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Wastewater reclamation and reuse in China: Opportunities and challenges

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ABSTRACT

The growing water stress both in terms of water scarcity and quality deterioration promotes the development of reclaimed water as a new water resource use. This paper reviewed wastewater reuse practices in China, and the opportunities and challenges of expanding reclaimed water use were analyzed. Rapid urbanization with the increasing of water demand and wastewater discharge provides an opportunity for wastewater reuse. The vast amount of wastewater discharge and low reclaimed water production mean that wastewater reuse still has a great potential in China. Many environmental and economic benefits and successful reclamation technologies also provide opportunities for wastewater reuse. In addition, the overall strategy in China is also encouraging for wastewater reuse. In the beginning stage of wastewater reclamation and reuse, there are many significant challenges to expand wastewater reuse in China including slow pace in adopting urban wastewater reuse programs, the establishment of integrated water resources management framework and guidelines for wastewater reuse programs, incoherent water quality requirements, the limited commercial development of reclaimed water and the strengthening of public awareness and cooperation among stakeholders.

Introduction

Many countries around the world are facing the increasing pressure of fresh water supply and that fresh water resources are becoming insufficient to satisfy water demand. As urban water scarcity is growing and water purification technology is advancing, wastewaters are being reclaimed in increasing volumes and being reused for more purposes around the world (Levine and Asano, 2004). The highest-ranked countries of the total wastewater reuse are the United States and Saudi Arabia, and Qatar, Israel, and Kuwait are the most remarkable countries based on the per capita wastewater reuse (Jimenez and Asano, 2008). In the United States, Florida and California represent the largest use of reclaimed water, and landscape irrigation use of reclaimed water increased rapidly from 44% in 2003 to 59% in 2009 in Florida (Chen et al., 2013b). More than 92% of wastewater is treated in Australia with the worse water scarcity problems. There are 580 municipal wastewater treatment plants which treat 2 billion m^3 of wastewater per year, and 21% of treated municipal wastewater is reused including 14% for irrigation in Australia (United Nations Environment Programme, 2015).

There are many severe water resource issues such as fresh water scarcity and unbalanced distribution in China which is one of the 13 lowest water availability countries (Yi et al., 2011). At the same time, its water demand and pollution also

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quickly increase with the rapid development of urbanization. Thus China has ambitious plans to promote wastewater reuse and make that reclaimed water becomes a key element of nationwide water resource management scheme. Since the 1980s, comprehensive wastewater collection and treatment systems and recycling of reclaimed wastewater started to develop gradually (Yi et al., 2011). In 2010, reclaimed water production and use rate were 12.1 million tons per day and <10%, and they were planned to be 38.85 million tons per day and 15% in 2015 respectively according to the 12th Five-year National Urban Sewage Treatment and Recycling Facilities Construction Plan. In addition, environmental and economic benefits of wastewater reuse such as decreasing pollutants emission, improving soil health and saving cost, can also promote the development of wastewater reuse in China (Fan et al., 2013; Chen et al., 2015a).

The successful development of wastewater reuse has the close relationships with the installation of wastewater treatment plant, integrated water resource management, economic and financial analysis and public acceptance. Because the additional treatment of wastewater beyond secondary treatment and installation of pipeline networks for reuse are needed, expensive capital cost is a very important issue of wastewater reuse implementation (Asano et al., 2007). Bixio et al. (2006) reported that integrated water resources management considered that wastewater reuse was still at its infancy in many regions of European, and suggested that related specialists should renew own knowledge to promote the implementation of more conscious and sustainable wastewater reuse. In addition, integrated water resources management should involve all stakeholders in the whole processes of water reuse operations (Asano and Bahri, 2011).

So far, wastewater reclamation and reuse level in China is not high on the whole, whereas the potentiality of wastewater reuse is huge. The objectives of this paper are to compressively analyze the current status of wastewater reclamation and reuse in China, and to summarize the opportunities and the challenges of expanding wastewater reuse, and then to put forth recommends for future wastewater reclamation and reuse in China and possibly other regions experiencing the similar situations.

1. Opportunities and drivers for wastewater reuse

Many driving forces can be identified in practices of wastewater reuse such as water scarcity, environmental and economic consideration as well as technology improvement. In China, urbanization and consequential water demand drive directly the development of wastewater reuse. Since the implementation of 'Reform and Opening-up' policy in 1978, China entered a period of rapid urbanization. The rapid urbanization aggravates water demand and wastewater discharge, resulting in decease of water environment and water supply, and then the decreasing of water resource inhibits the development of urbanization at some extent. Under the above situation, a worse cycle between urbanization and water resource is formed in many cities. Wastewater reuse which can increase water supply and reduce pollutant discharge into surrounding water bodies, provides a chance to unbuckle this cycle (Fig. 1). This positive cycle can alleviate water crisis and promote the development of cleaner production and circular economy. In addition, current technologies applied in wastewater reuse such as ultraviolet radiation, maturation ponds, membrane filtration and electrochemical treatment can remove effectively the pollutants including salinity, pathogens, heavy metals and emerging contaminants. The advanced wastewater treatment technologies greatly reduce the risks associated with wastewater reuse. According to the current policies, regulations and investments on wastewater reuse, wastewater reuse in China is expected to expand greatly in the following decades.

Five opportunities driving reclaimed water use in China are analyzed as follows.

1.1. *Urbanization*

Urbanization is a historical process of urban quantity increasing and urban scale expanding due to populations transferring and the secondary and tertiary industries gathering from rural to urban (Chen, 2002). As the population and economy scales are gradually closed to or more than water resources carrying capacity, the relationships between urbanization and

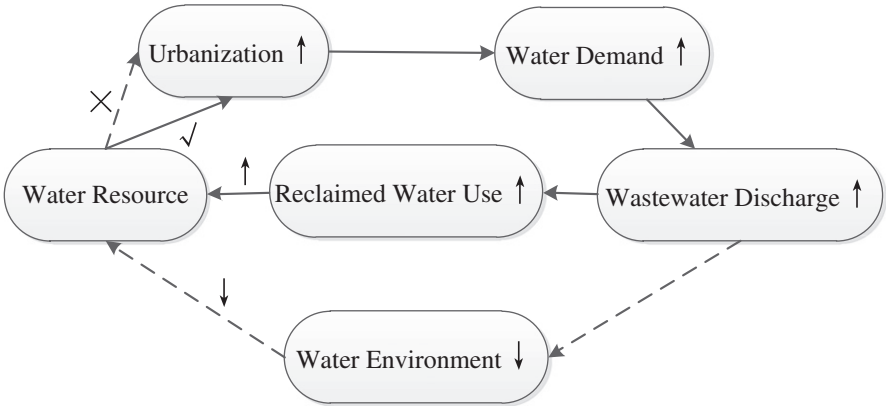

Fig. 1 – The relationship between urbanization and water resource. ↑ means increase, and ↓ means decrease. √ means the positive effects, and × means the negative effects.