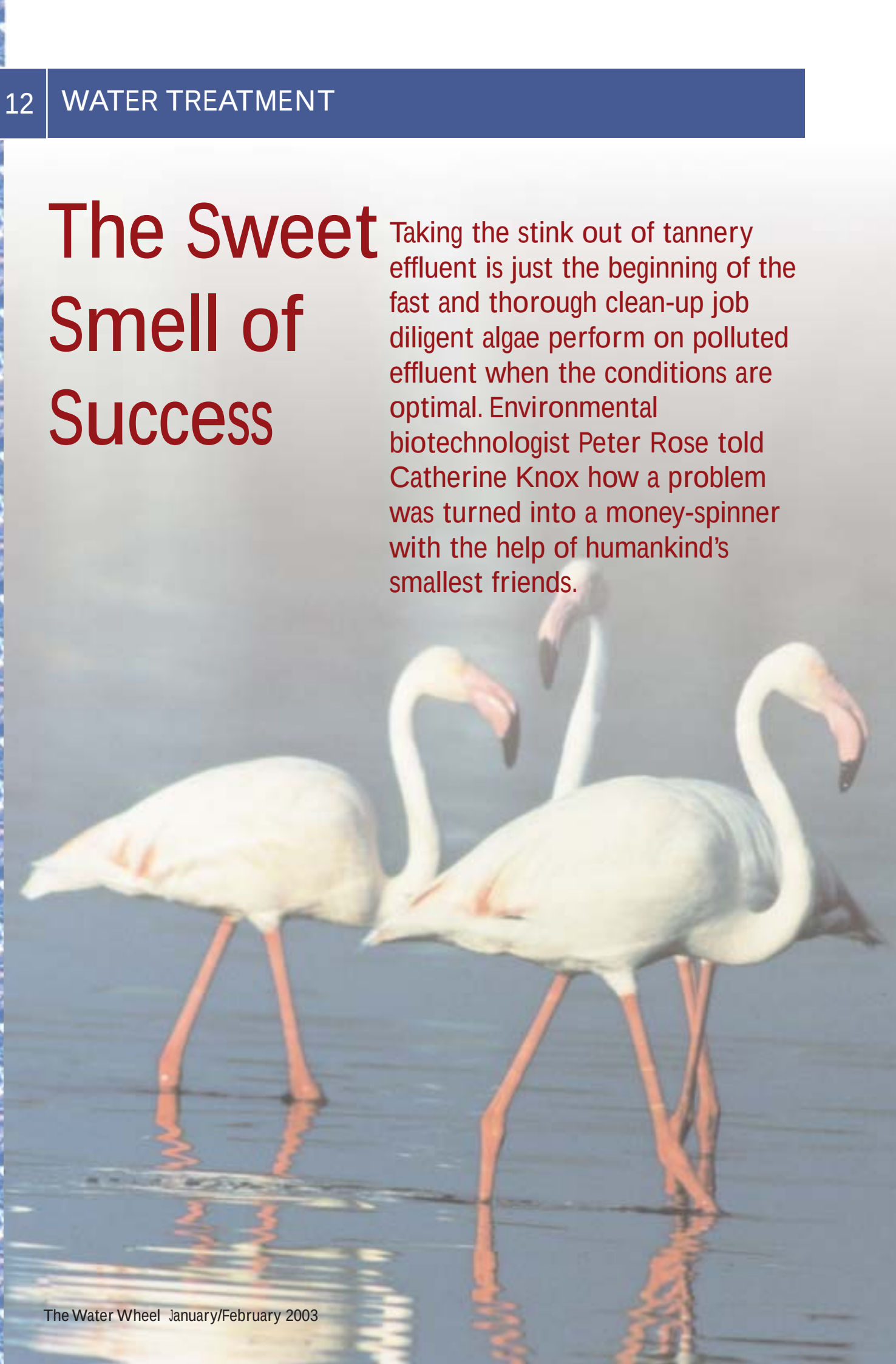
The Sweet Smell of Success

Taking the stink out of tannery effluent is just the beginning of the fast and thorough clean-up job diligent algae perform on polluted effluent when the conditions are optimal. Environmental biotechnologist Peter Rose told Catherine Knox how a problem was turned into a money-spinner with the help of humankind's smallest friends.



