Innovative Design of Earthworm Excrement Separator in the Disposal of Livestock and Poultry Manure

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Abstract. With the development of large-scale aquaculture, livestock and poultry manure pollution has become one of the priorities of rural environmental governance. Feeding treatment of livestock and poultry manure is an effective method for safe disposal and utilization of livestock and poultry manure. Separation and harvesting of earthworm manure, earthworm living bodies and residual organic wastes is a key link in the treatment, and the separating sieve of earthworm manure is one of the key equipment. On the basis of the overall scheme design and working principle analysis of the earthworm excrement vibration separating sieve, the innovative design of earthworm excrement vibration separating sieve is carried out from the following aspects: adopting eccentric rotating mechanism to vibrate rotating sieve cylinder, adopting crank rocker feeding mechanism to vibrate dynamic feeding, adopting three-stage sieving mode, adopting feeding barrier plate to slow down material moving speed, and adopting detachable structure of sieve cylinder, etc., it can effectively improve the sieving efficiency of earthworm excrement vibration separating sieve, improve the convenience of disassemble and assembly, reduce the space occupied by transportation, and improve the popularization of earthworm excrement vibration separating sieve.

Keywords: Livestock and poultry manure, Earthworm, Excrement separator

1. Introduction
At present, the rural ecological environment has become a prominent short-board for building a well-off society and building beautiful villages. The pollution of livestock and poultry manure has become one of the priorities of rural ecological environment management. Resource utilization of livestock manure is an effective and safe disposal method[1-6]. Livestock and poultry manure energy conversion (through anaerobic fermentation technology, organic waste in livestock and poultry manure into clean energy such as methane, hydrogen); livestock and poultry manure fertilization (through aerobic fermentation technology, livestock and poultry manure into stable decomposed matrix fertilizer for application to crops); livestock and poultry manure is planted in a matrix (after fermentation or high temperature treatment, livestock and poultry manure forms a total nutrient cultivation matrix material, and carries out the cultivation of a variety of fungi); livestock and poultry manure feed disposal (livestock and poultry manure can be used as feed for earthworm breeding after...
fermentation treatment)[7-10]. Different methods have their own characteristics and applicability in the treatment of livestock and poultry manure resources. According to the characteristics of the farm itself and the surrounding environmental advantages, combined with different treatment processes of manure, meet the environmental requirements, reduce the cost of enterprise manure disposal, and select the treatment method of livestock and poultry manure resources according to local conditions. Livestock and poultry manure for earthworm breeding disposal, on the one hand, produces high-quality fertilizer to return to farmland cultivation, on the other hand, earthworms themselves are high-quality protein feed and biomedical raw materials, which can bring certain economic benefits[1-3,7-8]. Livestock and poultry manure for earthworm breeding disposal has attracted the attention of scientific researchers.

2. Principle of Earthworm Breeding and Disposal of Livestock and Poultry Manure

Livestock and poultry manure is mixed with organic wastes such as straw and wood sawdust, which are fermented and decomposed as earthworm feed. The process of decomposing and treating livestock and poultry manure, straw and wood sawdust into stable humus and discharging earthworm manure with the help of the digestive system of earthworms and the synergy of microorganisms. The feed disposal of livestock and poultry manure for earthworm breeding not only realizes the harmless disposal of livestock and poultry manure, but also obtains the high-quality earthworm manure fertilizer with odorless, harmless and biological activity, so as to recycle nitrogen and phosphorus nutrients into agricultural ecosystem and realize the recycling of wastes. Moreover, earthworms themselves are high-quality protein feed and biomedical raw materials, bringing certain economic benefits to the aquaculture industry. In the process of earthworm breeding and disposal of livestock and poultry manure, the disposal effect and economic benefit are closely related to the types of livestock and poultry manure and organic waste, C/N ratio, temperature, humidity, PH value, earthworm species and inoculation density[7-8]. In addition, the separation and harvesting of the disposed earthworm manure, mature earthworm living bodies and residual organic waste is also a key link in the process of earthworm breeding and disposal of livestock and poultry manure. Low separation efficiency, high cost and lack of automation equipment have become one of the bottlenecks that need to be solved in livestock and poultry manure earthworm breeding and disposal, which has attracted extensive attention of scientific researchers. drying oven outlet 13; an air inlet 19 is arranged near the bottom of the other end side of the drying oven 10, and the air inlet 19 is connected with the air outlet of the hot air fan 11.

