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Relationship Between Livestock Pollution and the Environmental Behaviour of Farmers: A Case Study of Xiantao, China

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ABSTRACT

Livestock pollution is the main source of environmental pollution in rural areas. To explore the effects of the farmers' environmental behaviour on livestock pollution using the questionnaire and interview methods, the environmental cognition of farmers and their willingness to practice faeces decontamination in livestock breeding were analysed with survey data collected from 80 farmers in Xiantao of China, on September 2016. Results show that the environmental cognition of farmers is related to the status of rural development. In addition, when the farmers' educational level is high, the environmental cognition is also high. The farmers' environmental behaviour is also influenced by their state of environmental cognition and willingness to practice faeces decontamination. Production scale and government policies are also important factors affecting the behaviours of farmers. The choice of faeces decontamination has a positive interrelated relationship with the education levels of farmers, as well as the livestock breeding scale and time. This study's findings provide guidelines on the formulation of relevant policies to control pollution resulting from livestock farming.

INTRODUCTION

The livestock farming industry, which symbolizes the national or regional level of agricultural development, is an important part of the agricultural economy and has a significant impact on social development. The total output value of livestock farming in many developed European countries account for more than 50% of their total agricultural output value (Peterson 2000). In China, the livestock farming industry has also developed rapidly in recent years, with its production capacity, technology and product quality showing significant improvement. At present, the industry's output value accounts for more than 38% of the total agricultural output value, thus making it an important source of income for the agricultural industry in general and the farmers in particular. Since 2000, the production of livestock and poultry meat and eggs in China has rapidly increased every year at a rate of 5% (Cheng 2013). On the one hand, the development of the livestock farming industry enhances the production of meat and eggs, and greatly raises the residents' standard of living. On the other hand, breeding livestock has generated massive amounts of excreta, leading to rapid ecological degradation in a short period. Given that the industry also generates environmental pollution, this has seriously affected the ecological environment in rural areas and the farmers' quality of life (Gong et al. 2017). As the livestock farming industry develops rapidly, the environmental pollution caused by livestock farming has gradually become the major source of pollution, environmental acidification, water pollution, and eutrophication in rural areas. In some areas, livestock pollution is even greater than the sum of pollution emissions from residents, restaurants, and township industries.

For the reasons stated above, pollution prevention in the livestock farming industry has become an important rural environmental protection issue. However, compared with the concern about industrial pollution, the environmental pollution problem caused by livestock breeding has yet to attract adequate attention. China is a great agricultural country with large amounts of land, different geographic environments and low levels of agricultural development. At the same time, people have different views when it comes to environmental protection. In the process of livestock breeding, the different environmental behaviours of farmers have varying effects on the environment, which cause different degrees of livestock pollution. In order to control livestock pollution, some management measures and specifications have been taken in China. However, preventing livestock pollution using advanced ideas as well as sufficient regulations and facilities is not yet achievable in China. Therefore, using the livestock breeding industry in Xiantao of China, the current work investigates the livestock pollution and the environmental behaviour of farmers. The findings of this study can provide insights that can be used as guidelines in formulating policies to curb livestock pollution in the country.

STATE OF THE ART

The agricultural structure has changed considerably with the development of the chemical industry, modern agriculture and urbanization. In addition, livestock farmers who used to be scattered have changed to scale development, and this has contributed to the increase of farmers' agricultural efficiency and total income. On the one hand, scale farming has raised the technological levels of livestock breeding, increased the total amount of animal products, and brought considerable economic benefits. On the other hand, it has also given rise to the problem of properly treating livestock faeces. Hence, livestock pollution has become a major pollution source that cannot be ignored.

