IWRM Action Hub

CASE STUDY

# Korea: Resource Circulation Sanitation Showcase to Provide Sustainable Sanitation in Remote Areas


**Summary**

In this showcase project, an innovative sanitation system is developed to be promoted as a nature-based solution for problems of adequate access to sustainable sanitation in remote areas. The source-separated urine and feces undergo an onsite treatment process to be recycled and utilized as fertilizer and soil conditioner. The efficiency and sustainability of this system have been proved through scientific studies and field experiments at farming centers located in suburban areas of Seoul. A trained management committee sustained the operation and maintenance of the system. The system performed to be economically beneficial by using locally available resources and recycling sanitary wastes.


**Background**

The crisis of access to water and sanitation is a global concern. According to UNICEF and WHO, although from 2015 to 2020 2.1 billion people gained access to at least basic sanitation services, 2 billion people still have no access to safe and sustainable sanitation systems, 673 million people are practicing open defecation, and 3 billion people still lack basic sanitation.

Sanitation and hygiene become even more critical when it comes to rural and remote areas, which are generally suffering from a lack of sustainable access to appropriate sanitation. The recent pandemic of the COVID19, along with several pieces of evidence showing the existence of the virus in domestic wastewater, showed that substantial improvements to public health are required through the provision of sustainable and adequate access to clean water and sanitation for all, leaving no one behind.

Today, conventional sanitation systems, using a “flush and forget” system, are being used all over the world. These systems are based on the premise that urine and feces are waste that can only be disposed of in a “once-through” method, and so rely on flushing toilets or urinals using an average of approximately 10L freshwater for each event, which is sent directly to wastewater treatment units. The treatment units can be onsite (e.g., septic tank) or offsite by being sent to the sewage treatment facilities through a sewer system.

These systems are associated with high water and energy consumption, and their waste treatment procedure is often insufficient in the lack of safe and sound infrastructures. Lack of sufficient treatment leads to discharging excessive nutrient loads into natural water bodies. Accordingly, by considering the living conditions of remote and rural areas, these systems may not be a realistic solution for providing adequate sanitation access.

Recently, the idea of urine source separation has led to the development of urine diversion dry toilets (UDDT), to address the problems mentioned above. However, implementation of such systems has challenges, including limitations for onsite treatments, high initial costs, and low social acceptability due to little cleanliness, odor, or compatibility with different cultures.

Consequently, there is a demand for developing a safe sanitation system along with a practical, fast, sustainable, and reliable treatment of separately collected urine and feces to prepare them for safe final disposal or end-use without requirements of complicated infrastructure to make it suitable for remote and rural areas.

Accordingly, an innovative sanitation system named “Resource Circulation Sanitation (RCS)” has been developed, and supported with scaled-up showcase projects aiming to investigate the technical efficiency and sustainability of the system for offering public hygiene services in remote suburban areas of Seoul.

**Actions taken**

To investigate the technical efficiency and sustainability of the system for implementation in a remote area, two sets were designed for upscale field tests and installed at two different farming centers located in suburban areas of Seoul to offer public hygiene services.

The toilet room has a size of 1.8 m (L) × 1.2 m (W) × 2.5 m (H) and the system installed in it includes 5 main parts: urine division dry toilet, urine reactor, feces reactor, a rainwater harvesting system to provide water for sanitary applications, and a 19.3% efficient 400 W photovoltaic solar panel module to provide clean energy for maintenance processes. The seat efficiently separates urine from feces, storing them in their reactors. Urine is stored in a tank-in-series reactor. It is also possible to provide sustainable maintenance using smart technology, being equipped with internet-connected sensors to determine urine level, nitrogen composition, and fertility condition. Feces along with other hygienic materials, such as biodegradable toilet papers, are led into a batch reactor including sawdust for the composting process. The reactors are well-designed based on the estimated amount of usage and retention time of 10 to 15 days.

The nature-based treatment process includes adding a microflora, containing nitrifying microorganisms, to the urine and feces reactor. The nitrification process gives benefits for reducing the stabilization time for urine and enhancing the biodegradation of feces.

Thereafter, treated urine is collected from the last tank and composted feces is collected from its reactor and mixed with agronomic soil to prepare soil samples for plant cultivation. Similarly, another cultivating soil sample was made by mixing the agronomic soil with commercial fertilizer. These soil samples were used to cultivate white radish plants under the same planting to harvest procedure.

The rainwater harvesting system collects rain from the rooftop of the toilet room and goes for an onsite treatment using membranes and UV treatment before being stored in a 1.5 T tank to be used for handwashing and other hygienic uses. The water level and quality of the treated rainwater can also be checked using smart sensors. The produced greywater undergoes another similar onsite treatment and is stored separately to be utilized for irrigation purposes.

An active local sanitation committee trained to regulate the maintenance process. The committee members included volunteered local people and authorities. The committee members were taught about the performance, merits, and maintenance of the system through a short one-day theoretical along with two months of practical training programs. The committee was also instructed to be responsible for the system's general operation, monitoring the treatment process of source-separated urine and feces, performing the maintenance and cleaning up, and managing the economic benefits to cover the maintenance costs.

