Current Situation and Technology Applications of Rural Domestic Sewage Treatment

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Abstract: Because of the limitation of rural economic development and the lack of technical conditions, as a result, rural domestic sewage is not well treated, it has caused serious damage to rural water environment. This paper analyzes the characteristics of rural domestic sewage discharge and sewage treatment, and introduces several sewage treatment technologies suitable for rural areas in China, compare their advantages and disadvantages, the future development direction of domestic sewage treatment technology in rural areas is pointed out. It provides some reference for rural sewage treatment in China.

Keywords: sanitary sew age; sewage status; sewage treatment technology; water quality

1. Introduction

With the acceleration of urbanization in Chinese rural areas and the change of residents' lifestyle, the discharge of rural domestic sewage is also increasing. Due to the backward economic development and the imperfection of sewage treatment technology in rural areas, most of the villages lack perfect drainage channels and sewage treatment system. At present, only about 20% of rural domestic sewage in China is able to be treated [1]. The random discharged domestic sewage has caused serious pollution to the rural ecological environment, which poses a serious threat to the underground water system, causes eutrophication of nitrogen and phosphorus in lakes and leads to the formation of black and odorous water. So, it is urgent to solve the problem of rural sewage treatment. In the process of rural sewage treatment, adopting the method of adjusting measures to local conditions according to the local economic situation and the distribution and discharge of sewage is not only the key to solve the decentralized discharge of rural sewage, but also an important measure to improve the rural ecological environment. Based on this, this paper summarizes the technology and problems in the process of rural sewage treatment at this stage in China, in order to explore the technology and methods suitable for rural domestic sewage treatment.

2. Current Situation of Rural Sewage

2.1. Current Situation of Domestic Sewage of Rural Residents

According to the analysis of rural residents living habits, the source of domestic sewage and the quality and quantity of sewage, combined with the basic situation of rural areas, rural domestic sewage has the following characteristics:

(1) Scattered emission sites. Due to the lack of centralized sewage treatment facilities and drainage network in most rural areas of China, most domestic sewage is directly discharged to the ground, naturally evaporating or seeping into the underground water body. Or it is discharged to rivers, ponds and other outdoor low-lying places by simple drainage channels. Both ways of sewage discharge seriously pollutes the groundwater and leads to the surface water eutrophication.

(2) Great fluctuation of water quality and quantity. In China, the daily variation coefficient of rural domestic sewage discharge is high, and the discharge is time-dependent. There are three main periods (morning, noon and evening) during the peak period of daily drainage. Among them, the discharge amount of sewage at noon and at night are large. The sewage discharge at midnight is low or even zero. The change trend is obvious. The discharge of rural domestic sewage is affected by living habits, seasonal changes, living environment and other factors, and the source of sewage in different periods is also different [2] (Table 1).

Table 1. Main sources of rural domestic sewage in different periods.

Time Segment	Sewage Source
Morning (06:00-07:00)	Kitchen Sewage And Washing Water
Noon (11:00-13:00)	Kitchen Sewage And Laundry Water
Night (18:00-22:00)	Kitchen Sewage And Bath Water

(3) High content in organic substances. Rural domestic sewage mainly comes from kitchen water, washing water, toilet waste water and breeding waste water. The high concentrations of Nitrogen, Phosphorus, Ammonia Nitrogen and COD can easily cause water eutrophication, which is the main reason of rural water pollution [3].

2.2. Current Situation of Rural Domestic Sewage Treatment

The research on rural domestic sewage treatment technology started late in China. The development and research of rural domestic sewage treatment technology began in the 1980s. In rural areas, many small sewage treatment devices have been installed. However, the utilization rate of these devices is low and there are many problems. The main problems of rural domestic sewage treatment in China are as follows.

(1) Lack of water collection network and treatment system. The relatively dispersed living places and large population base of rural residents in China determines that the domestic sewage can not be discharged in a centralized way. No matter in towns or villages, there is no corresponding sewage pipe network. Sewage treatment facilities are not perfect at both places. Most of the sewage is directly discharged to the surface or discharged into rivers and ponds through ditches, which is the important factor causing rural water environmental pollution [4].

(2) Great fluctuation of water quality and quantity, and the increasingly complex composition of sewage. With the improvement of living standards of rural residents, the discharge amount of domestic sewage is also gradually increasing. Meanwhile, the composition of sewage is becoming increasingly more complex. Sewage directly discharged without treatment not only aggravates damage to rural water environment, but also increases the difficulty to evaluate the pollution load of domestic sewage, which affects the determination of sewage treatment scheme and treatment process.

