



SANITATION AND SUSTAINABLE DEVELOPMENT IN JAPAN

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Printed in the Philippines.

ISBN 978-92-9257-587-8 (Print), 978-92-9257-588-5 (e-ISBN)
Publication Stock No. RPT168293-2

Cataloging-In-Publication Data

Asian Development Bank.
Sanitation and sustainable development in Japan.
Mandaluyong City, Philippines: Asian Development Bank, 2016.

1. Wastewater management. 2. Sanitation. 3. Resource management. I. Asian Development Bank.

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CONTENTS

Tables and Figures	iv
Acknowledgments	v
Abbreviations	vi
Weights and Measures	vi
Introduction	1
Policy Brief	9
Project Briefs	20
Optimizing National and Local Government Financial Resources for Wastewater Management and River Clean Up	20
From Wastewater Treatment to Fuel for Transportation and Homes in Kobe	25
Collection, Treatment, and Recycling of Sludge from Johkasou: Case of Saitama	29
Integrated Planning of New Urban Center and Wastewater Reuse in Saitama	35
Ensuring Water Security and Ecological Conservation: Reuse of Treated Wastewater in Tadotsu	39
References	43

TABLES AND FIGURES

Table

1	Agencies Responsible for Wastewater Management in Japan	11
2	Sewer Systems in Japanese Cities	12
3	National Subsidy Ratio	14
4	Example of Cost-sharing Scheme	15
5	Income and Expenditure for Sewerage Systems in Japan	16
6	Infrastructure Intensive Development Plan (2011–2016): Target Outcomes	18

Figure

1	Trend of Sewage Works Investment in Japan	12
2	Sewered Population Rate and Achievement Rate of Environmental Standards in Japan	17
3	Water Quality of Sumida River and Sewered Population Rate in Tokyo, Japan	17
4	Changes in the Air and Water Quality at Dokai Bay and Murasakigawa River	24
5	Sewerage Network System in Kobe	26
6	Schematic Diagram of the Biogas Generation System in Kobe City	27
7	Flow Chart of Sludge/Night Soil Treatment Process in Saitama City	31
8	Sludge Recycling System in Saitama City	32
9	Treatment Process for Wastewater Reuse in Saitama City	36
10	Schematic Diagram of the Wastewater Reuse Project in Tadotsu Town	40

ACKNOWLEDGMENTS

Sanitation and Sustainable Development in Japan is a joint publication by the Sustainable Development and Climate Change Department (SDCC) of the Asian Development Bank and Japan Sanitation Consortium (JSC).

We gratefully acknowledge the work of JSC who provided expertise and technical support in implementing this publication. We would also like to thank Pierre Flamand for providing us with information and data that further improved the publication's content, to ADB's Wastewater Team under RETA 8060: Promoting Innovations in Wastewater Management in Asia and the Pacific—a technical assistance funded by the Japan Fund for Poverty Reduction—for valuable comments and suggestions for this publication, to Maria Corazon Ebarvia, Robert Domingo, Anna Navelgas-Capili, and Ginojesu Pascua for editorial and production matters, Anna Romelyn Almario, and Pia Corrina Reyes for overall coordination in production and publication. This publication also benefited from the support and encouragement of Vijay Padmanabhan, Jingmin Huang, Michiel de Lijster, and Ellen Pascua.

ABBREVIATIONS

BOD	biochemical oxygen demand
CO ₂	carbon dioxide
FY	fiscal year
¥	Japan yen
JSC	Japan Sanitation Consortium
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
MOE	Ministry of the Environment
O&M	operation and maintenance
PAWTP	packaged aerated wastewater treatment plant
SKS	Kobelco Eco-Solutions
WWTP	wastewater treatment plant

Weights and Measures

m ³	cubic meter
m ³ /day	cubic meter per day
m ³ /month	cubic meter per month
km	kilometer
km ²	square kilometer
mg/l	milligram per liter

INTRODUCTION

Sanitation has long been “beneath the radar” on the development agendas of governments worldwide. Aside from the massive investment requirements for putting in place sanitation interventions (both structural and non-structural measures) to benefit the community, the sanitation sector, in general, is unfairly classified as unappealing compared with other infrastructure subsectors such as power generation, transportation, and water supply. Too many governments are driven to achieve economic development and yet invest very little in promoting health and environmental conservation, considering how these two are strongly linked toward a country’s economic well-being.

Experiences from developed countries would attest that achieving universal access and coverage in sanitation for its citizens did not happen overnight. It took decades to reach their current state in sanitation, with a sizable investment infused to realize this lofty goal. Countries who have achieved considerable gains in advancing the sanitation agenda thrived on an enabling environment characterized by (i) enactment of legislative instruments prioritizing sanitation; (ii) a robust regulatory regime; and (iii) establishment of institutional arrangements and coordination mechanisms among stakeholders, where functions and responsibilities are clear-cut and delineated. On the financing side, given the capital-intensive nature of sanitation (sewerage, in particular), governments were initially at the forefront of allocating funds to finance sanitation interventions of varying complexities and scale. Toward the later years, the shift toward other forms of financing arrangements came into fruition, allowing the private sector to take a more active role in financing sewerage and sanitation programs and projects.

Sanitation and Sustainable Development in Japan highlights the country’s experience in achieving universal access and coverage in sanitation. The publication emphasizes government’s role (from the national, down to the local level) as pivotal in laying the groundwork and rallying the public in support of achieving clearly defined sanitation goals. The enactment of relevant policies, guidelines, and legal instruments pertaining to the various aspects of wastewater management (e.g., design standards, regulation, financing, and institutional arrangements) enabled the Japanese government to commit and bolster its resources toward implementing various wastewater management interventions across the country.

Examples from the cities of Kitakyushu, Kobe, Saitama and the town of Tadotsu exemplify a governance framework where the enabling instruments, institutional linkages, and management structures are all meshed up seamlessly toward a common goal of advancing sanitation in the country. Aside from pooling government resources to prioritize sanitation, the framework created enough room for technological innovations (with emphasis on resource recovery) to thrive, partnerships with the private sector established and strengthened, wastewater management operations done in a sustainable manner, and the public to be made aware and engaged as active partners in nation-building.



Source: M. Ebarvia

Enabling Policy and Laws

In Japan, the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) manages offsite sanitation (sewerage and wastewater management), while the Ministry of the Environment (MOE) handles onsite sanitation (johkasou, septage management with scheduled desludging, sludge treatment facilities). Both ministries are expected to work together.

To properly promote sewerage works subsidized by the national government, the Sewerage Law of Japan stipulates the structural criteria and standards for effluent quality; guidelines for planning, construction, and installation of pretreatment facilities; household connections; user fees; national government financial support; and the respective roles of national and local governments.

In areas where construction of a sewerage system is difficult, the households or small communities, located mostly in rural or peri-urban areas, use the onsite treatment system called *johkasou*.¹ The Johkasou Law mandates the owner to engage a desludging contractor for the facility at least once a year, with the owner paying the associated charge. The effluent water quality of the johkasou is monitored by the authorized inspection agency once a year in accordance with the law.

The Waste Management and Public Cleaning Law mandates local governments to create a Household Wastewater Treatment Plan for their municipalities, including a Sludge Disposal Plan. Sludge treatment facilities are to be constructed, operated, and maintained by municipalities and cities.

Financing mechanism. As part of the sanitation policy of Japan, financing arrangements were established to support the investment and operation and maintenance (O&M) costs. Laws and ordinances also regulate the scope of national subsidies, the procedures for the provision of subsidies, and complete examination of the constructed sewerage facilities. The Sewerage Finance Research Committee conducted several studies and discussions on the rational cost-sharing for sewage works. Following the principle of “stormwater at public burden and wastewater at private burden,” recommendations were made enabling the formulation of plans and implementation of sewage works. About half of the construction cost is financed through national subsidy. The remaining cost is financed mainly through local government bonds, which are repaid through user charges and the general account of local governments. Landowners in areas covered by sewerage systems bear part of the construction cost as a beneficiary payment. For maintenance cost, the stormwater cost is paid with the general account budget of local governments, while the cost for wastewater is paid by user charges.

¹ Johkasou (johka, purification, sou, tank) is a packaged aerated wastewater treatment plant (PAWTP). It is Japan's onsite or small-scale treatment system installed in individual houses, buildings, or a small community for collection and treatment of night soil (flush toilet wastewater) and domestic greywater. It can achieve high effluent quality of 20 milligrams per liter (mg/l) biochemical oxygen demand (BOD). The system is typically found in districts where sewerage systems are unplanned or difficult to construct. Source: Japan Education Center of Environmental Sanitation. 2009. *Johkasou Systems for Domestic Wastewater Treatment*. 4th Edition. Japan.

Sanitation as a business. Under the Local Government Finance Act of Japan, public sewerage systems are managed by public enterprises, but are required to become self-sustaining businesses using a special account separated from the general account. In essence, these enterprises adopt the self-support accounting system wherein costs are covered through the income generated. Transparency is also being practiced by making management information accessible to the citizens, as they are the taxpayers and, at the same time, users who bear the fees and charges. For the maintenance of sewerage systems, it has been noted that there is an increase in the number of cities entering into management contracts. The Private Finance Initiative is adopted in some cases, such as for power generation using digestion gas.

Kitakyushu: River and Coastal Clean Up

The city of Kitakyushu is an industrial city of approximately 1 million people (as of 2013) in western Japan. The city has a long coastal line of 210 kilometers (km) and abundant nature with 40% of the city area covered by forest. The city is also characterized by many heavy industries, such as iron foundries, which are located in the coastal area. This industrial activity caused major environmental issues in the 1950s–1960s with severe air and water pollution. From that time, countermeasures were gradually put in place and Kitakyushu became the first city in Japan to improve its water environment.

Currently, around 99.8% of the population is covered by the public sewerage system, while the remaining population (0.2%) is covered by onsite sanitation systems—mainly by the PAWTP called johkasou in Japan—in areas where sewerage construction is difficult.² The city has five wastewater treatment plants (WWTPs) using the conventional activated sludge process.



Swimming competition in Murasakigawa River.

Source: Kitakyushu Municipal Government, 2012.

² Kitakyushu Municipal Government. <http://www.city.kitakyushu.lg.jp/suidou/s01100015.html>

Stakeholder participation. During the period of 1950–1960, improvements made on its water environment were due significantly to a group of women who stood out among those calling for immediate action against the rising problem of pollution. Demands from women’s associations in the city provided the stimulus for the municipal government to establish counter measures. Spontaneously, pollution conditions were assessed. Based on the results, the government administration and businesses became proactive in initiating activities to alleviate the state of the environment. Various citizen groups conducted environmental research, river cleanup campaigns, and collection of cans and bottles thrown along roadsides. These became the catalyst for the introduction of the sewerage system and the redevelopment of riverbanks along the Murasakigawa River. Resettlement of informal settlers along the river was also done with consultations among the affected families.

Technology development. Environmental engineering development by both the public and private sectors was also enhanced due to demand for wastewater treatment. The developed technologies were also supplied outside Japan, resulting in payback for the large investment required for sewerage. Exporting the technologies enabled environmental improvement in other countries as well.

Kobe: Biogas as Fuel for Homes and Vehicles

Kobe City is one of the main cities of the Kansai region (Western Japan) with a population of approximately 1.54 million people as of 2013. In this city, domestic wastewater is treated through the public sewerage system and six WWTPs, which serve 98.7% of the population [over 1.52 million residents as of end of fiscal year (FY) 2013].³ The rest is served by the rural sewerage system (small-scale sewerage system) and PAWTPs (johkasou).



Kobe gas is produced at Higashinada WWTP.

