The Current Status of Wastewater Reclamation/Reuse in Taiwan

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ABSTRACT

Development of traditional water source in Taiwan has become more difficult than ever due to the strong public concerns. Seeking alternatives like reclaiming wastewater and promoting water reuse seems feasible and costs less than seawater desalination. It is generally termed as “reclaimed water”. In 2015, Water Resource Agency, Ministry of Economic Affairs, Taiwan has set a target to elevate the usage of reclaimed water in Taiwan to 1.32 million cubic meters per day (CMD), roughly 10\% of the supply from all water treatment plants in Taiwan, or 3\% of the total water consumption in Taiwan. In Ministry of Economic Affairs, “Task Force of Wastewater Reclamation Promotion” is founded to have a “top-down” promotion of using reclaimed water. A technical support project is established as well to have systematic investigation using the questionnaires and on-site visits, to figure out the trend of using reclaimed water and the amount growth. The project also intends to provide technology service to improve the water efficiency of the heavy users, including the industries, domestic users and wastewater treatment plants.

KEY WORDS:  water deficiency; reclaimed water; Water Resource Agency; wastewater treatment plant

INTRODUCTION

Climate change in the recent decades may lead to water crisis in Taiwan because of prosperous development of industrial sections. Meanwhile, development of traditional water source in Taiwan has become more difficult than ever due to the strong public concerns. Reallocating the surplus water resource for agricultural irrigation of paddy fields to industries or domestic users raises another controversial issue, including the possible damage to the ecology and underground aquifer, and depriving the farmers of rights. The situation in Tainan (Southern Taiwan) is a typical case (Fig. 1). Traditional water resource facilities like Transbasin Diversion Tunnel of Tsengwen Reservoir have been interrupted due to the strong opposition from the publics. However, in year 2031, if the construction of planned water resource facilities is not on schedule, the water deficiency in this region will grow up to 377,000 m\textsuperscript{3} per day. This will largely damage the local economical activities.

THE DEFINITION OF RECLAIMED WATER

Seeking alternatives like reclaiming wastewater and promoting water reuse seems feasible. According to the successful experience in United States and Singapore, it costs less than seawater desalination, and the destruction of ecology is less significant, too. In this study, the water resource produced from wastewater reclamation and water reuse is termed as “reclaimed water”. It becomes a potential alternative of water resource development in Taiwan.

In 2015, Water Resource Agency (WRA), Ministry of Economic Affairs (MOEA), Taiwan has set a target to elevate the usage of reclaimed water in Taiwan to 1.32 million cubic meters per day (CMD), roughly 10\% of the supply from all water treatment plants in Taiwan, or 3\% of the total water consumption in Taiwan (Fig. 2). Reclaimed water here includes four portions:

1. Reclaimed effluent of municipal wastewater treatment plants (WWTP) – reaching 770,000 CMD in year 2031;
2. Reclaimed effluent of WWTP’s of industrial parks – reaching 50,000 CMD in year 2031;
3. Reclaimed wastewater of domestic users (like universities, museums and so on) – reaching 50,000 CMD in year 2031;
4. Reclaimed wastewater of industrial users (like factories, harbours and so on) – reaching 450,000 CMD in year 2031.
CURRENT STATUS OF THE USAGE OF RECLAIMED WATER

To have more systematic statistics on the growth of reclaimed water, a survey has been conducted to collect the required information since March 2014. The information will be the reference for drafting the policies of water resource development. Using the questionnaire to investigate the water usage of large industries and domestic users, until October 2014, the total reclaimed water in Taiwan is 424,019 CMD, including 384,803 CMD from industrial users, 7,180 CMD from domestic users, 24,965 CMD from municipal WWTP’s, and 7,071 CMD from industrial park WWTP’s (Fig. 4). It is still far away from the aforementioned target of 1.32 million CMD (WRA, 2014).

