WATER RESEARCH COMMISSION

WORKING PAPER

Maximising the potential of alternative water sources: making a case for remix water treatment plants in South Africa

by
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Summary

Currently, about 77% of South Africa's water needs are met using surface water resources, rendering water supply highly vulnerable to impacts of climate change and variability. To meet future water demands, many water service institutions in South Africa are increasingly considering the development of a mix of alternative water sources. The use of alternative water sources, such as wastewater, seawater, groundwater, harvested storm or atmospheric water, individually or in combination, can serve as sustainable sources that can be used to help offset the overreliance on limited fresh surface water resources. While water reuse and desalination have been identified as key components of the water-supply mix, their implementation has been slow mainly due to governance, cost, and public perception challenges. However, since 2009, a new method of blending of seawater and treated wastewater effluent for drinking water production using the RemixWater™ technology has emerged. Current indications are that the blending and treatment of alternative water sources, such as seawater and wastewater as means of augmenting supply presents a unique opportunity for South Africa to be on track to operationalise and achieve the envisaged water resource mix by 2040. Pioneering and upscaling of the RemixWater™ technology in South Africa puts the country in a prime position to be the benchmark for the implementation of larger-scale projects around the world and sets the country on the right path to water security.

Keywords: water reclamation; water reuse; desalination; drinking water; water supply mix

1 Introduction

South Africa has an arid to semi-arid climate, with an average annual rainfall of 465 mm, with a total annual runoff of approximately 49 000 million m³/a. Out of this, the current reliable yield of surface water at an acceptable assurance of supply is approximately 10 200 million m³/a. The total nationally accessible groundwater potential is about 4 500 million m³/a; however, it is currently underutilised (Department of Water and Sanitation, 2019). This means that South Africa mostly relies on surface water resources for meeting national water demands. Trends of population growth, urbanization and climate change indicate that it will be increasingly difficult to adequately meet demands exclusively with one source of water. It is projected that if demand continues to grow at the current pace, a 17% deficit between water supply and demand will be experienced by 2030 (Department of Water and Sanitation, 2019). To ensure a water secure future, a combination of water conversation and demand management, as well as supply-side interventions are required to put South Africa in a desirable path to be able to meet the increasing water demands. On the supply side, limiting dependence on surface water sources by developing new or alternative water sources, as well as optimising the current water resources supply mix ratios has become more pressing. According to the current National Water and Sanitation Masterplan (Department of Water and Sanitation, 2019), about 77% of South Africa's water needs are met with surface water resources. It is planned that by 2040, water reclamation and reuse (treatment and reuse of acid mine drainage, industrial and municipal wastewater), desalination and groundwater will make a significant contribution to South Africa's water mix, with the overdependence on surface decreasing slightly (Figure 1).

