# The Institute for Environmental Biotechnology, Rhodes University

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The Institute for Environmental Biotechnology, Rhodes University (EBRU) targets research in Environmental Biotechnology at the interface between the fundamental and applied sciences. The Institute's research activities are supported by a strong emphasis on technology transfer from laboratory studies to full-scale industrial process applications and its main area of focus has been innovation and development of environmental bioprocesses related to remedial technologies.

In addition to participating in the training of postgraduate students, EBRU researchers undertake consultancy support to industry in areas related to industrial and domestic wastewater treatment, alternative energy and biofuels, rehabilitation and pollution control, and technology assessment and transfer. Most importantly, strategic research conducted at EBRU offers contextually specific options and aims to mitigate problems that may arise through the introduction of particular technologies.

# CONTENTS



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# Water, a potential driver of development

Located in the rural Eastern Cape, one of the provinces hardest hit by water quality concerns, backlogs and shortages, the Institute for Environmental Biotechnology, Rhodes University (EBRU) recognises water's potential as a driver of development, particularly in transforming the quality of life in rural communities.

**Along with dismal rates of unemployment, education and domestic violence, the Eastern Cape has the worst rate of access to water in the country (70.4%), well below the national average. Approximately 12.8% of households in the province experience regular water backlogs, with many residents in the Eastern Cape facing the daily challenge of searching for safe potable water.**

As many rural areas are isolated and beyond the reach of municipalities, many residents rely increasingly on springs, rain, water tanks, dams, pools, stagnant water and sales from water vendors. These households comprise many of the approximately one million households in the country out of an estimated 13 million that receive below a basic level or service that constitutes the backlog.

Informed by a holistic approach to resource management, in which communities are empowered through the management and maintenance of their resources, EBRU has pioneered low-cost alternatives to water treatment and purification systems. More than a decade of research into innovation and development of environmental bioprocesses related to water treatment and beneficiation have earned the Institute the reputation as one of the leading institutions in the country.

"It's no good having high-tech systems that no one can manage or maintain. We should consider the entire situation and find a grassroots system that is effective within that socio-economic, developmental context," Prof Cowan said.

According to Prof Keith Cowan, Director of EBRU, the Institute's research is premised on the notion of value recovery as central to sustainability in developing uniquely specific solutions to improving water quality and access in the Eastern Cape. While various alternatives to municipal wastewater treatment systems exist, the effectiveness of EBRU's system is its applicability to the rural Eastern Cape context.

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Lack of access to safe water is one issue which must be contextualised within a broader framework as this can be a catalyst for other unwanted dynamics. Along with poor access to water, many rural communities in the Eastern Cape lack formal sanitation infrastructure and comprise some of the 21% or 11 million South Africans who did not have access to sanitation in 2010. As a result, lack of access to water could result in a chain reaction from poor sanitation to childhood illnesses, infections and cross contamination of water sources.

According to a 2003 health survey hand washing with soap and water after contact with faecal material can

As one of the few universities in South Africa who do not have a pre-treatment system for their wastewater, Rhodes University is well poised to contribute in this area.

reduce diarrhoeal diseases by 35% or more (Curtis and Cairncross, 2003) while improving the quality of water at the house hold level can reduce risk of diarrhoea by 35% (Fewtrell et al, 2005).

Improved sanitation has a key role to play in the fight against HIV/Aids as worm infection from soil transmitted helminths – parasitic worms such as round worm, hook worm and whipworm – that spread through faeces (open defecation and raw sewage) causes a particular immune system response in children that makes it easier for HIV to gain access.

While huge strides have been made in the roll-out of waterborne sanitation to homes across South Africa, small to medium sized communities such as those around Makana are often hardest hit as they lack the ability to manage increasing wastewater flows.

According to Prof Cowan, the technology choices and approaches to delivering water and sanitation have important impacts on the general health and well-being of (rural) communities, and great care should be taken to devise and select the most appropriate technology solutions for specific contexts. "While high technology waterborne treatment systems are good when they are working properly, insufficient operations and maintenance can result in failures, and resultant sewage spills. Bigger and more high-tech is not necessarily better. Within this context it is crucial to consider each community as unique and find particular solutions for that community."

In this view, effective technology choices go far beyond scientific considerations. In addition, there are economic aspects. "Would it be fair to ask people with minimal economic resources to cover the cost of a high-tech system? Rather have a system that melts into that environment and uplifts it so the community and region become valuable," Prof Cowan said.

Service delivery as the responsibility of all residents is another cornerstone on which EBRU's research is premised. "In my view municipalities are a reflection of society. If you have assigned value to your community and want it to be the best it can be, you will make it the best. In the cases where things are not going well it is the duty of every resident to become involved to improve things," he said.

An example would include the commitment by certain sectors of society, such as hospitals, schools and institutions of higher education, who have the ability to exercise responsible decision making and offset the burden on wastewater treatment infrastructure to pre-treat their own waste. As one of the few universities in South Africa who do not have a pre-treatment system for their wastewater, Rhodes University is well poised to contribute in this area.

Any additional remediation systems will help in alleviating the strain on Makana's already fragile wastewater treatment system and decrease the risks of defunct sanitation systems, Prof Cowan explained. "This all has economic impacts as people get sick from unsafe water, children miss school and labour is compromised. Apart from the social aspects these dynamics all have a rand value and have negative effects on gross domestic product and on Grahamstown's economic contribution to the country," Prof Cowan said.

Located on the edge of the Karoo, Grahamstown forms part of Makana Municipality along with Alicedale, Riebeeck East, Fort Brown, Salem, Seven Fountains, and Sidbury. Like many other areas in the country, sporadic shortages and concerns over water quality continue to plague many residents, some of whom still do not have access to a formal water supply.

Grahamstown experiences unreliable rainfall of between 440-900mm per year. Sporadic droughts combined with ailing infrastructure has resulted

South Africa's 950 municipal wastewater treatment works treat 7 589 000 kL per day at an operational cost in excess of R3.5 billion per year (DWA 2009). At present all that waste is lost.

in dangerously low water levels at times with two supply dams, Grey and Milner, dropping to below 10% capacity on occasion. As a result, municipal-enforced water restrictions have been placed on various areas.

Water pollution continues to be a concern in and around the City: numerous streams run through carrying high levels of pollution into neighbouring rivers which include the Bloukrans, Bushmans, Great Fish, Kowie, Kariega and Palmiet (or Berg River). Sewage leaks, spilled oil, chemicals, and litter are carried downstream where farmers in the Belmont Valley draw from this river system to irrigate vegetables and food crops, and Bathurst and Port Alfred communities draw from the Kowie River for drinking water supplies.

The City's ailing infrastructure is thought to account for as much as 60% wastage, and where water is piped uphill, low pressure causes frequent water cuts which make supply uneven and sometimes unreliable.

With a waiting list of 12 000 houses, which will no doubt increase pressure on an already fragile system, Makana's water woes do not look set to improve anytime soon. However, the possible rezoning of the Belmont Valley for housing and relocation of the wastewater treatment works will provide the opportunity for

"Imagine a wastewater treatment system with zero pollution where wastewater is recycled for industrial use, meaning that all potable water would only be used for drinking purposes freeing up thousands of kilolitres and giving a sense of water security?" Prof Cowan suggested.


communities of Makana to revisit its water infrastructure and wastewater treatment processes and consider alternatives.

