

REVIEW ARTICLE

Development status and trend of livestock and poultry manure composting technology and equipment

Jiajia Su, Fengming Li*, Wei Li, Xiaohong Gao, Wei Guo, Jinhai Luo

Hohhot Branch of Chinese Academy of Agricultural Mechanization Sciences Co., Ltd., Hohhot 010020, Inner Mongolia Province, China

* Corresponding author: Fengming Li, lifeman_ok@126.com

ABSTRACT

The technological process of livestock and poultry manure composting and various composting technologies and equipment are briefly described. The development trend of livestock and poultry manure composting technology and equipment was analyzed. It can be seen that the technical equipment of livestock and poultry manure composting is an effective way to solve the problem of aquaculture manure disposal. Promote green development and the ecological cycle and provide references for the design, production, and application of livestock and poultry manure composting technology and equipment.

Keywords: transgenic plants; crop breeding and improvement; safety of genetically modified food

1. Introduction

With the rapid development of my country's economy, the scale of the livestock and poultry breeding industry is also getting larger and larger, and the number of breeding industries is in a state of continuous increase, so the production of livestock and poultry manure is also increasing. The treatment of manure has gradually become the focus of work. In the actual operation of large-scale aquaculture, the use of scientific and reasonable methods of manure treatment plays a crucial role in the operation of the farm^[1-3]. According to the data of the Ministry of Agriculture and Rural Affairs, by 2020, the utilization rate of livestock and poultry manure resources in my country will reach 75%, and the matching rate of livestock and poultry manure treatment equipment in large-scale farms will reach 93%^[4-6]. The comprehensive utilization of livestock and poultry manure resources can be classified into three categories: one is fertilizer, which is needed for crop growth; the other is feed, which is needed for animal growth; and the third is energy, which is needed for production and life. Among them, fertilization is the main method of comprehensive treatment of livestock and poultry manure, accounting for 60% of the comprehensive utilization of manure resources, and composting technology accounts for the vast majority of the fertilizer treatment technology for livestock and poultry manure resource utilization^[7-10]. Livestock excreta contains many useful substances, such as minerals and organic matter. After the treatment with composting fermentation technology at high temperatures to kill the harmful substances in the manure, the organic matter will be decomposed into humus. Then, combined with a

ARTICLE INFO

Received: 11 November 2022 | Accepted: 1 December 2022 | Available online: 30 December 2022

CITATION

Su J, Li F, Li W, et al. Development status and trend of livestock and poultry manure composting technology and equipment. *Advances in Modern Agriculture* 2022; 3(2): 2045. doi: 10.54517/ama.v3i2.2045

COPYRIGHT

Copyright © 2022 by author(s). *Advances in Modern Agriculture* is published by Asia Pacific Academy of Science Pte. Ltd. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<https://creativecommons.org/licenses/by/4.0/>), permitting distribution and reproduction in any medium, provided the original work is cited.

certain amount of compound microfertilizer, compound organic fertilizer can be made. Organic fertilizer can be used in field crops to promote their growth.

In order to develop the treatment method of mechanical livestock manure, many scholars have studied the mechanical treatment technology and equipment of livestock manure. Fan^[11] studied the comprehensive utilization technology of livestock and poultry manure resources and elaborated on the mode, technological process, and management points of the comprehensive utilization technology of livestock and poultry manure resources. Zhao et al.^[12] studied the fermentation technology and equipment of manure composting for livestock and poultry and analyzed the working principles and characteristics of different composting technologies and equipment. Sun et al.^[13] analyzed the technical mode of manure resource utilization in livestock and poultry breeding and compared the different modes and characteristics of manure resource utilization. Geng et al.^[14] studied the design and application effects of small rapid fermentation devices and designed and developed rapid fermentation treatment equipment. Wang et al.^[15] studied manure treatment methods on large-scale cattle farms, and the results showed that the comprehensive implementation of healthy breeding of livestock and poultry has become an inevitable trend in the development of the modern livestock and poultry industry.

In the waste resource utilization industry of the livestock and poultry industry, the mechanization treatment of livestock and poultry manure is the first thing to be realized. This paper discusses the present situation and development trend of manure composting technology and equipment for livestock and poultry.

