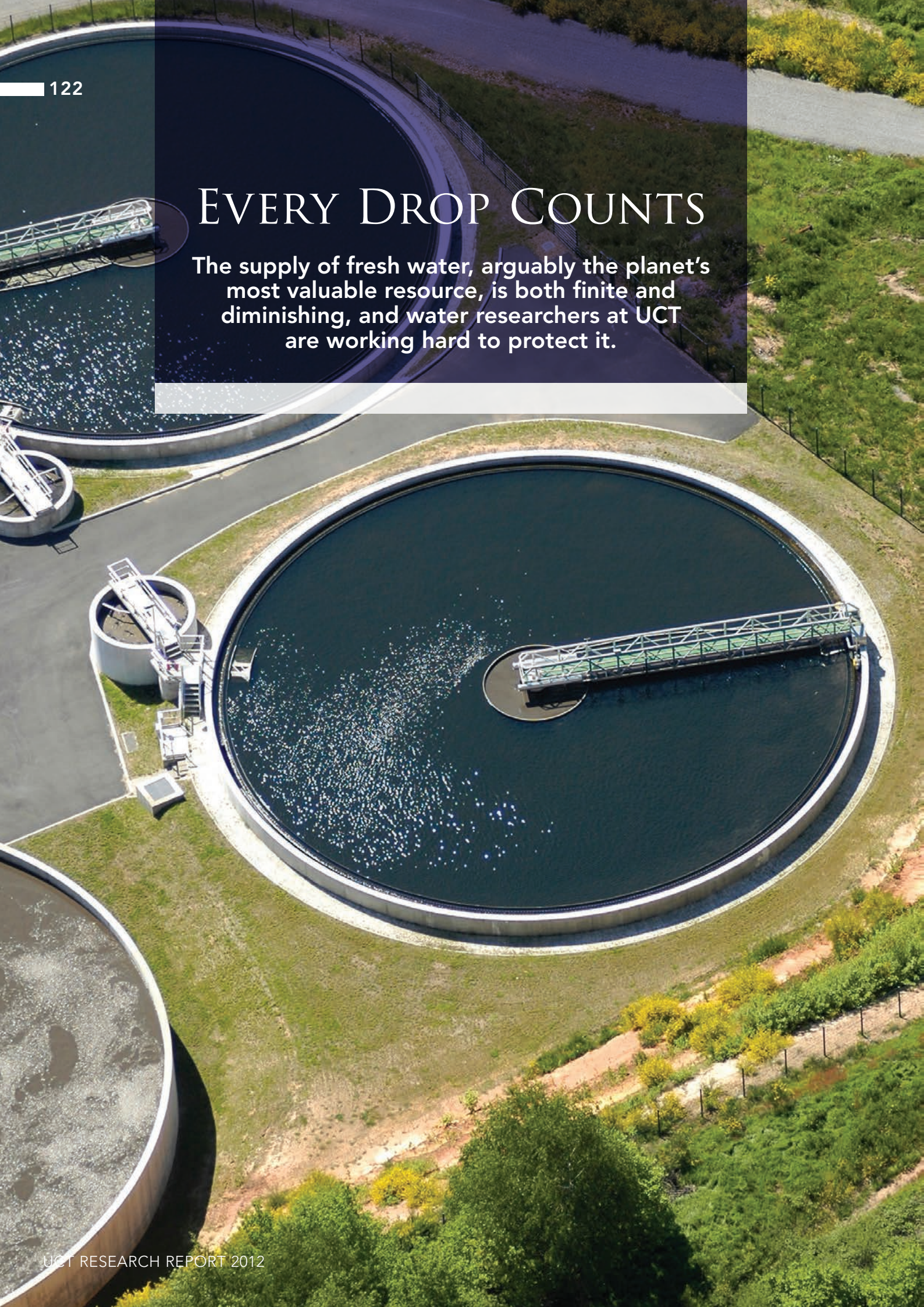
Every Drop Counts

The supply of fresh water, arguably the planet's most valuable resource, is both finite and diminishing, and water researchers at UCT are working hard to protect it.