Source: JSC.

³ Hyogo Prefectural Government. 2015. Penetration rate of sewer. Japan. http://web.pref.hyogo.jp/wd18/wd18_000000034.html

Disaster resilient. The sewerage system in Kobe City is characterized by the interconnection of four WWTPs forming a sewer network system that is resilient to disasters. The system is an outcome of the Great Hanshin-Awaji earthquake in 1995.

Climate change mitigation. Kobe also adopted a forward-thinking approach to fight global warming. The city implemented measures to maximize the potential of treating wastewater and sludge as valuable energy resources. Modern WWTPs require high levels of energy consumption. As such, Kobe City has set targets beyond the sanitation goal of public health and quality preservation of water bodies. The Higashinada WWTP concretely demonstrates that it can also be a resource recycling facility. After quality adjustment, Kobe biogas, the by-product of the facility, is not only used inside the WWTP but also as fuel for vehicles and as city gas in the distribution network of Osaka Gas. This project also contributes to the reduction of green house gas emissions. Around 2,700 tons of carbon dioxide (CO₂) per year is reduced because of the methane capture and the effective use of digestion gas.⁴

Saitama City: Sludge for Fertilizer

Saitama is a neighboring city of Tokyo, with a population of approximately 1.27 million people (as of 2015), and relatively high population density. The city combines offsite and onsite sanitation systems. Around 92% of its population is connected to the sewerage system, while the remaining 8% rely on the johkasou.⁵ Like many other cities in Japan, it is difficult to secure land for sanitary landfills where sludge generated by WWTPs and sludge treatment plants can be disposed. In Saitama City, the sludge generated in the johkasou located within the city boundaries is transported to two sludge treatment plants: the Omiya Purification Center and Nishibori Clean Center.



Residents in Saitama City use treated sludge as compost for gardening.

Source: JSC.

⁴ Data provided by Kobe Municipal Government.

⁵ Saitama Municipal Government. http://www.city.saitama.jp/001/006/003/002/001/p003157_d/fil/01.pdf

Sludge treatment and reuse. The revision of the Central Government's subsidy policy for night soil and/or sludge treatment facilities in 1997 prompted the city to develop a compact system for composting the sludge. As sludge contains phosphate—an indispensable fertilizer element for agriculture and produced in a very limited number of countries—sludge recycling became a more attractive option compared to sludge disposal and incineration. The technology adopted in the Omiya Purification Center is officially certified and widely used throughout Japan. It allows the safe recycling of sludge and composting for use as fertilizer.

Saitama Shintoshin: Wastewater Reuse

In Saitama Prefecture, the use of groundwater is restricted to prevent land subsidence, with more than 70% of the water are drawn from rivers every year.⁶ With increasing demands for water, funding a reliable supply of water is a challenge.

Aiming for the creation of an environmentally-friendly city, the main developers of Saitama Shintoshin (new urban center of Saitama Prefecture, with an area of 47.4 hectares located in the capital of Saitama City) considered rainwater and/or wastewater as an integral component for urban development since the planning stage of the urban center project.

Innovative technology for reuse application. Wastewater from households and commercial establishments in Saitama undergoes secondary treatment at the Saitama Sewage Treatment Center, using conventional activated sludge. To enable wastewater reuse, the treated wastewater is further treated at the Saitama Shintoshin Purification Plant using a combination of biofiltration and ozonation processes.



Separate piping system for water supply and treated wastewater.

Source: JSC.

⁶ Saitama Prefectural Government. Powerpoint presentation. <http://goo.gl/yoxVvj>

Water savings. The pipes for the supply of reused wastewater have been installed under the main roads of Saitama Shintoshin, enabling all buildings to be supplied with treated wastewater. About 250,000 cubic meters (m³) of freshwater is saved yearly, amounting to ¥104 million (approximately \$939,000) due to the provision of recycled wastewater.⁷

Tadotsu: Wastewater Treatment for Water Resource Management

Tadotsu is a town in Shikoku Island in Japan, located on the Seto Inland coast. This town is characterized by low rainfall. Consequently, Tadotsu regularly suffered from water shortages and droughts in the past, which put water resources under considerable stress. Securing stable water supply for drinking and irrigation, reducing the risk of droughts, and maintaining water levels in rivers and groundwater always proved difficult. For these reasons, the wastewater reuse was promoted.

Water resource management. Treated wastewater is now being reused for various purposes, such as river restoration; irrigation for agriculture, parks and gardens; ground water recharge; and augmentation of the streams and brooklets running through the town.

Recreational amenities and tourism revenues. The reuse of treated wastewater restored the ecological habitat and improved the natural environment of the town. It allowed the creation of new water amenities (brooklets) and the revitalization of parks. The Wastewater Reuse Project contributed to improving the town's attractiveness and enhancing tourism. It also resulted in a positive economic impact on the associated industries. Moreover, guaranteeing the supply of water for agriculture and the conservation of the natural environment paved the way for the conservation of the natural environment has provided a useful field for school education.



A park in Tadotsu Town.

Source: JSC.

⁷ Data provided by the Saitama Shintoshin Purification Plant.

POLICY BRIEF

The Evolution of Policy and Financing Mechanisms for Wastewater Management in Japan

Addressing the social problems associated with sanitation is indispensable to ensure a comfortable living environment, preservation of water quality, and sound urban development. It is one of the most important issues in Asia where economic growth continues at a rapid pace. To deal with worsening environment and sanitation problems in the region, decisions to solve these problems should be a national issue. Thus, a government policy that responds to existing conditions and associated challenges is required. Acquiring consensus from the people, especially on who should bear the cost of sanitation is likewise necessary.

In Japan, a rational mechanism that consists of rules and regulations is implemented for programs and projects relating to sanitation and wastewater management. The establishment of sewerage systems and wastewater treatment facilities is a national requirement in development plans. The country was able to make these infrastructures a reality and even sustainable due to national government subsidy for capital investment and cost-sharing scheme between national and local governments. The success of project implementation, however, lies on rational utilization of government subsidies, determined through a transparent stakeholder consensus-building process. Based on the experience of Japan, when government subsidies are used for sanitation issues, government's role is clarified as well as the cost-sharing ratio and cost recovery mechanism. In addition, a system for proper project implementation and management is needed. These matters are decided upon at the country level and regulated by laws and/or decrees. Sanitation is likewise managed in a stable and sustainable way by proper project implementation agencies.

Background

Sewerage works started in Tokyo with the construction of sewers made of bricks and clay in 1884–1885. Due to the cholera epidemics in Osaka in 1886 and 1890, sewerage works were also implemented in the old urban area of Osaka. The original Sewerage Law was enacted in 1900 to promote wastewater management. Sewerage construction began in some large cities; and WWTPs, which employed advanced technologies at that time, were also constructed. However, sewerage works were only carried out in limited urban areas of

some large cities and were often delayed due to small budget allocation and low priority given by the national government. The use of night soil (fecal sludge) in farmlands, likewise, constrained the demand for flush toilets. The night soil storage tanks were not equipped with flush toilets.

After World War II in Japan, a remarkable economic growth is stimulated but at the expense of the environment. Additionally, industrial wastewater was not sufficiently controlled in those days, and sewerage works were not actively promoted. As a result, public water bodies were heavily polluted. There was increasing alarm over air pollution in several of Japan's cities. In the 1960s, health issues related to pollution emerged. The Minamata disease caused deterioration of health and death of at least 2,267 people in the Yatsushiro Bay basin and 690 people in the Agano River Basin through food chain mercury poisoning. The contamination originated from the wastewater discharged by acetaldehyde producers.⁸ In the early 1960s, Yokkaichi asthma increased the incidence of chronic obstructive pulmonary disease and bronchial asthma in the population of Yokkaichi City, Mie Prefecture. This was caused by the sulfur oxide air pollution emitted by a petrochemical complex.⁹ Itai- itai disease caused deterioration of health and death of 184 people in the Jintsugawa River Basin in Toyama Prefecture through food chain cadmium poisoning, which originated from the wastewater discharged by a zinc mining company.¹⁰ With an overwhelming number getting sick and dying during these times, people demanded better living conditions, restoration of water bodies, and flush toilets.

'The Pollution Diet'

To address the worsening situation, the Environmental Pollution Control Headquarters headed by the Prime Minister was set-up in 1970. This resulted in the passing of 14 important laws in what became known as the Pollution Diet. The Pollution Diet aimed to establish the fundamental policy to control environmental pollution. Amongst the laws created were the Water Pollution Control Law and the amended Basic Law for Environmental Pollution Control and Sewerage Law. In addition to a dramatic decrease in air pollution, these laws paved the way for sewerage systems to be recognized as national minimum and established as indispensable facilities to improve people's living environment as well as preserve water quality of water bodies. Sewerage works were systematically promoted, especially in large cities.

Efforts to improve and protect water resources were also made in small- and medium-sized cities and towns.¹¹ Installation of onsite treatment facilities for households (johkasou) was initiated in less densely populated areas.

⁸ Ministry of the Environment. 2002. *Minamata Disease The History and Measures*. Environmental Health Department, Government of Japan. <http://www.env.go.jp/en/chemi/hs/minamata2002/>

⁹ Mie University. *Mortality and life expectancy of Yokkaichi Asthma patients, Japan: Late effects of air pollution in the 1960s-70s*. A university paper.

¹⁰ Kanazawa Medical University. *Itai-itai disease*. <http://www.kanazawa-med.ac.jp/~pubhealt/cadmium2/itaitai-e/itai01.html>

¹¹ Medium-sized cities may be defined as cities with population of 100,000 and more excluding the primate city; or cities between 100,000 and 1 million. Asian Urban Information Center of Kobe (AUICK). *Policy and Planning for Population and Development in Medium-sized Cities*. Chapter 5. The Asian Conference on Population and Development in Medium-sized Cities. <http://www.kicc.jp/auick/database/conf/conf1987/06/001.html>

Population covered by wastewater management reached 87% in 2011 from the sewered population coverage of only 7% in 1963 when the systematic nationwide sewerage construction (with the first Five-Year Program for Sewerage Construction) started.¹² “Population covered by wastewater management” means that the wastewater—including both blackwater and graywater—discharged by the population is effectively treated by either a WWTP or an onsite wastewater treatment system (johkasou) before its release into the water bodies. Today, almost 90% of Japan’s population is covered by wastewater treatment systems including offsite (sewerage facilities) and onsite (johkasou) system, making the country a much healthier place to live in.

Several legislations played a vital role in the increase of investment for wastewater treatment facilities. These legislations include the Local Government Act enacted in 1952, the Sewerage Law enacted in 1970, the Waste Management and Public Cleaning Law enacted in 1970, and the Johkasou Law enacted in 1983.

Table 1 highlights the agencies responsible for wastewater management in Japan, while Figure 1 shows the increase of investment in sewerage systems. Table 2, on the other hand, presents a breakdown of the sewer systems (e.g., separate or combined) operating in Japanese cities and municipalities. The table indicates that for relatively large cities, which started sewerage development at an early stage, the combined sewer systems are adopted as part of their sewerage system. For smaller cities, the preferred option is the separate sewer system.