At present, non-point source pollution from rural areas has affected 30%-50% of the total global land area. Of the 1.2 billion hectares of arable land in the whole world that has been subjected to degradation, rural non-point source pollution contributes about 75% of the lost land. Livestock sewage is the main part of rural non-point source pollution (Navarro & Font 1993). Agricultural pollution that occurred earlier in foreign countries has caused serious impacts, and of these, rural non-point source pollution has the greatest effect on the eutrophication of water resources (Carpenter et al. 1998). Agriculture is the largest source of water pollutants in the United States (Chesters & Schierow 1983). On the Mississippi Basin, 15% of nitrogen nutrients and pesticides flow to the Gulf of Mexico. The fertilizer and faeces of animals contribute about 65% to the nitrogen waste dispersed on the Gulf of Mexico (Goolsby et al. 1999). Due to excessive grazing, a large amount of livestock faeces cannot be disposed properly; thus European countries have begun to limit the maximum carrying capacities of farmers by enacting policies and regulations to reduce environmental pollution caused by livestock faeces (Mark & Jane 1997). In some developed countries, farm construction has been reduced to small and medium-sized scales, and the management of livestock faeces pollution must be approved with specific treatment facilities. The entire management process includes prenatal feed, production technologies and various methods, and post-natal faeces disposal and treatment (Christopher et al. 2006). Chulalaksananukul et al. (2006) reported that agricultural production has indeed caused environmental pollution in rural areas. However, farmers lack the necessary knowledge and skills to manage this problem, which contributes to the problem. The excessive dependence on natural resources of poor groups has also led to the overuse of the environment. Thus, poverty reduction and eradication is considered as a significant aspect of solving environmental problems (Michelsen 2008).

Meanwhile, livestock pollution has already exceeded industrial pollution. Although finding ways to solve this problem has become an urgent concern, especially in terms of sustainable development, existing research has only focused on the impacts of the livestock farming industry on water, soil, air, and other environmental aspects. From a sociological perspective, the pollution factors and the ecological and environmental science and engineering aspects have been rarely analysed. Furthermore, the relationship between the environmental behaviour of farmers and livestock pollution has yet to be fully explored. Therefore, we analyse the factors affecting the environmental cognition of farmers and their willingness to practice faeces decontamination by analysing data obtained through a combination of the questionnaire and interview methods.

METHODOLOGY

Investigation area and time: The areas of study are located in the towns of Guohe and Mianyang, located in Southwest Xiantao City of China. The agriculture, forestry and animal husbandry industries in Xiantao have undergone rapid development, with an output value of 14,913 million yuan in 2016, of which the output value of the animal husbandry industry is valued at 3,065 million yuan. These two towns are the key areas in the development of Xiantao's animal husbandry industry. In these areas, 4 breeding factories and 8 farming villages can be found, including 201 households for laying hens, producing 2.2 million chickens every year. The large-scale storage of feeds has caused severe pollution problems (Statistics Bureau of Hubei Province 2016). In 2016, about 2,447 prominent environmental problems were recorded in Xiantao, of which 1818 were caused by livestock production, accounting for 74.3% of the total. With the development of the livestock farming industry, the quality of the surrounding water in the two towns also decreased significantly, which seriously affected the daily lives of the nearby residents. In 2016, from September 8 to 21, we carried out a specific survey on the livestock pollution in the two towns.

Investigation content: Livestock pollution is the main cause of environmental pollution resulting from agricultural production. The livestock pollution problem has affected social stability and economic development in China, and this is why it is an urgent problem that requires immediate resolution. In the population structure of China, approximately 80% of the population live in rural areas. Hence, farmers are not just the main drivers of agricultural development and economic construction, but they also play a significant role in controlling livestock pollution. In order to investigate the present situation of livestock pollution and contribute to the development of policies to curb the problem, this

study mainly investigated the environmental cognition of farmers, their willingness to decontaminate livestock faeces, and the ways by which they choose to decontaminate livestock faeces.

Survey methods: In this study, we used questionnaires and interviews to obtain data from the survey objects based on typical and representative principles. Eighty local livestock farmers were selected as subjects. Through the questionnaire survey method, we extracted information about the subjects' understanding of environmental pollution, among other issues. Then, we interviewed the interviewed subjects further and analysed the factors influencing their environmental cognition, willingness to decontaminate faeces, and their views on government-related support policies.

RESULTS AND DISCUSSION

The feature distribution of the survey sample: According to the current farming conditions in the towns of Guohe and Miancheng, 80 households (30 households in Miancheng, 50 households in Guohe) were selected to carry out environmental cognition survey. On the basis of breeding scale, the specific conditions of the farmers were investigated in terms of educational level, breeding time, and breeding age. Data are given in Table 1. The educational level, breeding times, and breeding ages of the farmers are presented in Table 2.