2. Manure composting technology

Manure composting technology is a fermentation technology process that uses microorganisms to degrade organic matter in livestock manure under human control so that livestock manure is harmless and humifying. The composting technology of livestock manure can be divided into two forms: one is anaerobic composting technology, and the other is aerobic composting. The classification is based on whether oxygen is needed in the process of composting fermentation technology^[16]. The composting technology that does not require ventilation and oxygen is anaerobic composting fermentation technology, which takes several months to complete and takes a long time to compost. The composting technology that needs ventilation and oxygen is aerobic composting fermentation technology, whose temperature is relatively high, usually 55–65 °C, up to 70 °C, also known as high temperature composting. The composting technology process is shown in **Figure 1**.

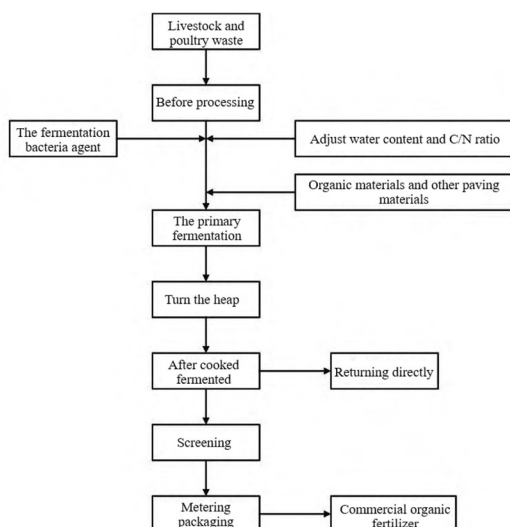


Figure 1. Process flow of composting technology.

Manure treatment and recycling of livestock and poultry manure can provide a new method and a new way for composting and utilization of livestock and poultry manure, and can solve the problem of mechanization, reduction and harmless utilization of livestock and poultry waste. The process mode of livestock manure recycling is shown in **Figure 2**.

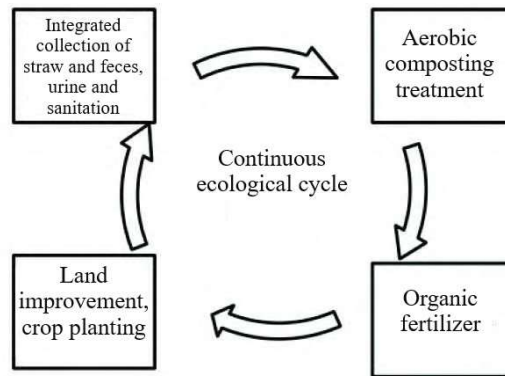


Figure 2. Livestock and poultry manure recycling process mode.

3. Manure composting technology and equipment

With the continuous development of mechanization, the traditional way of composting has been bid farewell. There are a variety of composting methods for livestock manure and poultry waste, as well as various forms of supporting machinery and equipment. The technical equipment of manure composting in this paper mainly refers to the technical equipment of aerobic composting. Manure composting technologies include raw material pretreatment, aerobic fermentation, and granulation. In the process of raw material processing technology, solid-liquid separation technology, auxiliary material comminution technology, raw material moisture content control, etc., to improve the whole effect, composting technology and granulation forming technology can mix shredded ingredients, such as process closely combining technology, eventually be able to generate suitable organic fertilizer needed for crop production.

3.1. Raw material pretreatment equipment

After pretreatment, the raw material can meet the actual demand of aerobic fermentation technology. The main equipment for raw material pretreatment includes solid-liquid separation equipment, auxiliary material crushing equipment, and mixing ratio equipment. Mechanical equipment that can mechanically separate solid feces from livestock and poultry manure is called solid-liquid mechanical separation equipment, which can quickly mechanically separate the solid feces in livestock and poultry dry feces and livestock and poultry blister feces. The solid-liquid separation equipment is shown in **Figure 3**. At present, the most commonly used solid-liquid mechanical separation equipment mainly includes screening mechanical separation equipment, filtration mechanical separation equipment, centrifugal mechanical separation equipment, and spiral mechanical separation equipment.

