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Future perspectives of using recycled manure on dairy farms

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Abstract

Agriculture is inextricably linked with the production of not only the main types of food products, but also a significant amount of waste. Therefore, the main task of modern agroengineering today is to develop or test new, more efficient and environmentally friendly agricultural technologies based on the intelligent use of natural resources. Problems with livestock manure are well known to experts, but the rest of the population is practically unaware of them and considers them insignificant. Since its production is constantly growing and negatively affects the state of the environment, it is important to set up effective measures that will be sustainable and financially acceptable in the long term. Recycling livestock manure with subsequent use as bedding is the right ecological way to use livestock manure.

1. Introduction

Dairy cattle housing has changed in modern dairy farming from stanchion barns, through free-stall mattress bedding barns, and compost bedded-pack barns to free-stall harmless-recycled manure bedding barns (Bewley *et al.*, 2017). Along with the changes in cattle housing, bedding materials have changed. Recycled manure solids, fermented manure, and treated dung have become more popular materials in recent years, opposite to conventional ones like concrete, sawdust, straw, or sand as well (Ferraz *et al.*, 2020). Calves on the farms are the most important article in the animal sector of agriculture, and the future of farms simultaneously. The calving phase is the time when cows develop the fastest, and how it is managed can have an impact on lactation, calving months, and reproduction (Krpáľková *et al.*, 2014). It has already been proven in the past, that Calves' behaviour, development, and health are all directly correlated with the bedding materials used. Hard bedding materials, such as concrete, diminish lying duration and alter the calves' daily distribution behaviour pattern and rhythm of lying down (Panivivat *et al.*, 2004, Camiloti *et al.*, 2012). It means that low-quality bedding materials stress calves while they breed pathogenic microorganisms that can be detrimental to the health of the calves. Common factors, such as temperature, pH changes, or wet bedding can cause, that Calves' heat stress will progressively affect the health status, and production parameters of dairy cattle (Kovács *et al.*, 2020). With this in mind, the right bedding management is important to reduce the health risks from environmental sources as well as other negative factors, that could initiate mastitis and negatively affect a cow's health status. The bedding used on the farm will depend

on availability and cost, as well as cow housing and slurry handling facilities. There are two main types of bedding materials used for dairy cows: Organic materials, including straw, sawdust, wood shavings, paper-based products, and recycled manure solids—inorganic materials, such as sand and chalk. Organic material can be used as a source of food by bacteria, especially if some milk leakage is added. Inorganic material (sand) contains no or fewer nutrients unless it is contaminated with organic material, such as manure or milk. If inorganic bedding is not well managed, it soon becomes organic with faecal contamination. A comparison between different types of bedding materials is difficult, but it is generally accepted that clean inorganic materials are better to prevent mastitis and should be used, wherever possible. Good bedding and cubicle management are critical to minimising risks and successfully using any bedding material. Bacteria multiply faster in damp and warm conditions. All types of bedding used must be as dry as possible (Rendos *et al.*, 1975; Van Gestelen *et al.*, 2011). Ideally, the bedding material should be clean and practical before use. Keeping the material dry could be ensured by storing it under a roof. Covering with plastic often results in mould formation and bacterial growth due to condensation. It is important to prevent the litter from absorbing moisture from a (damp) surface. In this case, it is possible to use a layer of gravel under it. If you want to use sand should be stored under a waterproof cover or sheet to keep it clean and dry. Straw and sawdust should be stored under a waterproof cover and kept dry at all times (Wolfe *et al.*, 2018).

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2. Characteristics of animal manure

Manure contains many useful and recyclable components, which are presented in Table 1. The physical and chemical characteristics of animal manure will impact its potential use particularly as a fertilizer and the ease with which it would be handled. According to **Malomo et al. (2018)**, animal manure can be categorized based on their consistency or moisture content into liquid manure (up to 5% solids), slurry and semi-solid manure (between 5 and 25% solids) and solid manure (more than 25% solids). In view of high variability in consistency, physical structure and chemical composition of animal manure from one location to other, preference should be given to locally derived manure characteristics.

