# Cornell Waste Management Institute

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# Use of Dried Manure Solids as Bedding For Dairy Cows
## and
## "How frequently should stalls be refreshed with new bedding" case study

## Overview

Good livestock bedding sources have become harder for farms to secure. The price of existing sources has increased and then those sources have started to disappear due to the demand for biofuels. At the same time, there is still plenty of manure on farms that might serve a similar purpose if processed by separation, digestion and or composting. In many cases we produce more manure than our crops need which can overload soils with nutrients. Dairies are looking for alternative bedding sources and some have implemented separated or dried manure solids (DMS) as bedding. Will it work in the Northeast? There has been concern that the wet and cold winters and hot, humid summers would not be good for using DMS and concern over using a bedding that may carry a pathogen load. Some farms seem to be making it work. Cornell Waste Management Institute (CWMI) contacted the farms that had been or were starting to use DMS bedding and conducted research on those farms to determine the feasibility of using manure solids as dairy cow bedding.


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*For additional bedding resources go to:*
*http://cwmi.css.cornell.edu/bedding.htm*

*Bedding stalls with manure solids.*

## Questions That Were Investigated

The areas of concern for the use of DMS, or any bedding material, revolve around the bacterial and physical properties of the material, their effect on udder health, the health of feet and legs, and the economics of use. We attempted to answer the following:

→ Are bacterial concentrations in the unused and used bedding different between the different farm/bedding strategies?

→ Are there physical factors such as moisture and particle size, in the unused and used bedding that are different among the farm/bedding strategies?

→ Do the bacterial counts in and/or the properties of the bedding have an effect on udder health?

→ Will the use of DMS contribute to the spread of Johnes disease in a herd?

→ What are the economic implications of using DMS as bedding?

→ What is the impact of the use of DMS on feet and legs?

## Research

### Design

Six farms using different types of DMS strategies, including a farm that also used sand as bedding, participated in this study. At each of the farms, we took samples of the bedding material (both unused and used) over a one year period and analyzed them for bacterial count, the presence of *Mycobacterium avium paratuberculosis* (MAP – the organism responsible for Johnes disease) and physical properties. We looked at farm records of mastitis and somatic cell count (SCC), and performed an economic analysis of the cost savings from using manure solids.

## Description of DMS Strategies

- Farm A separated their manure then put it through a drum composter with a retention time of 24 hours. The bedding was left in a pile for one day and then spread in a 3-inch layer on concrete stalls. Bedding was refreshed three times a week.
- Farm B separated their manure then windrow composted it for 10 days before spreading it in a 2-inch layer on mattresses. They put in fresh bedding six times per week.
- Farm C digested their manure then separated. They would take the solids from directly under the separator and spread them in a 2- 3-inch layer on mattresses. Fresh bedding was put in the stalls two times per week.
- Farm D separated, then piled their manure for about three days, or used it directly from the separator dependent on the volume of solids they had on the days they spread fresh bedding, which occurred twice a week. They used solids in deep beds which are about 12 to 24 inches. When bedding is refreshed in deep beds, an additional inch or two is added.
- Farm E was just starting to use manure solids when we started the study. This farm had been using sand and leased a drum composter (photo on page 5) with a 3-day retention time to use solids. The farm used green solids, composted solids, and sand so we could compare the three treatments. Deep beds were refreshed with solids twice a week and sand once a week.
- Farm F piled solids from the separator for seven days and spread them in deep beds twice a week.

### Are bacterial concentrations in the unused and used bedding different between the different farm/bedding strategies? (i.e., do the solids need to be composted or prepared in a specific manner?)

Dairy bedding is used to provide cows with a clean, dry, comfortable place in which to lie down. There are two types of bedding: organic, such as sawdust, straw and manure solids, and inorganic,

Numbers of Bacteria

The numbers of bacteria found in bedding materials can be reported on a wet weight ("as is"), dry weight or volume basis. Reporting on a wet weight basis has little significance since it will be highly dependent on how moist the material is. When comparing bacterial counts within the same type of bedding material, it makes sense to do it on a dry weight basis. For example, dry weights might be used when examining the change in concentrations over time in the same barn using the same bedding. Comparing different materials with very different densities, such as sand and DMS, is challenging since the bedding in a stall of sand will weigh more than a stall with DMS. For the same volume of material, the higher density of sand would result in lower reported dry weight concentrations than a lighter material so the sand would "look cleaner" while the same samples compared using volume based concentrations might show higher concentrations in the sand. On one of the farms, we were able to get information on sand bedding, therefore, all bacterial concentrations from these studies are reported on a volume basis.

