

MICROBIOLOGICAL ASPECTS OF RECYCLED MANURE USED IN DAIRY COWS BEDDING – REVIEW

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ABSTRACT

The economic and social value of cattle, especially dairy cows, is continuously increasing and is defined by the number of lactations during the production period or the milk yield of the individual itself. A significant influence on dairy production of dairy cows has housing comfort and therefore maintaining the quality parameters of the dairy farm is essential. The decreasing availability and increasing costs of traditional underlining materials have increased interest in finding and using alternative materials for underlaying. In this review, we focus on the separated fraction of livestock manure, which, after hygienization, can be a suitable bedding material for dairy cows. We identify possible negative impacts and risks in the context of human or animal health. This article also identifies pathogenic microorganisms that can initiate inflammation of the mammary glands in dairy cows and thus reduce the quality of final food products. Farmers using recycled livestock manure as bedding, reduce the total amount of nutrients which become part of the manure stream due to no net addition of nutrients in the form of bedding, thus increasing potential compliance with environmental regulations.

Keywords: cow manure, pathogen microorganisms, recycled slurry

INTRODUCTION

The livestock sector is an important part of agriculture in both developed and developing countries around the world. However, there are significant differences, where the livestock sector in developing countries has a better chance of increasing the value of livestock due to growing demand, while in industrialised countries we observe that such demand stagnates. However, the fact remains that livestock currently represent a global asset, accounting for more than 40% of global agricultural markets (WHO, 2017; Scarlat *et al.*, 2018). The World Food and Agriculture Organization (FAO) documents state that the global human population will increase from 7 billion today to more than 9 billion by 2050. This means an increase in overall demand, especially for milk, meat and eggs. It is therefore essential to increase attention to biosecurity at farm level. Biosecurity includes all actions that prevent the entry of pathogens, eliminate the development of potentially harmful microorganisms and prevent the spread of disease on the farm. It is clear that animal health is directly related to food security and therefore global policies should accept the fact that animal diseases are not a region or country problem but may pose a global risk (Rowbotham and Ruegg, 2016). With the rapid development of the cow breeding industry, intensive, large-scale farming has gradually increased. Although the development of intensive dairy farms provides high-quality milk for the market, manure and sewage from dairy cow farms are causing increasingly serious pollution to the environment, which hinders sustainable development in the dairy industry (Li *et al.*, 2018). Society also perceives livestock manure as a risk that pollutes the air or drinking water sources, while the increased accumulation of nitrogen and phosphorus concentrations in watercourses is a societal problem. The increase in air pollution is in turn attributed to emissions of ammonia and greenhouse gases such as carbon dioxide and methane, respectively. Livestock manure can contain high concentrations of various pathogenic microorganisms. There is therefore the question of the negative impact on the health of dairy cows, the development of mastitis or the quality of milk, which can immediately endanger the health of consumers (Bolán *et al.*, 2010; Liu *et al.*, 2019).

Recently, interest in the use of livestock manure as an alternative renewable energy source has increased radically. This is due to the ongoing economic and environmental problems faced by farmers and national governments (Demirer and Chen, 2005). Today, the possibilities of using recycled livestock manure as a material for cattle are being intensively studied, with the first mention of this concept dating back to the 70s (Keys *et al.*, 1976). Due to concerns about increased microbial load, additional treatment steps such as composting have been implemented in the technology for preparing recycled manure. His goal was to reduce the number of bacteria by increasing the temperature (Carroll and Jasper, 1978). Later, digestate, a solid material extracted from anaerobic digestion products of livestock manure, began to be used as bedding material (Timms, 2008a). We currently recognize many combinations of separation, digestion and

composting, allowing the successful use of recycled manure bedding (Timms, 2008b). Although this concept has strong support from farmers for objective reasons, it is important to note that livestock manure is a category 2 animal by-product and, according to European Commission Regulation (EC 1069/2009), its use is only possible if strict hygiene conditions apply and there are no unacceptable risks to public and animal health.

