SA waterbulletin

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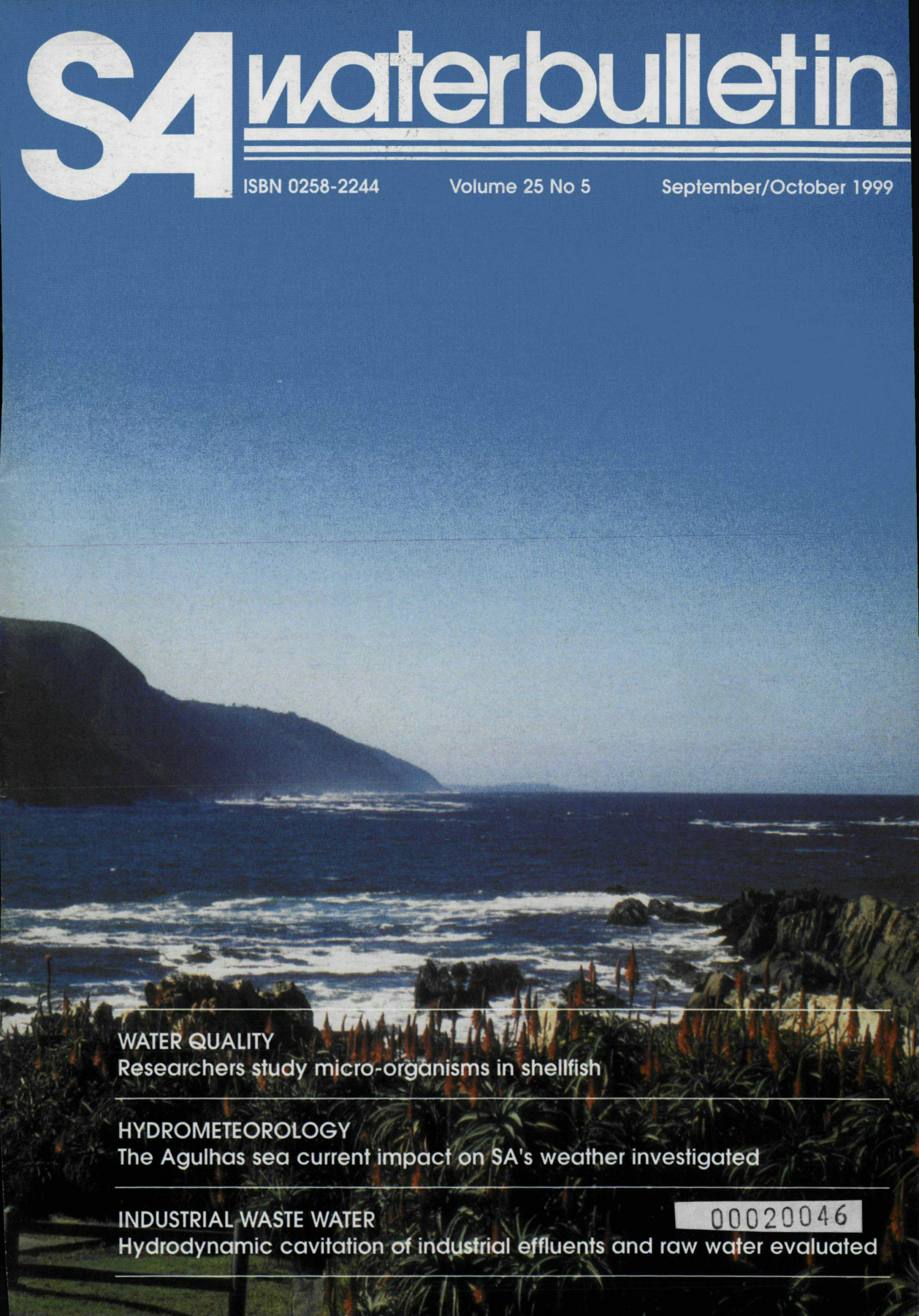

WATER QUALITY
Researchers study micro-organisms in shellfish

HYDROMETEOROLOGY
The Agulhas sea current impact on SA's weather investigated

INDUSTRIAL WASTE WATER
Hydrodynamic cavitation of industrial effluents and raw water evaluated

UNIVERSITY OF DURBAN-WESTVILLE

Department of Civil Engineering

MSc in Water and Environmental Management

The department has successfully been running an MSc degree course in *Water and Environmental Management* since 1995. The course content takes into account the multi-disciplinary nature of water and environmental management and has attracted **Civil** and **Chemical Engineering** graduates as well as **Honours graduates from Microbiology, Geography, Chemistry** and other related streams in the past.

Course Contents

This programme consists of two segments. In the first six months of study, each candidate is required to undertake six courses, three of which must be core courses and other three electives.

- The core courses are: Environmental Impact Assessment; Environmental Pollution and Control; Economics, Environment and Sustainable Development; Unit Operations and Processes, and Water Resources Planning and Management.
- The elective courses are: Earth and the Environment, Ecological and Biological Principles and Processes, Advanced Transport Phenomena, Convective Dispersion Modelling, Advanced Hydrology, Industrial Water and Wastewater Management, Land Drainage and Coastal Defence, Project Management, Rural Sanitation and Epidemiology, Applied Statistics and Operation Research, Water Chemistry and Microbiology, Water Distribution and Wastewater Collection Systems, and Principles of Water Quality and Legislation.

The remaining six months is devoted to an individual research project, which must be written up as a dissertation and submitted for examination. **Please note:** Classes usually commence in **February**.

The research work undertaken in this programme have been well-received and yielded publications in referred journals and conference proceedings. Graduates from this programme have a high marketability. Almost all of them have been absorbed into various governmental, semi-governmental agencies and the private sector.

This programme has special provision for serving engineers/scientists/consultants who wish to join. After completing the course work, they may undertake individual research project at their own work-place/organisation under the joint supervision of an academic staff member from the department and another person from their organisation (if available).

Most of the candidates admitted to this programme were supported through bursaries awarded by National Research Foundation (formerly Foundation for Research Development). A limited number of tutorship/laboratory assistantships may also be awarded depending upon the need and merit of the individual candidates.

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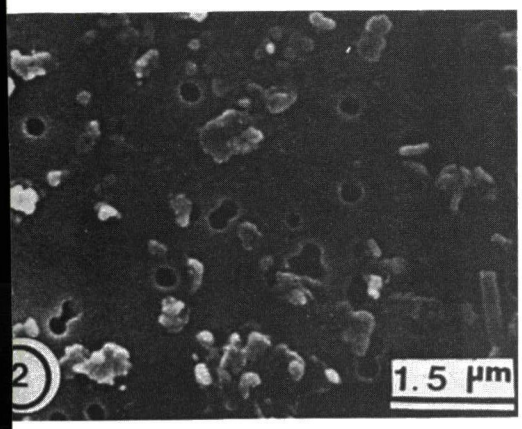

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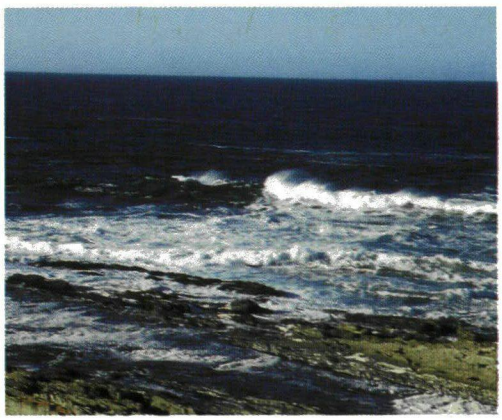

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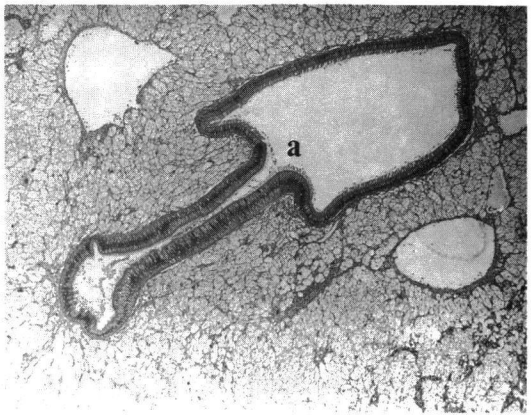

