Cornell CALS
College of Agriculture and Life Sciences

PRO DAIRY
Education & Applied Research

Dairy Environmental Systems

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Covers for digestate effluent storage from anaerobic digestion

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What to consider in management of digestate from dairy manure anaerobic digestion

1. **Effluent (digestate) volume from the anaerobic digester is slightly less than influent volume and it is difficult to estimate how much less.**
Planning for digestate storage and land application according to the dairy farm's nutrient management plan is necessary. Digestate will decrease based on the influent volatile solids (VS) reduction in the digester. An analysis of anaerobic co-digestion of dairy manure and food waste estimated that effluent flow is reduced by three percent or less than influent flow when off-site wastes account for 30 percent or less of the total digester influent VS but that percentage could increase with ratios of food waste greater than manure[i].

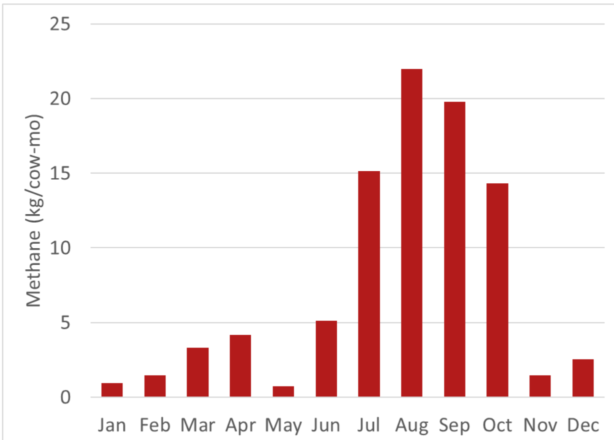
2. **Nutrients in feedstocks to the digester remain in the effluent, although the form changes. An impermeable cover on the effluent storage can increase nitrogen (N) content per gallon.**
Total nitrogen (N) stays nearly the same after digestion, while the amount of ammonium-N (available N) increases and organic N decreases, making N more available, but soil incorporation is important to reduce loss as ammonia (NH_3). Additionally, covered manure storage ammonium-N per gallon has been observed to be nearly twice that of uncovered manure[ii].

3. **Farms with limited existing manure storage and land application capacity should consider an impermeable cover over the storage to exclude rainwater volume.**
A one-acre storage can eliminate 400,000 gallons of precipitation per year, assuming about 40 inches of annual rainfall and 25 inches of annual evaporation at the storage location. Solid-liquid separation (SLS) can remove up to 20 percent of the volume going to liquid storage. This depends on the quality of solids separated. Anaerobic co-digestion systems taking in food waste or off-farm nutrients may particularly benefit from a cover to reduce volumes for storage and land application.

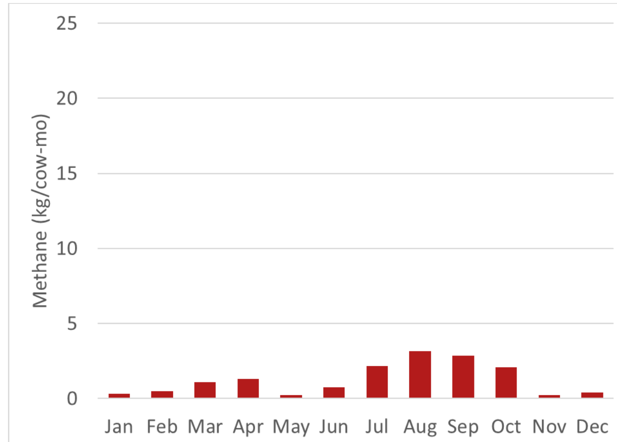
4. **Covering the anaerobic digester effluent storage captures remaining methane (CH_4) that is generated from leftover volatile solids not degraded in the digester, enhancing carbon market value when it is flared or utilized for energy.**

FIGURE 1. Digestate storage with impermeable cover and flare system.

Comparison of estimated greenhouse gas (GHG) emissions from raw manure and digestate storages



a)



b)

FIGURE 2. Estimated monthly methane emissions[iii] on a per lactating cow basis from long-term storage emptied twice per year of a) raw manure (no crust) and b) digested, separated manure.

Key variables that impact actual methane emissions include storage temperature, volatile solids in manure and digestate, and storage emptying practices. Volatile solids (VS) in manure excreted have a spectrum of degradability, with approximately half considered more degradable and half less degradable. Anaerobic digestion (AD) will degrade a portion of VS, generally the more degradable portion. Solid-liquid separation also impacts VS remaining in the separated liquid that goes to long-term storage. The digestate storage methane emission rate was calculated to be between 0.2 and 5.9 percent of a dairy manure digester's methane capture or production for energy use by varying a range of these parameters. Table 1 gives the calculated values for selected sets of conditions that represent low, baseline (or expected), and high digestate storage methane emissions.

TABLE 1. Calculated annual methane emission from uncovered digestate long-term storage under varying conditions. Each set of conditions assumes the storage is emptied in spring and in fall, with an annual average storage temperature of 56°F.

	Low	Baseline	High
More degradable VS (% of total)	42	50	50
Digested VS (% of total)	42	37	34
Separated VS (% of remaining VS after AD that are separated)	55	46	45
Digester methane production (kg cow^{-1} yr^{-1})	396.7	349.5	321.2
Storage methane emission (kg cow^{-1} yr^{-1})	0.6	15.1	18.8
Storage emission as percentage of digester production (%)	0.2	4.3	5.9

For more information

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[i] Labatut, R. A., Morris, J. W. and Gooch, C. A. (2022). A practical approach for estimating influent–effluent mass flow differences in dairy manure-based anaerobic co-digestion systems. Applied Engineering in Agriculture. Vol. 38(1):165-176. doi.org/10.13031/aea.14180.
[ii] Steinburg, S., C. Gooch, and K. Czymmek. (2015). Covered manure storage systems: Tangible and non-tangible benefits. The Manager.
[iii] Aguirre-Villegas, H.A., R.A. Larson, and M.A. Sharara. (2019). Anaerobic digestion, solid-liquid separation, and drying of dairy manure: Measuring constituents and modeling emission. Sci. of the Total Environ. 696: 134059. doi.org/10.1016/j.scitotenv.2019.134059.