As a rapidly urbanising country, South Africa faces multiple water challenges, including shortages, the growing burden of wastewater produced by the emergent and urbanising population, and the expanding and varying trajectory of the resource-based industrial sector, associated environmental issues, and fragmented and complex institutional structures.

Amongst the results of increased pollution are elevated salinity levels and nutrient enrichment (higher concentrations of nitrogen and phosphorus in water). The deteriorating quality of South Africa's surface and groundwater resources is particularly challenging as these supply systems underpin social and economic development in the country and impact directly on ecosystems. Water security is therefore of particular concern and climate change, water scarcity and water quality have the potential to worsen systemic water shortages over the medium to long term. Addressing these issues require ongoing inter-institutional and interdisciplinary research and the continuous improvement of the governance of water to ensure a successful transition towards water sensitivity, thereby building towards the nation's social, environmental and economic well-being.

Water research at UCT is a multidisciplinary endeavour, drawing in some of the highest-ranked academics across departments and faculties, many of whom have inspired postgraduate students to join them in working towards local water-management solutions. However, 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 consistently achieving accolades for their contributions. This can be attributed to the sharing of a fundamental vision to optimally manage the survival of this precious resource.

State-of-the-art

Water Laboratory In The Pipeline

Recognising that water is a national resource under considerable stress, UCT is committed to ensuring that it is optimally managed in all sectors and at all levels within the country.

Demonstrating this commitment, the university will, through the Crystallization and Precipitation Research Unit (CPU), establish a new laboratory with the capacity to provide a comprehensive service to water researchers. The H2O (aq) laboratory is expected to open in the Department of Chemical Engineering, possibly in 2013, and will feature a combination of new and existing research practices. The nature of the water research undertaken by the CPU already focuses on novel techniques for water treatment.

H_2O (aq) will offer specialist water and brine analysis, as well as research. The intention is to be able to offer a service to researchers who are investigating various water-related questions; in other words, it is not a standard water-analysis laboratory. For example, the laboratory will accommodate a researcher looking at how different river contaminants affect the aquatic life, a researcher investigating the effect of trace metals on water-treatment processes, and yet another studying the effect of water composition on concrete corrosion of bridges. Over the last decade, water analysis has become increasingly technical and, as such, requires the use of state-of-the-art equipment and fewer wet-chemistry techniques (although wet chemistry does still have a place). H_2O (aq) will use Inductively Coupled Plasma-Mass Spectroscopy (ICP-MS) for metal analysis, High-Performance Liquid Chromatography (HPLC) and spectrophotometry for anion analysis, and total organic carbon for bacterial tests, but the basic tools, such as pH testing and conductivity, will also be utilised. It is expected that such analyses will lead to multidisciplinary research projects and also to collaborations across faculties and between the projects through the common theme of water.

Drinking Acid Mine Water

The philosophy of Professor Alison Lewis, Director of the Crystallization and Precipitation Research Unit, is that researchers need to consider both water and its contaminants as resources, and to design processes that recover both.