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Contents

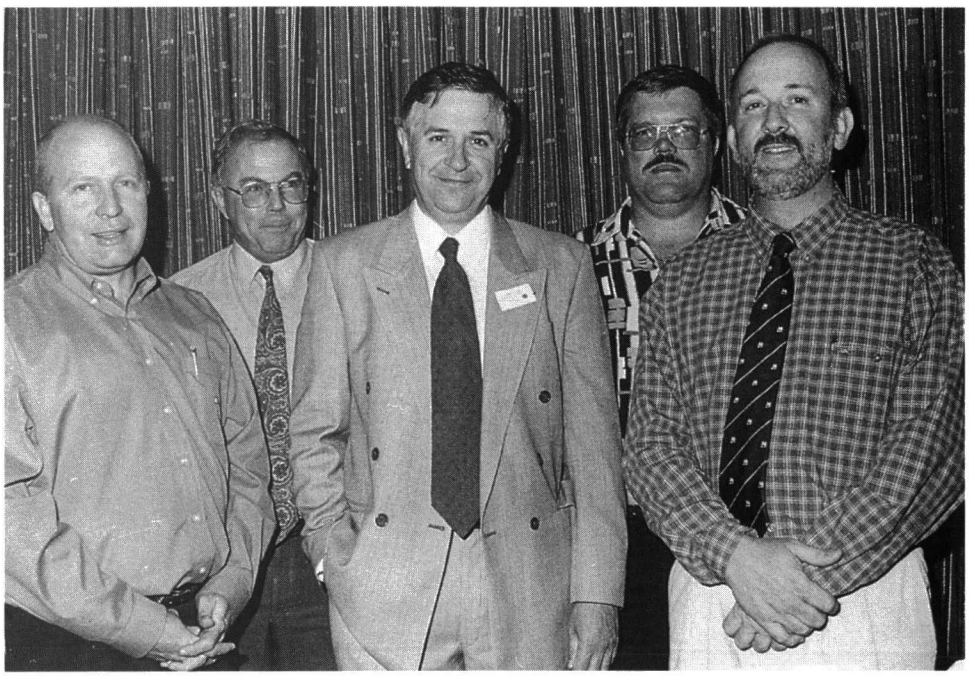
Cover: The warm Agulhas Current runs along the eastern and southern seaboard of South Africa. The core of the current is approximately 50 km wide and transfers about five times as much water vapour to the surrounding atmosphere as the surrounding waters. The results of a WRC research project confirm researchers' assertion that the moisture uptake above the Agulhas current contribute significantly to the moisture convergence and rainfall over interior areas adjacent to the coastline. Photo: Tsitsikama Coastline (Helene Joubert)

SA Waterbulletin is a two monthly magazine on water and water research published by the South African Water Research Commission (WRC), a statutory organisation established in 1971 by Act of Parliament. Subscription is free. Material in this publication does not necessarily reflect the considered opinions of the members of the WRC, and may be copied with acknowledgement of source. Editorial offices: Water Research Commission, PO Box 824, Pretoria 0001, Republic of South Africa. Tel (012) 330-0340. Fax (012) 331-2565. WRC Internet address: http://www.wrc.org.za Editor: Jan du Plessis (E-mail: Jan@wrc.org.za). Asst Editor: Helene Joubert (E-mail: Helene@wrc.org.za). Ed Secretary: Rina Human (E-mail: Rina@wrc.org.za). Layout: Ronel Urquhart - 4Images. Colour Separations: 4Images. Printing: Beria Printers.

Bird's eyeview

Update of the blue-green scene

A two-day workshop on Cyanobacteria (generally refered to as blue-green algae) was held at the end of August. All parties affected by, or interested in algal toxicity were invited. A group of almost a hundred delegates gathered at the Roode Vallei Country Lodge for the workshop. According to Dr Machiel Steynberg the main aim of the workshop was to gather all interested or affected parties together, to get a "snapshot" of the international scene, and an overview of the South African situation. He said that blue-green algae and algal toxins have been receiving much attention from researchers all over the world during the past few years.



Organisers of the workshop on Cyanobacteria (blue-green algae) with the two keynote speakers: Dr Machiel Steynberg (Rand Water), Dr Steve Mitchell (Water Research Commission), international keynote speaker Dr Geoff Codd (from the University of Dundee, UK), Dr Hein Du Preez (Rand Water) and South African keynote speaker Dr Bill Harding (Southern Waters).

The workshop started with a number of presentations to give delegates a bird's eyeview of "the blue-green scene". These invited presentations by experts gave delegates an understanding of the prevalence of Cyanobacteria, and the problems encountered with the toxic blue-green algae. This was followed by a workshop session on protocols for a national surveillance programme.

Day Two was allocated to techniques and methodologies with regard to sampling procedures, algal toxin extractions, toxin analyses and data assessment, as well as planning and management with regard to toxic algal blooms.

Dr Geoff Codd, from the University of Dundee in the UK, gave an international perspective on this global phenomenon, updating delegates on more recent events and research results on algal toxins . His presentation showed that "the blue-green scene" is a dynamic research field, and alarming, as new algal species and new microcystins (cyanobacterial toxins) are being discovered. Dr Bill Harding, of the company Southern Waters, presented a systematic overview of the South African situation, past and present, regarding toxic algal blooms, available data and research on blue-green algae in South Africa.

Speaking on the limnology of eutrophication, Prof Braam Pieterse from the Potchefstroom University gave the workshop group a glimpse into the daunting complexities of algal ecology. In the presentation on the effects of toxic algae on human health, Dr Philip Kempster of the Institute for Water Quality Studies, listed the various toxic algae, and their toxins, along with a description of the clinical symptoms and diagnoses related to each.

Prof Johan Joubert from the Onderstepoort Department of Toxicology discussed the effects of cyanobacterial toxins in agriculture, while Mr John Geldenhuis of Rand Water spoke on toxic cyanobacteria in water supplies.

It is quite evident that blue-green algae and associated cyanobacterial toxins are a global phenomenon. In the South African context the first records of cattle deaths due to toxic algae date back to the 1920's. Researchers' estimate that approximately fifty per cent of the blue-green algal blooms investigated in South Africa are toxic, indicates the potential hazard of these blooms. Management of the risk associated with this hazard is vital to prevent livestock losses or health-related problems in humans.

However, there is no evidence of acute toxification of humans from drinking conventionally-treated drinking-water, even if the raw water does come from a source with high concentrations of blue-green algae present.

TOXIC ALGAL FORUM

The workshop delegates unanimously approved the formal creation and establishing of a Toxic Algal Forum (TAF). The Forum will function under the auspices of the Water Research Commission (WRC) for the next three years. The TAF's first task will be to determine the occurrence and status of blue-green algal events as well as any consequences. This information will be issued as a Report which should be available by December 2000.

Enquiries: For further information please contact Dr Steve Mitchell at the Water Research Commission in Pretoria, on Tel. (012) 330-0340, Fax: (012) 331-2565 or E-mail: steve@wrc.org.za

The other invited speakers at the workshop were Mr John Geldenhuis (Rand Water), Prof Braam Pieterse (Potchefstroom University for CHE), Dr Johan Joubert (Onderstepoort Veterinary Science Research Institute) and Dr Philip Kempster (Institute for Water Quality Studies).

Delegates at the workshop on Cyanobacteria received an excellent overview of the "blue-green scene" from the experts.

Mr Serge Puyôo, from the SADC Water Sector Coordination Unit in Lesotho, having a word with Dr Emmanuel Naah, UNESCO representative in Nairobi, at the International Drought Conference held in Pretoria.

Conference scrutinise Drought Management

An International Conference on Integrated Drought Management was held in September at the CSIR Conference Centre, in Pretoria under the auspices of the International Hydrological Programme of UNESCO, as a contribution to the International Decade for Natural Disaster Reduction of the United Nations. The Water Research Commission, the Departments of Water Affairs and Forestry, Environmental Affairs and Tourism, Agriculture and Constitutional Development jointly hosted the conference which attracted 150 delegates from 26 countries. Africa was particularly well represented.

The conference theme, "Lessons for sub-Saharan Africa", focused the attention on this particular part of the world, as largely dry climates and large, growing but poor populations make this one of the most drought vulnerable regions. Much attention was given to the work done towards regional and international co-operation.

The interdisciplinary Conference covered subjects such as the challenges of forecasting, implications of climate variability, strategies that reduce vulnerability, and integrating drought considerations into policy. The Conference aimed at

- greater understanding of the factors predisposing people and landscapes to heightened vulnerability to drought;
- moving towards strategies and actions which can reduce drought vulnerability, and
- moving towards sustainable development and regional co-operation.

Papers were presented by speakers from a number of African countries as well as Europe, England, Malaysia and Australia. Mr Don Wilhite from the USA and Mr Clive Kapuyanyika-Bepura from Zimbabwe were the keynote speakers.

Opening the conference Mr Ronnie Kasrils, Minister of Water Affairs and Forestry, said that drought is with us to stay and that we have to learn to manage it better and better as water scarcity grows. He refered to "A wonderful example in this regard from the past ... the biblical wisdom of Joseph in ancient Egypt, advising Pharaoh on the need to prepare for the seven lean years to come, during the seven fat years", saying that it is the same concerns and approaches that have brought us together - making drought management part of sustainable development.

He considers co-ordinated gathering and dissemination of information to be one of the highest priorities as a basis for co-operative regional drought management, and said that the southern African region already has a number of initiatives towards pooling its information resources for common benefit. "I have been greatly encouraged by the progress in our region towards co-operation in the water management field ... and would like to mention the creation of a distinct sector for water within the SADC structure, with its SADC Water

Co-ordination Unit based in Maseru, and the formulation of a Regional Drought Management Strategy for SADC".

RESEARCH

Mr Kasrils pointed out that we will increasingly need our own research to be able to make crucial breakthroughs, and mentioned the South African Rainfall Stimulation Programme as an example of years of intensive research which brought breakthroughs which are now being acknowledged internationally.

Harnessing of science and technology along with a much greater public awareness is needed, together with positive action towards integrated drought management. "It is essential to create a much greater awareness about drought and growing water scarcity and about the massive and widespread impact of this phenomenon."