| | DMS | Sand |
|---|---|---|
| Volume | 120 ml | 120 ml |
| Weight | 40.6 g | 142.3 g |
| cfu/ml=(cfu/g)*(weight of material/volume of material) | 169.250 | 592.708 |

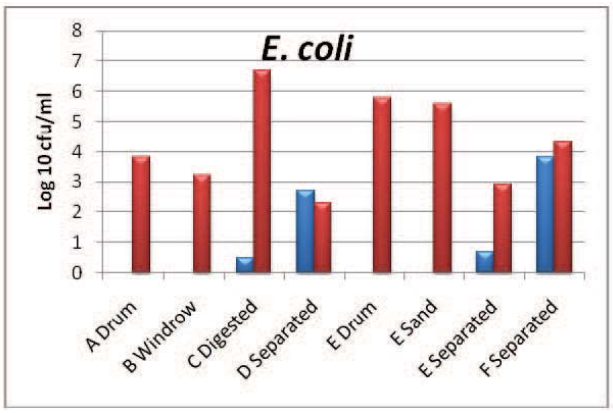

*Each 120ml. cup contains 500,000 cfu/g Klebsiella wet weight.*

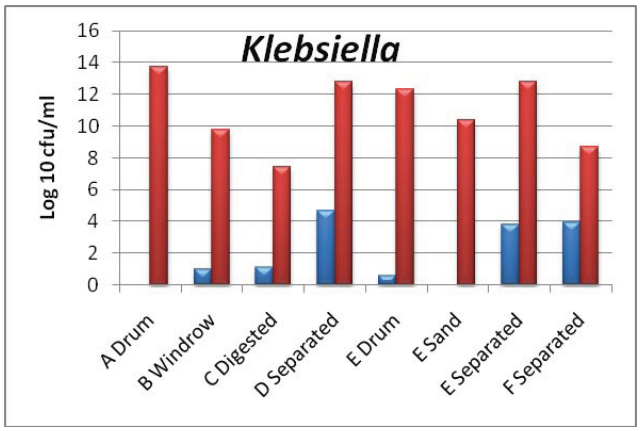
such as sand. Organic bedding materials contain nutrients required for bacterial growth, while inorganic bedding materials do not. However, once any type of bedding becomes soiled (with fecal matter and urine), pathogen growth can be supported. Inorganic bedding, such as sand, starts out with low pathogen concentrations, and some organic bedding materials start out with lower concentrations than others.

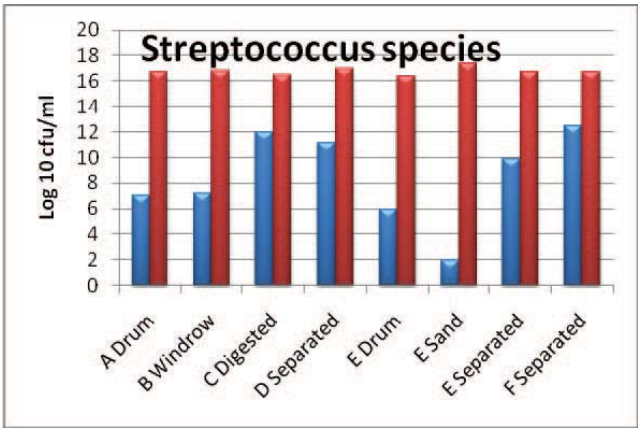
There has been a common rule of thumb that bedding materials should be kept below a maximum bacterial count of 1,000,000 colony forming units per gram (cfu/g) of bedding wet weight. This number appears to be based on one study where there were no new cases of coliform mastitis when bedding counts were at 10,000 and 100,000 one summer, but there were several new cases the following summer when bedding counts were at 10,000,000 cfu/g wet weight (Bramley and Neave, 1975). This paper does not claim that this is the magic number, but it appears to have been used extensively by farmers, veterinarians and farm advisors.

