

Research Progress Related to Rural Domestic Sewage Treatment

Yu Wang, Xiujuan Wang*

College of Public Administration, Shandong Agricultural University, Tai'an, China

Email: *xjwang0709@sdau.edu.cn

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Abstract

Rural domestic sewage treatment is an important part of the rural revitalization strategy and a key action to build a livable, livable and beautiful countryside. This paper composes and summarizes the relevant studies on rural domestic sewage treatment from the governance techniques and modes of governance subjects and research perspectives, in order to provide reference for the implementation of rural revitalization strategy and rural domestic sewage treatment research and action implementation.

Keywords

Countryside, Domestic Sewage, Sewage Treatment

1. Introduction

Rural sewage treatment is an important part of the improvement of the rural habitat environment, is an important initiative to implement the rural revitalization strategy. On February 14th, 2023, “the CPC Central Committee and State Council on doing a good job in 2023 to comprehensively promote the key work of rural revitalization” (hereinafter referred to as “Opinions”) was officially released. The Opinions point out that we should do a good job in the “three rural areas” in 2023 and in the future period, solidly promote rural development, rural construction, rural governance and other key work, build a livable, workable and beautiful countryside, and lay a solid foundation for a good start in building a socialist modern country. With the progress and development of society, the amount of rural domestic sewage discharge is also increasing year by year. According to the data of the seventh national census, as of May 2021, China’s rural population reached 509.79 million people [1]. From the data published by the Ministry of Housing and Urban-Rural Development, it can be seen that the total

amount of rural sewage discharge in China continued to rise in 2016-2020, and the annual national rural sewage discharge amounted to 33.71 billion cubic meters in 2020, while the rural domestic sewage treatment rate reached only 37.26%, far lower than the urban sewage treatment rate. In recent years, the country has continued to promote the improvement of the rural habitat environment, and gradually establish technical standards and norms for rural domestic sewage management, with obvious results. From an overall perspective, the amount of rural domestic sewage treatment has increased year by year, but the increment is relatively small [2]. At the present stage, rural domestic sewage treatment still faces many problems, such as: technology does not match the actual demand, lack of facilities for systematic treatment, and late operation and management of facilities cannot be guaranteed.

The current research in the field of rural domestic sewage treatment by domestic and foreign scholars is increasing, and the number of studies on treatment technologies has increased significantly. The purpose of this paper is to summarize and conclude the current research results in terms of rural domestic sewage treatment subjects, technologies and models, and different research perspectives, in order to provide relevant references for future rural domestic sewage treatment research.

2. Research on the Main Body of Rural Domestic Sewage Treatment

2.1. The Characteristics of Rural Domestic Sewage

Research on the characteristics of rural domestic sewage has a relatively consistent view among scholars. In terms of the components and composition of domestic sewage, Ma Lin and He Feng (2014), rural domestic sewage is mainly composed of two parts: one part is gray water containing kitchen drainage, sanitary shower water, and laundry water, and the other part is black water consisting of feces and urine and their rinse water, which presents high ammonia and nitrogen content, strong biochemical properties, and less harmful substances [3]. In terms of discharge characteristics, Li Bin (2017) pointed out that rural domestic sewage is different from urban domestic sewage and has the characteristics of relatively small discharge, high concentration of organic pollutants and uneven discharge [4]. Wang Bo (2022) also argued that due to the spatial distribution of villages is not concentrated, rural domestic sewage discharge is extensive and not easy to collect, and the discharge varies greatly from day to night, showing a seasonal pattern [5]. In addition, in terms of influencing factors, Leilei He (2022) argues that rural domestic sewage in China has certain uniqueness, mainly influenced by economic culture, geographical location and production and living habits, which shows a great difference from the characteristics of urban sewage [6]. Dong Liwei (2022) similarly pointed out that it is difficult to collect rural domestic sewage centrally, and due to the influence of villagers' long-term living habits, some domestic sewage is splashed nearby in the ditches along the road or

in the nearby water bodies [7].