"Imagine a wastewater treatment system with zero pollution where wastewater is recycled for industrial use, meaning that all potable water would only be used for drinking purposes freeing up thousands of kilolitres and giving a sense of water security?" Prof Cowan suggested.

According to Prof Cowan, an innovative new system would contribute to value-addition of Makana and hopefully encourage residents to actively engage with their communities. In turn this could encourage a real view of property as a price for being part of the region's functioning and effective systems of electricity, water and sanitation.

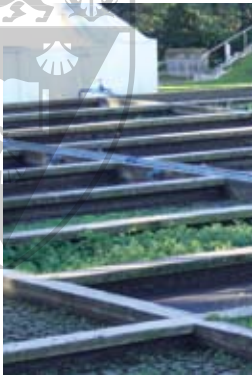
# WATER FACTS

## Water in Grahamstown

### Grahamstown has two bulk water supplies linked to two different river systems:

The **Kariega River** system feeds the Settlers and Howisons Poort dams located in Thomas Baines Nature Reserve. The water is fairly clear and low in mineral salts and is pumped to the Waainek Water Treatment Works, south west of Grahamstown.

The **Gariep/Fish River** system utilises water from the Orange (Gariep) River which is diverted via a long tunnel to the Fish River. It is turbid, high in mineral salts and less pleasant tasting. It is taken off at a weir and flows via a tunnel to the Glen Melville Dam, then is pumped into the James Kleynhans Water Treatment Works, north east of Grahamstown. Water from these treatment works is piped into different parts of Grahamstown depending on supply dam levels and the state of water mains.



# Wastewater and IAPS Overview – A solution to a range of wastewater treatment problems

In line with international trends seeking to optimise biological treatment processes, Rhodes University's Institute for Environmental Biotechnology's (EBRU) Integrated Algal Ponding System (IAPS) provides an alternative to address a range of wastewater treatment problems in Makana in the Eastern Cape, and South African more broadly.

**The IAPS is a cost-effective wastewater treatment technology for the small to medium-sized community such as Makana and the majority of small towns and cities in South Africa that produces three by-products: energy from biomass, biomass to be used as fertilizer, and effluent suitable to be used for irrigation or direct discharge into the river.**

Second only to malnutrition as the principal cause of death and disability-adjusted years lost globally, deficiencies in water supply, sanitation and hygiene pose serious threats to many people in developing and isolated areas such as Makana.

The Rural Development Services Network (RDSN) attributes the spread of cholera, from its origin in Kwazulu-Natal, to the Eastern Cape largely to the discharge of untreated or partially treated sewage. Yet despite the risks, it is estimated that up to 90% of sewage generated in cities in developing countries is discharged untreated. This wastewater is believed to have dire effects on the water resources into which it flows.

In South Africa, evidence of anthropogenic nutrient enrichment of water resources can be seen in highly populated and developed areas where poor maintenance of sewage systems and disposal of wastewater

In the Eastern Cape, only 34% of households have access to sewerage treatment facilities, with many residents being exposed to untreated sewerage in secondary water sources (State of South Africa Population Report).

practices contribute to increased levels of nutrients in receiving natural water systems. The nutrients promote the growth of biological material in receiving systems, causing a wide array of water quality problems.

With some of the most highly enriched surface waters in the world, which lead to algal blooms, South Africa's wastewater treatment processes can be toxic to animals and people, and lead to an increased cost in the purification of water for potable use.

In contrast to conventional works that use large amounts of electrical energy, mechanical equipment, chemicals, and require specific skills to run, the IAPS makes use of biological processes and micro-organisms which occur naturally in all sewage treatment processes and produces a high quality effluent without needing an external electricity supply, sludge handling or highly skilled operators.

Under standard operating conditions, the system is able to achieve levels of nutrient, organic and pathogen removal comparable to conventional wastewater treatment works, at a significantly reduced cost and energy requirement.

Designed specifically for small to medium sized sewerage treatment plants, which account for 83% of all wastewater treatment plants in South Africa, the IAPS has the potential

to contribute to the empowerment and development of local (rural) communities through job creation, increased productivity from improved water access and economic incentives in marketable by-products.

"A system like this has the potential to change the lives of people living in smaller areas who may not have experienced the benefits of access to water. It could create opportunities for entrepreneurship which had not previously existed and at the very least improve the quality of lives of people who would have an improved water source for domestic and agricultural use," Prof Keith Cowan, Director of EBRU explained.

Originally designed by Professor William Oswald of the University of California, Berkley, in the United States of America, the system consists of a primary facultative pond (PFP) containing a fermentation pit followed by a series of high rate algae ponds (HRAP).

Unlike most wastewater treatment plants in South Africa which include

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a pre-treatment step followed by a trickling filter and waste stabilization ponds, the IAPS does not require pre-treatment of the wastewater since the suspended solids are removed and degraded in the anaerobic pit of the PFP.

Conventional activated sludge systems, combined with a pre-treatment and sludge handling, require large amounts of energy and intensive maintenance, resulting in high operation and maintenance costs. This is often unsustainable for smaller localities which lack access to the technical expertise and funding requirements necessary to operate such systems.

In comparison, the IAPS hardly consumes any energy, and since the biological process is driven by the sun, the system is easy to operate and does not contain complex equipment, thereby alleviating the challenge of skills shortages in managing and maintaining conventional systems. No chemicals are required for disinfection as the algae eliminate most e-Coli by creating high pH values. Algal photosynthesis provides a solar-powered operation for achieving oxygen-saturated conditions in the partly-treated waters.

The HRAP uses a paddle wheel to keep the system mixed and its small electric motor can easily be driven by a solar panel. Both secondary and tertiary treatment occurs in this unit and, following algal floc removal in an elementary incline settler, a high quality disinfected final effluent is recovered. The algae grown in the HRAP are separated in a settling tank which are then dried on a drying bed and the final effluent is discharged to a nearby full-scale wastewater treatment plant.

Instead of waste sludge, which poses increasing challenges in conventional wastewater treatment plants around the country, a green fertilizer is produced with high commercial value, utilising wastewater as an energy source through solar methods. Feedstock for the system can include any biological waste, farm animal

waste, biomass, and residual sludge derived from the activated sludge treatment process.

In addition to the treatment of domestic sewage, the IAPS has also been investigated as a potential for the treatment of abattoir, tannery, winery and distillery, and mine drainage wastewaters, and also applications of water recycle and reuse in horticulture job creation programmes. A nine-year study of the system in collaboration with the Water Research Council was completed in 2010 and more than 10 reports have been published on various aspects of the work.

# WATER FACTS

## Water legislation in South Africa

There are two major pieces of water legislation in South Africa: the National Water Act (No. 36 of 1998) (NWA), which governs water resource management, and the Water Services Act (No. 108 of 1997) (WSA), which legislates the provision of water and sanitation.