Table 1: Agencies Responsible for Wastewater Management in Japan

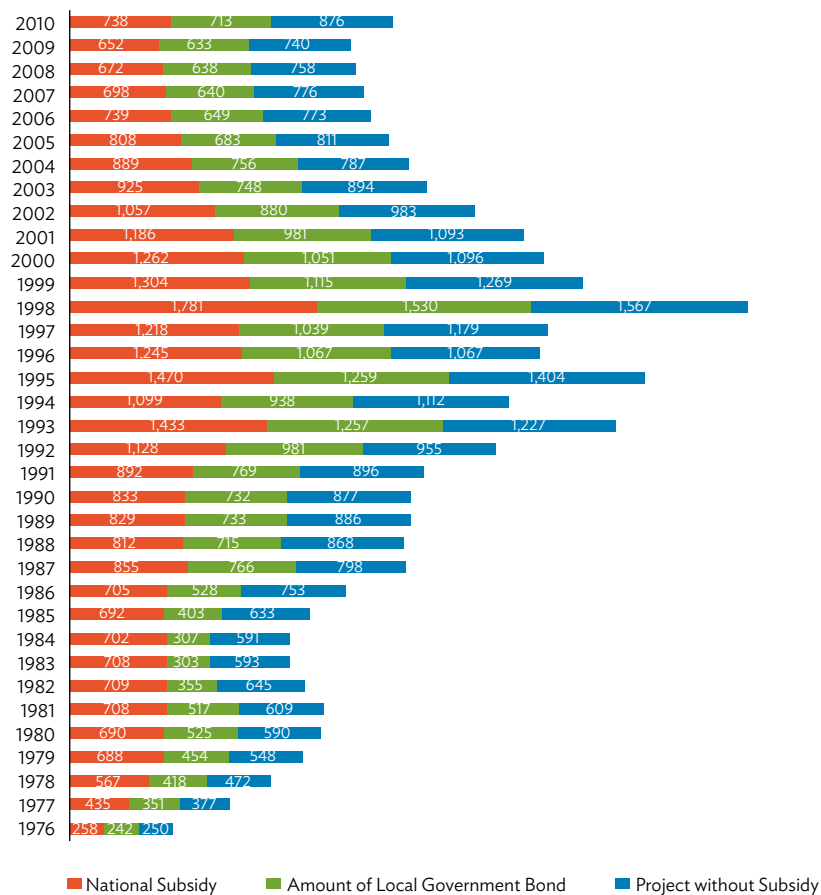
Type of wastewater management	Wastewater management system	Ministry (Policy, plan, and budget)	Implementing body (Investment and O&M)
Centralized wastewater management	Sewerage system	MLIT	Municipality Prefecture
Decentralized wastewater management	Johkasou	MOE	Individuals Municipality
	Rural sewerage system	MAFF	Municipality
	Community plant	MOE	Municipality
	Night soil/Sludge treatment plants	MOE	Municipality

MLIT = Ministry of Land, Infrastructure, Transport, and Tourism; MOE = Ministry of the Environment; MAFF = Ministry of Agriculture, Forestry, and Fisheries.

Source: JSC.

¹² MLIT. *Population covered by wastewater management at the end of Fiscal Year 2010*. Press Release. http://www.mlit.go.jp/report/press/mizukokudo13_hh_000139.html

Figure 1: Trend of Sewage Works Investment in Japan



Note: Figures in billion yen (¥).

Source: MLIT. 2009. Sewage Works White Paper.

Table 2: Sewer Systems in Japanese Cities

Size of cities (population)		SEWER SYSTEM				TOTAL
		Combined sewer system is dominant		Separate sewer system is dominant		
		Without separate sewer system	Partially with separate sewer system	Without combined sewer system	Partially with combined sewer system	
Ordinance-designed cities (large cities)		0	4	0	15	19
Municipalities	More than 300,000	0	2	13	39	54
	100,000 to 300,000	2	11	123	61	197
	50,000 to 100,000	0	3	226	38	267
	Less than 50,000	0	0	893	12	905
TOTAL		2	20	1,255	165	1,442

Source: JSC.

Policies to Address Wastewater Management

A. Supporting policies and laws

1) *Sewerage Law*. To properly promote sewerage works subsidized by the national government of Japan, the Sewerage Law stipulates the guidelines for the following:

- Role of national and local governments;
- Formulation of project planning;
- Comprehensive basin-wide planning of sewerage systems;
- Installation of pretreatment facilities; and
- Structural criteria and standards for effluent quality.

In addition, laws and ordinances also regulate the scope of national subsidies, procedures for the provision of subsidies, and complete examination of the constructed facilities.

2) The *Johkasou Law* provides guidelines on manufacturing, installation, maintenance, and desludging of the johkasou. The law mandates the johkasou owner to engage a maintenance contractor as well as a desludging contractor for the facility at least once a year. The owner pays the associated charges for the services rendered. The effluent water quality of the johkasou is monitored by the authorized inspection agency once a year in accordance with the Law.

3) The *Waste Management and Public Cleaning Law* mandates local governments to create a Household Wastewater Treatment Plan for their municipalities, including a Sludge Disposal Plan. Sludge treatment facilities are constructed, operated and maintained by municipalities and cities.

4) *Management of Sewerage Systems*. In order to preserve the water quality of water bodies, the sewerage systems constructed using national subsidies are managed in a stable and sustainable way. Under the Local Government Finance Act of Japan, public sewerage systems are managed by public enterprises. These enterprises adopt the self-support accounting system wherein costs are covered through the income generated. In essence, these enterprises become self-sustaining businesses. In addition, efforts are also made to undertake appropriate economic management based on tangible business objectives, precise business analysis, and future business prospects. Transparency is practiced by making management information open to the citizens, as they are the taxpayers and, at the same time, users who bear the fees and charges. It is therefore essential to gain their understanding and support in the sanitation initiatives.

The emergence of private sector participation and/or public-private partnership has been the focus of discussion recently. For the maintenance of sewerage systems, service contracts are used to engage private companies. Noteworthy is an increase in the number of cities entering into management contracts. O&M of sludge treatment plants can also be outsourced. The Private Finance Initiative is also adopted in some cases, such as for power generation using digestion gas.

B. Financing mechanisms

One of the most important reasons for the scarcity of sewerage projects implemented during the years of high economic growth in the 1960s was the difficulty of securing financial resources to meet project costs. To address this issue, the Sewerage Finance Research Committee was created in 1961. The first committee report included the very first major recommendation of the Committee: the principle of stormwater at public burden and wastewater at private burden.

In 1972, just after the Pollution Diet, the Committee pointed out the need for sewerage as an indispensable system to ensure that people meet at least the minimum living standards. It also recommended the expansion of public burden based on the premise that the public sector is responsible for providing sewerage systems like other public utilities. Consequently, subsidizing the sewerage construction cost from public funds is considered appropriate. Based on the Committee's reports, the basic concept of the fiscal principles of sewage works was established.

1) Cost-sharing principle among central and local governments, beneficiaries, and users for capital outlays

The national government is responsible for promoting sewerage works from a country's stand point. The local governments, on the other hand, are responsible for executing sewerage projects. Nevertheless, central and local governments, in principle, subsidize and/or bear the cost for promoting sewerage works (including stormwater facilities). Meanwhile, users assume the marketing cost for sewerage works based on benefits gained. The users are the ones benefitting from the improvement of living standards through the promotion of sewage works as well as they are the ones who are responsible for polluting the water bodies. Table 3 presents the current national subsidy ratio.

Table 3: National Subsidy Ratio

Classification		Ratio of National Subsidy	Cost-sharing Ratio of Local Governments
Sewer pipes	Granted project	1/2	1/2
	Unsubsidized project		10/10
Wastewater treatment plants	Granted project	5.5/10	4.5/10
	Unsubsidized project		10/10

Source: JSC.

About half of the construction cost is provided through national subsidy. The remaining cost is financed mainly through local government bonds, which are repaid through user charges and the general account of local governments. Although tariff increases are made upon advise by the national government (particularly for small municipalities), adoption of full cost-recovery, while possible, may be difficult to implement. The subsidy model remains as the preferred financial source among local governments in pursuing wastewater initiatives.

According to the City Planning Law, local governments can request part of the city planning project cost to the beneficiary who receives significant benefit from the project within the limits of the gained benefit. Based on this law, land owners in areas covered by sewerage systems shoulder part of the construction cost as a beneficiary payment based on the benefit (e.g., land price increase) from sewerage works (city planning project) on the request of local governments. A tax is levied annually to owners of lands and houses in a city planning area. The collected revenue is then allotted for city planning expenditures, such as roads, parks, and sewerage.

A certain percentage of the bonds issued by local governments are subsidized by the national government as a local allocation tax. This is provided to local governments when the standard financial needs exceed the standard financial revenue. The amount that the national government covers for the local government bonds depends on the financial situation of the local government.

When a local government issues local bonds, the local government should consult with/notify to the Minister of Public Management, Home Affairs, Posts and Telecommunications or the Prefectural Governor, depending on the status of each local government. In the case of cities or municipalities with deficit, or for which real debt expenditure ratio is high, an approval from the minister or governor to issue bonds should be obtained.

In addition to a full examination conducted by each local government as project owner and contractor, the Ministry that provides the subsidy conducts a complete assessment of work completion. Furthermore, the Government Accountability Office conducts a construction work inspection in the year following the work completion. These actions are carried out to verify that the output of the project meets the terms and conditions specified in the provision of subsidy. Should the output be found to be non-compliant with agreed upon terms, local governments are required to return the subsidy extended as penalty for utilizing the funds outside of its original intent/ purpose.

Table 4 presents an example of the principle of cost-sharing between the national and local governments.

Table 4: Example of Cost-sharing Scheme

	Construction cost		Maintenance cost	
	National Government subsidy	Local Government	National Government subsidy	Local Government
Stormwater drainage	36.6%	63.4%	–	100%
Separate sewer system	32.7%	67.3%	–	100%
Combined system	45.9%	54.1%	–	100%
Wastewater treatment	32.7%	67.3%	–	100%
Johkasou	–	–	–	–

Note: Data based on the case of Kitakyushu City during FY 2009–2011.

Source: JSC.

2) Basic concept of cost-sharing for sewerage maintenance

As for sewerage maintenance, cost-sharing is based on the principle of “stormwater at public burden and wastewater at private burden”. Because sewerage systems are classified as public utilities, it is considered appropriate to cover the maintenance costs associated with factors, such as water quality control and advanced wastewater treatment, from public financial resources. Note, however, that national government subsidies are extended only for capital investment requirements and not for O&M costs.

For maintenance cost, the rainwater cost is paid with the general account budget of local governments; while the cost for wastewater is paid by user charges. User charges cover the whole O&M costs plus part of the redemption cost of local bonds (principal and interest) for wastewater treatment. Expenditures on urban stormwater are entirely covered by the transfers from the general account of local governments. In the event that user charges are insufficient to cover O&M costs, funds from the general account of local governments may likewise be used to bridge the financing gap. Table 5 presents the overall income and expenditure for sewerage systems in Japan in FY 2005.