Table 1. Beneficial uses of manure (**Malomo et al., 2018**)

Manure component	Beneficial uses	Advantages
Nutrients	compost, fertilizer, animal feed, soil amendments,	cost savings on fertilizer and income generation from sales of manure
Organic matter	soil amendments	improves soil structure and water holding capacity, impact on crop yield
Solids	Bedding	saving on cost of bedding materials
Energy	biogas, biooils, and syngas	supplementary energy for farm use, reduced reliance on fossil fuels,
Fiber	peat substitute, paper, and building materials	potential environmental liability turned into useful commodities

3. Recycled manure solids

In addition to the above-mentioned traditional bedding materials, due to the increase in economic costs, alternative sharing practices have begun to emerge for dairy cows, while the use of recycled livestock manure is significantly increasing. Due to the significant limitation of some natural resources, the management of this product will have great potential in the future. Manure recycling with subsequent use for bedding is already one of the modern technologies. National regulations do not specify requirements for currently used types of bedding, including manure-based litter. However, foreign experience shows several economic, zootechnical and hygienic advantages of this material. Farmers using recycled manure solids, in contrast to other organic bedding types, 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 regulation (**Husfeldt and Endres, 2012**). According to **Bradley et al. (2014)**, this material offers several benefits for cows, including greater hygiene, less hock lesions, and increased comfort. Although fermented treated dung is a well-liked bedding material due to its affordability, accessibility, and recyclable nature, its common usage is constrained by poor information, and insufficient experimental proof in this area. Concerns began to arise, that fermented treated dung/recycled dung bedding could contain a higher number of pathogenic microorganisms. It means, that the risks associated with cow health problems and infections development would be higher compared to the straw bedding poses (**Beauchemin et al., 2022**). However, previous studies confirmed that bacterial counts in recycled dung bedding are

comparable to those in many other bedding materials. Farmers are hesitant to employ recycled dung for sheltering calves as a result of these contentious results (**Leach et al., 2015**).

4. Manure recycling & emission

Emissions to air and water bodies are to a certain extent an unavoidable consequence of the recycling of livestock manures within agriculture. Emissions arise from biological, chemical and physical processes associated with the degradation of organic materials during animal digestion, treatment, storage and after land application. Of particular regional and/or global importance are nitrous oxide (N₂O), methane (CH₄) and ammonia (NH₃) emissions to the atmosphere, and nitrate (NO₃⁻) leached to watercourses (**Weiske et al., 2006**). Agriculture is a major source of the three gases, for which national ceiling targets (NH₃) or target emission reductions (CH₄ and N₂O) have been established. Nitrate leaching contributes to eutrophication and may pose a threat to drinking water quality. Of more local concern are emissions of odorous compounds. Much research has been aimed at quantifying emissions from the various sources within the agricultural production system, and at understanding the key influencing processes (with the associated development of models at a range of scales and complexities) and developing mitigation measures. Research has often been focussed at the source level (e.g., NH₃ emissions from slurry storage) with the aim of establishing emission factors and assessing potential mitigation measures for that source. However, it is important that the whole-farm perspective is borne in mind, and that interactions such as secondary impacts on emissions from other sources and emissions of other pollutants are considered (**Webb and Misselbrook, 2004**).

5. Practical management of recycled livestock manure

The current scientific basis of information for the practical use of RMH on farmers' farms is severely limited. However, some previous studies (**Harrison et al., 2008**) suggest that proper and especially regular care has a more significant influence on the bacterial load of litter than the type of litter itself. However, RMH has some specifics, such as a higher initial pathogenic load or a higher capacity for water absorption/release. Farmers must also be aware of possible differences in the microbiological profile of pathogens depending on the climatic conditions of individual farms. It follows that uniformity of practical management in the use of RMH as bedding does not exist and therefore the accuracy of procedures is not guaranteed (**Webb and Misselbrook, 2004**). Although in general RMH should not be stored in a compacted covered pile, the total number of *Escherichia coli* or *Klebsiella spp.* did not increase significantly after 6 weeks (**Feiken and van Laarhoven, 2012**). An important question for farmers is whether to use RMH on mats, mattresses or in deep bedding. Deep bedding is likely to improve the physical comfort of dairy cows, but at the same time it will affect the environment in favor of the development of pathogenic microorganisms. On the other hand, shallow beds and frequent litter changes may provide better control of the development of coliforms (*Klebsiella spp.*), however, streptococci counts are likely to be higher (**Husfeldt et al., 2012**). Interesting information was provided by a study by **Schwarz et al. (2010)**, and **Schwarz et al. (2011)** who compared daily and weekly addition of RMH to a lagging area with deep litter. The conclusions of the study showed that the time of year had a more pronounced impact on the microbial profile of the lagging than the frequency of litter changes. It follows that a daily change of litter from RMH does not necessarily reduce the development of pathogenic microorganisms or affect the onset of mastitis

compared to weekly litter. Given the limited scientific evidence on optimal management of RMH work in lagerhood, it is clear that this area requires further research and the formulation of unambiguous conclusions and recommendations for practice.

6. Conclusion

Livestock manure management is a multidisciplinary task, therefore it is not possible to fully discuss all related factors in this document. For example, the integration of manure processing technologies with agronomic and economic aspects should be discussed on the basis of regional requirements. Future research is still needed to establish a systematic framework that guarantees the effective implementation of livestock manure management from a technical, environmental, agronomic, economic and social/health point of view.

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