# Water recycling systems in Tokyo

SUMMARY

Water resources for water supply of Tokyo depend mainly on surface water from many dams and rivers in the Kanto province and ground water in a part of Tokyo. But because of an increase in water demand and a reduction in water resource development, a water shortage has occurred every few years. The Tokyo Metropolitan Government (TMG) announced a new policy to conserve limited water resources and has implemented several measures to promote the consumers' consciousness for water conservation, use of reclaimed water and development of water-saving appliances. With water for miscellaneous use (=nonpotable use), the TMG has encouraged "reuse of treated wastewater", "use of industrial water for miscellaneous use", and "use of rainwater". According to three types of reclaimed water systems — individual building, limited area, and broad area recycling systems — the TMG established a guideline for the water for miscellaneous use. This paper describes the background of the issue, contents of the guideline, and results of the promotion and theme in the future.

## INTRODUCTION

Tokyo is located in the south of the Kanto plain in the middle of the Japanese archipelago. It has an area of about 2,182 km, which is 0.6% of Japan's total area. Tokyo is one of the largest cities in the world, with a

resident population of 12 million and a daytime population of approximately 14 million.

Tokyo has continued to extend and develop as the capital city of Japan and the center of the country's political, economic, social, cultural and international activities. However, as a result of the rapid urbanization and concentration of population, Tokyo is faced with many difficult problems such as strain on and delay of the urban infrastructure, deterioration of the living environment, etc. In addition, the excessive concentration of business in the center of Tokyo promoted a change in the pattern of land use and a change in the working pattern from residential to commercial; and an increase in multistory buildings has caused a high concentration of population.

## WATERWORKS IN TOKYO

The TMG supplied potable water to the approximately 11 million citizens living in an area of approximately 1,174 km comprised of 23 special wards and 22 cities and three towns in the Tama area. The TMG takes most of its raw water from the three rivers flowing through or nearby the Tokyo metropolitan area — the Tone, the Tama, and the Sagami — which supply about 79%, 17% and 3% of the gross raw water, respectively. In addition to this, the TMG takes some raw water from the ground water in the Tama district. At present, the TMG secures water sources

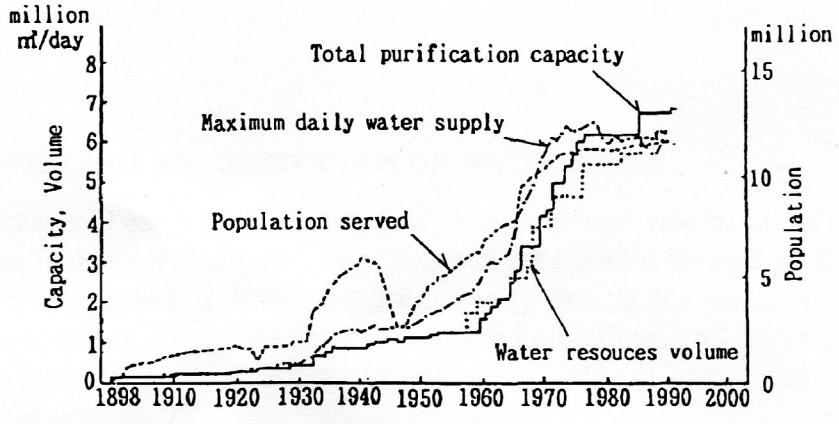


Fig. 1. Trend of water supply and demand.

equivalent to 6.02 million $m^3/d$ in total, and this figure is approximately commensurate with the demand. However, some of these water sources are not fully reliable as water source facilities have not been completed fully and the intake rate of water is occasionally restricted according to the situation of river flows and storage in dam reservoirs (Fig. 1).

Moreover, water demand likely increases gradually as a result of urbanization in the Tama area, the western suburbs of Tokyo, and will reach 6.7 million $m^3/d$ by the year 2000.

The TMG operates 11 purification plants which are capable of treating 6.96 million $m^3/d$. This represents one of the largest water purification systems in the world. Table I shows the outlines of waterworks in Tokyo.

