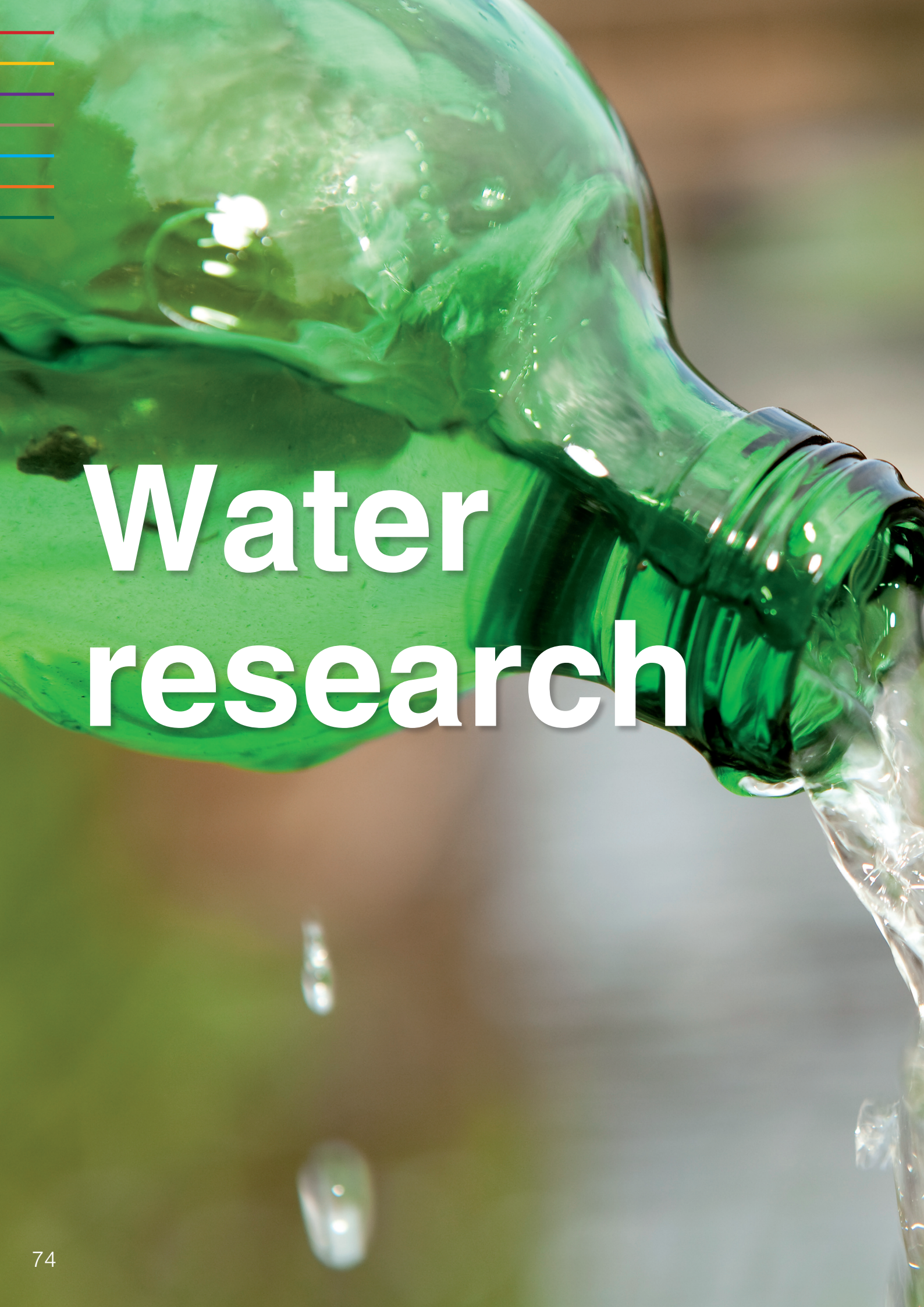

Water research

The Western Cape was recently named the province with the second-purest water, and the City of Cape Town achieved Blue Drop status – an honour reserved for municipalities scoring more than 95 percent in the purity audit. Now, a number of researchers at UCT are joining forces to ensure that it stays that way and to extend water quality across South Africa and the continent.

