# Small-Scale Domestic Wastewater Treatment Technology in Japan, and the Possibility of Technological Transfer

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## Abstract
In Japan, the coverage rate of domestic wastewater treatment among the population was 82.4% at the end of FY 2006, but the coverage rate of domestic wastewater treatment in areas with a population of 50,000 or less remains low (about 65%). In addition, because a small-scale treatment system requiring low construction and maintenance costs is sought because of municipalities' financial difficulties, past technologies are being reexamined. Based on the background mentioned previously, small-scale domestic wastewater treatment technologies were organized in search for technologies that can be transferred, and the ideal way for the future was proposed.

## Introduction
There is a trend in domestic wastewater treatment in which large city areas are accommodated more readily than medium and small city areas, or rural communities. Because the population density is less compared with large city areas in areas with smaller populations, a small-scale dispersed treatment system is sought. The conventional activated sludge process that is widely popular for domestic wastewater treatment in large cities is a stable treatment system, but the process is sometimes not suitable for a small-scale treatment system, so other systems are being selected. The issue of domestic wastewater treatment has been shifting from large-scale intensive systems for large cities, to small-scale systems necessary for small city areas, and rural communities. In addition, "locally suitable technology" that is adaptable to local social and economic conditions is sought in developing countries, but it is difficult to transfer the general Japanese technological system without modification. With these things as a background, this paper gives an overview of Japan's domestic wastewater treatment and small-scale treatment technology, and discusses cases of technological systems that are highly likely to be transferred. In addition, this paper will introduce cases of the technological development situation in China, where lifestyles have changed drastically due to economic development, and there is great demand for a small-scale treatment system. Lastly, this paper will sort out the future of technological transfers with regard to small-scale domestic wastewater treatment systems.

## The Situation and Problems of Domestic Wastewater Treatment in Japan
Figure 1 indicates the flow of domestic wastewater treatment in Japan. Domestic wastewater are roughly classified into human waste discharged from toilets (night soil), and wastewater discharged from kitchens and bathrooms (gray water). Domestic wastewater are mainly treated through wastewater facilities, rural community sewerage, and the in site treatment system (Johkaso).

When vault toilets are used instead of flush toilets, human waste is stored there. In this case, stored night soil is transported to night soil treatment facilities several times a year, and treated there, but gray water is discharged without treatment. For Johkaso, Gappei-shori Johkaso for treating night soil and gray water is used as a rule. However, Tandoku-shori Johkaso, used only for treating night soil, was supposed to be allowed to be used until 2001, but many of them are still being used now. Even when Tandoku-shori Johkaso is used, gray water is discharged without treatment.

The coverage rate of domestic wastewater treatment among the population was 82.4% at the end of FY 2006 in Japan. Its breakdown is 70.5% for sewage facilities, 2.8% for rural community sewerage, and 9.1% for Gappei-shori Johkaso. Tandoku-shori Johkaso and vault toilets are not included as treatment facilities. The coverage rate of domestic wastewater treatment among the population indicates the status of respective treatment facilities provided, and it does not necessarily indicate the actual rate of treatment. It is thought that the actual rate of treatment is about several percent to 10% lower than the rate, but no accurate statistics are available. The rate of flush toilets provided was 92.4% at the end of FY 2003. No statistics for the end of FY 2006 are available, however, assuming that the rate of flush toilets provided was 93%, the coverage rate of Tandoku-shori Johkaso among the population would be 10.6%. In any event, gray water of more than 17.6% per capita is discharged without treatment.

