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Water Reuse Policies for Potable Use

Edited by
Cecilia Tortajada and Choon Nam Ong

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As water demand has increased globally and resources have become more limited because of physical scarcity, over-exploitation and pollution, it has been necessary to develop more options for water supplies. These options include the production at large scale of high-quality reused water from municipal sources for potable uses. Their economic, social and environmental benefits have been many as they have addressed supply scarcity, efficient resource use and environmental and public health considerations.

This book includes discussions on potable water reuse history; emerging contaminants and public health; public-private partnerships in the water reuse sector; regulatory frameworks for reused water in the United States and Europe; experiences in Australia, China in general and Beijing in particular, Singapore and Windhoek; narratives and public acceptance and perceptions of alternative water sources.

The main constraints on implementation of water reuse projects in different parts of the world seem to have been lack of full public support due to perceived health hazards and environmental impacts. A main handicap has been that governments and water utilities have been slow to understand public concerns and perceptions. After several backlashes, public information, communication and awareness campaigns, broader participation and educational programmes have become integral parts of development policy and decision-making frameworks.

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Foreword

Peter Joo Hee Ng

PUB (Singapore's National Water Agency)

By now it is quite clear that the world is plunging headlong into water crisis. The warnings have been loud, and they are dire. Some of the latest come from the World Economic Forum (2015), which has unequivocally declared water – the scarcity of, the lack of access to, and the poisoning of – to be the biggest threat to human life in the next decade.

Water and the security of its supply have preoccupied Singapore's leaders and decision makers since the city-state's independence half a century ago. The late Lee Kuan Yew, Singapore's first prime minister, recognized from day one that enduring water security was nothing less than an existential challenge. Mr Lee had devoted his entire political life to securing Singapore's water future and once famously recalled, "Water dominated every other policy. Every other policy had to bend at the knees for water survival." So, perhaps more than any other country, Singapore has always treated the possibility that there would not be enough water as neither novel nor remote.

Unsurprisingly, then, reuse is a plank of Singapore's water strategy. At PUB – Singapore's national water agency – sewage treatment works are called *water reclamation plants*. Because, in our minds, the H_2O molecule is never lost and water is an endlessly reusable resource. Water can always be reclaimed and retreated so that it can be drunk again. PUB leads the world in this, and today we are able to, literally, turn wastewater into sweet water for very little money. PUB reclaims every drop of sewage and, for more than a decade, has turned much of it into drinking water again.

The Industrial Revolution gave humanity machines, factories and mass production, and greatly increased incomes and the standard of living. It also gave us an economy that takes, makes and disposes, generating massive amounts of waste in the process. Now, of course, we readily admit and acknowledge that taking the earth's resources to make the things that we desire, and then throwing them away when we do not want them anymore, is just not a sustainable way of doing things. Indeed, when it comes to life-giving water, it is simply unacceptable that it should be discarded after just one use.

Very early on, Singapore invested great effort and resources into researching technologies that would make wastewater potable again. When these become viable at the turn of new millennium, PUB adopted them with great zeal and promptly started manufacturing NEWater, which is ultra-high-quality recycled water, on an industrial scale. Today, we have enough NEWater capacity to supply about 40% of Singapore's daily demand.

Wastewater reuse is particularly attractive to Singapore because it is a drought-resistant source of potable water. The requisite treatment technologies that are involved have become commonplace; their reliability and efficacy are well-established and still improving by the day. Even better, and unknown to most, making sewage potable actually requires, litre for litre, far less energy than desalinating seawater.

Of course, the challenge, even for us in Singapore, is to persuade people to imbibe it after we have made the stuff. This remains a tricky issue the world over, as the various contributors to this volume make amply clear. Like it or not, the average person, if free to choose, will shun drinking processed wastewater, even if he believes it to be perfectly safe.

Public acceptance of NEWater has been high in Singapore, bolstered in part by the country's pre-existing water-stressed conditions. But we take nothing for granted, and continue to retain a careful and cautious approach. Thus, even though NEWater is entirely potable, we have not yet rushed into direct potable reuse.

When it comes to direct potable reuse, public acceptance and good regulation are two sides of the same coin. One reinforces the other. My own view is that, driven by necessity, direct potable reuse will come sooner rather than later. And it will become widely practised and a new norm once enough reputable jurisdictions enact suitable regulation.

Every Singaporean grade schooler is taught the hydrologic cycle and knows how Mother Nature reclaims and recycles water in all its forms. What we do in PUB's water reclamation plants and NEWater factories is, in essence, copying nature's way. In Singapore, we have every motivation to do this. I suspect the rest of the world will increasingly have to do the same.

