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Review

# Recycling manure as cow bedding: Potential benefits and risks for UK dairy farms

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ABSTRACT

Material obtained from physical separation of slurry (recycled manure solids; RMS) has been used as bedding for dairy cows in dry climates in the US since the 1970s. Relatively recently, the technical ability to produce drier material has led to adoption of the practice in Europe under different climatic conditions. This review collates the evidence available on benefits and risks of using RMS bedding on dairy farms, with a European context in mind. There was less evidence than expected for anecdotal claims of improved cow comfort. Among animal health risks, only udder health has received appreciable attention. There are some circumstantial reports of difficulties of maintaining udder health on RMS, but no large scale or long term studies of effects on clinical and subclinical mastitis have been published. Existing reports do not give consistent evidence of inevitable problems, nor is there any information on clinical implications for other diseases. The scientific basis for guidelines on management of RMS bedding is limited. Decisions on optimum treatment and management may present conflicts between controls of different groups of organisms. There is no information on the influence that such 'recycling' of manure may have on pathogen virulence. The possibility of influence on genetic material conveying antimicrobial resistance is a concern, but little understood. Should UK or other non-US farmers adopt RMS, they are advised to do so with caution, apply the required strategies for risk mitigation, maintain strict hygiene of bed management and milking practices and closely monitor the effects on herd health.



## Introduction

The concept of using material described as 'dairy waste solids', 'separated manure solids' or 'recycled manure solids' (RMS) as bedding for cattle (recently termed 'green bedding' in the UK) was established in the US in the 1970s (Keys et al., 1976; Timms, 2008a). Rising numbers of expanding housed US dairy herds increased the amounts of manure produced, but the ability to separate solid and liquid fractions using a screw or roller press facilitated handling the material.

The solid fraction of manure consists mainly of undigested fibres (Menear and Smith, 1973) and the potential of using this fraction as bedding material was explored initially in hot dry areas in the Western United States, in 'dry lot' dairies, where maintaining 'a high dry matter content' (Timms, 2008a) was easy. Due to concerns about high bacterial load, further processing steps were incorporated, initially composting, which aimed to reduce bacterial numbers by raising the temperature (Carroll and Jasper, 1978). Later, it became popular to use as bedding solid material extracted from the products of the anaerobic digestion of manure as a way of offsetting the cost of digesters (Timms, 2008b). Many combinations of separation, digestion and composting are now practised in the USA, allowing successful use of RMS bedding in cooler, wetter regions of the US (Timms, 2008a, 2008b, 2008c).

Increased marketing of high performance slurry separation machinery, that can produce separated manure solids with over 30% dry matter (DM), has generated interest in this practice in Europe, where there are very different climatic conditions (Zähner et al., 2009; Feiken and van Laarhoven, 2012; Marcher Holm and Pedersen, 2015). Livestock manures are Category 2 Animal By-products, as defined by EC Regulation 1069/2009. As such, their use as a 'technical product' (e.g. animal bedding) is only permitted if strict conditions apply which minimise the health risks involved. 'Safe end use' of a product derived from animal by-products is defined as use '*under conditions which pose no unacceptable risks to public and animal health*' (EC Regulation 1069/2009). Member State jurisdictions are approaching this requirement in different ways. In the UK, the Department for Environment, Food and Rural Affairs (Defra) and the

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Scottish Office have allowed the use of this bedding under controlled conditions, while research is carried out, while in Wales and Northern Ireland the practice is currently (May 2015) prohibited.

This review article considers in a UK context the scientific basis for the opportunities and challenges presented by RMS bedding. In view of the limited peer reviewed literature on the subject, we also draw on conference proceedings and unpublished research reports.

## Potential benefits

Farmers' interest in RMS is based largely on economics, availability and cow comfort and this is true in UK as elsewhere (Leach et al., 2014). Economic calculations must be made at individual farm level, considering the capital cost of equipment, management time and running costs, set against the purchase and management costs of current bedding materials. Availability is more under the farmer's control than when depending on an external bedding supplier. UK farmers, for example, perceive 'more comfortable cows', longer lying times and fewer hock lesions than on previous bedding materials including paper, sawdust, or even sand (Leach et al., 2014).

Physical attributes of RMS suggest potential advantages for cow comfort. It is soft, non-abrasive, and readily available. DM content appears to influence cow preferences; cows chose to lie less on stalls with 'dewatered manure solids' (29% DM), compared with 'dehydrated manure solids' (81% DM), and sawdust (81% DM), at equal depth (Keys et al., 1976). Cows have also shown preference for cubicles bedded with 'manure separates' compared to straw, sand and sawdust (Adamski et al., 2011). Longer lying times were recorded on three commercial farms following a change from mats to deep beds of RMS (Feiken and van Laarhoven, 2012).

