Research in Progress:
Effect of Solid Separation on Mitigation of Methane Emission in Dairy Manure Lagoons

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Dairy and Livestock Working Group Public Session
Subgroup #1: Fostering Markets for Non-Digester Projects
September 18th, 2017

Subgroup questions

1. Do mechanical solids separators reduce overall methane emissions from manure storage on dairies?
2. If so, can we quantify these reductions?
3. What is our certainty about these reductions? How can we increase certainty further?
4. What other environmental pros and cons result from use of mechanical separators (e.g. ammonia and VOC emissions, other GHGs, water quality/nutrients)
5. Does use of mechanical separators result in a net increase or decrease of electricity and/or fuel?

Outline

- Project objectives
- Project progress
- Description of manure management systems
- Sampling and analysis procedures
- Biomethane potential (BMP) results
- System operations
  - Manure flowrate
  - Total and volatile solids removal
  - Methane emission potential reduction
  - Literature values for solid separation efficiency
- Subgroup questions
- Other questions that might be important
- Acknowledgements

Project objectives

1. Determine the effect of existing solid-liquid separation technologies on methane emission potentials of flushed dairy manure.

2. Analyze the costs and benefits of various solid-liquid separation technologies and develop recommendations for selecting, applying, and improving the solid-liquid separation technologies for achieving different levels of methane emission reductions.

Project progress

- We have identified five farms for the project

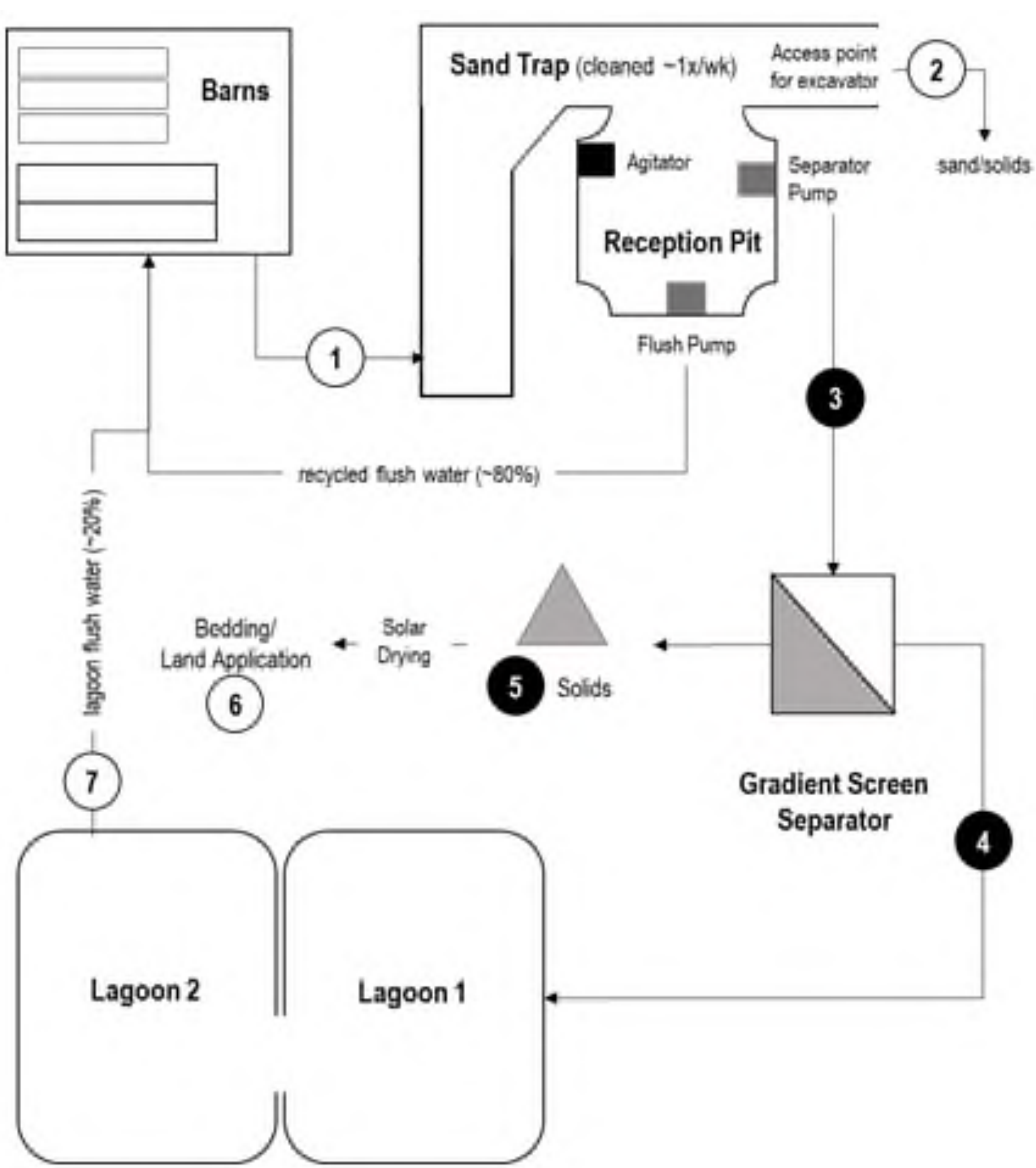
- Three farms (farms A, B, and C) have been sampled and the data for the first two (farm A and B) has been analyzed:
  - **Farm A – One stage sloped screen separator**
  - **Farm B – Dual stage sloped screen separator**
  - **Farm C – Advanced separation system**
  - Farm D – Dual stage horizontal screen separator
  - Farm E – Weeping wall

- One more farm still needs to be identified.