Reference

World Economic Forum. (2015). Outlook on the Global Agenda 2015. Retrieved from http://reports.weforum.org/outlook-global-agenda-2015/wp-content/blogs.dir/59/mp/files/pages/files/outlook-2015-a4-downloadable.pdf

Preface

Over the past decade, the issue of water crisis has become increasingly popular. In early April 2016, if one put 'water crisis' in Google, there were some 30 million references. Irrespective of where in the world one is located, very seldom does a week pass without a major story in the media on the so-called water crisis.

Any serious objective and comprehensive analysis of the overall water crisis issue will indicate that the world is not facing a crisis because of actual physical scarcities of water. This is true even for the most arid inhabited regions of the world. However, the world is indeed facing a crisis, because of continued mismanagement of water over decades, if not centuries. If the management process can be improved, there will be enough water in the world for all types of water uses, not only for the present but also for 2050. By 2050, the world population is projected to reach 9.7 billion, that is, 2.3 billion more than at present. Furthermore, human activities are expected to increase very significantly during this period. But even by 2050, by using good management practices, knowledge and technology available at present (in contrast to what may be available in the coming decades), and formulation and implementation of rational water policies, water crisis can be avoided. Thus, as Shakespeare said many centuries ago, the fault is with us and "not in our stars".

A major problem for the water sector has been the lack of realization that water is a renewable resource. It is not like oil or coal, which once used breaks down into various components and cannot be used again. Water is a renewable resource. It can be used, treated and then reused. This cycle can be repeated numerous times with good management.

For the domestic water use sector, there is currently enough knowledge and technology which can be successfully used to treat wastewater to a level that it can be of even better quality than the water supplied by the utilities. Singapore at present treats its wastewater so well that it is of better quality than the drinking water that its citizens receive. The treatment process is cost-effective. Monitoring and supervision of the treatment processes are very rigorous and strict so that water quality requirements are met consistently. There are no health risks, real or perceived. This means that in terms of technology and economics, there is absolutely no reason why all wastewater generated is not being treated extensively at present so that it can be reused time and again.

While the future is mostly difficult or even impossible to foresee, one prediction can be made with complete certainty. Scientific and technological advances in the coming decades will make wastewater treatment processes continually more and more efficient and cost-effective. In future, it would be a crime not to treat wastewater properly and then reuse it as many times as possible.

The legitimate question thus is, if wastewater can be cost-effectively treated to the level of drinking water, or even better, at present, why is this practice not being used extensively all over the world?

The reasons are many. However, the two most important ones are the following. First, historically, with the exception of very few countries like Singapore, most unfortunately, water has not been high on the national political agendas. Politicians and media are interested in water only when there are catastrophes like heavy floods, prolonged droughts or other serious national disasters like earthquakes. Once these catastrophes are over, political and media interests in water simply evaporate. Unfortunately, water problems can be solved only on a long-term basis, which requires sustained political interest. This is missing at present.

In addition, to the extent there is interest, this is almost exclusively with respect to water quantity; quality issues are seldom seriously considered. There is lot of rhetoric on the importance of water quality from national governments and international organizations. Sadly, sustained and well-thought-out actions are conspicuous by their absence. Thus, not surprisingly, almost all water bodies in and around centres of population and industrial developments in developing countries are heavily polluted with known and unknown contaminants. Furthermore, in most cases, water quality is steadily deteriorating, in both surface water bodies and aquifers.

Second, the fundamental problem with the use of properly treated wastewater is neither technological nor economical, but public acceptance of its use. No matter how well wastewater is treated, people remember its history, and are strongly opposed to its use even though its quality could be higher than provided by a utility. Even the discussions of the issue are often framed in pejorative terms. Thus, in California, the discussions were framed on the concept of "toilets to taps", and in Australia, it became "citizens against drinking sewage".

Generally people are uncomfortable with or averse to the idea of drinking treated wastewater, irrespective of all the scientific and technical evidence that categorically indicates that it is perfectly safe to drink. One study in the United States found that one in four people believe that wastewater cannot be treated to a high enough quality so that it can be actually drunk. In other words, no matter what is done, no matter what its quality is, its history ensures that its use is unacceptable. There appears to be a universal belief that once water has been in contact with a disgusting object like human excreta, it will always remain in contact, irrespective of the treatment processes.

