MINIMISING GASEOUS NITROGEN LOSSES DURING MANURE COMPOSTING

MANURE AIN'T WASTE

Increasingly, dairy farmers see their manure or pond sludge no longer as 'waste', but are instead looking for ways of using these residues to enhance soil productivity and reduce fertiliser costs. On-farm composting is often employed for processing manures and other organic residues. However, recent research has shown that characteristics of the composting mix, particularly the carbon to nitrogen (C/N) ratio, bulk density, porosity, and pH have to be within an optimum range to prevent significant nitrogen losses and minimise greenhouse gas emissions.

Desirable material characteristics for optimal composting

Carbon to nitrogen (C/N) ratio	25 – 30:1
Moisture content (%FM)	50 – 60 %
Porosity	35 – 45 %
Oxygen concentration	>10%
Bulk density	<640 kg/m^3
pH	6.5 – 8.0

The **National Agricultural Manure Management Program** seeks to advance manure management as a means of

- reducing nutrient losses and greenhouse gas emissions, and
- improving the efficacy and value of manure products for users, allowing for greater nutrient use efficiency and fertiliser input reductions.

This is the context in which a trial was carried out in western Victoria to determine the loss of nitrogen as nitrous oxide and the emission of carbon as methane when organic dairy wastes are stockpiled or composted.

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RAW MATERIAL CHARACTERISTICS

Due to their high bulk density (yard scrapings, pond sludge) and high moisture content (pond sludge) dairy farm residues are difficult to compost on their own. Hence, to achieve a raw material mix with desirable characteristics that will enhance the composting process, it is usually necessary to blend the manure / sludge with other on- or off-farm organic residues that have complimentary characteristics. At the farm where the trial was conducted, shredded vegetation residues (green waste) and chicken litter were added to the farm residues (yard scrapings from feed pad and sludge from first treatment pond) in order to improve characteristics of the compost mix, almost doubling the volume of input materials. Lime was also added to the mix to allow for simultaneous spreading. Despite these improvements, the blended composting mix used in the trial was still relatively dense and dry, and had a very low C/N ratio of 13:1, to which the high nitrogen content of the chicken litter contributed. Addition of lime resulted in high pH of the blended composting mix.

Characteristics of raw materials and compost mix used in trial

Product characteristics	Unit	Pond sludge	Yard scrapimgs	Chicken litter	Shredded garden organics	Blended composting mix
Bulk denisty	kg / L	0.94	1.16	0.56	0.33	0.61
Moisture	%	74.3	41.8	25.8	38.5	40
pH	-	7.38	8.08	5.88	7.32	7.9
Conductivity	mS/cm	1.88	4.4	17.82	6.2	6.26
Nitrate - N	mg / kg fm	7,1	5.2	65	4	6.1
Ammonium - N	mg / kg fm	742	184	8,526	470	1,479
Total N	% dm	1.32	0.79	4.9	1.7	1.62
Total C	% dm	14.4	9.5	35.2	30.5	21.1
Total organic C	% dm	14.4	9.3	34.5	30.5	19.5
C/N ratio	-	10.9	12	7.2	17.9	13

GHG Emissions

During the five-months trial, regular gas samples were taken from composting and stockpiled materials to determine emissions of methane (CH_4) and nitrous oxide (N_2O), the two most important greenhouse gases for the dairy industry. Methane is generated when organic matter is broken down in conditions where oxygen is deficient (e.g. in a slurry lagoon or a cow's stomach), and nitrous oxide is generated as part of the nitrogen cycle during the transformation of ammonium into nitrate and vice versa. High nitrous oxide emissions usually occur when excess nitrogen and ample labile carbon are present, and when environmental conditions (moisture, temperature) are favourable.

Stockpiled yard scrapings had low methane and nitrous oxide emissions. This was most likely because it contained considerable quantities of soil, stones and wood chips; materials that don't degrade easily and do not have a high nitrogen content. Stockpiled pond sludge on the other hand emitted the highest amount of methane per tonne of wet material.

Composting also resulted in sizable methane emissions, despite the relatively low moisture content of the composted material throughout the trial. This was caused by the high oxygen demand associated with intensive degradation of easily decomposable compounds during the initial composting phase. Further, as the dense materials used had low porosity, passive aeration could not supply adequate oxygen, resulting in anaerobic conditions and the generation of methane. Hence, the majority of methane emissions occurred during the first 60 to 100 days of composting and stockpiling.

Conversely, nitrous oxide emissions were mainly detected towards the end of the composting process when windrow temperatures declined to below 40 °C. These conditions are favourable for nitrifying bacteria, which transform ammonium into nitrate and create the potential for nitrous oxide generation and emission. Nitrous oxide emissions from the composted material were markedly higher than from the stockpiled pond sludge.

NITROGEN LOSSES

The excess nitrogen in the compost mix (low C/N ratio), a result of adding chicken litter, contributed to elevated nitrous oxide emissions and nitrogen losses. These losses totalled 158 g per tonne wet feedstock or 1.6% of total nitrogen contained in the compost mix during composting.

The issue that is more important from an agronomic and financial point of view however, is the loss of nitrogen as ammonia to the atmosphere through volatilisation. Ammonia losses were not measured in this trial, but estimates suggest that **total nitrogen losses during composting amounted to approximately 35%.** Most of these losses would have been through ammonia volatilisation. The very low C/N ratio (13:1), the high pH (7.9) and the elevated ammonium concentration (1,796 mg NH_4 kg^{-1}) of the compost mix are all predictors for high ammonia losses during the composting of dairy residues.

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CONSERVING NITROGEN

This 'real life' research project has shown that the addition of chicken manure and lime to the compost mix enhanced nitrogen losses through ammonia volatilisation and nitrous oxide emissions, and was detrimental to nitrogen conservation. A more cost effective and nutrient efficient strategy might have been to apply the chicken litter and lime directly to the pasture or preferably apply and incorporate them directly into the soil during cropping or pasture renovation.

A comprehensive soil testing program combined with the preparation of a farm nutrient budget should be used to determine whether the extra nitrogen and phosphorus contained in chicken litter is required in the farm fertiliser program. The high variability in the spatial distribution of nutrients across dairy farms also needs to be taken into consideration to ensure the nutrient and soil conditioning benefits delivered through the use of compost are maximised.

ACKNOWLEDGEMENT

Filling the Research Gap funds nationally coordinated research, such as the National Agricultural Manure Management Program to deliver practical options for land managers to reduce greenhouse gas emissions, build soil carbon and adapt to changes in climate while improving productivity and profit. More information may be found at the Department of Agriculture website at:
http://www.agriculture.gov.au/climatechange/carbonfarmingfutures/ftrg.

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https://www.qut.edu.au/research/research-projects/greenhouse-gas-research