Bedding can be analyzed for a number of different bacteria, but not all of them will have an effect on udder health. A wide range of microorganisms can invade and infect the udder; however, coliforms (of which *E. coli* and *Klebsiella* are two) and environmental streptococci are the most important in causing mastitis. Therefore, these bacteria are the ones on which this report will focus.

As can be seen from the figures, unused sand bedding had the lowest bacterial numbers, and composting (both drum and windrow), as well as digesting prior to separation reduced bacterial numbers in DMS prior to putting it in the stalls. However, after being in the stalls for one to six days, bacterial levels increased regardless of type of bedding. In some cases, those that started out with "clean" bedding tended to have significantly higher levels of bacteria in used bedding, indicating that the bedding may have started out too clean (i.e., no competition from other bacteria). In




*Figures. Average bacteria in unused (blue bars) and used (red bars) for each farm/bedding strategy.*

Bacterial concentrations are reported as log 10 colony forming units per milliliter (cfu/ml) of bedding material. That is, a value of 2.0 $\log_{10}$ is equal to $10^2$ or 100 cfu/ml, while a value of 6.0 $\log_{10}$ is equal to $10^6$ or 1,000,000 cfu/ml.

*Treatment of DMS bedding, type of stalls and frequency of re-bedding used at each farm.*

| Farm (code) | Bedding strategy (after separation) | Type of Stalls | Bedding Frequency |
|---|---|---|---|
| A (A Drum) | Drum composted for 24 hours | Concrete | 3x/week |
| B (B Windrow) | Windrow composted for 10 days | Mattresses | 6x/week |
| C (C Digested) | Digested before separation - used directly | Mattresses | 2x/week |
| D (D Separated) | Piled 3 days or used directly | Deep beds | 2x/week |
| E (E Drum)<br>(E Separated)<br>(E Sand) | Drum composted for 3 days<br>Used directly | Deep beds | 2x/week<br>2x/week<br>1x/week |
| F (F Separated) | Piled 7 days | Deep beds | 2x/week |

addition, the bacterial levels in the used bedding for sand, drum composted and DMS directly from the separator at farm E did not differ from each other. This indicates that bacterial levels in used bedding are more likely the result of bacteria in the fresh manure of the cow and how well the stalls are cleaned, as well as what is tracked in from the alleys, rather than how "clean" the bedding is when it is put in the stall.

*Composting solids in a windrow.*

## Are there physical factors in the unused and used bedding that are different among the farm/bedding strategies?

It has been suggested in the literature that with more moisture and more organic matter, bacterial populations thrive. It has also been suggested that the amount of fine particles in the bedding has an effect on the bacterial population on the teat ends; the finer the material, the more likely it will stick to the teat ends, and therefore they will have a higher population of bacteria. Bedding (both unused and used) was analyzed for % moisture and particle size.

Average moisture ranged from 64 to 73% in the unused DMS bedding and fine particles (less than 2 mm in size) ranged from 31 to 74%. These differences were dependent on the type and efficiency of the separator being used on the farm. Sand, as expected, was drier with only 11% moisture and contained 71% fine particles.

Average moisture in the used DMS bedding was higher in the bedding strategies that used deep beds (ranging from 43 to 60%) and lower on those that used mattresses (29 to 50%). Farms using mattresses spread the DMS in a 2" layer on top of the mattress, thus allowing it to dry out. Fine particles were also affected by type of stall and tended to be lower in those bedding strategies that used deep beds versus those that used mattresses. DMS in deep beds tends to mat together from the

weight of the cow, while the DMS on the mattress tends to either fall off, or spread out.

## Do the bacterial counts in and/or the properties of the bedding have an effect on udder health?

Udder health is measured by incidence of mastitis and SCC. Mastitis is an inflammation of the udder which causes clots in milk. It is generally treated with antibiotics and makes the milk unsalable. SCC is a count of white blood cells in the milk, which can indicate infection.

### Mastitis

Mastitis incidence over the course of the study in the pens used ranged from 4 to 10%. Incidence was different between the farms, but not between the three different bedding strategies at farm E. The factors that affected mastitis incidence on all farms were stage of lactation, milk production and cell count. Bacterial levels and bedding properties had no effect on the number of mastitis events.