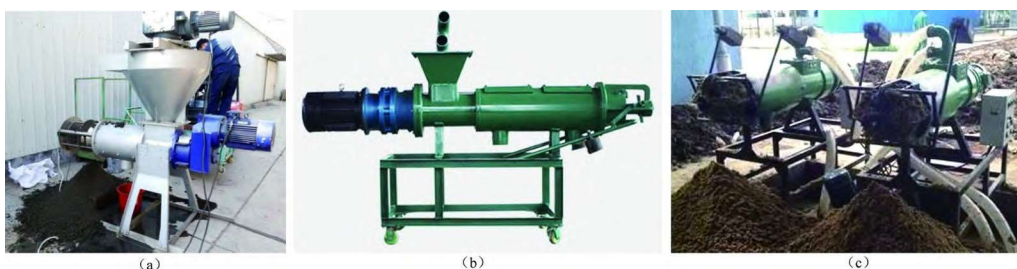


Figure 3. Solid-liquid separation equipment.

Screening and separation equipment is a kind of separation equipment that is not easy to plug and is simple in structure, but its efficiency in removing solid substances is low. Filtration and separation equipment is a kind of noise-free and vibration-free separation equipment with low energy consumption, but it has a high operation cost. Centrifugal separation equipment is fast and efficient in separating solid substances, but its energy consumption is high and its early investment is large. At present, the most widely used is new spiral separation mechanical equipment. In order to reduce the content of solids in feces before solid-liquid separation, the fecal water is stirred thoroughly. According to the actual situation, combining various process equipment in the pretreatment period of livestock and poultry manure can not only reduce the moisture content of solids but also improve the solid-liquid separation effect.

3.2. Aerobic fermentation equipment

In the process of aerobic fermentation technology, the most common fermentation technology includes strip-stack fermentation technology, tank fermentation technology, and reactor fermentation technology.

3.2.1. Stack composting equipment

Strip composting technology, also known as the original composting technology, is the form in which mixed livestock and poultry manure is arranged into a pile, which covers a large area, belongs to the open, and requires mechanical equipment to periodically turn over, so the fermentation cycle is long, but the process is simple and the cost is low. The mechanical turning frequency of strip composting is 3–5 times per week, and the fermentation of manure compost takes 40 to 60 days. Strip stack composting is shown in **Figure 4**.



Figure 4. Strip stack composting.

The size of the field for the strip composting technology depends on the amount of livestock manure and should be protected from rain. The size of the stack is usually 2–4 m wide, the height of the stack is 1.0–1.5 m, and the length of the stack is not limited. When a stack of compost is too large, it will release a large amount of odor when turned over. When the strip pile of compost is too small, the rapid heat dissipation of the compost means that its insulation is poor. For large-scale compost with a large amount of manure, it is necessary to do multi-row composting to meet the requirements. Composting of livestock and poultry manure should be turned over regularly, which is usually divided into two forms: manual turning and mechanical turning, but the

efficiency of mechanical turning is higher. The amount of microbial oxygen consumption in strip stack compost determines the number of stacks turned by strip stack composting technology. In addition, it is also affected by other factors, such as the degree of decomposition of manure compost, the type of turning machine equipment used, the space occupied by the strip stack, and economic conditions. The frequency of turning over in the initial stage of manure composting is higher than that in the later stage of manure composting. Generally, the frequency of turning over in manure composting is increased when the high temperature of strip composting reaches 70 °C. There are various forms of strip compost turning machines, as shown in **Figures 5–7**.



(a)



(b)

Figure 5. Self-propelled sliver compost turner.



(a)



(b)

Figure 6. Self-propelled integral continuous compost turner.



(a)



(b)

Figure 7. Trailed sliver compost turner.

3.2.2. Tank composting equipment

Trough composting is the process of composting manure in a trough, which is usually long and narrow. A turning machine is installed on the upper track of the tank wall to turn over the manure compost, which regularly turns over the compost in the tank to increase the permeability of the compost. A pipeline channel providing ventilation and aeration for manure compost is installed at the bottom of the tank to meet the oxygen demand of the compost in the tank. Therefore, the trough composting technology and equipment are the technical equipment to realize the fermentation of composting in the tank through the regular turning of the tank upturning machine under the condition that the tank bottom pipeline provides oxygen. Intelligent trough manure treatment equipment is shown in **Figure 8**.



