CHARACTERISING DAIRY MANURES AND SLURRIES

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Abstract

The rapid intensification on dairy farms in New Zealand since 2000 has increasingly focused attention on issues relating to effluent management. Increased cow numbers, greater use of fertiliser N and higher supplementary feed inputs on dairy farms has resulted in marked changes in the volume, content and types of effluent produced. Concurrently, more management options for removing stock from paddocks are also being practiced to protect pastures and soils from stock damage. Furthermore, best management practices for land application of farm dairy effluent are now often resulting in solid separation. With all of these system changes occurring, farmers are faced with handling higher solid content and nutrient enriched slurries and manures while coming under increased scrutiny from regional councils concerned about deteriorating water quality. Both the dairy industry and regulatory authorities have not had sufficient New Zealand based information with regards to these solid effluent types in order to help progress or confirm robust management practices designed to provide agronomic and environmental benefit and the development of sound regulatory policy.

This project examined 24 different products to characterise and compare the variability of slurries and manures from different farm and effluent management systems. From this data set some averaged values for dry matter %, Total N, mineral N, P, K, S, Organic C, C/N ratio and % mineral N are presented

Key words: dairy manure, dairy slurry, HerdHomes®, weeping walls, solids separation, wintering barns

Introduction

Until recently effluent generated on New Zealand dairy farms has resulted from the wash down of dairy yards after milking with clean water. This product has typically been called farm dairy effluent (FDE). Historically, dairy farms have not produced significant quantities of manures and slurries (accumulated animal wastes in a semi-liquid or semi-solid form), however this situation has changed with intensification and recent technology developments in effluent irrigation (DairyNZ, 2011; Houlbrooke et al., 2004; Houlbrooke and Monaghan, 2010; Monaghan et al., 2010), and off-pasture systems (Longhurst et al., 2006). The two main sources of dairy farm manures and slurries are separated solids from FDE and manure collected from stand-off pads and wintering barns/animal shelters. Regional councils have started to require/encourage some storage associated with land application of FDE to minimise adverse environmental effects. This has resulted in the accumulation of higher solid content effluents as they are separated into fractions prior to, or during, the storage process. The increasing uptake of feed and stand-off pads and animal shelters, while acknowledged as having the potential to minimise adverse environmental effects, has also contributed to the generation of dairy farm sludges and slurries (Longhurst et al., 2006).

We have defined three different effluent products based on solids dry matter content (%DM) with liquids or FDE being < 5% DM, slurry as 5-15% DM and solid manures as > 15% DM. for the following effluent management systems. These guidelines are similar to those published by NZAEI (1984) for conveyance and application methods.

Objective

The objective of this study was to better characterise the solids content and nutrient concentrations of New Zealand's dairy effluent manures and slurries.

Methodology

This study sought to characterise a large range of different manure and slurry management systems derived from either solid separation of FDE or effluent collection from off-pasture systems. A total of 24 manure or slurry products were characterised covering 8 different generic generation systems spread over 6 different dairy farming regions (Northland, Waikato, Bay of Plenty, Manawatu, Otago and Southland). The assessments included the following effluent management systems:

- Screw press solid separation
- Weeping wall solid separation (wet and dry)
- Static screen solid separation
- Scraped feed pad solids
- European wintering barns
- Carbon pads (wood chips, bark chips and saw dust)
- HerdHomes® Shelter (wet and dry (liquid removed))
- HerdHomes® Dairyard

Background information about each dairying system was obtained from the farmer including details such as: number of milking cows, lactation length, volume of storage available (liquid and solid fraction), operation time for animals off pasture facility, diet of cows and feed intake. The relevant farm operation and effluent system features for each product characterised were described in a series of case studies.

Physical, chemical and microbiological analysis

A minimum of three well mixed composite effluent samples were collected at each site and sent to an accredited commercial laboratory for analysis. The only exception was the sole static screen sampling undertaken by GEA Farm Technologies Ltd which was included in the study. Laboratory analyses undertaken were: %DM, total Kjeldahl nitrogen (TKN), total phosphorus (Total P), potassium (K), total sulphur (Total S), organic carbon (C), ammonium-N (NH_4-N), nitrate-N (NO_3-N). *Escherichia coli* were analysed within 24h of sampling using the traditional Most Probable Number (MPN) 9221B method (APHA, 1998). Not all samples were analysed for *E. coli* because of the time delay in getting to the laboratory.

Results and discussion

Manures

The manures sampled represented a wide cross-section of dairying systems. The carbon-based systems included bark/sawdust, post-peeling, wood chip and sawdust beddings represented from wintering barns and stand-off/calving pads. The weeping wall examples represented both North and South Island sites. Other forms of solid separation sampled included feed pad scrapings, a static screen, and mechanically separated.

Nutrient values, summarised in Table 1, show that carbon-based pads can have very high %DM content, particularly if covered (mean 34% DM, range 28-46%). Manures from other systems, except the static screen (n=1), had similar solids contents (23-27% DM) but differing nutrient values. The HerdHomes® Shelter, HerdHomes® Dairyard and feed pad scraping manures had the highest NPK concentrations. Where the HerdHomes® Shelter and Dairyard manures differed from feed pad scrapings was that the former have a higher proportion of mineral-N (28% v 6%, respectively). In comparison, separated solids systems such as mechanically separated and weeping wall solids had much lower NPK concentrations. For example, a higher proportion of the K fraction tends to pass into the post-separated liquid effluent stream.

