

Analysis of the Status and Influencing Factors of Rural Waste Classification and Treatment

—Based on the Empirical Study of Bengbu City

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Abstract

Realizing the classification and treatment of rural garbage not only has the practical significance of improving the quality of life of rural residents, improving the rural ecological environment, increasing the reuse rate of resources, but also the need to build beautiful countryside. Based on field survey data from Dougou Village and Xinbei Village, Bengbu City, the rural waste classification and treatment work is not well implemented by residents; the rural waste treatment methods are deficient; the infrastructure for waste treatment is insufficient; and the sources of funds for waste treatment are limited difficult. In order to analyze the influencing factors of China's rural garbage classification and treatment at this stage, this paper selects nine factors from five aspects: residents, government, society, economy, and family, and uses the analytic hierarchy process to compare the factors to find the main factors affecting rural garbage classification. Combined with the current status of rural waste classification and treatment, we provide effective suggestions for the development of waste classification and treatment in rural areas in China, in order to improve the current status of rural garbage treatment.

Keywords

Countryside, Garbage Classification, Influencing Factors, Analytic Hierarchy Process

1. Significance of Rural Garbage Classification and Treatment

1.1. Improve the Quality of Life of Rural Residents

At present, there is no complete garbage disposal system in rural areas in China, and incorrect garbage disposal methods have reduced the quality of life of rural

residents (Wang, 2020). Most rural garbage dumping can be seen everywhere. Open-air garbage dumping not only reduces the available area of rural land, but also hinders infrastructure construction. At the same time, the kitchen garbage such as vegetables and peels in the rubbish are extremely perishable in the summer, breeding a large number of bacteria, which seriously affects the health of residents near the storage site. It can be seen that promoting the waste separation and treatment in rural areas is conducive to improving the quality of life of rural residents.

1.2. Improve Rural Ecological Environment

The “garbage hills” everywhere and the rivers with foul smells have seriously affected the “face value” of rural areas. Waste incineration will produce some toxic and harmful gases. The incineration smoke contains mercury, cadmium, lead and other trace heavy metal substances, which are scattered in the air, reducing the air quality, and endangering human and animal and plant health. Moreover, the effect of incineration after garbage classification is different from that of direct incineration. After the garbage is incinerated, the amount of air pollutants contained in the flue gas is greatly reduced. Garbage is buried, but non-degradable plastic, glass, cans and other materials in the garbage will destroy the soil’s ability to decompose, change soil fertility, affect crop growth, and further reduce the amount of agricultural products (Hu et al., 2019). At the same time, the harmful substances in the garbage flow into the river through the rain, which will pollute the water resources and may cause eutrophication of the water body and damage the growth environment of fish, shrimp and other organisms. Sorting rural garbage and then processing it centrally can avoid air, soil, and river pollution caused by improper garbage disposal methods such as incineration and landfilling. So as to improve the rural ecological environment, improve the cleanliness and aesthetics of rural areas, and create beautiful countryside.

1.3. Improve Resource Reuse

Sorting and treating rural garbage can improve the re-use of resources. A considerable part of the garbage generated by rural residents every day is not really “garbage”. Waste paper, packaging boxes, etc. can be recycled for processing and reuse, thereby reducing tree felling. Among them, the garbage such as melon peel and vegetables can be used as green fertilizer for crop growth after treatment, which can improve the health quality of agricultural products (Wang et al., 2019). In addition, beer bottles and glass beverage bottles in the garbage can be reused after a series of treatments such as cleaning, sterilization, and disinfection. Separate and treat waste, reduce the amount of waste from the source, reduce the burden of waste removal and transportation, and recycle and reuse valuable resources at the same time, reduce the disposal of resources, and generate certain economic benefits.

2. Status and Challenges of Garbage Disposal in Bengbu City

2.1. Residual Garbage Sorting Is Not High

Most of the rural residents in Bengbu City have low initiative, enthusiasm and coordination in participating in waste sorting, which makes it difficult to effectively carry out waste sorting work in rural areas, which increases the difficulty of achieving waste sorting in rural areas from the source. First of all, residents are not aware of the importance of waste sorting. It is considered that the proportion of recyclable waste in the daily output of rural areas is small, and there is not much difference between classified and one-time disposal of waste, and it is ignored that non-degradable waste and toxic and hazardous waste cause serious damage to land and the environment. Second, residents are reluctant to sort waste. In consideration of their own interests, residents believe that sorting garbage and placing it at designated collection points will not only take time and trouble. Often, domestic garbage is dumped at the riverside or at the end of the village at will, resulting in an increased burden on waste sorting. Finally, residents lack knowledge of waste classification. At this stage, the rural residents have a low level of education and weak learning ability, and it is difficult to correctly classify the garbage. Usually, the garbage is misplaced. In the later period, staff need to reclassify the misplaced garbage.