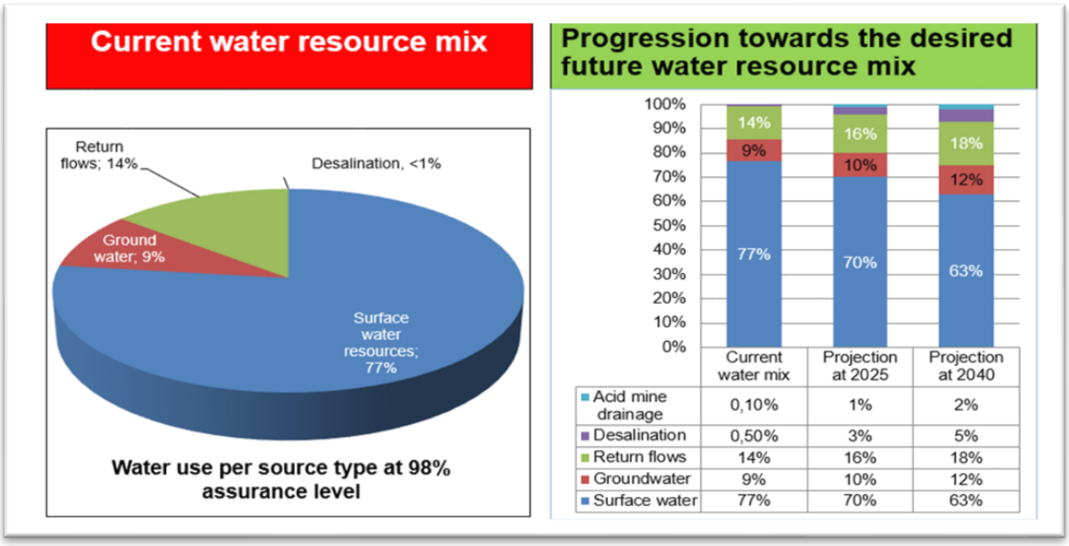

Figure 1: South Africa's planned progression towards an optimised water resource mix. Source: Mlilo (2020).

Many municipalities have already embraced this vision by developing and optimising their own water-supply mix strategies and programmes. For a while now, many municipalities have been water stressed, with some being on the verge of running out of water to supply their consumers (Figure 2). Overall, it is estimated that South Africa's water stress level is currently at 41%, with extremely high levels in parts of the Western Cape, Eastern Cape and North West (World Resources Institute, 2021). Recently, the Eastern Cape province experienced record-level water shortages, almost similar in magnitude to those reported for other coastal regions, such as the Western Cape and KwaZulu-Natal provinces in previous years. Consequently, measures have been put in place for the development of alternative water sources, such as groundwater, seawater and treated wastewater to augment municipal supply.

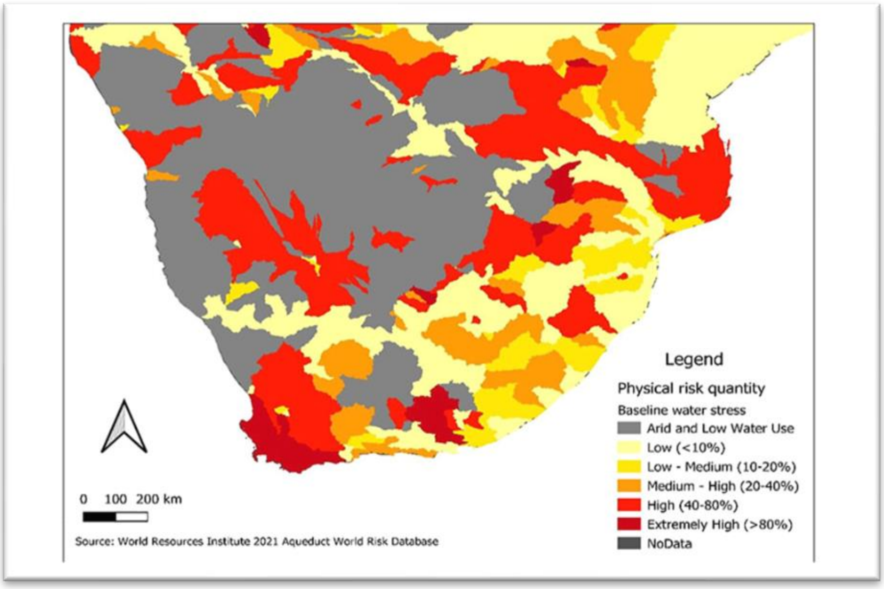

Figure 2: Water stress as a percentage of water availability. Source: World Resources Institute (2021).

In most cases, the development of an alternative or new source involves directing the feedwater of that source to a dedicated plant for treatment and distribution. In some cases, the treated new supplies are blended with existing treated surface supplies prior to distribution. However, in South Africa, a first of its kind remix water plant, treating a combination of seawater and wastewater for drinking water production has been successfully installed in Durban (Ethekwini Metropolitan Municipality) (Hitachi, 2017). Owing to its success, a similar, albeit smaller, plant is planned for Ndlambe Local Municipality (Ndlambe Municipality, 2021). Based on these two, it is likely that South Africa will see an increase in similar plants in the future. This paper provides a synopsis of current practices of water sources blending for drinking water treatment and describes the emerging approach of treating multiple alternative water sources (such as seawater and wastewater) within the so-called RemixWater™ technology.