*Percent of animals with mastitis and abnormal SCC over the course of the study for each farm/ bedding strategy.*

| Farm/Bedding | Mastitis | SCC |
|---|---|---|
| B Windrow | 10 | 24 |
| C Digested | 8 | 17 |
| D Separated | 8 | 52 |
| E Sand | 6 | 36 |
| E Drum | 4 | 30 |
| E Separated | 3 | 30 |
| F Separated | 6 | 34 |

### Somatic Cell Count

Because mastitis is frequently sub-clinical, estimating the SCC of a milk sample can detect infection. It has been generally accepted that the cell count for "normal" milk is nearly always less than 200,000 cells/ml for cows and 100,000 cells/ml for heifers. Higher counts are considered abnormal, or excessive, and indicate probable infection. Abnormal SCC over the course of the study in the study pens ranged from 17 to 50% of the animals. As with mastitis, the number of animals with abnormal SCC was different between the farms, but not between the three different bedding strategies at farm E. The factors that affected SCC were season, lactation number and stage of lactation. Bedding properties and bacterial concentration did not have an effect on SCC.

## Will the use of DMS contribute to the spread of Johnes disease in a herd?

There is some concern that since the bacteria responsible for Johnes disease (*Mycobacterium avium paratuberculosis* – MAP) is shed in the manure, using manure solids as bedding may spread the disease throughout the herd if the bacterium remains viable in the DMS. MAP was found in small numbers in several of the unused bedding sources, including sand (see table on top of page 6). In this study MAP was not consistently destroyed by separation, digestion or drum composting. Therefore, there could be some potential for the spread of Johnes through the use of DMS. Since the number of colony forming units was small, that possibility is also small, and may be of concern only in the bedding of calves. Cows do not tend to ingest bedding, where calves may.

*Drum composter - three day retention time.*

*Analysis of MAP in unused bedding for each farm/bedding strategy.*

| Farm/bedding strategy | # of time MAP found | Total # of samples taken | Total cfu MAP (average) |
|---|---|---|---|
| A Drum | 1 | 24 | 69.7 |
| B Windrow | 2 | 24 | 1.2 |
| C Digested | 2 | 21 | 1.0 |
| D Separated | 4 | 24 | 58.0 |
| E Drum | 0 | 15 | 0.0 |
| E Sand | 1 | 33 | 0.4 |
| E Separated | 11 | 36 | 8.9 |
| F Separated | 12 | 24 | 174.0 |

### What are the economic implications of using DMS bedding?

An economic analysis of using manure solids as bedding was performed. Returns were from the sale of solids, reduced hauling cost (not having to take the manure out in the field for spreading) and reduced costs on purchasing bedding. Costs include equipment to separate, other machinery costs, fuel, labor and other costs associated with bedding management. It was calculated as the cost or savings per hundred weight (cwt) of milk produced. In all cases there were savings which ranged from 1 to 26 cents per cwt.

## Conclusions

- ❖ Using manure solids can provide an economic benefit without adversely affecting herd health.
- ❖ Bacterial levels in the bedding alone are not what cause high SCC or mastitis. Management of the bedding in the stalls is much more important than analyzing it for pathogens. Keeping stalls free of manure and urine, regardless of bedding type, will go a long way toward keeping SCC and mastitis under control.
- ❖ Use a DMS system that fits into your farm's routine and one with which you are most comfortable.

