

Recycled manure solids as bedding for dairy cattle: A scoping study

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EXECUTIVE SUMMARY

This report is the output of a scoping study, the aim of which was to identify and summarise the information currently available on the use of RMS as bedding for dairy cattle. It does NOT constitute a full risk assessment or "claim to be the definitive document of RMS use". Suggestions for interim guidance on use are based on current knowledge but cannot be expected to provide "fool proof advice". All users of RMS have to accept responsibility for their own decisions with respect to its use. The authors of this report cannot be held responsible for decisions made on the basis of the information contained herein.

BACKGROUND AND AIMS

Recycled manure solids (RMS) (often colloquially referred to as 'green bedding') have been used as a bedding material for dairy cows for a number of years in some jurisdictions and the practice is becoming increasingly widespread in the UK.

There are significant uncertainties with respect to the associated risks to animal and human health from using RMS bedding. This in turn makes it difficult to establish whether the material can meet the requirements for safe use.

The aim of the report was to review the current knowledge with respect to the use of RMS as bedding for dairy cattle and thereby increase the understanding of the use of RMS as bedding in UK conditions.

SOURCES OF INFORMATION

Written sources used were peer reviewed journals, conference proceedings, articles in the popular farming press, and technical information available on-line. Experiences and opinions of researchers,

advisers, machinery suppliers and farmers in countries with longer experience of RMS use were sought, as well as similar contacts in the UK where available. Online searches were carried out and collation of information available through Web searches and on-line databases of publications was undertaken.

Information was gained from 3 manufacturers of manure separation equipment.

The experiences of 19 farmer users of RMS bedding were collated.

Additional information was gained from other UK industry contacts through the Nottingham Dairy Herd Health Group and BCVA as well as through DairyCo extension officers and other members of the Stakeholder group.

International information was obtained through researchers and/or advisers in 13 countries. At least one contact responded from The Netherlands, Spain, Portugal, Denmark, Poland, Switzerland, Austria, Germany and USA.

It is notable that there is a very limited amount of peer reviewed published information on the use of RMS as bedding, and particularly the material as currently used in the UK, *i.e.* physically separated solids with no further processing. Much of the available information appears in project reports and conference proceedings, and, these sources provide a combination of studies and anecdotal reports. A great deal of the experience and information is from the US and other countries where climate and farm systems differ from those of the UK. More recent adoption in Europe has not resulted in scientific publications, although useful recent reports are available from studies in the Netherlands. Information from the UK is limited to the practical experiences of a small number of

farms with a relatively short history of use.

REVIEW OF CURRENT TECHNOLOGIES

The technologies used to produce RMS bedding in the UK were identified and reviewed.

At the time of this study, the Bauer FAN screw press separator was the equipment most commonly used to produce RMS bedding in the UK.

UK TELEPHONE SURVEY OF CURRENT USERS OF RMS

A UK telephone survey of 19 farmers using RMS found that: Only five farmers had been using the system for a year or more. The average length of time was nine months, the maximum was four years. With one exception, involving a drum composter, separated solids underwent no further processing before use as bedding. The size of the survey was limited by the small number of UK based users of the technology.

- RMS was almost exclusively used in cubicles, both on mattresses and as deep beds.
- The majority of farmers reported an improvement in cleanliness of cows.
- The majority of farmers reported a benefit to the condition of hocks.
- Reports on changes in lying time were equally split between improvement and no change.
- With the exception of two farms, clinical mastitis incidence and somatic cell counts (SCC) were qualitatively generally considered to be equal to or lower than before the change

Table 1. Benefits identified by users in answer to an open question

Benefit	Number of farmers mentioning
Cost savings	10
Ease of slurry storage and handling	9
Cow comfort or increased lying times	8
Cow cleanliness	8
Availability, making it easy to use bedding	7
Reduced dust in buildings	7
Udder cleanliness	4
More effective utilisation of slurry	4
Cow welfare- reduced hock lesions	3
Bedding easy to handle	1
Not "buying in bugs" in bedding	1

to the use of RMS as bedding.

