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LIVESTOCK WASTE MANAGEMENT PRACTICES

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Abstract
The report focuses on livestock waste management, which is a key aspect of sustainable agricultural development. Animal waste, including excreta, bedding materials, waste feed, dead animals, and other by-products, represents a significant environmental pollutant. Proper management of this waste is essential not only for environmental protection but also for reducing farm costs, creating new market opportunities, and increasing the sector's competitiveness. The adoption of innovative practices in livestock waste management is a modern solution aimed at transitioning towards a circular economy and supporting the European Union's green policies.
The main methods for effective waste management include anaerobic digestion and pyrolysis. Anaerobic digestion is a process that occurs in the absence of oxygen and allows for the conversion of organic waste into biogas. This biogas can be used as a renewable energy source, significantly reducing pollution and decreasing reliance on fossil fuels. Another important by-product of the process is biosolids, which can be utilized as fertilizers to improve soil fertility. Pyrolysis, on the other hand, is a thermal decomposition process of biomass without oxygen, producing bio-oils and biochar, which also have applications fuels and soil conditioners.
The report highlights the social, economic, and environmental benefits of proper livestock waste management. Effective waste utilization contributes to improving soil structure, reducing methane emissions, and limiting water pollution. One of the most common methods of waste management is the application of manure to agricultural lands, which enhances the organic content of the soil. However, improper or excessive use of manure can lead to nutrient overload and environmental contamination, underscoring the need for precise management.
Innovations such as the use of artificial intelligence and blockchain technologies provide new opportunities for process optimization. These technologies help farmers manage resources more efficiently and reduce the negative impacts on the environment. The report concludes that integrating technology, improving regulatory frameworks, and investing in farmer education are essential for sustainable livestock waste management. By adopting these measures, livestock waste can be transformed into a valuable resource, supporting both agricultural sustainability and the global circular economy.
Key words: agriculture, environment, innovation, waste management
JEL: O3, Q1, Q53.

Introduction

The expansion of agricultural production naturally leads to increasing amounts of livestock waste, crop residues and by-products from the agricultural industry. It has

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been suggested that agricultural waste contributes to a significant proportion of the total waste in the developed world and pollutes the environment to the highest extent (Obi et al., 2016). Livestock wastes are found in different states – gas, liquid and solid wastes.

Proper management of animal waste can:

- improve the state of the environment;
- reduce farm costs;
- open up opportunities for new markets;
- increase the competitiveness of livestock farming as a sector.

The application of innovative practices, artificial intelligence, blockchain technologies, etc. in livestock waste management are good examples of modern solutions to the problem (Georgieva, 2023). The exploitation of resources should not exceed their regenerative capacity, and the disposal of waste should not exceed the capacity of the environment to absorb it (Atanasov, 2023). Good implementation of environmentally sound practices is key to achieving all the objectives of the CAP and in particular the environmental (Blagoev, 2022).

The goal of this report is to present some practices that can and are being applied in the livestock industry to reduce and/or convert operational waste into products of value.

Livestock waste includes:

- excreta mixture (manure);
- bedding material (sawdust, straw);
- waste feed;
- dead animals;
- broken eggs, feathers;
- and another farm waste.

In modern livestock farming, increasing attention is being paid to alternative ways of recovering waste from the operation, with pollution control being the main objective. Waste can be fully and completely utilized, but as livestock farming and the environment interact constantly, accurate waste management is essential to avoid harmful effects on nature and man. Livestock waste emits large quantities of carbon dioxide and ammonia, which can contribute to:

- ACID rain and the greenhouse effect;
- pollution of water sources;
- the spread of infectious diseases.

Social tensions over bad smells and water pollution can build up when livestock waste is discharged into water sources in an unplanned manner. Efficient utilization of animal waste from large farms is necessary to curb pollution and spread of diseases (Parihar et al., 2019).

The benefits of proper livestock waste management are:

- maintaining soil fertility in soils with insufficient organic content. Adding manure to soil increases nutrient holding capacity, improves the physical condition of the soil by increasing its water holding capacity, and improves soil structure;
- creating a better climate for soil microflora and fauna;
- using manure as fuel;
- producing energy from manure;
- reducing post-harvest losses;
- reducing the source of infection for animals and humans;
- reducing the source of methane emissions;
- reducing environmental pollution and odors;
- reducing the harmful effects of flies;
- reducing the loss of organic matter;
- reducing illegal dumping of waste, which poses a direct threat to soil quality and water sources;
- improving soil fertility, the nitrogen in manure is fixed in its organic state until, through decomposition, it is converted to a soluble form – ammonium nitrate (FAO, 2009).

Bioenergy sources are increasingly attracting attention as a sustainable energy resource that can help address challenges such as:

- growing energy demand;
- rising fuel prices;
- providing substitutes for expensive fossil fuels.

Biogas from animal waste provides renewable and environmentally friendly sources that support sustainable agriculture. In addition, the by-products from the "fermenters" provide premium quality organic waste (Arthur, Baidoo, 2011).

Practices for livestock waste processing

The effectiveness of waste management in livestock production is a multifaceted variable that is influenced by technological advances, regulatory frameworks, socioeconomic considerations, and the unique characteristics of regional farming practices. The implementation of resource efficiency practices in livestock production is inextricably linked to the effectiveness of waste management. Technological innovations, regulatory frameworks, circular economy principles, economic considerations, social dimensions, and geographic context all influence the success of resource efficiency initiatives (Wang'ombe, 2023).