*Cost of using DMS.*

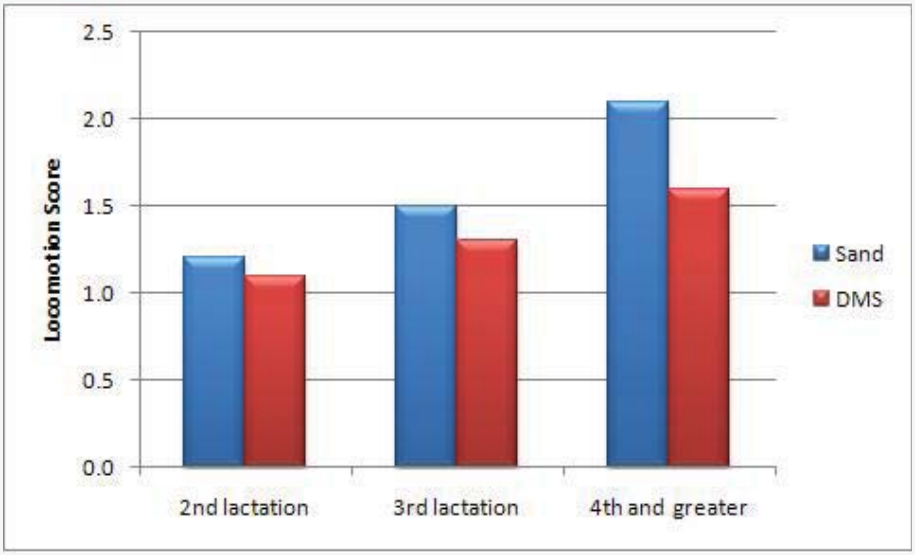
| | Returns (d) = a + b + c | | | (e) | (e-d) | |
|---|---|---|---|---|---|---|
| Farm | DMS Sales (a) | Savings on hauling (b) | Savings on bedding (c) | Total expenses | Annual cost to farm | Annual cost/cwt |
| B | $0 | $5,490 | $57,200 | $51,570 | -$10,940 | -$0.05 |
| C | $0 | $8,450 | $44,800 | $22,236 | -$31,014 | -$0.08 |
| D | $0 | $8,325 | $53,082 | $59,856 | -$1,552 | -$0.01 |
| E | $0 | $8,425 | $156,115 | $87,171 | -$77,378 | -$0.26 |
| F | $15,000 | $50,000 | $81,600 | $79,257 | -$67,343 | -$0.26 |

What is the impact of the use of DMS on feet and legs?

Some of the literature has indicated that sand is the best bedding for the health of feet and legs. One of the ways in which foot and leg health is evaluated is through locomotion scoring. Twice, over the study, at Farm E, cows in the sand pen and cows in the pen bedded with DMS from the separator were scored. The scoring done at this farm showed that cows on sand (particularly those in lactation 4 or greater) had significantly higher locomotion scores than those bedded on DMS.

**Locomotion Scoring:**

- 1 = Non-lame: Stands and walks with a flat back
- 2 = Slightly lame: Stands with an arched back, but walks with a flat back
- 3 = Moderately lame: Stands and walks with an arched back and takes short strides on one or more legs
- 4 = Severely lame: Stands and walks with an arched back and one or more limbs are physically lame or non-weight bearing.




*Average locomotion scores by lactation number for animals bedded on sand and DMS.*

## A case study of two farms:
## "How frequently should stalls be refreshed with new bedding"

"Common wisdom" says that bedding should be refreshed often to provide a clean environment, while a close reading of the research literature suggests that to be ill-advised from the point of view of pathogen re-growth (as well as being less economical). Pathogens in organic bedding reach high levels within a day or two of being placed in stalls and re-bedding provides fresh organic materials that serve as food for the organisms, thus frequent re-bedding may not make a difference.

Two farms that used DMS directly from the separator in deep beds, assigned two pens of animals to this study. The cows in each pen were of approximately the same parity and stage of lactation and were kept in the same pen for four full weeks in July and January. Farm 1 housed only first lactation animals in the two pens, while Farm 2 housed multiparous animals. One of the pens was bedded daily with fresh DMS, while the other was bedded every seventh day. Stalls in each pen were scraped and raked daily as per normal farm practices.

Quarter and bulk milk samples were taken at the beginning and end of the two trial periods and analyzed for bacterial concentration (i.e., milk culture) and SCC, respectively. During the second and fourth weeks of bedding, samples of unused and used bedding were taken on day 0, 1, 2, 5, 6 and 7 and analyzed for bacterial counts and physical properties. In addition, farm records were

*Fresh separated solids.*

accessed for individual cows in each of the pens over the two study periods to assess individual cow SCC and mastitis incidence.

## Bedding Bacteria

The frequency with which stalls were bedded with DMS had very little to do with the amount of bacteria found in the used bedding. The only bacteria that was found in significantly greater amounts in weekly versus daily used bedding was *E. coli*, and it occurred only in the summer at Farm 1 and only in the winter at Farm 2. Season had much more effect on bacterial levels than did frequency of bedding. Summer showed higher levels of coliform bacteria, while winter showed higher levels of streptococci.

