China Reclaimed Water Reuse Regulations

By Sasha Rodrigues (IWA);

Annex by Xujun Liu (Yunnan Water Industry Investment and Development Co, Ltd.).

Abstract

China faces serious water quality and availability challenges due to rapid urbanization, population growth and climate change. Six national technical standards on wastewater reuse were established between 2002 and 2005 which allowed for the development of an effective reclaimed water system nationwide, resulting in the improvement of the reliability and performance of municipal wastewater treatment processes (Yi et al., 2011). To maintain and continue water quality improvement there needs to be capacity development, integrated water resources management and the development of financing instruments.

Context

China faces serious water quality and availability issues due to rapid urbanization, population growth and climate change. A recent national environment bulletin showed that only 71.7% of rivers, 60.7% of lakes and reservoirs and 37.3% of groundwater wells met the water quality criteria for source water supply (MEP, 2014). China ranks 6thin the world for total water resources even though its annual per capita freshwater availability is only 2300m^3, which is a quarter of the global average (Cheng et al., 2009). One way to reduce water stress is through wastewater reclamation and reuse. Currently, this is not a popular option as water reuse is still far below the total production of municipal wastewater (Table 1). However, recent policy changes have demonstrated opportunities for developing municipal wastewater reclamation projects and their capacity to alleviate the pressure on water resources which need to supply multiple users (e.g. industry, urban, irrigation and environment).

Table 1: China's water availability and reuse potential

Total annual average water resources	**2.8 trillion m^3 / year (ranked 6thin the world)**
Renewable freshwater availability	2300 m^3 per capita/year (25% of the global average)
Total Municipal wastewater	24.4 billion m^3 / year
Wastewater reclaimed	976 million m^3/year (4%)

Source: Cheng et al. (2009)

Analysis

Perceiving China's potential for wastewater reuse as a means of water stress alleviation, the Ministry of Construction launched a series of projects in 1985 to improve national water pollution control measures in cities in northern China, including Tianjin, Tai'an, Xi'an and Taiyuan. These projects greatly enhanced the development of wastewater reclamation technology in China. This process provided an approach for other cities developing their own municipal

wastewater reclamation systems to deal with increasing water scarcity and demand.

To implement the national urban wastewater reuse plans, six national technical standards on wastewater reuse were established between 2002 and 2005, including regulations and criteria for industrial, urban, environmental and irrigation uses. These provisions, in addition to those aimed at ensuring efficient treatment systems, allowed for the development of effective reclaimed water systems nationwide and improved the reliability and performance of municipal wastewater treatment processes (Yi et al., 2011). Standards are presented and described in detail in the annex.

In 2006, the National Development and Reform Commission, the Ministry of Construction and the Environmental Protection Agency jointly developed the National Urban Sewage Treatment and Recycling Facilities Plan in an effort to direct local entities towards the expansion of reclaimed wastewater uses. The combined actions of these plans and the six national standards resulted in the development of detailed water quality standards and are expected to increase China's wastewater reclamation capacity by 6.8 million m^3 per day.

In 2012, the State Council issued the 12th Five-Year Plan for Construction of Municipal Wastewater Treatment Facilities and Wastewater Reclamation Facilities. According to this plan, the wastewater reclamation rate should reach 15% by the end of 2015 (State Council, 2012).

Lessons Learned

The regulations set up by the Chinese government have established detailed water quality standards and water use instructions regulating the quality of reclaimed water being used in the country. Supporting policies on the establishment of treatment plants and the promotion of the expansion of reclaimed water uses aimed to motivate local entities and regulators to use reclaimed wastewater. As a result, China's water infrastructure is improving. By 2010, China increased its municipal wastewater treatment rate to 75% and Beijing built an 8,000 m^3/day water reclamation facility to supply water for road washing, toilet flushing, and other non-potable uses (Da Silva et al., 2012). However, while the regulations are a promising step towards better management of the water needs of different users, there are still a number of aspects which must be considered in more detail. One example is the need for a detailed master plan for wastewater reclamation on a for each city.

As it stands, the demand for reclaimed water is low and only 4% of the 24.4 billion m^3 of discharged municipal wastewater is reclaimed (Cheng et al., 2009). Few public awareness and education programmes have been organised to promote the use of reclaimed water, and consequently public acceptance is low, which limits the effectiveness of the policy measures (Yi et al., 2011). Furthermore, uniform implementation and enforcement remain elusive and cities which do not experience water shortages regularly still rely on inter-basin water transfers (MWR, 2007; Yi et al., 2011).