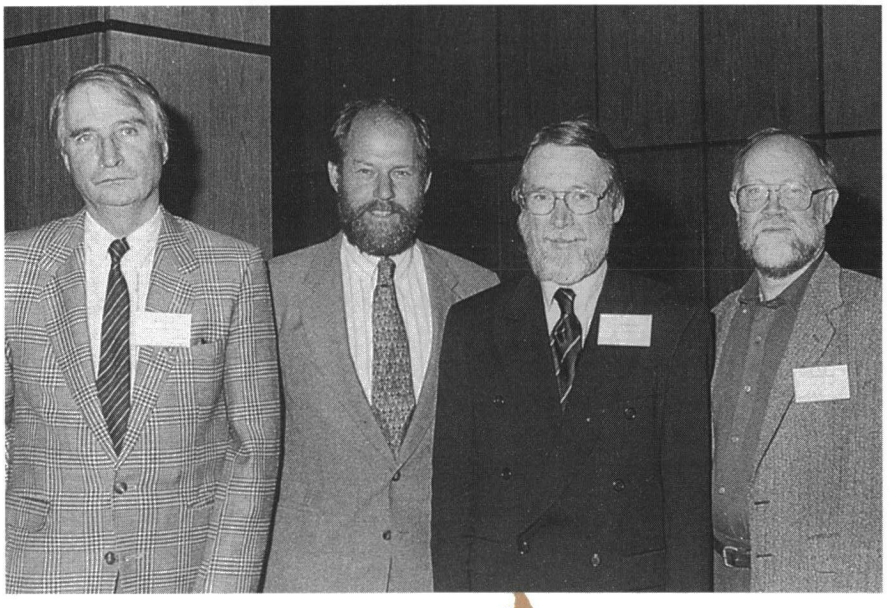
He said that South Africa has made great strides along the path of sustainable development with the National Water Act (1998) and the Water Services Act, as well we with a new policy for the agricultural sector and an overarching Disaster Management Policy. While sustainable resource use is the governing principle, agricultural policy also pays attention to food security and the small-scale black farmer. The main theme of the Disaster Management Policy is "Prepare, Prevent, Mitigate". He said that the envisaged National Disaster Management Centre, is aimed at coordinating activities at national level.

Mr Kasrils also said that according to UN experts the gap between poor and rich countries is the most obvious cause of the global environmental crisis, and challenged the conference to confront "this thorny nettle" and find lasting solutions.

Mr Clive Kapuyanyika-Bepura of the SADC Food Agriculture and Natural Resource Development Unit, based in Zimbabwe, gave an overview of Drought Management from an SADC perspective, along with the various developments with regard to drought management, which have taken place since the establishment of the Regional Early Warning System (REWS) in 1987.

Dr Don Wilhite, director of the National Drought Mitigation Centre, USA, said that an assessment of the status of drought preparedness of the countries in Africa's sub-Saharan region indicated that many countries have created the basic organisational structure necessary to plan for and mitigate the impacts of future drought events. He presented an overview of basic concepts of drought planning and methodology used in the USA and elsewhere, and said that recently much more emphasis has been placed on vulnerability assessment to reduce risk.

Amongst the speakers at the conference were: Dr Don Wilhite (National Drought Mitigation Centre, USA), conference chairman Hugo Maaren (Water Research Commission, South Africa), Mr Clive Kanyanyika-Bepura (SADC Food Security Unit, Zimbabwe), Dr David White (ASIT Consulting, Australia), Dr Mickey Glantz (National Centre for Atmospheric Research, USA), and Dr Margaret Seely (Desert Research Foundation of Namibia).



Mr Eberhardt Braune from the Department of Water Affairs and one of the organisers of the conference with some of the speakers: Dr Raymond Auerbach (Ntshongweni Catchment Management Project, KwaZulu-Natal), Mr Eduard Mellaart (Agricultural Research Council, Nelspruit), Mr David White (ASIT Consulting, Australia) and Mr Brett Garanganga (SADC Drought Monitoring Centre, Zimbabwe).

DROUGHT PLANNING

One of the lessons at the conference was that people tend to loose memory of previous events and respond in crisis mode again next time. It therefore takes a lot of foresight and will to introduce a planned approach to drought management.

The conference clearly indicated that drought management should not, as in most cases, just be a relief response, but a highly planned intervention which should form a normal part of integrated water resource and other planning. Swaziland's approach to have drought planning within their national development appears very appropriate. The South African concept of linking it with integrated rural development also offers important opportunities of interaction

An ecological view of drought response, which was put forward from Namibia, pointed out that during extensive drought periods completely different dynamics operate in town and rural areas, and need to be taken into consideration in drought planning.

The need for linking of macro and micro levels, eg. global and regional weather forecasts as well as satellite pictures on the one hand and the "at risk" rural community on the other hand, in drought planning and management was also pointed out. In West Africa high quality satellite pictures were complimented with ground truth data collection of the different landscape units, with the well-organised participation of the local people. It is important that these different levels work together in the assessment, as well as the management, of drought.

At the conclusion of the conference a proposal, in line with the growing trends towards globalisation and international collaboration, was put forward by Ms Joan Whitmore, a former director of the Hydrological Research Institute in South Africa. The proposal was accepted and suggests that:

- There is a need for an International Centre for Drought Research in the region, hosting international expertise, with the aim of minimising the impact of damaging drought events, by sound risk management
- The long-term objective would be to reduce dependency on relief assistance in time of extreme drought
- The initiative should be taken by a consortium of national governments of drought-prone countries, or an existing regional organisation (such as SADC); and that
- Part of the international financial resources currently used for drought relief assistance should be channeled into this initiative.

It is suggested that such a centre should mainly focus on policy and serve as an information-clearing house for the whole of the sub-Saharan region.

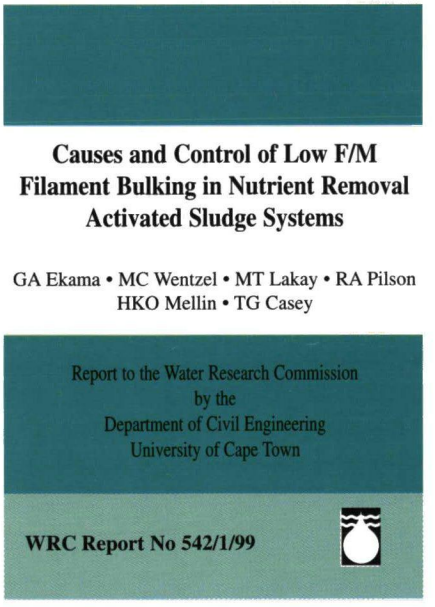
Research leads to a better understanding of filament bulking in activated sludge systems

The results of a research project which have contributed towards a better understanding of the factors that cause bulking in nutrient removal activated sludge systems are currently available (in the form of a final report) from the Water Research Commission in Pretoria. The report entitled **Causes and Control of Low F/M Filament Bulking in Nutrient Removal Activated Sludge Systems** (WRC Report 542/1/99) was compiled by a team of researchers from the Department of Civil Engineering at the University of Cape Town. The researchers involved were GA Ekama, MC Wentzel, MT Lakay, RA Pilson, HKO Mellin and TG Casey.

Two surveys of filamentous bulking in South African biological nitrogen (N) and nitrogen and phosphorus (N&P) removal plants indicated that bulking, caused by low food/micro-organism (F/M) filaments, is the major solid/liquid separation problem through poor sludge settleability in these plants. It has been estimated that if sludge settleability could be kept under control at diluted sludge volume index below 100mℓ/g by controlling low F/M filament proliferation between 50 to 100 per cent more wastewater could be treated in existing N and N&P removal plants. The large savings this would bring is the driving force behind research into the causes and control of filamentous bulking.

Establishment of the cause of low F/M bulking in nutrient removal plants would open the way to develop strategies for control of low F/M bulking in N and N&P removal plants. To achieve this end, this project had the following aims:

- To devise specific control strategies against low F/M filament bulking in biological nutrient removal (N and N&P) activated sludge plants.



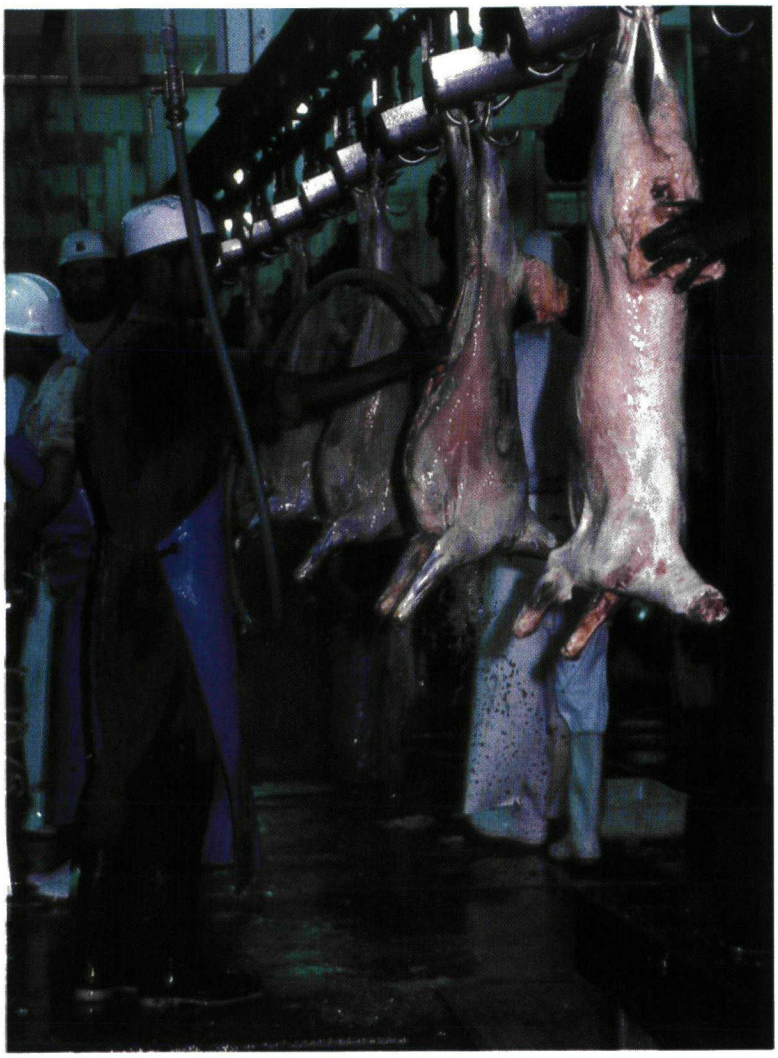
- To test control strategies on laboratory scale biological N and N&P removal systems that flow from the present understanding of the proposed cause of low F/M filament bulking.
- To confirm the hypothesis for the cause of low F/M filament bulking by examining the experimental data collected to date and conducting further experiments.