We also conducted a survey in regard of WWTP’s and their effluents, a source of reclaimed water. In 2014, the statistics shows that the total design capacity of 71 municipal WWTP’s in service is 3.71 million CMD, while the treating effluent is 2.87 million CMD (77% of the design capacity). The plants with effluent reuse more than 1,000 CMD include Dihua (Taipei), Bali (Taipei), Taihu (Jinmen), Fengshanxi (Kaohsiung), Douliu (Yunlin) and Dashi (Kaohsiung). The sum of water reuse is 24,965 CMD (Fig. 5). For the 55 industrial park WWTP’s in service, the total design capacity is 1.22 million CMD, while the treating effluent is 672,000 CMD (Fig. 5b). The effluent reuse for the 55 plants is 7,071 CMD. Most WWTP’s of industrial parks reclaimed their effluents using sand filter and disinfection for the miscellaneous usage in the plants. For example, Zhongli industrial park WWTP recycled its effluent for 1,500 CMD for washing and foam suppressing. One of the significant cases is the effluent reclamation plant in Nanzhi export industrial park. Taking the mixed industrial wastewater as the source, this plant produces 1,800 CMD using fibre filter, ultrafiltration (UF) and reverse osmosis (RO) for supplying the industries in the park. The reclaimed water is then supplied to the semiconductor factories for the manufacturing (Fig. 6 and Fig. 7).

Noticeably most reclaimed water is produced from the industrial users. They recycle their wastewaters or specific water streams from manufacture process. A variety of units are used in this reclamation, including chemical coagulation, activated carbon adsorption, ion exchange, and membrane filtration. The reclaimed water is generally redirected to the public water utility (PWU) for usage in the factories. For the domestic users, the reclaimed water is generally used for landscaping or toilet flushing. The units of reclamation are simpler than those in industries. The typical units are sand filter and chlorine disinfection.
Fig. 5 The wastewater treatment plants in service

(a) Domestic WWTP's

(b) WWTP's of industrial parks

Discharge to the river
15,000 ~ 16,000 CMD

Discharge to the sea
8,000 CMD

Hou-jing river

Factories in the Nanzi Park

Other petrochemical factories

Pumping station

Ocean outfall pipe

Reclaimed water quality
1. pH: 5.5 ~ 8.0
2. Conductivity <200 µS/cm
3. Hardness <10 mg/L as CaCO3
4. COD <10 mg/L
5. TOC <5 mg/L
6. SS <3 mg/L
7. Turbidity <0.2 NTU

Fig. 6 Effluent reclamation plant of Nanzi export industrial park: the process
An analysis on the current quality of effluent of municipal WWTP’s showed that the major pollutants that may interfere the reuse the microorganisms and nitrogen. It may cause serious biofilm growth and clog the reclamation units. It also causes unexpected risk for the users. Disinfection units like ultraviolet (UV) and denitrification biological units like membrane bioreactor (MBR) can be applied to remove the pollutants (Chu, Wu, Lin, and Chung, 2007). For WWTP’s of industrial parks, the main barrier is the conductivity, heavy metals, colloids and dissolved organics. The conductivity generally ranges from 2,000 μS/cm to 9,000 μS/cm, nearly 10 to 45 times higher than the tap water. Ultrafiltration (UF) followed by reverse osmosis (RO) are generally adopted to remove these pollutants (Chen, Yeh, and Shiau, 2005; Chu, Jiao, Hung, Lu, and Chung, 2009).

IMPORTANT SCHEMES OF EFFLUENT RECLAMATION UNDER PLANNING

In the near future, several large WWTP effluent reclamation projects have gradually been commenced, mainly to compensate the water scarcity in western Taiwan, especially the enormous requirement from large factories. The forthcoming effluent reclamation projects include (1) Zhongli municipal WWTP for supplying the Guanyin and Taoyuan technology industrial park (Taoyuan); (2) Fengyuan municipal WWTP for supplying the Central Science and Technology Industrial Park (Taichung); (3) Futian municipal WWTP for supplying the Taichung Harbour Industrial Park (Taichung); (4) Yongkang and Anping municipal WWTP for supplying the Southern Science and Technology Industrial Park (Tainan); (5) Fengshanxi municipal WWTP for supplying the Southern Science and Technology Industrial Park (Tainan); and (6) Southern Science and Technology Industrial Park to supply the factories in the park (Zhanghua). (7) Southern Science and Technology Industrial Park to supply the factories in the park (Tainan) (Fig. 8). In the aspect of industrial WWTP’s, it includes the cases like Hsinchu Science and Technology Industrial Park and Erlin park of Central Science and Technology Industrial Park. These projects will provide reclaimed water with the same quality to the tap water to the industrial users, and largely decreases the loading of regional tap water supply. As generally suggested in literatures (Durham, Rinck-Pfeiffer, and Guendertc, 2003), the reclaimed water of the aforementioned projects will be produced from UF-RO or membrane bioreactor (MBR)-RO process. The cost of reclaimed water typically ranges from 0.4 to 0.6 US dollar per cubic meter, which is higher than the city water tariff (0.3 US dollar per cubic meter). Although the cost is higher, the industrial users are now looking for “water insurance” to lower the risk in drought seasons by using more reclaimed water for manufacturing. An emerging market of wastewater reuse is gradually formed in Taiwan.

