TECHNICAL BRIEF

March 2018
The WRC operates in terms of the Water Research Act (Act 34 of 1971) and its mandate is to support water research and development as well as the building of a sustainable water research capacity in South Africa.

Assessing the provision of water from alternative sources

A Water Research Commission (WRC) study has conducted a comparative lifecycle assessment for the provision of potable water from alternative sources in South Africa.

Background

Water is becoming a scarce resource in many South African municipalities and, as a result, plans are being put in place to deal with increased urban demand for this resource. In the eThekwini Municipality, two methods are currently being considered, among other alternatives, namely the recycling of wastewater and the desalination of seawater.

Advanced plans and designs are being developed and many factors are being considered in this decision-making process, including the environmental performance of these methods. In land-locked South African municipalities which do not have access to seawater, the use and treatment of polluted water, such as mine-water, is a possibility.

This study investigated the environmental burden resulting from three different membrane methods of providing potable water from alternative water sources (seawater, wastewater and mine-water) available in local municipalities, and identifies the main contributions in overall burden of each method, focusing on areas of improvement.

Methodology

In order to gauge the environmental impact of three membrane water treatment processes, an environmental lifecycle assessment (LCA) was undertaken for each of them. A LCA is an analytical tool that is used to determine the potential environmental impact of a product of process by characterising and quantifying the inputs and outputs of a specific system.

In particular, the procedure provides an evaluation of the product's lifecycle from 'cradle-to-grave', i.e. from raw material acquisition through production, use, end-of-life treatment, recycling and concluding with final disposal.

Thus, an LCA can be utilised to quantify the amount of energy used, the consumption of raw materials, emissions to the atmosphere, as well as the amount of waste generated during a product's lifecycle. These inputs (energy and raw materials) and outputs (emissions to air, soil and water bodies) are scaled in relation to a functional unit, which in this case was defined as 1 kl (1 m^3) of treated water at potable water standards, for all three technologies.

All inputs and outputs for the production of water by these three technologies were inventoried and quantified. For these quantifications, mass and energy balances were used. Based on the quantities of these inputs and outputs the potential impacts on the environment were calculated in different impact categories.

The three technologies investigated are based on exiting or planned water treatment plants in South Africa, and three case studies were selected. These three case studies are in early stages of project development and, therefore, improving their environmental performance is possible.

For desalination technology, the desalination plant planned for the south of eThekwini Municipality was used. This project has moved from the feasibility stage into the pilot plant stage, and for this study the data and calculations contained in the feasibility report was used.

Data from the operation and design of phase 1 of an existing mine-water reclamation scheme situated in Mpumalanga was collected to model the environmental impacts of treating mine-affected water.

The eThekwini Municipality is planning to implement membrane treatment of municipal wastewater using Remix technology, which combines wastewater with seawater. This project was selected as a third case study.

The impact categories, on which the environmental performance of the three methods of producing potable water was compared, include global, regional and local impacts. They are as follows: global warming, stratospheric ozone depletion, photochemical ozone formation, acidification, nutrient enrichment, ecotoxicity, human toxicity and waste).

The process of conducting a LCA is iterative in nature and requires the use of a software package capable of modelling large amounts of data. The SimaPro LCA software was utilised for the purposes of this study.

Results and discussion

Environmental scores were generated for the three case studies investigated. For desalination and treatment of mine-affected water, the operation stage of the lifecycle assessment carried the highest environmental burden, with reverse osmosis processes making the highest contributions.

For all three case studies, the energy required for the treatment of the different types of water was the predominant factor determining environmental scores. A direct comparison of these scores is not possible due to the large differences in the design and environmental modelling of the three technologies/case studies investigated. These results show that the main contributor in terms of the environmental impacts from these three technologies can be traced back to the generation of electricity as undertaken in South Africa.

Energy requirements differed with desalination needing about 3.73 kWh/kl of potable water, the membrane treatment of wastewater and seawater needing 2.6 kWh/kl of potable water and the membrane treatment of mine-affected water needing, theoretically, about 2.16 kWh/kl of water treated.

However, the mine-affected water treatment plant, which is the only plant where calculated theoretical data was compared with real, operational data, currently operates with a much lower demand for energy (about 1 kWh/kl of water intake).

As energy inputs were considered quite significant for all three technologies, a series of additional modelling was undertaken in order to estimate whether renewable energy sources improve the environmental performance of desalination and the treatment of mine-affected water. The environmental burden of energy provided from alternative sources (solar and wine-generated electricity) was modelled and showed that the overall environmental scores can be reduced, in particular, by employing solar electricity to run the desalination plant.

Some of the chemicals which are used, or are planned to be used, in the three case studies also have a considerable environmental impact, namely the chemicals used for post-treatment (lime and carbon dioxide for desalination) and for pre-treatment (ferric chloride and biocide for the mine-affected water case study). In the case of Remix technology, sodium hydroxide had the highest environmental burden.

Conclusions

Energy usage is the most important contributor to the overall environmental performance of the processes investigated. The reverse osmosis stage in the operation of the three membrane plants investigated makes the highest contribution in terms of environmental burden.

Environmental improvement can be achieved by making this stage more energy efficient, improving system design, reducing membrane fouling, developing low-energy membranes and using alternative sources of power which have a lower environmental burden.

It is envisaged that the energy efficiency of reverse osmosis will be improved by the development of novel membranes; however, this process needs time. There is also a chemical and technical limit to the improvements that can be achieved with regard to membrane development and the energy requirements of the process.

Therefore, in South Africa using energy efficiency measures (e.g. using variable frequency drives on energy intensive motors) and alternative energy sources for desalination that are based on existing technology should be encouraged as a possible short-term intervention which can achieve the best environmental improvements under current conditions.

Further reading:
To obtain the final report, ***A comparative lifecycle assessment for the provision of potable water from alternative sources in South Africa*** (**Report no. TT 731/17**) contact publications at Tel: (012) 761-9300; Email: orders@wrc.org.za or Visit: www.wrc.org.za.