- There was some qualitative opinion that mastitis or cell count problems were associated with fresh bedding material of lower dry matter content than usual.
- The three most common reasons for using RMS were cost, cow comfort and difficulties with supply of alternative bedding materials.
- Other benefits given were: ease of slurry storage and handling, cow cleanliness, reduced dust and ease of bedding handling.

Table 1 illustrates the benefits mentioned by farmers.

REVIEW OF KEY PATHOGENS

Initially, a "long list" of pathogens likely to be found in cattle faeces was collated.

Pathogens perceived, or known, to be likely to have a high load in cattle slurry were then identified (notifiable diseases were also included).

Based on the findings of a literature review, existing knowledge, experience and consultation, a subset of pathogens was derived that were either likely to have high load in slurry, or unlikely to have a high load, but likely to be of major significance if present.

The rationale for selecting pathogens as 'important', or excluding them, was partly on the basis of risk, considered in terms of both likely presence in slurry and exposure route. Note; this exercise did not in itself constitute a formal or complete risk assessment.

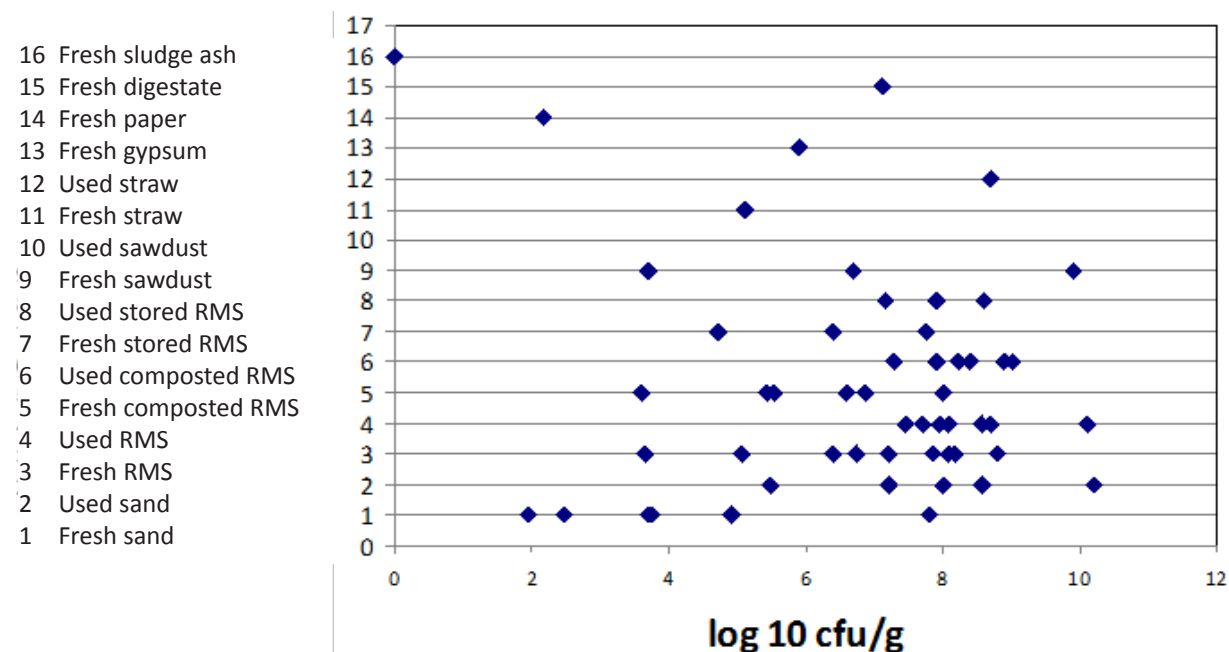
A final list of key pathogens was compiled, with an assessment of likely load in slurry, transmission route and consequences for animal and human health.