In 1994 the government published its first White Paper on Water and Sanitation Policy, which led to the Water Services Act of 1997. The Act calls for higher cost recovery, which proved a challenge due to widespread poverty and a culture of non-payment for water in many informal settlements. Higher water tariffs and rigorous cut-offs for non-payment, or flow reductions through the installation of 'tricklers' that allow only a very limited flow of water, imposed hardships on the poorest. The Act also modified the role of Water Boards, providing a clear legal definition of the functions of Water Boards and municipalities. Water Boards have historically been the only bulk water providers. Municipalities were obliged to buy water through them. The Act allowed municipalities to develop their own bulk water supply infrastructure or to buy bulk water from providers other

than Water Boards. Conversely it also allowed Water Boards to provide retail water services at the request of municipalities. Since the Act has been passed the capacity of both Water Boards and many water service providers has increased significantly.

Institutional support for these Acts is devolved across three levels of government. At the local level, water resource management is the responsibility of Water User Associations (WUA) and catchment forums (CF). Water service provision has been decentralised to the municipal level of local government. As there is little guidance for linkages between WUA and forums with municipal structures, there is little direction for municipal action in water resource management. This leaves the challenge of integrating sustainable management of water resources (which supports and limits water use) and effective water service provision to the municipality.

## Stakeholders

The public water and sanitation sector in South Africa is organized in three different tiers:

The national government, represented by the Department of Water Affairs (DWA), is primarily responsible for the formulation and implementation of policy governing water resources management and drinking water supply. Concerning sanitation, the portfolio was moved from DWA to the Department of Human Settlement (DHS) in 2010, although some regulatory functions apparently remain with DWA.

Water Boards, which provide primarily bulk water, but also some retail services and operate some wastewater treatment plants, in addition to playing a role in water resources management;

Municipalities, which provide most retail services and also own some of the bulk supply infrastructure.

Banks, the professional association WISA, the Water Research Commission and civil society also are important stakeholders in the sector.

# WATER FACTS

## Policy and Regulation

### Free Basic Water Policy (2001)

In 2000 South Africa introduced a policy of free basic services, including water, electricity and solid waste collection. In July 2001 free basic water became a national policy through a revised tariff structure that included at least six kilolitres (cubic meters) of free water per month (40 litres per capita per day for a family of five or 25 litres per capita per day for a family of eight). As part of the policy, every household is entitled to receive the first six cubic meters per month for free. In 2012 the program reached 86% of all households. Based on an average consumption of five cubic meters of free water per household per month, an estimated eight million beneficiary households, and an estimated water supply cost of R4 per cubic meter, the annual cost of the policy can be estimated at R2bn or almost 0.5% of GDP in 2011.

Despite the intentions of privileging the previously disadvantaged through the policy, in 2005, of the 32 million people that received free basic water, almost half were not poor. Many poor in rural areas, who receive limited amounts of water for free through standpipes, do not benefit fully. Those without access to publicly provided water do not benefit at all from the program. The policy is more successful in wealthier municipalities, which have the ability to cross-subsidise water provision for the poor, than in poorer, often rural municipalities.

### Basic Sanitation White Paper (2001)

In response to access to sanitation's lag behind access to water, the White Paper on Basic Household Sanitation was published in 2001. It called for universal access to basic sanitation by March 2010 and for Infrastructure Grants to municipalities to finance investments in sanitation. While the paper noted that it is

government's responsibility to provide free basic services to the poorest, it does not spell out how this policy will be implemented in the case of basic sanitation.

## Decentralisation (2002)

Following a second White Paper on water supply and sanitation policy published in 2002 a national policy was established to further decentralise the sector, phasing out national government's involvement in service provision and limiting DWA's role to policy and regulation. In some rural areas this policy of decentralisation has been supported by the Masibambane program, a sector-wide approach linked to budget-based donor support for rural water supply and sanitation. The initial investment was R2.2 billion with a focus on the three poorest provinces and a target to reach about 2.5 million people.

## National Sanitation Strategy, Bucket Eradication Programme and Free Basic Sanitation Implementation Strategy (2005)

In February 2005 the government launched a programme to eradicate the use of bucket toilets. Approximately 250,000 bucket toilets were recorded in formally established settlements in 2005.

As of March 2008, 91% of the bucket toilets were replaced by flush toilets or Ventilated Improved Pit Latrines where water was not readily available. However, communities resisted the construction of latrines, forcing construction to a standstill and asking for flush toilets. There had been no community participation in the choice of technologies and the programme was focused on the provision of infrastructure, with little emphasis on sustainability and hygiene promotion.

In August 2005 a National Sanitation Strategy was published, followed by a Free Basic Sanitation Implementation Strategy in March 2009, with the aim of reaching universal access to sanitation by 2014.

## Blue/Green Drop

In 2008 the Department of Water Affairs introduced the 'blue drop' incentive-based water quality regulation strategy. Under the strategy municipal service providers are certified with a 'blue drop' if they fulfil certain requirements which include compliance with water quality standards, the existence of a water safety plan, process controlling and the credibility of sample results.

In 2009, 23 water supply systems obtained the Blue Drop certification. In 2010, nine lost it and 24 gained it for the first time, bringing the total to 38 (less than 5%) out of 787 systems that were assessed.

The three top performers were Johannesburg, Cape Town and the small town of Plettenberg Bay (Bitou Municipality).

## Successes

Despite the serious challenges to water quality and availability, important progress has been made in minimising services backlogs for access to water supply and sanitation since 1994 and speaks to major efforts on the part of government.

About 15 million people were without safe water supply and over 20 million without adequate sanitation services in 1990.

Today, approximately 95% of South Africans have access to an improved water source; government has achieved universal access to an improved water source in urban areas; and access in rural areas has increased from 66% to 79% between 1990 and 2010.

# CASE STUDY

## United Nations Environment Programme (UNEP)

### Bushman's River Sewage Treatment Works

As part of a United Nations Environment Programme (UNEP) supported initiative, EBRU researchers investigated the feasibility of a demonstration-scale application of the high rate algal pond system at the Bushman's River Sewage Treatment Works and surrounding community.

The small resort town frequently experiences severe water shortages and droughts, relies heavily on an expensive reverse osmosis process to meet potable water supply demands, has a very high unemployment rate, and the sewage works polluted its major tourist attraction, the Bushman's River estuary. A demonstration plant was planned to be linked to an existing horticulture job creation programme. This research was envisaged to offer a solution for the many works run by small local authorities which suffer from ageing and overloaded plant infrastructure, and which present a high health risk threat to surrounding communities.

Application to horticulture studies at EBRU have also shown that the algal floc produced in the HRAP provides a fertiliser function in high-value horticulture which is at least equivalent to, if not better than, commercial chemical fertilisers. This valuable input to organic farming opportunities has led to the development of a water beneficiation programme in which the disinfected treated water is recovered and recycled leading to job-creation programmes in developing communities.

Since the completion of this research UNEP has identified the potential of the system and has sponsored its application for roll-out elsewhere in Africa and the developing world. Studies have shown that a wide range of activities can be supported including urban and peri-urban gardening, high-value horticulture, hydroponics, aquaculture and bee-keeping enterprises.