UCT researchers combine to protect one of South Africa's most valuable resources: water

The amount of water on the Earth has remained constant for more than two billion years. Pour a glass of Adam's ale at your local pub and it is likely that you are consuming particles that have been around since the first life forms.

This cyclic process of our most precious natural resource means that it is vital for us to conserve, preserve and respect our water. After all, would we want our thirsty great-great-grandchildren to be taking in the chemicals, medical residues, and pollutants of today?

With this in mind, water-conscious Capetonians had much to smile about with the release of Water Minister Edna Molewa's Blue Drop report – an annual national assessment of drinking water quality. After an exhaustive 2011 audit of 153 municipalities and nearly all of the country's 931 water plants, the Western Cape ranked as the second-highest performing province in the country. At a metropolitan level, the City of Cape Town retained its Blue Drop status, scoring 98,14 percent. Blue Drop status – the highest category of purity – is awarded only to those municipalities scoring more than 95 percent in the purity audit.

And now, a group of researchers at UCT is working overtime to preserve this status in future, combining conservation, awareness and technological development to maintain Blue Drop status and combat water scarcity.

Waste not, want not

Water research at UCT is a multi-disciplinary endeavour, drawing in some of the highest-ranked academics, many of whom have inspired keen postgraduate students to join them in working towards local water management solutions.

One such academic is internationally renowned expert in wastewater management and NRF A-rated scholar Professor George Ekama, who heads up the Water Research Group – a collection of researchers and academics housed in the Department of Civil Engineering. With more than 30 years' experience in wastewater management, he has been at the forefront of a multitude of water-related developments, but it is his work in biological nutrient reduction research, system modelling, and optimisation that is currently making news.

Working in close collaboration with faculty members and postgraduate students, such as Dr David Ikumi (PhD 2011) and Theo Harding (MSc 2009), Professor Ekama has been developing computer program models that can simulate the entirety of the wastewater treatment plant. Not only are these models fully customisable, with the flexibility to be adapted to any treatment plant with variable data input, they also allow for several groundbreaking – and meaningful – adaptations to data calculations based on current treatment modelling.

"Water research at UCT is a multi-disciplinary endeavour, drawing in some of the highest-ranked academics."

Previous models relied on data prediction that dealt only with individual system components, making the process of gathering a full system report both time-consuming and, often, inaccurate. With Professor Ekama's holistic model, however, engineers are given the ability to estimate accurately the necessary oxygen resources, electricity requirements, and the amount of sludge by-product produced with one integrated system. With the entire wastewater treatment process optimised, energy usage is minimised, water is purified and valuable phosphorus can be gathered, measured, and harvested.

Escalating food prices can often be attributed to the scarcity of phosphorus, one of the most important minerals to be found in fertilisers and the subject of another of the research group's innovative projects. Since urine contains 50 percent of the total phosphorus content of our wastewater, the group is undertaking feasibility studies into how this mineral can be extracted from the wastewater system, with particular emphasis on doing so biologically, instead of chemically.

Professor Ekama proposes a dual distributive system, where fresh water is channelled into the city via traditional steel pipes and, in parallel, seawater is carried in plastic pipes (to negate the effects of rust). The pure water would be pumped to taps and the salinated water would be reserved for sanitary systems such as flushing toilets.

In conjunction with the possibility of designing compartmentalised toilet systems that separate urine

Professor Alison Lewis of the Crystallization and Precipitation Research Unit, who has developed a technique known as eutectic freeze crystallisation to treat acid mine water.

from solid waste, this proposed wastewater management process would not only be able to recover valuable phosphorus contained in urine, but would aid in saving energy and reducing biological footprints across the treatment process. The sulphates found naturally in the salinated water would also help to break down the wastewater, turning the process from one that is aerobic (using oxygen) to one that is anaerobic (without oxygen): that is considered a bonus in that it both reduces costs and is useful in the removal of organic pollutants in the wastewater. The resulting significantly lowered sludge production and reduced energy requirements would make the system sustainable from the dual perspectives of ecological and operational economy.

