Economic benefits comparison of two pig breeding cycle modes -- Taking Liaoning Province as an example

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Abstract. Pig breeding pollution has become one of the important sources of environmental pollution, and the circular economy has provided an effective way to alleviate the pollution of pig breeding. In this paper, the "Three-in-one" and "Four-in-one" mode of circular economy with methane as link were constructed, and taking Liaoning Province as the research area, the economic benefits of different pig breeding modes were compared and analyzed. The results show that: (1) The modes of circular economy use the pig manure waste as raw materials through the digesters, solar greenhouse to generate new resources, compared with the traditional farming methods, created considerable economic benefits and also alleviated the pressure of pollution, is an effective way to control the pollution of pig breeding. (2) The economic benefit of the "Four-in-one" mode in Liaoning was much higher than the "Three-in-one" mode. The economic benefits of biogas digesters were higher than the "Three-in-one" mode of 125 million yuan, while the solar greenhouse would introduce the planting industry into the recycling chain, with a net profit of about 38.64*10^8 yuan.

1. Introduction

The scale of livestock and poultry breeding has been expanding, and the pollution caused by it has become increasingly prominent. Livestock breeding industry has become the main source of agricultural non-point source pollution. The United Nations Food and Agriculture Organization (FAO) reported in 2013[1]: "livestock production accounts for 18% of the world's total greenhouse gas emissions." And the pig farming is the main livestock, the contradiction between economic benefits and environmental pollution of pig breeding has become a major bottleneck for the sustainable development of the pig industry, seeking a way of pollution control to achieve economic benefits is necessary. The circular economy provides a theoretical basis to effectively alleviate pig manure pollution, and can effectively alleviate the pollution while achieving economic benefits [2]. At present, the EU's environmental protection efforts will gradually shift to a recycling economy [3]. The Chinese government also attaches great importance to the development of circular economy. In April 2017, the fourteen departments jointly formulated "circular development leading action", and pointed out that it is necessary to vigorously develop circular economy. Circular economy is the trend of social development in the twenty-first Century. To explore the economic benefits of different pig farming...
patterns is conducive to make the choice of the future recycling economy mode and its smooth implementation.

In recent years, there has been a new upsurge in the study of circular economy abroad [4-7]. In 2016, Nature magazine [8-10] published a special article on circular economy which reflects the new trend of the recycling economy. However, there are few studies on the economic benefits of the cycle mode of livestock breeding. At present, China's research on the economic benefits of recycling mode is mainly based on field monitoring of specific breeding sites, data collection and quantitative analysis[11-14], but less on different modes. Taking Liaoning Province as the research object, the "three-in-one" and "Four-in-one" circular economy modes of pig breeding are constructed. Combined with the mode, based on the micro analysis of data, use micro analysis parameters and cost-benefit-analysis, comparatively analyze the economic benefits of different modes, to provide reference for the selection of pig breeding mode.

2. Parameter selection of circular economy mode for pig breeding

2.1. The function principle of the circular economy mode

By connecting the waste logistics to the possible beneficiaries, the circular economy can change the negative externalities into positive effects [15]. The circulation mode of pig breeding is based on the local conditions, the benefit and the "3R" principles of the circular economy, supported by the theory of circular economy, pursuit of economic, environmental and social benefits, combine with the development characteristics of the region, construct the appropriate modes. Its core can be simplified as "pig farming" - the waste produced in the process of pig farming - some kind of production activity (waste disposal) - resources". The general way of pollution control is difficult to take into account both economic efficiency and pollution mitigation, while the circular economy is in pursuit of economic benefits while achieving environmental benefits. Therefore, it is effective to use the theory of circular economy to achieve pollution control. In this paper, methane pool mode is selected to build a suitable mode of circular economy, comparative analysis of economic benefits may be created under certain conditions.

2.2. Technical parameters selection for benefit estimation of circular economy

Based on the relevant parameters of Li Jincai [11] and Xiong Feilong [16], this paper analyzes and determines the parameters of this study:

(1) Biogas digesters are calculated according to the service life of 10 years, and the average annual cost of biogas digesters is 15 yuan /m³. The service life of solar greenhouse is calculated according to 15 years, and the average annual cost of solar greenhouse and its facilities is 7.95 yuan /m².

(2) The calculation of biogas production is mainly based on two ways: the amount of excrement and the volume of methane tank. The total volume of biogas pool in this study is an estimate, therefore, in this paper, a relatively accurate calculation of the amount of pig manure is carried out. The daily fecal amount per pig is 4kg, and the fecal gas production per ton is 15.5m³.

(3) The value of biogas should not replace the traditional energy, as coal and firewood, and should choose natural gas and other conventional energy trading value. Therefore, the price of biogas is converted to natural gas by using its calorific value, which is 1.81 yuan /m³.

(4) Biogas slurry is mainly used as fertilizer and pesticide, a single 10 m³ annual production of biogas digester, biogas manure as fertilizer, biogas slurry to prevent and control pests and diseases can be a savings of 300 yuan.

