Emissions from Dairy Compost Storage and Field Application

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Many dairies in the western U.S. compost manure from a variety of sources

- Manure scraped from dry lots
- Manure removed from settling basins
- Manure from solid separation

1.2% N
13% C

Why Compost?

- Effective way to reduce volume and weight of manure – transport further
- If properly managed can reduce weed seed viability and pathogens

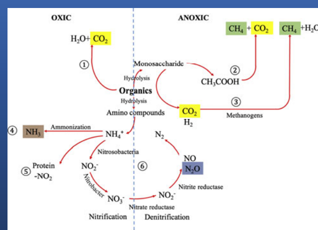
Most commonly utilized methods for dairy manure are:

- **Static** – composting in piles with no turning for mixing
- **Turning** – composting in piles with regular turning
- **Windrow** - composting in long narrow strips with frequent mixing
- **Silo/Vessel** – composting within an enclosed container, continuous turning, computerized control of temperature and aeration

Emissions from composting of manure

During the composting process losses of ammonia (NH_3), methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O) occur.

- CO_2 release occurs with microbial breakdown of carbon in both oxic and anoxic environments
- CH_4 is produced from anoxic breakdown of carbon via methanogens
- N_2O is produced in anoxic environments as a byproduct of denitrification
- NH_3 is lost in oxic environments from ammonium (NH_4)



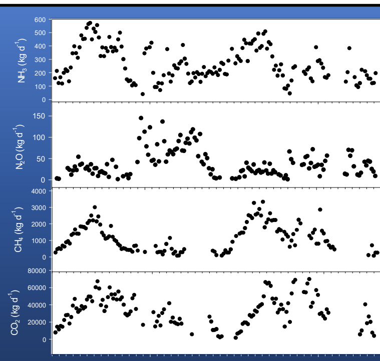
On-farm measurements of NH_3, CH_4, and N_2O emissions from composting dairy manure

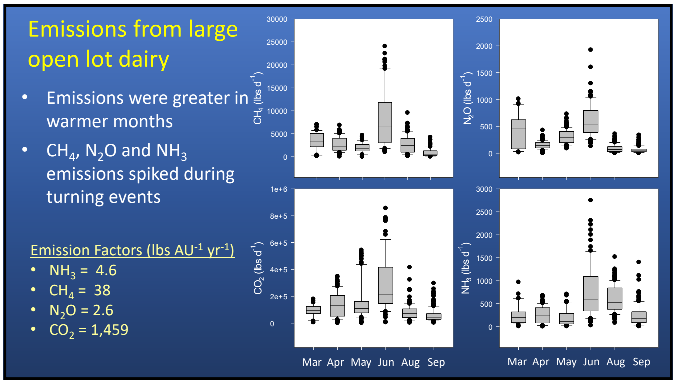
- We monitored emissions from two open-lot dairies where manure was scraped from the lots and windrowed.
- Measurements made each month during the composting process (large dairy) and seasonally (small dairy).

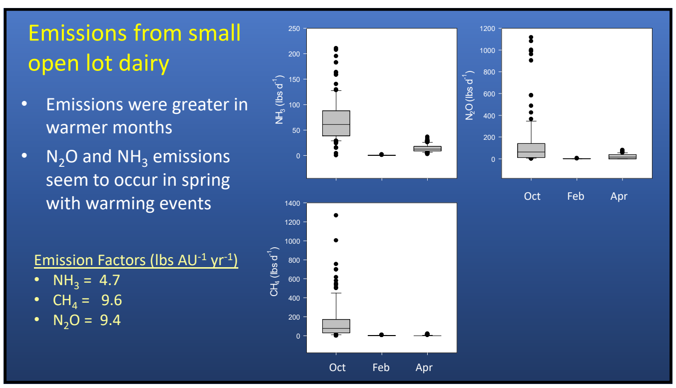
Leytem et al., 2011

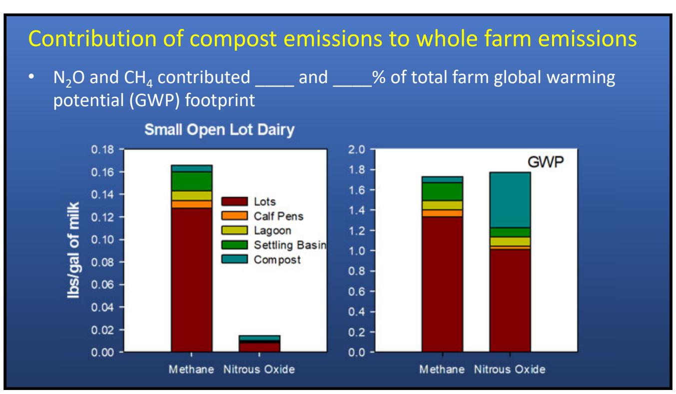
Diurnal changes in emissions

- In warmer months there are distinct diurnal patterns in emissions of NH_3, CH_4 and CO_2
- Emissions tend to increase with increasing temperatures and wind speed throughout the day
- N_2O emissions seem to be more sporadic