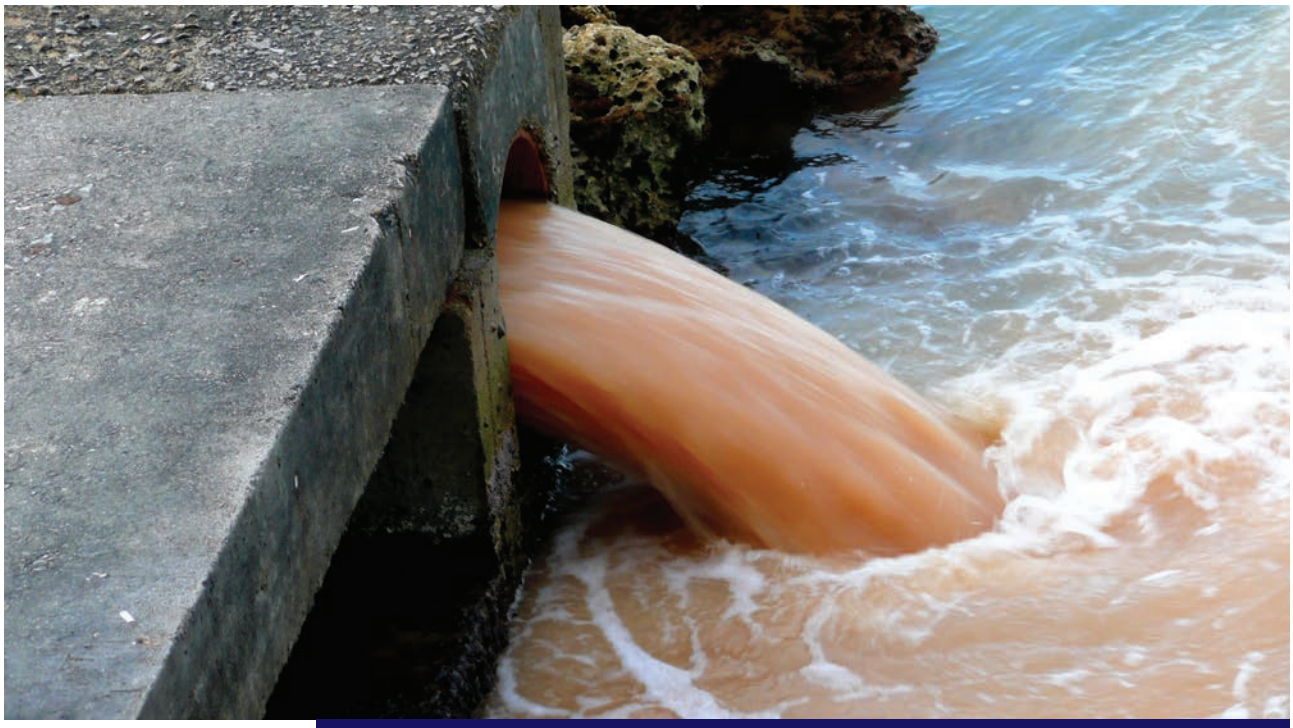
Master's student Michael Kapembwa

With this in mind, she and her team have devised a means of treating acid mine water so that it is 'good enough to drink', and are taking one step closer to achieving the goal of water security, one of the most significant challenges facing the country. In her technique, known as Eutectic Freeze Crystallization (EFC), the contaminated waste stream is frozen to a point where both ice and salt are formed – ice is the form in which water is recovered. For this reason, it is important that the ice formed is pure to ensure that good-quality water is obtained. The process, which is both environmentally friendly and cost-effective, also allows for usable salts to be extracted from the toxic acid mine water. It can, furthermore, be used in a broad range of industrial sectors that produce wastewater.

Master's student Michael Kapembwa won an award for the Outotec "Sustainability in Mineral Industry" best paper presentation at the Southern Africa Institute of Mining and Metallurgy-SAIMM MinProc 2012 workshop for his paper *Ice growth mechanisms in electrolyte aqueous solutions*. Michael was born in Luanshya, a small mining town in Zambia, and completed his primary and secondary education in Livingstone. In 2009 he graduated with a bachelor's degree in Metallurgy and Mineral Processing from the University of Zambia. After working at different mines in mineral processing and hydrometallurgy and in a full-time job with Non-Ferrous Africa Mining Cooperation as a Metallurgist (Foreman), he decided to join the Crystallization and Precipitation Research Unit to further his studies in chemical engineering with a focus on wastewater and mining brine treatment.

Paying for Storm Water?

Professor Neil Armitage of the Department of Civil Engineering and director of the interdisciplinary Urban Water Management Group, is accustomed to pooling the perspectives and resources of academics from various departments to find integrated, sustainable solutions to water-management problems, particularly as they affect Southern African communities. Professor Armitage is also the only African representative on the joint committee on urban drainage of the International Association of Hydraulic Engineering and Research and the International Water Association.



In a recently completed project, Professor Armitage and PhD student Lloyd Fisher-Jeffes examined the possibility of charging for storm water in South Africa. While this may seem incomprehensible and possibly even nonsensical, it should perhaps be viewed in the context of the social, economic and environmental impacts of poor water quality on South Africa's urban aquatic systems, which are increasingly being highlighted by the media. Improving the water quality in these systems will require catchment-wide strategies, including the monitoring and management of point and non-point source pollution collected in storm water. Significant costs may be incurred; however, international experience suggests that these are outweighed by the benefits.