RMS has advantages for hocks over mats with or without sawdust or straw (Zähner et al., 2009), or dolomitic limestone (Hippen et al., 2007). However, hock lesion prevalences when on RMS of 40–53% for deep beds (Zähner et al., 2009; Husfeldt and Endres, 2012), and 63–72% for mattresses (Husfeldt and Endres, 2012) have been reported. From a survey of 297 dairies, Lombard et al. (2010) reported a higher prevalence of severe hock lesions in cows bedded on dry or composted RMS compared with sand, straw and sawdust. The main advantage may be that farmers are willing to use more generous amounts of RMS (Leach et al., 2014); deeper layers of bedding have been associated with lower prevalence of hock (Brenninkmeyer et al., 2013) and claw lesions (Barker et al., 2009).

In support of farmer perception of cow cleanliness (Leach et al., 2014), Hippen et al. (2007) reported a trend for cleaner cows on RMS than on dolomitic limestone, and Timms (2008c) an 'improvement' in cleanliness on RMS from a previous, unspecified bedding material. Feiken and van Laarhoven (2012) found cows on RMS to be dirtier than those on sawdust or wheat straw, but cleaner than those on compost. However, visual cleanliness does not necessarily mean absence of pathogens, and, in view of the bacterial load of the bedding, close attention should still be given to pre-milking teat preparation (Endres and Husfeldt, 2012).

The lower dust levels reported with RMS compared with chopped straw or sawdust (Leach et al., 2014) or oat hulls (Meyer et al., 2007) may have benefits in terms of respiratory health for both animals and humans, and reduced transmission of pathogens via dust particles, but there is no information on the transmission of pathogens by aerosols related to this material.

## Risks posed by RMS used as bedding on dairy farms

The main potential risks of RMS bedding are to animal health, human health, product quality, and consumer perception. From the financial perspective of the farmer, there is also the risk of future prohibition if threats to animal or human health are deemed to be too high.

Based upon literature review and input by Defra (the UK 'Competent Authority') to a scoping study (Bradley et al., 2014), key microorganisms that should be considered are shown in Table 1. Lungworm and most intestinal parasites have not been included since these would be unlikely to complete their full life cycle in the manure, and experience with other farm species indicates that total confinement systems are not associated with high parasite burdens. Information to evaluate risk for viruses is extremely limited.

Tables 2 and 3 summarise the data available on pathogen load in RMS before use, after separation only, and after further processing, respectively. Table 4 summarises data on pathogen load for various used bedding materials, including RMS. These data illustrate the fact that, although bacterial counts in RMS as a raw material are high, counts in many other materials can reach similar levels once in use as bedding.

Any increased potential for development and perpetuation of antimicrobial resistance caused by recycling manure would have implications for both animal and human health. There is one report of an association between use of RMS and presence of antimicrobial resistant strains of *Salmonella* in cattle faeces (Habing et al., 2012).

### *Animal health risks*

No studies were found that directly related RMS use to clinical incidence or prevalence of any infectious disease other than mastitis. The three health conditions for which there is any more than a theoretical basis for consideration of the risks associated with RMS bedding are discussed below.

#### *Udder health*

In view of work that has linked risk of mastitis to pathogen numbers in bedding (Bramley and Neave, 1975; Carroll and Jasper, 1978; Hogan et al., 1989), RMS must be considered as at least a theoretical risk, based on the pathogen levels reported in the literature. However, evidence to quantify the risk of actual clinical outcomes compared with other bedding materials is limited, particularly from climates comparable to the UK.

Some case studies reported udder health problems, and others demonstrated no detrimental effects arising from changing to RMS bedding. Case studies in Italy (Locatelli et al., 2008) and the USA (New York State; Ostrum et al., 2008) have linked increases in environmental mastitis caused by *Escherichia coli* or *Klebsiella* spp. with separated manure solids that were stored before use. In three Dutch herds converting to RMS, no increased incidence of *Klebsiella* spp.-related mastitis or total cases of clinical mastitis was identified, although the concentration of *Klebsiella* spp. was higher in the RMS than in sawdust (Feiken and van Laarhoven, 2012).

On two American farms, Buelow (2008) failed to find a correlation between bacterial counts in RMS bedding and clinical or subclinical mastitis. Husfeldt and Endres (2012) reported a range of mastitis incidence of 9–109 cases per 100 cows per year on 34 farms in the American mid-West using RMS bedding. Cows were culled more frequently for mastitis on the study farms than in the national population, with mastitis being given as the most common cause of culling, compared with infertility for the national population.

Harrison et al. (2008) retrieved mastitis records and individual cow somatic cell count (ICSCC) data for six farms using different types of RMS bedding, but although mastitis incidence differed between 'experimental units' (farm/bedding strategy combinations), neither bacteria levels nor physical properties of bedding affected mastitis incidence. Prevalence of elevated SCC (>200,000 cells/mL for cows and >100,000 cells/mL for heifers) did not differ between three groups of animals kept on sand, separated and composted RMS on one of these farms. No detailed analysis has been made of ICSCC dynamics as cows are introduced to RMS bedding.