The mechanically separated solids were collected from four different types of screw-press separators. The solids content produced varied from 22 to 35% DM. Compared to other forms of manures the mechanically separated solids had lower Total N concentrations at similar solids content. The mechanically separated solids also had the widest C/N ratio and lowest proportion of mineral N indicating that these manures are likely to have slower plant availability than other types of dairy manures.

Table 1: Solids content and nutrient concentrations (kg/t) of various manures.

Solids system (number of samples)	**DM %**	**Total N**	**Mineral N**	**Total P**	**Total K**	**Org. C %**
HerdHomes® Shelter (12)	23	5.6	1.56	1.41	6.67	9.7
HerdHomes® Dairyard (6)	27	7.4	1.03	1.97	7.59	9.7
Scraped – feed pad (6)	26	5.9	0.35	1.28	7.69	8.3
Weeping walls (12)	23	2.4	0.25	0.61	0.87	5.0
Mechanically separated (14)	25	3.6	0.15	0.59	1.00	10.0
Static screen (1)	11	2.3	-	0.43	0.72	-
Carbon-rich pads (11)	34	3.9	0.40	1.10	6.60	11.6

Slurries

The dairy slurries sampled represented those from HerdHomes® Shelters in the Waikato and Bay of Plenty. Some form of agitation occurred at each site, using vertical stirrers, to produce a homogenous product. On two sites, additional liquid (~10-15% by volume from the effluent pond) was added to the manure so that an appropriately suitable slurry consistency could be produced for land application.

One Southland site sampled had a large European style wintering barn that used rubber scrapers on a moving chain to systematically remove animal excreta to an outdoor storage pond (Orchiston et al., 2011). The slurry was then removed from the pond while being stirred to create a homogenous product.

Table 2 presents the mean concentrations of slurries sampled. The HerdHomes® Shelter slurries had a mean solids content of 11% DM (range 4-15%). This solids content was slightly higher than the mean of 9% DM (n=29) previously reported by Pow *et al.*, (2010) for these slurries. As a result of higher solids content, the nutrient concentrations found in HerdHomes® slurries in the current study were also higher than those previously reported, for example, mean concentrations for N were 4.3 vs 3.4 kg N/m^3 and for K, 6.4 vs 5.7 kg K/m^3, respectively. However, the ratio of N to K was similar: 0.67:1 (this study) vs 0.60:1 (previously reported).

Pond stirring of the wintering barn slurry was effective in producing a homogenous product as the CV% for DM, N and K were 6, 3, and 4%, respectively. Mineral-N comprised 43% of the total N of the wintering barn slurry which was slightly higher than the mineral-N of the HerdHomes® slurry (39%).

Table 2: Solids content and nutrient concentrations (kg/m^3) of dairy slurries.

Slurry systems (number of samples)	DM %	Total N	Mineral N	Total P	Total K	Org. C %
HerdHomes® Shelter (12)	11.0	4.31	1.67	0.99	6.43	3.7
Scraped – winter barn (3)	8.1	3.19	1.38	0.80	4.24	3.1

Case study 1: Weeping wall

On a Marton dairy farm the changes in nutrient concentration pre and post solids separation were investigated in more depth. FDE from the 1,400 cow herd was pumped to either one of two weeping wall ponds. Each pond measured 40m L x 8m W x 2m D (640m^{3}storage). The pond width was limited to 8m to enable solids removal by digger. Solids accumulated for two months behind the horizontal wooden slats before being removed. Post separated effluent drained to a large storage pond before land application via pivot irrigator. The weeping wall solids produced contained 21(± 4) % DM (Table 3). Nutrient concentrations (Table 3) show that an N-rich solid is produced but with low mineral-N. The solids should be land applied based on the N loading, this is unlike the post-separated liquid effluent that is K-rich.

Table 3: Mean nutrient changes through weeping wall system in Manawatu.

%	FDE	Solids	Liquid
DM	1.8	21	0.3
Total N	0.07	0.26	0.03
Mineral-N	0.03	0.01	0.02
Total P	0.02	0.05	0.01
Potassium	0.06	0.08	0.04
Carbon	0.6	3.7	0.1
Mineral-N/Total N	44	1	67
N:K ratio	1.3:1	3.4:1	0.6:1

Case study 2: Mechanically separated solids

Mechanical separation was used on this 520 cow Himatangi dairy farm to produce 22 (±1) %DM solids (Table 4). FDE passed through the Bauer screw-press separator that was housed on a platform above a covered solids storage bunker. Post-separated liquid effluent drained to a storage pond prior to land application via a travelling irrigator. Nutrient concentrations, apart from carbon, in the separated solids (Table 4) were all similar to solids produced from the Manawatu weeping wall in spite of having a more dilute FDE source.

Table 4: Mean nutrient changes through mechanical separation system in Manawatu.

%	FDE	Solids	Liquid
DM	0.6	22	0.3
Total N	0.02	0.24	0.02
Mineral-N	0.01	<0.01	0.01
Total P	0.009	0.055	0.007
Potassium	0.04	0.08	0.05
Carbon	0.2	8.8	0.1
Mineral-N/Total N	53	1	81
N:K ratio	0.5:1	3.2:1	0.4:1

The post separated liquid effluent was very K-rich, relative to N, meaning that land application should be based on its K loading.

Conclusions

The data presented in the tables can be used as typical or default values as a starting point for expected nutrient content of different effluent management systems. However, we recommend this data should be used in combination with either a representative laboratory analytical test of the effluent product to be applied or a nutrient budget assessment to determine the expected nutrient loading to the block receiving the dairy slurry or manure.

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