(a)



(b)

Figure 8. Intelligent trough manure treatment equipment.

The size of the manure compost tank is determined by the amount of livestock manure and the type of material turning machine used in manure compost. The role of the manure compost turning machine is to stir the compost, so that the compost is evenly mixed up and down the tank, and the broken and loose compost is

thrown at the same time, to increase the supply of oxygen, so as to ensure that the manure compost fermentation in the manure compost tank is uniform, so that the compost is good uniformity. The oxygen in the manure compost fermentation tank comes from the ventilation pipeline technology system laid at the bottom of the tank, which can ensure the oxygen demand of the compost in the tank. Livestock manure can reach 45 °C in 1–2 days after entering the compost tank. The fermentation period of compost in the tank is usually 30–40 days. The trough composting machine for the wide chain plate is shown in **Figure 9**. A from waste composting fermentation tank feed port, and then through the waste turns the role of the casting machine will waste compost to the port of discharge and also feed the feed port again, again through the turn the role of the casting machine the material to the port of discharge, and when at the end of the composting fermentation period, material discharge from the discharge end, such a batch of a batch of feed, turn left, move, Known as batch feeding and discharging, flipping plays the role of oxygen supply, grinding and stirring. The other is that the tank is filled with material at the beginning, and when the compost fermentation cycle is finished, all the materials are discharged at one time, which is called the overall feeding and discharging method.



Figure 9. Trough-type composting wide chain plate turning and throwing machine.

3.2.3. Reactor composting equipment

The reactor composting technology is a closed and integrated aerobic composting fermentation technology that has the functions of feeding, discharging, aeration, stirring, and deodorization. There are various forms of reactors, including tower reactors, silo reactors, tunnel 16 agricultural engineering equipment, mechanization kiln reactors, and churning box reactors. At present, automatic manure composting technology equipment mainly includes biological fermentation tower technology equipment, fermentation chamber technology equipment, and high-temperature aerobic fermentation tank technology equipment. The biological fermentation tower is composed of multiple fermentation warehouses, which can realize automatic adjustment, stable transmission, and continuous discharge, fully automatic control of production materials, automatic oxygen supply, temperature regulation, dehumidification, and the use of aerobic biological bacteria to produce bioenergy to achieve zero pollution and zero emission of organic waste such as manure and urine. The tower composting equipment is shown in **Figure 10**.



Figure 10. Tower composting equipment.

Fermentation chamber composting is a composting method in which the mixture is placed in a simple box structure for fermentation. Bin composting usually uses forced ventilation, which has the same ventilation system composition as static ventilation composting. Compost is done in closed containers, free from odorous pollution. The compost fermentation process can be controlled well, and the compost fermentation bin can be transported freely, which is conducive to the centralized treatment of scattered manure. The closed composting reactor is a composting technology equipment that adds materials to the top of the silo and then discharges materials from the bottom of the silo through the oxygen supply of high-pressure turbines. Usually, the height of silos is 4–6 m, and the fermentation period of compost is generally 7–12 days. The silo composting equipment is shown in **Figure 11**.

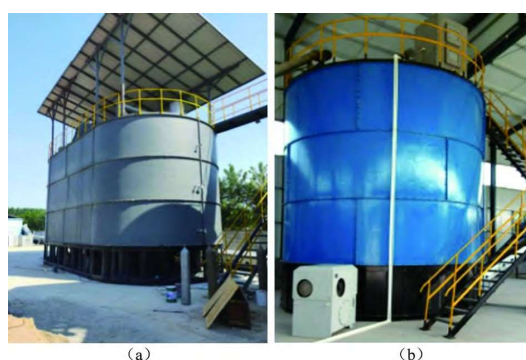


Figure 11. Silo composting equipment.