Antimicrobial resistance was considered but the understanding of the persistence of genetic material encoding antimicrobial resistance and resistant organisms in the environment and more specifically the impact of the use of RMS is currently limited. The potential impact of antimicrobial resistance should be borne in mind when considering the effects of incorporating faeces and urine from animals under treatment, and milking machine washings (which will contain disinfectants), in slurry that is to be used for separation to provide bedding materials. This lack of understanding and current knowledge suggest a cautious approach would be prudent.

EFFECTS OF TREATMENT AND PROCESSING OF RMS ON MICROBIAL POPULATION

A variety of treatments of RMS were considered in terms of their influences on pathogen load but although evidence was identified, it was limited

Figure 1. Total bacterial counts in different bedding materials



and it is difficult to draw definitive conclusions.

Separation is unlikely to alter the microbial load greatly from fresh slurry, though there is little published information to substantiate this comment. Composting and digestion have the potential to reduce the pathogen load if performed in optimum conditions. However, pathogens are not completely eradicated. Knowledge of processing indicates that temperature is likely to be critical and that composting can be difficult to control.

REVIEW OF PATHOGEN NUMBERS IN BEDDING

Bacterial counts appear to vary greatly both within and between different bedding materials, and the ability to compare studies is limited because of differences in the methods or units used to express results.

Total bacterial counts in fresh RMS of the order of 10^4 and 10^8 cfu/g fresh bedding have been reported. Fresh sawdust shows a similar range and even "fresh" sand, claimed to be inert, can provide some samples with very high load. With use, there is a trend for all products to move towards or beyond the higher end of the range for fresh material.

Figure 1 illustrates the range of total bacterial counts for a number of bedding materials using some examples from the literature and samples submitted to QMMS laboratory before the start of the study.

Coliforms are very variable in all bedding materials, in some samples falling below the level of detection, but can frequently be found at levels at or above 10^6 cfu/g for both used and unused sawdust, and RMS of all types. *Klebsiella* spp counts are extremely variable within bedding types, but

have been reported at least once at relatively high levels (10^4 cfu/g or more) in all materials both before and after use, apart from sand. *E. coli* has been reported in most materials. Used RMS, whether or not composted or stored, demonstrated some of the highest levels (10^6 cfu/g or more). Counts from fresh and used sawdust are also high.

Figure 2 illustrates the range of total coliform counts for a number of bedding materials, using some examples from the literature and samples submitted to QMMS laboratory before the start of the study.

REVIEW OF POSSIBLE IMPACTS OF USING RMS BEDDING

Impact on cow comfort and welfare

In general it can be expected that there will be benefits for cow comfort with use of RMS, whether on mats or in deep beds, compared to the situation with mattresses and sawdust. There may be little difference between the situations with deep bedded sand and deep bedded RMS.

Impact on animal health

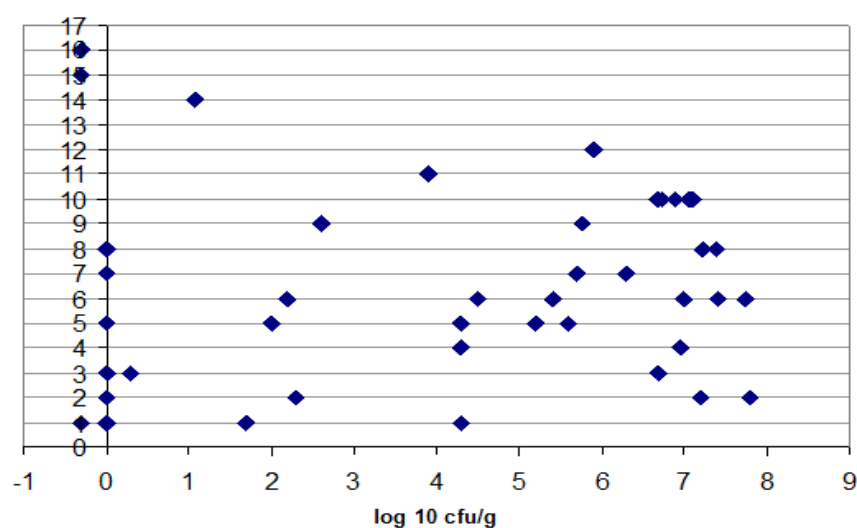
Consideration was made of the pathways and risks associated with the use of RMS as bedding.