2.2. The Current Situation of the Main Body of Rural Domestic Sewage Treatment

Rural domestic sewage management in China usually involves the government, enterprises, NGOs and villagers, and is not only the responsibility of the government (Wang Bo, Zheng Lijie, Wang Xiahui, 2020) [8]. Tsagarakis K P and Georgantzis N (2003) studied villagers' willingness to use unconventional water resources from the perspective of income and education level, and found through data analysis that higher income and education level of villagers were positively correlated with willingness to participate [9]. Rural domestic sewage management in China usually includes three main bodies: government, enterprises and villagers. According to Cai Luxiang (2015), the current problem of overlapping functions of administrative agencies for rural domestic sewage management greatly hinders the coordination and cooperation between departments; the management tools of township environmental protection agencies lag behind the local agricultural environmental protection needs [10]. Ju Changhua (2016) pointed out that China's rural domestic sewage operation management subject diversified, in the early stage of the completion of the equipment is generally run by the construction unit on behalf of the construction, equipment acceptance after the transfer to a qualified operating company is responsible for the operation, and the later maintenance of equipment by the village, the town itself to run more [11]. According to Wang Bo (2020), due to the government's long-term "big package", imperfect market mechanism, and the lack of endogenous power of farmers' participation, the main body of rural domestic sewage management at this stage presents a monolithic situation [5]. Guo Fang (2022) argues that the current administrative agencies involved in rural domestic sewage management have serious cross-functional, unclear and fragmented responsibilities, which makes supervision more difficult [2].

3. Rural Domestic Sewage Treatment Technology and Model

3.1. Rural Domestic Sewage Treatment Technology

Foreign research on sewage treatment started earlier and has accumulated rich experience. Hellström D and Jonsson L (2004) found that decentralized sewage treatment systems are more suitable for rural areas where the population is scattered and the sewage is small and difficult to collect [12]. Ham J H, Yoon C G, Jeon J H and Kim H C (2007) found through a study that constructed wetland and sewage stabilization ponds as a sewage reclamation system in a decentralized rural area achieved more satisfactory sewage treatment [13].

China's research on rural domestic sewage management began only in the late 1980s and early 1990s, a late start compared to foreign countries that began in the mid-19th century. In recent years, with the continuous promotion of rural habitat improvement actions, various forms of rural domestic sewage treatment

technologies have been promoted and applied. Scholars mostly classify sewage treatment modes into two categories, decentralized and centralized, according to the different ways of sewage collection and treatment. Su Donghui (2005) discovered the new technology of “FILTER” sewage irrigation, which combines filtration, land treatment and dark pipe drainage [14]. According to Ma Lin (2014), the more decentralized sewage treatment technologies currently used in rural areas of China include artificial wetlands, high-efficiency algae pond technology, and earthworm ecological filter, etc., but various technologies have limitations, thus giving rise to treatment technologies that combine multiple processes, which can be roughly divided into three major categories: biological combination technologies, ecological combination technologies, and biological-ecological combination technologies [3]. Huang Pei (2017) pointed out that the common domestic sewage ecological treatment technologies in rural areas are artificial ecological wetland treatment technology, stabilization pond technology, and land treatment process technology; the biological treatment technologies used are anaerobic biological treatment technology, aerobic biological treatment technology [15]. Hu Xiaobo (2020) pointed out that in order to break the limitations of traditional domestic sewage treatment technology by the economic and land area conditions, bio-ecological combination technology to complement each other, and currently bio + artificial wetland combination technology and bio + other ecological combination technology are more common [16]. Zhang Xiaoliang (2022) pointed out that the “primary treatment” method currently used in some areas has the problems of not being able to “remove phosphorus and nitrogen” and the poor disinfection quality of the effluent, which cannot well realize the reuse of water resources [17].