The numbers certainly add up. But will Capetonians be comfortable with the construction projects required to implement a dual pipe system in the city, let alone the suggestion of compartmentalised toilets? While Professor Ekama recognises the possibility of social resistance to both models, he remains firm that change is not only possible but, indeed, inevitable. "The time for convenience is over," he argues. "We have to be more aware of our environmental impact and make small changes to our behaviour to reduce our environmental burden."

This research carries within it the promise of uniquely aligned economic, ecological, and social benefits. International attention has certainly been showered upon Professor Ekama's findings, with his research into alternative uses for sea water having recently won an award for Excellence and Innovation in Water Engineering Projects from the International Water Association (IWA).

Professor Ekama and his group have also co-authored four of the IWA's scientific and technical reports on activated sludge modelling, community analysis, and secondary settling tanks. In addition, he has been a visiting professor at Virginia Tech, the University of Padua and the UNESCO-IHE Institute for Water Education in The Netherlands. Such is his standing in the international community, that he is one of only a few environmental engineering professors listed on Thomson Reuters (ISI) Highly Cited Research website.

Collective Culture

Down the hall from the Water Research Group, Professor Neil Armitage, Professor Ekama's colleague in Civil Engineering, and others are also making contributions to the discipline well beyond South Africa's borders.

The inter-disciplinary Urban Water Management Group pools the perspectives and resources of academics from various departments and seeks to find integrated, sustainable solutions to water management problems, particularly as they affect Southern African communities. Professor Armitage is also the only African representative

Research grouping associated with this theme

■ Crystallization and Precipitation Research Unit

Industrial crystallisation research began in the Department of Chemical Engineering in 2000 and the Crystallization and Precipitation Research Unit was formally accredited by UCT in 2006. Although crystallisation and precipitation are some of the oldest unit operations known, understanding of these processes is still very limited. In this context, the main aim of the unit is to advance existing fundamental knowledge in the fields of crystallisation and precipitation, especially related to mineral processing and extractive metallurgy. Particular interests of the research group are modelling and simulation approaches to industrial research, such as the particle rate process approach for modelling of industrial crystallisation processes, aqueous chemistry modelling, and computational fluid dynamics modelling. All these modelling techniques are aimed at deepening the understanding of these chemically complex, multi-phase processes. The ultimate objective of furthering this scientific understanding is to optimise and control industrial crystallisation and precipitation processes, including treatment of effluent streams. Another interest of the research unit is the development of eutectic freeze crystallisation (EFC) for the treatment of hypersaline mining brines. The unit is also involved in the development and presentation of various continuing professional education courses that satisfy the demand for skills in this area, from both an industrial and an academic standpoint.

Director: Professor A.E. Lewis *E-mail*: Alison.Lewis@uct.ac.za *Web*: http://www.chemeng.uct.ac.za/research/crystal/ or http://www.crystal.uct.ac.za

on the joint committee on urban drainage of the International Association of Hydraulic Engineering and Research and the IWA.

Among the group's chief participants are Professor Andrew Spiegel from the Department of Social Anthropology and Dr Kevin Winter from the Department of Environmental and Geographical Science. As Professor Spiegel notes, "Inter-disciplinarity is crucial. My work over some years with Professor Armitage and Dr Winter has provided me with certain insights into the technical problems engineers face, but without my having to become an engineer or environmental scientist myself. It has also enabled the two of them to begin to understand the centrality of social science approaches to facilitating the kinds of interventions they plan."

The group is currently occupied with two major projects, one concerning creating alternative sewerage systems, with a particular focus on informal settlements, and the other on water-sensitive urban design. Both are partially funded and fully endorsed by the Water Research Commission.