## Bedding Physical Properties

Frequency of bedding had an effect on the moisture content and percent of fine particles of the used bedding. It was drier and less fine in the weekly bedded stalls. Both of these characteristics of bedding have been attributed to affecting SCC and mastitis. When teat ends are exposed to bedding that is wet and fine, it is more likely to cause higher SCC and mastitis. If this is the case, then weekly bedding of DMS could have a positive impact on SCC and mastitis.

## Udder Health

### *Milk Cultures*

Culturing milk samples for mastitis pathogens can provide a great deal of valuable information for a dairyman. A single milk sample from an individual cow may provide significant information for that particular cow; however, multiple samples from many cows will provide much more information for mastitis prevention and control within the herd. Bacteria found in the milk of a cow can help identify infections early, facilitate treatment decisions and allow management changes that will have the greatest impact resulting in fewer new infections. Generally, milk culture results can be divided into two or three categories:

- ✓ Positive culture results:
  - ❖ Major pathogens (*Staph aureus*, *Strep* spp., *A. pyogenes*, serratia and proteus)
  - ❖ Minor pathogens (*Staph* spp., C. species, G+ bacillus)
- ✓ Negative culture results

The animals in each pen on both farms had milk samples taken at the beginning and end of each four week trial to determine if length of time between bedding would have an impact on the number or odds of an animal having a positive culture at the end after having a negative culture in the beginning. The odds of having a positive milk culture at the end of the bedding frequency scheme were not affected by frequency of bedding. It was affected by the farm and lactation number. Since Farm 1 had only heifers, and Farm 2 had only multiparous cows on the study, the two variables are basically the same. Heifers were less likely to have a positive post culture than second or greater lactation cows.

The number of animals with positive post cultures at Farm 1 was affected by frequency of bedding and the amount of *E. coli* in the bedding.

However, heifers in the daily bedded pens were 7.2 times more likely to have a positive post culture than those in the weekly bedded pen and *E. coli* was negatively correlated, meaning that the more *E. coli* found in the bedding, the fewer animals with positive cultures. Since daily bedded pens had more moisture and fine particles than weekly bedded pens, increased positive cultures makes sense, but higher bacterial levels causing fewer animals to have a positive culture is hard to explain. There were no indicator variables at Farm 2 that had an effect on the number of animals with positive post cultures.

### *Somatic Cell Count*

SCC was evaluated on all animals in each of the pens to determine if those with a normal count in the beginning would have an abnormal count at the end of the four week period based on whether they were in the daily or weekly bedded pens. The number of animals with abnormal post SCC was affected by frequency of bedding at Farm 1 and the amount of *E. coli* in the used bedding at Farm 2. At Farm 1, weekly bedded cows were more likely to have an abnormal post SCC than daily bedded cows which was the same farm where weekly bedded cows were less likely to have a positive post milk culture. If SCC has a direct relationship with the amount of bacteria in the milk, this does not make a lot of sense. At Farm 2, the amount of *E. coli* in the used bedding was positively correlated with the number of animals with abnormal post SCC. However, at Farm 2, there was no difference in *E. coli* levels between the two pens. Because the farms responded differently, it is more likely that other variables, such as milking parlor procedure and/or cleanliness of the animal, are playing a bigger part in the number of animals with abnormal cell count.

### *Mastitis*

Mastitis events over the study period were few; 5 out of 400 animals (1.3%) at Farm 1 and 12 out of 350 animals (3.4%) at Farm 2. The odds of a cow getting mastitis were significantly higher for those cows that had an abnormal pre SCC at Farm 2 while none of the indicator variables had an effect on the odds of getting mastitis at Farm 1. In addition, the number of mastitis events was not affected by any of the indicator variables.

Daily bedding of DMS can be time consuming and expensive and may not have any positive impact on bacterial levels or milk quality and mastitis. Less frequent bedding in deep beds may even have a positive impact by reducing the moisture and the amount of fine particles.

## Cited Reference

Bramley, A.J., and F.K. Neave. 1975. Studies on the Control of Coliform Mastitis in Dairy Cows. British Veterinary Journal 131:160-169.

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