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CONFERENCE REPORT

Workshop on 'Water reuse policies for direct and non-direct potable and industrial reuses', Singapore, 15–16 June 2015

Water, essential to quench our thirst, grow our food, supply energy and manufacture the goods we consume, is becoming increasingly polluted and scarce. The World Economic Forum's *Global Risks 2015 Report* identifies the water crisis as the risk with the largest potential impact on society (World Economic Forum, 2015). As the population grows larger so does the demand for water. Meanwhile, climate change is increasing uncertainty in water supplies with more extreme and prolonged droughts. As conventional sources of water (e.g. surface, groundwater, etc.) become insufficient at meeting water demand, finding new water supplies is essential. The reuse of treated wastewater (TWW) for both potable and non-potable water is technologically feasible and safe. It is already being employed in several places around the world, most notably Windhoek (Namibia), Singapore, California and Texas (both USA). TWW reuse is growing in prevalence and represents a viable option to increase water supply to accommodate present and future demand.

To address future water scarcity concerns, 40 experts in water resources development met at a conference in Singapore. They discussed research from seven different areas of the world including Australia, China, the European Union (EU), Namibia, Saudi Arabia, Singapore and the United States. Professor Asit K. Biswas was the Keynote Speaker and his address presented the global problems of water scarcity and insufficient wastewater treatment. It stated the necessity of such a conference and set the stage for the topics covered during the conference. Those topics included TWW technology, regulations, business models, energy use and, most importantly, public acceptance. All these topics must be considered in order for TWW reuse to be successfully implemented.

It is necessary to understand the different scenarios in which TWW reuse can be employed. First, the final water product must be deemed potable or non-potable. If non-potable, it will be used for industrial, agricultural or other non-drinking uses. If potable, it will be supplied to households and is suitable for direct consumption. Second, there are two types of treatment schemes: direct and indirect. Direct reuse occurs when the wastewater is treated to a particular standard and immediately delivered to the consumer. Indirect reuse occurs when the wastewater is treated, delivered to the environment, recollected, treated again and delivered to the consumer. Indirect reuse is more common than direct reuse and is often done unintentionally (e.g. when one town releases wastewater into the environment upstream of another town that uses the water in its treatment system).

Several presenters discussed the policies surrounding reused water. Dr Rosario Sanchez covered the two US regulations for water quality standards: the Clean Water Act (CWA) and Safe Drinking Water Act (SDWA). These regulations largely dictate state regulations. Only four states have laws specific to indirect potable reuse (IPR) and two other states review specific

IPR projects on a case-by-case basis. No state has laws specific to direct potable reuse (DPR), but California is anticipated to release new regulations by the end of 2016.

Dr John Fawell discussed regulations in the 28 member state EU. There are two primary pieces of legislation that dictate water quality: the Drinking Water Directive and Water Framework Directive. However, these are not directed at promoting water reuse. The European Commission has begun to examine the need for new legislation related to reuse and will propose a way forward by the end of 2015. Uncertainty in the EU has the potential to be a barrier to trade, particularly for agriculture. Countries in- and outside the EU that reuse water to irrigate agricultural land could violate certain countries' laws, which could prevent trade within and outside the EU. Although there is no unified standard, six countries in the EU have developed some TWW reuse standards.

Other presenters discussed water reuse regulations/guidelines or lack thereof in other parts of the world including China, Australia and Saudi Arabia. The consensus was that there is much inter- and intra-country inconsistency and guidelines would be helpful. The World Health Organization (WHO) is in the process of developing TWW reuse standards for both non-potable and potable reuse and these will likely form the basis for many countries' water reuse standards. Although this is expected to provide guidance to those countries, requiring different standards relative to conventional water sources implies that reused water is less safe as a source of water. This is not supported by scientific evidence and contradicts improving public acceptance of reused water.

In general DPR is the least accepted reuse scheme by the public. Dr Anna Hurlimann's presentation demonstrated a negative trend between a willingness to use recycled water as the use became more personal (e.g. drinking, washing oneself, etc.). Dr Leong Ching discussed the social science between public acceptance of recycled water as not just an issue that can be argued for on purely scientific grounds, but rather one that must encompass a richer narrative, such as economics, security and/or history, as a means to public acceptance. Her paper's focus on Singapore's IPR 'NEWater' attributed public acceptance to thicker narratives including water security and environmental realities, among others. An economic argument was echoed by many participants as a means of public acceptance – pricing water appropriately is inherently difficult and cheap water is a disincentive to people's acceptance of reused water. Pierre van Rensburg's paper on DPR in Windhoek, Namibia, is another example of a 'richer' narrative – the area was so water-scarce that DPR was developed in 1968 to accommodate demand. This bolsters forecasts that public acceptance of water reuse will increase as water scarcity increases.

