SPATIAL VARIABILITY OF NUTRIENTS IN A HERDHOMES® SHELTER MANURE BUNKER

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Abstract
As dairy intensification has taken place within the dairy industry over the past decade there has been the desire to protect pastures and soils from stock treading damage. Amongst the wintering options being practiced in New Zealand for removing stock from paddocks is the use of HerdHomes Shelters®. These plastic-roofed structures allow stock to be stood-off pastures and feed in sheltered conditions. Captured excreta is collected and stored in an under floor manure bunker for later removal and land application when soil conditions are appropriate. A dairy farm in the Waikato with one 60m long HerdHomes Shelters® was intensively sampled to determine the spatial variability of solids content and nutrient concentrations that may occur within a manure bunker. The study also sort to identify how many manure samples are required to obtain a truly representative sample.

Keywords
HerdHomes Shelters®, bunker manure, solids content, total N concentration

Introduction

Since the inception of HerdHomes Shelters® ten years ago by Northland farming couple, Tom & Kathy Pow, their growth and popularity has spread both nationwide within New Zealand and internationally. Farmers find that having a combined animal shelter, feed pad and stand-off pad provides more management options and flexibility in coping with adverse weather events while protecting soils and reducing environmental risks (Longhurst *et al*, 2006).

When the cows use the shelters their excreta drops through the slatted floor and is contained within the concrete manure bunker. The manure bunkers are usually 1.2m depth and are covered with a series of concrete slats.

When it comes time for emptying the manure bunkers, farmers want to know the composition of the manure, for OVERSEER® nutrient budgeting (Wheeler et al., 2003), before land application. However, how do you collect a representative sample from a HerdHomes Shelters®? The typical shelter is 60 m long x 10 m wide. Each shelter has two parallel manure bunkers that run the entire length (Pow *et al*., 2010). The bunkers are separated by a 15 cm concrete wall that serves as the support for the concrete slats that form the floor of the shelters. The concrete slats, made of pre-stressed reinforced concrete, measure 3.5m across and 1.5m long and weigh about 800 kg each. The slats have 35 mm gaps in them that allow cow excreta to fall through and into the concrete lined manure bunker below.

Because of the sheer weight of the slats it is not an easy process to lift them for sampling purposes. Trying to collect manure samples through the slats is also difficult. The slats are not designed to carry the weight of a farm tractor and using the front end forks on tractors limits access only to the slats at each end of the shelters. Inventor, Richard Stewart, has devised and built a simple tripod tool with a winch capability that can drag the slats 30-50 cm, thereby allowing access to any slat in the HerdHomes Shelters® (Plate 1).

Aim

A dairy farm with one 60m HerdHomes Shelter® was intensively sampled to determine the spatial variability that may occur in manure within a shelter and sort to identify how many sub-samples are required to obtain a representative sample.

Materials and Methods

Site

The sampling took place in March 2011 on a 60 ha dairy farm located near Karapiro, Waikato. The farmer winter milks his 190 Friesian cow herd on a farm that has a large area of Gley soils. About 8 ha of maize is grown on farm for supplementary silage feed with an additional 80-100 t DM maize silage imported. The HerdHomes Shelter® is used intensely for feeding and shelter throughout the year but especially during the May to September period. During excessively wet periods lactating cows may be housed for up to 20 hours/day but they would stay out at night if possible. The dry cows used the shelter for 22 hours/day during wet conditions and are only allowed back to paddocks when optimal pasture covers are reached.

Sampling procedure

An intensive sampling regime of collecting samples from throughout the shelter was undertaken. The approach used was to collect six samples across the shelter, three from each bunker, at ten sites along the length of the shelter. Each sampling site was 4-5 slats away from the next one. Within each row, samples were collected 1m in from each side of each bunker and directly in the middle of each. In total, 60 manure samples were collected.

Richard Stewart had devised and built a simple tripod tool with a winch capability that can drag the heavy slats 30-50 cm, thereby allowing access to any slat in the shelter (Plate 1). Actual collection of the manure samples was undertaken using a 1.5 m long x 0.3 m diameter PVC column (Plate 2). This sampling device was also designed by Richard Stewart. A handle on the column turned an agitating blade that could homogenise the manure profile within the column at each sampling site (Plate 2). After a sample was collected the column could then be lifted out using handles on the side of it. Richard kindly made both these tools available and also assisted in the sampling procedure.