DAIRY A – Single sloped-screen separator

- Dairy Size: 2,000 milking cows
- Manure management unit operations:
  - Sand trap → Processing pit → Separator → Lagoon
- Separator: One separator with two sloped-screens
- Screen Size: top 2/3rd: 0.025”; bottom 1/3rd: 0.020”
- Manure pumped to the top of separator.
- Manure gravity flows down the two sloped screens
- Filtered Water travels to the lagoon
- Solids dried and used as bedding
- Flush cycles:
  - 3 cycles per day, 4.5 hours each

Farm A: Manure management

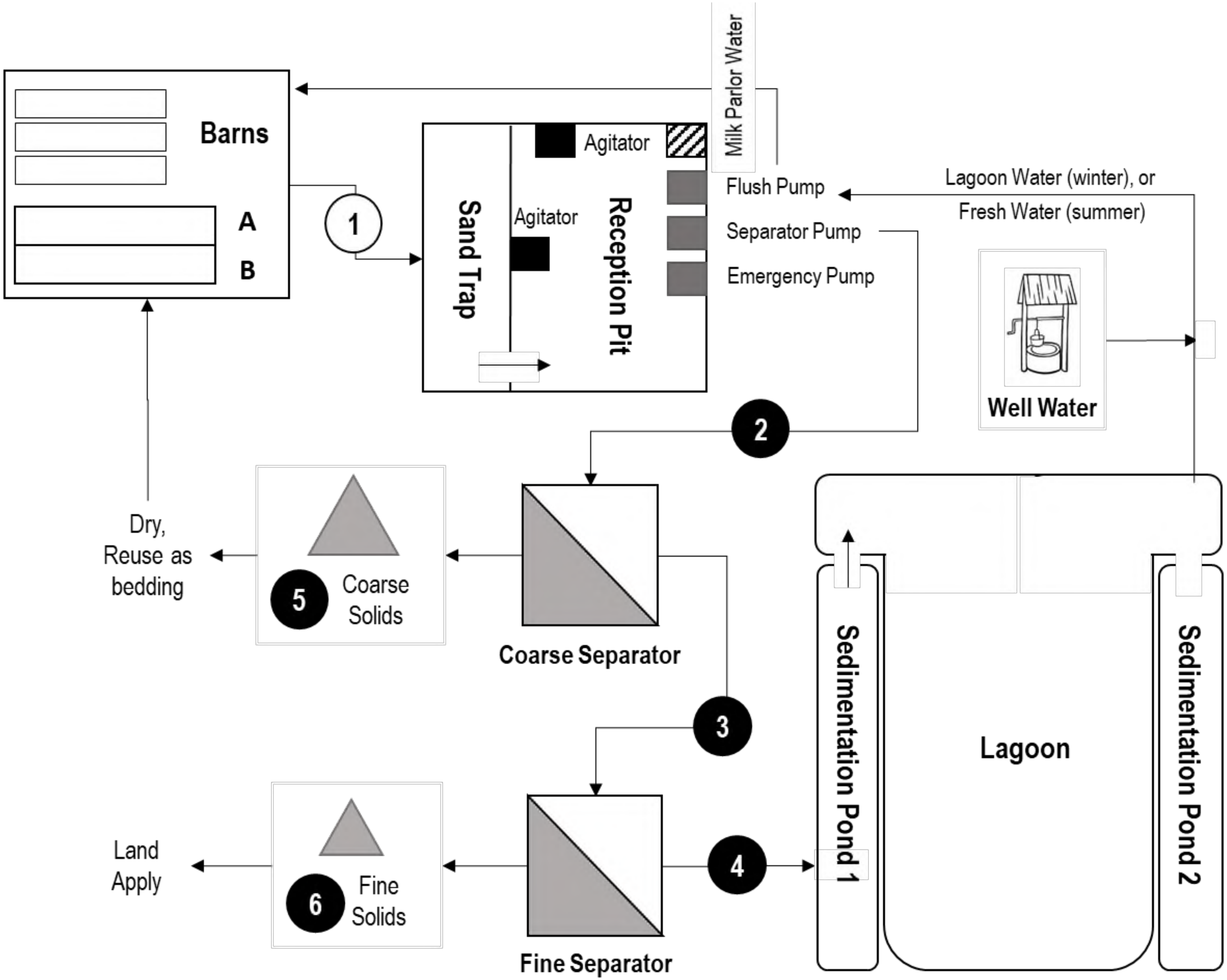





DAIRY B – Double sloped-screens separator

- Dairy size: 3,000 milking cows
- Manure management unit operations:
  - Sand pit → reception pit → two sequential separators → settling pond → lagoon
- Barns are flushed during 4 hr flush cycles
- Manure separation system: two separators in series (coarse and fine separators)
- Each separator: two-vertically sloped-screens
- Screen Size:
  - Separator 1: (Top 2/3rd) 0.025”; (Bottom 1/3rd) 0.02”
  - Separator 2: (Top 2/3rd) 0.015”; (Bottom 1/3rd) 0.01”
- Flush cycles:
  - 6 cycles per day, 4 hrs. per flush

Farm B: Manure management











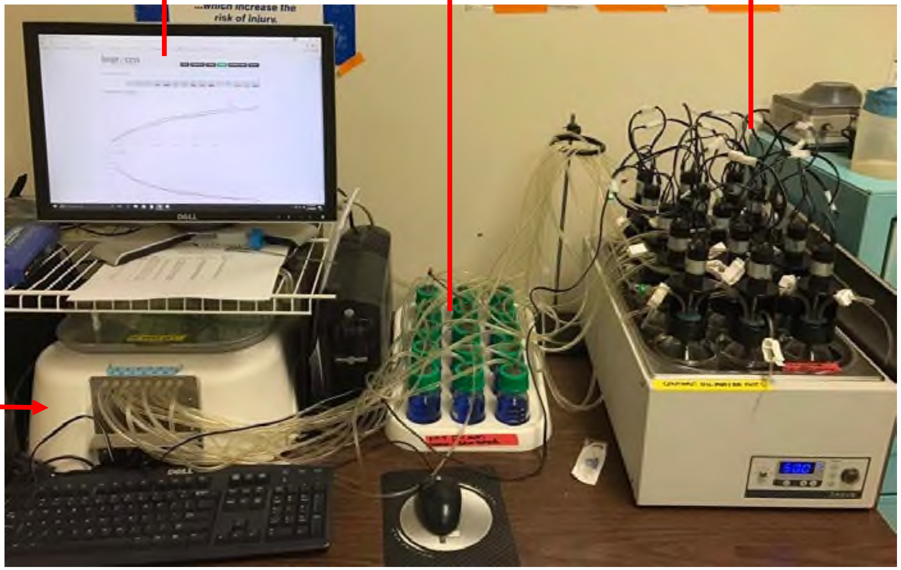

Sampling and analyses

- Separator inflow, outflow, solids collected at regular intervals during a 24 hr period
- Inflow rate measured using a Doppler flow insertion meter
- Samples analyzed for total (TS) and volatile (VS) solids
- Composite samples created from individual samples
- Biomethane production potential was measured