Biomass energy is renewable, sustainable and environmentally friendly, derived from renewable sources such as agricultural and municipal waste. Biomass can be converted into gaseous fuels using various methods such as anaerobic digestion and gasification or converted into a form of energy – biofuel (Mathew, Zakaria, 2015).

Anaerobic digestion (a biological process for converting waste materials into biogas in the absence of oxygen) is the most efficient way to convert waste into resources and is an alternative technology for energy production It is a natural process that occurs in many places in nature:

- at the bottom of bodies of water;
- in the bodies of ruminants;
- in soils, etc. (Tufaner et al., 2017).

The two main by-products of anaerobic digestion are gas and solid – biogas and biosolids. Gas is a natural by-product and manure is a by-product of bioreactors processing biodegradable waste. As a stable carrier, biogas is usually composed of methane (35-40%) and carbon dioxide (60%) and various other gases such as ammonia, hydrogen sulfide, hydrogen, oxygen, nitrogen, and carbon monoxide (Sun et al., 2015). The biogas production process is affected by temperature, pH, volatile fatty acid content, etc. Good control of these factors determines the quality and quantity of biogas produced. The production of biogas from animal waste is an important step towards the utilizations of one of the most widespread but still underused energy sources. Anaerobic digestion is an environmentally friendly method leading to the production of energy in the form of biogas and residue which could be used as soil conditioner (Dhanalakshmi Sridevi, Ramanujam, 2012).

The advantages of anaerobic digestion of waste are:

- less number of odors emitted;
- reduction in the number of pathogens;
- use of decomposed organic waste as manure (Iglinski et al., 2015).

The increase in the number of livestock heads raised, respectively, increases the amount of waste from livestock farms, which in turn increases the risk of air and environmental pollution. Anaerobic digestion is an example of a cost-effective way to dispose of animal waste and reduce dependence on fossil fuels (Mulka et al., 2016).

Thermochemical conversion of biomass to produce various solid, liquid and gaseous products can be carried out by pyrolysis, a method in which the organic matrix undergoes direct thermal decomposition in the absence of oxygen. The thermal decomposition behavior of different biomasses affects the composition of the bio-oil and its production rate (Yang et al., 2014). Pyrolysis, is a complex process consisting of many steps and depends on:

- temperature;
- oxygen content;
- the composition of the introduced biomass (due to oxidation).

Pyrolysis can be an exothermic process, but due to reduction processes it is mostly endothermic. For most biomass species containing oxygen-rich hemicellulose, decomposition is endothermic below a temperature of about 400 – 450 °C and exothermic above this threshold (Lewandowski et al., 2020). From an economic point

of view, the proportion of the liquid fraction in biomass pyrolysis products should be the largest (Kowalik, 2008), (Popczyk, 2008). In the pyrolysis process, biomass decomposes at high temperature in the absence of oxygen (Lim et al., 2012). Not only the value of temperature but also the rate of its increase affects the course of thermal decomposition as well as the composition of the products of the process, therefore pyrolysis is divided into slow, fast and flash processes (Bridgwater, 2012). The flash pyrolysis process is preferred for processing biomass into liquid fuel, e.g., bio-oil, while the slow pyrolysis is used for biochar production (Pragya et al., 2013), (Mahlia et al., 2019).

The most widespread practice for animal waste management is the spreading of animal manure (solid and/or liquid) into the soil. The advantages of animal waste fertilization are:

- soil properties are improved;
- supply nutrients needed for the growth of the crops grown;
- increases the organic matter content of the soil.

A disadvantage of this method is the risk of using excessive amounts of manure, which leads to a build-up of nutrients in the soil. A certain amount of the nutrients present in manure can be used by plants to regulate various physiological processes, but the excess nutrients end up in the surrounding ecosystem and cause environmental pollution. In order to improve the sustainability of manure management, researchers worldwide have been focusing on developing and testing various biological, physical and chemical processes to treat the highly polluted waste streams from livestock production over the past few decades (Chowdhury et al., 2020).

Conclusion

Addressing the problem of waste and by-products in a sustainable and environmentally friendly way is a crucial issue for the agricultural production and food industry. The generation of increasing amounts of waste, including from animal husbandry and animal product processing, raises questions about its management, minimization and the search for ways to recover it. Livestock farms generate a large amount of animal waste. Managing manure as a resource can bring benefits to livestock farmers. Livestock waste management helps to maintain soil fertility in soils with insufficient organic content. Effective management of livestock waste helps to enhance the socio-economic status of developing countries as well as reduce the likelihood of spread of diseases from waste. The effective utilization of livestock waste can be achieved through the development of an integrated methodology for its management, by implementing various policies and strategies with a priority on ensuring consumer health and environmental quality.

Livestock, as an integral part of global agriculture, is facing increasing and serious challenges related to waste management and resource use. The following recommendations can serve to address, if not all, then a large part of them:

- promote precision agriculture technologies;
- improving the regulatory framework;
- integrating circular economy principles;
- investment in farmer training;
- information campaigns;
- research and development initiatives.

Farmers who are willing to process farm waste innovatively largely lack the necessary information and/or experience. For other farmers, it is necessary to explain that waste has an added value when properly treated. With good planning, proper infrastructure and proper financing from banking institutions, farmers can find new uses for livestock waste.

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