Laboratory analysis

Manure samples collected were immediately put into a chilly bin and forwarded to ARL, Napier. Unfortunately, labels on 10 samples became illegible due to the ice melting in the chilly bin during transit. The samples were dried at 65^{o} C before being analysed so that nitrate could be retained in the total N analysis. The total N was analysed through combustion and then detected via an infra red cell (Leco CNS) so that the ammonium and nitrate fractions are included.

Statistical methods

A Bayesian smoothing technique (Upsdell (1994)) was used to estimate the spline and its 95% confidence interval. This technique was used to create contour plots using Flexi to demonstrate spatial variability throughout the bunker.

Plate 1: Tripod assembly easily winches slat allowing access to bunker manure.

Plate 2: Sampling column inserted into manure, handle turned to mix the manure profile within the column.

Results and Discussion

Solids and nutrient content

The mean solids content of manure was near 18% DM but varied from 7 to 44% DM. Upon questioning the farmer, it was learnt that solid manure material which fell outside the HerdHomes Shelters® on the concreted entry/exit area was regularly scraped onto the first row of slats in the shelter and subsequently fell into the bunker below (Plate 3). This management practice resulted in a significant gradient effect throughout the manure bunkers as presumably this action of placing drier material forced more liquid to the opposite end of the shelter. A contour plot illustrates this gradient effect on solids content (%DM) throughout the length of the shelter (Figure 1).

Plate 3: Manure deposited outside shelters' entry/exit was also scraped into bunkers.

Nutrient concentrations are greatly influenced by the solids content of manure. Results of the manure analysis are presented in Table 1. The nutrient present in the highest concentration was potassium (K), averaging 7 kg K/t (range 2.7-10.7 kg K/t). This finding is supported by Pow et al., (2010) and Longhurst et al., (2012). Large variations also existed in nutrient concentrations between other nutrients, for example, Total N content averaged 3.4 kg N/t, but ranged from 1.5-6.9 kg N/t. The average N and K concentrations were lower than those reported by Pow et al., (2010) of 5.7 kg N/t and 7.4 kg K/t for typical HerdHomes Shelters® manures of 19% DM solids content. Larger gaseous N losses may be occurring on this farm.

The variation in concentrations within other nutrients was of a similar magnitude based on CV% (Table 1). Mean concentrations of magnesium were very similar to those for phosphorus and sulphur. Nutrient concentrations for Ca, Mg and Na were all lower than the 4.0, 1.5 and 0.8 kg/t, respectively, previously reported by Pow et al., (2010). With the exception of iron, the trace element concentrations are remarkably similar to those found in pasture. Iron concentrations were elevated probably due to cows bringing in soil on their hooves and it falling into the bunkers. The bunker manure is an alkaline solid (mean pH 7.9).