Table 5: Income and Expenditure for Sewerage Systems in Japan

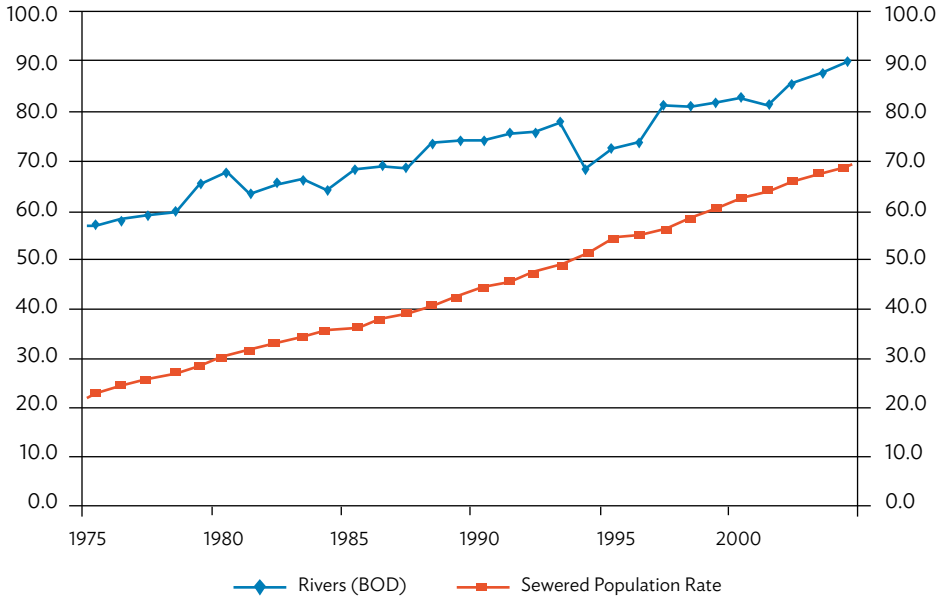
Expenditures		Unit: ¥ billion	
Costs for wastewater treatment from houses, factories, etc.		Costs for urban stormwater and drainage	
2,400		1,163	
Local bond	O&M	Local bond	O&M
Principal and interest redemption		Principal and interest redemption	
1,706 (71.1%)	694 (28.9%)	981 (84.4%)	182 (15.6%)
Transfers from general account of local governments	User charges	Transfers from general account of local governments	
1,040 (43.3%)	1,360 (56.7%)	1,163 (100%)	
Income		As of end of FY 2005	

Source: Japan Sewage Works Association. 2008. *Promoting Sustainable Sewage Works*.

Sewerage and Sewage Works Continue...

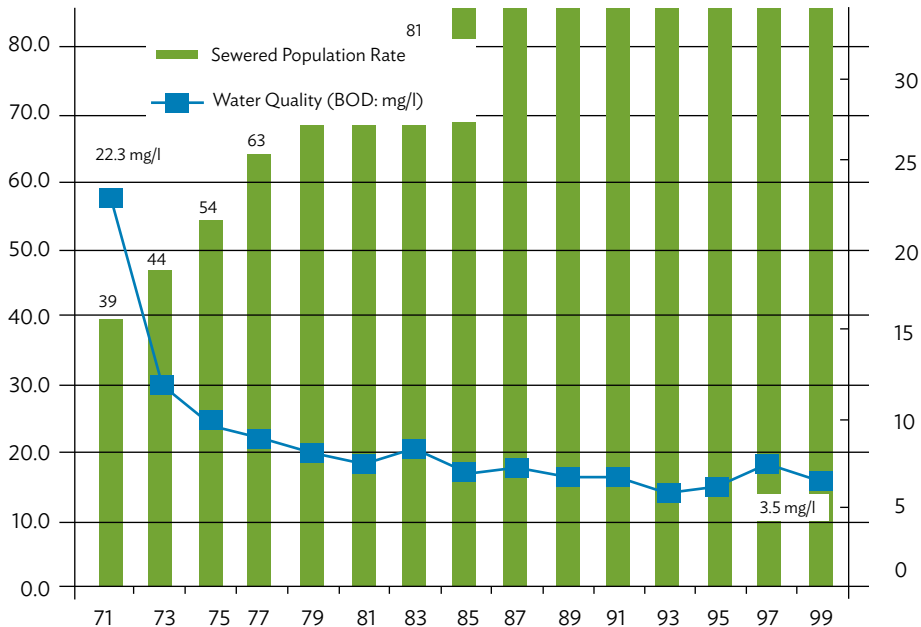
The national government started the first Five-Year Program for Sewerage Construction in 1963, and continued until the Eighth Program (1996–2002). The main target of the program includes the allocation of sufficient funding to increase sewerage coverage throughout the country. With the promotion of sewage works based on this program, the water environment greatly improved. Figure 2 shows the trends in sewered population rate and achievement rate of rivers that comply with water quality standards (i.e., BOD). Another example of environmental improvement through the promotion of sewage works can be seen in Figure 3 with the water quality improvement in Sumida River in Tokyo.

Figure 2: Sewered Population Rate and Achievement Rate of Environmental Standards in Japan



Sources: MLIT and MOE.

Figure 3: Water Quality of Sumida River and Sewered Population Rate in Tokyo, Japan



Source: Tokyo Metropolitan Government.

The Cabinet Office formulated the first Infrastructure Intensive Development Plan for major facilities (e.g., roads, airports, harbors, and sewerage facilities) in 2003. The First Plan (2003–2007) emphasized several outcomes of the projects under the MLIT.

Currently, the Third Plan (2011–2016) set four priority targets and outcomes. These include (i) reduction of large scale and broad-based disaster risk; (ii) reinforcement of industrial and economic foundation and global competitiveness; (iii) achievement of sustainable and dynamic country and communities; and (iv) enforcement of appropriate maintenance and renovation for social structure. In the field of sewerage works, 10 outcomes relating to the priority targets are formulated. Table 6 shows these target outcomes, highlighting the outcomes specifically for sanitation.

Table 6: Infrastructure Intensive Development Plan (2011–2016): Target Outcomes

Priority Target A – Reduction of Large Scale and Broad-based Disaster Risk	
1. Achieved rate of countermeasures against earthquakes for major sewerage facilities	From 34% (2011) to 70% (2016)
2. Number of flooded houses which ought to be urgently demolished	From 61,000 households (2011) to about 41,000 households (2016)
3. Achieved rate of countermeasures against inundations by sewer systems	53% (2011) to 60% (2016)
4. Rate of municipalities with hazard map and conducted disaster drills	15% (2011) to 100% (2016)
5. Achieved rate of formulated Tsunami Business Continuity Plan (BCP) for sewerage systems	6% (2011) to 100% (2016)
Priority Target B – Reinforcement of Industrial and Economic Foundation and Global Competitiveness	
Priority Target C – Achievement of Sustainable and Dynamic Country and Communities	
6. Utilization rate of sewage sludge as energy source	From 13% (2011) to 29% (2016)
7. Reduction of greenhouse gas emission by sewerage systems	From 1.29 million tons (CO₂)/year (2011) to 2.49 million tons (CO₂)/year (2016)
8. Wastewater-treated population rate	From 87% (2011) to 95% (2016)
9. Rate of population served by advanced wastewater treatment systems	From 33% (2011) to 43% (2016)
Priority Target D – Enforcement of Appropriate Maintenance and Renovation for Social Structure	
10. Achieved rate of planning for sustainable sewerage facilities	From 51% (2011) to 100% (2016)

Lessons Learned

The government's role and responsibilities in sanitation are clarified to rationalize the use of subsidies to address sanitation issues. Likewise, bases and arrangements for cost-sharing (e.g., government's responsibilities, the measures for subsidy provision, project inspection, audit account, disclosure of information, mechanism for accountability, etc.) are important aspects that need to be clearly established.

In Japan, the Sewerage Finance Research Committee conducted several studies and discussions on the rational cost-sharing for sewerage works. Recommendations were made, enabling the formulation of the current fundamental concept for sewerage works based on the principle of stormwater at public burden and wastewater at private burden. In addition, recommendations were made on the cost items that should be shouldered by the national government given the public nature of sewerage works. Recommendations were also done on policies to ensure financial resources for construction and maintenance.

The Sewerage Law indicates the basic purpose of sewerage works, the role of the national and local governments, as well as the planning, design, management and collection of user charges, and other important aspects related to wastewater management. Laws and ordinances also regulate the scope of national subsidies, the procedures for the provision of subsidies, and complete examination of the constructed sewerage and wastewater and sludge treatment facilities.

Several construction programs of wastewater treatment facilities were conducted, and national subsidies were also provided to these programs. The scope and procedures for providing subsidies and project implementation measures were also formulated similar to that of sewerage works. By combining these measures, the wastewater-treated population coverage reached 87% in 2011. These measures contributed to water quality preservation and the improvement of the living environment.

Efficient and sustainable maintenance and management of the sewerage and wastewater treatment facilities constructed with national subsidies are important tasks. Identifying and developing the appropriate agencies to implement the project is necessary to ensure the sustainability of the sanitation project. The important aspects of policy recommendation include: (i) financial system for sanitation; (ii) establishment of a legal framework; (iii) institutional and management arrangements; (iv) human resource development; and (v) technology options for drainage and wastewater treatment as well as reuse applications. Japan cleaned up due to clamor from the public and by convincing the academe and businesses that potential profits lay in solving environmental problems.

PROJECT BRIEFS

Optimizing National and Local Government Financial Resources for Wastewater Management and River Clean Up

Kitakyushu City, Fukuoka Prefecture, Japan

The city of Kitakyushu is an industrial city in Western Japan, with a population of 1 million. The city has a long coastal line of 210 km and abundant nature with 40% of the city area covered by forest. The gross domestic product of this city is approximately ¥3.5 trillion (approximately \$31.6 billion) and many heavy industry groups, such as iron foundries, located in the coastal area. In the 1960s, the pollution at Dokai Bay, which is located in the middle of an industrial area, became so serious that its marine life became completely extinct. The area was called the Sea of Death. The water quality of the Murasakigawa River, which flows through the center of Kitakyushu, was extremely polluted in 1967 with a BOD value of 58 mg/l (around 1 mg/l currently).¹³ This is due to the city's rapid industrialization and urbanization as well as lack of wastewater treatment facilities. As a result, residents disliked approaching the river.

Technology options

- Around 99.8% of the population is connected to the public sewerage system.¹⁴
- Onsite sanitation systems—mainly PAWTP or johkasou in Japan— cover the remaining population (0.2%) in areas where sewerage construction is difficult.
- For a rapid and relatively cheap manifestation of sewerage benefits, (i.e., water quality improvement and flood damage reduction) the combined sewer system was introduced in the 1960s in almost all of the central city area.
- At the final stage of sewerage implementation, the combined sewer system, which covers an area of 3,422 hectares, represents 20% of the whole wastewater-treated area, while the separate sewer system has been installed in the remaining 80%.¹⁵

¹³ M. T. Oyama. *Improvement of the Urban Environment; Activities of Kitakyushu City to Support Sustainable Urban Development*. Powerpoint presentation. Kitakyushu Waterworks and Sewage Association. http://www.fukuoka.unhabitat.org/kcap/activities/egm/2011/pdf/Kitakyushu_City.pdf#search='Kitakyushu+Sewerage'

¹⁴ Footnote 2.

¹⁵ Footnote 2.



The two photos provide a description of Kitakyushu in 1960 and present day (2014). More than half a century ago, Dokai Bay was seriously polluted and the marine life was completely extinct. For this reason, this area was called the “Sea of Death”. The bay has been revived since. More than 110 species of marine life now call Dokai Bay their home.