TABLE I

The outlines of waterworks in Tokyo (1991)

| | |
|---|---|
| Volume of water resources, $m^3/d$ | 6,200,000 |
| Number of purification plants | 11 |
| Purification capacity, $m^3/d$ | 6,959,500 (1993) |
| Population served | 10,995,380 |
| Households served | 5,095,999 |
| Maximum daily supply, $m^3$ | 5,955,200 (1990) |
| Mean daily supply, $m^3$ | 4,872,400 |
| Volume of clear water reservoirs, $m^3$ | 2,595,000 |
| Total length of pipeline, km | 21,100 |

## WATER SHORTAGE AND RESTRICTION ON WATER SUPPLY

At present Tokyo's water demand is nearly equivalent to its water resources. However, the water source is not yet reliable enough so that the TMG's water intake is restricted occasionally during the water shortage period in summer. Water intake was restricted nine times and water supply was restricted eight times in the past 20 years. Table II shows the history of water shortages.

TABLE II

Water shortages in Tokyo

| Year | Water intake[a] | | Water supply[b] | | Max. effect[c] |
|---|---|---|---|---|---|
| | TD[d] | MRV[e] | TD | MRV | |
| 1972 | 40 | 1.55 | 22 | 0.75 | 83,000 |
| 1973 | 36 | 1.80 | 18 | 0.54 | |
| 1978 | 68 | 1.80 | 57 | 0.55 | 530,000 |
| 1979 | 58 | 1.50 | 42 | 0.40 | 190,000 |
| 1980 | 44 | 1.50 | 44 | 0.25 | |
| 1982 | 26 | 1.50 | 17 | 0.25 | |
| 1985 | 12 | 1.30 | — | — | |
| 1987 | 122 | 2.40 | 71 | 0.86 | 430,000 |
| 1990 | 104 | 1.95 | 65 | 0.58 | 145,000 |

[a]Restriction on water intake.
[b]Restriction on water supply.
[c]Maximum effect (=reduction, suspension) (households).
[d]Total days.
[e]Maximum restricted volume (million $m^3/d$).

## THE GUIDELINE FOR THE USE OF MISCELLANEOUS WATER

Water demand in Tokyo has increased year by year during the 1960s and 1970s. An increase of 1.2 million $m^3/d$ every 5 years during those decades took place along with rapid economic growth in Japan. Hereafter water demand in Tokyo is also expected to increase slightly but steadily. At the same time it is becoming more and more difficult to develop new water resources, which are now recognized as limited. It has been necessary for Tokyo to become a water conservation-conscious city. In 1973 the TMG announced a new policy on conserving the limited water resources and has promoted measures through campaigns of voluntary saving and through development and commercialization of water saving equipment. The TMG also continues to promote the recycling of water.

In 1973 the TMG began to promote use of reclaimed water in large buildings in order to use water effectively and to reduce the load to the sewage system; and in 1984 the TMG established guidelines for the

recycling of wastewater and moreover has promoted the above-mentioned measures.

In Tokyo there are three types of reclaimed water systems, listed according to their capacity, as follows:

1. Individual building system — type that an individual building has its own reclaiming equipment to treat its own wastewater and rain water on its given premises. The treated water is utilized for miscellaneous use within the building.
2. Limited area system — type that several buildings in a relatively limited district, for example, large apartment complexes and urban redeveloped area, have a common reclaiming equipment to treat wastewater.
3. Broad area system — type that many buildings in broad area use largely and widely reclaimed water which is usually supplied from sewage treatment plants or industrial water works.

