



## Public perception and acceptability toward reclaimed water in Tianjin



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### ABSTRACT

Tianjin is a large, rapidly growing urban center in northern China. This region has a semi-arid climate and limited water resources. Tianjin has a thriving economy and a growing population with a substantial and growing water need. Efficient use of limited water resources is critical to its continued growth. While the development of new water sources is ongoing, the reclamation of existing water can provide a substantial contribution to meeting the water needs of the region. A positive attitude by the public toward the use of reclaimed water is critical to the full development and utilization of this resource. The present study examines public knowledge, perceptions and attitudes toward water resources, with a focus on the use of reclaimed water as gaged by a survey. Survey results indicate that the general public is aware that water resources are limited, but is relatively unaware of where their water comes from, which sectors are the largest water consumers and what happens to the water after it has been used. Further, public awareness of the need to conserve water is relatively low. Reclaimed water is currently used by 54% of the population. The public is highly receptive to the use of reclaimed water, but not for domestic use and potable use. Analysis of the survey results indicates a correlation between people's social and economic background, and their attitudes toward the use of reclaimed water. People with a higher education and income level are more inclined to use reclaimed water and are more willing to pay for it. The study makes recommendations for improving the receptivity of the public toward the use of reclaimed water.

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### 1. Introduction

The annual water use per capita in Tianjin is 153 m<sup>3</sup> (Li et al., 2013), which is substantially less than the national average level of 455 m<sup>3</sup> (Zheng et al., 2014). This is due to the fact that there is very limited ground and surface water resources in Tianjin as it has semi-arid climate with long-term annual precipitation of 550 mm. Water is a key subsystem of a sustainable urban system (Minne et al., 2011), especially for a urban system like Tianjin that has water shortage issue (Zhang et al., 2001a). In order to solve the water shortage in Tianjin, water diversion and alternative water resources (such as rainwater harvest, seawater desalination, and reclaimed water) are developed to supply water to Tianjin. The annual alternative water use is 1.9 billion m<sup>3</sup>, of which 80% is reclaimed water. Several large scale water diversion projects are operating, including the South-to-North Water Diversion, the East

Route Diversion and the Luan River Diversion. Such projects require considerable time and investment. Seawater desalination has been developed to provide water to Tianjin, but the associated cost and energy consumption is relatively high. Rainwater collection provides limited additional water due to the semi-arid climate. The development of reclaimed water can be accomplished at lower cost, and in shorter time. Reclaimed water constitutes 6% of Tianjin's total water use, a significant, if minor, contribution to Tianjin's water supply. Reclaimed water can be utilized in many ways and it is a local, reliable, and considerably less costly source of water (Li et al., 2007). Reclaimed water has a great deal of potential in Tianjin and its use is expected to increase rapidly in the coming years. To effectively make use of reclaimed water, it is imperative for the local government to develop an integrated reclaimed water use plan, a comprehensive and efficient regulatory framework, and methods for financing the required infrastructure. However, success requires increased public awareness of the available water sources, the current rate of consumption, and of its treatment. It also requires that they be receptive to the use of reclaimed water (Yi et al., 2011).

When Tianjin first introduced the use of reclaimed water, public receptivity was low, and utilization was low. The government

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therefore turned to long-distance inter-basin water transfers, and largely abandoned the use of reclaimed water (Li et al., 2007). This first attempt to use reclaimed water on a large scale faltered due to the public's lack of knowledge of water resources, and, consequently, a lack of receptivity toward reclaimed water use.

The receptivity of the public is essential to the successful implementation of water resources policy. No matter how reasonable a policy may be, public resistance will make water or other resources policy implementation much more difficult (Zhang and Balay, 2014). The use of reclaimed water in the United States and other developed countries has faced similar challenges (Dolnicar et al., 2011; Buyukkamaci and Alkan, 2013; Miller, 2006). Therefore, research into the state of public knowledge about water resources, and about their receptivity toward the use of reclaimed water is essential to the effective development of reclaimed water as a water supply source.