Water resource management in China is shared amongst various agencies and levels of government including State and Provincial environmental protection bureaus, the Ministry of Water Resources, the Ministry of Construction and the Ministry of Land and Resources (Cheng et al., 2009). Although each governmental level has policies regulating different aspects of water shortage management, these policies do not work together on multiple scales. China's current management challenges include the integration of the institutional system, policy design, monitoring and enforcement, water rights, the establishment of water markets and an emphasis on engineered solutions rather than holistic management solutions (MWR, 2007).

Finally, although government policy encourages industries to make use of reclaimed water, the

main obstacle preventing this from happening is that large infrastructural investments, including pipelines and updating of treatment facilities, are required. For example, in 2012, the reported reclaimed wastewater price in Beijing was set at about RMB 1/m^3 (US$0.16/m3), a subsidised fee which only partly covers operational costs, in order to encourage wastewater reclamation (Chang & Ma, 2012). Current pricing structures are not sufficient to cover capital investments and the costs of treatment systems and distribution networks (Yi et al., 2011). While lower prices promote the use of reclaimed water, they contribute less to the necessary investments to initiate construction, pipe networks and the operation of water reclamation plants (Chang & Ma, 2012).

Clearly, the use of reclaimed water in China still faces a number of challenges. However, none are insurmountable and a number of recommendations have been put forward in Table 2 to address these challenges. Some of these recommendations are already beginning to emerge in Chinese management plans.

Table 2: Regulation weaknesses and recommendations

Gaps/Weaknesses	Issue	Recommendation
Capacity Development	Poor public acceptance, low awareness (Yi et al., 2011)	• Public education campaigns • Focus on reclaimed water use in areas such as industry, urban greening, road cleaning, and river supply
	Poor implementation and enforcement (MWR, 2007; Yi et al., 2011)	• Work towards uniform implementation (i.e. through master plans for wastewater reuse) and develop governmental capacity to enforce standards and regulations (Yi et al., 2011)
Integrated management	Fragmented management among various provincial, state and environmental bureaus (MWR, 2007)	• Management plans based on interagency and multidisciplinary approaches • Combining approaches to improve use efficiency while promoting nonconventional water supplies
Financing Mechanisms	Inaccurate water pricing	• Improve government financing programs to encourage capital investment (current low reclaimed water pricing deters investment) such as subsidies, tax abatement and international financing agencies (Chang et al., 2012). • Initial investment should focus on distribution networks so reclaimed water is more accessible to populations and industries (Chang et al., 2012)
	Lack of incentives (Chang et al., 2012)	• Create incentive structure to promote local utilities and regulators to implement water efficient technologies. Incentive structures will also motivate companies and regulators to use reclaimed water more (Chang et al., 2012).

Conclusion

The Chinese reclaimed water reuse regulations present an innovative and efficient way to promote water security in water stressed urban centres while simultaneously alleviating competition between users. The regulations set up by China's government are comprehensive, providing detailed technical standards and guidelines for different uses. The implementation of these regulations can be more effective with integrated water resource management. Further work on implementation, enforcement and capacity development will improve current results.

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Annex -Water quality standard for reclaimed wastewater in China

By Xujun Liu (Yunnan Water Industry Investment and Development Co, Ltd.)

The complete standard series for reclaimed wastewater consist of the following six national standards, which were issued by the central government in the period from 2002 to 2005：

- The reuse of urban recycling water- Classification Standard（GB/T 18919-2002);
- The reuse of urban recycling water-Water quality standard for miscellaneous urban water consumption（GB/T 18920-2002);
- The reuse of urban recycling water-Water quality standard for scenic environment use (GB/T 18921-2002);
- The reuse of urban recycling water-Water quality standard for industrial water consumption(GB/T 19923-2005);
- The reuse of urban recycling water-Water quality standard for groundwater recharge(GB/T 19772-2005);
- The reuse of urban recycling water-Water quality standard for farm irrigation (GB 20922-2007).

During the practice of the usage of the reclaimed wastewater, the national standards mentioned above should be taken into account based on the actual usage of the reclaimed wastewater. The five water quality standards cover the most possible cases in reusing reclaimed wastewater.

The reuse of urban recycling water-Classification Standard（GB/T 18919-2002）

The standard has divided the usage of reclaimed wastewater into five different categories as shown in Table 1.