Source: City of Kitakyushu

- Since 2003 and the revision of the Sewerage Law Enforcement Ordinance, Kitakyushu City has continuously pursued improvement of the combined sewer system while gradually shifting toward the use of separate sewer systems and the construction of stormwater reservoirs for flood control during events of heavy precipitation.
- Small-scale sewerage zones were planned in suburban areas with low population density. Separated from the urban area, the wastewater unit load and the minimum diameter of sewer pipes were determined based on past records of supplied drinking water. Sewer pipelines include many manholes equipped with a pump, which enabled reduction of piping cost.
- The city has five WWTPs. These plants use the conventional activated sludge process and have a total capacity of 621,000 m³/day (as of 2015).¹⁶

Institutional and management arrangements

- Kitakyushu City's Water and Sewer Bureau manages sewage works. Although the Water Bureau and Sewer Bureau merged in April 2012, their special accounts (for public business including water supply and sewage works) remained separate.
- The sewerage utility account is independent from the general account of the city.
- The financial regulations of the Local Public Enterprise Act are applied since 1985 and a corporate accounting method is adopted.
- Since the 1970s, the operations at the central control center of the WWTPs are outsourced to private companies through contracts renewed annually.
- In the 1950s, a group of women (women's associations in the city) provided the stimulus to start a movement demanded action against pollution. This led to the initiation of antipollution activities. Various citizen organizations conducted environmental research, river cleanup campaigns, and collection of cans and bottles thrown along roadsides.
- In 1968, Kitakyushu City created the Countermeasure Convention of Murasakigawa River as a special organization to tackle water pollution issues. This was followed by a resettlement plan for the informal settlers located along the river. This included consultations with the residents to be relocated in building plots and apartments provided by the city, which proved to be successful in paving the way for the redevelopment and revival of the river.
- The private sector took part in the restoration project for the Murasakigawa River as early as the planning stage. They were involved in promoting the redeveloped waterfront by hosting various competitions and events in the area.

¹⁶ Data provided by Kitakyushu Municipal Government.

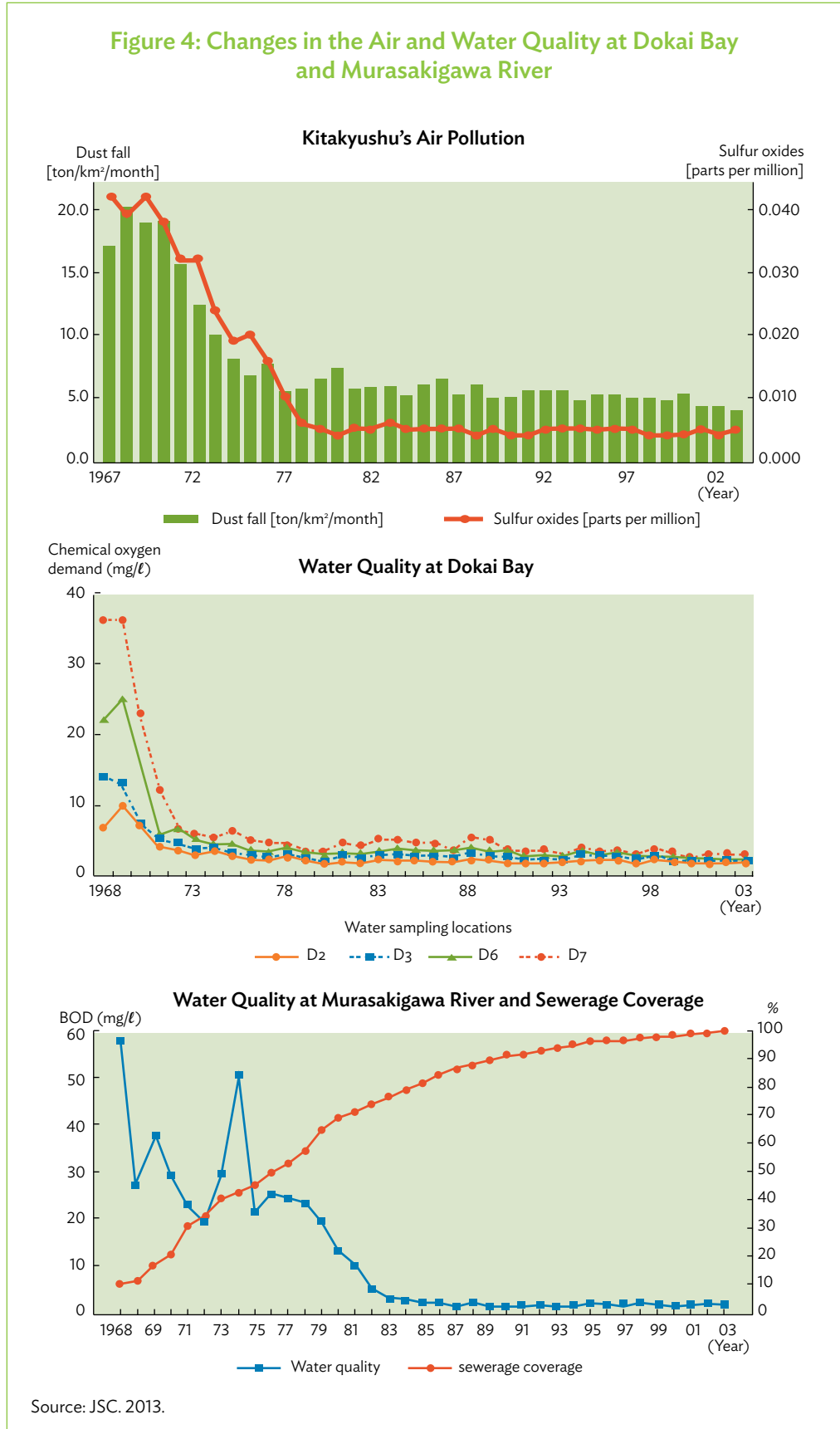
Financing arrangements

- In Japan, the implementation of sewage works is placed under the responsibility of local governments.
- The Sewerage Finance Research Committee was created, consisting of experts and knowledgeable persons from central and local governments. The role of the committee was to determine the financial principle appropriate for sewerage works according to socioeconomic conditions (decision of subsidy rules with transparency).
- The central government provides subsidies at fixed rates, which vary depending on the type of facilities.
- The current subsidy rate is 55% for eligible WWTPs, and 50% for sewer lines.
- Funding of unsubsidized facilities is through local bonds; while the remaining cost is transferred from the general account of local governments. Residents also pay partly for the capital cost through beneficiary contribution.
- The total capital investment cost for sewerage facilities in Kitakyushu exceeded ¥600 billion (approximately \$5.4 billion) over the past 40 years. This cost is shared among municipal bonds (65% of total cost), subsidies from the central government (26%), beneficiary contribution (3%), and the general account of the city (6%), according to the fundamental principle of sewerage finance established by the Sewerage Finance Research Committee.
- At the time of bond repayment by local governments, the law authorizes about 50% redemption with the national tax revenue allocated to local governments for this purpose.
- Generally, sewer user charges are calculated by adding the basic charge and the charge from the amount of the water supplied. In the case of Kitakyushu, for a family that uses 20 m³/month, the sewer user charge is ¥4,415 (approximately \$39.86) for 2 months. This is equivalent to ¥110/m³ (approximately \$0.99). This amount is cheaper than in many cities of Europe.

Project outcomes

- As with many cities of Japan in the 1960s, the bay and rivers of Kitakyushu were extremely polluted, a situation comparable to the conditions currently found in cities of developing countries. Pollution was greatly reduced because of the investment made by private factories in wastewater treatment facilities for industrial effluent, as well as the significant public investment made to develop the sewerage system. Figure 4 illustrates these changes and/or improvements to air and water quality.
- Continuous efforts made by the City of Kitakyushu, residents, and the private sector enabled sewerage progress.
- Kitakyushu was the first city in Japan that was able to improve its water environment.
- Improvement of the water environment in the country's cities not only supported Japan's economic development, but also allowed all sorts of environmental engineering development by both the public and private sectors. The developed technologies supplied outside Japan enabled environmental improvement in other countries as well. This provided significant returns of the investment required for sewerage.

Figure 4: Changes in the Air and Water Quality at Dokai Bay and Murasakigawa River



Source: JSC. 2013.

Positive outcomes of sewage works in Kitakyushu include:

- (i) Development of a legal and financial support system from the central government was a powerful incentive for sewerage implementation.
- (ii) Determination of a business scheme well-suited to the characteristics of the city enabled effective project cost reductions.
- (iii) The combined sewer system was adopted in areas with urgent needs.
- (iv) A monitoring system was established to assess water quality in the major discharge points receiving industrial wastewater from factories.
- (v) The strong will of the city authorities represented by the mayor and supported by the residents was a powerful driving force for sewerage projects.

From Wastewater Treatment to Fuel for Transportation and Homes in Kobe

Kobe City, Japan

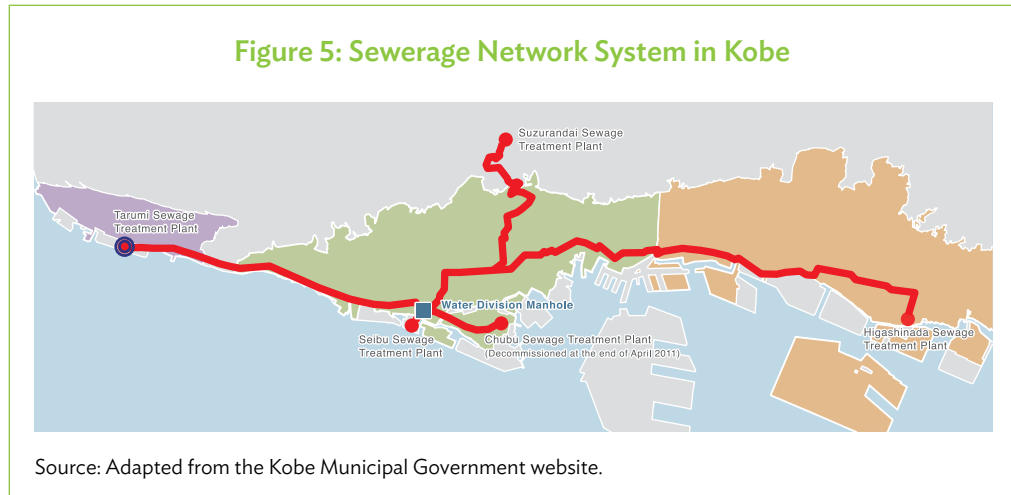
Kobe City is one of the main cities of the Kansai region (Western Japan) with a population of 1.54 million people. In this city, domestic wastewater is treated through a combination of systems. While 98.7% of the entire population is covered by the public sewerage system, the remaining population is served by the rural sewerage system (small-scale sewerage system) and the onsite system (johkasou). Presently, the sewerage system consists of six WWTPs, which annually treat 180 million m³ of wastewater (as of FY 2012), and a sludge incinerator.¹⁷

The sewerage system in Kobe City is characterized by the interconnection of four WWTPs forming a sewer network system that is resilient to disasters. The system is an outcome of the Great Hanshin-Awaji earthquake in 1995. Considered as the longest sewer network in Japan, it can withstand disasters as well as cope with reconstruction and renovation of facilities. The remaining WWTPs—Tamatsu and Port Islands—are not included in the Sewer Network System because of the constraints of the areas where they are located and the low cost-effectiveness of their connection to the network. Figure 5 shows a map of Kobe's sewerage network system.

The city formulated measures to cope with global warming in the Action Plan of Kobe City for the Prevention of Global Warming. Consequently, the city aims for more than 25% reduction of the amount of greenhouse gas emissions (from 1990 levels) in the whole city area by 2020. This requires proactive efforts to reduce greenhouse gas emissions and use renewable energies.

Modern WWTPs require high levels of energy consumption. As such, Kobe City sets targets beyond the sanitation goal of public health and quality preservation in public water bodies. They also adopted a forward-thinking approach to fight global warming by implementing

¹⁷ Footnote 4.



measures to maximize the potential of treating wastewater and sludge as valuable energy resources. As a result, gas generated from the anaerobic digestion of sludge is recovered and highly refined to achieve 97% methane concentration. Thus, its value increased as a renewable energy source.

Since 2009, the highly refined gas—known as Kobe biogas—is supplied as vehicle fuel. And to promote further use of the refined digestion gas, the Kobe biogas is directly injected in the distribution pipeline of the local city gas company after undergoing additional purification requirements.