# CASE STUDY

## Algal Biotechnology: Carbon sequestration, bio-fuels and bio-hydrogen production

EBRU's research collaboration with SASOL from 2010-2012 was aimed at decreasing the company's carbon emissions by exploring opportunities for developing strategies and technologies to allow Sasol to navigate the field of biological carbon sequestration, greenhouse gas (GHG) mitigation, and alternative energy production. As such, the research sought to explore two key areas: how to maximise algae production, as vast quantities of algae would need to be produced to be a viable and sustainable energy source; and what is the most efficient way of converting algae into energy. Options for reducing GHG emissions include a reduction in fossil fuel utilisation, substitution of raw materials, sourcing alternative energy, utilisation of carbon dioxide, and biological and non-biological carbon dioxide capture and storage. However to date, there has been no cost-effective, efficient and dependable mechanism to minimise GHG emissions.

As the world's largest single-site CO2 emitter, Sasol produced a total of 75 Mt in 2006, contributing approximately 16% to the South African load which is estimated to be 379.8 Mt CO2 yr-1 (UNFCCC, 2000). South Africa is one of the biggest CO2

producers on a per capita and per GDP basis and generates approximately 80% of the African continent's anthropogenic CO2 emissions. Given these statistics and the efforts to curb such extensive greenhouse gas emissions, Sasol has established several initiatives to manage these trends but to date no viable solution has yet been forthcoming.

Several companies had suggested responses to these challenges in 2007 following heightened global interest in algae, as they claimed to drastically increase algae production. However, many of these technologies failed to produce the desired results and many companies closed. By mid-2009 EBRU's research suggested that algae farming is simply a different form of crop production in which variables such as water and their inputs need to be carefully managed to maximise outputs. EBRU's IAPS were utilised in this research, which focused on establishing the efficiency and viability of three possible ways of converting algae biomass into energy:

1. **The production of biodiesel** – natural oils are extracted from an organism and converted into diesel. However, this proved to not be economically viable as only about 20% of algal biomass is oil and once it has been converted only yields about 10% in diesel.
2. **Conversion of algal biomass into methane gas via digestion in large anaerobic digesters** – the use of anaerobic digesters has become popular in northern European countries such as Sweden, Denmark and Finland where in many municipalities, the local transport system is entirely dependent on biogas derived from the digestion of locally produced waste. Through this research EBRU has established that if algae is cultivated under commercially viable constraints and then converted into methane through the use of digesters, there is a positive carbon balance (more carbon dioxide is used than produced).
3. **Gasification** – this process involves feeding dried microalgae into a high temperature furnace and capturing the gases

produced. The Fischer-Tropsch process converts these gases into synthesis gases including hydrogen, methane and carbon dioxide (which can be sold to companies bottling fizzy drinks). This process yields a 95% return and is carbon neutral (the same amount of carbon dioxide used as produced).

According to Professor Keith Cowan, the research enabled EBRU to establish an enviable network of academics, scientists and researchers and catalysed further research on rethinking the technology arena. He believes EBRU's research helped to dispel myths of failed solutions to the challenges and brought the potential of bio-methane to the fore.

# CASE STUDY

## Integrated Biogas Pilot for Rural Schools: Installation of Pilot System at Three Crowns School

In 2011 EBRU collaborated with a multi-stakeholder research team to demonstrate the viability of integrated biogas technology as an appropriate technology at Three Crowns School in the Lady Frere District in the Eastern Cape. The research formed part of the DBSA funded Chris Hani District Environmental Management (CHDEM) System programme and built on the success of the Chris Hani District Municipality (CHDM) and WESSA's ongoing 'blueprint for a Sustainability Commons' programme at the school, established in 2007, which provides effective sanitation, renewable energy in biogas energy for cooking, nutrient recycling in the form of pathogen free algal biofertilizer and recycled pathogen free water for irrigation of the school gardens. The programme had grown through support from the CHDM and the ESKOM Energy and Sustainability Programme and required the inclusion of an

integrated learning approach to the technologies.

The commons has been used by the Lady Frere district office of the Department of Education (DoE) as a platform for all schools in the district to be able to visit the school and learn about energy efficiencies and replicability of similar projects within their own schools.

Following indication from the DBSA that it was mandated to assist with the provision of appropriate sanitation to 600 rural schools in the CHDM, the integrated biogas pilot was recommended by People's Power Africa to Coastal Environmental Services as part of the expansion of the commons project. This was intended not only as an effective sanitation system but as a mock life science laboratory that teaches through the practical demonstration of important sustainability concepts such as zero waste, Environmental Biotechnology, renewable energy production, resource recovery and recycling as well as climate resilient agro-ecological food production systems.

The school services the surrounding community where there is a serious lack of services such as reticulated water, electricity, and sanitation in many of the households.

As part of the pilot various demonstration technologies were built at the school, including a greenhouse made from recycled plastic bottles, solar cookers, two different models of a solar water heater, a hot-box, integrated bio-gas digester and algal ponding systems, eco-circles (vermiculture and permaculture), zeer fridge and wind energy generator. The overall pilot design included a product/component development and value analysis of an off-grid high rate algal pond including a solar or wind powered paddle wheel and required the integrated biogas pilot to perform the following functions:

- Provide robust low maintenance sanitation for the 170 staff and pupils at Three Crowns School as well as the co-digestion of the associated kitchen/garden waste (17kgs/day)

- Demonstrate effective resource recovery and energy generation from biowaste streams through the production of biogas energy for cooking; pathogen free biofertilizer for the garden; pathogen free water for reuse as irrigation in the school's gardens
- Create a demonstrable and educational example of zero waste environmental biotechnology.

The pilot was based on EBRU's patented AIWPS for secondary treatment as this provided pathogen free microalgae for biofertilizer as well as nutrient rich highly oxygenated (bright water) for aquaculture and irrigation of the food gardens.

The AIWPS process is similar to those of conventional wastewater treatment plants and involves primary sedimentation, flotation, fermentation, aeration, secondary sedimentation, nutrient removal, storage, and final disposal.

The hybrid AIWPS system is composed of a series of four processes, including the digester, facultative pond, high rate algal pond (HRAP), and maturation pond. The biogas digesters provide a consistent quality of digester effluent (digestate) to the algal ponding system and require minimal maintenance apart from the periodical flushing of the algal settling pond and the removal of dried algal matter from the algal drying beds once every fortnight.

The wind powered paddle wheels require annual greasing of bearings and it is recommended that the bearings are replaced every five years. The resultant pathogen-free edible algae is an excellent source of garden mulch and compost as it contains nutrients, plant hormones and compounds that stimulate plant growth.

