Decentralized Domestic Wastewater Treatment in Rural Areas in China—Efforts of the Japan-China Water Environment Partnership Project

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Abstract

As part of the Japan-China water environment partnership project agreed on between the leaders of the both countries, the Japanese Ministry of the Environment started a four-year rural area decentralized wastewater treatment model project in 2008. This project is intended to install model treatment facilities in some regions with typical requirements or conditions based on the experience of the both countries, and to work on the penetration of these systems in the future. In 2008, treatment systems were installed in Taizhou, Jiangsu and in mountain areas of Chongqing, in light of the conditions of these areas. A gravel contact aeration system and an constructed wetland system were selected for Taizhou and Chongqing, respectively. A gravel contact aeration system based on Japanese technologies and a constructed wetland system based on Chinese technologies were used. Both countries will further study the operation of these treatment systems to promote their penetration in the future.

Keywords: Domestic wastewater, Rural area, Decentralised system, Japan-China water environment partnership, Adaptability evaluation

Introduction

In China, the amount of domestic wastewater has accounted for a larger percentage of the total amount of wastewater than that of industrial wastewater since 1999, and the gap has been widening year by year. Therefore, promoting domestic wastewater measures has been a major issue. To cope with this situation, heavy investments have been made in the development of sewage systems in urban areas, where 1,178 sewage treatment plants have been built and operated across the country by the end of 2007. This pushed up the sewage treatment rate to 60 percent. A total of 472 out of the 1,178 sewage treatment plants were built between 2006 and 2007, and it is believed that the development of sewage systems in urban areas will further pick up speed in the future. Thus, domestic wastewater measures in urban areas have almost been put into place, but rural areas, with a larger population than urban areas, are far behind urban areas in these measures.

Rural areas, which are less densely populated than urban areas, require a decentralized sewage treatment system to cover a relatively highly populated area rather than a large-scale centralized sewage treatment system as seen in urban areas. In view of the economic situation of rural areas, systems that have low construction, maintenance, and operation costs are required.

In Japan, the sewage treatment rates in Tokyo, Osaka, and other urban areas with a population of over one million have reached almost 100 percent, but those in local city areas with a

population of less than 50,000 still remain around 65 percent. In these local city areas, decentralized treatment systems that have low construction, maintenance, and operation costs have been introduced on a trial basis. Under these circumstances, those involved in the Japan-China water environment partnership project started to work to build decentralized domestic wastewater treatment systems in rural areas in China based on their respective experience, as part of the project.

Necessity of Domestic Wastewater Treatment in Rural Areas in China

There is less information available on domestic wastewater discharge conditions in rural areas than on those in urban areas, and there are many unknowns. Liu, et al. estimated the nitrogen flow in rural areas by supplementing the existing statistical data with field work surveys, and studied the effects of human life on the flow[1)]. They estimated the nitrogen flow in Taoyuan, Hunan and Taihe, Jiangxi located in the middle to lower reach of the Chang Jiang River. Both districts are rice-producing rural areas, but Taoyuan has introduced more machinery into its agriculture. In rural areas in China, raw sewage has been recycled as fertilizer over a long time[2)]. The recycle rates of raw sewage in terms of nitrogen in Taoyuan and Taihe were 27 percent and 67 percent, respectively. In Taoyuan, about 70 percent of lavatories have been converted into flush toilets and this shows the gradual development of sewage systems, but sewage treatment has lagged behind the development of sewage systems. In Taihe, on the other hand, the recycle rate of raw sewage is high, and flush toilets account for only about 30 percent of all lavatories because vault toilets are widely used, and people there are less satisfied with their toilet conditions than those in Taoyuan. In Taoyuan, chemical fertilizers account for 70 percent of nitrogen put on agricultural land, which reflects the advanced mechanization of agriculture. These study results suggest that the recycle rates of raw sewage in rural areas will be lowered following the increasing mechanization of agriculture and improvement in people's living standards, and the necessity of domestic wastewater treatment will be increased. The necessity of domestic wastewater treatment will be further increased at an accelerated speed by new agricultural village construction projects and other urbanization policies. Thus, construction of domestic wastewater treatment systems in rural areas is an urgent issue to be addressed for the improvement of hygienic conditions in rural areas and the reduction of effects on watersheds.