It is common knowledge that sewerage systems in informal settlements have been the cause of many divisive actions and debates. The Urban Water Group is seeking to change that by focusing their collaborative approach on a sustained monitoring, evaluation, and development project that has the potential to impact 300 to 400 informal settlement sites. Based chiefly in the Barcelona settlement of Gugulethu for the past four years, the project attempts both to understand why the installation of flushing toilet systems in townships tends to be operationally unsuccessful, and to provide a workable model in the near future.

The group proposes to pilot a settled sewerage scheme in the Barcelona district, where specially designed tanks will filter out solid waste. Key to the project's success will be fostering a janitorial relationship with the City of Cape Town in order to retain facility maintenance. In support of the group's research, the Bill and Melinda Gates Foundation has made funding available for two university fellowships over the next few years to tackle the challenges that lie ahead, including navigating the necessary municipal processes, and addressing the shortage of trained personnel at maintenance level.

Their second ongoing research project works with the International Sustainable Drain System project – a Construction Industry Research and Information Association (CIRIA) initiative. The group is seeking alternatives to conventional storm water drainage systems by creating more eco-friendly drainage solutions. All three researchers have drafted a document laying out national guidelines and best practice for water drainage systems, currently in its final draft prior to publication.

There can be no doubt that creatively fostering collective solutions can combat collective problems. As Professor Armitage explains, "Our projects seek to re-imagine Cape Town as a space where water is seen as the city's most valuable resource."

That's a vision that the likes of Professor Alison Lewis, Director of the Crystallization and Precipitation Research Unit at UCT, and Associate Professor Ulrike Rivett, head of the UCT research team of Information for Community Oriented Municipal Services (iCOMMS), share. Both have contributed, through their research, to securing the quality of valuable water resources.

"The valuable mentoring that these leading researchers provide is creating rising research stars, with postgraduate students increasingly making a splash on the scene."

Professor Lewis and her team devised a means to treat acid mine water, so that it is "good enough to drink". In her technique, known as eutectic freeze crystallisation, the contaminated water is frozen to a point where clean water can be recovered as ice, while usable salts can also be extracted from what was toxic and wasted acid mine water.

"It's an environmentally friendly and cost-effective technology that can be used in a wide range of industrial sectors that pollute water and thus produce brine," says Professor Lewis.

Associate Professor Rivett, meanwhile, is using mobile technology to protect water quality. Her group has developed a number of mobile applications that work on cellphones to support municipalities and give them the tools to easily and cost effectively monitor the quality of the water supply that they have a constitutional obligation to deliver.

The work of both Associate Professor Rivett and Professor Lewis is described in detail in the Innovation section of this report.

Ripple effect

Of course, water research at the university is not limited to senior academics. Rather, the valuable mentoring that these leading researchers provide is creating rising research stars, with postgraduate students increasingly making a splash on the scene.

Master's degree candidate Raymond Siebrits is one such student. A scientist with a passion for target-driven research, he created the Aqua d'UCT project, recently awarded full support by the Water Research Commission. Aqua d'UCT aims to gather, analyse, and disseminate data from targeted water stakeholders ranging from academics, funders and NGOs to government institutions at a national level. Siebrits seeks to identify the most pertinent research issues in the field and identify common problems experienced across a range of water-focused disciplines.

The Urban Water Group at UCT is seeking alternatives to conventional storm water drainage systems by creating more eco-friendly drainage solutions.

Other PhD candidates, such as Jeremy Shelton, continue to champion research in freshwater ecology. His work investigates the community-level effects of non-native trout in the headwater streams of the Cape region, monitoring invasive species' effects on Cape Town's natural freshwater system. "Nowhere is water-related research as important as on a dry continent like Africa," he says. "Our knowledge about the functioning of freshwater ecosystems in South Africa is critical to the smart management of our freshwater resources and the many life forms that depend on them."

Water researchers at the university believe strongly in combining collaborative undertakings with department-specific project focus areas. There is also a strong emphasis on pairing up-and-coming talent with leading specialists. And, most importantly, they share a key vision: helping our two-billion-year-old liquid legacy to survive going forward.