An aim of the guideline is formation of a water saving city to promote use of reclaimed water in large buildings which is safe and has appropriate maintenance and management of the equipment for reclaimed water. The content of the guideline is as follows:

1. Area: 23 special wards and the Tama district, except Okutamamachi town and Hinoharamura village.
2. Buildings: (a) A building that has a total floor space of more than 30,000 $m^2$ and has planned miscellaneous water supply of more than 100 $m^3/d$ (individual building, or limited area system; (b) a building that has a total floor space of more than 5,000 $m^2$ or apartment complex that has more than 230 households in service area of industrial water works; (c) a building that is equal to (a) in area where the advanced treated water from sewage works can be supplied (broad area system).
3. Use of miscellaneous water is limited for flushing toilet as a rule.
4. Quality of miscellaneous water is required to suit the following:

| | |
|---|---|
| Coliform group | Must not exceed 10 in 1 ml |
| pH | 5.8–8.6 |
| Odor and appearance | Not to be uncomfortable |
| Residual chlorine shall be in existence. | |

The scale of the building is decided on the basis of consumers' cost of reclaimed water is proportionate to the sum of potable water and sewerage charge. Therefore, it has been accepted to owners of buildings almost without problems, although the guideline is not enforceable.

As a result of the promotion based on the guideline of the TMG, the number of consumers of water recycling has been increasing steadily and reached 196 buildings and 26,672 $m^3/d$ in individual and limited area systems together, 19 and 6082 $m^3/d$ in a broad area system in Shinjuku subcenter district, and 328 and 20,818 $m^3/d$ in industrial waterworks supply, respectively (Tables III and IV). Examples of individual building systems are "Ikebukuro Sunshine City" and "Tokyo Dome", etc.

TABLE III

Summary of the promotion (1993.3)

| | | No. of buildings | Total use Volume A | Reclaimed Volume B | B/A (%) |
|---|---|---|---|---|---|
| Individual | Practice | 121 | 85,731 | 19,039 | 22.2 |
| | Planned | 29 | 17,972 | 4,543 | 25.3 |
| Limited | Practice | 75 (21) | 40,602 | 7,633 | 18.8 |
| | Planned | 29 (13) | 19,903 | 4,199 | 21.1 |
| Broad | Practice | 19 | 18,887 | 6,082 | 32.2 |
| | Planned | 3 | 2,546 | 619 | 24.3 |
| Total | Practice | 215 | 145,220 | 32,754 | 22.6 |
| | Planned | 61 | 40,421 | 9,361 | 23.2 |

Volume is designed value ($m^3/d$). ( ) is number of area.

Major treatment methods adopted in individual building and limited area systems are biochemical treatment methods including activated sludge, contact oxidation, and soon, and physically treated methods including ultrafiltration methods (Fig. 2). The former has reached 72 facilities and the latter has reached 70 facilities. In recent days the adoption of ultrafiltration has increased.

Most of the facilities have treated effluent from hand washing, restaurant drainage, and cooling drainage. In 44 buildings rain water has compensated for miscellaneous water. The treated water is used generally for flushing toilets. However, some part of it is also used for sprinkling and airconditioning.

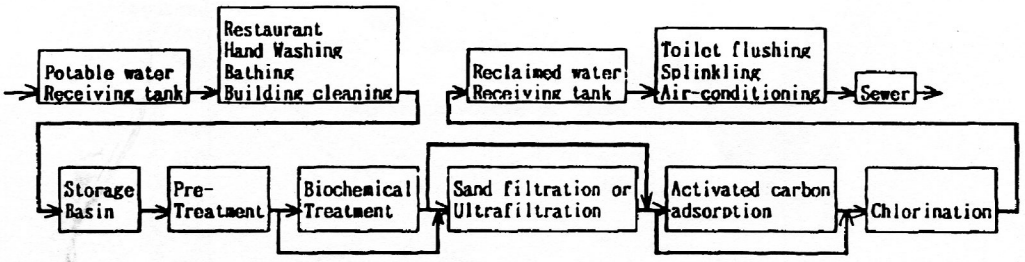


Fig. 2. Schematic diagram of recycle system.

## SUPPLY OF INDUSTRIAL WATER FOR NON-MANUFACTURING CUSTOMERS

The Industrial Waterworks of the TMG is responsible for the supply of water for industrial use to the Koto and Johoku area in eastern Tokyo. This task has been done to prevent the pumping up of ground water, which caused serious land subsidence in that area in practice.

