Linking two of South Africa's major water pollution problems, a unique research programme proves the old adage "Where there's muck there's brass", using living systems to clean up sewage and industrially polluted waters, producing sweet water and marketable by-products in the process. **Catherine Knox** spoke to Peter Rose who heads the group that engineered this breakthrough in the quest for sustainable development.

From problem to profit:

Environmental biotechnology unlocks the value in polluted wastewaters

FLAMINGOS – NATURE'S SEAL OF APPROVAL

Several dead flamingos were found on site when work began on an algal ponding system to cope with effluent at Mossop Western Leathers co, near Wellington. Shortly after the system was commissioned, a sizable flock of flamingos occupied the ponds – an eloquent indicator of a healthy and naturally functioning saline aquatic ecosystem.The flamingo was immediately adopted by Rose's group as its emblem and appears on the cover of each of the 12 parts of the study report: *Salinity, Sanitation and Sustainability*

PEOPLE PRODUCTS

South Africans trained to make a difference are one of the most valuable by-products of the Water Research Commission's funded research projects at Rhodes University. High-level skills transfer has been a constant in the decade-long process, involving two Post-doctoral fellows, 11 PhDs and 14 MSc degrees.

Dr Oliver Hart,the WRC's first manager for this programme, accepted a fellowship from Rhodes University when he retired because of the opportunity to work with students."I have been in the water business for 50 years and anything to do with water is exciting to me," he says."But I specially enjoy working with the students."

Other knowledge by-products include 97 conference papers – 24 for overseas and 73 for South African conferences.No less than 19 patents have been registered and 24 journal papers published.

"Inventive and creative" are words clean-water innovator Peter Rose uses almost as often as "sustainable". Professor Rose is the author of the 3-volume, 12-part, 1000-page good news story presented as South Africa's special show-and-tell contribution to the recent World Summit on Sustainable Development in Johannesburg. The work was funded by the Water Research Commission in response to the sustainability objectives articulated in Agenda 21 of the Rio World Summit held in 1992.

In his foreword, Minister of Water Affairs and Forestry Ronnie Kasrils, writes:"We can point with a justifiable sense of pride and achievement to ...the work ... as being 'made in South Africa', at a time when social, environmental, political and economic calls are being made to all of Africa to stand up in the continental and global communities of nations."

Sustainability requires a radical overhaul of the means by which human needs are fulfilled – this has been generally acknowledged. Rose and his Rhodes-University-based Environmental Biotechnology Group (EBG) took up this challenge shortly after it was issued and they have boldly rewritten old paradigms ever since. With unflagging zeal and inventiveness,they tackled salinity and sanitation (the two key pollution problems threatening development), linking them in a way never done before and applying the new thinking of biotechnology (working with living systems rather than synthetic processes to achieve desired ends) with results that often surprised even themselves.

"Salinity and sanitation – which includes clean drinking water and waste disposal – impact severely on six of the seven priority pollution issues facing our region," says Rose. "One of the most pressing of these is the threat to the Witwatersrand of acid mine water decanting from disused mines. The scale and impact of saline pollution are vast and long-term in their effects."

Confirming numerous previous studies, including several by Rose's EBG, the 2000 White Paper on Integrated Pollution and Waste Management identifies salinity and sanitation as critical issues undermining sustainable development in Southern Africa.

In the new paradigm underlying the EBG work, salinity and sanitation are not only linked and dealt with in tandem,they are also re-imagined as resources rather than problems.

"The paradigm has changed from one of 'managing problems' to one of 'engineering opportunities," in Minister Kasrils' words.

MICROBES

The main characters of Rose's narrative are busy microbes and the exciting sub-plots all illustrate a central theme: the mobilisation of living systems to turn harmful waste products into valuable assets.

"Beneficiation is the core of the idea," says Rose, who is understandably partial to the term commonly used for the conversion of raw materials into finished products. Beneficiation writes sustainability into the scenario. Take the example of the toxic water that wells up, threatening to decant from disused mines, and the rising tide of sewage produced by urban sprawl – both threatening the East Rand right now. Nature, in her infinite wisdom, has provided a bug that can sort out the problems in the

acid water drainage, but this bug needs certain nutrients to sustain it.These nutrients just happen to exist in raw sewage. Put the bug, the minewater and sewage together and the bug digests the sewage while it facilitates the chemical reactions that make the metals and other pollutants settle out of the minewater. Clean water (a precious commodity) and useful inorganic by-products come out at the other end.These include sulphur, metals, algal bio-products and sulphuric acid.

Experience has shown that toxic mine-water could continue welling up for centuries – mines dug by the Romans are still decanting. And the sewage problem is here to stay.This means our communities will be dealing with both in the long-term. Expensive, high-tech solutions are not feasible. Biological processes with hard value as a by-product mesh with the development realities of both today and tomorrow, reconciling economic and environmental goals.

The research paradigm is flexible and has been adapted to deal with a variety of related problems with different benefits. In several cases full-scale plants are already operational, completing the cycle of research, development and implementation.

SPIRULINA

A version of the recipe successfully applied to manage tannery waste produces large quantities of Spirulina,a popular dietary supplement which is also used in stock feed.Beta-carotene, used in cancer treatment, is one of the by-product of treating waste from a soda-ash plant in Botswana.