There are other anomalies in human perception as well. One American study indicated that people are more willing to drink treated wastewater if it has been stored in an aquifer for 10 years, compared to only 1 year. Some 40% of the people are willing to try it if it has travelled in a river for a hundred miles, as opposed to only one mile. Somehow, it seems, the longer it is stored, or the further it travels, more acceptable it becomes.

In other words, irrespective of all the scientific and technical evidence which indicates that treated wastewater is safe to drink, the gut feeling of most citizens is that it is not so, primarily because of the 'yuck factor'.

This leads to another issue. Historically, the water profession is dominated by engineers and technologists. There is no question that in the coming years they will make the treatment processes continually more efficient and progressively more cost-effective. However, this development alone is unlikely to change the opinions of the vast majority of the people in terms of drinking properly treated wastewater. The breakthroughs are likely to come only if behavioural psychologists and economists play a major role in convincing the society that their attitudes to and perceptions of use of treated wastewater are irrational. This behaviour needs to undergo a sea change, which will be difficult to achieve without the help of behavioural scientists.

The good news is that behavioural psychologists and economists are starting to take an interest in this issue. While this is a good beginning, we need a critical mass of such experts working all over the world to convince the people that current practices of wastewater treatment can ensure that the resulting water is perfectly safe to drink. This has to be complemented with proper long-term monitoring and safeguard practices.

If water is not reused extensively, the world's water problems cannot be solved. It is thus very heartening to see that National University of Singapore and PUB (Singapore's national water agency) have brought together some of the world's leading experts to discuss this complex topic from multidisciplinary, multi-sectoral and multi-issue perspectives. This special issue of

the *International Journal of Water Resources Development* is a direct result of this meeting. I am confident that this issue will indeed contribute to finding implementable and socially acceptable solutions to a complex and difficult problem.

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Introduction

In an increasingly globalized world, societies have become less resilient in regard to their natural environment. Long-term changes such as economic development, population growth and urbanization, as well as the impending threat of climate change, have increasingly resulted in global impacts on natural resources. Water resources, in particular, have become more polluted, mismanaged, misgoverned and poorly allocated.

As water demand has increased for numerous uses and users, and resources have become more limited because of physical scarcity, over-exploitation and pollution, it is therefore necessary to develop more options for water supplies. These options include the production at large scale of so-called non-conventional sources of water, such as recycled water from municipal sources, and desalination of seawater and brackish groundwater.

Appropriate planning and management consideration and improved treatment technologies can result in the production of high-quality water with no negative health or environmental impacts. Their economic, social and environmental benefits are many, as they address water supply scarcity, efficient resource use and environmental and public health considerations. Overall, they are used for potable and non-potable purposes, either directly or indirectly. Their usages include agriculture, landscape, stream and groundwater augmentation and managed aquifer recharge, cooling water for power plants and oil refineries, processing water for mills, toilet flushing, dust control, construction activities, concrete mixing and artificial lakes (United States Environmental Protection Agency [USEPA], National Risk Management Research Laboratory & U.S. Agency for International Development, 2012).

According to the US Environment Protection Agency, direct potable reuse is

> the introduction of reclaimed water (with or without retention in an engineered storage buffer) directly into a drinking water treatment plant, either collocated or remote from the advanced wastewater treatment system. Indirect potable reuse (IPR) is the augmentation of a drinking water source (surface or groundwater) with reclaimed water followed by an environmental buffer that precedes drinking water treatment. (USEPA, National Risk Management Research Laboratory & U.S. Agency for International Development, 2012, pp. 1–2)

However, terminology can be different in other countries. The terms 'reused', 'recycled' and 'reclaimed' water are also not always used interchangeably. For example, in the United States, reused water is known in different states as 'recycled' or 'reclaimed' water (Miller, 2006); in Singapore, it is known as NEWater (Lee & Tan, 2016).

Interest in the potential of reused water has increased globally, with studies focusing on policy, management, technology and public acceptance. With the best of the knowledge and experience available, governments, water utilities, academic institutions, non-governmental organizations and members of society are trying to develop or contribute towards development of guidelines and risks analyses; better understanding of economic aspects; safety, health and water quality considerations; social perceptions; environmental impacts and benefits; and more advanced and cost-effective technologies (e.g. ATSE, 2013; Eslamian, 2016; National Research Council, 2012). The analyses concur on the enormous potential of reused wastewater as a reliable source of clean water that also enhances urban resilience.

Rather than technological aspects, the main constraints on implementation of water reuse projects in different parts of the world seem to have been lack of full public support due to perceived health hazards and environmental impacts. A main handicap has been that governments and water utilities are usually slow to understand public concerns and perceptions. After backlashes