BMP experiments

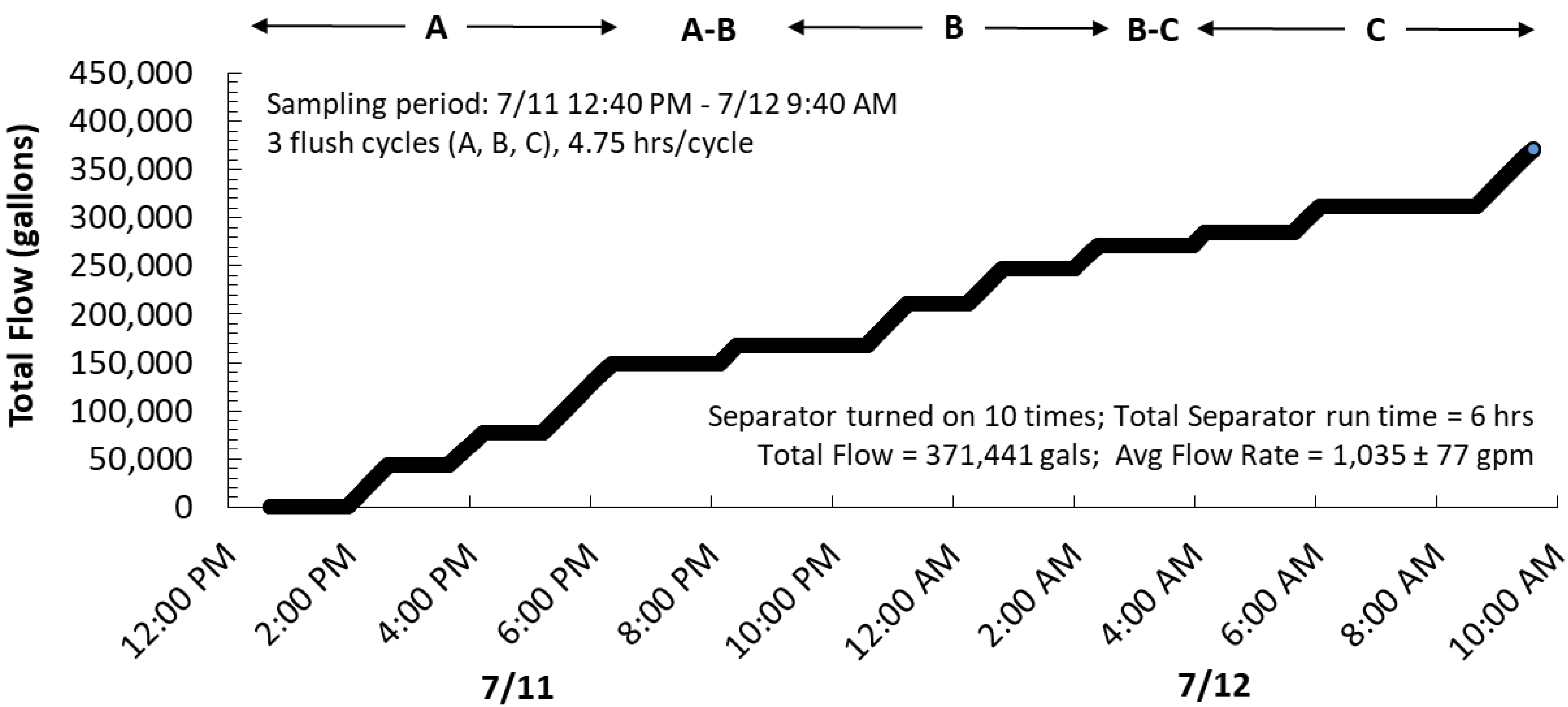
Fixed parameters

- Organic loading: 5 g[VS]/L
- Food/Microorganism: 1/1
- Temperature: 50°C
- Initial pH: 8.0
- Effective volume: 400 ml
- Run time: 21 days