(5) Solar greenhouse temperature is suitable, at least two kinds of vegetables can be planted at one year. In the case of growing cucumber, it is assumed that every greenhouse is 350m², and the annual yield is 9600 yuan. Seed, chemical fertilizers, pesticides and other inputs and costs, and opportunity cost of occupying traditional land crops is 2000 yuan, then the average yield of solar greenhouse is 21.7 yuan /m².
(6) Biogas generation is related to the temperature, the average temperature of the cities in Liaoning Province generally only 7 months can be maintained at 10-25 degrees, the other 5 months of the temperature at zero degrees, are not conducive to the production of biogas pool gas; the normal operation of the greenhouse can maintain the biogas pool.

3. Benefits of "Three-in-one" and "Four-in-one" mode

3.1. Pattern structure difference
"Three-in-one" mode, namely "pig - biogas - farmers", "four-in-one" mode based on "three-in-one", according to the characteristics that the northern climate is cold, increasing the greenhouse, namely "pig - biogas - farmers - greenhouse", the recycling industry chain has been further extended (Figure 1).

![Figure 1. "Three-in-one" and "Four-in-one" mode.](image)

In northern China, the mode of circular economy research is based on the test point of the "Four-in-one" mode. But the survey found that the backyard farmers, lacking of established greenhouse space, with farmers and pig as a biological source, the fecal waste material flow through the digester to the soil along with the process of biogas and biogas residues and other valuable products. "Four-in-one" mode is a typical mode of agricultural circular economy pilot in Liaoning, there are certain requirements for space, suitable to leave courtyard. In this study, farmers farming courtyard implement "three-in-one" mode, farmers farming outside courtyard implement "four-in-one" mode. Compared with the "three-in-one" mode, implementing "four-in-one" mode, the methane tank can run throughout the year, and the sunlight greenhouse can create economic benefits.

3.2. Economic benefit comparison of circular mode
It was assumed that all the pig farms in Liaoning have a "Three-in-one" mode, each household built a 10m3 biogas digester for fecal storage. When the weather is cold in Liaoning, biogas digesters are basically not functioning, so that biogas digesters can operate normally for only 7 months, 5 months as a storage tank for pig manure. A total of 820 thousand farmers with live pig scatter in Liaoning Province in 2015, bred 7.4*10^6 pigs. All of them implemented the "three-in-one" mode, biogas
digesters could be normal operation from April to October (214 days), produced biogas 9.82*10^7 m^3, could create value about 178 million yuan. Slag slurry instead of chemical fertilizers and pesticides could create 246 million yuan. The single biogas construction cost average only 150 yuan every year, in Liaoning all construction costs an average of 123 million yuan. Compared "three-in-one" mode with the traditional mode, it not only created new economic benefits 301 million, but also effectively alleviated the pollution caused by pig breeding (Table 1).

![Table 1. Economic benefits comparison of different modes. Unit: 100 million yuan](attachment:image)

If all the pig farms in Liaoning outside courtyard for breeding, implement the "four-in-one" mode, and each household builds a 10m^3 biogas digester for fecal storage. Compared with the "three-in-one" mode, implementing "four-in-one" mode, the methane tank could run throughout the year, only part of biogas digester would generate five more months of biogas, biogas production increased 6.93*10^7 m^3, increased the value 125 million yuan. The new greenhouse link extend material flow chain, along with the flow increased value about 38.64*10^8 yuan. Compared "four-in-one" mode with the traditional mode, the economic benefit increased by 43.72*10^8 yuan, and compared with "three-in-one" mode, increased by 40.71*10^8 yuan.

4. Conclusion
1. The mode of circular economy can create considerable economic benefits. Compared with the traditional mode, implementing "three-in-one" mode could create new economic benefits 301 million yuan, and implementing "four-in-one" mode could create 43.72*10^8 yuan.
2. Economic efficiency of "Four-in-one" mode is much higher than the "three-in-one" mode. Implement "Four-in-one" mode, the methane tank in the northern cold season can operate normally, only part of biogas digester would increase the value 125 million yuan. The greenhouse link extends material flow chain and increased new net benefits about 38.64*10^8 yuan. Circular economy industrial chain extension can add greater economic benefits, the mode of circular economy construction should be possible to extend the cycle chain.
3. Liaoning province should implement circular economy mode. The mode of circular economy can use pig manure wastes as raw materials, through the digesters, solar greenhouse to generate new resources. It alleviates the pressure of pollution while creating economic benefits, and is the effective way to control the pollution of pig breeding, should be widely implemented. However, because of the land scattered, space constraints and other factors, although the implementation of the "four-in-one" mode is encouraged, farmers generally remains the implementation of "three-in-one" mode, seriously affect the greenhouse effect. In order to promote the "four-in-one" mode, the policy constraints of farming courtyard should adopt to encourage farmers to change the mode of operation.
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