The pilot system demonstrated that the system can be installed using labour intensive low tech contraction technologies suitable for roll-out as an Extended Public Works Programme (EPWP)

and is linked to a number of social, financial and local economic impacts including improved school attendance; staff motivation and loyalty; improved public health due to improved sanitation and nutrition for children in the community; savings in costs for LP gas (including transport); increased security of supply of energy, nutrients and water; employment opportunities for supervision of the system (funded by financial income of locally produced energy, nutrients and recycled water); reduction in economic outflows to oil companies (for bottled gas), petro chemical companies (for fertilizer),the district council (for water) and the local economic multipliers which arise from reduced financial outflows and increased food gardening; energy production; tourism (the school and community could benefit financially from tours of the system).

To date, quantifiable financial benefits from the implementation of the project include:

- LPG gas savings for the cooking of school meals estimated at R12 856/annum
- Biofertilizer production up to R7 000/annum
- Improved productivity of school's gardens (20%)
- and/or savings in feeding scheme costs R4 000/annum.

# CASE STUDY

## Amathole District Municipality: Passive wastewater treatment technologies

EBRU partnered with a multi-stakeholder working group, comprising the Mvula Trust and a range of process and civil engineers and municipalities, focused on promoting technology choice for sustainable wastewater treatment. In an effort to find sustainable solutions to wastewater treatment, EBRU participated in a multi-pronged approach to researching passive wastewater treatment technologies capable of achieving compliant effluent at a fraction of the energy inputs required for mechanical treatment, and significantly lower skills levels for operation and maintenance.

The working group, established as an outcome of a jointly hosted workshop by the Mvula Trust, Development Bank of South Africa and Water Research Commission, supported by the Increasing Sustainable Local Government Services programme (USAID), had extensive engagement in supporting the Amathole District Municipality to develop and pilot an approach to the upgrade of a non-compliant pond system that was envisaged to provide a blueprint for other municipalities.

The workshop attracted delegates from a diverse range of organisations including National Treasury, senior engineers from the Department of Water Affairs, the Municipal Infrastructure Grant, technical directors from municipalities, wastewater engineers, the South African Local Government Association and South African universities.

According to Professor Keith Cowan, it was hoped that the success of this intervention would inspire a fundamental shift towards sustainability in wastewater treatment in small towns in South Africa; one that doesn't attempt to solve operation and maintenance failures by building new infrastructure, but rather prioritises investment in human resources and management

systems to support the sustainable functioning of environmentally friendly technology. The research involved in-depth engagement with the City of Johannesburg and the Amathole District Municipality, the commissioning of designs and costings to allow for comparison with conventional systems, and intensive advocacy work.

According to Prof Cowan, this work has resulted in important climate change issues such as electricity consumption and resource recovery from wastewater treatment being placed on the agenda of decision-makers.

Key outcomes from the research include:

- **Working Group established** to promote and support sustainable wastewater treatment in small towns
- **Advanced Ponding Systems** successfully promoted as a viable solution for wastewater treatment in small towns
- **Designs of advanced ponding systems** undertaken for specific works and comparative benefits quantified
- **Climate change impacts of technology** choice for wastewater treatment highlighted for decision-makers
- **Municipal decision-makers** supported to critically evaluate technology options in context of life cycle costs
- **Civil society** established as an important voice in the wastewater treatment debate.

# EBRU Staff & Students

## Peter Rose

Emeritus Professor of Biotechnology at Rhodes University, Peter Rose's illustrious career is testament to the passion which informs it. Since moving to Grahamstown to pursue a position as lecturer in Microbiology, Prof Rose has helped to establish the discipline of Biotechnology at Rhodes, pioneering a range of initiatives and founding EBRU.

His work spans fundamental and applied research, lecturing, supervision and industry consulting, researching and writing. It's passion for the subject which keeps him actively involved in various projects and initiatives, despite having formally retired from academia in 2008. "It's not a rare event for academics to go bananas on retirement. It's a 24/7 job teaching, researching, marking, supervising – it's absorbing and so easy to get lost in it. When you shift away from academia I believe it's important to keep the fires burning," he said. During his years in academia Prof Rose supervised 73 PhD and Masters students, secured approximately R55 million in industry research funding, and patented 24 processes. He was one of the first to register a patent at Rhodes, and assisted in establishing a patent policy at the university.

In considering what prompted his love for the subject, Prof Rose describes a deep-seated commitment to finding sustainable alternatives and solutions to the highly exploitative and environmentally destructive processes associated with the industrial economy. By the time he moved to Rhodes to start lecturing in the early 1980s, environment and Biotechnology were already developing fields in their infancy, but

"Most people tend to view science as being slow and turgid but it has an excitement that's unparalleled at times. One is really translating from an abstract view of reality into a material form, which for me is an extremely privileged area to be involved in. I really love that," Prof Rose explained.

Environmental Biotechnology was unheard of. "Biotechnology was just genetic engineering in those days," he said.

Not only was he passionate about the subject, he had a sense it would "fit well" with Rhodes University. "At that stage there were the first hints that there was going to be increased interest in environmental issues and I could sense that this was becoming a major area of research and development. I was very fortunate to be part of such a movement," he said.

According to Prof Rose, Rhodes provided wide latitude for inventiveness. "What you want as a scholar in a scholarly community is the backing when you need it and minimum interference when you don't. Rhodes does that exceptionally well. I notice with myself and my students, inventiveness bring out really fundamental capacities. The ability to look at the material world through the lens of an intellectualised view and then to bring into the material world something completely new that has never existed before - there is an excitement about such activity which is difficult to convey to others," he said. He believes Biotechnology was a very good fit at Rhodes as it didn't have an engineering faculty. "Biotechnology doesn't require huge input costs of infrastructure that engineering requires. After we linked Microbiology, Biochemistry and Biotechnology early on in the 1980s, we received good institutional support from Rhodes," he said.

After four years as Director of LIRI Technologies Research Institute and consulting on various Environmental Biotechnology projects around South Africa, Prof Rose returned to the department as the first professor and Chair of Biotechnology and assumed the role of Head of Department for three years during the late 1990s.

"While fulfilling this role I realised that for the sort of Biotechnology we were doing at Rhodes, and had become well-known for: that of being able to translate fundamental research into biological processes, we needed a bioprocess experimental field station off campus. Given a shift in national policy imperatives after 2004, waterborne sanitation became a priority area to provide services at ultra low-cost for rural and disadvantaged communities. It was important to make a contribution in this area by applying process research already developed in other fields," Prof Rose explained.

He had been looking into the integrated algal ponding system (IAPS), pioneered by American William Oswald, for low-cost wastewater treatment systems. This system can be applied to many waste streams on a small to medium scale and generates useful by-products. Having established a collaborative relationship with Oswald at UC Berkeley in the USA, Prof Rose facilitated his consulting on the development of an experimental demonstration IAPS plant in Grahamstown.

An agreement was reached with the local municipality regarding the short-term lease of land where the field station would be erected, and Dr Oliver Hart, who Prof Rose had previously worked with at the Water Research Commission, was brought on board to manage the field station following his retirement. Together with Dr Hart they decided to construct the buildings for the new unit that became EBRU using shipping containers. "This seemed like a quick and easy solution and it didn't make sense to use bricks and mortar when our lease was only temporary. We were very fortunate having gifted students who could get involved in the fundamental and applied research underway in the new high tech labs, and also enable technology transfer of biological processes," he said. Here they implemented the ponding system and prioritised processes related to acid mine drainage. The patented BioSURE process uses sewage sludge (a waste product from the sewage treatment process) to treat acid mine water. This process has been successfully tested and not only solves mine water pollution, but can potentially save municipalities millions that would otherwise be spent in sludge disposal costs. Soon there were research groups of between 15 and 20 postgraduate students involved on a range of different research projects.