The main risks to animal health that may alter as a result of a switch to the use of RMS as bedding are considered to be:

- Infectious diseases transmitted by pathogens present and persisting in the recycled bedding;
- Effects of inhalation of bedding particulates – lower exposure since less dust is reported;
- Exposure to a higher level of ammonia and

Figure 2: Total Coliform counts in different bedding materials

- 16 Fresh sludge ash
- 15 Fresh digestate
- 14 Fresh paper
- 13 Fresh gypsum
- 12 Used straw
- 11 Fresh straw
- 10 Used sawdust
- 9 Fresh sawdust
- 8 Used stored RMS
- 7 Fresh stored RMS
- 6 Used composted RMS
- 5 Fresh composted RMS
- 4 Used RMS
- 3 Fresh RMS
- 2 Used sand
- 1 Fresh sand



ammonium compounds – although published reports of emissions differ.

The likely routes of infection are:

- Intramammary - via the streak canal
- Contact with skin (particularly digital dermatitis)
- Respiratory - pathogens carried on dust particles
- Ingestion - the oral route
- Reproductive – via the reproductive tract and navel

The only disease of which the consequences have been studied in any detail is mastitis. There are anecdotal reports of serious outbreaks of clinical mastitis associated with RMS bedding use (including outbreaks specifically attributed to *Klebsiella* spp and *Pseudomonas* spp). However, these are outnumbered by reports of successful use. Of two attempts to investigate the long term influence on somatic cell count in the US, one suggested a slight increase in SCC, but numbers were small and methods not particularly robust so we do not claim to have found supporting evidence for this. However, it should be remembered when making comparisons between countries that the US national tolerance for SCC is much higher than in the EU, at 700,000 cells/ml, compared with 400,000 cells/ml for the EU. It has been concluded that excellent cow preparation at milking time, sanitation of milking equipment, cow hygiene, adequate dry cow housing and bedding/stall management appear to be critical in maintaining a low SCC while successfully using manure solids for bedding.

Impact on Human Health

There are no reports of the impact of RMS on human health.

In the light of current knowledge, the likely impact to farm workers, as long as routine hygiene precautions are taken, might be beneficial in comparison with sawdust or chopped straw, because of the reported reduction in dust.

There is little information available on the possible transfer of pathogens from bedding to milk. In the absence of this, it would be prudent to recommend that milk from RMS herds is pasteurised before consumption.

ASSESSMENT OF HOUSING EFFECTS

Information was gathered from the survey of UK users and reports from other countries on the structural and infrastructural aspects of different types of housing in which RMS is being used.

It should be remembered that many of the published reports are from countries with warmer and drier climatic conditions than the UK

There is some evidence from a laboratory study of potential negative impacts of gaseous ammonia when using RMS while preliminary measurements from barns in Denmark indicate that the increased emission compared with straw bedding is likely to be of little practical significance.

The consensus from UK farmers is that dust levels are low with RMS.

Factors affecting general hazards and risks associated with bedding materials in dairy cow housing include; ambient temperature, bed management, microbial competition, humidity and frequency of bedding. There are specific aspects of RMS use which are particularly affected by all of these, due to a large extent to the capacity of the material to absorb and release large amounts

of moisture.

RISK MITIGATION WHEN USING RMS

Critical control points are considered to be:

Source of material

There are likely to be additional risks associated with the use of material not originating from the premises on which it is being processed and used. For this reason RMS should only be generated on the unit on which it is to be used and only from product originating from that unit - *ie* manure should not be moved between units either before or after processing.