A high-temperature aerobic fermenter is a new type of fermentation equipment. Using high-pressure, high-oxygen, and high-heat fermentation technology, it can heat animal feces at high temperatures to achieve the required high-temperature conditions for animal feces fermentation. At the same time, it overcomes the ordinary manure fermentation technology of biological bacteria and the oxygen shortage that makes animal feces fermentation incomplete. Through high-temperature and high-oxygen fermentation, biological bacteria can be activated so that animal feces can be thoroughly fermented into biological organic fertilizer. Less energy consumption and low operation costs Make full use of space and your small footprint. High degree of automation: the combination of PLC and upper computer achieves remote control. The treatment process is completely closed and does not produce secondary pollution.

The manure treatment of small and medium-sized livestock and poultry farms usually uses the composting technology equipment of a closed reactor, which is suitable for the in situ composting treatment of livestock and poultry manure. It has the advantages of a small area, a short fermentation cycle, good energy-saving and heat-preserving effects, good airtightness, easy odor control, and a high degree of automation.

3.3. Granulation and molding equipment

The final production process of crop organic fertilizer is granulation, granulation, and molding.

Granulated fertilizer can improve its commercialization and enhance the slow-release effect of granulated fertilizer so that it is not easy to decompose in storage and transportation. At present, extrusion granulation technology and aggregate granulation technology equipment are the two most common granulation technology pieces on the market.

Extrusion granulation molding technology is a method of rolling extrusion, the first material into the machine hopper through mechanical extrusion molding, and then defouling the ball, which is then transmitted to the machine crushing screen, and then the new material is returned to the material after re-mixing granulation. Extrusion granulation molding technology equipment has two advantages: high efficiency and smoothness. The extrusion granulator is shown in **Figure 12**. There are two types of agglomeration granulation molding technology equipment: one is a disc granulation machine, and the other is a roller granulation machine. The disk granulator application range is wide and has been quite mature. The material enters the granulating disk, made of a circular arc structure, from the atomizing nozzle. Under the rapid rotation of the disk, the wet material rapidly condenses, forms, and finally forms a granular shape. The disc granulator is shown in **Figure 13**.



Figure 12. Extrusion granulator.

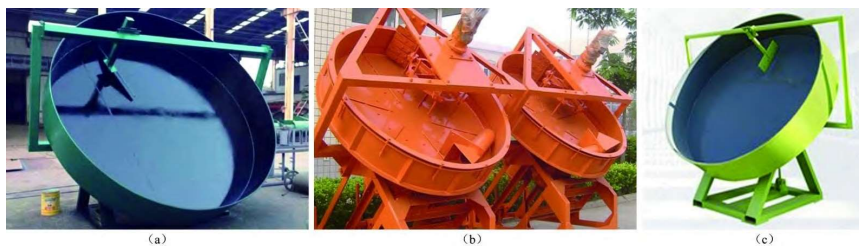


Figure 13. Disc granulator.

The roller granulator, through the same body rotation movement, has formed materials under the control of specific humidity and temperature requirements, condensation aggregation to form spherical materials, and the final formation of the spherical material technology process, whose internal structure is more special. The granular material after granulation needs a process, that is, drying and cooling, so it is necessary to configure applicable drying and cooling modules in granulation molding technology and equipment. Such treatment can not only optimize the granulation process but also save on the cost of technical equipment. The roller granulator is shown in **Figure 14**.



Figure 14. Rotary roller granulator.

4. Development trend

The development of manure composting technology and equipment can solve the problems of manure treatment difficulty and waste manure pollution in the livestock and poultry breeding industries and accelerate the development of the livestock and poultry breeding industries. It is an economical and effective way to prevent manure pollution in the livestock and poultry breeding industry. The recycling of livestock and poultry manure can accelerate the transformation of pollution prevention and control in the livestock and poultry industry from paying attention to standard discharge to paying attention to full utilization and effectively promoting the coordinated development of the production and manufacturing of the livestock industry and ecological environment protection.

With the increasing demand for livestock manure treatment technology, livestock manure composting technology equipment will be diversified and suitable for different places. Through the introduction of the present situation of manure composting technology and equipment, it can be concluded that the mechanization level of manure composting for livestock and poultry will be upgraded. High degree of automation, remote control, and fault monitoring; the productivity of mechanical equipment is further improved and the reliability is higher; manure treatment without secondary pollution promotes the ecological cycle. Therefore, livestock manure composting technology and equipment will be large, intelligent, and information-driven.

