WATER PERSONALITY

South Africa's 'professor of toilets' helps to drive global water-saving plans

The Durban-based Pollution Research Group has established itself as a world-leader in water conservation and pollution research – especially through its drive to re-invent toilets, save water and develop better sanitation solutions for poor communities and the environment. Prof Chris Buckley spoke to Tony Carnie about how it all started, and the journey still ahead.

Tony Carnie

The nascent Pollution Research Group (PRG) began to bubble back in the early 1970s, housed in the Chemical Engineering building at the former University of Natal in Durban.

Nearly 50 years later – but now in the subterranean basement – the university's world-acclaimed contract research group has grown considerably under the co-leadership of Prof Chris Buckley and Susan Mercer.

Now aged 70, but still sprightly and brimming with ideas, he has supervised more than 100 Masters and PhD students at the PRG, and for several years has been among the University of KwaZulu-Natal's top grant-holding fund raisers.

In the mid-1960s, Prof Buckley obtained a student loan from the old Durban Corporation to study chemical engineering, later entering the cavernous main laboratory to launch his fourth-year project: finding ways to reduce the volume of industrial dyes in textile effluent. Buckley recalls that as a youngster, he was placed in the "D class" at Westville Boys' High School, where he enjoyed geography and book-keeping (accounting).

"I was no good at learning subjects like history or Latin, and my spelling and writing were terrible (and still is) . . . But I could add up pounds, shillings and pence just by running my fingers down a column of numbers."

Tony Carnie

Buckley with a framed photo of the 1970 crop of final-year chemical engineering students. He has been based in the same building ever since.

To pay back part of his student loan, he was required to spend his vacations as an underling in various divisions of the local municipality.

"You would be apprenticed to a welder or a diesel mechanic; in the roads, construction or water works departments and you were the lowest of the low. They gave me a Land Rover and I would spend my days driving around the city collecting water samples from the Umlaas River or municipal swimming pools and dropping them off for lab analysis. It was pretty routine stuff, but I got to see parts of the city most people never get to."

After completing a MScEng partially based at the Southern Wastewater Treatment Works on the filtration of sewage sludge Prof Buckley started work on his PhD thesis on the filtration of compressible sludges, but never completed it.

"There were just so many other far more interesting things to do," he says.

It was around this time that the newly-established Water Research Commission (WRC) began to fund a series of water pollution research projects at the then University of Natal. Prof Buckley was already attached to a similar research group established by AECI (African Explosives and Chemical Industries), but soon moved over to join the university's new Pollution Research Group, which was now funded for contract research by the WRC.

Prof Buckley took over leadership reigns in 1985, and was appointed as the full-time head in 1987. During these early years, his research focused on reducing water pollution and energy costs in the textiles industry, later moving towards waste minimisation and cleaner production in metal finishing, metal processing, mining, petrochemicals, sugar, beverages and power plants.

Clients included Eskom, Sasol, several textile groups, Tongaat Hulett and Iscor. "Each project increased our knowledge and experience and we started to get quite a lot of repeat business for our contract research work."

But it was the WRC, he says, which played a central role in sustaining the development of the PRG. "I can't recall a single year since the mid-1970s where we have not had some form of funding from the WRC. Without that continuity of funding, which kept us going, our people would have disappeared. It meant that we did not have to keep writing new funding proposals each year, because we had a retainer and this allowed us to develop a clear vision.

Tony Carnie

Ncebakazi Ngubane collects dried faecal pellets from a LaDePa machine, a laboratory-scale version of a device which extrudes faecal sludge into pelletised form which is then heated at high temperature to inactivate pathogens.

"At the beginning, the PRG was tiny – just three or four people. We gradually expanded a bit, and for many years there were generally less than eight people (compared to almost 35 salaried staff today). At one point we had three people called Sue working for us (Sue Mercer, Sue Winship and Sue Wadley). There seemed to be so many Sues around that we renamed our office the 'Sue-wer'," he chuckles.

It was a nickname that captured the often mischievous sense of humour of the maverick professor, and the PRG's growing research focus on better ways of dealing with poop and reducing water waste. Two decades ago, the collection and management of human urine and faeces was not an issue that many academics really wanted to get involved in – but that was not the PRG's approach.

