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Meteorological variables can be used to predict nitrogen volatilisation from dairy cow manure during housing and short-term storage

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INTRODUCTION

The nitrogen (**N**) volatilisation losses (**Nvol;** as % of N excreted by animal) coefficient from dairy cow manure quantifies both the gaseous forms of N able to pollute the atmosphere and the remaining amount of N spread in the field, which is then used to calculate the sustainable animal stocking rate. This rate is expressed as kg of N per ha according to the Council Directive 91/676 EEC on prevention of soil pollution.

The objective of this research was to find biological predictors of **Nvol,** so that the partitioning of excreted N between air and manure in the period from excretion until the end of short-term storage can be also predicted.

MATERIALS AND METHODS

The experiment was carried out in 4 farms with cubicles free-stall barns (Table 1), located on the West Coast of Sardinia, Italy (city of Arborea: lat. 39°46'26" N; long. 08°34'53" E; alt. 7 m a.s.l.), for one year between 2006 and 2007.

Nvol from lactating dairy cow manure were determined between excretion and the end of short-term storage in buried-uncovered tanks.

Nvol within each tank filling cycle was determined with the following indirect method:

Nvol = N excreted - N residual in manure

where:

N excreted = N in feed – N in milk

N residual in manure = volume $\times$ [$N_{organic+inorganic}$] of the manure.

Animal performances, manure treatments and meteorological variables were recorded and related with observed values of **Nvol**.

All calculated and recorded data refer to the mean of each storage period.

Table 1. Farms characteristics and manure management.

Farm	Bedding in cubicles	Scraper (2 x day)	Tank surface and capacity		Mixing before emptying
n°	material	type	m²	m³	type
1	Mattresses	Automatic	126.5	240	Screw
2	Straw+dry manure	Automatic	102.0	186	Screw
3	Straw	With tractor	128.0	253	Screw
4	Straw+dry manure	Automatic	64.2	83	Screw

RESULTS

Even if the 4 barns differed in herd size, facility types, nutrition management and milk production levels, N excretions were compatible with those reported in literature (Tables 2 and 3).

Table 2. Animal performances and excretion in the 4 studied farms.

Farm	Cows	DM intake	N diet	Milk yield	N milk	N excreted
n°	n°	(kg/day per cow)	(% DM)	(kg/day per cow)	(%)	(g/day per cow) %
1	117.1	21.7	2.56	29.5	0.521	403
2	53.9	22.3	2.39	27.6	0.517	390
3	123.7	21.2	2.60	31.3	0.505	392
4	92.5	24.7	2.72	35.8	0.505	493
Mean	102.8	22.3	2.58	31.3	0.511	418
SEM	3.8	0.3	0.02	0.6	0.001	8

Table 3. Duration of manure storage and N content of manure.

Farm	Filling cycles sampled	Storage length	Storage length	Manure N content
	n°	days	days/m² per 100 cows	% DM
1	12	18.7b	0.12b	3.38
2	8	37.5a	0.68a	3.15
3	16	19.9b	0.13b	3.29
4	11	8.0c	0.13b	3.13
Mean		19.8	0.22	3.25
SEM		11.8	0.02	0.36

Nvol were significantly affected by seasons but not by farms, with losses being higher in spring and summer than in winter and fall (Table 4). **Nvol** were significantly associated with different climatic and animal variables (Tables 5).

Table 4. Seasonal and farm means of measured Nvol (% of N excreted).

Farm	Spring	Summer	Fall	Winter	Mean	SEM
1	48.1	50.2	37.4	35.7	**43.0**	2.1
2	56.6	52.5	42.3	38.7	**45.7**	2.6
3	46.3	53.9	36.4	30.4	**41.7**	1.8
4	45.4	55.9	37. 7	39.5	**44.0**	2.3
Mean	**48.1ᵃ**	**53.1ᵃ**	**38.4ᵇ**	**35.3ᵇ**	**43.3**	1.6
SEM	2.9	1.9	1.7	2.1	1.5	

a,b Means within rows with a different superscript differ significantly ($P < 0.01$).

Table 5. Pearson correlation coefficients between measured Nvol (% of N excreted) and various measured variables.

Meteorological Variables	Nvol	Animal and manure variables	Nvol
Mean air temperature[1], °C	0.758*	**MilkN/N intake[1], (EUN)**	-0.679**
Relative Humidity[1], %	-0.756*	**Milk yield[1], kg/d per cow**	-0.371*
Rainfall[2], mm	-0.298**	**CP diet[1], % of DM**	-0.183NS
Temperature humidity index[1], (THI)	0.758*	**Storage[4], days/m²/cow**	0.242*

[1]mean of storage period; [2]sum of storage period; [3]at storage end; [4]days of storage/tank surface per 100 cows: *$P < 0.05$;**$P < 0.001$; NS = non significant

A multiple regression was calculated to estimate **Nvol** using only significant predictors:

Nvol (% of excreted) = $7.5 - 1.38 \times EUN + 1.23 \times THI - 8.22 \times Rainfall + 8.51 \times Storage$ R^2 Adj. = 0.67

Most of the **Nvol** variability was explained by the mean air temperature during the filling cycle (Figure 1) confirming the large positive effect of temperature on ammonia production from urinary urea.

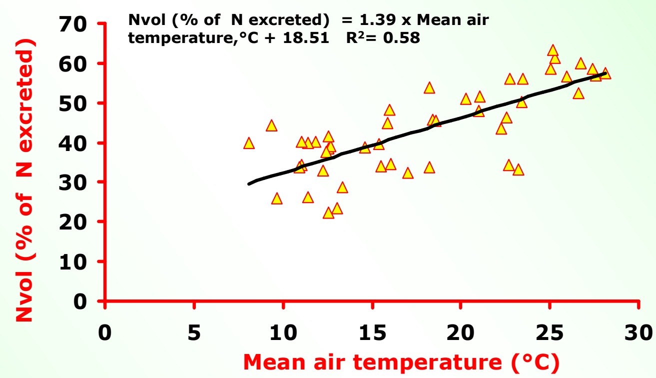

Figure 1. Nvol (% of excreted) as a function of air temperature by pooling the data of the 4 farms.

CONCLUSIONS

➢ N volatilisation was related with animal and environmental factors, as reported in literature, but air temperature alone explained most of the variability;

➢ By using local meteorological data on air temperature it is possible to estimate with good accuracy the short term **Nvol** from dairy cow manure in cubicles free-stall barns.

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