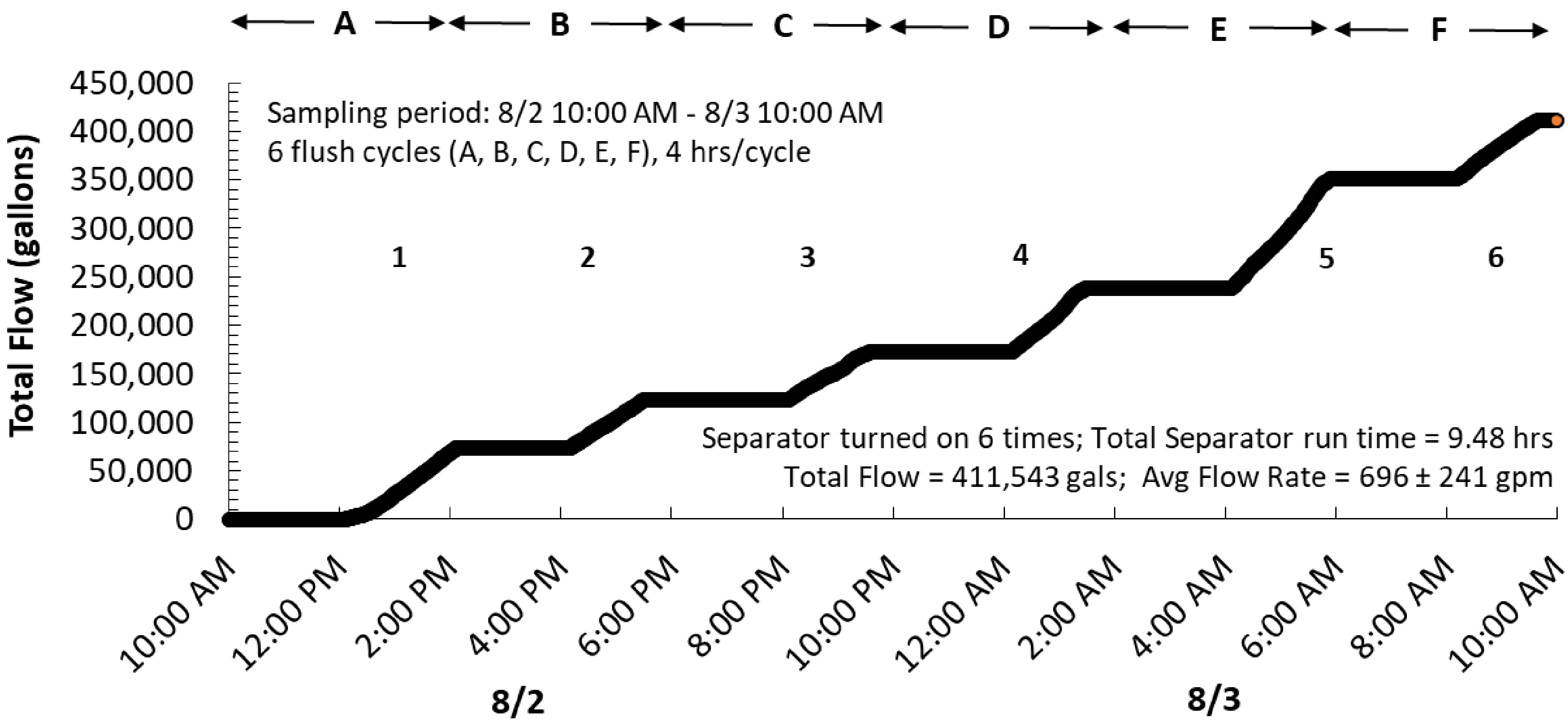


AMPTS Machine (Bioprocess Control AB, Sweden)