3.2. Rural Domestic Sewage Treatment Model

Since rural areas in China have different topographical features and temperature conditions, and villagers have different living habits, it is crucial to reasonably choose a suitable local domestic sewage treatment model. Dong Ruihai (2014) proposed a rural sewage ecological treatment model with material separation at the source of rural sewage, which facilitates the recycling of valuable materials in close proximity for sewage resource treatment [18]. Yu Fawen (2019) summarized three rural domestic sewage treatment models. The first is the urban-rural unified treatment model, which is economical and efficient in that the domestic sewage collected centrally by the pipeline network is treated by the urban sewage treatment plant without the need to build a sewage treatment station in situ. The second is the village centralized treatment model, which requires several conditions to be met to adopt this model: villagers live centrally, have the conditions for pipeline network laying or constructing culverts, have easy to build anaerobic treatment ponds, artificial wetlands and other simple sewage treatment facilities of vacant land. This model is widely used in rural areas. The third is the decentralized treatment model of farmers, which is the use of villagers’ own sewage

treatment facilities such as biogas digesters for sewage treatment, and is suitable for areas with scattered residence [19]. Xue Nan (2021) analyzed what are the urgent problems of decentralized treatment mode in the application of rural domestic sewage treatment and put forward relevant suggestions [20]. Chen Xiuli (2022) analyzed the sewage treatment mode in terms of economic benefits and treatment effects, and found that selecting a reasonable treatment mode according to the conditions of geographical location, topography, population distribution, and surrounding municipal pipeline network support can effectively improve the utilization rate of resources [21]. Dong Liwei (2022) proposed four models that can meet the resourceful reuse of rural domestic sewage: the coupling model of pollutant reduction and cash crop cultivation, the tailwater irrigation model, the water quality regulation type on-demand discharge model, and the black ash water quality resource utilization model [7].

4. Perspectives on Rural Domestic Sewage Management Analysis

4.1. Theoretical Analysis Perspective

Although China's research on rural domestic sewage treatment started late compared with Western countries, domestic scholars have accumulated fruitful research results in related fields based on different disciplines and schools of thought. Zhu Mingfen (2010) found that in the construction of rural domestic sewage treatment facilities, village collectives, villagers, and private enterprises show very active voluntary participation behavior, which is contrary to the view that the supply of public goods requires government intervention or else it cannot meet the demand, as argued by neoclassical economics. Therefore, she represents rural domestic sewage treatment facilities as a rural public good and explores its voluntary supply mechanism and induction mechanism [22]. Based on microeconomic theory, Huang Jikun (2019) proposes that whether villagers participate in the behavior of rural domestic sewage treatment can be considered as a solution to the problem of maximizing villagers' utility under certain budget constraints [23]. Based on the analytical framework of planned behavior theory, Wei Tongyang (2022) used the improved conditional value assessment method (CVM) with single boundary plus payment card type, and the Heckman two-stage model to analyze the differences in farmers' payment behavior and key factors [24].

4.2. Farmers' Analytical Perspective

4.2.1. Villagers' Willingness to Participate in Rural Domestic Sewage Treatment

Regarding the study of villagers' willingness to participate in rural domestic sewage management, some scholars focus on "whether villagers have the willingness to participate". Su Shu Yi (2020), through collecting statistics of 160 villages in Shandong Province, pointed out that 75.17% of the villagers were willing to

support or participate in the collective village domestic sewage management, and 24.83% of the villagers were unwilling to participate in it [25]. Scholars have mostly explored the influencing factors of villagers' willingness to participate through a combination of theoretical and empirical analyses. Dutch scholars Victor Silvan van den Berg and Frank van Lamoen (2007) proposed to establish a community of practice at a pilot scale, where user groups within the community exchange and share information, and then share the acquired information with stakeholders across the region, thus playing an important role [26]. After theoretical analysis of villagers' willingness to participate in rural domestic sewage management, Fang Juanjuan (2018) further used an ordered logit model to analyze the influence of villagers' personal and their family characteristics, the current situation of water resources utilization and the perception of water pollution management on villagers' willingness to participate in water pollution management, and proposed that the responsibilities of each interest body should be clarified, and the measures such as implementing environmental monitoring and information disclosure should be used to strengthen the communication between subjects should be strengthened through the implementation of environmental monitoring and information disclosure [27]. Based on research data from 16 localities in Shandong Province, Su Shuyi (2020) concluded, after using a binary choice Logit model analysis, that factors such as farmers' own literacy, farmers' concern for surrounding water quality, toilet sewage discharge methods, whether their village attaches importance to domestic sewage treatment, and whether the village committee popularizes domestic sewage treatment knowledge are associated with villagers' willingness to participate in rural domestic sewage treatment in a significant positive correlation between [25]. Wei Tong Yang (2022) pointed out that villagers' willingness to participate in the management and care of rural domestic sewage treatment facilities was consistent with the theory of planned behavior and showed significant correlations with behavioral attitudes, subjective norms, perceived behavioral control, age, whether they were party members, health status, and total household income [24].