A strong believer in the link between cutting edge and fundamental research, Prof Rose encouraged his students to spend a portion of their time exploring the fundamental and basic nature of the processes they were working with, "so they would

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have a sound base from which to understand the more technical applied side. This type of background adds depth and becomes essential to a coherent approach to process development. At this level you can't make the insightful leaps you need to make unless you have the fundamental knowledge at your fingertips."

Given the extent of the work at the Field Station, Prof Rose stood down as head of department and returned to EBRU as its first full-time Director, committed to converting EBRU from a field station to a fully-fledged research institute. The institute has grown over the years and established itself as a leading research unit in the field.

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involved in. I really love that," Prof Rose explained. Perhaps surprisingly, he sees his craft as essentially creative. "I believe that underpinning it all, people are essentially creative and aim to reach beyond themselves, beyond the spoken word and formulated thought, to be able to bring it back into concrete form. There is an artistic component to this. In a way it appears given, as though you have prepared the groundwork and it comes together as something given from elsewhere. Our quest in science is nowhere as directly aesthetically composite as the artist's work, but I view it as a different form of art – the art of science which is every bit as pleasing."

# Keith Cowan

Professor Keith Cowan, Director of the Institute for Environmental Biotechnology, Rhodes University (EBRU) believes in the potential of Environmental Biotechnology as "the technology of the present day and of the future".

According to Prof Cowan, modern societies are undergoing a new industrial revolution in which Environmental Biotechnology has a key role to play. "We are changing from being a global population of extractors, having used up much of our finite resources to requiring a new way of thinking about how we can achieve precisely the same ends but by using different methods," he said.

Rather than continuing the cycles of extraction, Prof Cowan is calling for the utilisation of natural processes which produce the same results but by using natural processes to our advantage. The simplest way of doing this, he said, is by considering the potential of remedial processes to return used resources such as water, land and air into usable products. "Now that we are into the 21st century we really need to embrace ways of thinking that are biotechnologically based and change the way in which we view our resources. If we can change the dynamics of our technology and lifestyle relationships then we can change the consequences," he said.

Prof Cowan obtained a PhD in plant science (plant biochemistry) in 1988 and prior to joining Rhodes served as senior scientist at Nutra-Park in Madison, WI where he headed basic research on the commercialisation of phospholipid growth regulators.

"We are changing from being a global population of extractors, having used up much of our finite resources to requiring a new way of thinking about how we can achieve precisely the same ends but by using different methods," Professor Cowan said.

In this role, Prof Cowan managed research direction and scientific information transfer, and championed company and research outcomes to industry, customers and academia. He previously served as Professor at the Swedish University of Agricultural Science, Uppsala and Professor and research leader at the Faculty of Agriculture and Agribusiness at the University of Natal.

Prof Cowan has an extensive publication record and is on the editorial board of two journals, a referee for many scientific journals and a reviewer for international grant-funding agencies.

# Eric Igbinigie

Having witnessed firsthand the environmental degradation of exploitative resource extraction processes in the Niger Delta, Dr Eric Igbinigie has chosen to dedicate his time to finding alternatives. With a view of contributing to a knowledge gap in bioremediation processes in his hometown of Benin City, within the Niger Delta area of Nigeria, Dr Igbinigie has developed the skill set to make a change.

After completing an undergraduate degree in biochemistry in Nigeria, Dr Igbinigie pursued his lifelong interest in bioremediation and moved to Rhodes University in 2003 to study for a Masters degree in Environmental Biotechnology. Little did he know he would still be in Grahamstown a decade later, contributing to environmental awareness as a consultant with a doctorate to his name.

With a focus on mine wastewater beneficiation, Dr Igbinigie's Masters thesis investigated the enzymatic recovery of platinum from platinum waste streams. The research, which was funded by Anglo Platinum, a subsidiary of Anglo American, South Africa, facilitated Dr Igbinigie's contribution to several technical reports on platinum wastewater treatment submitted to Anglo Platinum. Following this, he continued his studies to a doctorial level at the Institute for Environmental Biotechnology at Rhodes University (EBRU) researching the biotransformation of coal materials to promote the revegetation of coal dump during rehabilitation. This study, supervised by Prof Peter Rose

"I suppose to me Biotechnology is about industrial implementation and after so many years of studying I was ready to explore that side of things and experience what it would be like to apply theories to industry," Dr Igninigie said.

and funded by Anglo Coal South Africa, contributed significantly to the beneficiation of coal waste material and led to a patented technology. During his studies he also served as Laboratory Manager and reported to the Director of the Institute. His research also contributed to several coal bioremediation publications and technical reports submitted to Anglo Coal. His work also contributed to him winning a four-year research grant that was awarded to the Institute by Anglo Coal, for the continuation of the coal biotransformation research. After securing a postdoctoral research fellowship from the Institute in 2008 and serving as a Senior Scientist in 2009, Dr Igbinigie researched and contributed to the beneficiation of algal sequestered industrial CO2 (derived from flue gas) for the production of biofuel (bio-methane and bio-diesel) and other fine chemicals.

"Coming from the Niger delta which is one of the biggest oil producers in Africa, I have seen the huge environmental issues there. On top of the environmental issues there is a lot of political instability. I would like to be able to contribute to environmental sustainability and management in my home community eventually," he said.

Experiencing a shift in his research interest from research to industrial application and implementation, Dr Igbinigie joined a consulting firm. "I suppose to me Biotechnology is about industrial implementation and after so many years of studying I was ready to explore that side of things and experience what it would be like to apply theories to industry," he said.

He joined the team at Coastal Environmental Services (CES), a fully-fledged environmental consulting firm in 2010. As Senior Environmental Consultant, he travels

to mines, companies and industries to implement bioremediation and wastewater treatment, which he describes as "hands on work". "I really enjoy getting to spend a few weeks in the field and experiencing what it's like to go down into mines and help companies all over Africa understand the context of our work," he said.

A frequent challenge is the perception that consultants should be able to provide solutions to problems relatively quickly. "When you are dealing with people who are not science-oriented they often want results immediately. It's part of my job to explain to them that it doesn't work like that and that (sustainable) biological systems take time to give results unlike physico-chemical processes, where you see almost immediate results but with residual recalcitrant waste products. There are no quick fixes" he said. Time is required to ensure that biological organisms can adapt to changing systems, which, being living entities, is not always guaranteed. In addition, a lack of understanding of biological systems can cause disasters in systems. As such, Dr Igbinigie spends a fair amount of time explaining the basic principles to his clients, helping them to better understand scientific principles.

Dr Igbinigie's consulting experience has also led him back to his home

country, Nigeria, where he has contributed to several environmental projects.