(3) Weak awareness of environmental protection. Rural residents lack the concept of environmental protection. Thus, some environmental protection measures are difficult to implement in rural areas. Besides, residents are not willing to invest too much in environmental protection equipment. As a result, some environmental protection policies are difficult to carry out in rural areas.

(4) Lack of corresponding management measures. At present, there are few related laws and regulations on sewage treatment in rural areas. There are differences in different regions and the lack of relevant professionals can not guarantee the normal operation of sewage treatment [5].

In summary, process with small scale, low investment, low operation cost, good treatment effect, simple management and convenient maintenance should be chosen.

3. Application of Rural Domestic Sewage Treatment Technology

At present, the treatment measures of rural domestic sewage in our country are mainly aimed at the concentrated residential areas in towns, communities that can collect sewage and some villages with sewage collection pipe network around the county and villages with sewage treatment facilities. China's rural sewage treatment methods are mainly as follows.

3.1. Constructed Wetland

The constructed wetland treatment system is a process of planting reeds, cattails, eichhornia crassipes and other aquatic plants on artificial substrate and filtering and absorbing pollutants through the relationship between plants, microorganisms and soil. Constructed wetland is a relatively new sewage treatment technology, which is suitable for rural areas with relatively low population density. Through the construction of constructed wetlands to treat rural sewage and achieve the effect of landscaping at the same time. Chen Liang et al. [6] selected integrated equipment and horizontal subsurface flow constructed wetland system as the main treatment process to treat rural sewage. After the stable operation of the system, indexes such as ammonia nitrogen, BOD and COD can meet the Class A standard. After the completion of the Maliao river wetland, located by Fuxian Lake, Chengjiang County, Yunnan Province, the daily sewage treatment capacity reaches 40000m3. After purification, the water quality meets the Class B standard (GB 18918-2002) [7]. Compared with traditional treatment technology, constructed wetland has the advantages of low investment, simple operation and low operation cost. However, constructed wetland covers a large area and is easy to be affected by diseases and pests, so it requires a long time for stable operation.

3.2. Land Infiltration Technology

Land infiltration technology purify sewage water by discharging sewage to the surface of the soil where crops are grown under the condition of artificial control. The sewage is purified by the physical, chemical and biological treatment of soil, plant system and microbial system. It is a non-power treatment process, therefore the infiltration technology has been paid more attention by our country. The research results of Shenyang Institute of Applied Ecology, Chinese Academy of Sciences show that, it is feasible to treat domestic sewage by soil infiltration technology in some areas of northern China, and the effluent can be used as reclaimed water [8]. In the Ministry of Science and Technology Major Projects in 2000, Tsinghua University adopted Land Infiltration Technology to domestic sewage in rural areas. The application has achieved good results and shows high removal rate and stability for nitrogen, phosphorus and organic matter in domestic sewage. The removal rates of NH3-N, CODCr, BOD5 and TP were higher than 90%, 80%, 90% and 98%, respectively. After purification, the water quality can meet the Class B standard (GB 18918-2002) [9]. Soil infiltration technology has the characteristics of low investment, obvious treatment effect, easy maintenance and management, as well as suitable for operation in rural areas with scattered residents, small population density and no complete sewage treatment system.

3.3. Stable Pond Treatment Technology

Stable pond is to build dikes around the pond and to build an anti-seepage layer at the bottom after the land is trimmed artificially. Through physical, chemical and

physico-chemical processes of microorganisms growing in the pond, the pollutants are adsorbed, degraded, precipitated and transformed, so as to achieve the harmless and resource utilization of sewage. Zhang Boxiong et al. [10] selected river type ecological stable pond to treat rural sewage. The results show that the contents of COD, TP and ammonia nitrogen in the treated waste water meet the second level standard (GB 18918-2002). The conventional stable pond covers a large area and its treatment effect is obviously affected by the weather. Besides, the hydraulic retention time is long and the sludge is not easy to discharge and easy to cause secondary pollution. In order to solve these problems, Professor Oswald from the University of California, Berkeley, designed an efficient algal stable pond based on the symbiosis of bacteria and algae. In this pond, microorganisms make the maximum use of oxygen produced by algae, so that microorganisms in the water rich in dissolved oxygen are more efficient at removing organic pollutants. The removal rates of BOD, COD, TN and TP were 60%, 75%, 75% and 50%, respectively. The high efficiency Algae Pond has the characteristics of small area, low operation cost, stable operation and short hydraulic retention [11], which is suitable for the control of rural non-point source pollution.