Table 1 The category of urban recycling water

Serial number	Category	Scope	Example
1	Agriculture, forestry, animal husbandry and fishery water	farm irrigation	Seeds, food and feed crops, cash crop
		afforestation and seedling	Seeds, nursery stock, nursery garden, ornamental plants
		livestock and breeding	Livestock, farm animal, poultry
		aquaculture	freshwater aquaculture
2	Urban miscellaneous water	urban landscaping	public lawn, residential district greening
		toilet flushing	toilet flushing
		Road cleaning	Urban roads washing and spraying
		Car washing	Car washing
		building operations	Cleaning, washing and dust suppression of construction plants, concrete preparation and maintenance, the washing of concrete structures and buildings
		fire control	Hydrant, water cannon
3	Industrial water	cooling water	straight-flow, recirculate-flow
		Washing water	Cinder and ash flushing, washing
		boiler water	Medium and low pressure boiler
		process water	Dissolving, water bath, stewing, rinsing, hydraulic mining, hydraulic

			handling, humidifying, diluting, beneficiation, Oilfield reinjection
		Water for Production	Slurry, the chemical formulation products, coating
4	Environmental water	recreational water environment	Rivers, lakes and waterscape
		Ornamental water environment	Rivers, lakes and ornamental waterscape
		Wetland water environment	natural wetlands restoration, constructed wetland
5	Source of supply water	Supplement of surface water	Rivers, lakes
		Supplement of groundwater	Recharging water source, fresh water supply to prevent the seawater invasion, backfilling the groundwater

The reuse of urban recycling water -Water quality standard for industrial water consumption (GB/T 19923-2005)

The industrial use of reclaimed wastewater is classified into the following five categories:

- Cooling water: including straight-flow and recirculate-flow supply water;
- Washing water: including the water used to flush cinder and ash, remove smoke and dust, and wash etc.;
- Boiler water: including supply water for medium and low voltage boilers etc.;
- Process water: including the water used in dissolving, water bath, stewing, rinse, hydraulic mining, hydraulic handling, humidifying, attenuation, stir, beneficiation and Oilfield reinjection etc.;
- Water for Production: including slurry、chemical preparation、coating etc.

In the case of urban recycling water used for industries, all criteria included in Table 2 (which indicates the standard for reclaimed water used as industrial water) should be met. Water produced from municipal wastewater (except water used for construction, vehicle washing, road sweeping, etc. – see Table 3) needs to comply with the upper limit value of each index of “the first class of pollutants” and “selective control items” listed in the discharge standard of pollutants for municipal wastewater treatment plants (GB18918). In the case of using recycled water as cooling water (including straight-flow and recirculate-flow supply water) and washing water, the criteria listed in Table 2 should be met and the recycling water can also be mixed with fresh water for cooling.

Table 2 Reclaimed water used as industrial water - water quality standard

Serial number	Control items	Cooling water		Washing water	Boiler feed water	Process and product water
		DC cooling water	Open cycle cooling water system to add water			
1	pH	6.5—9.0	6.5—8.5	6.5—9.0	6.5—8.5	6.5—8.5
2	SS（mg/L）≤	30	—	30	—	—
3	NTU≤	—	5	—	5	5
4	chroma≤	30	30	30	30	30
5	BOD5mg/L）≤	30	10	30	10	10
6	COD Cr（mg/L）≤	—	60	—	60	60
7	Fe（mg/L）≤	—	0.3	0.3	0.3	0.3
8	Mn（mg/L）≤	—	0.1	0.1	0.1	0.1
9	Cl-（mg/L）≤	250	250	250	250	250
10	SiO2≤	50	50	—	30	30
11	Total hardness（CaCO3/mg/L）≤	450	450	450	450	450
12	TN（CaCO3 mg/L）≤	350	350	350	350	350
13	Sulphate（mg/L）≤	600	250	250	250	250
14	Ammonia nitrogen（mg/L）≤	—	10①	—	10	10
15	TP（以P计 mg/L）≤	—	1	—	1	1
16	TDS（mg/L）≤	1000	1000	1000	1000	1000
17	oil（mg/L）≤	—	1	—	1	1
18	LAS（mg/L）≤	—	0.5	—	0.5	0.5
19	Residual chlorine②（mg/L）≥	0.05	0.05	0.05	0.05	0.05
20	Faecal coliform≤	2000	2000	2000	2000	2000

Note: ①If the heat exchanger is made of copper, the ammonia nitrogen of circulating cooling water system should be less than 1 mg/L. ② the residual chlorine at the endpoint of networks.

The reuse of urban recycling water-Water quality standard for urban miscellaneous water consumption（GB/T 18920-2002）

The water quality standard using recycled water for urban miscellaneous water consumption applies to toilet flushing, road cleaning, fire control, urban landscaping, vehicle washing and construction. Water for these uses should meet the criteria listed in Table 3. When recycled water was used to produce concrete, its quality should also meet the relevant provisions included in JGJ 63.