2.2. Large Defects in Rural Garbage Disposal Methods

According to the survey of the rural garbage disposal methods in Bengbu City, 36.7% of the villages choose to separate and recycle the garbage for centralized treatment; 15.7% of the villages will burn the garbage on-site; 23.9% of the villages will bury the garbage on-site; Waste is composted *in-situ*; 3.3% of villages choose other waste disposal methods. It can be seen that about two-thirds of the rural areas in Bengbu have not sorted the garbage. *In-situ* incineration will increase atmospheric pollutants and affect air quality; *in-situ* burial will cause toxic and harmful substances in the garbage to damage the soil structure and reduce the fertility of the land; *in-situ* composting requires people to spend time selecting organic substances in the garbage, and this treatment. The method takes up a lot of land. More than half of the rural areas of Bengbu City have defects in their waste disposal methods. There is an urgent need to improve and upgrade the garbage disposal methods in rural areas.

2.3. Inadequate Waste Treatment Infrastructure

First, the problem of garbage classification and treatment in rural areas has not attracted enough attention from the relevant government. Most of the rural areas in Bengbu lack basic garbage disposal equipment such as garbage bins and garbage trucks, resulting in rural residents having to throw away garbage at will. Secondly, there is still a gap between the scale of the rural garbage disposal system and the amount of garbage generated in Bengbu City. Some domestic garbage disposal sites have more garbage disposal capacity than loading operations,

resulting in the inability to process garbage outside the processing capacity in a timely manner, resulting in garbage accumulation. Third, the development of rural areas in Bengbu City is relatively backward, the government's financial funds are limited, and the investment in waste disposal in rural areas is insufficient, so it lacks effective waste disposal equipment.

2.4. Limited Sources of Waste Disposal Funding

The construction of garbage treatment facilities in rural areas and the subsequent maintenance and repair of equipment require a large amount of financial support, but the current sources of waste disposal funds in rural areas in Bengbu City are limited. On the one hand, among the residents who support waste sorting in rural areas, most of them are unwilling to pay a certain amount of waste disposal costs. On the other hand, enterprises in rural areas of Bengbu City have less funding for waste sorting. Therefore, the funds for garbage disposal in rural areas mainly come from the government, but the government funds are limited, and the scope of use of the funds is wide, and fewer funds can be invested in the classification and treatment of rural garbage. There are few sources of funds for the waste separation and treatment in rural areas of Bengbu City, which is a huge challenge for the smooth development of rural waste separation.

3. Investigation

Dougou Village, Guxian Town, Bengbu City, and Xinbei Village, Wuhe Town were selected as survey objects. Residents were surveyed to analyze the status of waste disposal in rural areas from the perspective of residents, and to find relevant factors affecting the classification and treatment of waste in rural areas.

3.1. Basic Situation of Investigation

3.1.1. Investigation Place

Bengbu City has implemented garbage cleaning since 2010. Although some cleaning results have been achieved, overall progress has not been smooth and there are still many shortcomings. There are a total of 45 townships and towns under Bengbu City, and Dougou Village of Guxian Town and Xinbei Village of Wuhe Town were selected as the survey objects. Dougou Village, Guxian Town is the earliest batch of townships in Bengbu City to start garbage cleaning. The cleaning effect of Dougou Village in Guxian Town is better than that of other townships. However, Xinbei Village in Wuhe County is relatively remote, and the garbage collection work has been carried out relatively late. The selection of these two villages makes it easier to compare and analyze the waste disposal situation at the two locations and to perform statistical analysis on their problems.

3.1.2. Survey Content

The survey was conducted from three aspects: the basic information of the villagers, the current status of garbage disposal, and related factors affecting garbage disposal. The basic information part includes the respondent's age, gender,

occupation, and residence time; the status of waste disposal includes the status of waste pollution, treatment methods, and facilities; related factors affecting waste disposal include the degree of interest, understanding, and implementation of residents' disposal of waste. Degree, government attention and participation, law enforcement efforts, social propaganda, capital investment status, household waste classification and education impact.