Additionally, the anaerobic process is significant in achieving efficient sludge treatment, and has the advantage of reducing the volume of sludge through the separation of gas in digestion tanks, which is particularly valuable in countries such as Japan where land availability is an issue. Biogas production in Kobe City is a concrete example of how sewage works can contribute positively to the environment, as well as how large volumes of sludge, which poses substantial problems in developing countries, can be safely managed and disposed.

Technology options

- Kobe biogas is produced at the Higashinada WWTP, which serves approximately 380,000 people and has a treatment capacity of 241,500 m³/day.
- The plant treats wastewater using the conventional activated sludge treatment process. Figure 6 shows a diagram of the system. The sludge that settles in the sedimentation tanks is further concentrated in the thickening tanks and then conveyed to the digestion

tanks where anaerobic digestion generates methane gas. After digestion, the sludge is sent to dewatering machines before incinerating it to produce ash.

- The anaerobic digestion process is adopted to stabilize sludge and reduce its volume through conversion to biogas in digestion tanks.
- To fuel vehicles and supply the city gas network, Kobe City conducted collaborative research with a private company (Kobelco Eco-Solutions or SKS) and developed a technology called high-pressure water scrubbing to increase methane purity from 60% to 97%. The technology allows digestion gas to achieve the same quality as that of the city gas and prevent corrosion of equipment and machines.

Figure 6: Schematic Diagram of the Biogas Generation System in Kobe City



Source: JSC.

- More than 12,000 m³ of digestion gas are generated daily at the Higashinada plant, of which about 6,000 m³ are highly refined to produce Kobe biogas.
- After the successful development of the high-pressure water scrubbing technology, the Kobe Biogas Eco-station opened in 2009 to supply biogas as alternative for vehicles using natural gas for fuel.



Digestion tanks and Kobe Biogas Eco-station.

Source: Sewage Works in Japan. 2010

Institutional and management arrangements

- Kobe City is responsible for all decisions made in the Kobe Biogas Project.
- Kobe City and SKS collaborated on the purification of the biogas produced by the Higashinada facility to generate fuel for use by the treatment plant, city buses, and garbage trucks.
- Osaka Gas joined Kobe City and SKS to conduct further research for the distribution of gas in the city gas pipeline.
- The Construction Bureau of Kobe City is managing and supervising the project.
- SKS manages both the Kobe Biogas Eco-station that supplies fuel for vehicles as well as the facilities for the injection of Kobe biogas in the city gas distribution pipeline.
- Kobe City and SKS have a contract for the sale of Kobe biogas to the areas where the gas is supplied.

Financing arrangements

- Half of the construction cost of the eco-station is financed through a subsidy from MLIT under a program supporting innovative sewerage systems using underutilized energy sources.
- The Ministry of Economy, Trade and Industry subsidized the cost of the demonstration experiment conducted for the gas distribution business in the city pipe network. The cost for the construction of these facilities was ¥450 million (approximately \$4.06 million).

- The refined digestion gas from the Higashinada WWTP is supplied to SKS and sold as Kobe biogas. The sale covers the costs of the Kobe Biogas Eco-station and the outsourced work for O&M of the equipment used for the distribution of gas into the city pipeline network.
- In FY 2012, the unit price of the biogas supplied as automobile fuel varied between ¥65–¥70 (approximately \$0.59–\$0.63). This was more than 50% cheaper than the unit price of gasoline [¥148/liter (approximately \$1.34/liter)] in Hyogo Prefecture where Kobe is located.
- Osaka Gas sells the biogas injected in the city gas distribution network after purification. It was noted that the biogas has similar qualities to the city gas from other sources. Hence, households do not pay extra for the biogas. According to Osaka Gas, a standard family uses an average of 33 m³/month of gas at a cost of ¥6,167/month (approximately \$55.68/month) or ¥186.9/m³ (approximately \$1.69/m³).

Project outcomes

- The project concretely demonstrates that a wastewater treatment system can also be a resource recycling facility.
- After quality adjustment, Kobe biogas is not only used inside the Higashinada WWTP, but also as fuel for vehicles and as city gas in the distribution network of Osaka Gas. Currently, Kobe biogas is provided to about 14,000 vehicles annually. This includes buses and waste collection trucks in Kobe City. In addition, gas for about 2,500 standard households is supplied in the region (as of FY 2012).¹⁸
- According to Kobe City, this project highly contributes to the reduction of gas emissions for global warming prevention. Around 2,700 tons of CO₂ per year are reduced because of the effective use of digestion gas.¹⁹ The recycling of energy contained in wastewater into a resource concretely shows the contribution made to the environment and helps in increasing public awareness on wastewater and energy issues.
- Digestion gas separation is a technology that enables the reduction of the weight and volume of sludge, which are essential features for its efficient treatment and disposal.

Collection, Treatment, and Recycling of Sludge from Johkasou: Case of Saitama

Saitama City, Japan

Saitama is a neighboring city of Tokyo, with a population of 1.27 million (as of 2015) people and relatively high population density. The city combines offsite and onsite sanitation systems. Around 92% of its population is connected to the sewerage system while the remaining 8% rely on onsite system (johkasou).²⁰

¹⁸ Kobe Municipal Government. <http://www.city.kobe.lg.jp/life/town/waterworks/mizbiz/img/kobebiogas.pdf>

¹⁹ Footnote 4.

²⁰ Footnote 5.

The johkasou (or PAWTP) is a compact and highly efficient onsite wastewater treatment facility for individual households or small communities located mostly in rural or peri-urban areas where there is no access to a sewerage system. The johkasou can treat both blackwater (wastewater from toilets) and greywater (nonfecal wastewater from kitchen, bathroom, etc.) to achieve high effluent quality of less than 20 mg/l BOD.

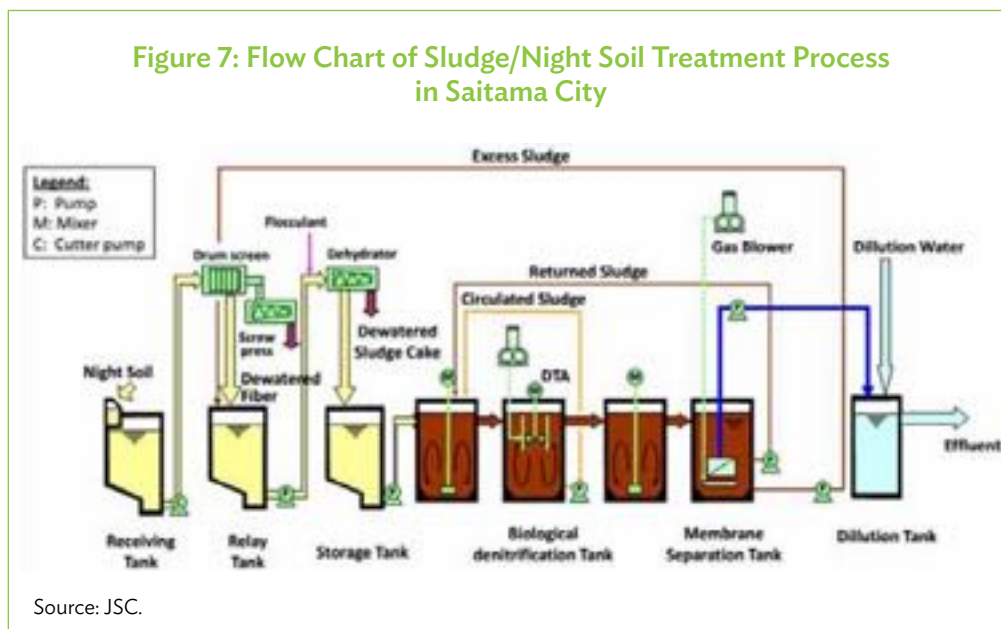
Although the johkasou is a highly efficient onsite treatment facility, the treatment performance deteriorates if an excessive amount of sludge accumulates. It is essential to remove sludge regularly and transport it to sludge treatment facilities where it can be treated in a hygienically and environmentally safe manner. In Saitama City, the sludge generated in the johkasou located within the city boundaries is transported to two sludge treatment plants: the Omiya Purification Center and Nishibori Clean Center.

Like many other cities in Japan, it is difficult to secure land for sanitary landfills where sludge generated by wastewater and sludge treatment plants can be disposed. The revision of the Central Government's subsidy policy for night soil and/or sludge treatment facilities in 1997, which makes subsidy eligible only for facilities that include a resource recycling facility, prompted the city to develop a compact system for composting the sludge. As sludge contains phosphate – an indispensable fertilizer element for agriculture and produced in a very limited number of countries, sludge recycling became a more attractive option compared to sludge disposal and incineration.

Technology options

- To treat sludge from onsite sanitation facilities and use it as a valuable resource through recycling, Saitama City renovated one of the sludge treatment plants in 2001 and constructed the Omiya Purification Center. It has a capacity of 179 m³/day. The cost of the construction of the facility was ¥3.150 billion (approximately \$28.44 million), of which 5% was used for the construction of the compost facility. The finished compost is provided to residents to be used as soil improvement additive for house gardens.
- To prevent polluting the river where effluent is discharged and ensure that the residents around the sludge treatment facility approve its construction, a high-capacity membrane separation treatment process was adopted with a discharged effluent achieving the following performances: less than 2 mg/l BOD, less than 1 mg/l suspended solids, and less than 4 mg/l total nitrogen.
- The membrane technology was needed to achieve the self-imposed targets for effluent quality (for example, BOD below 5 mg/l). Although this technology is energy-consuming, 10% of power consumption can be saved through a Dissolved Oxygen Automatic Control System in the biological reaction tank, which controls the use of power for the blowers generating aeration. In addition, the technology used in the Omiya Purification Center uses minimal footprint, is needed to build such facility in an urban area where land is very limited.
- The treatment process of the wastewater contained in sludge includes pretreatment, biological treatment, and advanced treatment. It uses the following processes and technologies:
 - (i) *Biological treatment process*: combination of recycled biological nitrification-denitrification processes and ultrafiltration membrane.

- (ii) *Chemical precipitation process*: combination of added inorganic flocculants and ultrafiltration membrane.
 - (iii) *Activated carbon absorption process*: treatment with downflow activated carbon adsorption type.
 - (iv) *Sludge treatment process*: compost with vertical mechanical fermenter type.
- The excess sludge generated through the treatment process is dewatered using a filter press. After this operation, the level of water contained in the dewatered sludge is adjusted through the fermentation process to produce compost with 40% moisture content.
 - The sludge fermentation process includes a vertical heating fermenter type, which is designed to heat sludge at an average temperature of about 70°C during a period of approximately 14 days. Inside the fermenter, agitation and heating devices have been installed. The level of water in sludge is adjusted using woodchips.
 - Figure 7 presents a schematic diagram of the sludge and/or night soil treatment process. Figure 8, on the other hand, presents the sludge recycling system in Saitama City.



Institutional and management arrangements

- In Japan, offsite sanitation (sewerage) is managed by MLIT; while onsite sanitation (johkasou), septage management with scheduled desludging, and sludge treatment facilities) are managed by the MOE. Both ministries are expected to work together.
- The Waste Management and Public Cleaning Law mandates local governments to create a Household Wastewater Treatment Plan for their municipalities including a Sludge Disposal Plan. When a municipality applies for central government subsidy

Figure 8: Sludge Recycling System in Saitama City



Desludging



Collection
and Transport



Treatment



Reuse

Source: JSC.

for the construction of a sludge treatment facility, this plan needs to be submitted for review to the central government (MOE) through the prefectural government.