3. Overall Scheme Design and Working Principle of Earthworm Excrement Separator in Livestock and Poultry Manure Earthworm Breeding and Disposal

3.1. Overall Scheme Design of Earthworm Excrement Separator in Livestock and Poultry Manure Earthworm Breeding and Disposal

As shown in Fig. 1, the earthworm excrement separator mainly includes base 1, speed regulating motor 2, pulley (1) 3, belt 4, pulley (2) 5, drive shaft 6, drive shaft support 7, central shaft 8, sieve support 9, sieve mesh 10, driven drive shaft 11, driven drive shaft support 12, discharge box 13, feed box 14, feed box crank rocker vibration mechanism 15 and other components. The main drive shaft 6 and the driven drive shaft 11 are installed on the drive shaft support 7 and the driven drive shaft support 12 on the base 1 respectively, and the inner ends of the two transmission shafts are provided with eccentric mounting holes; the two ends of the central shaft 8 are respectively fixed and connected with the two eccentric mounting holes, so that the whole sieve cylinder rotates eccentrically and produces the effect of vibration sieving. The opening end near the drive shaft 6 on the sieve cylinder is the feeding end, and the feed box 14 is set at the feeding port of the sieve cylinder; the feed box 14 is set in a downward inclined manner towards the feeding end, and the feed box crank rocker drive mechanism 15 is connected under the feed box 14 to achieve the effect of dynamic feeding by
vibration. The feed box 14 is positioned at the upper end of the base 1 opposite to the sieve cylinder. Earthworm manure and earthworms are collected in different areas of the discharge box 13.

3.2. Working Principle of Earthworm Excrement Separator in Livestock and Poultry Manure

Earthworm Breeding and Disposal

The working principle of earthworm excrement separating sieve is that the mixture of earthworm and excrement is poured into the feed box 14 by manual or other means, and the speed regulating motor 2 is started, which drives the whole eccentric rotation of the sieve cylinder through pulley (1) 3, belt 4 and pulley (2) 5. At the same time, the feed box crank rocker drive mechanism 15 drives the feed box 14 reciprocating vibration, and pours the mixture material from the feed end into the sieve cylinder. With the rotation of the sieve cylinder, the feces are separated and sifted into the feces falling area in the front section of the discharge box 13, and the earthworms falling into the earthworms falling area in the back section of the discharge box 13, thus realizing the separation of earthworms and feces.

4. Innovative Design of Earthworm Excrement Separator in Earthworm Breeding and Disposal of Livestock and Poultry Manure

4.1. Eccentric Rotating Mechanism is Adopted to Make the Sieve Cylinder Rotate Vibratively to Improve Sieving Efficiency

As shown in Fig. 1, the two ends of the central shaft 8 are respectively fixed and connected with the eccentric mounting holes on the drive shaft 6 and the driven drive shaft 11. During the sieving process, the sieve cylinder rotates and vibrates simultaneously. On the one hand, the rotating vibration movement of the sieve cylinder accelerates the separation of earthworms and feces and improves the sieving efficiency. On the other hand, it can effectively reduce the amount of feces adhering to the inner wall of the sieve cylinder, thus avoiding the blockage of sieve mesh holes, which helps to improve the sieving efficiency and achieve better sieving effect.
4.2. Adopting Crank Rocker Feeding Mechanism to Vibrate Dynamic Feeding to Improve Sieving Efficiency

As shown in Fig. 1, Fig. 2 and Fig. 3, the feed box crank rocker drive mechanism 15 is connected to the lower end of the feed box 14. The upper end of the rocker 18 is fixed to the bottom of the feed box 14 through the feed box bracket 19, and the lower end of the rocker 18 is connected to the upper end of the rocker bracket 20 fixed on the rocker bracket board 21 through the rotary pair 22. The lower end of crank 23 is fixedly connected with crank drive shaft 24. The crank drive shaft 24 is supported on the upper end of crank drive shaft bracket 26 through bearing seat 25. The lower end of crank drive shaft bracket 26 is fixedly connected with crank drive shaft chassis 27. The crank drive shaft 24 and the center shaft 8 are connected by a pair of meshing bevel gears 28. The two ends of the connecting rod 29 are respectively connected with the upper end of the crank 23 and the upper end of the rocker 18 through respective rotating pairs. Under the swing of crank rocker mechanism, the feed box 14 is driven to form a vibration dynamic feeding mode, which can realize the preliminary separation of earthworms and feces, and help to improve the sieving efficiency.

