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Sustainable Water Systems of the Future – How to Ensure Public Health Protection?

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Introduction

The main critical issues facing water utilities over the next 50 years are climate change and a rising population. The changes in rainfall patterns have the potential to impact on water sources, possibly increasing the risk of contamination due to surface run off or by concentration of contaminants during drought. The increase in population is putting pressure on the aging infrastructure and capability of utilities to meet water demand. Estimates vary widely but for example, the investment required to keep water infrastructure performing at current standards in the USA is predicted to be $150 billion by 2025 and $204 billion by 2040.[1] While considerable focus for drinking water system operation, particularly in the UK[2], is on customer affordability, one of the primary services that this infrastructure provides is public health protection, with provision of clean drinking water and sanitation services playing a key role in the control of infectious disease. This is ranked as one of the great public health advances of the 20th century.[3]

From a sustainability perspective, there is much about the current water infrastructure that is less than desirable. Centralised systems extract large volumes of water from the environment, often at a considerable distance from the end users, and require significant quantities of energy and chemicals to treat and convey. The construction of heavy infrastructure to support the delivery of water and sanitation services is also energy intensive and disrupts roadways, businesses, and citizens in their daily life. Facing the investment and construction burdens of replacing our current water infrastructure, it can appear more sustainable to look for decentralised or partially-decentralised options that could harvest local water resources such as rainfall, thereby avoiding pumping and transport and potentially taking advantage of local small-scale renewable energy generation. However; such alternative water systems may not provide the same degree of public health protection as centralised systems[4], particularly when responsibility for operation and maintenance is transferred to homeowners or business owners who lack specialised water expertise. While large, centralised water utilities are not immune to public health problems or waterborne disease outbreaks, as was seen in Flint (lead, likely also *Legionella*)[5] and Milwaukee (*Cryptosporidium*)[6] for example, the transition from a fully-centralised to a partially-decentralised paradigm with a potential mix of technologies and interventions may pose a different type of risk.

Water Efficiency versus Water Quality

A recently released report by the National Infrastructure Commission (NIC) of the UK, entitled 'Preparing for a Drier Future', highlights the need for water demand management and recommends a target of 118 litres of water per capita per day (lcpd), a reduction of 23 lcpd from the current UK average of 141[7]. WHO recommends a minimum of 70 lcpd to maintain a healthy standard of living, excluding garden and recreational uses[8]. Unfortunately, the dilemma posed by transitioning our current water infrastructure to sustainable systems with lower water consumption is that water efficiency measures could lead to degradation of drinking water quality. While water efficiency does need to be prioritised, the potential for adverse unintended consequences related to water quality should also be highlighted in customer education and outreach programmes, something that is not always taking place at present.

Consider the case of lead in drinking water. An acknowledged public health concern, lead contamination of drinking water is primarily caused by lead service pipes, which were common in homes built before 1970. The UK Drinking Water Inspectorate recommends that homes with a confirmed lead problem should first flush a volume of water equivalent to a kitchen sink (25 to 30 litres, typically) before drinking the water[9]. US water utilities are recommending flushing until the water temperature changes, then for an additional 1 to 2 minutes before consumption[10]. Assuming that a typical home has a 1.25 cm diameter service pipe, 40 m in length, this gives an initial flushing volume of 5 litres. The additional 1 to 2 minutes of flushing at typical flow rates[11] equates to a total flushed volume of 11 to 20 litres. Clearly this practice is not going to help with water efficiency targets. Stagnation of water within household plumbing has been shown to increase dissolved lead concentrations,[11] so water efficiency measures that reduce flows, such as low-flow showers or rainwater harvesting for toilet flushing, will have a water quality impact. The retrofit of water saving devices in older homes that could contain lead pipe, solder, or lead-containing fittings should therefore be pursued with caution.

The case of lead contamination illustrates the conflict between drinking water quality and water efficiency. At best, consumers will be confused by mixed messages about what they should and should not do. At worst, consumers who unknowingly have lead sources within their household plumbing may be increasing their exposure to lead by trying to conserve water.

Potential Pathways Forward

Greater collaboration between researchers, water utilities, manufacturers of water efficiency devices, the public health community and regulators is needed to bring visibility to the potential water quality issues and identify solutions to achieve both water quality and sustainability goals. Untreated rainwater that is harvested for reuse has been shown to have poor microbial quality[12] but hard controls could be engineered into rainwater harvesting systems, including failsafe modes, multiple treatment barriers, and greater use of water safety plan approaches. These controls are generally excluded from commercially-available systems at present for cost minimisation. Additional monitoring and remote control could speed the time to detection and response of water quality problems.

Soft control measures will be equally necessary. Many outbreak investigations cite a lack of training of the water utility staff as a key factor[13]. Regulatory changes may be necessary to support full implementation of decentralised water system configurations and proper integration of water efficiency devices. Business models that keep maintenance of treatment units under expert control may offer one solution.

Outreach to customers, home builders and plumbers is essential to increase training on the potential consequences of their actions. After decades of centralised water delivery in many developed countries, there is little knowledge in the general public about how to ensure that a water supply is safe. While some progress has been made in collaboration, there remains a need for the water industry to work closely with public health professionals to plan for a safe and sustainable future of water service provision.

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