The TMG began to supply treated sewage water as industrial water in the Koto area in 1964. As a result, land subsidence has been effectively stopped and its mission has been accomplished (Fig. 3). The demand for industrial water, however, has gradually decreased due to the relocation of factories outside the TMG's supply area and due to water recycling efforts.

The TMG began to supply industrial water to non-manufacturing customers, i.e., incineration plants, truck terminals and schools in order to conserve potable water from 1973 and have supplied apartment complexes

TABLE IV

Supplied industrial water to non-manufacturing customers

| | Koto area | | Johoku area | | Sum | |
|---|---|---|---|---|---|---|
| | No. | Vol. | No. | Vol. | No. | Vol. |
| Business | 166 | 9,312 | 125 | 7,648 | 291 | 16,960 |
| Apartment complexes | 25 (18,817) | 2,070 | 12 (16,251) | 1,788 | 37 (35,068) | 3,858 |
| Sum | 191 | 11,382 | 137 | 9,436 | 328 | 20,818 |

cf. Vol. is presented as contracted supply ($m^3$/d). ( ) is no. of households.

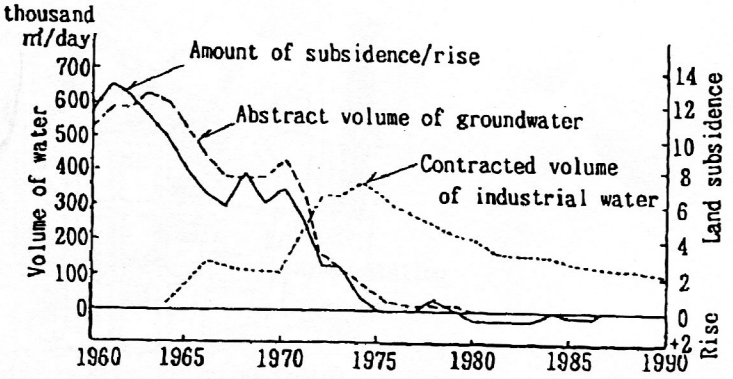


Fig. 3. The effect of industrial waterworks in the prevention of land subsidence.

for flushing toilets from 1976. The system of the Koto area uses treated sewage water sa its water resource and contributes greatly towards the creation of a water conservation conscious city. Table IV shows the supply of industrial water to non-manufacturing customers.

## OUTLINE OF BROAD AREA SYSTEM USING TREATED SEWAGE WATER

In 1984 the Sinjuku Water Recycle Center started to perform a broad area recycling of treated municipal wastewater in the Shinjuku Subcenter District for high-rise buildings which were constructed as the redevelopment project of the District. Rapid sand filtrate from the Ochiai Treatment Plant is carried to the Water Recycle Center and is then chlorinated and distributed to 19 high-rise buildings to be used only for flush toilets (Figs. 4 and 5).

The distribution area will be spread out over 80 hectares in the part of the Shinjuku Subcenter District and the maximum quantity of miscellaneous water supply of the plant will reach 8000 $m^3/d$.

Further, in the coastal subcenter, to be developed on a landfill site in Tokyo Bay, the Ariake sewage works will distribute the advanced treated water to the neighbouring building complexes. In addition the broad area recycling system of the advanced treated wastewater is planned in a large scale redevelopment project area.

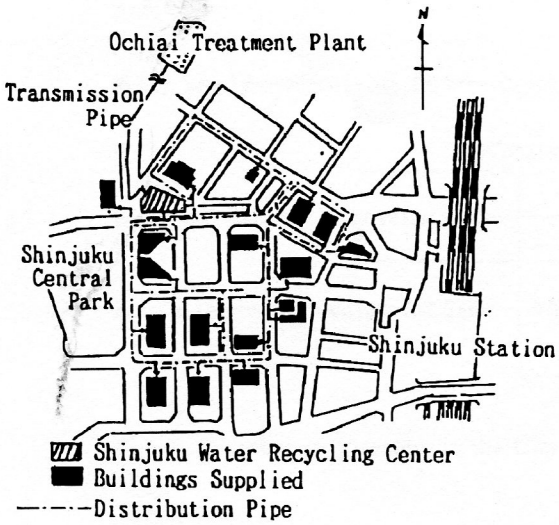


Fig. 4. Shinjuku Water Recycling Center.