According to Tables 1 and 2, most of the farmers in the two towns are mostly in the middle and old-age groups; data also suggest that young people in the two towns are less engaged in livestock breeding. The distribution of breeding time in Guohe is more average compared with that in Miancheng. The farmers in Miancheng are mostly engaged in agricultural activities for five years or above, and less people are considered new to the livestock farming industry. The educational level of the farmers in the two towns is mainly concentrated in the primary and junior high school levels, with very few farmers reaching the high school level.

Environmental cognition of farmers: According to the different conditions of the farmers, their cognition of the effect of livestock breeding on environmental pollution was investigated. Their cognition of livestock pollution can be divided into two categories: the definition that livestock breeding can cause pollution is referred to as "cognition," and the definition that livestock breeding cannot cause pollution is labelled as "no cognition." Among 80 livestock farmers, 27 (33.75%) have "no cognition" and 53 (66.25%) have "cognition." The specific data on farmers' cognition based on different locations, age group, educational level, breeding time, and breeding scale are shown in Table 3.

As can be seen, the farmers in Guohe have a cognition rate of 74%, which is 20.67% higher than that of farmers in Miancheng. In terms of age, a negative correlation exists between farmers' cognition and breeding pollution and age. The young farmers' awareness of livestock pollution is 100%, whereas the cognition level of middle- and old-age farmers is lower. In terms of educational level, there exists a positive correlation between farmers' cognition and education: farmers with a high school education or above have an awareness rate of 100%, whereas those with middle school, primary school, and lower educational levels have low live-

Table 1: Statistical table for the sample selection of livestock farmers.

District	Breeding scale			
	Large-scale farmers	Medium-scale farmers	Small-scale farmers	Family farmers
Guohe	20	10	10	10
Miancheng	0	10	10	10
Total	20	20	20	20

Table 2: Statistical table of sample of livestock farmers.

		Guohe	Miancheng
Breeding age	Youth (≤ 30)	6	2
	Middle age (>30, ≤ 50)	24	18
	Old age (>50)	21	10
Breeding time	Less than 5 years	17	6
	5-10 years	18	14
	Over 10 years	15	10
Educational level	Primary school and below	9	10
	Junior high school (including secondary school)	39	17
	High school and above	2	3

stock pollution awareness. In terms of breeding time, we find a positive correlation between breeding time and farmers' pollution awareness. When breeding time is longer, their awareness is also high. As for the scale of breeding, we find a positive correlation breeding scale and farmers' cognition of breeding pollution. A significant difference exists between family farming and large-, medium- and small-scale farming. Most family farmers possess low awareness of breeding pollution, whereas large-medium-, and small-scale farmers have high awareness of livestock pollution.

The main reason why farmers in Guohe have a higher cognition degree than those in Miancheng is because the two towns have different development orientations. Guohe is a famous livestock farming town in Hubei Province. Hence, the scale of breeding has produced massive amount of manure, which has had a direct impact on the ecological environment in the region, resulting in environmental problems in terms of drinking water pollution and soil pollution. These problems have seriously affected the farmers' health and quality of life, thus forcing them to pay more attention to the pollution caused by livestock farming (Wu et al. 2017). In comparison, Miancheng is mainly dominated by crop farming, and lesser farmers are engaged in livestock breeding. Thus, the problem of livestock pollution is not as significant as that of Guohe farmers (Ju et al. 2016a).

In terms of age group, the cognitive level of young people is significantly higher than that of the elderly population, because most of the young people have received the nine-year compulsory education and are aware of the seriousness of the livestock pollution. Therefore, they choose to adopt pollution-free ecological farming and breeding methods and have a higher perception of livestock breeding pollution compared with the older farmers. In other words, when their educational level is high, their cognition of pollution is also high. In addition, they are aware that improper livestock production can lead to environmental pollution (Liu 2017).

The obvious difference between family farming and scale farming is that the former only operates based on what the farmers need for their own agricultural land, and their belief that livestock faeces do not need further treatment (Chen 2017). Mainly, they use the faeces produced by traditional farming as a kind of fertilizer so they do not view this as a possible source of pollution at all. Although there are no large-scale farming households in Miancheng, most cage-free households in the town have a habit of randomly dumping livestock faeces, causing serious pollution to nearby water sources. The raw sewage and livestock faeces increase due to the expansion of livestock production and breeding scale. At present, however, the farmers have a better understanding of the phenomenon. At the same time, with the expansion of the breeding scale, the relevant government departments have also increased their focus on farmers and have launched programs to increase farmers' awareness of livestock pollution through publicity and education.