"I guess our work takes a special sort of enthusiasm and quite a bit of cajoling, but now we are the go-to people for data in this area, along with testing and development of new sanitation solutions.

"Bear in mind that about 35% of the water used in most households gets flushed down the loo – and one of the reasons for this is that some of the first flush toilets were developed in the 1800s, and their design was shaped by the need to have a 4-inch diameter outlet pipe."

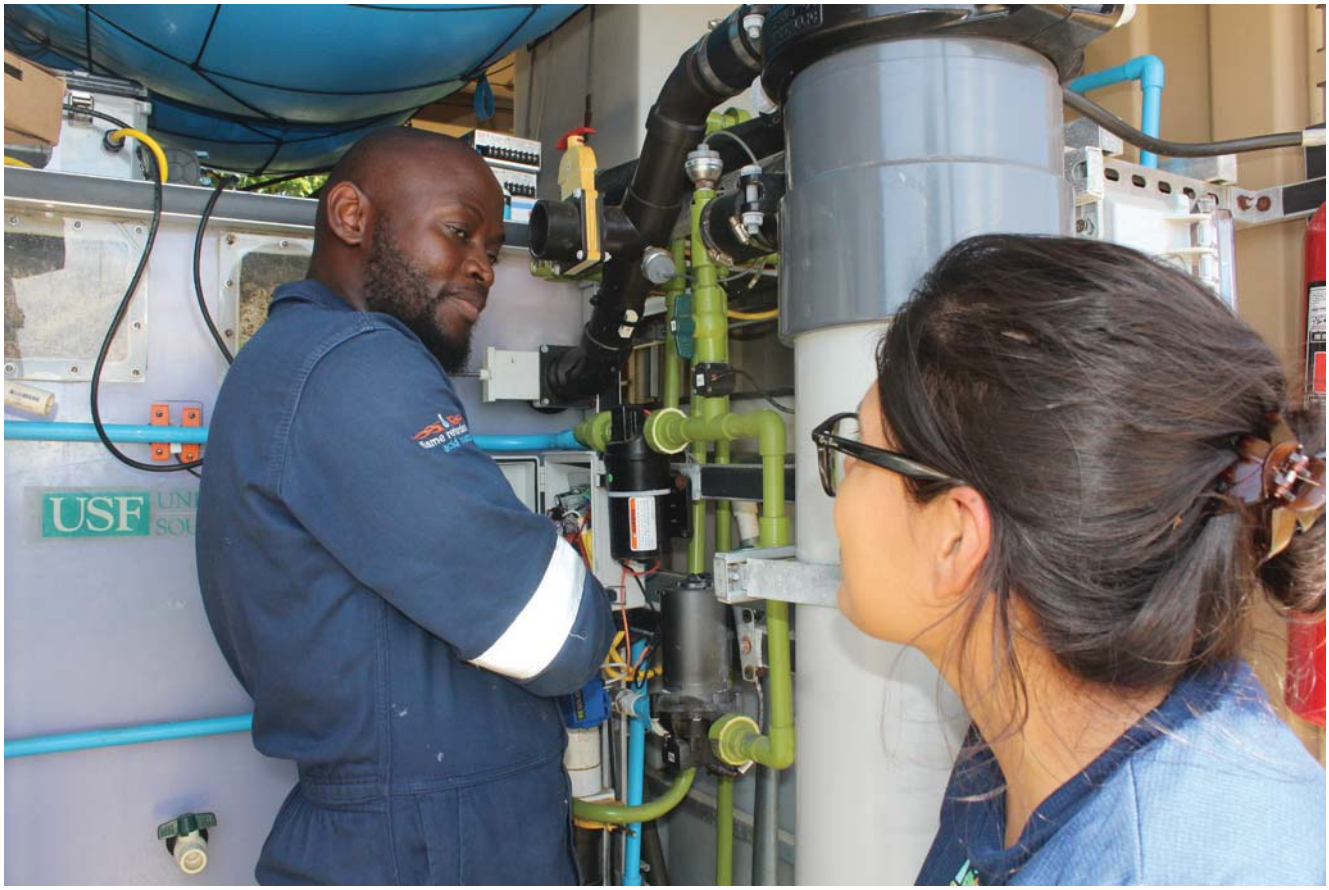
This was because early pipe glazing techniques were determined by the width of a glazier's hand. This resulted in large diameter pipes and correspondingly large volumes of water being used to flush the u-bend effectively.