2 Blending multiple source waters for drinking water treatment and supply

Based on the 77% reliance on surface water, it is expected that most municipal water treatment plants use a single source for drinking water production. Such plants typically utilise a multi barrier treatment process to treat the water to the quality stipulated in the South African National Standards for drinking water quality (SANS 241). However, due to a combination of growing water demand, ageing infrastructure, poor surface water quality, stricter environmental and water quality regulations, fast diminishing freshwater reserves and climate variability, water service institutions are under increased pressure to consistently provide reliable, adequate and safe water services to their consumers. This problem is not only unique to South Africa, more than ever, but local government authorities around the world are also increasingly exploring ways to supplement their supplies and increase resilience to water scarcity shocks. As a result, there has been an unprecedented global progression towards either the optimisation of existing water resource mixes and, or the development of new or alternative water sources through the commissioning new advanced water treatment plants (International Water Association, 2015).

Whether the new water sources are conventional (such as surface water) or alternative (e.g., groundwater, brackish water, seawater, water recovered from aquifer storage, wastewater, harvested water), they can serve as a vital water supply in support of water resilience. As part of water resource mix optimisation, water service authorities have also considered blending multiple water sources. However, in other instances water sources blending has been implemented as a non-treatment alternative to improve the final water product and to achieve a certain degree of dilution of the contaminants prior to treatment. For example, since the introduction of the new Arsenic standard in the United States of America, it has become common practice to blend two source waters: one with arsenic (As) levels well below 10 ppb, and that with much higher concentrations (USEPA, 2003). Generally, the blending of multiple water sources or feedwaters for treatment within one plant is not a new phenomenon, however, it is seldomly practiced, due to process control challenges. Blending of multiple sources requires a high level of operational surety, appropriately-sized storage and mixing zones, and a firm understanding of potential impacts on process performance and distribution system stability (Stanford et al., 2017). This is because blending multiple feedwaters for treatment may alter the original balanced environment in water networks, and if not managed adequately, can result in pipe corrosion, decreasing disinfectant residual and microbiological growth, and general water quality deterioration (Imran et al. 2005).

According to Dewis and co-workers (2008), there are several considerations that need to be taken into account for blending different water sources. These include assessing the water quality and related variations for each source; a detailed assessment and description of the physical characteristics and hydraulics of the supply system; identifying system operational constraints; evaluation of potential impacts based on key criteria, such as regulatory compliance, water compatibility, system equilibrium, customer concerns, etc; and the use of modelling tools and tests for evaluating the blending prior to implementation. Globally, there has been many attempts to institutionalise the practice of multiple water sources blending for treatment and use. In 2003, the United States Environmental Protection Agency (USEPA), proposed a blending policy for wastewater treatment. However, the policy was rejected and not finalised for implementation due to non-compliance with existing water quality regulations, public and environmental health impacts (Copeland, 2005).

Recently, the blending of multiple sources in the context of water reclamation and reuse has been considered. To support this practice, several tools and guidelines/manuals have been developed as a means of limiting the impact on plant operations, water quality, public and environmental health (Stanford et al., 2017). In 2010, Hitachi successfully developed and commissioned a demonstration water treatment system facility that blends seawater with treated wastewater effluent as a means of diluting the salt content prior to desalination using reverse osmosis. This method has been reported to result in more than 30% reduction in power consumption, compared to conventional seawater reverse osmosis desalination plants (Hitachi, 2017). Recently, the metropolitan municipality of Ethekwini (Durban, South Africa) followed suite by implementing a first of its kind full-scale remix water plant in Africa, treating a combination of seawater and wastewater for drinking water production. Operational information from this plant will serve as a benchmark and will be important in guiding future decisions on the installation of similar plants, not just in South Africa, but globally.

3 The RemixWater™ System

RemixWater™ is a registered trademark of Hitachi, Ltd. in Japan, Australia, South Africa, Saudi Arabia, and Qatar. This technology was introduced for implementation in 2009, by Hitachi and Toray Industries, Inc., who are members of the Global Water Recycling and Reuse System Association, Japan (GWRA). This technology was developed as an alternative to the high operational costs and negative environmental impact associated with seawater desalination systems. In 2010, the first ever RemixWater™ demonstration facility was commissioned at Water Plaza Kitakyushu. This plant integrates the seawater desalination process and a wastewater reclamation process (Figure 3).