RESULTS

The research has shown that the promoted specific control method of selectors which stimulate removal of influent readily biodegradable COD in anaerobic, anoxic or aerobic selectors by metabolic or kinetic selection are not successful for controlling bulking in biological N&P removal plants. It was found that the conditions which stimulate biological nitrogen removal are conducive to bulking on nutrient removal plants, i.e. if denitrification is not complete at the time, conditions switch from anoxic to aerobic, then proliferation of low F/M (renamed Anoxic-Aerobic to accurately describe the conditions under which they proliferate) filaments takes place.

A large body of laboratory scale evidence of an indirect nature supporting this alternative explanation for bulking in nutrient removal plants has also been accumulated in the research.

Copies of this report are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 20).



Testing modern membrane treatment technology on abattoir effluents

One of the first demonstrations in the world of the feasibility and cost effectiveness of using membrane treatment technology in the meat processing industry has been documented for the Water Research Commission by JAC Cowan from the firm Steffen, Robertson and Kirsten Consulting Engineers. Membranes were used to separate the organic contaminants from abattoir effluents and recover a high quality water for reuse.

According to the final report summarising the project results, the primary objective of making this effluent treatment technology available to the South African Abattoir Corporation (Abakor Ltd) was to provide the industry the opportunity of becoming familiar with membrane technology and assessing its value in abattoir applications using a hands-on approach.

The report says no reference is made in the international literature to the use of membrane processes for treating abattoir effluents. Despite the potential for radical and cost-effective treatment of abattoir effluents using membranes, the novelty of the approach carries some risk and the chances of successful implementation, on a commercial scale, is rather small without further development work in partnership with the industry.

Facing the likelihood that the membrane approach to abattoir effluent treatment, being the culmination of many years of development work (funded by the Water Research Commission), might end up merely as a novel idea in a series of technical reports, Steffen Robertson and Kirsten (SRK) proposed that a stage of technology transfer to the user industry should be considered.

Discussions with Abakor, the largest representative in the abattoir industry in South Africa, indicated a high level of interest as well as a wide variety of situations amongst their eleven abattoirs where this technology could be applied. Agreement that the exercise proceed was formalised in a tripartite contract between the WRC and SRK and the South African Abattoir Corporation (Abakor Ltd).

The objective was for the WRC to make available to the abattoir industry, a pilot plant equipped with ultrafiltration and reverse osmosis to be used by the industry to test its capabilities at no significant financial or technical risk to the industry. This allowed the industry to become familiar with the technology at first hand, and to assess not only its effectiveness in treating selected effluent streams, but also its requirements in terms of supervision, control, operation and maintenance in the abattoir environment.

The South African firm Membratek (Pty) Ltd built a skid-mounted pilot-plant and leased it to the project. The ultrafiltration

(UF) system comprised 12 commercial tubular polyethersulphone modules, while the reverse osmosis (RO) system contained 24 commercial tubular cellulose acetate modules. Each module had a membrane area of 1,75 m^2. The pilot plant was located at the Cato Ridge abattoir in KwaZulu-Natal where the feed stream of mixed process effluents was pretreated by screening and fat removal by coarse bubble aeration.

RESULTS

The results of the project may be summarised as follows:

- The performance of the membranes compared reasonably well with that obtained in previous test work, using imported non-cellulosic membranes. Rejections of COD, by UF in particular, were extremely good, but other rejections by UF are worth noting in that they were not fully expected.

  These include:
  - an apparent salt rejection of 25 per cent, measured as conductivity;
  - a typical rejection of about 85 per cent of soluble phosphates, possibly as a result of complexing with proteinaceous materials.

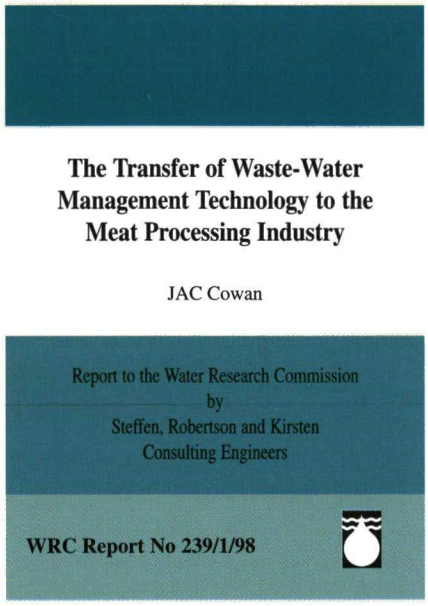
- Flux decline was rather more severe than indicated by previous work with abattoir effluents.

- As the trials proceeded it became clear that the more gentle cleaning techniques were becoming less effective and that clean membrane fluxes were not being fully recovered.

- The harsher cleaning techniques were somewhat more effective, and in most cases more expensive, but promoted the risk of damaging the membranes with repeated use, potentially shortening the life of the membranes.

- After some months of this declining trend in membrane cleaning efficiency, it appeared that the entire exercise may have to be aborted on the basis of high cleaning costs, excessive down-time during inordinately long cleaning runs, and membrane damage.

- A series of short laboratory-controlled cleaning trials using enzymatic preparations designed for general cleaning in the abattoir on fouled membranes was carried out at the Institute for Polymer Science, Stellenbosch and yielded spectacular results. When chemical cleaning was assisted by sponge balling, flux improved more than threefold. No damage to the membranes was detected as a result of using these preparations.



EVALUATION

Level of supervision

The operating programme assumed that the equipment would largely run itself and require the presence of an operator only when samples needed to be taken, or for cleaning routines or for start-up and shut-down. For certain periods of operation, this philosophy proved adequate, even though an operator may have been available for the entire day. Night-time running was generally unattended. Now that cleaning regimes have been very largely optimized it seems probable that full-time attendance would not be necessary for full-scale commercial plant operation.

Monitoring and analysis

Although the exercise was not designed as a research investigation, it was necessary to monitor performance on a far more frequent basis, for design purposes, than would be expected in a full-scale commercial plant. Based on extensive monitoring it is concluded that in this application the membrane equipment:

- is tolerant of widely variable feed quality.
- performs satisfactorily after only rudimentary pretreatment.
- consistently maintains the required product quality under a wide range of operating conditions.

Equipment maintenance

Minor screening and pumping difficulties experienced appeared more related to the specification of the pilot plant than to the nature of the equipment, and in full-scale applications, maintenance requirements would be expected to be fairly minor.