![Diagram of feed box and rocker mechanism](image)

14. Feed box 18.Rocker 19.Feed box bracket 20.Rocker bracket 21.Rocker bracket board 22.Rotary pair 23.Crank 24.Crank drive shaft 25.Bearing seat 26.Crank drive shaft bracket 27.Crank drive shaft chassis 28.Bevel gear 29.Connecting rod

**Figure 2.** Crank rocker feeding mechanism of earthworm excrement separator in earthworm breeding and disposal of livestock and poultry manure

4.3. Adopt Three-stage Sieving Method to Improve Sieving Efficiency

As shown in Fig. 1, along the direction from the feed end to the other end, the first, second and third sieve zones are formed respectively between the sieve support frame (1) and the sieve support frame (2), between the sieve support frame (2) and the sieve support frame (3), between the sieve support frame (3) and the sieve support frame (4). The sieve mesh holes corresponding to the first, second and third sieve zones gradually increase. A partition board is arranged in the discharge box 13, and the discharge box 13 is divided into faeces and earthworm discharge areas. The faeces discharge areas is aligned with the first and second sieve zones. The third sieve zone has earthworm and faeces discharge areas at the same time in different areas.

4.4. Using Feed Barrier to Slow Down the Material Moving Speed and Separate the Material by Full Rotation and Vibration

As shown in Fig. 1, the feed barrier (1) 16 and the feed barrier (2) 17 are respectively installed at the positions of the sieve support frame (2) and the sieve support frame (3). The material in the sieve is rotated and moved from right to left, and the material is blocked by the feed barrier (1) 16 and the feed barrier (2) 17, so that the material can be fully rotated and vibrated to separate and obtain better separation effect.

4.5. The Sieve Cylinder Adopts a Detachable Structure, Which is Convenient for Disassemble, Assembly and Maintenance, and Reduces the Space Occupied by Transportation
As shown in Fig. 1 and Fig. 3, the sieve cylinder is a separable structure consisting of four groups of sieve support frames and sieve mesh 10. Each group of sieve support frames is composed of a sieve mesh support shaft (1) 30 and a sieve mesh support shaft (2) 31 which are cross-shaped and installed on the central shaft 8. Sieve support frames is fixed by a lock nut (1) 29 connected with a thread outside the central shaft 8. The outer end of the sieve mesh support shaft is connected with the sieve mesh 10 and fixed by a lock nut (2) 34. The threading and assembling parts of the cylindrical sieve and the sieve mesh support shaft are arranged in sequence from inside to outside as follows: the sieve support plate 32, the sieve mesh 10 and the sieve pressure block 33. The sieve cylinder adopts a detachable structure, which is convenient for disassemble, assembly and maintenance, and reduces the space occupied by transportation.

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5. Conclusion
Rotary cylinder sieving machine has the advantages of large sieving component and high sieving efficiency. In view of the shortcomings of the rotary sieve cylinder sifter at present, for example, because earthworms and feces are viscous, it is easy to stick to the cylindrical sieve and block the sieve holes during the sieving process, which results in the decrease of the sieving efficiency and poor sieving effect of the sieving machine; moreover, with the extension of the sieving operation time, the more earthworms and feces are adhered to the sieve mesh, the lower the sieving efficiency and the lower the sieving effect. The sieve cylinder is an integral structure, which occupies a large space for transportation, and it is difficult to install and maintain. In this design, the whole sieve cylinder is eccentrically supported on the drive shaft and the driven drive shaft, which makes the sieve cylinder rotate and vibrate at the same time. On the one hand, the motion mode speeds up the separation of earthworms and feces, improves the sieving efficiency, on the other hand, it can effectively reduce the amount of feces adhering to the inner wall of the sieve cylinder, thus avoiding the blockage of sieve mesh holes. It is helpful to improve sieving efficiency and achieve better sieving effect. The lower end of the feed box is connected with the vibration driving mechanism of the feed box to form a vibration feeding mode, which can realize the preliminary separation of earthworms and feces and help to improve the sieving efficiency. In addition, the sieving efficiency can be improved by adopting three-stage sieving mode and feed barrier to slow down the sliding speed of materials. The sieve cylinder
adopts a detachable structure, which is convenient for disassemble, and assembly, and reduces the space occupied by transportation.

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