The willingness of farmers to decontaminate livestock faeces: Meanwhile, local governments have introduced regulations to control livestock pollution. Since July 2014, Xiantao has carried out activities in Miancheng and Guohe. According to our survey, 82.5% of the respondents are willing to carry out the harmless decontamination of livestock faeces, and only 17.5% said they have no intention to do so. Based on further interviews, we find that the farmers' willingness is influenced by subjective and non-subjective factors as well as by rational and irrational factors. When asked about the specific reasons behind their un/willingness to deal with harmless decontamination, the farmers have different answers. The main answer of 66 willing farmers is shown in Fig. 1, and Fig. 2 shows the data from the 14 farmers who are unwilling to decontaminate livestock faeces.

According to the analysis of the above statistical data, a relationship exists between the willingness of farmers to decontaminate livestock faeces and their cognition of livestock pollution. If farmers learn that livestock pollution causes harm to the environment, they are more likely to practice faeces decontamination. However, those who do not believe that livestock production leads to pollution or do not suffer from the impact of livestock pollution, think that decontamination of livestock faeces is not necessary (Zhu 2017).

Meanwhile, special regulation policies have been implemented in Miancheng and Guohe, which affected the farmers' willingness to decontaminate livestock faeces. The government has allocated special funds to help farmers install related sewage facilities, and has provided corresponding decontamination subsidies. The lower the costs involved in harmlessly handling poultry and animal faeces, the greater the farmers' willingness to do it (Zhang et al. 2015). On the contrary, the farmers in the areas where special regulations have not yet been implemented are reluctant to practice faeces decontamination, especially because they have to spend their own money on the construction of decontamination facilities. Apart from subsidies, government-sanctioned punishments have also played an important role in influencing farmers' willingness. More than half of the farmers (57.58%) are forced to practice decontamination because of the punishment, whereas more than 1/4 farmers (28.57%) are not afraid of the punishments after finding loopholes to avoid them.

The farmers' choice of livestock faeces decontamination: With the rapid economic development in China and the

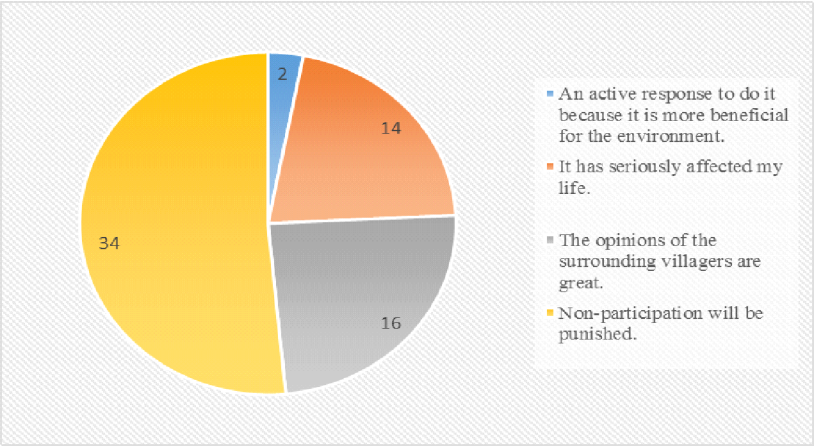

Fig. 1: Statistical graph of 66 farmers who expressed willingness to decontaminate livestock faeces.

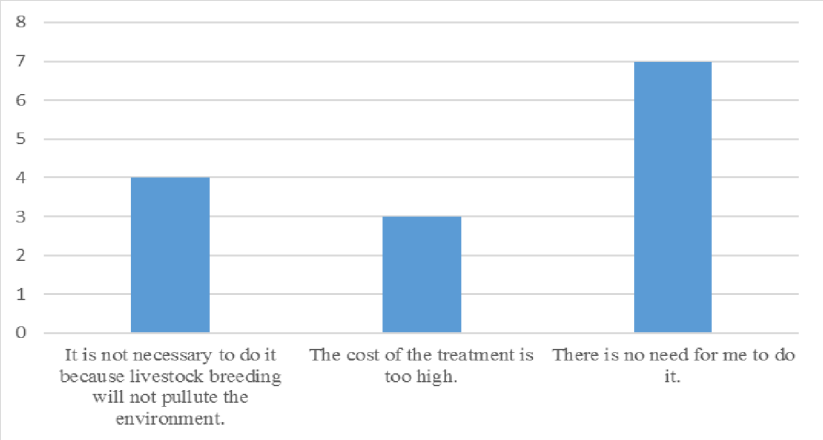

Fig. 2: Statistical graph of 14 farmers unwilling to decontaminate livestock faeces.