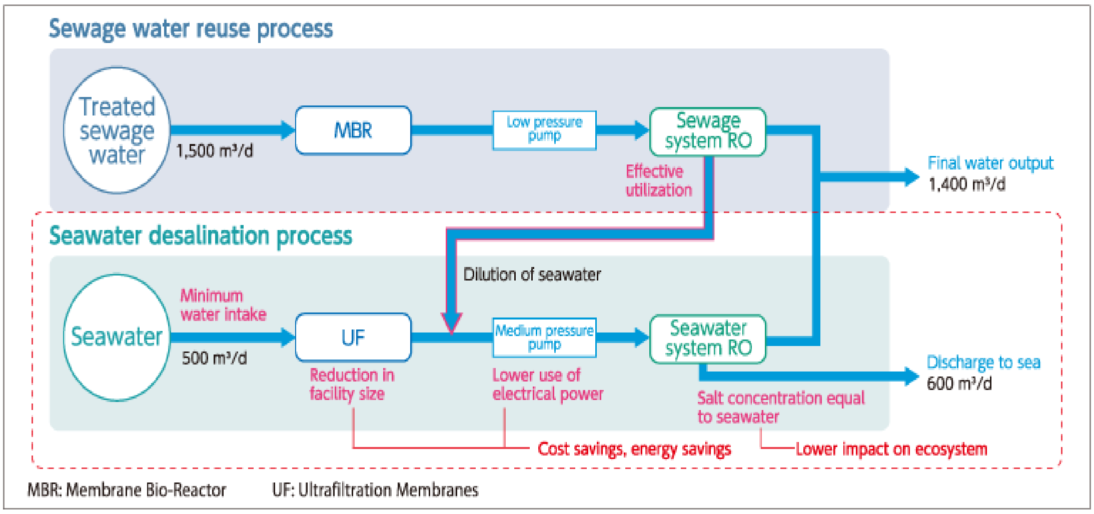

Figure 3: Overview of the Hitachi et al RemixWater^{TM} System. Source: Hitachi (2017).

Owing to the success of this plant, Hitachi was appointed to design, construct and operate a similar demonstration RemixWater^{TM} system for the eThekwini Metropolitan Municipality, in Durban, South Africa (Hitachi, 2017). The move by Ethekwini municipality to consider alternative means for supplementing water supply was motivated by a study conducted to assess the future water demand in the eThekwini region, which revealed that demand will exceed the water supply in 2020 (Masha, 2019).

The Durban RemixWater^{TM} Plant

The eThekwini Metropolitan Municipality RemixWater^{TM} system demonstration facility was commissioned in 2019 through a collaboration between the New Energy and Industrial Technology Development Organisation (NEDO) and Hitachi (Masha, 2019). The purpose of the demonstration plant was to test the technology, optimise and validate the performance of the technology, with regards to its ability to reliably produce water of drinking water quality standard. The implementation of the demonstration plant comprised a 300 m^3/day containerized unit and a 6,250 m^3/day demonstration plant. The period of demonstration was set at 12 months, and thereafter a permanent plant commissioned (Masha, 2019). The Durban RemixWater^{TM} Plant involves blending and treatment of seawater from the Durban Harbour (which is an Estuary), wastewater from the Central Wastewater Treatment Works at Bluff, Durban, and potentially, groundwater (Maitland, 2017). The effluent from the Central Wastewater Treatment Works is treated with membrane bioreactor technology (MBR) and brackish water reverse osmosis (BWRO), and the reject water from the BRWO process unit is used to dilute the seawater before the Seawater reverse osmosis (SWRO) process to decrease the salinity (Masha, 2019) (Figure 4). Operational data obtained from the demonstration facility shows that a 40% reduction in energy consumption can be achieved under optimal conditions, compared to conventional SWRO desalination plants. Based on this plant, the Ndlambe Local Municipality, is also considering installing a similar plant in the future (Ndlambe municipality, 2021).