3.1.3. Determination of the Sample Size of the Questionnaire

The determination of the sample size requires comprehensive consideration of the differences in economic development status and people's cultural level between the surveyed areas, and is also affected by sampling methods and confidence levels. In order to obtain the most scientific results and reduce the survey costs, the following formula is used to predict the necessary sample size:

$$n_i = \frac{N_i z_{\alpha/2}^2 P(1-P)}{N_i \Delta_p^2 + z_{\alpha/2}^2 P(1-P)}$$

Among them, n is the necessary sample size (the necessary sample size is the remaining amount after removing the invalid survey objects), N_i is the total number of people in the survey area i , $z_{\alpha/2}$ is the critical value at the confidence level α , P is the sample proportion, and Δ_p is the allowable Maximum sampling error. The number of people in Xinbei Village of Wuhe County and Dougou Village of Guzhen County in this sampling survey plan is 1196 and 2394 respectively. We assume that the proportional sampling error is 5% and the confidence is 95%, so $z_{\alpha/2} = 1.65$, because the data about such surveys are completely lacking, set P to 0.5 to maximize the overall variance and meet our requirements for accuracy.

Substituting the total population of Xinbei Village and Dougou Village into the formula respectively, the necessary sample size values are 221 and 244 respectively. Considering that there may be invalid questionnaires in the questionnaire survey, the effective rate is between 0.75 and 0.8. According to the conservative principle, the design questionnaire volume is n_{0i} as follows:

$$n_{0i} = \frac{n_i}{0.75}$$

After adjusting according to the above formula, the number of questionnaires determined in Xinbei Village and Dougou Village was 295 and 325 respectively.

3.2. Survey Data Analysis

3.2.1. Respondents' Basic Information Analysis

According to the survey results, male residents accounted for 41.6% of the respondents, female residents accounted for 58.4%, and the ratio of men and women was more balanced. The age of the residents surveyed is mainly concentrated in the age group of 21 - 40 years old, accounting for 70.82% of the age distribution. In terms of occupations, students, business and civilian personnel participated in a large number of questionnaire surveys, and the sum of the three

occupations accounted for 76.4%. The three professionals have a relatively high level of education, which increases the credibility of the survey results (Table 1).

3.2.2. Analysis of the Status of Garbage Disposal

Due to the early implementation of garbage cleaning work in Dougou Village, Dougou Village currently has less waste pollution than Xinbei Village, more reasonable waste disposal methods, and more waste disposal equipment.

According to the data on the status of waste pollution in Table 2, there is a big difference between the status of waste pollution in Dougou Village and Xinbei Village. Generally speaking, the waste pollution in Xinbei Village is more serious than that in Dougou Village. 68% of the residents in Dougou Village think that the garbage in the village has little pollution to the environment, while 63.4% of the residents in Xinbei Village think that the pollution in the village is more serious. According to the data of rural waste disposal methods in Table 3, 53.8% of residents in Dougou village choose to separate waste for recycling and centralized treatment, 22.5% of residents choose to perform *in-situ* composting. The proportion of waste incineration and landfill disposal is relatively small. It can be seen that the overall waste disposal method of Dougou Village is more reasonable and has less environmental pollution. Among the waste disposal methods in Xinbei Village, waste incineration methods accounted for 24.1%, and waste landfill methods accounted for 35.3%. More than half of the residents' garbage treatment methods had a greater impact on rural living environment pollution. According to the survey data of rural garbage disposal equipment in Table 4, Dougou Village is basically complete in the equipment configuration of village cleaners, garbage transfer stations, garbage rooms, garbage cleaning tools, sewage treatment systems, incinerators, etc., and some equipment is insufficient. There is a serious shortage of garbage disposal equipment in Xinbei Village, and the number of basic equipment such as garbage bins and garbage cleaning tools has yet to increase.

Table 1. Basic information of respondents (%).

Basic Information	Gender	Male	41.6%
		Female	58.4%
	Age	13 - 20 years	17.05%
		21 - 40 years old	70.82%
		41 - 60 years old	11.80%
		Above 60 years old	0.328%
	Occupation	Agricultural staff	5.902%
		Migrant workers	15.08%
		Doing Business	22.62%
		Civilian	22.30%
Student		31.48%	
Other		2.623%	

Table 2. Status of garbage pollution (%).

Status of garbage pollution	Dougou Village	Xinbei Village	Total
Serious pollution	4%	5.8%	4.9%
Severe pollution	26.2%	63.4%	43.9%
Less pollution	68%	28.8%	49.5%
Don't know	1.8%	2%	1.7%

Table 3. Rural garbage disposal methods (%).

Treatment method	Dougou Village	Xinbei Village	Total
Classified recovery, centralized processing	53.8%	18%	36.7%
In-place incineration	8%	24.1%	15.7%
Buried on-site	13.5%	35.3%	23.9%
Compost <i>in situ</i>	22.5%	18.3%	20.3%
Other	2.2%	4.4%	3.3%

Table 4. Rural waste treatment equipment (%).