Control of material entering the pool for separation

Manure should only be recycled as bedding to the species from which it was originally produced. Manure from different species should not be introduced as this increases the risk of introducing different pathogens; care should be taken to make sure that 'runoff' from manure sources from other species, such as from a midden, does not reach the pool for separation. It is suggested as a further disease control precaution that slurry from adult cattle should not be used to produce bedding for youngstock under 12 months, and vice versa, due to differences in shedding of, and susceptibility to, pathogens.

Additional consideration should also be given to certain notifiable diseases. In the case of notifiable exotic disease additional controls over the use of RMS as bedding may be implemented. Consideration should be given as to whether the use of RMS should be suspended in herds experiencing a TB breakdown.

The introduction of other material should also be minimised – waste milk carries the risk of recycling mastitis pathogens onto the bedding and the inclusion of milking machine wash water carries a similar risk as well as potentially introducing disinfectants into the slurry pool which may have adverse effects with respect to the development and perpetuation of antimicrobial resistance. The effect of used footbath contents entering the slurry pool is unknown.

Careful consideration should be given to biosecurity and how new stock, and therefore their faeces, are added to the general population and the implications that may have for the spread of disease. This area has not been studied and is poorly understood. For this and other disease control reasons, material from isolation pens should not be added to the pool for separation.

Control of separation process to achieve the

optimum dry matter content

The composition of the slurry to be separated has a significant impact on consistency and quality of the extracted solid fraction. The content of the slurry pool needs to be managed to optimise the RMS output. Recycled solids should be prepared and stored under cover to avoid an increase in water content prior to application.

Control of storage to minimise pathogen multiplication

Extracted RMS should be used immediately unless some further processing/preservation is employed. Further processing could encompass processes such as forced air drying, heating, composting, digestion or anaerobic ensiling.

Control over ventilation in the building

Good ventilation is essential and overstocking should be avoided to ensure further drying of RMS once applied to bedding as well as to minimise the levels of ammonia in the housed atmosphere.

Control over further drying and temperature on the beds

Material should be added to the beds in limited quantities to allow further drying to take place. Beds should be managed to minimise 'heating' and therefore bacterial multiplication after application.

Control of hygiene of the bed

As with any bedding material, beds should be designed and managed to minimise contamination with urine and fresh faecal material.

Control over animals using the bedding

Avoid use with calving cows. Bedding hygiene is of increased importance around the time of calving. Grooming of calves post calving could result in the ingestion of significant quantities of RMS by cows. Exposure of new born calves to pathogens of adult animals which might be present in the bedding presents a high risk, particularly for Johne's Disease. RMS should therefore not be used in calving areas. RMS use should also be avoided in transition cow accommodation due to the risk of early parturition.

Avoid use with youngstock

Even for weaned youngstock, there are risks attached to the use of the material, since younger animals are potentially naïve to pathogens in the adult herd which may be present in the bedding. Welfare legislation may preclude the use of RMS as bedding for calves, however we suggest that RMS must not be used for youngstock under the age of

6 months. As a precautionary measure we suggest RMS should not be used for youngstock under the age of 12 months.

Control of teat hygiene by parlour practices

Pre-milking teat preparation and pre-dipping should be a pre-requisite of herds using RMS in view of the reports of increased numbers of thermotolerant and psychrotrophic bacteria in bulk milk in herds employing RMS.

Avoid risk of cross contamination of feed

There should be no shared equipment for the handling and processing of feed and RMS. If any equipment is shared (loaders *etc*) it must be thoroughly cleaned between uses.

Control of end product (e.g. milk) processing

Until there is a better understanding of the changes in risk associated with the use of RMS as bedding, advice should be that milk from farms utilising RMS for lactating cows must be pasteurised and its use in "artisan" milk products should be avoided.

Personal protection for farm workers

Farm personnel should be provided with appropriate PPE and made aware of the importance for personal hygiene during and following the handling of RMS.