It is evident from numerous studies that improving the level of awareness of domestic sewage management in rural China is crucial for the successful promotion of sewage management. Wei Tongyang (2022) suggested based on the findings that villagers' participation in domestic sewage treatment can play a facilitating role, and villagers' behavioral decisions will be influenced by social pressure, herd mentality, and other factors based on economic rationality, so the publicity of domestic sewage treatment should be increased to encourage some groups with higher environmental awareness to participate first, so that villagers are fully aware of the sewage treatment bring ecological benefits [24]. Fang Juanjuan (2018) specifically pointed out in the context of the actual situation in the countryside that the villagers' awareness of domestic sewage treatment can be improved through radio, television, slogans and village performances [27].

4.2.2. Villagers' Subjective Evaluation in Rural Domestic Sewage Treatment

The term “sense of gain” was first introduced by General Secretary Xi Jinping in 2015 and has local characteristics. Based on the satisfaction model and TOE theoretical framework, Zheng Fanghui (2021a) measured villagers' sense of gain and satisfaction in the process of rural domestic sewage treatment and found that it was much lower than the overall satisfaction of rural revitalization. Further using ordered logistic regression analysis, it was found that villagers' sense of gain in rural domestic sewage treatment was related to farmers' income, government performance, degree of participation, and mode of governance, and was significantly and positively correlated [28]. Based on the result-oriented and public satisfaction-oriented, Zheng Fanghui (2021b) took rural domestic sewage management in G province as an example and found that there is a correlation between government performance goals and public satisfaction through an empirical study, and proposed that the performance goals of local governments should be more relevant to actual needs and motivate villagers to participate in the whole process of domestic sewage management [29].

5. Literature Review

To sum up, domestic and foreign scholars have made abundant research results on rural domestic sewage management. Rural domestic sewage has its own characteristics and shows great differences from urban sewage. In terms of governance subjects, some scholars proposed to carry out collaborative governance, avoiding the phenomenon of “the government taking the lead” and giving full play to the maximum role of different subjects. The number of studies on sewage treatment technologies and models is huge, and many scholars have researched the combination of technologies that focus more on local utilization and recycling of resources on the basis of traditional technologies and processes. At present, most scholars focus more on the technologies and models of rural domestic sewage management, compared with less research on topics such as villagers' participation behavior and subjective evaluation. However, villagers are both stakeholders of rural domestic sewage treatment and one of the subjects that can play an important role in the treatment process.

6. Conclusions and Outlook

In recent years, China's rural domestic sewage management has made great progress, the state has continued to introduce relevant laws and regulations to protect the smooth promotion of governance actions. The study found that rural domestic sewage exhibits characteristics such as difficult to collect, small scale, and scattered discharge, and some of the villagers' long-standing habits and awareness cannot be easily changed, the governance work has a certain degree of complexity. At present, there are many governance technologies and models, but how to choose according to the local characteristics of scientific and reasonable,

needs to be further explored by scholars. Whether villagers, as one of the main subjects of rural domestic sewage treatment, can be satisfied in practice, and how to measure villagers' satisfaction, still needs to be explored by experts and scholars to provide strong support for the development of rural revitalization strategy.

This paper summarizes and composes the relevant studies on rural domestic sewage management in recent years, but the number of literature studies is limited, and rural domestic sewage management is still evolving, so it is expected that a more comprehensive understanding and improvement will be carried out in future studies.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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