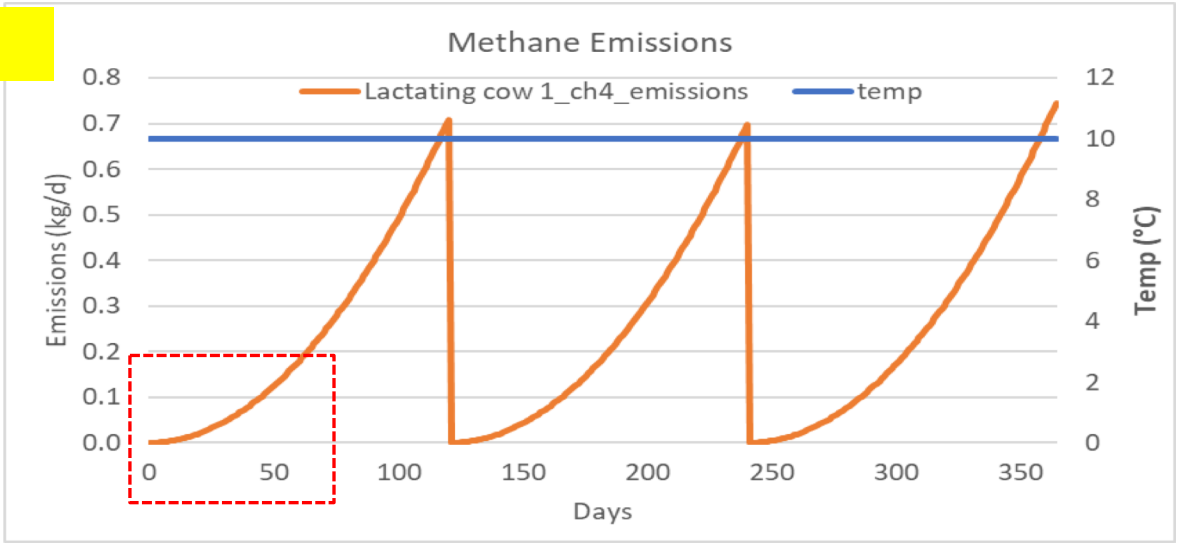
Methane Emissions

- We simulated one lactating cow for 365 days
- 120 days emptying frequency
- Temperature (°C) - Varying (1a) & constant (1b)
- Note the effect of lower temp on emission rate (red dashed box)

1a

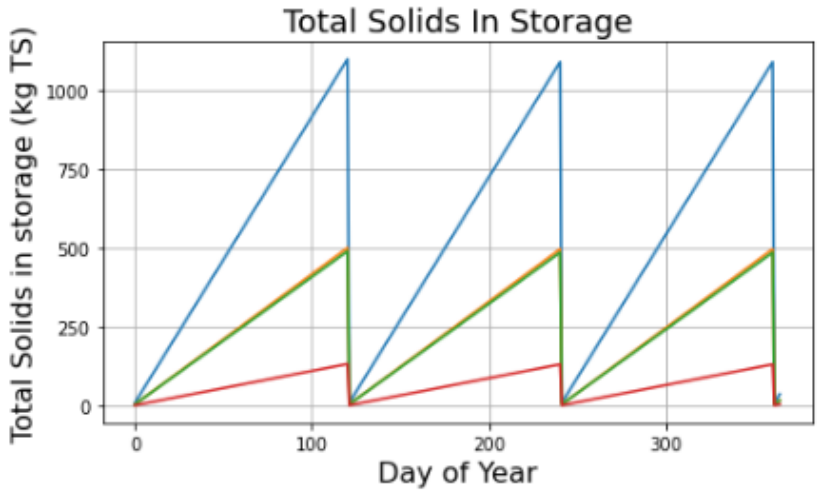


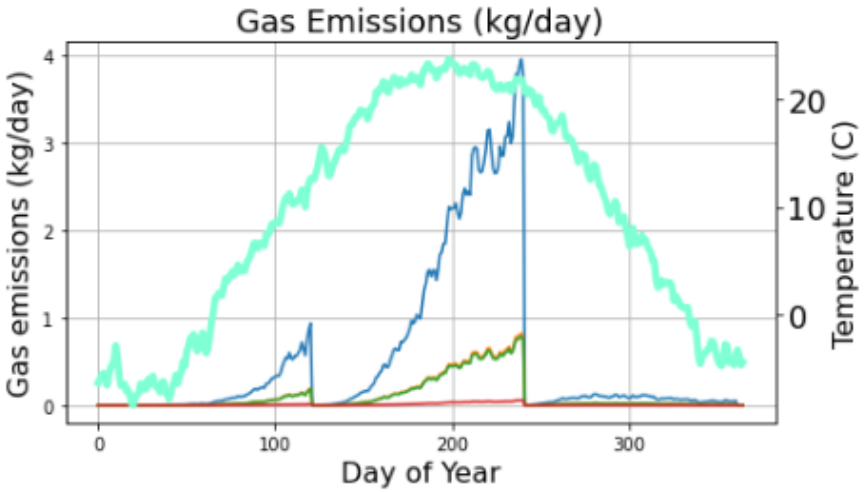
1b

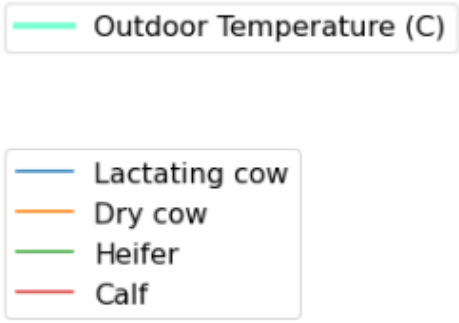


Solids accumulation & Methane emissions: Slurry storage

- Different animal classes
  - Lactating cow
  - Dry cow
  - Heifer
  - Calf
- Total solids accumulation (kg) with volume after emptying (land application)







Manure Application to Field - Interface

- Total manure mass/volume and nutrient content is used to calculate optimal application quantity.
- The manure level in storage is then reduced by the applied quantity.

(1) Check manure properties

-Query the manure properties in storage including total amount, TS, and NPK.

(2) Land application day (requested quantity)

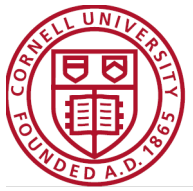
-Returns the amount of manure to take out of storage

-Updates storage levels

Next steps

- Enabling the outputs (manure data) - to Crop and Soil Module.
- Merge - other treatment methods (Lagoon and Anaerobic digestion).
- Tracking the manure (daily time step) during storage and processing/treatment.
- Implement other gas emission methods (beyond methane: Ammonia, Nitrous oxide..).

RuFaS Manure Module Team



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Thank you !!