Herd health monitoring

A final stage of any risk mitigation process should be for the user of RMS as dairy cow bedding to actively monitor cow health, in particular intramammary health, as well as bulk tank milk quality, to ensure the effective implementation of mitigation strategies.

Risk modelling

Unfortunately, insufficient quantitative information was available to inform a Bayesian based risk analysis for major diseases and health issues.

Based on the information in this report, suggested 'interim guidelines' have been drawn up and are presented in the main body of the report. Lack of data means it has not been possible to base many of these guidelines on robust scientific evidence, meaning that it is essential that key issues/deficiencies highlighted in the report are addressed so that these guidelines can be refined. Key points are:

I. Sources of RMS

- Bedding must be made from slurry produced on the farm where it is to be used.
- Only waste from adult cattle should be used as a

raw material for RMS

- Excreta from calving and hospital pens should not enter the reception and processing area
- Excreta from other species must not enter the reception and processing area
- The following materials should not enter the source of slurry to be used for bedding:
 - × Placentas, and manure from calving areas.
 - × Unsaleable milk - ie from fresh calved cows or cows under treatment.
 - × Output from washing the milking plant should if at all possible be diverted from the reception pit, as the presence of disinfectants may increase the risk of development and persistence of antimicrobial resistance.
 - × Waste footbathing material should ideally not be added to the reception pit for RMS processing for the same reason as that outlined for plant washings.
- The use of RMS as bedding should be suspended in herds experiencing a TB breakdown.

II. The separation process

- Target DM (dry matter) content of end product should be at least 30% and ideally 35% at initial separation.
- Consistent and homogeneous input material is important.
- Monitoring machine performance and servicing as required is important.
- Storage of freshly separated solids in a pile is not generally recommended due to the risk of uncontrolled changes in bacterial populations with heating.

III. On farm management of RMS

- Buildings need to be well ventilated and well drained to ensure the humidity of the environment remains as low as possible.
- RMS can be used as both a thin layer (2-5cm) on mattresses and in "deep beds" (7.5cm or more deep). Where deep beds are created, they should be built up gradually to allow the bedding to dry out as depth is created.
- As with all livestock bedding material, the surface should be kept clean and dry and soft. Soiled material should be removed from beds at least twice daily.
- Whether using a thin surface layer or creating a deep bed always apply as a thin layer but ensure bedding cover is maintained to achieve a good level of comfort and dryness.
- It is recommended that cattle under the age of

Table 2. Comparison of bedding costs

Bedding material	Illustrative cost per cow: pence/week in a 400 cow herd	Illustrative cost per cow: pence/week in a 200 cow herd
RMS	71	130
Sand	140	140
Straw	160	160
Sawdust	75	75
Paper by-product	95-135	95-135

12 months are not bedded on RMS, predominantly to reduce the risk of infection with MAP bacteria that cause Johne's disease, but also with gastrointestinal and respiratory pathogens.

- Pre-milking teat disinfection should be practised on farms using RMS as bedding.

IV. Contingency plans

An alternative source of bedding material, compatible with the slurry handling machinery employed on farm, should be readily available.

V. Human health protection

Farm workers working with RMS should employ the normal personal protection measures and personal hygiene associated with handling slurry and manure.

VI. Product/food safety issues

- To guard against any possible increase in bacterial numbers in milk it is recommended that milk from RMS bedded cows is pasteurised before human consumption.
- Farms utilising RMS as bedding should not be allowed to sell unpasteurised milk to the public.
- It is recommended that RMS is not used on farms providing milk for artisan cheese making or by producer processors, as milk will not be mixed with milk from non RMS farms, so any effect of RMS use will be more marked.

Economic and environmental assessment

- From farmers' reports, the bedding can be economically attractive if the size of the herd is large enough to cover the capital costs of equipment.