Potential of recycled livestock manure

Modern dairy production is not only concerned with ensuring massive milk production, but also with ensuring perfect health and comfort of dairy cows. The overall cost of dairy production is increasing, so farmers have started looking for various alternatives that would lead to a significant reduction in input costs. The ideas of greening the production or recycling of some resources, including livestock manure, gradually began to come to the fore (Bewley *et al.*, 2017). Many farms around the world have therefore begun to address the issue of using treated and recycled livestock manure as bedding material. In addition to treading materials such as concrete, sawdust, sand or straw, procedures are gradually being implemented that would ensure the creation of hygienically safe and health-friendly subshipment material from buttery manure without negative impacts on animal health, product quality or consumer health (Ferraz *et al.*, 2020). Recycled bedding from cows' dung is prepared through a multi-step process that begins with the collection of solid mass - cow's manure. It consists of bedding straw and residues of silage or haylage. Together with liquid components, they are transported by pipe to the tank-fermenter. Subsequently, the mixing of both components starts to run, and the fermentation of mass occurs over a few weeks. The material mixture is regularly turned over until the temperature increases above 55°C. Treated dung can be rendered harmless if the fermentation temperature exceeds 55°C for 5 to 7 days during the treatment process (Niu *et al.*, 2022). After the time has passed, the mass in the fermenter is moved to the separator, where the liquid part is separated from the denser component. The next phase of the denser fraction of the process is sanitization, during which it is dried at a temperature of 60–80 °C and hygienically treated. The resulting by-product is a separate, which is repeatedly used for bedding the beds in the stables.

Benefits & Risks of recycled butter manure

The representation of individual types of bacteria in materials that are used as ordinary bedding material in stables for livestock and especially cows is significantly diverse. The differences are due to various factors such as particulate size, dry matter content, pH and other exogenous influences are also taken into account (Hogan *et al.*, 1989; Ward *et al.*, 2002). The population of bacteria in the litter material can significantly influence the health of animals as well as the quality of the resulting products. Many scientific studies have confirmed that poor-quality

bedding material (Hogan et al., 1999) can initiate the development of pathogenic microorganisms and cause clinical mastitis in cows.

To counteract these negative impacts, chemical disinfectants began to be used, which were added to the organic materials of the litter and thus inhibit the growth and development of pathogens. In addition to the financial complexity and complicated management of application security, the persistence of the antibacterial effect was also problematic (Tančin and Tančinová, 2008). The innovative technological approach of livestock manure treatment has significant economic benefits, while we can talk about a significant increase in the comfort of cows. In particular, farmers perceive longer lying time, fewer injured hooves and a decrease in the incidence of mastitis in dairy cows. Recycled livestock manure has more suitable physical properties, is soft, non-abrasive and readily available (Leach et al., 2014). Other studies report that farmers perceive greater cleanliness of cows. However, visual cleanliness does not necessarily mean the absence of pathogens, and due to the bacterial load of the litter, great attention should be paid to the udder before milking (Endres and Husfeldt, 2012). From the perspective of cows' respiratory health, lower levels of dust particles in the environment have been observed when compared to straw or sawdust, which may ultimately reduce pathogen transmission via dust particles (Leach et al., 2014).

Impact on animal health

To date, there have been several studies that have investigated the correlations between the occurrence of pathogenic microorganisms and bedding material in cattle lairage. Individual risks, which are linked to the quality parameters of the subconsignment material, relate primarily to the animal health itself, the quality of products or the health of the consumer and the entire population (Bradley et al., 2014). In the context of recycled livestock manure, several key microorganisms that may pose potential risks to animal health have been identified (Table 1).

Table 1 Occurrence of microorganisms in consideration of potential animal health risks

Bacterial pathogen	Impact on	Risk of occurrence	Experimental data sources
<i>Escherichia coli</i>	AH	High	Harrison et al., 2008
<i>Mycobacterium avium subsp. paratuberculosis</i>	AH	relatively high	Timms, 2008b,
<i>Salmonella spp.</i>	AH	Medium High	Meyer et al., 2007
<i>Streptococcus uberis</i>	AH	High	Zehner et al., 1989
<i>Bacillus cereus</i>	AH	relatively high	Feiken and van Laarhoven, 2012,
<i>Klebsiella spp.</i>	AH	Medium	Feiken and Van Laarhoven, 2012, Hogan et al., 1999

AH – animal health,

Currently, there is no direct and conclusive evidence to suggest a direct correlation between the use of recycled manure and the clinical occurrence of mastitis in cows. However, it is necessary to point out the theoretical risks that may arise in the event of inadequate hygienization of a recycled consignment (Locatelli et al., 2008; Leach et al., 2015). Some studies suggest that the use of recycled manure acidifies udder inflammation caused by *Escherichia coli* or *Klebsiella spp.* in several dairy cows. However, many studies have shown no harmful animal health effects associated with recycled bedding (Locatelli et al., 2008; Ostrum et al., 2008). Feiken and Van Laarhoven (2012) even found that although an increased prevalence of *Klebsiella spp.* in recycled manure was detected, an increased incidence of mastitis manifestations in dairy cows was not demonstrated. An important indicator of the quality of milk is its total number of somatic cells. Of course, this can be influenced by many endogenous or exogenous factors, while the quality of the lining material plays an important role. Studies conducted to date (Harrison et al., 2008; However, Husfeldt and Endres, 2012) do not suggest that there is a reduction in the number of somatic cells in milk or a decrease in milk quality in dairy cows with recycled bedding. In addition to the problems mentioned above, there is a risk of *paratuberculosis*, which is associated with the appearance of bacteria *Mycobacterium avium subsp. paratuberculosis*. This intracellular pathogen attacks the cells of the immune system, and its incubation at home can exceed even 3 years. At low temperatures, it can survive for up to 250 days (Elliot et al., 2015). Interesting results were provided by Bonhot et al. (2011), which