Ultimately, he would like to go back to Nigeria and contribute to a knowledge gap in his area of expertise. "People in Nigeria live naturally, heavily depending on organic processes but they are exposed to a lot of environmental degradation. Industries get away with a lot more there because there is a lack of awareness, whereas in South Africa, they can't get away because of the more advance environmental legislation and implementations. Environmental awareness is still in

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its infancy there, even though it is increasing globally. The economic growth in Nigeria is heavily dependent on the petroleum industry that is being fuelled by several multinationals which contribute immensely to the environmental degradation happening there. I am hoping the government will come to the party and implement policies that would reverse the current environmental degradation and promote sustainability," he said.

# Bonga Zuma

Having served as a post-doctoral fellow with EBRU between 2012 and 2013, Dr Bonga Zuma's collaboration with the institute continues through ongoing research aimed at addressing various challenges related to the implementation of the integrated algal pond system (IAPS) in wastewater treatment.

Although Dr Zuma currently serves as a Consulting Scientist at Goadex Water and Science Consultants in East London, he continues to work with EBRU as a partner and peer reviewer of scientific manuscripts for international journals.

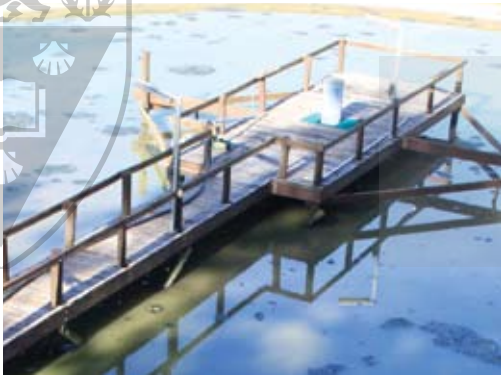
Dr Zuma's post-doc research project titled "Investigating the efficacy and application of the selected duckweed plants as a scrubber for the IAPS effluent", was envisaged to produce the duckweed scrubber system's effluent that meets the requirements for the release of soil, ground and surface water into the environment. Through the process, good organic matter, bacterial and nutrients removals were undertaken. This process is robust, measuring high efficiency in relatively short hydraulic retention time, and, compared to the maturation pond process, requires less land for implementation and is relatively low cost In addition, according to Dr Zuma, higher chemical oxygen demand (COD) present in the final effluent of the EBRU IAPS, as compared to the stipulated Department of Water Affairs' environmental wastewater effluent release standards, is likely to put a "stamp of approval on the potential of the IAPS as an alternative domestic wastewater treatment system", especially in remote areas.

Dr Zuma's PhD focused on investigating the use of an effective, low-cost and readily available material in wastewater treatment. This research demonstrated that with the locally available material, it is possible to treat domestic and agricultural run-off to enable its reuse and safe disposal.

At the time of joining EBRU, Dr Zuma held Atlantic and International Foundation of Science Fellowships. He said he chose to pursue his postdoctoral research at EBRU because of its strengths and proven track record in this area.

Today, Dr Zuma's research expertise and experience include greywater treatment for reuse and safe disposal purposes, and application of microbial ecology in freshwater ecosystems. During his honours degree he designed, constructed and monitored a laboratory scale greywater treatment system. Since 2007 this system has been in the process of being up-scaled to pilot level. The monitoring and investigation of proposed modifications to this system formed part of his PhD project. During his MSc Dr Zuma focused on microbial activity responses to water quality changes as a means of assessing river health in the Buffalo River in the Eastern Cape. One of the external examiners saw potential in this research to contribute to assessing river health using a microbiological index. Dr Zuma's PhD focused on investigating the use of an effective, low-cost and readily available material in wastewater treatment. This research demonstrated that with the locally available material, it is possible to treat domestic and agricultural run-off to enable its reuse and safe disposal.

Dr Zuma's work has been published in peer reviewed international journals, book chapters and conference proceedings with an academic background spanning Biochemistry, Microbiology Biotechnology and Water Resources Science.



# Prudence Mambo

Describing herself as "water-centric" and a "bio-entrepreneur" Ms Prudence Mambo believes in the potential of African-based researchers to contribute to the field of sustainable development and resource management, having been exposed to the realities of a lack of basic services, among which water and sanitation feature prominently.

Ms Mambo is currently a doctoral candidate and holds among others, a Postgraduate Certificate in Education and a Masters in Environmental Biotechnology from Rhodes University. The focus of her MSc, biological remediation of acid mine drainage, informed her interest in the Integrated Algal Ponding System (IAPS) which stemmed from her interest in the biological remediation of waste water. "Initially I was very interested in industrially generated waste water, however, over time and through reading I realized that there was insufficient remediation of domestic waste water in South Africa and Africa as a whole and though many varsities were looking into amending this, there was not much of a voice for biological technologies that could be community run," she explained. By combining an anaerobic digester with an aerated system the IAPS treats water and acts as a final polishing step prior to the discharge of effluent into the environment, providing an essentially clean biologically generated water stream. Also, being conceptually advanced yet simple in implementation, the IAPS could be run by laymen. "This opens up a number of possibilities including the generation of biomass and power. I realised through reading that communities could be trained

"There was insufficient remediation of domestic wastewater in South Africa and Africa as a whole and though many varsities were looking into amending this, there was not much of a voice for biological technologies that could be community run," Ms Mambo explained.

to remediate their own wastewater thereby decentralising their waste water remediation needs while mitigating preventable diseases and ensuring a consistent supply of water for irrigation and, after minor modifications to the system as it stands, energy generation and water for household activities. I believe in science with a conscience, science that can address the immediate needs of the people to ensure standard of living and lifestyles improve for all over time."

She believes working in the South African water sector, which she describes as dynamic, will afford her the opportunity to participate in and contribute to exploring innovative and sustainable solutions to avert a water crisis in the country. "I believe this sector will provide consistent intellectual stimulation and the opportunity to directly integrate indigenous knowledge and/or needs with current technological advancements while fostering self-reliance," she said.

Ms Mambo was selected to participate in an Advanced Academic Research Institute workshop in June 2013 at Brown University in Providence, Rhode Island, America. The Brown International Advanced Research Institute is a faculty development initiative that brings promising young scholars from developing countries together with leading researchers in their fields for mentorship opportunities and intensive workshops. For Ms Mambo, the event gave her the opportunity to immerse herself in cutting edge research and glean as much information from the experts.

"I hope in this lifetime to help give everyone access to clean water and sanitation, which I believe could have been resolved long ago and would have solved a lot of problems such as detrimental effects on the national economy. I genuinely believe that the only thing that can stop you from accomplishing whatever you set your mind to is yourself, and that the only thing that would stop me from achieving my goals are the limits of my own imagination," she said.

# Dirk Westensee

Inspired to make a difference in the lives of people living in rural areas with lack of access to clean water, Mr Dirk Westensee is reading for a Masters degree with a focus on post-treatment systems for Integrated Algal Ponding System (IAPS).

As current components don't comply to the Department of Water Affairs standards, Mr Westensee is researching how additional polishing systems, such as maturation ponds, slow sand filters and rock filters can be incorporated into the process on site.