**Outcomes**

During the showcase projects, the resource circulation sanitation (RCS) system served approximately 80 people per month which led to about 50,000 L per year of water conservation. The energy conservation is estimated to be about 500 – 700 kWh per year considering the requirements for the maintenance as well as provision and treatment of water for sanitation applications.

The treatment showed efficiency in increasing the fertilizing potential of urine by modifying its nitrogen profile. In particular, the controlled initial addition of nitrifying microorganisms can optimize and sustain the ratio of ammonium to nitrate at 1:1 within the retention time. Moreover, pH reduction as a result of nitrification led to reducing ammonia losses as gas to about 40% along with odor production.

This treatment method also enhanced the feces composting process. After the retention time, about 90% of the total organic carbon has been degraded by providing a more favorable condition for heterotrophic microorganisms. This provides compost with a sustainably constant C:N ratio near 30, making it suitable to be utilized as a soil conditioner. Furthermore, this method was useful in the efficient removal of fecal indicators. In particular, no Escherichia coli and total coliforms have been detected after the retention time. These results yield that the system can produce clean and safe material to be utilized as fertilizer or soil conditioner.

Results of white radish cultivation show that there was no statistically significant difference in nutrient release in soil samples treated with the products of RCS and commercial fertilizer. Thus, the water and sugar content along with the accumulated nutrients in leaves and roots of white radish plants cultivated in soil treated with the RCS produces was 20% – 30% more than the other ones.

The sustainability of the RCS system was proved in this project by its efficiency in reducing water and energy consumption along with recycling urine and feces to be utilized as fertilizer and soil conditioner. The benefits acquired by fertilizer production, water-saving, and higher agricultural productivity are substantial.

The local sanitation committee was active and played an important role in the social promotion of the system. The trained members of the committee involved local people to regulate the maintenance process and transfer the knowledge and awareness about sustainable sanitation in the community. Consequently, the committee could practice creating a sense of ownership and social responsibility for the presented new concept of sanitation.

Estimated annual production and utilization of 500 kg of treated urine and feces resulted in an additional cost-saving for fertilizers of around 500 USD/year. As for agricultural production, considering the cultivation of white radishes in a typical $500m^2$ tract of farmland and a single annual harvest, the financial benefit from increased agricultural production using this system can be estimated as 400 USD/year.

Although it was traditionally and socially acceptable to use urine as a fertilizer in Korea, modern norms have undercut this approach. The scientific modifications undertaken in this system make it possible to overcome social and public health challenges and implement this otherwise beneficial system. Considering these benefits, although the visitors and users could access flushing toilets located nearby, 98% of them preferred using the RCS. Moreover, no direct contact with sanitary wastes makes the system safe, preventing the spread of infections like COVID19.

The system employs a nature-based biological treatment for treating urine and feces, meets the criteria of WHO guidelines for a “safe sanitation system,” and can be considered a step ahead of SDGs 1, 2, and 6. It has been nominated for and won several national and international awards including “Energy Globe Republic of Korea National Award 2019” and “Leaving No One Behind Innovation Award 2019.”

## Lessons Learned

The presented nitrifying microorganism-assisted resource circulation sanitation system is replicable throughout the world because it is technologically designed to be profitably operated by producing fertilizer from source-separated urine, which can be especially useful for remote areas with food shortages and/or agriculture-based communities.

The system is affordable and sustainable due to the use of local resources, making it possible for local users to construct and operate it. It saves a remarkable amount of water and energy, which is especially applicable in remote areas facing water shortages and beneficial to local governments by reducing the demand for the provision and use of freshwater.

The system is designed to be sustainable and easy to maintain while overcoming problems such as odor. It meets the definition and criteria of the WHO for a “safe sanitation system”, does not need complicated infrastructure, and provides nature-based solutions for water and sanitation challenges; making it suitable for implementation in remote and rural areas.

The system provides a notable contribution to overcoming the challenges of achieving SDGs 1, 2, and 6. Therefore, it would be welcomed and accepted by individuals, local governments, donor agencies, and United Nations-related organizations. Similar projects could be implemented in areas short of freshwater or in areas where regional cultural preferences might otherwise provide a barrier to use.


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Urban , Water services , Ecosystems/Nature-based solutions , Climate , Private Sector
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**Supporting Materials**
Field evaluation of the fertilizing potential of biologically treated sanitation products
Economic analysis and probability of benefit of implementing onsite septic tank and resource-oriented sanitation systems in Seoul, South Korea
Sanitation Sustainability Index: A Pilot Approach to Develop a Community-Based Indicator for Evaluating Sustainability of Sanitation Systems
Resource Circulation Sanitation Showcase Supporting Materials-Including Photos.pdf

**Related IWRM Tools**
Human Rights Based Approach, Public sector water utilities, Recycle and Reuse, Nature Based Solutions