Operating costs

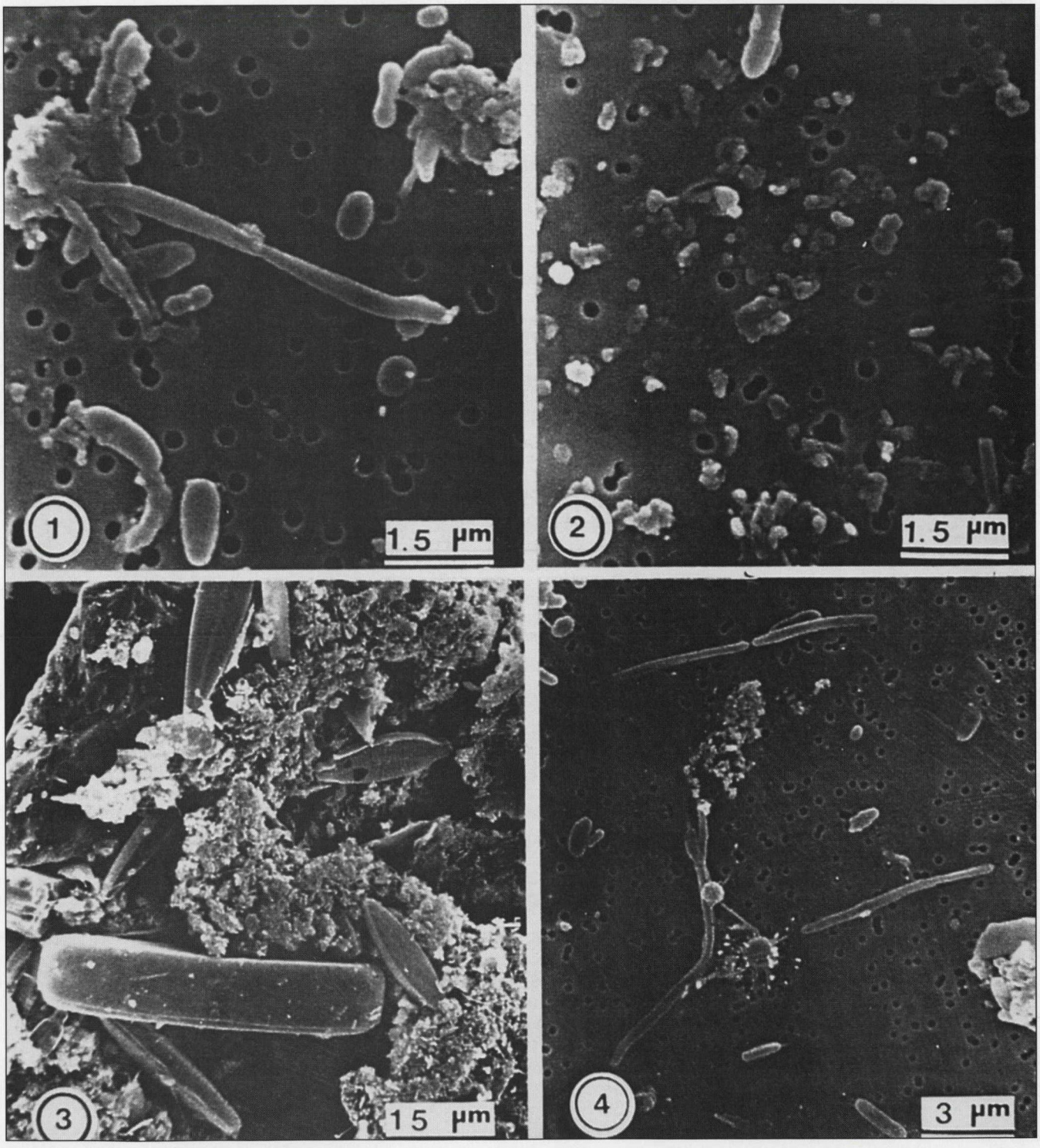
The more significant operating costs associated with the process include:

- Membrane replacement
- Personnel for operation and supervision
- Power
- Chemicals for membrane cleaning
- Maintenance

The trials indicated that personnel requirements, cleaning chemicals and mechanical maintenance need not be costly. Membratek (the membrane suppliers) considered that a membrane life of at least 18 months was probable, and up to three years was likely. This should be confirmed by longer term trials under stable operating conditions. Abakor considers this to be a major uncertainty, that impacts negatively on the wider application of this technology in the abattoir industry.

Copies of the report entitled **The Transfer of Waste-Water Management Technology to the Meat Processing Industry** (WRC report 239/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$20, via surface mail).

Evaluating hydrodynamic cavitation for the treatment of raw water and effluents



Scanning electron micrographs of non-cavitated (Micrographs 1,3 and 4) and cavitated (Micrograph 2) samples of raw water.

The Water Research Commission has funded a project in which the benefits and the limitations of hydrodynamic cavitation for the treatment of industrial effluent and raw water treatment were highlighted.

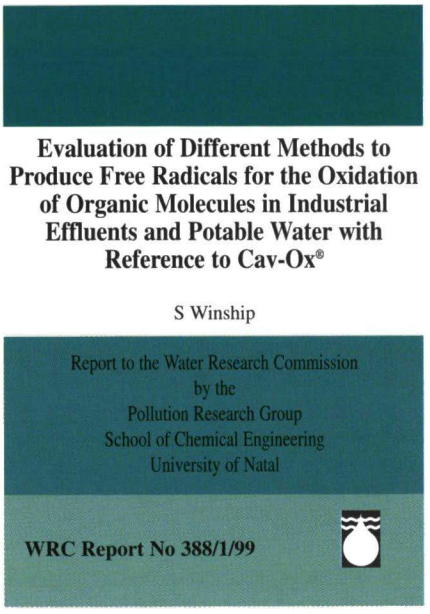
Unfortunately, results from the study show that the use of hydrodynamic cavitation for the treatment (disinfection) of raw water is not recommended, "since chlorine will be required in any case to ensure adequate disinfection". Similarly, the application of hydrodynamic cavitation as a single advanced oxidation process is also not recommended.

The researcher, S Winship from the Pollution Research Group, School of Chemical Engineering, at the University of Natal, says in the final report to the Water Research Commission, that environmental legislation and the increasing pollution of water supplies have necessitated the evaluation of existing technologies and the development of new technologies for the removal of organic pollutants from industrial effluents and potable water, and for the disinfection of potable water by the inactivation of bacteria and pathogens.

Recently, advanced oxidation processes have developed as potentially powerful methods for the treatment of organic pollutants in water and the disinfection of potable water. The processes involve the generation of highly reactive free radical intermediates such as the hydroxyl radical. The advantage of these oxidation processes is that the organic pollutants can be completely mineralised to carbon dioxide, water and a small amount of acids, while the degradation process usually operates at or near ambient temperature and pressure. In some cases, complete mineralisation may not be achieved due to excessive reaction times, nevertheless, advanced oxidation processes are potentially beneficial as pretreatment steps that complement other treatment processes. For example, advanced oxidation processes can be used to enhance the biodegradation of highly toxic pollutants.

The rates of advanced oxidation processes are greatly enhanced compared to those of oxidation with conventional oxidants because of the high reactivity of the radical species, primarily hydroxyl radicals. In order for advanced oxidation processes to be used for water treatment purposes, hydroxyl radicals must be generated in excess. One way in which to achieve this is the irradiation of hydrogen peroxide with ultraviolet light which induces the decomposition of hydrogen peroxide to form two hydroxyl radicals. Advanced oxidation technologies include processes involving hydrogen peroxide, ozone, ultrasound and ultraviolet radiation, or combinations of these.

The rates of chemical reactions can be increased by concentration, pressure, catalysts, ultraviolet light and cavitation.



Cavitation

Cavitation is defined as the formation, expansion and implosion of bubbles in a liquid. Bubbles are formed due to the reduction of local pressure in a liquid to the vapour pressure of the liquid at a specific temperature. Theoretical calculations indicate that a minimum pressure (known as the cavitation threshold) of 1 013 MPa is required to form bubbles. However, experimental observations indicate that the cavitation threshold varies from 101 to 2 532 kPa, although a cavitation threshold of 20 260 kPa has also been reported. The cavities collapse when the local pressure is greater than the vapour pressure of the liquid. Collapse of these bubbles leads to the release of considerable energy which is claimed to generate sufficient localised temperatures and pressures to form hydroxyl and hydrogen radicals from the thermal dissociation of water molecules. It has been predicted that localised temperatures between 2 273 K and 5 000 K and pressures ranging from 101 MPa to 101 300 MPa occur upon the collapse of the bubbles.

Cavitation can be produced in a liquid by four different methods:

- Hydrodynamic cavitation is produced as a result of pressure variations in a flowing liquid due to the geometry of the system.
- Acoustic cavitation is produced by sound waves in a liquid which cause pressure variations.
- Optic cavitation is produced by photons of high intensity light (i.e. laser) that rupture a liquid.
- Particle cavitation is a result of any type of elementary particles, e.g. protons, rupturing a liquid.

CAV-OX®

A company called Watergroup (USA) has developed an advanced oxidation technology (the CAV-OX® process) that employs ultraviolet radiation, hydrogen peroxide and hydrodynamic cavitation to degrade organic compounds present in water at milligram per litre concentrations to non-detectable levels by photolysis and oxidation. Ideally, the end products of the process are water, carbon dioxide, halides and, in some cases, organic acids. The major components of a CAV-OX® system are the cavitation chamber, UV reactor and control panel. In addition to the production of hydroxyl radicals by the ultraviolet photolysis of hydrogen peroxide in the ultraviolet reactor, it is claimed that hydrodynamic cavitation, induced in a venturi nozzle in the cavitation chamber, generates hydroxyl and hydrogen radicals which recombine to form hydrogen peroxide and hydrogen gas. The CAV-OX® system has been used to treat groundwater contaminated with volatile organic compounds such as trichloroethylene, benzene, toluene and nylene. A similar oxidative process combining hydrogen peroxide, hydrodynamic cavitation and ultraviolet radiation has resulted in up to 98 per cent decreases in the organic concentrations of various wastes, e.g. beverage-making effluent, tannery waste, activated sludge and raw sewerage.

Preliminary evaluation of the CAV-OX® system in 1990 by the Pollution Research Group at the University of Natal, indicated that hydrodynamic cavi-

peroxide and ultraviolet radiation on the decolourisation of dye effluent, thus supporting the claims that hydrodynamic cavitation generates hydroxyl radicals. It was also proposed that hydrodynamic cavitation alone may have the potential to inactivate pathogenic bacteria since ultraviolet radiation and hydrogen peroxide, the other constituents of the CAV-OX® system, are known to successfully inactivate bacteria. Hydrodynamic cavitation could therefore provide a less capital intensive technique to the present use of chlorine as a disinfectant for raw water treatment since cavitation venturi nozzles could be installed in water systems to exploit the existing pressure and velocity head, e.g. for rural water supply.