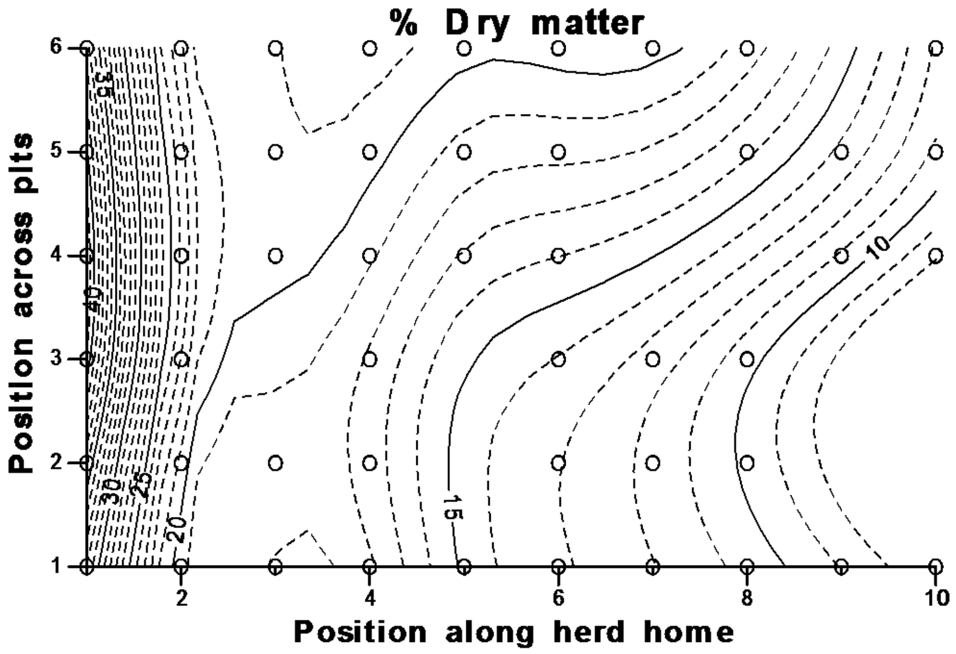

Figure 1: Contour plot illustrating solids (%DM) graduations along length of the HerdHomes Shelters®.

Table 1: Results of chemical composition (major elements, kg/t; trace elements, mg/kg) for fresh manure in bunker (n=60).

Sample	**DM %**	**Total N**	**Mineral N**	**Total P**	**K**	**Total S**	**Organic C**	**C/N ratio**
Mean	17.9	3.43	0.51	0.92	7.04	0.90	53	16
Std. Dev.*	8.5	1.12	0.12	0.33	1.85	0.32	17	1
CV % **	48	35	24	36	26	35	31	7
Lowest	7.2	1.50	0.30	0.40	2.70	0.40	23	12
Highest	44.5	6.90	0.70	1.50	10.70	1.80	86	18

Sample	**Ca**	**Mg**	**Na**	**Fe**	**Mn**	**Cu**	**Zn**	**pH**
Mean	1.72	0.89	0.64	753	77	8	48	7.9
Std. Dev.*	0.77	0.39	0.19	729	38	3	10	0.2
CV % **	45	44	29	35	50	34	20	3
Lowest	0.50	0.10	0.40	233	29	4	29	7.6
Highest	3.90	1.60	1.20	3587	208	14	68	8.5

* Std. Dev. = standard deviation; ** CV = co-efficient of variation

Figures 2 and 3 present the Total N concentrations throughout the shelter. The entry/exit is on the left-hand of the figures and shows the elevated N concentrations.

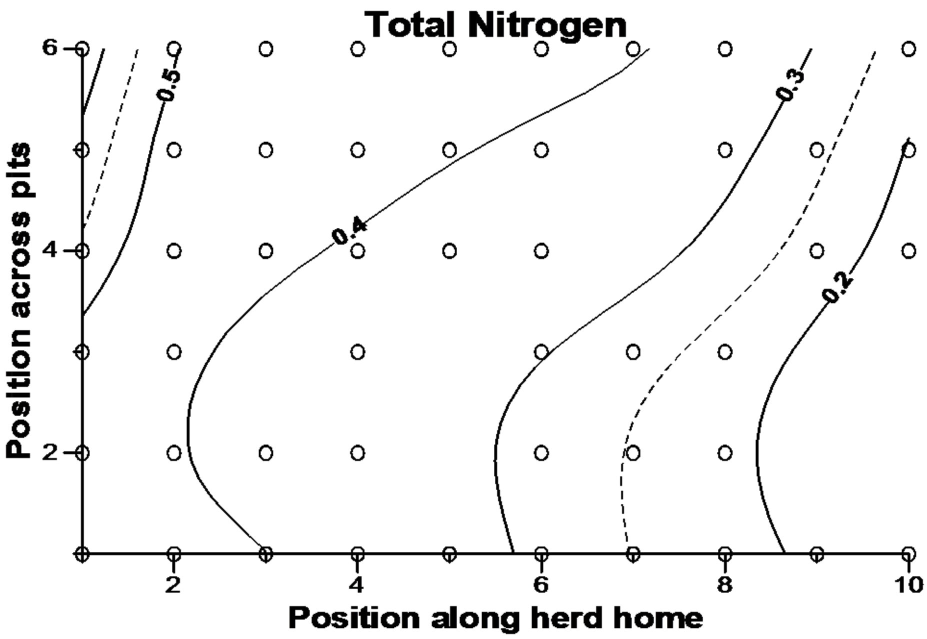

Figure 2: Contour plot illustrating solids (%N) graduations along length of the Herd Home Shelter®.