Municipalities across South Africa charge their citizens for potable water and sewerage. Storm-water management, however, is generally funded through municipal rates. Competition with other pressing needs frequently results in the storm-water departments being significantly under-funded – at times only receiving a tenth of what is required for water-quantity management. Internationally, an increasing number of cities have introduced a direct charge for storm-water management in order to secure the funding required to manage storm water and its associated water pollution, and to serve as a disincentive to polluting practices on the part of landowners. The study has found that, in order to ensure adequate funding for storm-water management in South Africa, municipalities will need to consider charging for storm-water management based either on an Equivalent Residential Unit or a Residential Equivalent Factor, combined with an appropriate discount scheme for on-site storm-water management. This project was supported by the Water Research Commission.

Urban Water Management

Urban water management – and the impacts that rapid population growth, industrialisation and climate change are having on it – is gaining increasing attention worldwide.

In South Africa, cities are under pressure to respond not only to the challenges of water availability and quality, but also to economic transformation and social division. New solutions for improving the sustainability of cities need to be found, including the development of tools to guide decision-makers. Several benchmarking initiatives have been implemented in the South African water sector – mostly in terms of performance measurement of specific water services for regulatory purposes – but none provide an integrated analysis to enable a deeper understanding of sustainability.

The research undertaken by Dr Kirsty Carden and Professor Neil Armitage focused on using a systems approach to create an understanding of, and measurement of the potential for, sustainability in a South African urban water context. The research resulted in the development and evaluation of a composite index, the Sustainability Index for Integrated Urban Water Management (SIUWM). The first step involved compiling a vision of sustainability for the South African water sector, and expanding it into a sustainability framework to help identify suitable indicators for the assessment process, as well as those which link with existing measurement initiatives. Key performance indicator results from the Department of Water Affairs' Regulatory Performance Management System and the Blue Drop/Green Drop schemes were used as partial input to the SIUWM, and scores were computed for the nine member cities of the South African Cities Network. The SIUWM links the results from the regulatory systems with a broader sustainability assessment process to provide a more detailed analysis which can be used to establish goals and inform strategic processes to leverage support for improved water services. In this way, the connections that link the different aspects of urban water management can be used to generate a greater awareness of the underlying issues by key decision makers and thus guide appropriate action.

Research Project

Social Norms and Moderation of Water Consumption in Cape Town

A study by master's student Grant Smith and Associate Professor Martine Visser of the Environmental Policy Research Unit involved testing a strategy of managing water consumption by delivering comparative norms-based reports on water use to households in the city of Cape Town.

In doing this, they assessed, by means of a randomised control trial, the various behavioural elements usually involved in such a strategy. The aim of the study was to influence consumer behaviour by using behavioural interventions rather than using price mechanisms. The results are encouraging in that they strongly suggest that behavioural elements may be leveraged in order to reduce household water consumption at the municipal level. Although the savings were roughly 1% of total water consumption, they were significant. Across a municipality, such savings would certainly be meaningful in relatively water-scarce months. Of the treatments considered, it was the method that utilised a simple comparative social-norms strategy which yielded the most consistent water saving. This is the first study that illustrates the impact of social norms on demand for water for a developing country.

Research Groupings
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.

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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, multiphase 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 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.