In general and on average, RMS is likely to be cheaper than most other commonly used bedding materials in the UK. Estimated costs are outlined in the body of the report, but are dependent on current prices and individual farm situations. Table 2 outlines an estimated cost per cow per week, in a 400 and a 200 cow herd, for different bedding materials (2013 prices). RMS capital cost based on

finance at 5% over 6 years.

The greatest environmental benefit of using RMS as bedding appears to be the replacement of operations with a large "carbon footprint", and other potential negative environmental impacts of the production and haulage of alternative materials.

The overall impact and net release of gases from the slurry itself is unlikely to be changed by the extra step in the chain of recycling the manure.

The more efficient uptake of nutrients by plants from separated slurry could be considered an environmental benefit, but this is not linked to the use of the material as bedding.

BACTERIOLOGICAL ANALYSIS OF BEDDING SAMPLES FROM UK FARMS

Samples of RMS bedding from farms (16 freshly separated and 18 from beds immediately prior to adding fresh bedding) were submitted from farms for bacteriological analysis. The results of total bacterial counts are illustrated in Figure 3.

Further reporting on other microorganisms found in fresh material and used bedding can be found in the main report.

The counts of all organisms were significantly higher in used bedding samples than in bedding before use. There were no significant differences

Figure 3: Total bacterial count (log cfu/g) in un-used RMS and used bedding from mattresses and deep beds. Samples from 16 farms.

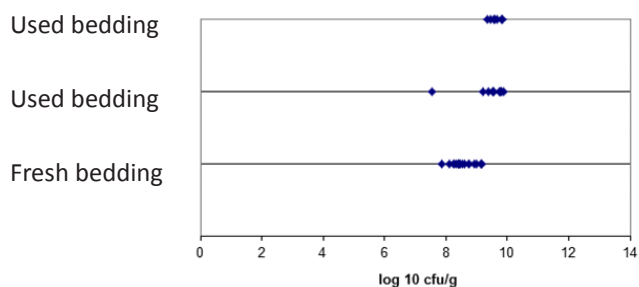
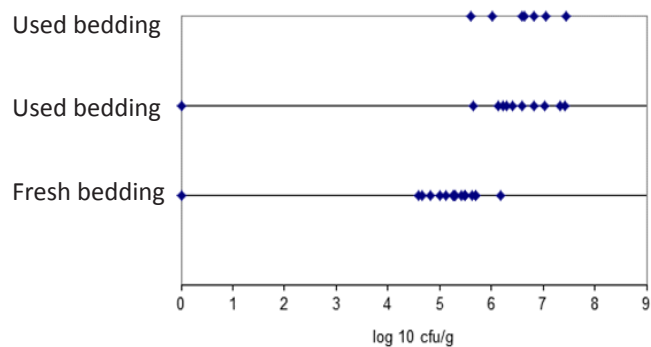


Figure 4: Total Coliform count (log cfu/g) in un-used RMS and used bedding from mattresses and deep beds. Samples from 16 farms.



Zero vales indicate < 10⁴ organisms/g

in counts from bedding applied on mattresses compared with those from deep beds (5-12cm deep) There were numerically higher counts of organisms in samples that were collected in damp weather, though the differences were not significant.

PERFORMANCE REVIEW OF CURRENT USERS

Data was collated and anonymised to allow a performance review of current users of RMS in the UK. Analysis was undertaken using somatic cell count and clinical mastitis records from ten and six farms respectively. Performance was compared with an anonymised cohort of dairy herds recording with QMMS. It was not possible to undertake a comprehensive analysis of the potential effect of the use of RMS given the short duration of time since adoption and the limited numbers of farms available. However, analysis suggested that the use of RMS is not necessarily associated with deterioration in udder health.

GAP ANALYSIS

A gap analysis was conducted and it was deemed that, in particular, more information is needed in the following areas (more specific details are available in main report):

- The presence of pathogens and their survival in slurry.
- Impact of the use of RMS on human and animal health including the long-term effects.
- Management of RMS on farm.
- Risk pathways associated with RMS use.
- Detailed economic analysis of RMS.

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