strengthened consumer power of the citizens, the consumption structure has dramatically transformed. Animal products are now in great demand-an irreversible trend that has led to the rapid increase in livestock production and accompanying waste products. For example, the number of large-scale farms in Guohe has increased to 19 in the past five years, compared with less than 10 farms ten years ago. The livestock breeding industry will keep growing in the future, and so will the pollution caused by it. This clearly reflects the conflict between the growing breeding industry and increasing environmental pressure, thus making it a significant example of the conflict between economic development and environmental protection (Ju et al. 2016b).

Among 80 farmers investigated, 36 directly use livestock faeces as manure without any decontamination treatment; 19 use them to generate biogas for electricity; 44 send the livestock faeces to large-scale organic fertilizer factories, such as Feilong and Tian Xingjian, for further processing with the approval of the government; and 4 farmers employ other methods. Among the 80 farmers, 19 farmers choose two ways to decontaminate the faeces. The results of the specific investigation are given in Table 4.

"Used as fertilizer" means the farmers directly use the livestock faeces as fertilizer without any decontamination, which might greatly pollute the environment. If overused, it will not benefit crops but may cause severe pollution in the countryside. Among the farmers who choose to directly put the livestock faeces back to the field as manure, all are farmers with lower than middle school education, whereas among those who choose various ways to dispose faeces have secondary school education or higher. Thus, their educational level has an effect on their cognition of livestock pollution, which also affect their specific processing behaviours when choosing a decontamination method. Among

Table 3: Statistical table of the environmental cognitive status of different farmers.

Recognition condition		Cognition	No cognition	Cognitive proportion (%)
Regions Location	Guohe	37	13	74.00%
	Miancheng	16	14	53.33%
Age group	Youth	8	0	100%
	Middle age	27	14	65.85%
	Old age	17	14	54.84%
Educational level	Primary school and below	10	19	34.48%
	Junior high school	36	20	64.29%
	High school and above	5	0	100%
Breeding time	Less than 5 years	7	16	30.43%
	5–10 years	22	10	68.75%
	Over 10 years	24	1	96.00%
Breeding scale	Family farmers	6	14	30.00%
	Small-scale farmers	13	7	65.00%
	Medium-scale farmers	15	5	75.00%
	Large-scale farmers	19	1	95.00%

Table 4: Statistics table of 80 farmers' behaviour in selecting faeces decontamination methods.

Treatment methods		Used as fertilizer	Biogas	Organic fertilizer
Educational level	Primary school and below	24	1	4
	Junior high school	12	15	29
	High school and above	0	3	2
Breeding time	5 years	3	11	20
	5-10 years	14	6	19
	Over 10 years	19	2	5
Breeding scale	Family farmers	20	1	0
	Large-scale farmers	0	15	23
	Medium-scale farmers	2	3	15
	Small-scale farmers	14	0	6
Recognition condition	No cognition	20	0	26
	Cognition	16	19	18
Age group	Youth	0	2	6
	Middle age	16	16	27
	Old age	20	1	11
Regions	Guohe	11	15	33
	Miancheng	25	4	11

Table 5: Governance condition of livestock pollution in Miancheng and Guohe.

Regions	The total number of managing households					
	The total number of regulations	Dismantled	Dismantling area (m^2)	Shut down number	Renovated number	Total
Miancheng	24	3	2810	1	20	24
Guohe	198	1	700	8	176	185

the farmers who chose to directly put the faeces back to field as manure, 70% believe that livestock faeces without decontamination can cause pollution. Meanwhile, among the farmers who use various ways to dispose faeces, 54% believe that putting livestock faeces back to the field without further processing can lead to severe pollution. Hence, a positive correlation exists between the choices of farmers and their attitudes toward livestock pollution.