The archived presentation is available at:
https://lpelc.org/archived-webinars/

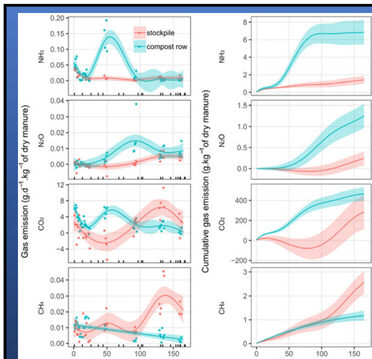
Other studies…..

Losses of carbon and nitrogen during manure treatment/storage

- Looked at the effect of diet on manure composition and C/N losses during storage
- No effect of diet
- Static pile of manure lost ~50% of C and 45% of TN
- Turning the pile to dry quickly (not really composting) decreased losses of C (28%) and N (20%).

	Estimates (mean ± SD)		
Manure Property	Slurry†	Static Pile	Turned Pile
Carbon			
Initial mass, lbs	17.6	18.0	18.7
End mass, lbs	10.6	9.0	13.4
Mass reduction‡, %	40.4	50.4	27.9
Nitrogen			
Initial mass, lbs	1.1	1.2	1.2
End mass, lbs	0.57	0.64	0.95
Mass reduction, %	46.8	45.0	20.2
Total Solids			
Initial mass, lbs	42.2	41.6	43.1
End mass, lbs	25.3	23.3	33.7
Mass reduction, %	40.0	44.3	21.8

Niu et al., 2017



Effects of compost management on emissions from beef feedlot manure

- Windrowing increased cumulative losses of NH_3 and N_2O
- Static piling had greater cumulative CH_4 emissions
- Cumulative CO_2 emissions were similar

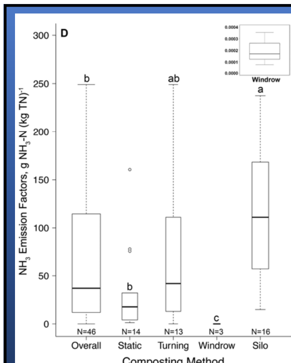
Bai et al, 2019

Meta-analysis of greenhouse gas and ammonia emissions from dairy manure composting


ELSEVIER
ScienceDirect
Review
Meta-analysis of greenhouse gas and ammonia emissions from dairy manure composting
Shidi Ba, Qingbo Qu, Keqiang Zhang, Jeroen C.J. Groot

Ba et al, 2020

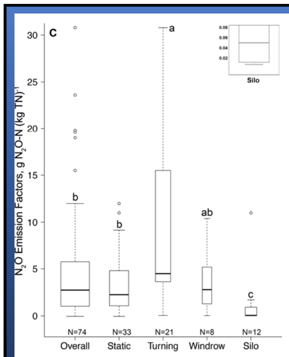
Effects of compost management on emissions (meta-analysis)



Ammonia losses greatest in silo then turning with windrow having the least losses.

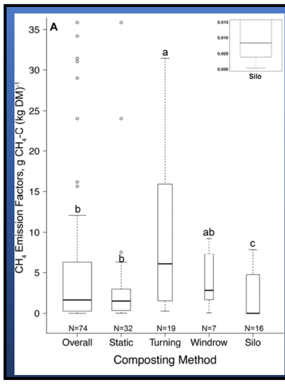
Ba et al, 2020

Effects of compost management on emissions (meta-analysis)



Again, turning piles released the most N_2O while having vessel/silo composting released the least amount.

Ba et al, 2020

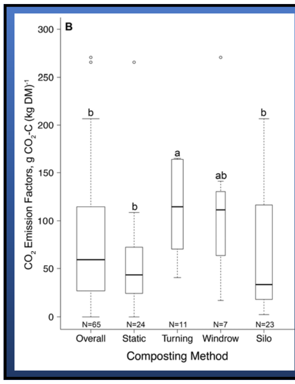


Effects of compost management on emissions (meta-analysis)

Turning piles and windrows had the greatest CH_4 emissions, followed by static piles and silo composting.