showed a significant reduction in the number and survival of *Mycobacterium avium subsp. paratuberculosis*. Evidence on the safety and benefits of recycled livestock manure has been provided by Timms (2008b) and Adamski et al. (2011), who report that foot and leg health as well as lameness has been significantly improved by the introduction of recycled submission. The hooves of dairy cows were dry, without lesions or incidence of hoof diseases. In the context of the use of recycled livestock manure as bedding material, a study by Habing et al. (2012) raised the question of the possible development of antimicrobial resistance. Recycled litter circulates in the "closed cycle" of the housing environment in close contact with cattle as well as humans. This is in violation of the usual manure manure accumulation, which is applied to the fields, and under the influence of exposure to external conditions, the degradation of pathogenic microorganisms occurs. However, there is a lack of expert information on how this "closed cycle" will affect the virulence of pathogens to the genetic material transmitting antimicrobial resistance. However, for the time being, there is evidence that at least one resistant strain of *Salmonella spp.* isolated from faeces is more likely to use a subconsignment of composted or dried manure.

Impact on human health

In terms of identifying risks arising from the use of recycled bedding and impacts on the health of farm workers, there is very little evidence available for a possible correlation. It is believed that the application of protective equipment, dust reduction, special preventive hygiene practices and milk pasteurisation are crucial strategies for reducing health risks for farmers. At the same time, it is important to monitor the emergence of key pathogens *Salmonella spp.* and *E. coli* (especially O157), which can initiate a wide variety of human health problems. Although their incidence may be higher in the case of recycled livestock manure bedding, elimination is well researched, and the relative risk can be eliminated by technologically correct pasteurization. In the case of transfer of microorganisms from the subconsignment to milk, significant changes were noted not only in the abundance of macro and microelements in milk, but at the same time its reduced shelf life was confirmed. This aspect of quality is mainly influenced by thermophilic and mesophilic bacteria or aerobic spores (Driehuis et al., 2012). A significant risk of microbial pathogens in recycled manure was demonstrated in this analysis the same authors. The zoonotic pathogen *Bacillus cereus* is transmitted through food and can also survive heat treatment. Elevated spores of *Bacillus cereus* have been detected mainly in samples of recycled livestock manure used for bedding, so this fact cannot be ignored. At the same time, however, the authors did not identify a condition where elevated levels of this pathogen would be confirmed only in bedding made of recycled manure compared to straw or sawdust for submission. In Table 2, we provide an overview of pathogens of recycled bedding affecting human health and food quality.

Table 2 Occurrence of microorganisms in consideration of potential, human health risks and food quality

Bacterial pathogen	Impact on	Risk of occurrence	Experimental data sources
<i>Mycobacterium avium subsp. paratuberculosis</i>	HH	relatively high	Harrison et al., 2008
<i>Bacillus cereus</i>	HH, FQ	High	Driehuis et al., 2013
<i>Salmonella spp.</i>	HH	High	Timms, 2008b
<i>Mesophilic spore</i>	FQ	High	Driehuis et al., 2013
<i>Escherichia coli</i>	HH	really high	Harrison et al., 2008
<i>Thermophilic spore</i>	FQ	Medium High	Driehuis et al., 2013

HH – human health, FQ – food quality

CONCLUSION

Recycled livestock manure can currently be a very suitable alternative sub-material for cattle for farmers. The advantages in terms of availability, comfort and, in some cases, economic benefits are clearly the strengths of this material. Although the literature currently provides limited evidence of absolute benefits, there are several advantages over many abrasive materials. A sensitive issue that requires an urgent solution is the prevalence of clinical or subclinical mastitis in cows in the context of the use of recycled subshipment material, as well as the impact on quality parameters of milk or population health. Although much evidence has shown that

this bed is harmless, many other pieces of evidence contradict each other. If farmers decide to accept recycled livestock manure bedding, they are advised to do so carefully, apply the required risk mitigation strategies, maintain strict bed and milking hygiene, and closely monitor the health of the entire herd.

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