Rural Area Decentralized Wastewater Treatment Model Project

Under these circumstances in rural areas, the Japanese and Chinese ministers of the environment signed the "Memorandum on a Joint Rural Area Decentralized Wastewater Treatment Model Project" on May 8, 2008. Following the conclusion of this memorandum, the Japanese Ministry of Environment started the project by working on the installation of model decentralized wastewater treatment facilities in China and the following items:

(1) Study the reduction of water pollutants and what water environment management should be

i) Analyze the current situation and issues of the model project areas

ii) Collect and analyze basic information necessary to introduce decentralized domestic wastewater treatment technologies

iii) Work on the formulation of policies or laws and regulations on decentralized domestic wastewater treatment

(2) Introduce decentralized domestic wastewater treatment technologies
i) Introduce decentralized wastewater treatment technologies
ii) Determine the effects of decentralized wastewater treatment technologies

(3) Help those involved in the Chinese government with capacity building and enhance policy dialogue

(4) International seminar on theory and practice on total pollutant amount control in Japan and China

Based on the installation of model decentralized wastewater treatment facilities in China, this project will promote the penetration of these facilities in China from 2008 to 2011.

Installation of Model Decentralized Wastewater Treatment Facilities

Overview of Model Installation Areas

In 2008, model facilities were installed in the Chang Jiang River basin, or in Taizhou, Jiangsu, which has attracted many industrial complexes and been urbanized because of the resultant economic growth, and in Zhong and Wanzhou, Chongqing, located in the upper reach of the Three Gorges Dam. In Taizhou, new agricultural village construction has promoted the readjustment of land for industrial use, agricultural land, and residential land, and residences, which had been scattered over agricultural land before, have now formed villages of hundred to several hundred families. Thus, wastewater treatment must be provided for each of these villages. These villages basically use flush toilets, but conventional treatment facilities, which were based on septic tanks installed in individual households, do not provide satisfactory treatment of wastewater. In this area, creeks run around the villages like the mesh of a net, and wastewater from the villages is discharged into the creeks. Thus, insufficient treatment of wastewater may affect the surrounding water environment. In addition, economic growth has increased the convenience of the land to make it difficult to acquire a large land lot for a wastewater treatment plant, which makes it inevitable that wastewater plants will be installed near residences.

On the other hand, Zhong and Wanzhou of Chongqing are comprised of purely agricultural, mountain villages with large, terraced paddy fields. In these mountain areas located in the upper reach of the Three Gorges Dam, villages of several thousand people are scattered, and wastewater treatment must be provided for each of these villages. Since the incomes of those in the purely agricultural villages are not so high, construction, maintenance, and operation cost requirements for wastewater treatment plants in these areas are severe. However, a relatively large land lot can be secured for a wastewater treatment plant, though it is difficult to secure a flat land lot in the hilly areas.

Selection of Treatment Systems

In Taizhou, compact and high-level treatment technologies should be used because of the difficulty of acquiring large land lots, and the proximity of treatment plants to residences requires measures against odor to be taken. Considering the future spread of these treatment plants, construction, maintenance, and operation costs as well as the production of sludge, the major problem in operating treatment plants, must be kept low. In view of these requirements, a gravel contact aeration system, which has been increasingly used as a decentralized

treatment facility in Japan, was introduced in Taizhou. A treatment facility of this system is topped with soil to produce fewer odors. Based on a biofilm process, this system produces less sludge than an activated sludge process. The target quality of treated water is a CODcr of 60 mg/L or lower, a BOD_5 of 20 mg/L or lower, an SS level of 20 mg/l or lower, ammonia nitrogen of 15 mg/L or lower, and a coli form bacteria count of 10^4 MPN/L or lower. This quality of water complies with Class 1-B of the discharge standard of pollutants for municipal wastewater treatment plant in China. The target maintenance and operation cost was set at 0.09 US$ per m^3 of sewage.

In Chongqing, to keep treatment plant construction, maintenance, and operation costs low, a treatment system based on a constructed wetland was applied. To secure stable operation of a constructed wetland over a long time, a preliminary aeration process was combined. A general contact aeration system was adopted for preliminary aeration to reduce the production of sludge, and a plastic filter medium commercially available in China was selected as a contact medium. The target quality of treated water is a CODcr of 100 mg/L or lower, a BOD_5 of 30 mg/L or lower, an SS level of 30 mg/l or lower, and ammonia nitrogen of 25 mg/L or lower. This quality of water complies with Class 2 of the discharge standard of pollutants for municipal wastewater treatment plant in China. Considering the economic conditions in the region, the target maintenance and operation cost was set at 0.05 US$ per m^3 of sewage. Because Japan has no experience in domestic wastewater treatment using a constructed wetland, a constructed wetland designed by China with a good track record was combined with this wetland.