Reusing and recycling water and other natural resources is an important resources conservation measure and has received attention in literature recently (Lakhan, 2014; Kim et al., 2013; Zaneti et al., 2011; Prestin and Pearce, 2010; Xue et al., 2010). Research on public receptivity toward reclaimed water outside of China is relatively plentiful (Dolnicar et al., 2011; Po et al., 2003; Bruvold et al., 1981; Sims and Baumann, 1974; Bruvold and Ward, 1970; Hartley, 2006; Baggett et al., 2006). Studies may be focused on different regions, but they have consistently concluded that the public has an important influence on the successful utilization of reclaimed water. Bruvold and Ward (1970) studied public receptivity and attitudes toward renovated wastewater, and found that there was a need for research on actual usage, and on how that relates to the stakeholders' attitudes, beliefs and choices with respect to water use. Baggett et al. (2006) argued that the general public's impressions and attitudes can have dominant impact on any reuse projects. They concluded that the successful implementation of technology will be determined by cost or engineering performance attributes and an understanding of the social environment in which the technology is to be applied. Thus the public receptivity toward water development is critical to effective water resources management. Kasperson (1986) found that the failure in the design and implementation of programs requiring public participation is partly due to the programs being "rarely subjected to searching, ongoing and retrospective evaluation". During the design, implementation and assessment of public participation process, it is crucial to unite theory with practice. With respect to social background, Hartley (2006) argued that "information, knowledge, local context, and education all play an important role" in shaping public perception and the nature of public participation. While there is serious opposition sometime, the public is generally interested in being meaningfully involved in water supply and reuse decision-making process, and in finding ways to ensure an independent and secure water supply system for their communities and cities (Hartley, 2006). McKay and Hurlimann (2003) found that the greatest opposition to water reuse schemes was from people aged 50 years and older. Tsagarakis and Georgantzis (2003) arrived at a similar conclusion, and identified educated people as more willing to use recycled water. Miller (2006), in a survey of the public in England and America, reported that most of the public could accept the reclaimed water being used in non-potable ways such as scenic environmental use, but with respect to potable use, public opinion was less favorable, with psychological factors having a significant impact. While some findings in other parts of the world could be extended easily to China, tradition and culture could play significant role in shaping public perception of and receptivity toward the use of reclaimed water. Thus, an investigation of public perception and receptivity regarding the use of reclaimed water in China would be valuable to identify specifics of Chinese receptivity toward the use of reclaimed water.

At present, there are few studies (Zhang et al., 2012) about public awareness toward reclaimed water in China, although the literature on public participation and environmental awareness, including water quality (Cai and Zhang, 2007), watershed protection (Wang, 2002), environmental protection (Yan et al., 2010), and environment awareness (Li et al., 2006), is relatively extensive. Survey is a common way to explore public awareness and receptivity toward environment and resources issues and it is used in this study (Buyukkamaci and Alkan, 2013; Liu and Bai, 2014; Keramitsoglou and Tsagarakis, 2013; Owusu et al., 2013; Nijhawan et al., 2013; Achillas et al., 2011; Domenech and Sauri, 2010). Our investigation and analysis of public knowledge of municipal water sources, and receptivity toward the use of reclaimed water in Tianjin, has made possible a deeper understanding of the current status of reclaimed water use in Tianjin, and of the public's attitude toward it. Combined with other background information, the problems in program implementation can be analyzed coherently, allowing specific recommendations for improved implementation. The decision makers in China often have extensive information on the reclaimed water treatment technology, engineering economic analysis of reclaimed water, risk analysis of reclaimed water usage, and water resources system analysis (Zhang et al., 2001b; Guo et al., 2004). However, the public perception and receptivity toward reclaimed water is often missing though it is critical to the successful development and utilization of reclaimed water projects. This work will contribute a framework that can be used elsewhere of China to investigate general public perception and receptivity toward reclaimed water. It also provides policy makers with specific results on public knowledge and receptivity toward reclaimed water in a city with a chronic shortage of water.

Tianjin is one of several large metropolitan areas located in semi-arid northern China. Reclaimed water is used to meet its water needs, but development of this resource has been slow, and it remains under-utilized. The present study surveyed the public with respect to their knowledge of water resources (supply, use and treatment) and their receptivity toward the use of reclaimed water. This study presents a fairly clear description of the public's knowledge of water resources and their receptivity toward the use of reclaimed water.

## 2. Methods

### 2.1. Distribution of the questionnaire

Our study is based on the results of a survey carried out by students who interviewed, in person, individuals from 300 households using a questionnaire developed for this study. Five communities within Tianjin were selected for interviews based on location and population characteristics (Fig. 1). Surveyed locations included old town, heavy manufacturing districts, rural districts, and residential areas. The survey included residents of different ages, occupations, locations, educational backgrounds and income levels (Table 1). According to the population census of 2010, 53.4% of the people in Tianjin are male and 46.6% are female. 9.8% of the population are at the age of 0–14, 81.7% are 15–64, and 8.5% are over 65. 18.3% of the population has a primary school education, 40.9% have a middle school education and 22.1% have a high school education, and 18.7% have a college education. To assure the survey results are representative of the entire city, the survey sample were randomly selected within individual locations. Ideally, the social background of the survey sample would closely resemble that of the city population. Due to the survey sample being selected randomly, the social background of the survey sample does not precisely match that of the entire city, but is deemed to be reasonably representative.

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