5. Conclusion

Discusses the livestock and poultry waste composting technology and the composting technology and equipment, analyzes the development trend of equipment of livestock and poultry waste composting technology, it is concluded that in promoting the development of the livestock and poultry waste composting technology and equipment at the same time, should follow the development of the natural ecological concept, combined with planting and raising mechanism, according to the planting and balance the moderate development coordinated development, to ensure the rational development and utilization of livestock and poultry waste composting technology and equipment, It provides a theoretical basis for the innovative design, manufacture, popularization and application of livestock manure composting technology and equipment. Use mechanical equipment for the transformation of livestock and poultry waste to achieve reasonable use of livestock and poultry breeding wastes, creating a healthy, green, and environmental protection. An efficient livestock and poultry breeding industry can benefit from the planting and breeding industry, which can promote sustainable development in agriculture and be conducive to stable ecological cycle development.

Conflict of interest

The authors declare no conflict of interest.

References

1. Zhang J. Research on livestock and poultry manure composting fermentation technology and equipment (Chinese). *The Chinese Livestock and Poultry Breeding* 2020; 16(5): 66.
2. Hu J. Harm and control measures of manure pollution in animal trace (Chinese). *Graziery Veterinary Sciences (Electronic Version)* 2020; 18: 143–144.
3. Xue H. *Establishment of Evaluation Index System for Comprehensive Utilization Technology of Manure in Small and Medium-Scale Pig and Cattle Breeding Industry* (Chinese) [Master's thesis]. Hebei University of Science & Technology; 2020.
4. Wang F. *Design and Experiment of Small Composting Equipment for Fecal Matter of Livestock and Poultry Based on Heating by Aeration* (Chinese) [Master's thesis]. Inner Mongolia Agricultural University; 2021.
5. Zhang J. *Study on Design and Performance of Silo Aerobic Composting Reactor* (Chinese) [Master's thesis]. Jiangxi Agricultural University; 2020.
6. Zeng Q, Liu M. Application of aerobic composting technology and equipment in the recycling of agricultural

- waste (Chinese). *Modern Agricultural Equipment* 2018; 2: 53–57.
7. Guan F, Li Z, Han L, et al. Low-temperature fermentation and composting technology of mixing livestock and poultry manure and straw (Chinese). *Modern Agricultural Science and Technology* 2019; 18: 158.
 8. Chen H. Study on processing technology and application of livestock and poultry manure organic fertilizer (Chinese). *Agricultural Development & Equipments* 2021; 12: 122–124.
 9. Yang X, Liu H, Zhu J, et al. Comprehensive model for treatment and utilization of livestock and poultry manure (Chinese). *China Animal Industry* 2021; 5: 42–43.
 10. Wu B. Harmless resource utilization model of livestock and poultry breeding waste (Chinese). *The Chinese Livestock and Poultry Breeding* 2019; 15(7): 66.
 11. Fan M. Livestock and poultry manure resource utilization technology (Chinese). *The Chinese Livestock and Poultry Breeding* 2021; 17(6): 81–82.
 12. Zhao M, Wu D, Zhang X, et al. Livestock and poultry manure compost fermentation technology and equipment (Chinese). *Agricultural Engineering* 2019; 9(9): 46–51.
 13. Sun J, Zhang Z, Sun J. Research on the technical model of manure resource utilization in livestock and poultry breeding (Chinese). *Jilin Animal Husbandry and Veterinary Medicine* 2021; 42(9): 118+123.
 14. Geng W, Li Z. Study on the design and application of a small fast Fermentation plant (Chinese). *The Chinese Livestock and Poultry Breeding* 2021; 17(1): 44–46.
 15. Wang X, Zhang C, Tian C, et al. Large-scale cattle farm manure treatment method (Chinese). *Jilin Animal Husbandry and Veterinary Medicine* 2021; 42(5): 104+107.
 16. Wu Y. Current situation and prospect of resource utilization of livestock manure (Chinese). *Chinese Journal of Animal Husbandry and Veterinary Medicine* 2021; 10: 24.