Such historical anachronisms, Prof Buckley observes, can be perpetuated in design for centuries – much like the narrow gauge of several modern railway lines, which some historians say can be traced back to the width needed to accommodate the backsides of two horses pulling a Roman war chariot.

Now, with clever modern technology and re-engineering, Prof Buckley says it is possible to re-design toilet pedestals to use as little as 1.5 litres to flush away faeces – compared to the 10 litres used in some of the older chain-pull toilet cisterns. "In a water scarce country like South Africa we need to keep squeezing down the volume of water wasted on toilet flushing."

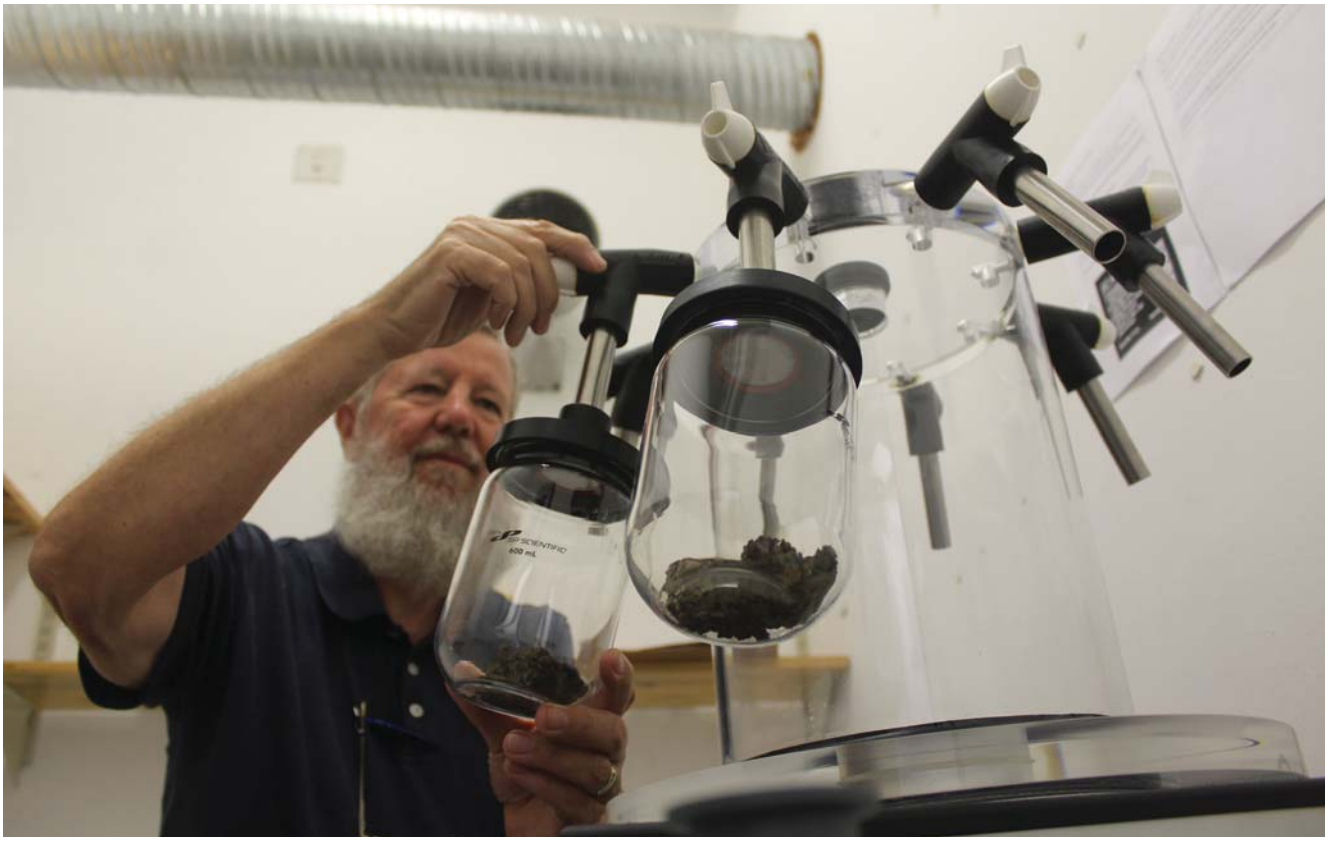
The PRG's more recent focus on sanitation and toilet design dates back to the mid-1990s, when Prof Buckley's group and the Ethekwini Municipality began to work together with funding from the WRC on an anaerobic baffle reactor to digest human waste at the Umbilo Wastewater Treatment Works. Later, the PRG and Ethekwini also collaborated on the design and operation of ventilated pit latrines and urine diversion toilets.