Research has shown that the act of turning the piles releases CH_4.

Ba et al, 2020



Effects of compost management on emissions (meta-analysis)

Similar trends seen with CO_2 emissions, where disturbance of the pile generated more emissions.

Vessel/silo has similar emissions to static pile.

Ba et al, 2020

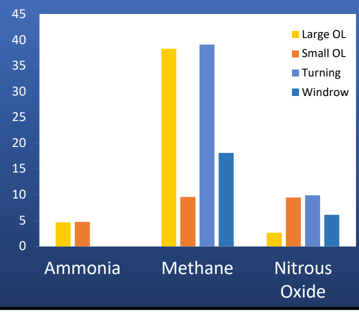
The calculations of overall GHG emissions from different composting methods (lbs•AU^{-1}•year^{-1})

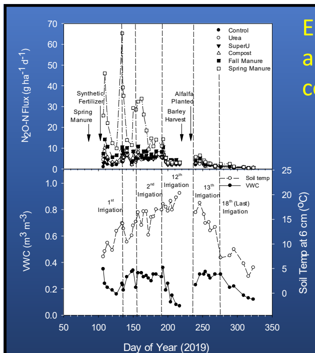
	Composting gases emissions			CO_2 equivalents of gases emissions		
	CH_4	CO_2	N_2O	CH_4 CO_2-eq	N_2O CO_2-eq	total CO_2-eq
Static	9.7	765	4.91	272	168	1,205
Turning	39.1	2,026	9.9	1,098	337	3,457
Windrow	18.1	1,969	6.09	507	208	2,685
Silo	0.1	588	0.11	1.8	3.8	593
Overall	10.6	1,045	6. 0	297	205	1,546

Ba et al, 2020

Comparison of on-farm and meta analysis data (lbs•AU^{-1}•year^{-1})

- Ammonia emission factor similar between farms
- Methane varied by farm but was within the Turning and Windrow emission factors
- Nitrous oxide also varied between farms (sampling?) but was similar to Turning and Windrow emission factors.





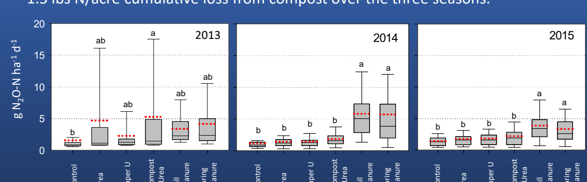
Emissions of N_2O from land application of dairy manures and compost

- Emissions tend to be greatest early in the growing season
- Spikes in emissions occur with N applications and irrigation events

Dungan et al., 2017

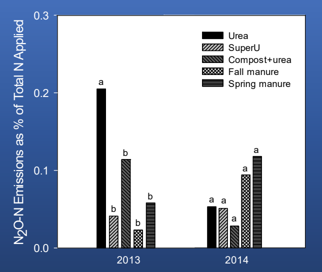
Nitrous oxide fluxes from land application of composted dairy manure vs. raw manure.

- Raw manure tended to produce the greatest N_2O fluxes
- Fluxes from compost were similar to that of fertilizer treatments
- Average N_2O-N fluxes from compost over the three years were ~0.003 lbs per acre
- 1.5 lbs N/acre cumulative loss from compost over the three seasons.



Losses of N_2O-N as a percentage of total applied N

- Under corn the greatest %N lost as N_2O-N occurred with urea while compost and manures were similar.
- Under barley, treatments were statistically similar although losses appeared to be less from compost than raw manure
- These emission factors are less than the IPCC default values of 1%.



Net global warming potential (GWP) of manure and compost applications

- Losses of N_2O from cropping system can be offset by gains in Soil Organic Carbon (SOC).
- ___________________________________
- Net GWP was -15.8 T CO_2 eq ac^{-1} for compost

	Soil Organic Carbon				
Treatment	2017	2018	2019	Net SOC	GWP
	----------------- T C ac^{-1} -----------------			------- T CO_2 eq ac^{-1} -------	
Control	18.5b	19.5b	19.7c	-	-
Urea	19.1b	19.5b	20.1c	-	-
Super U	18.8b	20.0b	19.5c	-	-
Compost + Urea	20.0b	22.0b	23.0c	16.2	-15.8
Fall Manure	23.3a	25.3a	33.9a	58.8	-58.2
Spring Manure	24.6a	25.3a	28.7b	22.5	-21.8