Treatment equipment	Dougou Village	Xinbei Village	Total
Large number of equipment, well equipped	60.3%	14.6%	38.5%
Average number of equipment, lack of effective equipment	30%	49.8%	38.9%
Low number of equipment, lack of basic equipment	10.7%	35.6%	22.6%

4. Hierarchical Analysis of Influencing Factors

4.1. Constructing AHP Model of Influencing Factors

4.1.1. Establishing a Hierarchical Model

After a field survey of the current status of garbage classification in Dougou Village and Xinbei Village, Bengbu City, combined with existing literature, it is believed that the factors affecting rural garbage classification come from the residents themselves, the government, society, economy, and family. Therefore, the current status of rural garbage disposal is used as the target layer; residents, government, society, economy, and households are used as the standard layer; the level of residents' knowledge, interest, and implementation of garbage classification, the government's attention and participation, and law enforcement efforts. The nine aspects of the declared strength of society, the impact of economic funds, the atmosphere of household waste sorting, and family education are used as index layers to establish a hierarchical structure model of the factors that influence waste sorting.

4.1.2. Construction of Discriminant Matrix

According to the filled-in questionnaire content, AHP was used to calculate the weights of each level and point. Compare the importance of each factor in the same layer to the corresponding factor of the previous layer (such as the degree

of influence on the residents in terms of understanding, interest, and execution) to construct a comparison discrimination matrix.

Assume that factor C_k in the criterion layer is related to M_1, M_2, \dots, M_n in the next layer, and compare the importance of M_i and M_j to C_k in pairs to construct a weight judgment matrix:

$$A = (A_{ij}^i)_{n \times n}$$

For the matrix, the 1 - 9 scale method proposed by Saaty is used: A_{ij}^i is the scale of comparison between B and C, and the importance is assigned on the scale of 1 - 9. If M_j is absolutely more important than M_i , then the value of A_{ij}^i is 9; if M_i is absolutely more important than M_j , then the value of A_{ij}^i is. **Table 5** lists the meaning of each scale in the 1 - 9 scale method.

4.1.3. Consistency Inspection

Consistent judgment is required on the discrimination matrix to prove the correctness of the logical relationship between the influencing factors in the analytic hierarchy model.

1) Calculate the consistency index CI of the evaluation matrix, that is $CI = (\lambda_{max} - n) / (n - 1)$ where: n is the order of the evaluation matrix, that is, the number of evaluation elements, and λ_{max} is the order of the discrimination matrix.

2) According to the corresponding numerical relationship between the random consistency index RI and the order n in the AHP method, the average random consistency index RI related to the consistency ratio CR can be obtained.

3) Calculate the consistency ratio CR, that is, $CR = CI / RI$. When $CR < 0.1$, the evaluation matrix can be considered to have good consistency; otherwise, the matrix needs to be corrected for consistency.

Using MATLAB software to find the weight of the criterion layer (resident, government, society, economy, family) on the target layer (the status of garbage classification) is: 0.44, 0.35, 0.10, 0.06, 0.05, and $CR = 0.0507 < 0.1$, Passed consistency check. Using the same method to calculate the weight of each index between levels, you can get the weight of the influencing factors at each level of the garbage classification status assessment system. The comprehensive score and ranking of influencing factors are shown in **Table 6**.

4.2. Results Analysis

According to the weight analysis of each influencing factor in **Table 6**, among the five influencing factors of residents, government, society, economy and family, residents and government have a greater degree of influence on the status of rural waste classification and treatment, with weights of 0.44 and 0.35. Society also has a certain degree of influence on the status of rural garbage classification and treatment. The weight of social factors is 0.10. Compared with the three factors of residents, government and society, economic and household factors have less impact on the status of rural waste disposal.

Table 5. Example of 1 - 9 scale method.

Scale	Definition	Description
1	Equally important	Both elements are equally important
3	Slightly important	Compared with the two factors, the former is slightly more important than the latter
5	Obviously important	Compared with the two factors, the former is obviously more important than the latter
7	Much more important	Compared with the two factors, the former is much more important than the latter
9	Extremely important	Compared with the two factors, the former is more important than the latter
2, 4, 6, 8	Judgment median	Take the median importance of neighboring judgments
Reciprocal of the above numbers	Inverse comparison	If the ratio A_i^j of importance between i and j is n , then the ratio of j to i is $A_j^i = 1/n$.

Table 6. Comprehensive scores and rankings of influencing factors.