During this collaboration, a question arose on whether the solids (sludge) from urine diversion toilets could be used to grow trees and vegetables or to manufacture agricultural fertilisers.



Tony Carnie

PRG engineer, Lindelani Xaba, and University of South Florida postdoctoral scholar, Dr Cynthia Castro, discuss the operation of a prototype water-saving system at a community toilet block in the Durban North area. The system, designed by the University of South Florida, saves water by passing wastewater through an anaerobic digester and advanced membrane filters. The recycled water is used to flush toilets



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Prof Chris Buckley prepares faecal samples for freeze-drying in the PRG laboratory.

Prof Buckley suggested that the best way to find out was to do actually do it, and the Ethekwini Water and Sanitation Unit decided to provide the funding and equipment to establish a test site.

The PRG leader is a firm believer in the dictum that you need to practise what you preach, when testing new toilet designs. Thus, in 2008, he installed a prototype version of a modernised 'thunderbox' in the back garden of his home in Westridge, Durban. This toilet was designed to separate human urine and faeces at source as a means to reduce the volume of effluent entering municipal sewage treatment works and also to turn poo and pee into valuable commercial resources.

Prof Buckley and his students tested it for more than a year – a tradition that continues today at the PRG, where nearly 20 prototype toilet systems are being tested and developed as part of the Bill & Melinda Gates Foundation "Re-invent the Toilet Challenge".

During a recent visit to the PRG headquarters, Prof Buckley took me on a tour through the basement and showed me many things – including a much-improved urine diversion pedestal developed by the Vienna-based EOOS Design Studio. Near the entrance there is a Biosafety Level 2 warning sign – as well as an Uncle Sam sign (adapted from a 1917 US wartime poster) exhorting staff and visitors to the PRG to test-drive the latest prototype for the benefit of science.

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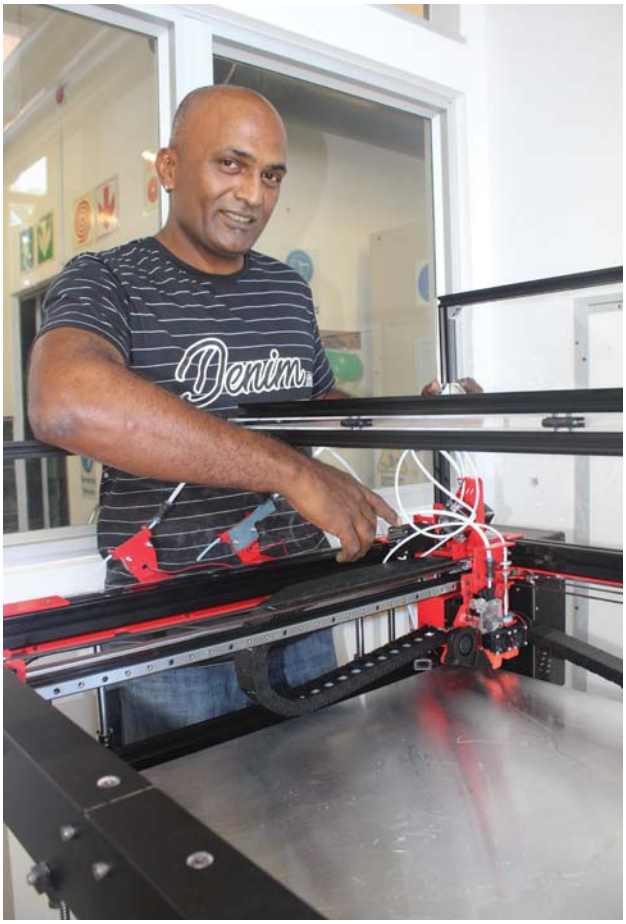


PRG technician, Christy Govender, busy installing a 3D printing machine that will be used to manufacture a variety of prototype toilet pedestals.