- The Johkasou Law mandates the owner to engage a maintenance contractor and a desludging contractor for the facility at least once a year. The owner shall pay the associated fees. Private contractors approved by the relevant municipality conduct the desludging and transportation of johkasou sludge.
- Sludge treatment facilities are constructed, operated, and maintained by the municipalities and cities. The O&M of sludge treatment plants can be outsourced. But in the case of the Omiya Purification Center, staff of the Saitama City Government conducts O&M.
- The Omiya Purification Center is included in planning for environmental education with the establishment of an environmental education corner. The environmental education corner consists of a nature garden adjacent to the treatment plant's building, as well as an observatory and a study room inside the building. The nature garden recreates the forests, brooklets, and marshes that had once existed in the nearby area, and is home to many insects and birds. From the observatory, visitors can view the nature garden using binoculars provided. The study room provides a venue where the impacts of wastewater on the environment as well as the schematic diagram of the flow of wastewater treatment process in the facility are exhibited. Study tours for school children and junior high school students are conducted upon request.
- The effluent water quality of the johkasou is monitored by the authorized inspection agency once a year, in accordance with the Johkasou Act.
- The effluent water quality of sludge treatment plants, such as the Omiya Purification Center, is monitored once a month by the prefectural government. The prefectural governor has the authority to order the interruption of operations if the facility fails to comply with effluent quality standards.



Omiya Purification Center

Source: JSC.



Omiya Environmental Education Corner

Source: JSC.

Financing arrangements

- The construction cost of the Omiya Purification Center was ¥3.150 billion (approximately \$28.44 million), of which 30% has been subsidized by the Central Government, in accordance with the national subsidy rules. About 60% of the cost was shouldered by the municipality through low interest loan from the prefectural government; while 10% came from municipality tax.
- For areas not covered by a sewerage system, the national government also provides subsidy of about 40% of the installation cost for households that install the johkasou.
- This facility is the only individual property subsidized in Japan because its installation benefits individuals, cities and towns, and contributes to the improvement of the water quality in public water bodies.
- The financing rule for septage management adopted in Japan is that the O&M costs for onsite sanitation facilities are borne by households or building owners; while sludge treatment facilities are borne by the public sector (i.e., municipalities). This is considered to be the most realistic rule for a sustainable septage management system even in developing countries.
- On average, a household (with five family members) using the johkasou pays typically about ¥65,000 (approximately \$586.91) in total for O&M per year. This includes the electricity fee [¥13,000 (approximately \$117.38)] paid to the electricity company; inspection fee [¥5,000 (approximately \$45.15)] paid to the inspection agency; maintenance fee [¥21,000 (approximately \$189.62)] paid to the maintenance contractor; and desludging fee [¥26,000 (approximately \$234.76)] paid to the desludging contractor.

- The O&M costs of the sludge treatment plant are financed by the municipality. In FY 2013, the O&M cost reached ¥216 million (approximately \$1.95 million). This includes electricity, chemical (coagulant), and consumable supplies.
- The direct O&M cost for composting was ¥10.8 million (approximately \$98,000) in FY 2013, representing about 5% of the whole sludge treatment cost. However, the sale of compost generated is estimated to be around ¥80,000 (approximately \$722).

Project outcomes

- The septage management system in Japan (in particular for the johkasou installation and O&M in Saitama, including sludge collection, transport, and treatment) is considered sustainable since this system is working efficiently over the last few decades. This system is supported by a comprehensive regulatory framework and sustainable financial structure.
- The choice of composting for disposal is advantageous in areas where landfilling is restricted and sludge is required to be incinerated for volume reduction.
- Compost from sludge recycling was also favored by Saitama City as it gets attention from residents and raises awareness on the importance of preserving the environment. Environmental education, such as the one conducted in the environmental learning corner at the Omiya Purification Center, is widely done in Japan and enhances the acceptance and sustainability of sanitation systems.
- The adopted technology for the Omiya Purification Center is an officially certified technology, widely used throughout Japan and supported by the authorized training system for operators. It allows the safe compost and recycling of sludge as fertilizer.

Integrated Planning of New Urban Center and Wastewater Reuse in Saitama

Saitama City, Japan

Japan is not a country with abundant water resources. Particularly in Tokyo and its suburban area including Saitama City, the amount of water resources per capita is only 903 m³ per year, which is at the level of water stress considered below 1,000 m³. Therefore, Japan is actively striving to maximize reuse of treated wastewater. In FY 2006, the total amount of reused wastewater in Japan reached 200 million m³.

In Saitama Prefecture, the use of groundwater is restricted to prevent land subsidence, and more than 70% of the water source every year is required to originate from rivers.²¹ With increased demand, a reliable supply of water has become a challenge. Aiming for the creation of an environmentally-friendly city, the main developers of Saitama Shintoshin (new urban center of Saitama, with an area of 47.4 ha)—the Central Government, Saitama Prefecture, and the Housing and Urban Development Corporation (the current Urban Renaissance Agency)—considered rainwater and wastewater as a concept for urban development as early as the planning stage of the urban center projects.

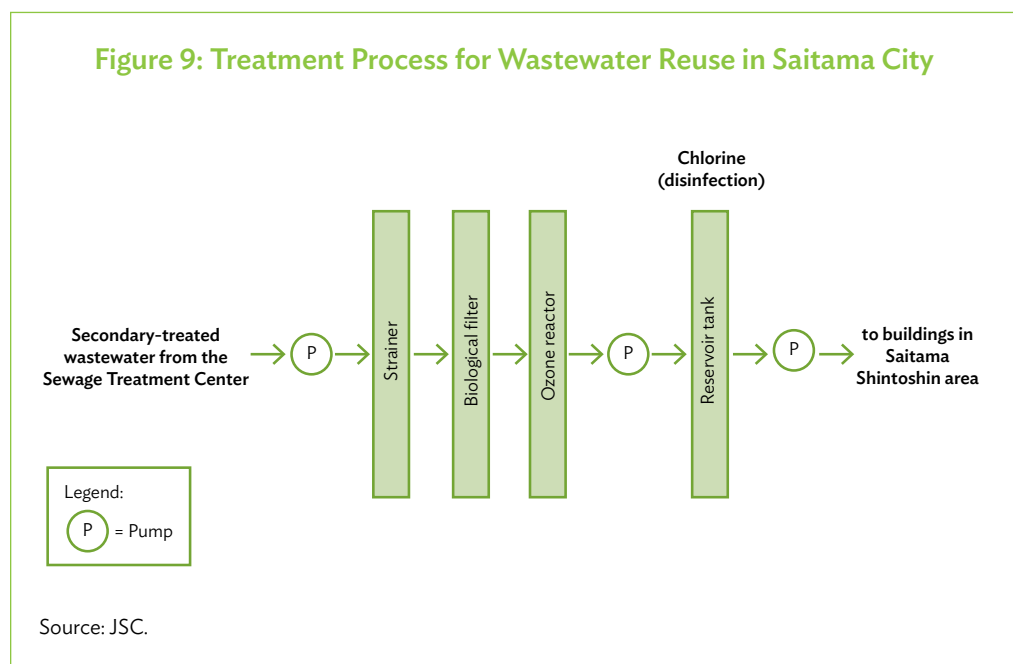
²¹ Footnote 6.

Saitama Prefecture, which developed the wastewater reuse project, created a plan for possible utilization of treated wastewater and concluded an agreement with building owners on the schedule for construction in the new urban area. The project was launched on 1 May 2000.

The wastewater reuse project of Saitama City is an example of Japan's experience in this domain, in which planning for wastewater reuse was developed alongside planning for the construction of a new city center.

Technology options

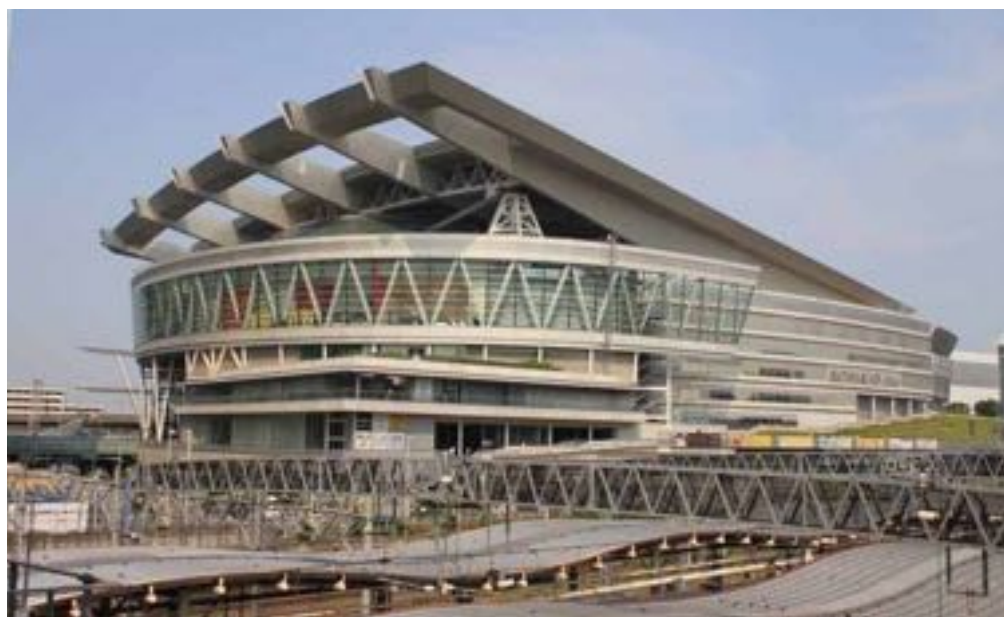
- Wastewater from households and commercial establishments in Saitama undergoes secondary treatment at the Saitama Sewage Treatment Center using conventional activated sludge.
- To enable wastewater reuse, the treated wastewater is further treated at the Saitama Shintoshin Purification Plant, using a combination of biofiltration process and ozonation, as shown in Figure 9. The current wastewater reuse capacity of the Saitama Shintoshin Purification Plant is 4,000 m³/day.
- In accordance with the standards for toilet flushing stipulated in the Manual for Water Quality Standards for Reused Wastewater from MLIT, the water quality must meet the following criteria:
 - (i) E. coli not to be detected;
 - (ii) Turbidity ≤ 2 units;
 - (iii) pH 5.8–8.6 (acidity or alkalinity levels);
 - (iv) Free residual chlorine 0.1 mg/l or combined residual chlorine ≤ 0.4 mg/l; and
 - (v) A sand filtration facility or a facility with equal or better function is required.



- The selected process took into account the prevention of odor, color, and slime adhesion, in addition to meeting the above standards from the MLIT manual.
- The pipes for the supply of reused wastewater are installed under the main roads of Saitama Shintoshin, enabling all buildings to be supplied with treated wastewater.
- Under the responsibility of the building owners, the recycled wastewater sent from the Saitama Shintoshin Purification Plant is drawn into each building and reused for nonpotable purposes. The water piping system in the buildings consists of two piping systems differentiated by colors, with one of the two systems used for drinking water and the other for wastewater reuse.
- As water source for nonpotable uses, building owners have alternatives, such as reused wastewater, stormwater, groundwater (with limitation), and water from a separate circulation system. Depending on the buildings' purpose and size, the most economically advantageous source of water can be chosen and used. However, as most of the buildings in the new city center area are for public use, the preferred source of water is the recycled wastewater.

Institutional and management arrangements

- The land and building owners and other involved parties of Saitama Shintoshin have established the Saitama Shintoshin Urban Development Promotion Council.
- The Saitama Shintoshin Wastewater Reuse Project was implemented by the Prefecture of Saitama as part of the basin-wide plan for sewerage systems, while the O&M was entrusted to the Saitama Sewage System Agency, which is a public sewerage corporation of the municipality of Saitama. The Local Public Enterprise Act mandates local governments to separate the account of revenue-generating activities, such as water supply and sewerage, from their general account. As a result, the accounting of the basin-wide sewerage plan for sewerage systems is separated from the prefecture's general account.