Originally from the Eastern Cape, Mr Westensee completed a Bachelor of Science in conservation ecology at Stellenbosch University before pursuing postgraduate studies at Rhodes University. The son of a medical doctor, Mr Westensee witnessed the effects of poor water quality in many of his father's patients who had contracted common water-borne diseases such as dysentery, due to the poor quality water they were consuming. "Through his work my dad inspired me to try and make a difference in these people's lives by stopping this dilemma in its tracks and helping people to have the bare necessities in life, such as clean water, which is a democratic right in South Africa," he said.

Mr Westensee is sceptical of the future of access to safe potable water, with current projections suggesting struggles for water availability are going to become commonplace. "On current trends our water is going to run out in the near future. As scientists and human beings we need to find alternative ways of restoring water and find alternative

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techniques for reusing water. This is not impossible. Our kind of research at EBRU is geared towards these objectives and also making water cheaper and more accessible," he said.

To date Mr Westensee has published in the *Water, Sewerage and Effluent Journal* (April 2013) and submitted 'Yes! Golden Pond', an accepted paper to the *Water Science and Technology Journal*, called 'Operation and Compliance of an Integrated Algae Pond System for the Treatment of Municipal Sewage' as well as an accepted paper to *Water South Africa* called 'The IAPS in retrospect'.

He is keen on pursuing avenues for contributing to water quality testing, especially in rural areas, where water quality is extremely poor due to the lack of infrastructure. Mr Westensee is also committed to providing people in rural areas with the information and education necessary to inform them of the basics of water sanitation.

# Lerato Sekhohola

After completing an Honours in Biotechnology at Rhodes University in 2009 Ms Lerato Sekhohola followed her passion for the subject and started her Masters in 2010. At the time EBRU was offering a bursary for studies into coal mining rehabilitation processes and Ms Sekhohola jumped at the opportunity to pursue her studies.

By the end of the following year Ms Sekhohola had been advised to upgrade her research to a PhD, an opportunity she was keen to take advantage of. "My upgrading the MSc to a PhD is not really something that I had to think long and hard about. When my supervisor suggested it, I agreed without any hesitation because it seemed less scary. To me, upgrading simply meant more time to go deeper with my research and hopefully make some ground-breaking and exciting scientific discoveries. I was already familiar with my work and had an idea of what I wanted to pursue further. This was certainly a different approach to my perception of registering for a PhD research and tackling a new different topic, which I think would have been a bit scary for me to take on," she said.

However, there have been many obstacles along the way and the road to completing her doctorate has been somewhat challenging. "I have had to overcome a lot of challenges and even abandon some of the ideas I initially had for my research due to a number of reasons beyond my control. But then again, I believe such is research. With the continuous help of my supervisor I had to improvise and come up with new ideas

"I think for quite a while people were under the impression that whenever you spoke about anything scientific that you were speaking rocket science, but what I love about Biotechnology is that it's about the application of science to everyday life," said Ms Sekhohola.

immediately. Looking back I have to say I'm glad I upgraded because I have had an amazing opportunity to grow as a person and as an aspiring researcher."

Describing her research topic, of developing an efficient rehabilitation process for the South African coal mining industry, as a dynamic and evolving process, Ms Sekhohola embarked on various field trips to coal mines across the country to conduct trials on the degradation of coal into a substrate which could be used further, with a focus on rehabilitation processes.

Following the field trips she recalls the range of emotions which consumed her including frustration and excitement. I would bring the samples from the tests back to the lab and sometime would feel such frustration at the processes and lack of findings, but then sometimes it was crazy exciting when I did get results," she said. Ms Sekhohola is the first author on a review journal article entitled, '*Biological degradation and solubilisation of coal*' and another manuscript has been accepted for publication. "I intend to submit all my research chapters for publication before handing in my thesis. For me all this is a great achievement and I am grateful to my supervisor for being such an amazing mentor," she said.

During her studies Ms Sekhohola admits to having fallen in love with the work of Biotechnology and how it "brings science and the rest of the world into a space where they can appreciate one another". "I think for quite a while people were under the impression that whenever you spoke about anything scientific that you were speaking rocket science,

"As a major coal producing country South Africa has lots to explore in terms of coal rehabilitation. There is major waste being generated and someone has to take care of this. I would like to contribute to this area especially as there is a lack of available literature on this in South Africa as compared with India or China. I think we're the right people to take it further," Ms Sekhohola said.

but what I love about Biotechnology is that it's about the application of science to everyday life."

Given her love for the subject Ms Sekhohola is open to pursuing a career in the field and exploring the major coal resources. "As a major coal producing country South Africa has lots to explore in terms of coal rehabilitation. There is major waste being generated and someone has to take care of this. I would like to contribute to this area especially as there is a lack of available literature on this in South Africa as compared with India or China. I think we're the right people to take it further," she said.

# Gerald Edeki

After completing a Masters degree in Environmental Biotechnology and witnessing the disastrous effects of petrol spillages in Nigeria, Mr Edeki decided to pursue his interest in petroleum microbiology and read for a PhD at Rhodes. "After seeing the size of the problem and the amount of spillages I thought it would be wise to go into that type of research," he said.

"I came to EBRU with the intention of learning more about liquid fossil fuel. Little did I know that South Africa is the highest coal producing nation in the world," he explained, noting that EBRU has a strong focus on coal rehabilitation, which he decided to incorporate into his research.

Today he is researching rehabilitation of hydrocarbons and coal with a focus on developing bacteria that breaks down coal. This work, Mr Edeki explained, is indirectly linked to water research, which is another research interest of his and a focus of EBRU. During the process of coal mining ground water pollution occurs via surface run-off and transportation of liquid fossil fuels. "My sole intention is to work with oil producing companies and I can't wait to dive into the water rehabilitation aspect," he said.

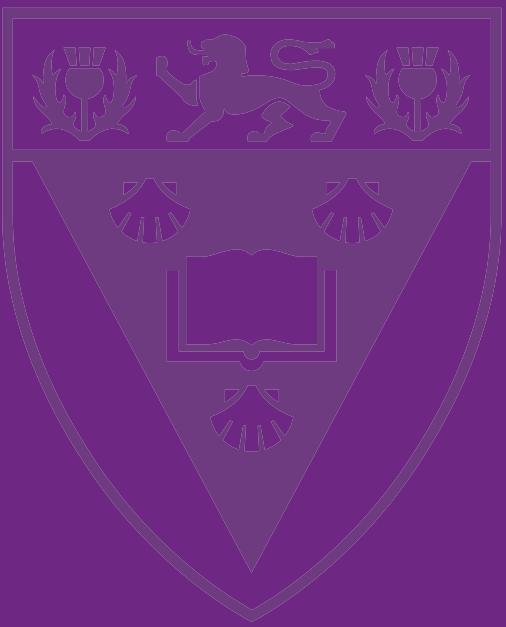
Writer & Editor: Sarah-Jane Bradfield

Photography: Mathieu Dasnois

Produced by: Communications & Marketing Division
Rhodes University, Grahamstown, 6140

e: communications@ru.ac.za

t: +27 (0) 46 603 8570



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