Elsewhere in the basement, technician, Christy Govender, was busy installing a 3D printing machine that will be used to 'print' a variety of new toilet pedestals, while lab technician, Thabiso Zikalala, was collecting faeces samples from a refrigerated archive for further analysis.

Fellow lab technician, Ncebakazi Ngubane, helped to explain the workings of a large, red "LaDePa" machine (**La**trine **De**hydration and **Pa**steurisation), a laboratory-scale version of a device which extrudes faecal sludge into pellets which are then heated at high temperature to destroy or inactivate pathogens and intestinal parasites such as the Ascaris egg. The objective is to process the organic, nitrate and phosphorous components of faecal waste streams into farm fertilisers, or alternatively, as a new source of biofuel.

Neil Macleod, former head of the Ethekwini Water and Sanitation Unit, has commented previously that: "We recognise faeces and urine as potential sources of nutrients and energy, rather than as material to be 'avoided at all costs' and kept as far away from people as possible. This pelletiser is part of a series of interventions to recover nutrients from human waste and then recover energy from what is left."

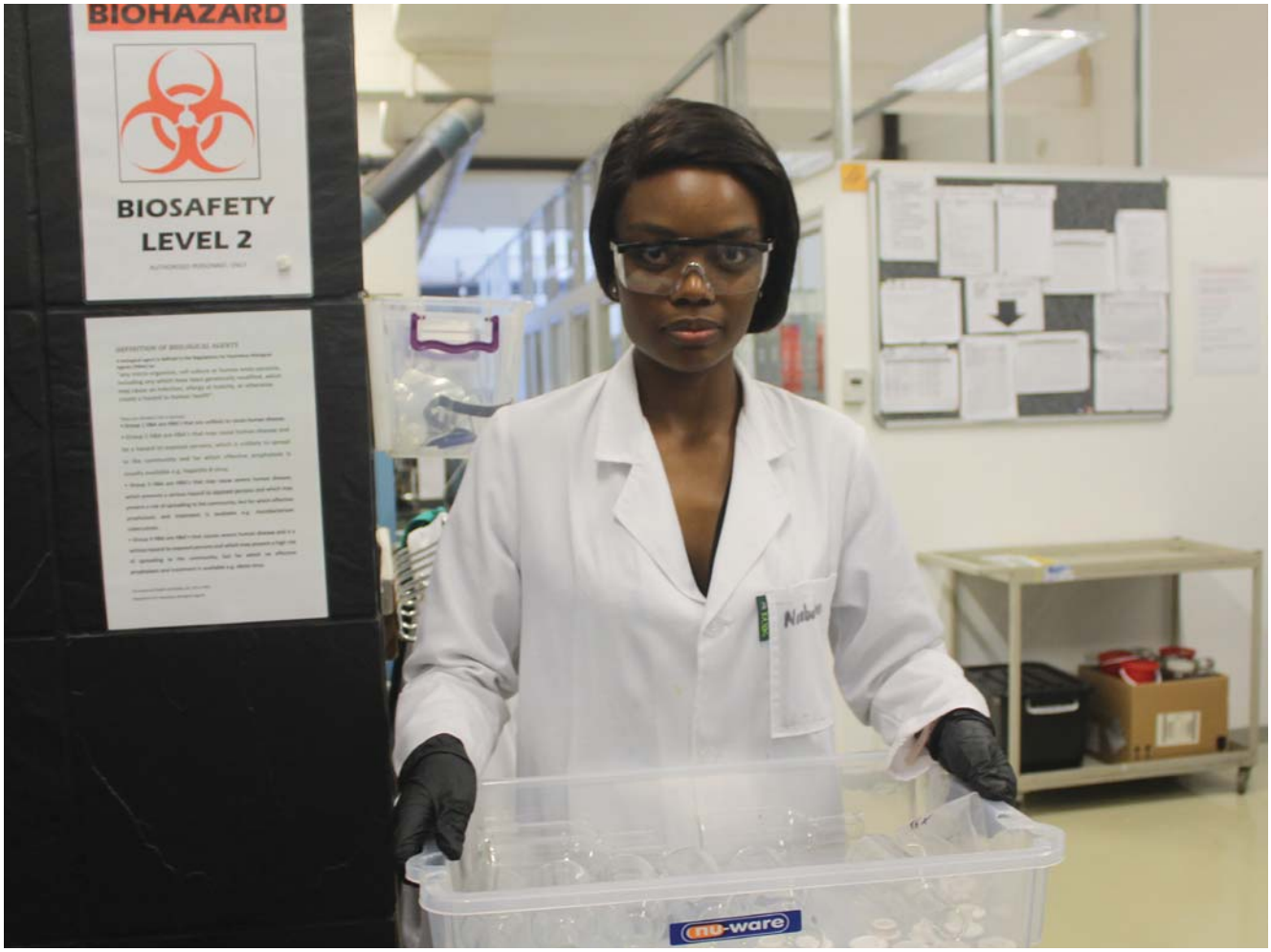
Much of this research would not have be possible, however, without extensive financial support from the WRC and the Bill & Melinda Gates Foundation. Gates visited Durban in 2004, and Prof Buckley and municipal officials spent three days guiding him and other senior foundation officials around several dense informal settlements in Durban to showcase a variety of innovative sanitation projects.