Table 3 urban miscellaneous use - water quality standards

Serial number	Items	Toilet Flushing	Road sweeping / fire control	Urban landscaping	Vehicle washing	construction
1	PH	6.0～9.0				
2	chroma≦	30				
3	Olfactory	No odour				
4	NTU ≦	5	10	10	5	20
5	TDS（mg/L）≦	1500	1500	1000	1000	—
6	BOD5 （mg/L）≦	10	15	20	10	15
7	Ammonia nitrogen (mg/L) ≦	10	10	20	10	20
8	LAS (mg/L) ≦	1.0	1.0	1.0	0.5	1.0
9	Fe (mg/L) ≦	0.3	—	—	0.3	—
10	Mn (mg/L)≦	0.1	—	—	0.3	—
11	DO(mg/L)≦	1.0				
12	Total residual chlorine (mg/L)	contact 30min later≥1.0, The endpoint of pipe network≥0.2				
13	Total coliform ≦	3				

The reuse of urban recycling water-Water quality standard for scenic environment use (GB/T 18921-2002)

Scenic water refers to water used to create urban landscape or waterscape, such as river, lakes, waterfalls, fountains, recreation, etc.

Water quality for the above usage should meet the criteria listed in Table 4.

In such case, it is better to use the municipal sewerage as a source and avoid using industrial wastewater. When the landscape or waterscape is supplied fully with reclaimed wastewater, the hydraulic retention of water should be less than five days. In the case that the water temperature is more than 25 ℃, the retention time should not exceed three days. If the water temperature is less than 25℃, the retention time could be extended up to a month.

Table 4 landscape water standard of reclaimed water(unit: mg/L)

Serial number	item	Ornamental landscape water			Recreational water		
		River	Lake	Waterscape	River	Lake	Waterscape
1	Basic requirements	No debris, no odour					
2	pH ≤	6~9					
3	BOD5 ≤	10	6		6		
4	SS ≤	20	10		——		
5	NTU ≤	——			5		
6	DO ≥	1.5			2.0		
7	TP ≤	1.0	0.5		1.0	0.5	
8	TN ≤	15.0					
9	Ammonia nitrogen ≤	5					
10	Faecal coliform≤	10000		2000	500		Not detected
11	Residual chlorine ≥	0.05					
12	Chroma ≤	30					
13	oil ≤	1					
14	LAS ≤	0.5					

Note 1: in the case that recycling water is transported by pipeline, the chlorine disinfection should be applied; in other cases, the disinfection method is not addressed.

Note 2: When the wastewater treatment is not equipped with nitrogen and phosphorus removal, it is highly recommended to cultivate the water plants, with which the nitrogen and phosphorus could be controlled within the limit listed in table 3-4, while the water plants listed above have economic advantages.

The reuse of urban recycling water-Water quality standard for farm irrigation (GB 20922-2007)

Reclaimed wastewater for irrigation use should meet the criteria listed in Tables 5 and 6. For fibre crops (cotton, sisal hemp) and dry field corn, the reclaimed water can be treated only by primary treatment (physical treatment).For paddy field grain or vegetable, reclaimed water should undergo secondary treatment (physical plus biological treatment).

Table 5 Maximum limited index of basic control item and water quality (unit: mg/L)

Number	Basic control item	Irrigated crop's type			
		Fibre crops	**dry field corn Oil crops**	**paddy field grain**	**vegetable**
1	BOD 5	100	80	60	40
2	COD Cr	200	180	150	100
3	SS	100	90	80	60
4	DO ≥			0.5	
5	pH	5.5~8.5			
6	TDS	None saline-alkali land 1000, saline-alkali land area 2000			1000
7	Chloride	350			
8	Sulphide	1.0			
9	Residual chlorine	1.5		1.0	
10	Petroleum	10		5	1
11	Volatile Phenol	1.0			
12	LAS	8.0		5.0	
13	Mercury	0.001			
14	Cadmium	0.01			
15	Arsenic	0.1		0.05	
16	Chrome (Ⅵ)	0.1			
17	Lead	0.2			
18	Number of faecal coliforms(a/L)	40000			20000
19	Number of ova of roundworm (a/L)	2			

Table 6 Maximum limited index of selective control item and water quality (unit: mg/L)

Number	Basic control item	limiting value	Number	Basic control item	limiting value
1	Be	0.002	10	Zn	2.0
2	Co	1.0	11	Boron	1.0
3	Cu	1.0	12	Vanadium	0.1
4	fluoride	2.0	13	Cyanide	0.5
5	Fe	1.5	14	Trichloracetic aldehyde	0.5
6	Mn	0.3	15	Acrolein	0.5
7	Mo	0.5	16	Methanol	1.0
8	Ni	0.1	17	Benzene	2.5
9	Se	0.02			