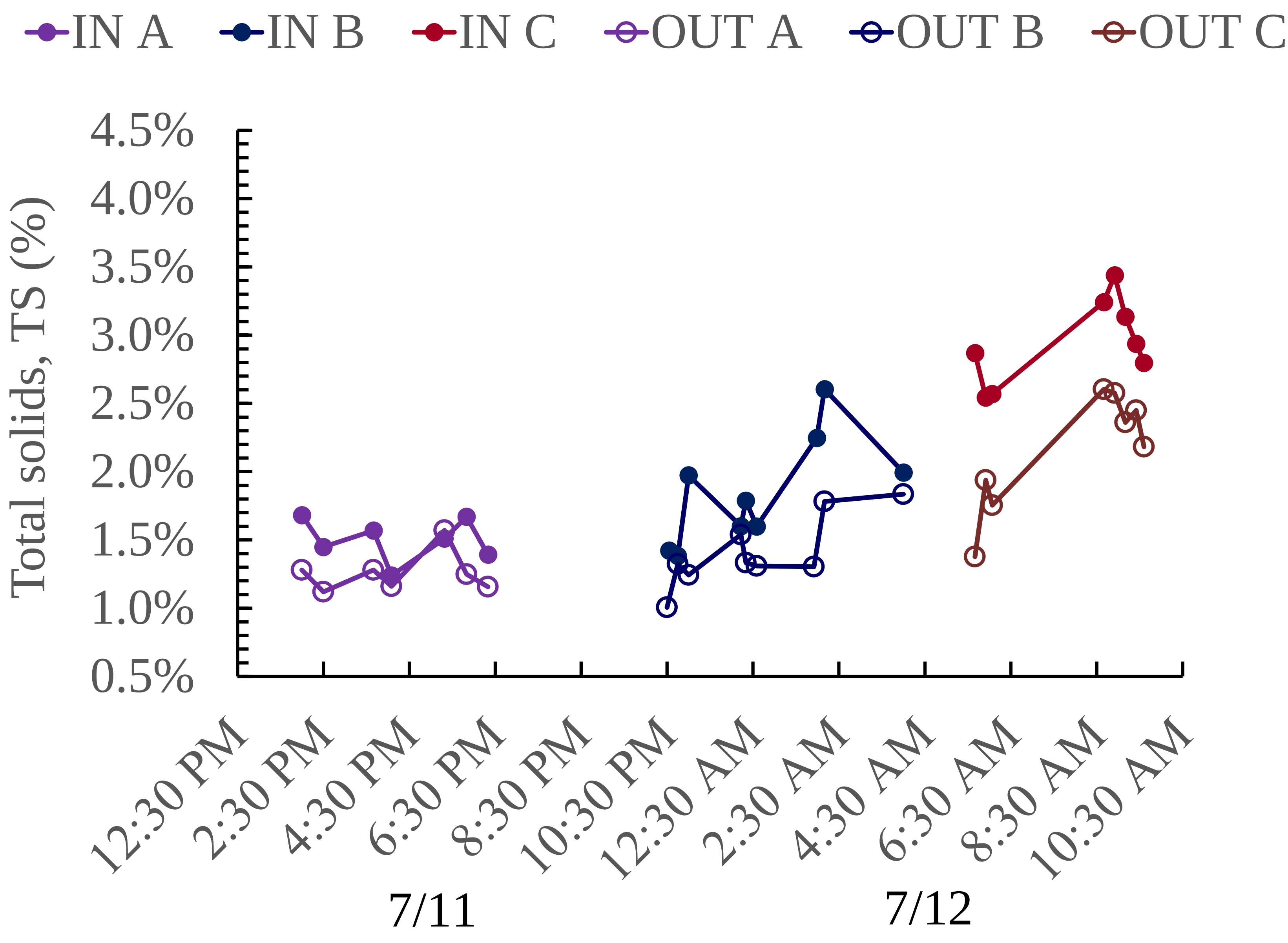
Farm A: Total flow of manure



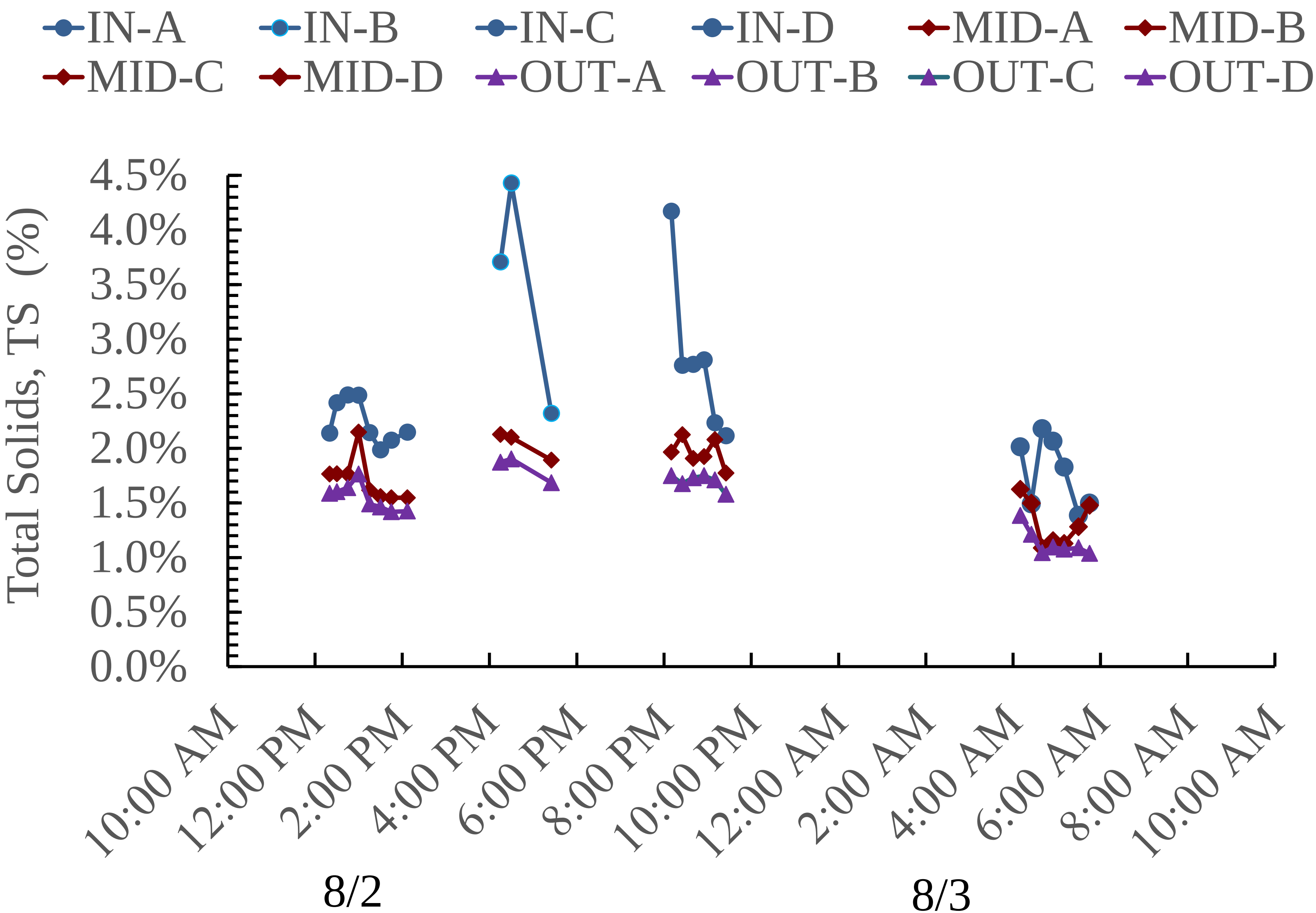
Farm B: Total flow of manure



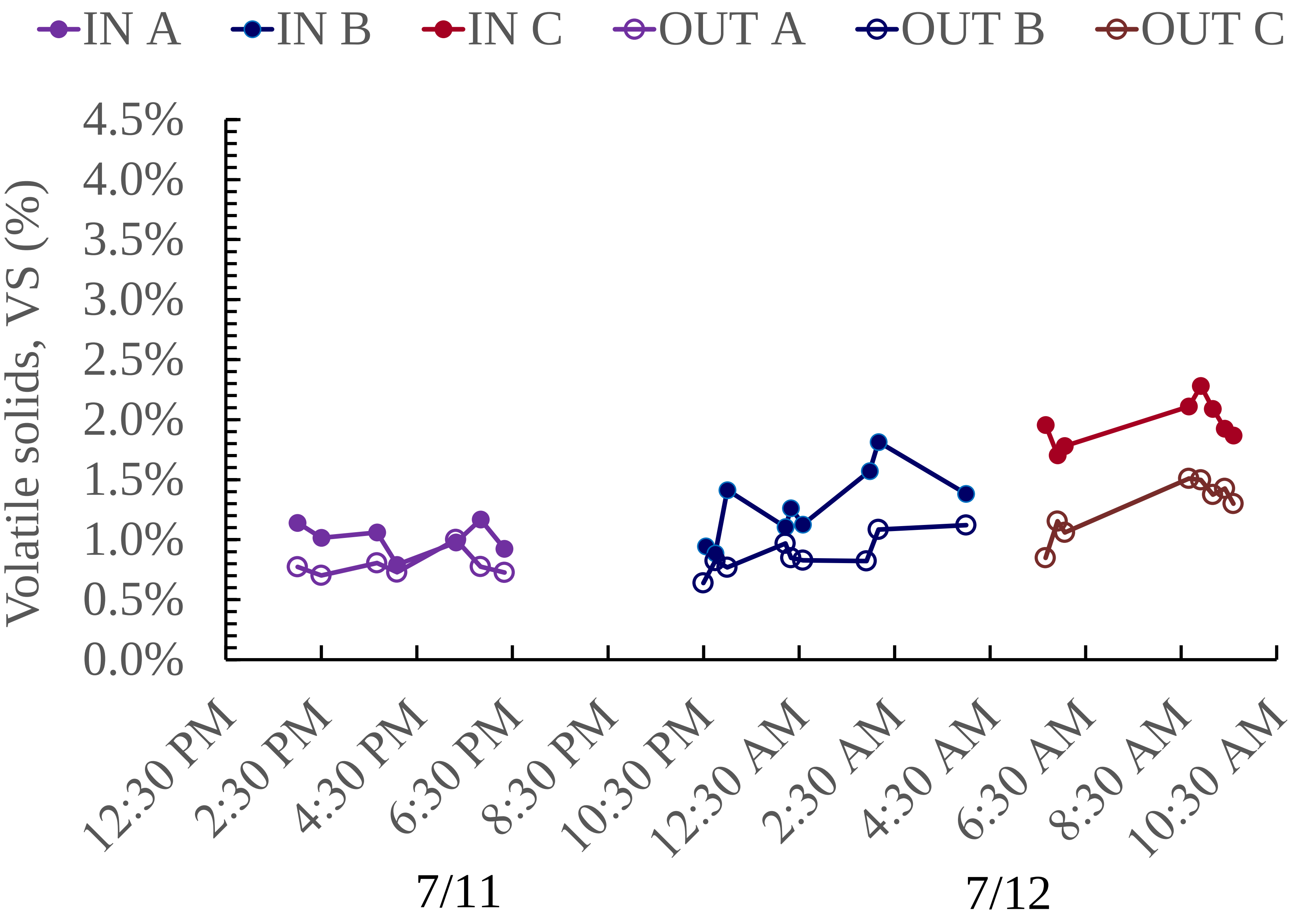
Farm A: Total solids



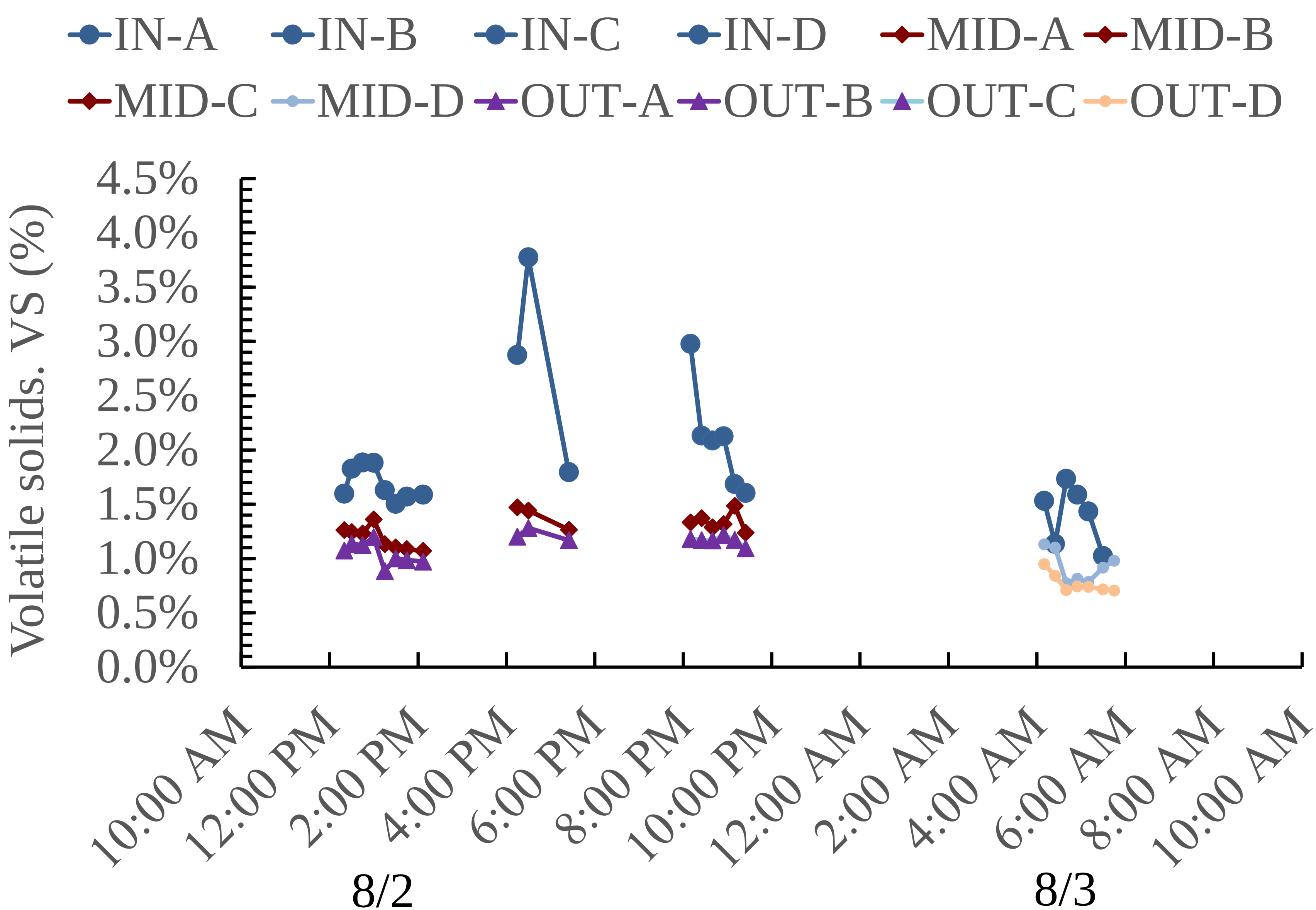
Farm B: Total solids



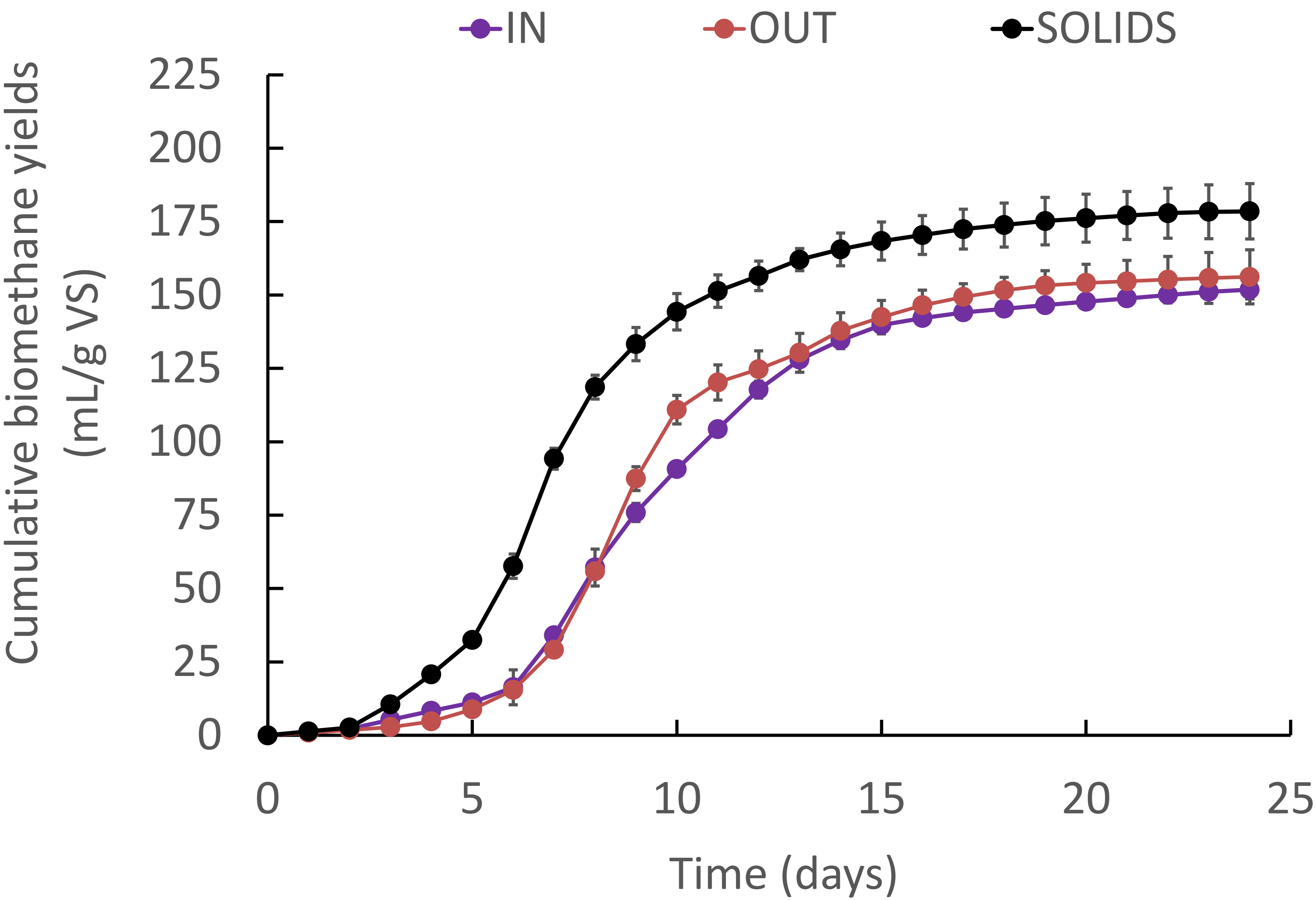
Farm A: Volatile solids



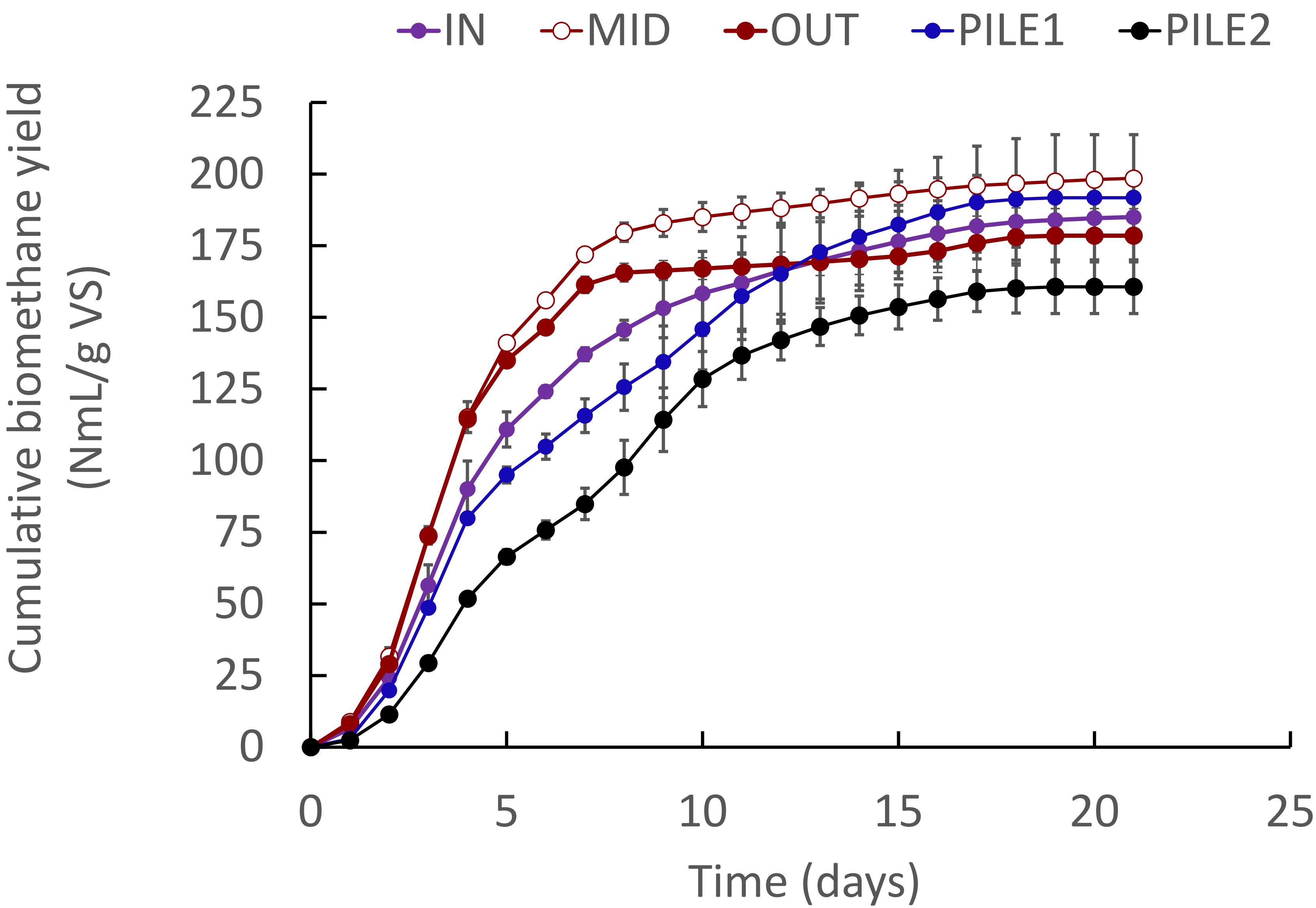
Farm B: Volatile solids



Farm A: Biomethane production potential



Farm B: Biomethane production potential



Farms A & B: Biomethane potential

FARM A

Parameter	Units	Value
BMP of inlet	m^3/ton VS	137.8 ± 2.9
BMP of outlet	m^3/ton VS	141.8 ± 8.4
BMP of solids	m^3/ton VS	162.1 ± 8.5

FARM B

Parameter	Units	Value
BMP of inlet	m^3/ton VS	168.0 ± 5.8
BMP of midpoint	m^3/ton VS	180.2 ± 0.0
BMP of outlet	m^3/ton VS	162.1 ± 8.6
BMP of solids 1	m^3/ton VS	174.1 ± 20.0
BMP of solids 2	m^3/ton VS	145.9 ± 8.5

Farms A & B: System performance

FARM A – SINGLE SEPARATOR

Parameter	Unit	Value
Average TS removal efficiency	%	45.2
Average VS removal efficiency	%	58.4
Methane potential reduction	%	57.2

FARM B – DUAL SEPARATOR

Parameter	Unit	1st Stage	2nd Stage	Full System
Average TS removal efficiency	%	52.0	8.2 (12.2*)	60.2
Average VS removal efficiency	%	57.3	7.5 (12.9*)	64.8
Methane potential reduction	%	54.2	11.8	66.0