Category	Element	Overall weight	Overall weight ranking
Residents (0.44)	Knowledge (0.60)	0.26	1
	Level of interest (0.28)	0.12	4
	Performance (0.13)	0.06	6
Government (0.35)	Focus on participation (0.5)	0.17	2
	Enforcement of law enforcement (0.5)	0.17	2
Social (0.10)	Publicity (1)	0.10	5
Economy (0.06)	Funding impact (1)	0.06	7
Household (0.05)	Atmosphere for household waste sorting (0.4)	0.02	8
	Education impact (0.6)	0.03	9

For the resident factor, the level of understanding of garbage classification is more important than the level of interest and enforcement. Therefore, it can be seen that the degree of residents' knowledge of garbage classification and treatment determines their behavior. The more residents pay attention to the problem of garbage classification and treatment, and the more they know about garbage classification, the more resident individuals tend to participate in garbage classification. As far as government factors are concerned, the government's attention to participation in rural waste sorting and law enforcement has equal weight. Therefore, for the government, if we want to realize the waste separation and treatment in rural areas, we must pay attention to the progress of waste separation work in rural areas in real time, and strengthen law enforcement.

5. Conclusions and Recommendations

At present, there are still many problems in the classification and treatment of

rural garbage in Bengbu City. First of all, residents do not have a high level of understanding of rural garbage classification, lack of knowledge of garbage classification, and poor self-discipline; there are many towns and villages in Bengbu City, and their residences are scattered, making it difficult to manage them uniformly. Secondly, there is no special organization to carry out publicity and education on garbage classification in rural areas, organize residents to learn garbage classification knowledge, and manage the status of garbage classification and treatment. Furthermore, the lack of relevant laws, regulations and punishment systems for waste disposal in rural areas, combined with inadequate enforcement, has made it difficult for rural residents and village cadres to hold people accountable even if they do not actively cooperate with the development of rural waste sorting. Finally, the limited source of funds for rural waste separation and treatment affects the construction of waste treatment facilities in rural areas. In addition, a small number of residents will use the waste bins placed near their homes for their own use, resulting in waste disposal basic facilities in rural areas can be used rarely.

Aiming at the difficulties in developing garbage classification in rural areas, this article puts forward the following suggestions, hoping to improve the status of rural garbage disposal.

5.1. Increase Residents' Awareness of Waste Classification

Residents, as manufacturers of rural garbage, must have a strong sense of garbage classification and reduce the workload of rural classification and treatment from the source. On the one hand, the government must carry out in-depth publicity work on garbage classification in rural areas, so that residents are deeply aware of the importance of rural garbage classification, and recognize the benefits that garbage classification brings to the country, society, environment, and residents themselves. The traditional form of knowledge promotion is monotonous and boring, which is likely to cause resistance among residents. Combining knowledge with the daily lives of residents, and using the methods of life to teach residents the relevant knowledge. Rural residents have less daily free time, and relevant departments should establish appropriate reward mechanisms to stimulate residents' enthusiasm for learning. On the other hand, residents must seriously participate in the training of waste classification knowledge carried out by relevant departments, and at the same time use the resources available around them to learn the knowledge of waste classification autonomously.

5.2. Broadening the Sources of Funding for Rural Waste Disposal

The construction of basic facilities for rural waste separation and treatment is limited by the amount of funds. To increase the investment in basic equipment for waste treatment in rural areas, the source of funds must be widened and there must be sufficient financial support. First, understand the range of waste disposal costs that residents are willing to pay, and charge a certain amount of

waste disposal costs within the acceptable range of most residents, so that residents can participate in infrastructure construction. Second, increase the tax rate for enterprises that exceed the pollutant discharge standards in rural areas, and promulgate preferential policies for the development of enterprises in rural areas to attract social capital investment. The increased tax and investment capital will be used in the construction of rural waste treatment infrastructure. Finally, the government must establish a strict fund management mechanism, make reasonable use of financial funds, and appropriately increase the proportion of investment in rural waste treatment infrastructure. Residents, society, and the government must participate in the construction of waste treatment infrastructure in rural areas in order to provide sufficient funding to support the separation of rural waste as soon as possible.

5.3. Establish a Sound Legal System

The law is the guarantee to ensure the implementation of various national policies. To solve the problem of rural domestic garbage disposal, many laws must be implemented. The details of waste disposal in rural areas are numerous and tedious, and the involved areas are wide. It is necessary to establish and improve the legal system in this regard to fill the gaps in laws and regulations on rural waste disposal. Use it to clarify the rights and responsibilities of relevant subjects. Establish a sound legal system, clarify the responsibilities and obligations of residents, cadres, governments and other themes in carrying out rural garbage classification and treatment, increase the punishment of random disposal of garbage, reduce the source of rural garbage, and improve the status of rural garbage disposal.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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