RAINWATER AND RECLAIMED WASTEWATER FOR SUSTAINABLE URBAN WATER USE

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As the urbanization progresses, water abstraction from surface water and groundwater inevitably increases to support human activities. Urban water consumption has a major factor to impact on natural water cycle and brings quite a lot of changes in the aquatic environment. Concern about the sustainability of urban water use is the strong motivation to understand the potential of rainwater use and water recycling in urbanized cities. The achievement of the sustainability is required ensuring a long-term supply of water with adequate quality for all designated purposes minimizing adverse economic, social and ecological impacts.

The predicted rapid growth in urban population in Southeast Asian region shows a similar trend in Japan's early urbanization stage from 1950s to 1970s. We had a history that natural water cycle has partially been damaged, and various problems have been occurring, such as instability of river flow, drying up of spring water and deterioration of the ecosystem due to the rapid progress of urbanization with economic development. The history of water supply in Japan and its experience may provide useful information to develop sustainable urban water use and find future possible tasks in rapidly growing cities. Besides, various innovative strategies to meet the current and future water demand in Tokyo may help us to consider new approaches adjusting to the developing mega cities in Asia.

Fig. 1 shows the water balance in Tokyo. The average annual rainfall is 1405mm in Tokyo. The precipitation is distributed to runoff (634mm: 45%), infiltration (359mm: 26%), and evapotranspiration (412mm: 29%). The runoff fraction is remarkably higher in Tokyo than the nationwide average, which is almost one third of the precipitation. In spite of the poor infiltration and limited water availability within Tokyo, the human consumption is more than the 1100mm equivalent rainfall including recycle water use (199mm) and reclaimed wastewater use (5mm).

DWTP:Drinking water treatment plant, WWTP: Wastewater treatment plant, AT: Advanced treatment, DATA from Tokyo Metropolitan Government (1999)

The escalating water demand in Tokyo led to the extensive water withdrawal from a river flowing nearby and the dam construction at the upstream. Furthermore, new water resources were developed in distant rivers flowing outside of Tokyo. Therefore, we have made efforts to economize and make effective use of water, which leads to reduce water intake from natural water system and to secure the sound water cycle in and out of Tokyo. This indicates that the water demand in mega cities is to be fulfilled with several alternatives of latent water resources under several constraints.

Tokyo has taken several measures to find alternative water resources towards sustainable water use as well as the above-mentioned ones. As a result, rainwater and reclaimed wastewater have been applied for miscellaneous purposes. Rainwater harvesting

for miscellaneous use such as toilet flushing and water cooling is employed in an individual scale as well as in a large scale. The storage of rainwater is also a useful measure for water demand in emergency cases. In addition, the rainwater use can work as a kind of environmental education to make citizens aware of sustainable urban water use. There are 850 facilities for rainwater use in Tokyo.

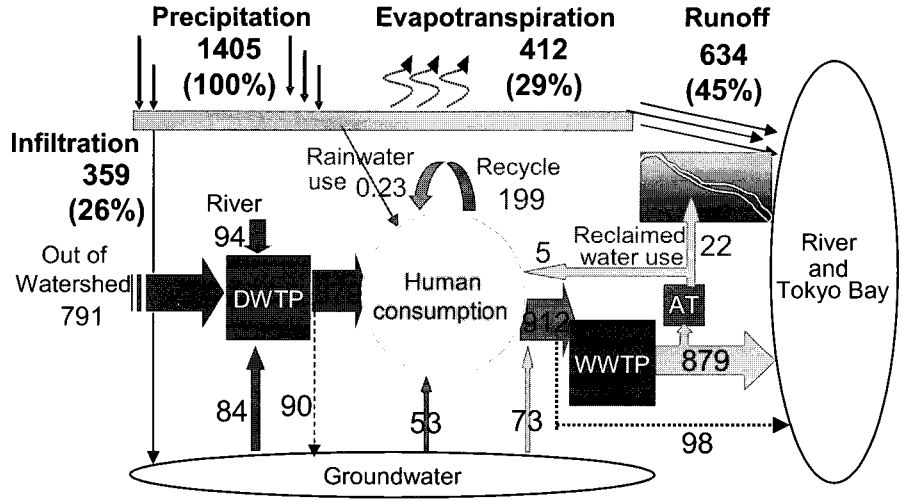

Fig. 1 Water balance and recycle in Tokyo (unit: mm/year)

The reclaimed wastewater use has been carried out in both open-loop and closed-loop. Table 1 summarizes the recent state of water recycling for miscellaneous purposes such as washing, water-cooling, and toilet flushing in Tokyo. There are 560 facilities, which are categorized into individual building, block-size, and large-scale recycling systems. In addition, a huge water volume of reclaimed wastewater has also been utilized for waterway restoration and creation of recreational waterfront. The Ministry of Land, Infrastructure and Transportation has established and revised water quality criteria and guidelines on the reuse of reclaimed wastewater for miscellaneous purposes since 1981. To protect the public health, the reclaimed water quality standard within buildings has become more stringent in 2002. From the viewpoint of human health risk, pathogens and new micropollutants such as estrogens, endocrine disrupters and surfactants should be considered as quality guideline parameter besides the conventional ones.

Table 1. Facilities of water recycling for miscellaneous purposes in Tokyo (March, 2002)

Recycle Type	Number of facilities	Recycled water use [m^3/day]	Recycle percentage* [%]
Individual building	293	43,809	22
Block-wide	170 (50 blocks)	20,167	22
Large-scale	97 (4 regions)	17,062	27
Total	560	81,038	23

* Recycle percentage = (Recycled water use/Total water use) x 100

Importance of infiltration-type sewerage system should be also highlighted to recharge the groundwater and to secure the sound water cycle. Although Tokyo has restricted and controlled groundwater use these days, it is a potential storage of water resource and can be withdrawn in the future if necessary. The infiltration facilities provide a secondary benefit such as reduction of CSO frequency and non-point pollutant loads from urban surfaces. These past and current practices on rainwater harvesting and reclaimed wastewater use as well as rainwater infiltration will be worthy of consideration in the urban water use of future mega cities in Asia.