The Saitama Super Arena.

Source: JSC.

Financing arrangements

- For wastewater reuse projects in Japan, the government provides half of the project cost through national subsidy. In this project, the prefecture funded the other half.
- The construction cost for the first phase was ¥4billion (approximately \$36.11 million) in total.
- The cost included ¥2.3 billion (approximately \$20.77 million) for the construction of the wastewater reuse facilities and ¥700 million (approximately \$6.32 million) for the installation of water pipes.
- As a user charge for wastewater reuse (from secondary-treated wastewater), Saitama Prefecture pays ¥6/m³ (approximately \$0.054/m³) to Saitama City.
- For the O&M of the wastewater reuse facilities, Saitama Prefecture collects ¥273/m³ (approximately \$2.47/m³), tax included, from the building owners. This represents about 63% of the charge paid by the customers using a large amount of water to the Saitama City Waterworks Bureau, which is ¥414.75/m³ (approximately \$3.74/m³).

Example of reused wastewater application

- The Saitama Super Arena is a multipurpose indoor arena used for musicals, sports, industrial and cultural events. In FY 2010, the facility's annual consumption of water from various sources were as follows:²²
 - (i) Water supply: 12,289 m³ (24.6%)
 - (ii) Reused wastewater: 15,869 m³ (31.8%)
 - (iii) Rainwater: 21,790 m³ (43.6%)
- Other wastewater reuse projects were implemented elsewhere in Japan. In the case of Tadotsu Town, the Wastewater Reuse Project reduced the critical problem of water shortages and enabled the creation of a revitalized water environment in a region that traditionally suffered from insufficient water resources.

Project outcome

By providing recycled wastewater, the city is able to save 250,000 m³ of freshwater yearly, amounting to about ¥104 million (approximately \$939,000).²³ Usage of recycled wastewater (700 m³/day) is smaller than the capacity (4,000 m³/day) because of the slower than expected development of the new urban center. Nevertheless, the opening of a big shopping mall and two large hospitals are expected to increase water distribution. Recycled wastewater can then become a possible source of water for these new establishments.

Lessons learned and recommendations

- In general, to enable sustainability of wastewater reuse projects, the three following points are particularly important:

²² Data provided by the department managing the Saitama Super Arena to JSC during one of their meetings.

²³ Footnote 22.

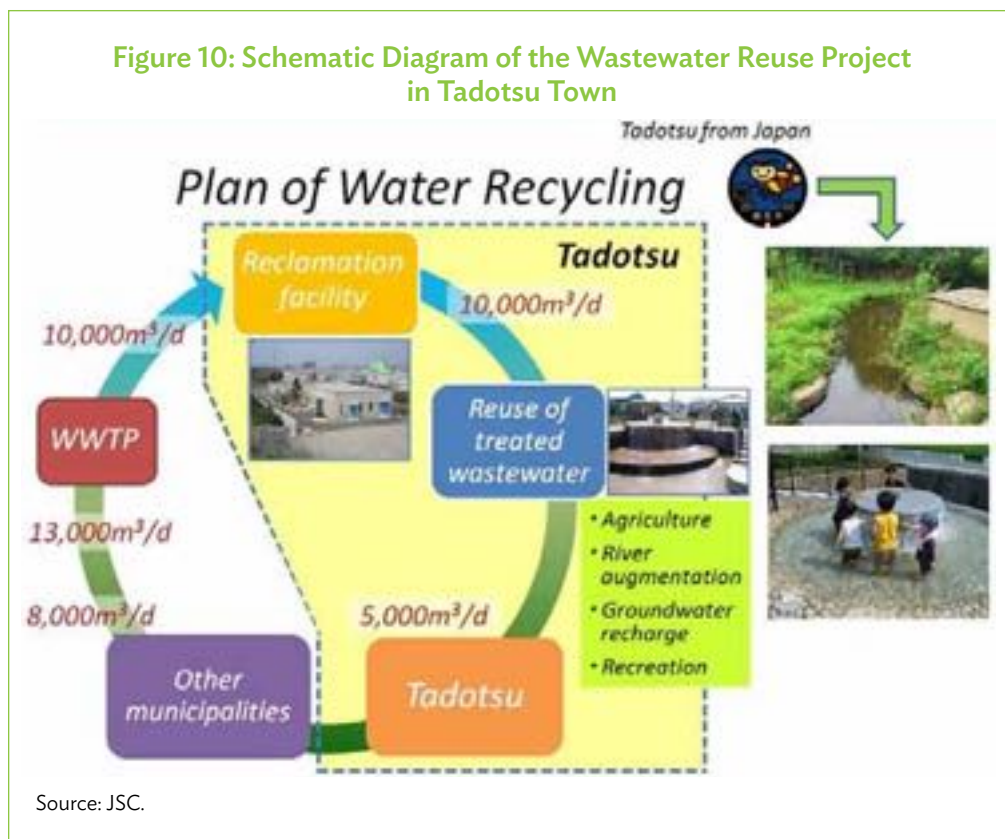
- (i) To continuously promote wastewater reuse projects, it is important to predict demand at the planning stage of a newly developed urban area.
 - (ii) It is essential to clearly identify the financing sources for construction and O&M.
 - (iii) It is necessary to plan a rational water recycling system with an adequate combination of stormwater and wastewater reuses depending on the building's configuration and structure.
- Implementing wastewater reuse in existing buildings or an existing city area is a difficult task. Introducing such system with the construction of new buildings or the development of a new urban area is easier and advisable.
 - It is preferable to promote wastewater reuse in residences and buildings in newly developed urban areas. Specific water quality standards for wastewater reuse, suitable to local conditions, should therefore be created that will provide balance between supply cost and use.

Ensuring Water Security and Ecological Conservation: Reuse of Treated Wastewater in Tadotsu

Tadotsu Town, Kagawa Prefecture, Japan

Tadotsu is a town in Shikoku Island in Japan, located on the Seto Inland coast. This town benefits from more sunny days than in most parts of Japan, and is also characterized by low rainfall. In addition, rainfall tends to concentrate during the rainy season or the typhoon period. Consequently, the population of Tadotsu regularly suffered from water shortages and droughts in the past, which place water resources under considerable stress. Securing stable water supply for drinking and irrigation, reducing the risk of droughts, and maintaining water levels in rivers and groundwater always proved difficult. For these reasons, wastewater reuse was promoted.

A project for the reuse of treated wastewater as a new water resource was launched in 2000 under the theme, "Ensuring Stable Water Resources and Environment Conservation." Figure 10 shows a schematic diagram of the wastewater reuse project. It was completed in 2004. Treated wastewater is now being reused for various purposes: river restoration; irrigation for agriculture, parks, and gardens; groundwater recharge; and augmentation of streams and brooklets running through the town, which was created as a result of the new water resource provided by the reuse of treated wastewater. The town can now enjoy a restored water environment. Tadotsu's case is an example of the best practices and multiple utilization of recycled wastewater in water-scarce areas.



Technology options

- As part of the Chyusan basin-wide sewerage system, about 13,000 m³/day of wastewater from Tadotsu (5,000 m³/day) and other towns (8,000 m³/day) are collected and treated at the Kanakuragawa WWTP, which uses the conventional activated sludge process. Around 77% of the treated wastewater is sent to a reclamation facility (the Water Environment Treatment Facility), wherein the effluent receives further treatment.
- In the Water Environment Treatment Facility, the effluent takes two different routes and treatment processes after high-rate sand filtration, depending on the intended purpose.
- For water used for the town brooklets, the treatment system consists of ozonation and activated carbon process.
- For agriculture, river flow augmentation, and groundwater recharge, the other treatment process consists of activated carbon process and chlorination.

Institutional and management arrangements

- To fight against water shortages and droughts, guarantee stable water resources, restore waterways, and reinstate ecological habitats with fireflies, a project team,—Wastewater Reuse Project Assessment Team Committee, was formed to work on the Tadotsu Master Plan for Wastewater Reuse.

- The O&M works of the Water Environment Treatment Facility is outsourced to a private company.
- An automatic voice information system was set up to help get feedback to the people in charge of maintenance whenever a problem or an issue occurs.
- The brooklets and amenities are maintained through volunteer activities initiated by the municipality and local residents. The local high school students are in charge of maintaining the brooklet located in front of the Town Hall. Cleaning activities are done on weekdays at a time allocated by the school (about 15 minutes).
- Numerous meetings and public relations events were held to explain about the safety and water quality of recycled wastewater. These were essential to achieve consensus with the local residents and obtain the agreement of 1,300 farmers for the utilization of treated wastewater for irrigation. Information and educational campaigns were done and are still regularly organized by the municipality to promote the project and ensure its sustainability and long-term utilization of the facilities.

Financing arrangements

- The estimated capital cost of the project is about ¥3.513 billion (approximately \$31.72 million).
- Three ministries—MLIT, MOE, and Ministry of Agriculture, Forestry and Fisheries—partly financed (about 45%) the wastewater reuse project.
- The three ministries and the prefecture of Kagawa subsidized more than 50% of the project (¥2.04 billion; approximately \$18.4 million). It was a unique experience to have three different ministries and a local government collaborating to finance one project.
- For the wastewater reuse project, Tadotsu Town issued a bond of ¥1.15 billion (approximately \$10.4 million). The remaining amount was financed through the general account budget of the town.
- The annual O&M costs (as of FY 2011) of the reclamation facility is estimated at around ¥32 million (approximately \$289,000) and are fully covered by the general account of the town.
- Local residents pay sewer charges for the wastewater collection and treatment, but do not pay any additional charge for production of treated wastewater for reuse.

Project outcomes

- The project reduced the critical problem of water shortages in Tadotsu Town, and enabled the creation of a revitalized water environment in a region that traditionally suffered from insufficient water resources.
- The project allowed the restoration of the water environment with the augmentation of river streams. The recharge of groundwater with treated wastewater enables groundwater to be used indirectly as a source for water supply, as well as prevents depletion and seawater intrusion. Reuse of treated wastewater provided a stable source of water for agriculture and an indirect source of water supply (through river restoration). It also restored the ecological habitat and improved the town's natural environment. It allowed the creation of new water amenities (brooklets) and the revitalization of parks.

- The project contributed to the improvement of the town's attractiveness and enhancement of tourism. This resulted in a positive economic impact on the associated industries.
- Guaranteeing the supply of water for agriculture and the conservation of the natural environment provided a useful field for school education.
- The strong leadership of the mayor of Tadotsu, together with the cooperation and financial support of the central and local governments through the three ministries and the prefecture of Kagawa, played an essential role in ensuring the implementation and the successful achievement of the project.



Revitalized stream in Tadotsu.

Source: JSC.



Water Fountain in Tadotsu.

Source: JSC.

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Sanitation and Sustainable Development in Japan

This publication documents Japan's experience in pursuing sustainable sanitation solutions in the context of economic development. Five case studies illustrate how sound sanitation policies are essential in achieving a nation's growth. Selected projects in Kitakyushu City, Kobe City, Saitama City, Saitama Shintoshin, and Tadotsu Town provide examples of how robust sanitation systems can deliver economic and environmental benefits. Produced by ADB in cooperation with Japan Sanitation Consortium, this publication also documents key policies and laws that enable the integration of sewerage systems and wastewater treatment facilities in development plans. It shares learnings on how the sanitation challenge can be met, not only at the community, but also at the national level.

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