THE RELEVANT POLICIES TO PROMOTE THE USAGE OF RECLAIMED WATER

For integration’s sake, “the Task Force of Wastewater Reclamation Promotion” was established in Ministry of Economic Affairs to have a “top-down” promotion of using reclaimed water. Meanwhile a service corps was set up to have systematic investigation of the growth of reclaimed water usage, as well as to provide technical supports to improve the water efficiency and energy efficiency of heavy users, including the industries, domestic users and wastewater treatment plants. There are several major barriers for promoting reclaimed water: (1) In Taiwan, due to the low tap water tariff (NT$ 11/m³, or 30 US cents/m³), the reclaimed water is basically more expensive than the tap water. It decreases the intention of the industrial users to apply reclaimed water immediately. (2) According to the strict law of hygiene and public health, an independent pipeline is always necessary because the reclaimed water cannot be mixed and pumped with the tap water, even the reclaimed water is purified using RO modules. The construction of this extra pipeline further increases the cost. (3) Currently MOEA is the water resource authority. On the other hand, the local city and county governments own the municipal WWTP. There may always be controversial issues to argue which the optimal way is to use the effluent from WWTP.
In December 2015, The Legislative Yuan has passed the “Reclaimed Water Resources Development Act” in Taiwan, providing a clear legal framework for the recycling and reuse of wastewater/sewage and effluent. Taiwan will enter a new era of diversified water resources. The primary idea is that in the regions with serious water deficiency, the local government should provide the effluent with no charge. When confirming the users that should use reclaimed water (usually the newly founded factories), MOEA may establish the effluent reclamation plant as well as the pipelines. The facilities are then transferred to local governments or private sections for further operation. The users pay the tariff to cover the capital investment and operation cost.

According to the inventory and investigation in this study, it is very common that the industrial users recycle their own wastewater, especially the semiconductor-related factories. Facilities like reverse osmosis and ultrafiltration are generally adopted to filtrate the impurities. In general the cost to recycle one ton of reclaimed water in the factories is higher than NTS 30/m³ (one US dollar per ton) (Chu, Jiao, Lin, Yang, and Chung, 2007). Although the concept and cost are widely accepted by the industries, their willingness to apply the reclaimed water from the municipal WWTP’s outside the factory is low. Apparently the cost is not the only factor. The major barrier is the lack of confidence of users, including the water quality and stability effluent from the municipal WWTP’s. It takes more efforts to establish the tools and monitoring system that can be accepted by the industries, to ensure the quality of reclaimed water. Health risk assessment, on the other hand, is also a proper tool to persuade users that the safety of reclaimed water is acceptable.

CONCLUSIONS

Reclaimed water is an important alternative for replenishing the water scarcity. Until the end of 2014, the total reclaimed water in Taiwan is 424,019 CMD. It is still far away from the preset policy target (1.32 million CMD). To effectively promote the water reuse and reclamation, in Ministry of Economic Affairs, “Task Force of Wastewater Reclamation Promotion” is founded to have a “top-down” promotion of using reclaimed water. A technical support project is established as well to have systematic investigation using the questionnaires and on-site visits, to figure out the trend of using reclaimed water and the amount growth. To further elevate the usage of reclaimed water, several important schemes of effluent reclamation from wastewater treatment are highlighted and promoted by Water Resource Agency. If successfully, these projects may supply reclaimed water with the same quality to the tap water to the industrial users, and largely decreases the loading of regional tap water supply. It also largely increases the usage of reclaimed water to more than 300,000 CMD. Although the high cost of reclaimed water in relative to natural source makes the promotion difficult. From the other angle, industrial users may look for “water insurance” to prevent the risk in drought seasons. A new market of effluent reclamation is now emerged in Taiwan.

REFERENCES