Dr Joseph Cotruvo led a discussion on the monitoring/testing technology available today. Water testing can now identify contaminants at the part per trillion level and emerging contaminants not traditionally a part of water quality standards (Fawell and Ong, 2012). This is beneficial because identifying these contaminants at such low levels provides information to the overall quality of the treatment system and can indicate failures/quality degradations that may require maintenance. On the contrary, public acceptance is made more difficult by the information resulting from increased testing technology available today. At such a low concentration, the presence of contaminants, whether innocuous or not, is inevitable, which can lead to negative press casting doubt on water quality with little to no scientific evidence about the threat the contaminants pose to health.

Participants acknowledged the general drinking water quality standards of organizations such as the WHO are acceptable, safe and capable of being achieved by technologies to clean wastewater. However, a discussion was brought up about the long-term effects of contaminants present in TWW at very low levels for drinking. Further research on the health of those living in places utilizing TWW for potable reuse could elucidate the long-term effects, if any.

Dr David Lloyd Owen discussed the trends in public–private partnerships (PPPs) for TWW reuse. Such partnerships have increased drastically from covering 0.74 million people in 1998 to 29.44 million people in 2014, with the most water-stressed areas having the largest increase in TWW reuse contracts. Wastewater treatment and reuse is easier to price than general water service providers. This lends more security to the parties involved in wastewater treatment contracts as evidenced by the fact that all contracts were fulfilled to their executed completion date. Since it is easier to price TWW appropriately, it is easier to price reused water as there is a direct linkage to the source acquisition and treatment. Dr Owen's research demonstrates an optimistic outlook for future TWW reuse via PPPs since the investment is less risky than conventional water utilities.

Dr Ying Chen and Xudong Yu presented on China and Beijing respectively. Water reused in China is not for potable reuse and Dr Chen stated that is not a near-term goal partly because there is insufficient monitoring of water quality. Rather TWW reuse is used to improve the 'scenic environment', industry, agriculture and non-potable uses such as street cleaning. Yu found in the more urbanized areas that plants are dominated by a few larger facilities, while the suburbs have many smaller facilities. This hybrid model of wastewater treatment has advantages including better demand responsiveness, resilience to supply failures and reduced energy requirements to convey water outside the city. The hybrid model also has disadvantages rooted in the many small plants, including poor management and coordination, fewer economies of scale (thus increased costs), and lower reliability to provide a quality water supply.

The quality of the water from a supplier is of utmost concern to public and environmental health. Having a decentralized water utility, whether TWW or not, must have a verification body to ensure the water quality meets the stipulated standards. In developed and stable countries such as Singapore and the United States the government can be relied upon for this (WHO, 2011). In countries with less transparency and a higher risk of corruption, a decentralized system is risky without a third-party verification system to ensure the quality of the water. Thus TWW reuse, especially for potable reuse, must be predicated by a reliable body to ensure its quality.

Another aspect that must be considered for TWW reuse is the energy consumption component to treat the wastewater. Energy consumption has an effect on the price of water, and if using conventional energy sources emits greenhouse gases. Chelsea Burns's presentation looked at energy consumption for several different sources of water including groundwater extraction, desalination and treating wastewater. The research also categorized energy consumption used for pumping, treatment and conveyance, providing useful insight into energy consumption for different water supply schemes.

Burns's research insights on energy consumption and water supply provided a viewpoint not previously discussed at the conference about the need to consider energy consumption when building water supply infrastructure. Considering water scarcity is partly a consequence of climate change, it is careless to neglect it when deciding on a water supply. Thus both energy and water policy-makers should be present when building new water infrastructure.

The conference allowed academics and practitioners to discuss the importance of TWW reuse, the state of regulations, technical and non-technical barriers, business models, and environmental issues pertaining to its implementation. It was exceptionally valuable at bringing together experts with diverse study disciplines and areas of water expertise coming from different regions of the world to exchange information and increase the depth of knowledge of the participants. Participants consistently brought up public acceptance as the largest barrier to TWW reuse implementation. Considering this, future conferences and research may benefit from having experts with a background in behavioural science to help understand the crux of the psychological barriers to acceptance of TWW reuse as well as media presence to spread the science-based information to the public.

The papers presented are being reviewed and will be published in a special issue on water reuse policies in the *International Journal of Water Resources Development*.

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