Prof Buckley fretted that those three days might come to naught, but he was later invited to Seattle to develop a detailed funding proposal and in 2011, the PRG landed a US$400 000 grant to advance global toilet technology through the foundation's global "Re-Invent the Toilet Challenge". Yet, technologies developed in a laboratory still have to be proven to work in the real world.

So we hop into Prof Buckley's late-1980s model Toyota Corolla sedan for a guided tour of some of the PRG technology demonstration projects, including several informal settlements which lack formal electricity or sewerage networks. At one such project, we meet PRG engineer, Lindelani Xaba, and visiting postdoctoral scholar, Dr Cynthia Castro, who are busy evaluating the performance and operation of a prototype water-saving system at a community toilet block in the Durban North area.

The system, designed by the University of South Florida, saves water by passing wastewater through an anaerobic digester and advanced membrane filters. The treated water is then returned to the ablution block to flush the toilets. The system also captures biogas, which could be used as a heating fuel, and incorporates a solar-powered energy system so that it can be used in remote areas which are not connected to the electricity grid.

Our next stop is the Newlands Mashu Agro-Ecology Hub, where wastewater is collected from 86 nearby homes and treated with a combination of technologies to clean the water to fertilize



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Lab technician, Ncebakazi Ngubane prepares water samples for analysis.

and irrigate (fertigate) farm crops. The wastewater first passes through an anaerobic baffled reactor and associated anaerobic filters and then through a constructed wetland before the final treated water is used to fertigate a variety of crops such as bananas, rice, sorghum or taro (madumbe).

Tony Carnie

The entrance to the PRG research toilet.

While there is still some way to go, Prof Buckley's team has placed Durban and the PRG firmly on the map as world leaders in the arena of water conservation, wastewater treatment and the potential valorisation of unwanted human 'waste'. He has also shared his knowledge widely and continues to train a new generation of water researchers and 'poop scientists'.

Former PRG student, Dr Sudhir Pillay (now a senior sanitation research manager at the WRC), recalls that he was not particularly charmed when Prof Buckley drove him down to the Amanzimtoti wastewater treatment works in 2003 to suggest that it was an ideal site to embark on his Master's degree. Dr Pillay demurred at first, but as things turned out they chatted further over a few beers later that evening and Dr Pillay ended up working with Prof Buckley and the PRG for 10 years.

"Working with poop was fun and exciting and the PRG was run like a family environment. Chris always had an open-door policy and much of what I learnt was through Chris, either directly or through his vast national and international network."