PROJECT

The emphasis of this Water Research Commission project was to study hydrodynamic cavitation and evaluate its ability to produce free radicals for the treatment of potable water and industrial effluents, with particular reference to the CAV-OX® system. The aims of the project were to be achieved by investigating the following research areas:

- ❑ The microbiological assessment of hydrodynamic cavitation for the treatment of raw water.
- ❑ The evaluation of hydrodynamic cavitation in the CAV-OX® system.
- ❑ The effect of ultrasonic cavitation on organic pollutants in industrial effluents.
- ❑ The computational fluid dynamics of hydrodynamic cavitation in a venturi.

RESULTS

- ❑ The potential use of hydrodynamic cavitation for the treatment of raw water without the addition of chemicals has been disproved since hydrodynamic cavitation is not an effective method for the inactivation of bacteria in raw water.
- ❑ The application of hydrodynamic cavitation as a single advanced oxidation process is not recommended as the concentration of hydrogen peroxide produced by the hydrodynamic cavitation of water (less than 0,034 mg/ℓ) would be ineffective for the oxidation of organic pollutants in industrial effluents and potable water.
- ❑ The manufacturer's claims about the role of hydrodynamic cavitation in the production of hydroxyl and hydrogen radicals in the CAV-OX® system have not been validated by the results obtained.
- ❑ The study found that the function of hydrodynamic cavitation produced in the cavitation chamber of the CAV-OX® system is to disperse the effluent to be treated prior to its oxidation with hydrogen peroxide and ultraviolet light.
- ❑ The degradation of organic pollutants (1-methylhydantoin) by ultrasonic cavitation in the ultrasonic cleaning bath indicates the potential of sonochemistry as an advanced oxidation process for the treatment of industrial effluents.
- ❑ The sonochemical formation of hydroxyl radicals by ultrasonic cavitation can be enhanced for industrial treatment purposes by the addition of hydrogen peroxide and oxygen, but this will mean additional treatment steps and costs.
- ❑ Computational fluid dynamics is a useful tool to indicate the potential of a fluid to undergo cavitation, however, the computational fluid dynamics of hydrodynamic cavitation which involves two-phase flow has not been achieved in this project because of the complex flow system.

Copies of the final report entitled **Evaluation of Different Methods to Produce Free Radicals for the Oxidation of Organic Molecules in Industrial Effluents and Potable Water with Reference to Cav-Ox®** (WRC report 388/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

Fingerprinting the microbial community structure in activated sludge systems

Many biological phosphorus removal activated sludge plants do not remove phosphorus adequately to satisfy effluent discharge standards. Currently ferrous sulphate is added to almost all South African nutrient removal activated sludge plants discharging effluents to sensitive catchments to mitigate potential eutrophication. Elimination of the need for chemical addition and improved biological phosphorus removal would therefore significantly reduce chemical and sludge disposal costs and also benefit the environment.

Until now it has not been possible to isolate a pure culture of bacteria that could be responsible for biological phosphorus removal and various methods have been considered to determine the difference between phosphorus removing and non-phosphorus removing activated sludge systems. Hence, there is a need for techniques that do not necessarily identify individual species of bacteria, but that can differentiate between bacterial communities in terms of their various constituents.

One such method is the analysis of total proteins. Analysing the total proteins extracted from a sample taken from an activated sludge reactor, can be used as a "fingerprint" to determine the diversity in the sample, in a way similar to grouping of bacteria according to enzyme polymorphisms and immunological reactions. Such fingerprints may eventually be used to monitor the deterioration or enrichment of species diversity in microbial communities.

WRC PROJECT

In a project funded by the Water Research Commission (WRC), researchers from the Department of Microbiology and Plant Pathology at the University of Pretoria tried to elucidate the metabolism of microbial communities in activated sludge plants by characterising metabolic zones in a typical activated sludge reactor, as well as in different designs of activated sludge plants. The researchers, MM Ehlers, A Erasmus and TE Cloete, say in their final report tot the WRC the protein profiles of the different samples were scanned with a densitometer and analysed with the Gel Compar computer program to determine the relatedness between the different zones and sludge systems. This gave an indication of the metabolic diversity amongst zones of the same system and amongst systems with different phosphate removing capabilities. Metabolic shifts indicated either population shifts or a change in metabolic pattern of resident population.

The specific objectives of the research project were as follows:

- Monitoring a specific activated sludge plant over time (e.g. every week) using polyacrylamide gel electrophoresis (PAGE) analysis of the total cell protein extracts.
- The comparison of metabolic zones within the same system using PAGE analysis of total protein extracts.
- Comparing different systems according to their design and phosphorus removal using PAGE analysis of total cell protein extracts.
- The comparison of systems which remove phosphorus to those which do not remove phosphorus using PAGE analysis of protein extracts.
- Comparing the same system when removing phosphorus and when not removing phosphorus using PAGE analysis.

RESULTS

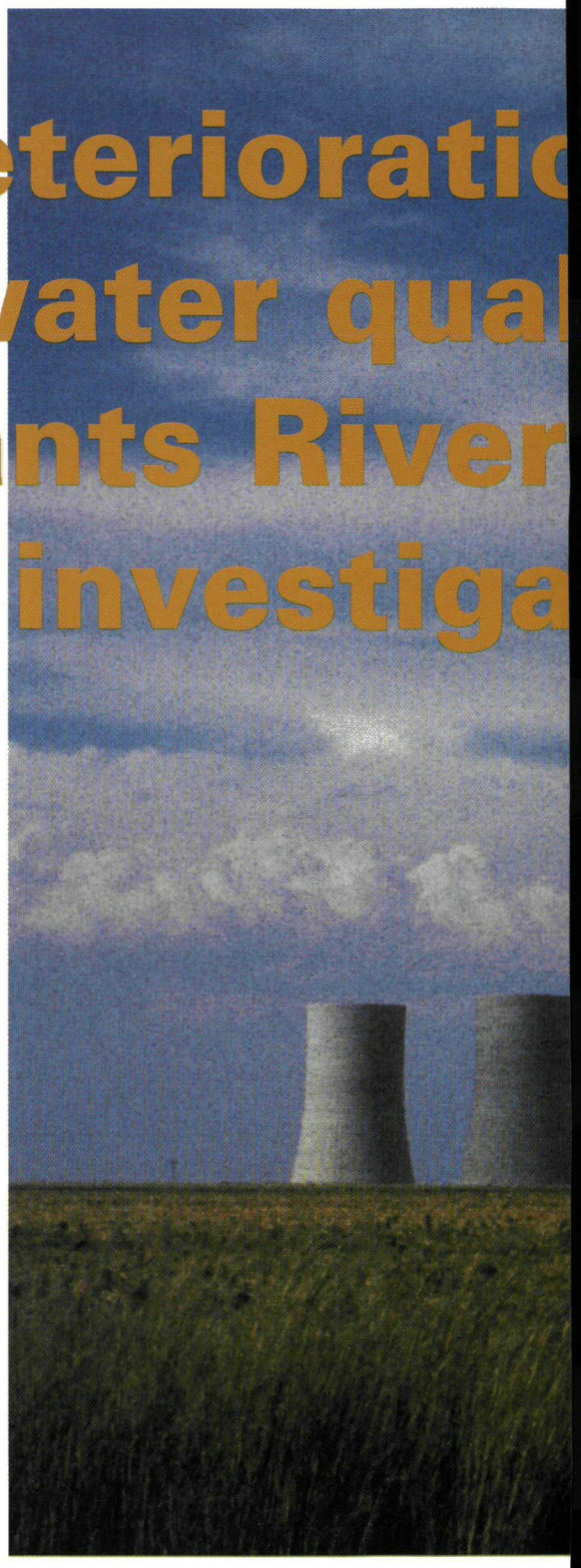
The results indicated that the protein fingerprinting method was a sensitive tool for the determination of the bacterial population structure in activated sludge plants. The polyacrylamide gel electrophoresis (PAGE) analysis was used because it obviates the need to culture bacteria before analysis, therefore, there is no selection of specific bacterial groups.

The following conclusions were drawn from this study:

- The PAGE analysis of bacterial proteins showed no differences between the protein profiles of bacterial community structures from different activated sludge zones.
- The bacterial communities of phosphorus and nitrogen removing laboratory scale systems showed no differences in their protein profiles when analysed by the PAGE method.
- Differences in system design and the type of wastewater treated did not alter the protein profile of bacterial proteins. This indicates that the microbial communities of activated sludge plants are closely related and that each sludge microbial community contains the genetic potential to treat a variety of wastewater types.
- The results of monitoring the Daspoort activated sludge plant in Pretoria over a 34 week period showed that seasonal changes did not alter the protein profiles of the bacterial community.
- The protein profiles of a P-removing and non P-removing system showed a high percentage of correlation, this indicates that there is no significant variation in their bacterial communities.
- Activated sludge systems are not dominated by any specific group of bacterial species but consist of different bacteria species which co-exist and function together in a complex microbial community.