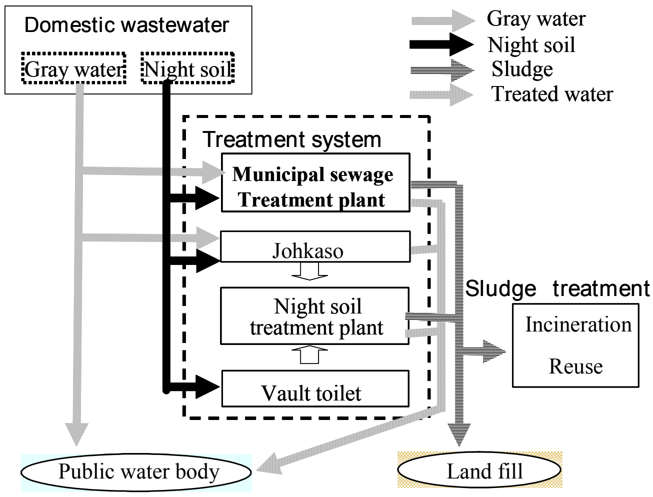


Figure 1. the flow of domestic wastewater treatment in Japan

In addition, the coverage rate is low (65.5%) in areas with a population of 50,000 or less, like regional municipal areas. The reason for this lies in a severe fiscal situation in those regions, and a provision method advantageous to cost is called for.

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With respect to sewage facilities, 1,049 small-scale treatment facilities capable of treating 5,000 $m^3$ or less of water per day were in operation at the end of FY 2004, and 70% of sewage facilities adopted the oxidation ditch process. Though the oxidation ditch process is advantageous in terms of maintenance because primary sedimentation tanks are unnecessary, the treatment and disposal of the large volume of sludge generated becomes a major issue, like the conventional activated sludge process.

Agricultural community wastewater treatment programs are intended to provide domestic wastewater treatment facilities for a single or multiple rural communities where domestic wastewater treatment facilities have not been sufficiently provided. In principle, domestic wastewater treatment facilities are provided for each large area as a unit in order to facilitate the time-consuming provision of wastewater facilities. In the beginning, there were cases where budgetary waste was pointed out due to inconsistency with wastewater facility plans, but about 3,900 facilities are now in operation. A treatment process is being indicated in stages for the treated population of from 51 to 10,000 (JARUS type). The contact aeration process, the sequencing batch reactor process, and the oxidation ditch are adopted according to the size of the population, from a small population to a larger population.

Johkaso is an on-site treatment facility that has been technologically developed uniquely in Japan. In Japan, human waste was treated as manure for a long period of time, however, because chemical fertilizers were popularized after World War II to the high economic growth period, and there was an increasing demand for flush toilets, on-site treatment facilities without the need for pipes became widespread. At first, Tandoku-shori Johkaso were used, and a simple treatment process like the trickling filter process and the horizontal oxidation process were adopted. However, in order to achieve stable treatment performance, the contact aeration process came into widespread use. In the 1980s, development concerning the downsizing of Gappei-shori Johkaso that had been treated only by relatively large treatment facilities were conducted in order to prevent water pollution. Gappei-shori Johkaso started to be provided in individual houses. The settling separation contact aeration process is common as a treatment process, and Gappei-shori Johkaso made of reinforced concrete was originally often field-installed at the site, but Gappei-shori Johkaso that is made of fiber-reinforced plastics (FRP) and is factory-produced is mainly used now. An advanced treatment-type Johkaso that can remove nitrogen and phosphor has recently been developed.

In Japan, domestic wastewater treatment has been carried out with sewage facilities as a base with the help of Johkaso and rural community sewerage. However, because an enormous amount of money is needed to provide these, a low-cost treatment system that requires minimum maintenance has recently become a necessity. So, the soil covered gravel contact aeration process has been drawing attention.

Figure 2 outlines the soil covered gravel contact aeration process. The process is relatively simple structurally, so it can be designed in response to the varied size of the treated

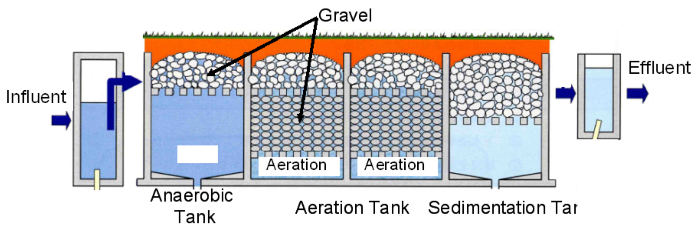

Figure 2. The outline of the soil covered gravel contact aeration process.