***Removal based on outflow from first separator**

Literature values for solid separation efficiency

Type of separator	Screen size (mm)	TS of inflow (%)	Dry matter removal (%)	Reference
Rotary screen	0.75	0.52	5	Hegg et al., 1981)[1]
		0.81	10	
		1.14	4	
		2.95	14	
Sloped screen			67	Graves et al. (1971)
Inclined stationary screen	1.5	3.83	60.9	Chastain et al. (2001)
Two-stage stationary screens	1st stage: 0.5 2nd tage:0.25		First stage 50.3 Second stage: 9.4 System 59.7	Chastain et al. (2008)
Rotary screen separator	3	6-16	40-70	Pain (1978)
Flat belt separator	1	3.2-10	22-55	Pain (1978)
Roller press	1.5	3.2-13.5	24-65	Pain (1978)
Vibrating screen	0.75-1.5	4.7.5	17-50	Pain (1978)

Subgroup questions

1. Do mechanical solids separators reduce overall methane emissions from manure storage lagoons on dairies?

- They reduce methane emissions from storage lagoons because of reduction in volatile solids. However, the recycling of separated solids as bedding, as well as other variables complicates the answer. Proper management of separated solids also needs to be addressed in order to reduce the emissions from the dairy as a whole.

2. If so, can we quantify these reductions?