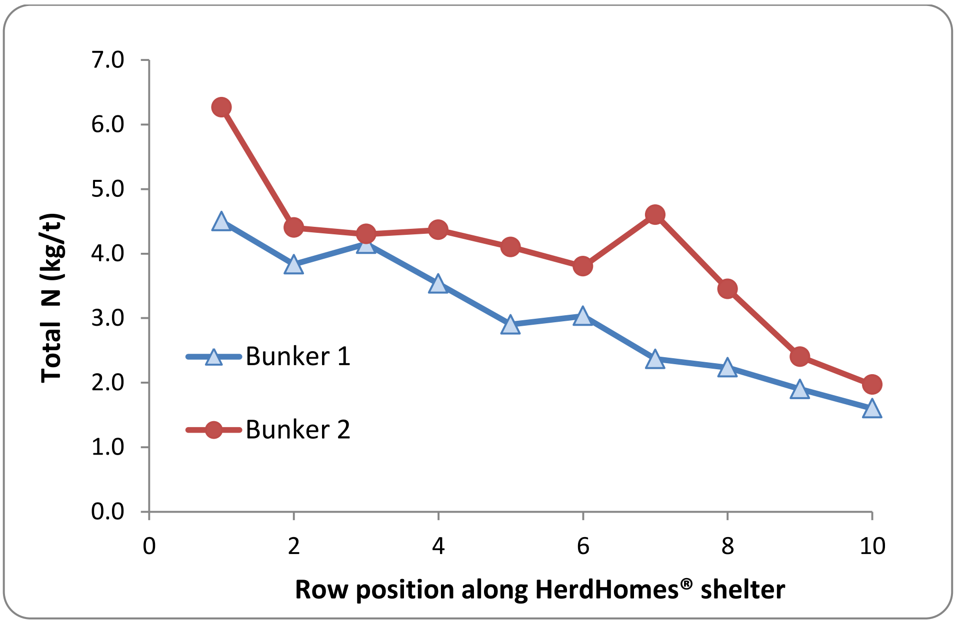

Figure 3: Nitrogen concentration (kg N/t) in parallel bunkers along the shelter.

How many samples are enough to be representative?
Based on the mean N and K values of 3.4 and 7.0 kg/t, respectively, the question of which approach for obtaining a representative sampling was investigated. Obviously collecting a number of sub-samples to combine for a composite sample is the ideal. However, there are a couple of caveats: 1) although tempting because of easier access, no sampling should occur

near each end of the shelters, 2) as Figure 3 demonstrates, sampling should not be restricted to one bunker only. For example, if sampling occurred down the length of the shelter but from only one bunker, then, on this farm, mean N concentrations would be 3.2 versus 4.0 kg N/t for bunkers 1 and 2, respectively, over or under estimating nutrient loadings depending on which bunker was sampled.

An alternative approach would be to sample across the bunkers near the middle of the shelter, collecting 8-10 sub-samples for a composite sample, based on this farm, would give a good estimate of the bunkers nitrogen content but not necessarily those of other nutrients. With any sampling it is important to remember that individual HerdHomes Shelters® management can have a major influence on nutrient variability within bunkers.

Conclusions

Obtaining a representative sample of manure from HerdHomes Shelters® is a difficult task. The extent of variation for solids and nutrients on a Waikato dairy farm showed a definite gradient for solids and nutrients along the length of the shelter. The farmers' practice of scraping external manure into the end of the bunker appeared to influence %DM and nutrient concentrations. The bunker manure was a K-rich material with concentrations twice those of Total N.

The best approach to obtaining a representative sample would be to collect 8-10 sub-samples from along the length of both bunkers. No sampling should ever occur near the ends of the shelters. An alternative approach for obtaining a representative sample would be to collect samples (8-10) across the bunkers in the middle of the shelter particularly if knowing the N concentration was the main interest.

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