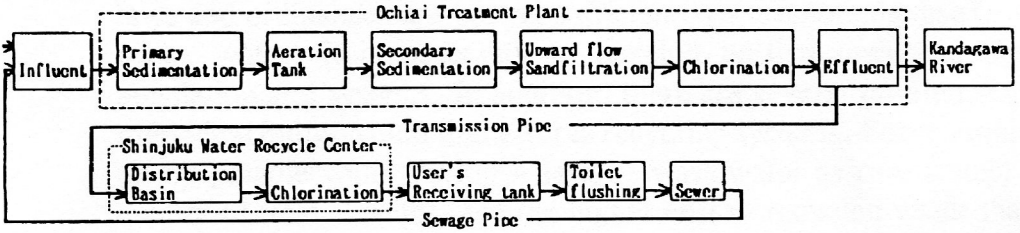


Fig. 5. Schematic diagram of the broad area system in the Shinjuku Subcenter.

## WATER RECYCLING SYSTEM IN THE NEW CITY HALL

The new City Hall, TMG's office, completed in April 1991, is included in the area served by the Shinjuku Water Recycle Center. The new City Hall uses reclaimed water from the Center for flushing toilets, which requires water over 300 $m^3/d$; the rate of reclaimed water to total supplied water is 37%. Besides, rainwater that falls on the new City Hall site is collected and filtrated with a micro-strainer and then used or sprinkling, ponds and flushing toilets. The rainwater used miscellaneously is about 60 $m^3/d$. The volume of the storage tank for rain water is 1320 $m^3$ and 700 $m^3$ of the stored water is always reserved for fire prevention, in addition to an amount which is treated by ultrafiltration to supply drinking water in an emergency (Fig. 6).

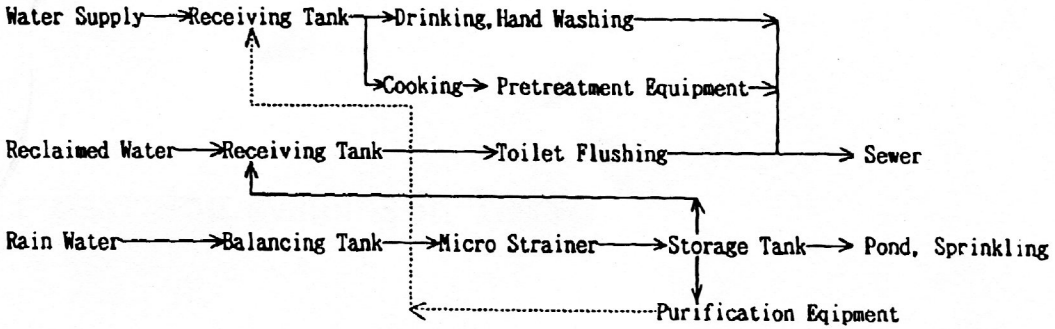


Fig. 6. Water supply system in the City Hall.

## THEME IN THE FUTURE

Because the use of reclaimed water is a new type of water use, related laws and ordinances are not yet sufficient. To promote the use of miscellaneous water, it is necessary to develop unified measures concerning legislation and systems. In addition, there are several problems also about individual building and limited area recycling systems. For example, make-up by potable water during a lack of wastewater as raw water, unstable quality of treated water, and the higher cost of recycled water than that of potable water. In order to solve these problems, it is necessary to promote the cooperation of investigations with the national government for reduction of users cost, development of new water treatment technology, and stabilization of quality of treated water.

To use water effectively, it will further be required to promote the recycling of reclaimed water and the use of industrial water and rain water.