- Yes, in our current project, we quantify the reductions in methane emission potential. Based on the laboratory data, we will try to develop a preliminary model for estimating and predicting the emission reduction in lagoons following the solid separators. However, there is a need for developing comprehensive emission models and measuring the emissions from lagoons and other manure storages to determine the reductions and use the data to verify the emission models.

3. What is our certainty about these reductions? How can we increase certainty further?

- There are several approaches that can be used to quantify these reductions, but we are confident that they can be measured accurately using the standard method. However, the actual emissions from the lagoons and other storages are influenced by storage time, solids content, weather conditions, and other factors. There is a need for modeling and measuring the emissions under farm conditions.

Subgroup questions, cont.

4. What other environmental pros and cons result from use of mechanical separators (e.g. ammonia and VOC emissions, other GHGs, water quality/nutrients)

- Solids separation of manure using mechanical separators could potentially
  - Increase emissions of ammonia from manure storage
  - Reduce the emissions of VOC from manure storage
  - Reduce the emissions of N_2O
- They reduce the nitrogen and phosphorus contents in manure, the degree to which they do so will depend on the cut off in particle size of the separated solids.
- They do not significantly change EC, and Na, and K contents

5. Does use of mechanical separators result in a net increase or decrease of electricity and/or fuel?

- Separators consume electricity and solid trucking consume fuel
- Energy consumption for decanting centrifuges and mechanical screen separators is 3.0 and 0.5 kWh/ton, respectively.
- We will determine the energy consumption in pumps and separators on the selected dairies

Other questions that might be important

- Effect of bedding materials on separator efficiency and methane emissions
- Effect of flow rates on the performance of different separators
- Effect of different quantities and qualities of flush water on separator efficiency and methane emission
- Effect of different flush regimes/schedules on methane emissions
- The emissions of GHG from manure drying on dairies
- Effect of the integration of solid–liquid separation technologies with post treatments on the reduction of emissions

Acknowledgments

- California Department of Food and Agriculture
- Two dairies mangers and personnel
- Casey Walsh Cady, Senior Environmental Scientist, CDFA
- Mike Francesconi, Supervising Auditor I, CDFA
- J.P. Cativiela, President Cogent Consulting & Communications
- Paul Sousa, Western United Dairymen