Copies of the report entitled **Fingerprinting of Activated Sludge Systems Using PAGE Analysis of Total Protein Extractions for the Optimisation of Biological Phosphorus Removal** (WRC report 776/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

Possible deterioratio of groundwater qual in the Olifants River catchment investiga

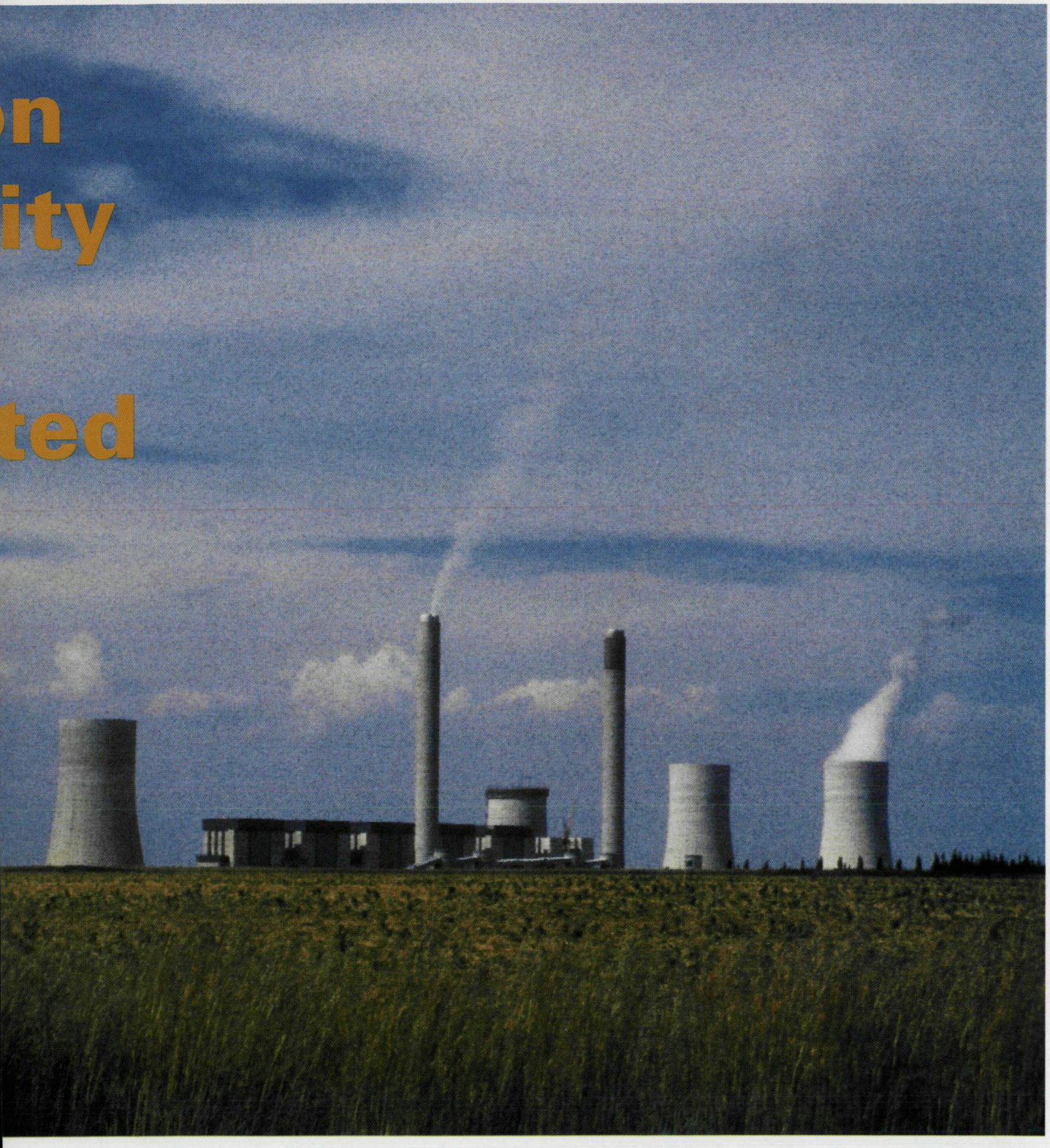


Two researchers from the Institute for Groundwater Studies at the University of the Orange Free State, FDI Hodgson and RM Krantz, have carried out an investigation in the Olifants River catchment in Mpumalanga to try and quantify the possible contribution of the various activities in the area such as mining, power generation, municipal waste disposal, etc., to the worsening water quality and groundwater pollution in the catchment. This was after elevated sulphate and low pH levels provided clear indications that the quality of the surface waters of the Olifants River, specifically the Witbank Dam sub-catchment, was deteriorating.

A final report summarising the findings of the project is currently available free of charge from the Water Research Commission in Pretoria. It is titled: Groundwater Quality Deterioration in the Olifants River Catchment above the Loskop Dam with Specialised Investigations in the Witbank Dam Sub-Catchment (WRC report 291/1/98). (Overseas price of the report: US$ 30, via surface mail).

The University of the Orange Free State, through its Institute for Groundwater Studies, entered into a research contract with the Water Research Commission, the Department of Water Affairs and Forestry, the Chamber of Mines of South Africa and Eskom to study the groundwater quality deterioration in the Olifants River catchment. The aims of the investigation were to:

- Quantify the contribution of various activities which may result in a deterioration of the groundwater resources in the catchment above Loskop Dam, with special emphasis on the Witbank Dam sub-catchment.
- Predict future salt loads in groundwater, based on projections of probable development in the area, and extrapolate information to other catchments



The disposal facilities at the power stations investigated are well managed, with minimal groundwater pollution.

that supply water to the Olifants River catchment.

- Investigate and research improved management and precautionary measures which could be utilised to minimise groundwater quality deterioration.
- Integrate groundwater information with other investigations in the area, including the water management programme of the Department of Water Affairs and Forestry, with the aim of deriving a catchment management programme at the end of the project.

RESULTS

The researchers say several studies on specific water related issues have been conducted by other investigators since this project was initiated. Where appropriate, use has been made of the find-

ings of these studies to supplement this project's investigations. A massive amount of data were gathered and interpreted to satisfy the aims of the project. The main findings were:

❑ Groundwater

Natural groundwater quality in the weathered aquifer used by farmers is excellent. Since yields are low groundwater is sufficient for domestic use, but not for irrigation.

❑ Surface water

There exists a direct link between the water quality in many of the surface streams and development (mostly mining) in the catchment. Sulphate levels in several streams have over the past twenty years increased from about 20 mg/ℓ to between 100 and 900 mg/ℓ.

❑ Opencast mining

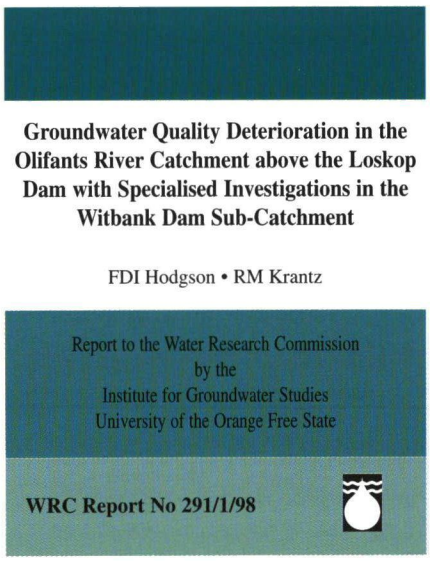
Of all the activities in the Olifants Catchment, opencast mining has the greatest impact on groundwater quality. The following is a selection of the main research findings:

- ❍ Methodologies have been developed to quantify the acid-base potential of opencast coal-mines. Seven of the mines which were tested have severe acidic tendencies, two are borderline cases and one is alkaline.
- ❍ The rate of sulphate generation in backfilled opencast areas, as calculated from this investigation, is between 5 - 10 kg/ha/d. On the basis of the present scale of opencast mining in the Witbank Catchment, this amounts to 70 t/d of sulphate. This amount is over and above the 33 t/d presently entering into the Witbank Dam on average from other sources.
- ❍ Pits that have been mined out, fill up with water to their decant level within 5 - 10 years after mining has ceased.
- ❍ Three water management options at opencast coal mines stand out. These are selective spoil handling, flushing under certain conditions and containment.

❑ Underground mining

Shallow underground mining has, in many instances, mined into the weathered aquifer, with the result that rain water actively recharges these mines. Most of the shallow underground mines west of Witbank are currently full of water and are decanting acid water onto surface.

- ❑ Deep bord-and-pillar underground mining does not pose a long-term threat to groundwater pollution. On the other hand, high extraction underground mining results in the collapse of overlying strata, usually resulting in the overlying strata and aquifers adjacent to these areas being dewatered. As a rule, the effect of dewatering is not noticeable more than 500 m away from current high extraction mining. Water in high extraction areas has any of a range of chemistries, depending on the evolutionary stage of the water. The quality of this water is inadequate for disposal into public streams. A viable disposal option is to create underground storage space.



❑ Power generation

Possible sources of groundwater pollution at power stations are mainly that of fly ash disposal, coal stockpiling and dirty water dams. The investigation concluded that the disposal facilities at the power stations are well managed and groundwater pollution is minimal.

❑ Municipal waste disposal

Although general waste of municipal origin may pose a threat to groundwater pollution, this threat is very localised.

❑ Sewage effluent disposal

Sewage works do not significantly impact on groundwater quality. Treated sewage effluent, which is discharged into streams, has ameliorating effects on the acid-mine drainage.

❑ Metal industry

Metal industries, comprising mainly steel, stainless steel, ferrosilicate and vanadium producing plants have little regional impact on groundwater quality. Locally, problems are experienced with the disposal of saline liquids, slimes, slags, phenol and in the case of the stainless steel industry, chromium and nickel. Groundwater pollution is of a localised but intense nature.

❑ Agriculture

Agricultural pollution of groundwater is local and isolated. Nitrate (N) and phosphate (PO_4) levels in the groundwater are generally less than 2 mg/ℓ. Groundwater pollution at feedlots is localised and site-specific. Pesticide and herbicide levels are low in surface water and very low in groundwater.