population, and according to the site conditions. The process is characterized by producing almost no odor from the treatment facilities because the tops of the treatment facilities are covered with soil. Conglomerates are used as a contacting material. In general, the contact aeration process generates little sludge, so the process is characterized by lower maintenance costs. The process was installed in 32 places across the country for sewage treatment facilities. The size of the treated population varies from 50 to 4,500. Compared with the oxidation ditch process, which was commonly used for the same population size, it is said that, though a larger site area is required for wastewater treatment facilities, this process lowers construction and maintenance costs. At present, the process has been increasingly adopted as a treatment process by local governments overseeing sewerage services and facing more difficult financial conditions. The process was installed in 30 places for rural community sewerage facilities. This process was originally developed for Gappei-shori Johkaso 25 years ago, and it has recently been adopted for sewage treatment facilities.

In addition, the soil trench process was developed in Japan as a process that requires low construction and maintenance costs. But the process is not used so much now because a large site area is necessary for treatment, and clogged facilities were found here and there due to incomplete construction work, and the lack of knowledge concerning inflow loads.

In Europe and the U.S., the constructed wetlands have recently been utilized as small-scale domestic wastewater treatment facilities, and technological developments are actively being progressed. Each country has established design guidelines, and Japan has just started conducting studies including verification tests concerning livestock wastewater treatment and the treatment of disused mine effluents as treatment technology.

**Cases of the Technological Transfers of Small-Scale Wastewater Treatment from Japan**

***Johkaso***

The Japan International Cooperation Agency (JICA) provided the technological transfer of mainly Johkaso technology for China from 2001 to 2006. Japanese Johkaso made of FRP was installed at the site, and technological guidance concerning its structure and maintenance was provided. However, the comprehension of China's social conditions concerning domestic wastewater treatment, and the sorting of problems concerning future dissemination, including the comprehension of these conditions, were not sufficient enough to conduct a study on the ripple effects of the technological transfer.

The Japan International Corporation of Welfare Services provided the technological transfer of Johkaso technology for Indonesia with the use of field-constructed Johkaso from 1995 to 1997. Even in Japan, Johkaso used to be mainly field-constructed, but they have been replaced dominantly by factory-produced Johkaso made of FRP due to soaring labor costs, and in order to secure the performance of Johkaso. However, because labor costs are not so high in many developing countries, a method with a higher percentage for labor costs for the provision of Johkaso becomes advantageous to lower construction costs. Therefore, it is thought that the technological transfer of field construction technology for Johkaso should be continuously stressed in the future.

This field-constructed Johkaso is one of the locally suitable technologies to be considered, though it depends on local construction and maintenance costs. However, because the project period was short (about two years), it was thought to be necessary to provide support a little longer than that in order to stabilize the technology.

***Land treatment system***

The Ministry of the Environment of Japan provided a model treatment facility using the soil trench process with nutrient removal in Guiyang City, China in 2000. The soil trench process, which is an advanced treatment process requiring extremely low power consumption, was developed by the National Institute for Environmental Studies for the purpose of applying it to developing countries. Figure 3 indicates its treatment flow.

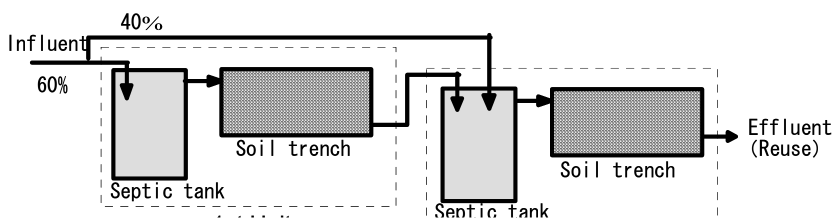


Figure 3. The treatment flow of advanced soil trench process.

With a combination of a septic tank (anaerobic) and a soil trench (aerobic) as a unit, the two units are combined in tandem. In the soil trench process, a trench pipe with numerous fine holes opened almost evenly is buried in soil, and wastewater seeps in through the holes. That wastewater is then treated through the process of seeping through the soil layers, and is collected at the bottom. Incoming wastewater is divided 60/40 into each unit, and nitrogen nitrified in the soil trench of the first unit will be denitrified on the anaerobic filter bed of the second unit. Organic substances in wastewater distributed to the second unit will be used as a hydrogen donor for denitrification.