Part two of a series of good news water stories taken from Peter Rose's 12-volume report on an integrated WRC-funded project. Prof Rose is the director of Rhodes University's Environmental Biotechnology Unit. (Note that the article on the biological remediation of sewage and acid minewater mentioned in the last issue of Water Wheel will appear in a forthcoming issue).

People don't call Wellington "Smellington" anymore, even though the local tannery is still in operation. What changed? Rhodes University's Environmental Biotechnology Group, headed by Prof Peter Rose, got to work and proved that if natural systems are allowed to operate at full-strength problems can be turned into opportunities.
Today, instead of a stink, a rich harvest of *Spirulina* is produced in the tannery ponds.

Bad smells are one of nature's ways of warning people about toxins and the suffocating sulphurous miasma that emanated from old-style tannery waste stabilisation ponds announced a worst-case scenario of the pollutants that may be encountered in this kind of pond system, says Peter Rose.

Tannery effluent contains a range of components including heavy metals and high levels of sulphate, ammonia, nitrates and protein nitrogen. Which is precisely why Rose and his group chose to start here in their quest for a sustainable and integrated wastewater beneficiation technology suitable for a variety of applications.

The waste stabilisation ponds at Mossop-Western Leather tannery near Wellington was identified as a good example of a model environmental-scale bioreactor system. The waste stabilisation ponding used for many years in the tanning industry offers a low-cost, quasi-passive system relying on microbial action to "digest" pollutants. But nature was clearly taking the strain at the Wellington tannery. When the team started work on site, they came upon a sad pile of crumpled pink feathers: a dead flamingo.

A detailed study of the microbe ecology in the ponds revealed the dominance of *Spirulina* and *Dunaliella* species in near mono-

An impressive paddle wheel keeps the water flowing steadily round the 2 500 m² high rate algal pond at the Wellington tannery where Spirulina *biomass is produced commercially today.*

The pilot plant at Wellington featured high rate algal ponds scaled down to 80 m² (just under one third of the size of the full-sized operational pond).

A PERK FOR PERLEMOEN

When it became apparent that a significant mass of *Spirulina* would be the by-product of the bioremediation of tannery effluent, Peter Rose approached Peter Britz, head of Ichthyology and Fisheries Science at Rhodes University. Would *Spirulina* be useful in aquaculture? was the question Rose posed. *Spirulina* is already widely recognised as a human dietary supplement and has proved its worth in cattle feed as well.

A young perlemoen (abalone) nibbles at an offering of Spirulina-*rich Abfeed*

Britz and his group found that *Spirulina* harvested from a tannery ponding system was a high-value food additive that complied with aquaculture nutritional standards. Tests on day-old chicks produced no adverse results, proving that pesticide residues and heavy metals were within prescribed levels. "We found that a *Spirulina*-rich diet enhanced the colour of goldfish and of rainbow trout. The trout meat was also improved," says Britz. But there was more commercial significance in successfully adding *Spirulina* to Abfeed, the ration concocted by Rhodes scientists for use in commercial abalone farming. If a big and steady supply of *Spirulina* were available it would a standard ingredient of Abfeed, says Britz.

cultures and at different stages in the increasing salinity gradient as the evaporation process progressed from pond to pond. This led to the development of a *Spirulina*-high rate algal pond to optimise and intensify the function of the algae. An added benefit of the high rate ponds is that it occupies only 10% of the footprint of a waste stabilisation system.

In the high rate algal ponds, an association is established between high populations of algae and micro-organisms that eat organic matter, with the production of oxygen (through photosynthesis) providing for the breakdown of organic substances in the water and the algae in turn using the inorganic nutrients (such as sulphates).