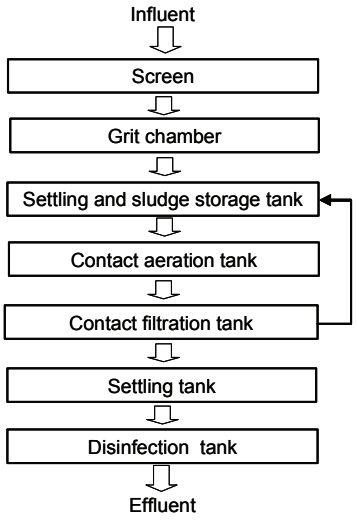

Figure 1. The treatment flow of gravel contact aeration system.

Overview and Features of Treatment Systems

Gravel Contact Aeration System

This system consists mainly of a settling and sludge storage tank, a contact aeration tank, and a settling tank, and uses gravel as a contact medium. Figure 1 shows the treatment flow. Sludge produced by treatment is stored in the settling and sludge storage tank, and must be removed once or twice a year. The removed sludge is recycled as a liquid fertilizer. The sludge production is about 15 to 25 percent of that for a commonly used standard activated

sludge process or oxidation ditch process. Because the treatment facility is topped with soil, a treatment plant may be installed in a corner of a residential area in Japan, and so not so much consideration needs to be given to measures against odor. In Taizhou, a facility with a treatment capacity of 150 m^3/day and another facility with a treatment capacity of 40 m^3/day were installed. While the facility with a capacity of 150 m^3/day is of reinforced concrete, the facility with a capacity of 40 m^3/day uses a liner sheet, concrete blocks, and other building materials rather than concrete building frames to keep the construction cost low. This construction method cannot be used for a large facility, but can keep the construction cost low for an ultrasmall facility. Figure 2 shows the construction status in Japan.

Figure 2. The construction status of the low cost facility.

Preliminary Contact Aeration—Constructed Wetland System

As shown in Figure 2, depicting the treatment flow, this system consists mainly of a settling and sludge storage tank, a preliminary contact aeration tank, a sedimentation tank, and an constructed wetland. According to the guidelines in China, wastewater put to a constructed wetland must not contain a CODcr of greater than 200 mg/L, a BOD_5 of greater than 70 mg/L, an SS level of greater than 40 mg/l, and ammonia nitrogen of greater than 30 mg/L. Since this quality level cannot be achieved by settling separation alone, a preliminary aeration process must be combined. The aeration time was set at four hours, but it must be optimized through actual operations because the length of the aeration time greatly influences the maintenance and operation cost. Produced sludge can be stored in the sedimentation separation tank for up to about one year.

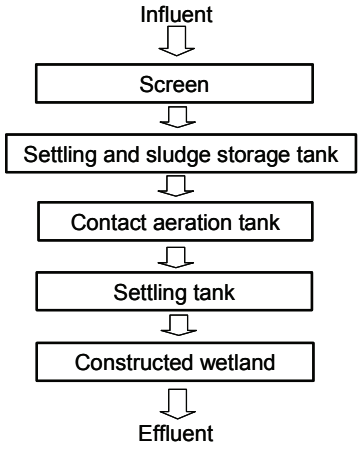

Figure 3. The treatment flow Preliminary Contact Aeration-Constructed Wetland System.

Future Prospects and Issues

Model treatment technologies were selected and installed in Taizhou and Chongqing in light of the situations of these regions. In Taizhou, where the readjustment of residential land has been promoted by new agricultural village construction, a compact, simple treatment flow system was selected. Not a pre-fabricated treatment system popular in Japan but a system that can be constructed in China was used. In Chongqing, a constructed wetland system was selected in light of the economic conditions of the rural areas and the relatively warm, humid climate. However, to allow stable operation of a constructed wetland over a long time, preliminary biological treatment was combined. In the future, Japan and China will jointly study the operation of the model treatment systems to develop them into more advanced, versatile systems.

This time, the reduction of sludge production was a criterion for selecting these treatment systems. However, because the production of sludge cannot be avoided, treatment or disposal of sludge must be further studied with an eye toward the future. Basically, produced sludge should be recycled as fertilizer for use in these rural areas, and how it should be recycled must be studied also from the perspective of farmers. Especially, whether to recycle sludge as liquid fertilizer or dry fertilizer, which decides whether to add a sludge drying process or influences the design of a treatment system in other ways, must be clarified in view of the form of agriculture in that region.

This model project has been promoted based on adequate discussions between the Japanese and Chinese governments and engineers. Therefore, adaptable cooperation of China can be expected, and the project will be further promoted with the experience of the both countries. Since these decentralized domestic wastewater treatment systems are also important in other countries, improvements both in tangible and intangible aspects for the development of adaptable systems must be sought, and further efforts must be made to develop the Japan-China water environment partnership project into foreign aid based on cooperation between the both countries.

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