In Datong City, a NPO that provides support for a forestation reuses domestic wastewaters as irrigation water, so treatment facilities with the multi-layer soil (MLS) process were provided under the JICA grass-roots project. The MLS process was developed as a countermeasure for clogging caused by the soil trench process and it is designed to treat wastewater by filtering the water through highly permeable pumice stone between soil layers, and by having wastewater permeate from the top surface of a rectangular soil treatment layer. The MLS process is characterized by its large amount of treated water per soil volume in comparison with the soil trench process. Therefore, although there was a trend that treated water quality was somewhat inferior to water treated through the soil trench process according to treatment conditions, satisfactory water quality was obtained for irrigation water in the case of Datong City. Figure 4 outlines treatment equipment.

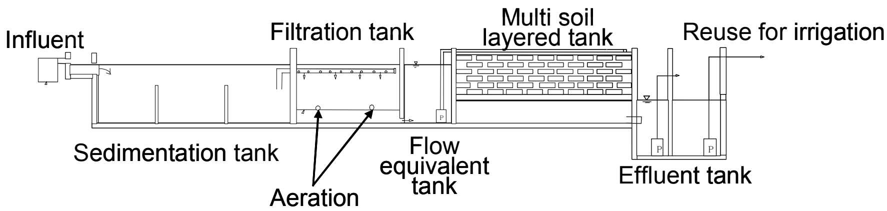


Figure 4. The treatment flow of MLS process introduced in Datong City, China.

**Cases of Technological Development in China**

In China, research and model projects are promoted as a part of the measures to reduce area source loads for human waste from rural communities under the national program, which was launched in 2001 to control the contamination of Taihu Lake, and restore the body of water, and technological development based on the following preconditions is underway:

(1) Communities mostly consist of 20 to 200 households, small-scale treatment is required.

(2) There is a strict restriction on the construction cost and operation management cost of treatment facilities (1,000 to 1,300 RMB per one cubic meter of domestic wastewater for construction costs, and 0.1 to 0.3 RMB per one cubic meter of domestic wastewater for maintenance costs).

(3) The goals for removing nitrogen and phosphor are 70% and 80% respectively.

Under these strict conditions, treatment technology combined with the secondary treatment process requiring inexpensive construction and maintenance costs, like the trickling filter process and the rotary disc process, and the natural treatment process, like the constructed wetland process, is actively being developed.

**Ideal Way of Technological Transfer**

Wastewater treatment technology changes according to social conditions, and takes the most suitable form for a society that uses the technology, apart from its basic elements. Therefore, when the technology is transferred to another society, it is necessary to examine its adaptability from various aspects. The difficulty in transferring Japanese technology to developing countries without modification is widely known. In Japan, highly systemized compact technological development has been demanded because of soaring land prices, and the fact that treatment facilities have been provided in densely-populated areas. However, in recent years, there has been an urgent need to provide treatment facilities in regional areas without so much population, and processes requiring low construction and maintenance costs as the gravel contact aeration process are sought because of municipalities' financial difficulties. The process was used 25 to 30 years ago, but it can be considered leading-edge technology that takes into account the current social conditions. Therefore, in order to consider future technological transfer, it is necessary to not only consider current technology but also to look into previously developed or adopted technology, and to evaluate it from current technological or economic standpoints.

In addition, because technology is not stationary, but constantly transforms according to the situation at the site where the technology is needed, it is possible to select technology more suited to the site, and develop new technology, as required, through additional examination of technological development cases as in the Chinese case outlined above.

Moreover, "locally suitable technology" is selected according to the current situation of a region where the technology is adopted, but a plan adaptable to changes afterwards must be considered. In order to also gain a panoramic view of a future recycling-based society, it is necessary to comprehend and rearrange the trend again. In any event, previous measures for wastewater treatment were taken to solve actual problems; however, future "locally suitable technology" must ensure future sustainability.