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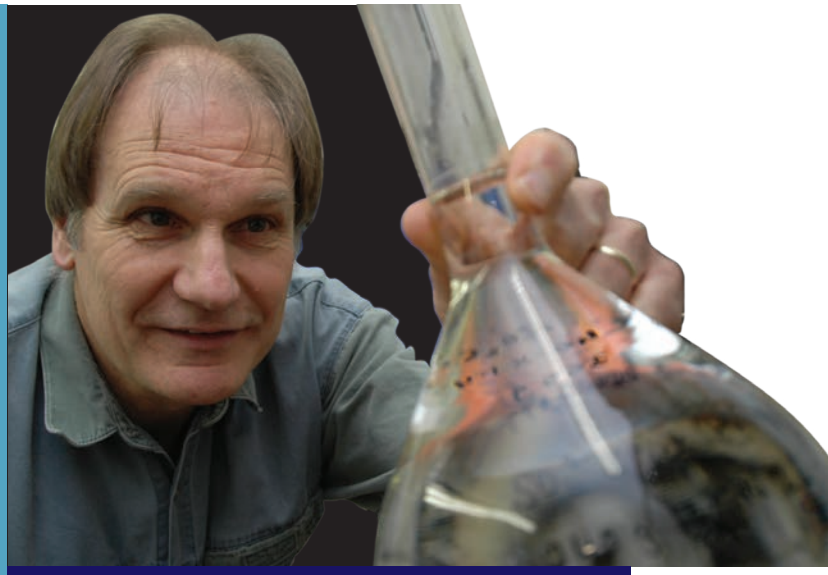
International Award for Professor George Ekama

Working in close collaboration with faculty members and postgraduate students, NRF A-rated Professor George Ekama has been recognised internationally for his research that has provided innovative solutions to enhancing and improving wastewater treatment and, in so doing, has helped South Africa find answers to its water-shortage problems. He lives by a simple research credo: "Locally inspired, globally relevant".

Professor George Ekama was part of an international team which received a Global Grand Honour Award in the Applied Research category at the 2012 Project Innovation Awards for their project "Making use of seawater as an alternative resource". His team members were representatives from Hong Kong University of Science and Technology, Hong Kong Airport Authority, Hong Kong Drainage Services Department, and Delft University of Technology. The Project Innovation Awards Programme was established by the International Water Association (IWA) in 2006 to recognise excellence and innovation in water-engineering projects throughout the world. The awards programme supports IWA's goal to "connect water professionals worldwide to lead the development of effective and sustainable approaches to water management".



Professor Ekama is to be awarded in Silver, the National Order of Mapungubwe, by the Presidency of South Africa in 2013. The Order will recognise Professor Ekama's research excellence and exceptional achievements which have benefitted communities in both South Africa and beyond.

Water, food, energy and sanitation are basic humanity needs. Nevertheless, water scarcity, water pollution, global warming, and food shortages are affecting many parts of the world. Although the planet has plenty of water, 97% is in the ocean, which is too salty for human consumption. The aim of the research is to make use of seawater as an alternative resource of water, energy and fertiliser through an integrated Triple Water Supply (TWS) System, the SANI (sulfate reduction, autotrophic denitrification and nitrification integrated) Process and the Urine Phosphorous Recovery (UPR) System. The TWS System integrates freshwater supply, seawater supply for toilet flushing, seawater-based cooling and grey-water reuse as an integrated water-supply and sanitation system. This has been applied in the Hong Kong International Airport, saving 52% of its freshwater demand and 30,000 MWh of electricity annually.

Making use of sulfate originating from seawater, the SANI Process introduces a sulfur cycle into the carbon and nitrogen cycles for sewage treatment. Sulfur acts as the electron carrier for passing the electron from organic carbon to oxygen through heterotrophic sulfate reduction, autotrophic denitrification and autotrophic nitrification. As all the three biochemical reactions produce minimal sludge, the SANI process effectively minimises sludge handling and disposal, which can save 50% of cost and one-third of energy consumption. Making use of the magnesium ion in seawater, the new UPR technology recovers phosphorus from urine in the form of magnesium ammonium phosphate, a valuable phosphorus and nitrogen containing fertiliser, by mixing hydrolysed urine with seawater. While the TWS, SANI and UPR systems can be applied individually, the integrated system would provide the greatest financial and environmental benefits, especially for islands and coastal cities of developing countries.

Professor Ekama has published over 150 research papers together with his research group have been co-authors of four of the IWA Scientific and Technical Reports on activated sludge modelling, community analysis and secondary settling tanks. He has been a visiting professor at Virginia Tech, the University of Padua and the UNESCO-IHE Institute for Water Education in the Netherlands. He is one of only a few environmental engineering professors listed on Thomson Reuters (ISI) Highly Cited Research website.