3.4. Biological Filter Tank

Biological filter tank is a traditional process for waste-water treatment achieved by biological membrane method. Biological filter tank is a kind of artificial biological treatment technology based on the self-purification ability of soil. Intermittent sand filter and contact filter were added in the sewage infiltration. In the process of filtration, sewage will drop onto the surface of filter material layer in the form of water drops. After the sewage flows through the surface of the filter material layer, a layer of biofilm will be formed. After this, the microorganisms inhabiting on the biofilm will take the organic matter in the sewage as nutrients to survive and reproduce by decomposing and absorbing these organic matters, so as to achieve the function of purifying sewage. In Minfeng village, Changzhou City, Southern Jiangsu, Huang Weili et al. [12] treated waste-water with composite biological filter tank. The results showed that the effluent quality of rural sewage after treatment by composite biological filter tank can reach the Class B standard (GB 18918-2002). Guo Ying [13] studied the treatment effect of rural domestic sewage with a multi-media soil layer system using quartz sand, natural river sand and zeolite as the permeable layer materials. The effluent effect can reach the Class B standard (GB 18918-2002). Biological filter tank can be used as a separate treatment system or combined with other processes to form a multi-stage combined process technology. Shi Chang et al. combined the unpowered upflow anaerobic biological filter tank with the subsurface flow constructed wetland to improve the effect of nitrogen and phosphorus removal by increasing the plant density of the subsurface flow constructed wetland [14].

3.5. Treatment Technology of Anaerobic Biogas Pond

Treatment technology of anaerobic biogas pond is the most extensive and economical method in the process of domestic sewage treatment in rural areas of China. It is also the most effective way to reflect the combination of environmental protection and economic benefits. A large amount of organic matter in sewage can produce biogas after anaerobic fermentation. The majority of the organic matter is removed in the process of fermentation. Biogas produced in the process can be used as daily energy for residents. In rural areas of China, there are a large number of raw materials can be combined with domestic sewage for anaerobic biogas treatment technology, such as crop straw, human and animal manure. These are suitable for domestic use in rural areas in China, because the biogas pond technology can be used to purify aquaculture and domestic wastewater after anaerobic fermentation. The effluent quality meets the *Standard of Irrigation Water Quality* (GB 5084-2005). The biogas pond has the advantages of simple process, low investment cost and convenient operation, which can bring certain economic benefits to farmers while purifying sewage.

4. Comparison of Domestic Sewage Treatment Technologies

According to the literature, several common rural sewage treatment technologies in China are briefly introduces in this paper. The advantages and disadvantages of then are shown in Table 2.

Table 2. Comparison of domestic sewage treatment technologies.

Technologies	Treatment Effect	Scope of Application	Disadvantages
Constructed Wetland	the Class B standard (GB 18918-2002)	Villages with relatively flat terrain and relatively concentrated living conditions	The treatment effect is easy to be affected by the weather due to its large floor area and long stable operation time
Land Infiltration Technology	the Class B standard (GB 18918-2002)	Villages with flat terrain, stable foundation and relatively backward economic development	The hydraulic load is small and the purification capacity is limited
Stable Pond Treatment Technology	the second level standard (GB 18918-2002)	Villages with relatively backward economic development and less climate change	It covers a large area, the treatment effect is unstable and the hydraulic retention time is long
Biological Filter Tank	the Class B standard	Villages with more developed economy	It covers a large area, has a long process

	(GB 18918-2002)	and less climate change	cycle, is easily affected by the weather and is easy to be blocked
Treatment Technology Of Anaerobic Biogas Pond	Standard Of Irrigation Water Quality (GB 5084-2005)	Villages with developed economy, relatively concentrated residence and better development of animal husbandry and agriculture	The treatment effect is not stable, it is easy to be affected by the weather, and it is not convenient to clean up the waste in the pool

5. Conclusion and Prospect

With the acceleration of urbanization and the rapid development of rural economy in China, some rivers and lakes in rural areas are seriously polluted. Rural domestic sewage is one of the main pollution sources. More attention is paid to the construction and development of rural domestic sewage treatment system. Owing to the characteristics of rural areas, the determination of rural sewage technology should be based on local development and economy condition, so as to select sewage treatment system which is low-cost, easy to operate and environmentally friendly. On basis of all above, the following conclusions are drawn as follow.

(1) The determination of sewage treatment mode must fully consider the conditions of economy development and environmental factor of different areas.

(2) The determination of sewage treatment technology should be based on the amount of residents, population density, topography features, climate change and different sources of sewage, so as to select the best treatment technology and change sewage treatment into sewage utilization as far as possible.

(3) Establish a perfect sewage collection system. There is a lack of complete pipe network facilities in rural areas. Casually discharge sewage in rural areas seriously pollutes groundwater and surface water bodies.

(4) Raise the environmental awareness of rural residents and enhance their responsibility in the process of rural sewage treatment, so that residents can take an active part in the prevention and treatment of the rural sewage.

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