In optimal conditions the algae not only functioned more efficiently, they also bloomed, fixing solar energy as biomass, and floating rafts of algae capped the effluent waters, reducing the smell. Rose and his colleagues were also able to develop and test membranes suitable for straining out and thus harvesting value-laden *Spirulina* biomass.

As yet another bonus, water that had been treated in the *Spirulina*-high rate algal pond was clean enough to be returned to the tannery for use in certain stages of production.

Once a pilot-scale system had been tested a full-size operation was commissioned. Not long afterwards, a flock of flamingoes occupied the ponding system – a sure sign of a healthy and naturally-functioning saline aquatic ecosystem. Rose was so moved by the grace with which Nature approved his efforts that he adopted the flamingo as the emblem for his group's quest.

The work had proved to the team that integrated algal ponding systems might indeed offer opportunities for a more general approach to saline wastewater treatment. And without delay, they set to work following up on the *Dunaliella* species they had found in the hyper-saline water in the ponds at the end of the cascade.

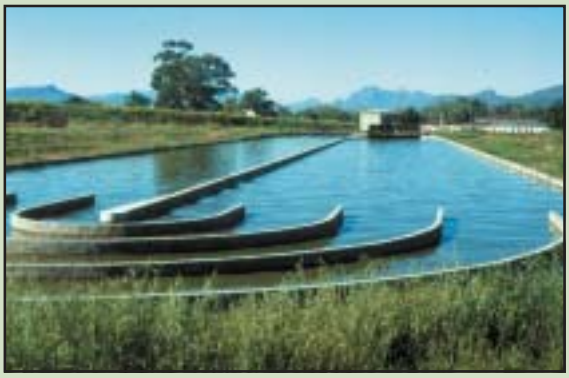
***Next issue**: Harvesting cancer-fighting beta-carotene as part of soda-ash production in Botswana.*

HOME, SWEET HOME, FOR *SPIRULINA*

Len Dekker and an assistant harvesting Spirulina *biomass*

The Mossop Tannery project produced a healthy crop of young scientists: a number of postgraduate students grew to professional maturity as they worked under Prof Rose's supervision. Len Dekker was one of them, Kevin Dunn another. A leading member of the team, Dunn is about to launch his own independent consultancy specialising in algal biotechnology with a strong environmental slant. He and Rose are planning to collaborate on further projects in the future.

TOPPING UP SA'S SCIENTIST POOL



The 2 500 m^2 *Spirulina* high-rate algal pond which was constructed as part of the full-scale integrated algal ponding system to treat tannery wastewaters at Mossop-Western Leathers at Wellington. This and five of the series of waste stabilisation ponds are currently used by Gerald Tutt's firm, Eco-aqua, to produce high-quality *Spirulina* biomass. Tutt says, "If it weren't for Prof Rose's work, no one would have realised you could farm *Spirulina* here." Ironically, Tutt has to feed his *Spirulina* as operations at the tannery have changed so the effluent produced is less saline and no longer contains sufficient nutrients for the algae.

COLOUR-CODED MICROBES AT WORK

The dark green colour of ponds where *Spirulina* bloomed are clearly visible in this aerial shot taken of the waste stabilisation ponds at the tannery near Wellington at the time Peter Rose's Environmental Biotechnology Group started work there. The first five ponds in the cascade are at the top end in the picture. The dark brown-grey colour of the raw tannery effluent changed to bright pink and then purple in these ponds because of the changing dominance of microbial populations. The effluent was then pumped to the pond at the bottom end and from there back through the successive ponds towards the middle. The dark red-brown colour of the bottom two ponds was produced by purple sulphur and non-sulphur bacteria. The green ponds were near the end of the cascade and thus contained a high concentration of salinity and nutrients due to the progressive process of evaporation. The salinity and nutrient load in the last two ponds was high enough to support small blooms of *Dunaliella salina* and *Dunaliella viridis* – the beta-carotene-producing organisms which were to be the subject of a subsequent Environmental Biotechnology Group project.