WATER RESEARCH COMMISSION

October 2009

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.

TECHNICAL BRIEF

Membrane technology

Assessing the impact of water-related membrane research

This study assessed the impact of the WRC's investment into water-related membrane research over the last few decades.

Membrane research – is the return on investment worthwhile?

Water-related membrane research in South Africa has, to a large extent, been driven through funding made available by the WRC. It is generally appreciated that this research has heightened awareness and increased understanding of membranes and also enhanced membrane technology applications under South African conditions.

Membranes are now increasingly being accepted as a viable option in the treatment of water and effluent in South Africa; over 15 local and international companies are marketing membrane-based technologies locally.

Membrane technology is used in a wide range of applications. Examples of water-related applications include its use to clean water for domestic and industrial use, to treat effluent water and concentrate waste streams. Membranes are further used in food and beverage industries to produce the highest quality water needed to ensure compliance with health and safety regulations.

Although it is recognised that membrane research has provided a stimulus for membrane technology in South Africa, the impacts and benefits of membrane research activities have yet to be properly assessed. Consequently, a study was undertaken with the aim of establishing, as far as possible, the economic, social, health and environmental benefits that the research has brought to South Africa.

The *status quo* of SA membrane research

Since the establishment of a dedicated membrane programme by the WRC in the early 1990s, 66 membrane research projects have been funded. These projects have constituted by far the largest proportion of South Africa's membrane research effort.

A rough categorisation of the impact areas of these projects reveals that most contributed to the category **new product and process development**. Projects in this category have often led to the commercialisation of new products. They have further resulted in guidelines that have significantly impacted on operational improvements in the application of membrane processed, helped to decrease fouling and created methods to extend the life of membranes.

The next most projects contributed to the category, **membrane understanding and operation**. While these cannot be rated as high impacts projects, they created new ideas for high impact research and contributed positively to the understanding and operation of membranes in South Africa.

The smallest number of projects has fallen into the category, **knowledge expansion**. Although these have not resulted in new technology or guidelines, they have, importantly, allowed various hypotheses to be tested, knowledge to be expanded and limitations of membrane technology to be revealed.

Membrane products and processes that have been and are being developed through research include:

- ***Ultrafiltration (UF) membranes***: These are used for producing ultra-pure water. Since they are able to remove bacteria from water they are ideal for applications in small rural communities.
- ***Reverse osmosis (RO) membranes***: These are commonly used to desalinate seawater and thereby, to augment available water resources. They are also able to remove bacteria, viruses and some dissolved chemicals.
- ***Woven-fibre microfiltration membranes***: A tubular system, consisting of two layers of a woven polymer material, stitched together to form rows of parallel filter tubes called a 'curtain', is commonly used for water clarification and can also be used for sludge dewatering. A simplified flat-sheet system, designed for immersion in liquid, is a subsequent development suitable for potable and industrial water treatment.
- ***Electroconducting membrane systems***: These use positively and negatively charged membranes to remove particles from the liquid stream and some are able to produce sodium hypochlorite or ozone as byproducts.
- ***Supported liquid membranes***: These show potential for extracting metals such as nickel from liquid streams.
- ***Membrane bioreactors (MBRs)***: Most employ the outer-skinless UF membrane as a bioreactor, e.g. with fungi for bioremediation of wastewater. Flat-sheet woven microfilter units show great promise as inexpensive, robust, immersed MBRs.
- ***Membrane defouling***: Processes used in membrane defouling

include electromagnetic defouling, enzymatic and chemical defouling and surface modification.

- ***Affinity separation***: This is a process that involves extracting 'wanted' elements from the liquid stream through chemical reaction, currently being developed for detection of endocrine disrupting contaminants.
- ***Nanostructured membranes***: Nanotechnology is allowing entirely new and more effective membrane architectures to be engineered and developed.

The outcomes of membrane-related R&D funded by the WRC (typically new membrane products, improved products and guidelines for membrane applications) have, in general, yielded benefits such as job creation, skills development, enhanced membrane use, export opportunities, increased revenue opportunities, improved use of technology, enhanced productivity and best practices implementation of membranes. By considering economic, social, environmental and health impacts of the research outcomes, it is, however, possible to be more specific about the benefits that have been derived from research projects.

Economic benefits

A number of new membrane products that have been developed have subsequently been commercialised. These products are used for the treatment of industrial effluent, providing increased access to water by rural communities and the treatment of municipal waste streams. The development and supply of such products decreases the need to import membranes, reduces the local cost of membranes, creates jobs, generates revenue for the suppliers, creates export opportunities and generally has a positive effect on economic growth.

Based on research outcomes, various products have been developed and sold to the local market. One such product, designed for use in small communities with limited access to electrical power, is a solar-powered RO plant for desalinating salty borehole water. It is simple to use and, once set up, will start automatically when exposed to the sun, providing up to 3 000 ℓ/day of purified water.

Numerous other membrane installations of various capacities are in economically-beneficial, industrial use at organisations such as Eskom, Sasol, Chevron and Anglo Platinum.

Social benefits

Research has focused strongly on producing and commercialising membrane-based water purification units suitable for small community use in rural and coastal settings where there is normally limited or no access to water that is safe to drink and of acceptable quality in terms of odour, taste and appearance. In many remote rural communities the need is to purify brackish groundwater which may also have been contaminated by bacteria and viruses of faecal origin. Along the coast the need, typically, is for seawater desalination to augment limited freshwater supplies. Numerous examples already exist of applications that have strongly benefited the quality of life of the various local communities. Such examples are expected to strongly multiply in number in the foreseeable future.

An additional social benefit of membrane-related research has been capacity building. More than 70 research participants have to date received higher degrees and most of these have entered the commercial sector which, ultimately, is the provider of membrane-based water treatment systems to communities. These former researchers, in turn, pass on knowledge to various associates and beneficiaries during project development and implementation.

Health benefits

Considering the high risk of outbreaks of waterborne diseases attached to consumption of untreated or inadequately treated water, the development of membrane systems that are capable of removing all pathogens from drinking water is bound to have an enormously beneficial health impact. In measuring the impact, the cost of treating waterborne diseases (ultimately borne by the State) as well as the loss of productivity of affected individuals, would have to be taken into account.

Environmental benefits

It has been proven that it is less costly to prevent pollution than it is to treat polluted environments. For this reason, South African water legislation is geared to ensuring that water users consider downstream users and prevent pollution. Through the increased utilisation of appropriate membrane technology developed through research, water can be treated to acceptable standards at the source of pollution and the treated water released into the environment (or re-used), thus reducing pollution.

Conclusion

The majority of membranes used in South Africa are still imported and valuable foreign currency is being spent on them. Through the research funded by the WRC, more opportunities for local companies are materialising and export opportunities are being created. This, in turn, is stimulating local economies and has a significant effect on the social wellbeing of individuals and the health of communities and the environment.

Further reading:
To obtain the report, *Membrane Related Water Research Impact Assessment* **(Report No: TT 366/08)**, contact Publications at Tel: (012) 330-0340; Fax: (012) 331-2565; E-mail: orders@wrc.org.za; or Visit: www.wrc.org.za