The Environmental Biotechnology Group has demonstrated that integrated algal ponding systems provide the appropriate core technology for the delivery of their objectives. The ponds exposes a large surface area of water to sunlight accelerating the worker-algae's ability to capture radiant energy through photosynthesis. Oxygen is released in the process.The depth of the pond is also important to enable microbes to circulate between aerobic (near the surface) and anaerobic (near the bottom) conditions.

OPUS

The Rose opus is titled "Salinity, Sanitation and Sustainability: a study in environmental biotechnology and integrated wastewater beneficiation in South Africa" and it was almost 12 years in the researching and writing. To the insider, it reads like a thriller: there's danger, good guys,baddies, time-shocks, serendipity, excitement, but no fiction. In forthcoming issues, *The Water Wheel* will retell some of the key moments of a project which is a testament to the sustaining passion for the environment that fired Rose way back in the 1980s.

He recalls that in the 80s there was a widespread passion for the environment manifesting itself in some circles through panic and despondency about the prospects for the future. Rose said he decided to "get stuck in and do something about it."

Environmental biotechnology was "newly-invented" and his study was the first to apply the new thinking to salinity and sanitation with beneficiation as a bonus. He has always been fired by a strong sense of social purpose. He says now that the first chapter of his work is written,"I feel a sense of congruence. We have successfully completed a coherent study around a major theme articulated more than ten years ago."

THE RIGHT MAN FOR THE JOB

Prof Peter Rose's own background is poetically congruent with his work.The son of a mining engineer, he was reared in the arid Northern Cape, spending holidays on his grandparent's irrigated farm (with the attendant problems of salinity) in the Sunday's RiverValley near Addo. As an undergraduate at UCT, Rose proposed to the atomic energy board that the warm water emitted from Koeberg could be used for a range of aquaculture projects and he was awarded funding to flesh out his proposal.His stint as a farmer (on irrigated lands near Grahamstown) provided him with hands-on personal experience of the water problems specific to agriculture. At Rhodes he served as a lecturer, director of LIRI (the Leather Industries Research Institute) and as head of the Department of Biochemistry, Microbiology and Biotechnology. In January 2003 he takes up the position of director of the new Environmental Biotechnology Research Unit which includes an experimental field station which is a joint project of the WRC, Rhodes University and the Makana Municipality.

A FLEXIBLE AND WIDE-RANGING STRATEGY

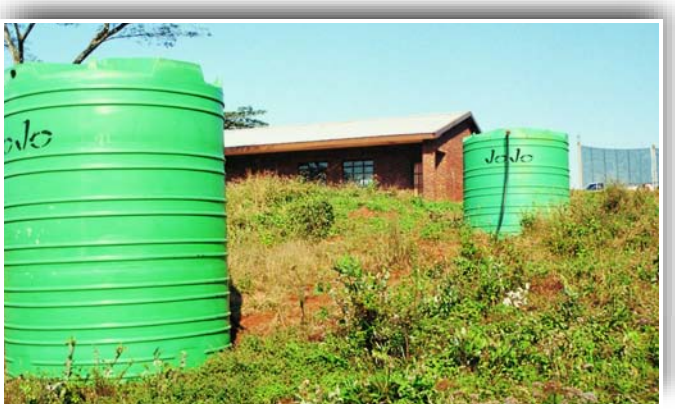
The 12 reports published under the title *"Salinity, Sanitation and Sustainability: a study in environmental biotechnology and integrated wastewater beneficiation in South Africa,"* include an overview and individual reports on successful and integrated projects dealing with wastewaters from

- gold and coal mines, including Grootfontein on the East Rand; municipalities, including Makana and the East Rand
- the Cato Ridge abattoir in KwaZulu/Natal,
  the Brennokem Co wine lees plant near Worcester,
- the Mossop Western Leathers co tannery near Wellington,
- the Botswana Ash Co at Sua Pan,

The story began with a visit to the Rhodes-based Leather Research Industry by Dr Piet Odendaal (then director of the WRC). Following his discussions with Rose, the WRC funded a one-year feasibility study. In his Editor's Note to the full research report, Greg Steenveld who now manages the programme, praises the "clarity, breadth and depth of the vision" expressed in the initial report. "The 'sustainable biotechnology' originally conceptualised by the researchers has ... by dint of rigorous research development, experimentation and testing, been translated into a suite of practicable processes for delivering treated water as well as value-adding organic and inorganic co-products."

Coming in our next issue: the story of the EBG-developed Rhodes BioSURE® process — a sustainable solution to the acid minewater drainage which threatens the Wit watersrand.

The **Namib fog beetle** is a feisty little creature. Every morning he makes an arduous journey to the top of a sand dune, where he turns his body into the wind, straightens out his rear legs and lowers his head. The fog rolling in from the sea gradually collects on his back, forming droplets of water, which glide downwards and hang from the insect's mouthparts. In this way, the *Onymacris unguicularis* is always assured of a healthy morning drink, despite being miles from the nearest fresh water.



Signs of success: Two additional tanks have been erected further down the slope, to collect overflow water from the main storage tank at Tshanowa Primary School, where a fog harvesting system has been installed.