Among the farmers who choose advanced methods of faeces decontamination, 47.8% have taken up livestock breeding for less than five years, whereas those who use livestock faeces as biogas or organic fertilizer make up 86.96% of the sample. Hence, farmers who have spent longer times engaged in this occupation are less likely to accept new concepts and technologies, proving the correlation between breeding time and farmers' choice of faeces decon-

tamination. The longer they have taken up livestock breeding, the greater the influence of traditional concepts on their farming choices. Breeding area refers to the region that might be affected by livestock pollution. If the area where the farm is located has a dense population, the farmers also face greater pressure from pollution, possibly producing a positive effect on farmers' choices of livestock faeces disposal. On the contrary, if the farm lies in a remote village, farmers may think that pollution will not make a difference to others, which reduces the possibility of such farmers choosing advanced methods (Li 2017).

The breeding scale is one of the major features of livestock breeding and is the main goal of farmers' production behaviour. According to statistics, when the farming scale is large, the proportion of farmers choosing advanced methods is also high. The proportions of middle and large-scale farms practicing advanced measures make up 100% and 90% of the sample, respectively. This is because large-scale production can bring about a large amount of faeces production, which then draws close attention from the government and other farmers (Xi & Hou 2017). Given the pressure exerted by the government, large-scale farms are more likely to adopt faeces decontamination. Specifically, the farmers in Guohe are more likely to send the faeces to factories for further processing into organic fertilizer, whereas farmers in Miancheng tend to directly put the livestock faeces into the field as fertilizer. According to Table 5, the government pays more attention to Guohe because more large-scale farms can be found here than in Miancheng. As a result, the government puts lots of energy on the harnessing of the breeding industry. Meanwhile, four large-scale factories producing organic fertilizers can be found in Guohe, which creates a positive effect on the farmers' choice of faeces decontamination. In comparison, no such factories exist in Miancheng.

Meanwhile, among the 80 farmers investigated, only 23.75% dispose the faeces by leaving them to ferment in the fermentation pool. This is because in both towns, people know little about the use of biogas. At present, farmers in both towns employ three methods to harness livestock faeces through biogas generation: family-use biogas, centralized biogas supply, and self-built biogas systems. A centralized biogas supply refers to the provision of raw material for large-scale demonstration base of biogas. However, because livestock faeces, especially chicken faeces, contain a large amount of water, some faeces may spill during the transportation, hence, only nearby farms can send their livestock faeces to the facility. Moreover, cyromazine in chicken faeces can inhibit the production of ammonia, accelerate organic hydrolysis, and produce organic acid, which prevent the metabolism of the organisms and energy transformation. This phenomenon, in turn, affects the production of methane and reduces the efficiency of biogas production, thus resulting in a treatment plant's inability to use chicken faeces and limits the utilization of livestock faeces (Wu et al. 2014).

Farm biogas equipment is the most important aspect of a large centralized gas supply. Nevertheless, the considerable cost of system maintenance and the lack of technological support have long troubled the interviewed farmers. During the investigation, we found that biogas systems in many farms in Guohe are not actually used. Thus, we can say that the high cost of maintaining such a system has become the main factor to prevent the spread of biogas technology.

CONCLUSION

In this study, 80 farmers in Xiantao of China were surveyed on September, 2016. Based on this survey, the environmental cognition of farmers and their willingness to decontaminate livestock faeces were analysed, along with their choice of livestock faeces decontamination. The relationship between livestock pollution and the environmental behaviour of farmers was also discussed. Several conclusions can be drawn from the results.

1. The environmental cognition of farmers is related to the development orientation of rural areas. Well-educated farmers and those who practice large-scale farming tend to possess high environmental cognition, whereas farmers who have taken up this occupation for a longer time than others appear to have low environmental cognition.
2. The environmental behaviour of farmers is greatly influenced by their environmental cognition and their willingness to decontaminate livestock faeces. Farming scale and government policies are two major factors affecting farmers' choices.
3. A positive correlation exists between the decision of farmers to decontaminate livestock faeces and the education they received and the scales of their farming, whereas a negative correlation exists between their choice of faeces disposal and how long they have been in this line of work. In addition, farmers who settle their farms in densely populated areas are more likely to carry out faeces decontamination.

To a certain extent, this study revealed the relationship between livestock pollution and the environmental behaviour of farmers, thus providing a theoretical reference and decision-making basis for controlling livestock pollution in the future. However, limitations still exist in the scope of the investigation and the sample size may have also affected the findings. Therefore, in future studies, we need to further expand the scope of the investigation and deepen

the studies on the relationship between livestock pollution and the environmental behaviour of farmers through the use of a large sample.

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