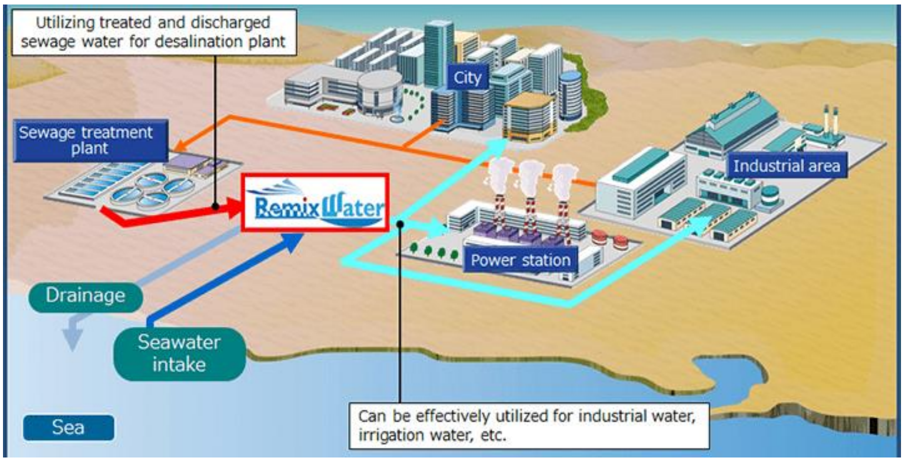

Figure 4: Schematic of the Durban Remix plant. Source: Masha(2019).

4 Summary and conclusions

When it comes to blending and treatment of multiple water sources for drinking water production, it is important to understand source water quality, blending ratios, intended/unintended consequences of blending to the final water quality water and supply infrastructure. While the use of multiple water sources can provide sustainable means of water-supply augmentation if not well managed it can result in water quality problems. A recent Water Research Commission guideline report by Swartz et al (2015) provides practical recommendations for water quality monitoring in the context of water reuse and is based on a risk-based process of identifying, selecting and analysing the concentrations of a list of all water quality constituents of concern. Three main monitoring programmes are recommended for such plants, namely raw water monitoring, operational and control monitoring and compliance monitoring. The report by Stanford et al (2017) provides a comprehensive review of several tools and guidelines/manuals to support the implementing of multiple water sources blending for water reuse schemes. Water reuse and desalination are regarded as key alternative options for addressing localised water scarcity, and as such upscaling the implementation of remix-type water treatment plants, that allow for multiple sources blending will contribute immensely towards achieving water security.

5 Implications for maximising the potential of alternative water sources in South Africa

South Africa has already set a vision to optimise the water resources mix by increasing the use of alternative water sources, such as through the reclamation of wastewater and desalination, by the year 2040. Lessons from installed plants have shown that both water reuse, brackish and seawater desalination can reduce demand for freshwater resources, diversify water sources and enhance reliability of access to resource. Furthermore, these alternative water-supply systems are flexible and adaptable to changes in population and consumption and technologies. However, challenges with widescale adoption and implementation in South Africa remain, and these are related to lack of specific norms and standards (regulations) for water reuse and desalination; high cost of implementation resulting in low affordability and willingness to pay; scarce human capacity to design, build, operate and maintain the plants, and the low public confidence in water service institutions to produce safe water. It follows then that the potential of using alternative water sources for increasing supply and improving resilience can only be maximised under specific circumstances, ie, those that address the identified and high priority governance and technical challenges associated with the implementation of alternative water supply systems. The RemixWater™ technology and similar technologies present a unique opportunity for South Africa to be on track to operationalise and achieve the envisaged capacities for water reuse and desalination by 2040, thereby setting the country on a trajectory towards water security. With regards to the RemixWater™ technology, current indications from local experiences show that this technology holds great potential for not only lowering the costs involved with the use of alternative water sources but might also have a positive impact on final quality of the water, thereby promoting the public acceptance of both water reuse and desalination. Furthermore, the lessons learnt from the existing Durban Remix plant will guide the implementation of larger-scale projects around the world.

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