The researchers say a sufficient understanding of processes within the various activities in the Olifants Catchment has been obtained to enable conceptualisation, description, modelling and ranking of all issues that contribute to groundwater pollution. All relevant data have been entered into the HydroCom database.

Prediction of future salt loads has been done through chemical equilibrium, mixing cell and finite element mass transport modelling. These models are sufficient to describe chemical reactions and pollution plume modelling at any of the waste management facilities in the Olifants Catchment. As part of this modelling exercise, management options at opencast mines and fly ash dams have been evaluated. By superimposing this information onto the average annual run-off for the Witbank Catchment, extrapolation on a catchment basis has been accomplished.

Very few improvement management options are available at existing facilities due to cost considerations. Where considered necessary, options that need further investigation have been identified on a site-specific basis in the report.

Researchers investigate the role of the Agulhas sea current in South Africa's weather

As Southern Africa is for the greater part surrounded by ocean, it is to be expected that the weather and climate of South Africa will be strongly influenced by these water masses. According to researchers from the Department of Oceanography at the University of Cape Town, statistical results have indicated that the oceanic environment and specifically heat losses in the Agulhas Current and Agulhas retroflection play an important regulating role in the weather and climate of the subcontinent.

"Anomalies of sea surface temperatures in the South Atlantic and South Indian oceans are geographically extensive and have a life-time of weeks to years. Furthermore, significant statistical teleconnections between these oceanic temperature anomalies and precipitation over South Africa's summer rainfall region have been demonstrated."

The researchers, M Rouault, JRE Lutjeharms, AM Lee-Thorp, MR Jury and M Majodina, say in their final report to the Water Research Commission that having established statistical connections, an understanding of the actual processes involved becomes important if ocean variability is to be used in future to predict rainfall patterns over land.

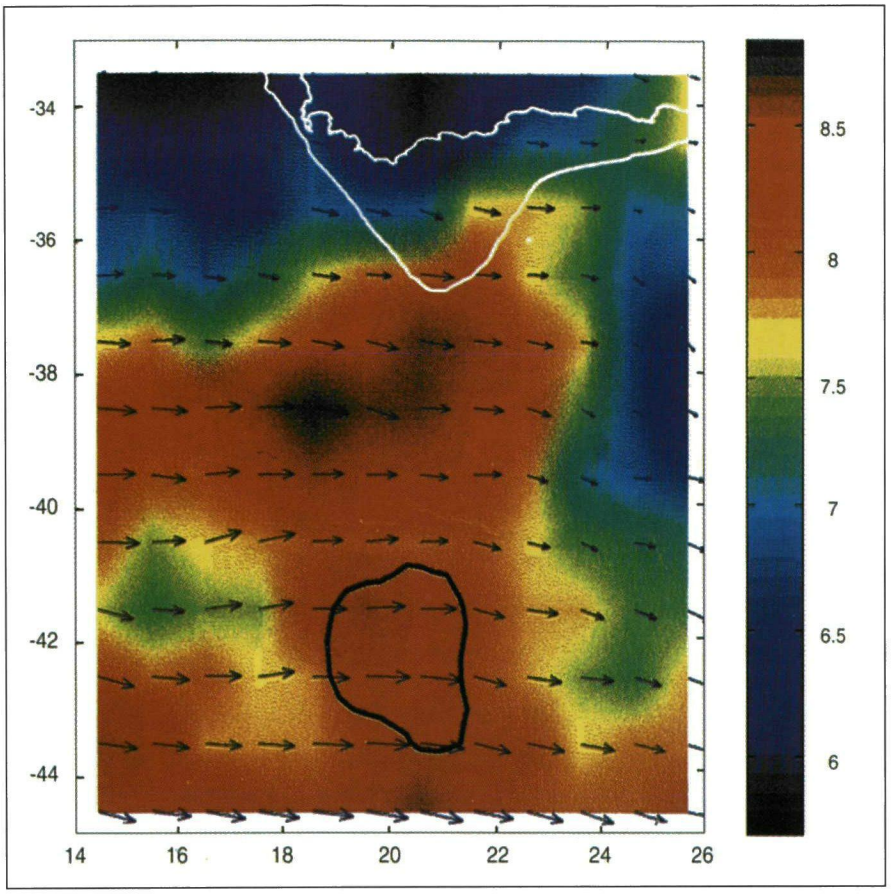
A five year research programme was funded by the Water Research Commission to investigate the physical mechanisms of ocean-atmosphere interaction in the Agulhas Current and how the Agulhas Current affect the weather through this ocean-atmosphere interaction.

The first goal of this programme was to perform high quality measurements over the Agulhas.

"To understand the interaction of the ocean and atmosphere, to calibrate satellite detected meteorological parameters and to improve air-sea interaction parameterization in the current numerical models, it is mandatory to have high resolution and accurate measurement of sea surface temperature, wind speed, air temperature and humidity, short and long wave radiation and to use them to calculate the turbulent and radiative fluxes and the net heat budget at the air-sea interface."

Knowledge of the turbulent fluxes allows

researchers to describe the structure of the lower part of the marine atmospheric boundary layer, that is, the vertical profiles of air temperature, humidity and wind. To link these surface measurements to the rest of the marine atmospheric boundary layer, radiosondes must be used. The researchers say the interaction between the atmosphere and the oceans takes place in the marine atmospheric boundary layer and the oceanic mixed boundary layer. The marine atmospheric boundary layer is about one to three kilometres thick while the oceanic mixed layer is less than hundred metres deep. Both are decoupled from the remainder of their fluid bodies by a stratified layer called an inversion in the atmosphere and a thermocline in the ocean. The atmospheric boundary layer is currently better understood than the marine boundary layer. It is composed of a few millimetres thick laminar layer, a surface layer where the turbulent fluxes of momentum, latent and sensible heat are almost constant and a mixed layer up to the inversion zone. The surface layer is supposed to be horizontally homogeneous and processes are essentially turbulent.



ERS1 surface mean wind speed and direction form May to August 1993 above Eddy Lesly and the southern Agulhas Current.

The turbulent fluxes of momentum (wind stress), sensible heat and latent heat at the air-sea interface are important in numerous aspects of oceanography and meteorology. The latent heat flux is the energy flux connected with the vertical transport of water vapour, the evaporation. Oceanic evaporation leads to the latent heating of the atmosphere and participates in the creation of hurricanes and cyclones. Water vapour is advected above the continents by physical processes not well understood and depending on ocean-atmosphere interactions. Only a fraction of it precipitates above the continents. Consequently the global cloud coverage, precipitation rates and their distribution depend mainly on the latent heat fluxes over the ocean. In turn evaporation leads to significant cooling of the upper ocean. The sea surface temperature field and the related thermohaline circulation depend on the net heat budget at the surface. Evaporation and precipitation at sea are the main forcing of the thermohaline circulation of the oceans. Oceanic motion is mainly due to atmospheric forcing by wind. This oceanic motion again affects the seasonal and climatic atmosphere temperature distribution. Gas exchange between the oceans and the atmosphere is directly regulated by the sea state, wind speed and the air-sea temperature difference. Water vapour is a greenhouse gas - it plays an important role in the radiative balance of the atmosphere. On a smaller scale, latent and sensible heating in a strong convective regime, radiative heating and precipitation all have a strong influence on storm dynamics and regional circulation.

The researchers say that satellite imagery and computer manipulation have succeeded in revealing roughly, the coupling between the atmosphere and the oceans. While numerical simulation yields interesting results, gross parameterization of boundary conditions, limitations due to the size of the modelling grid and the present impossibility to take into account all the time scales involved, prohibit a good description of exactly those small scale phenomena which are responsible for the ocean-atmosphere engine.

"Ideally, to understand the influence of air-sea interaction on a large scale, high quality *in situ* measurements have to be made jointly with satellite observations and the product should be assimilated in an atmospheric general circulation model. The feedback between the fluxes and the different scales involved are responsible for the complication of the theory. Yet, there still is a lot of room for experimental studies and research programmes of measurements in this field, especially over the Agulhas Current."

RESULTS

According to the final report submitted to the Water Research Commission, the project consisted of five interlinked parts: assemblage of the measuring array; observations during a winter cruise to the Agulhas Return Current; a sea-land experiment at East London; an observational programme between Cape Town and the Prince Edward Islands and, last; a dedicated cruise in the Agulhas Current.

❑ Measuring array

The whole project was totally dependent on measurements of the very highest quality. A start was made by assembling a portable, state-of-the-art, air-sea inter-

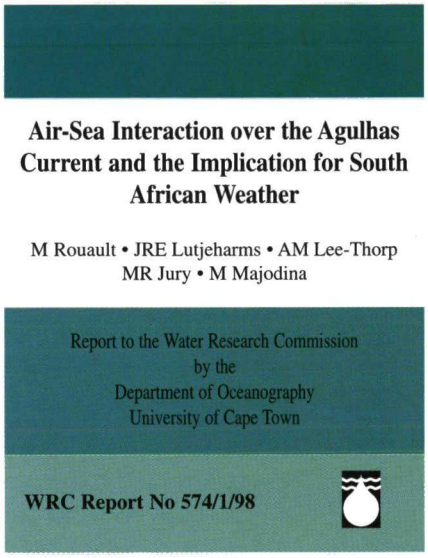
action measurement system, including a *Gill* sonic anemometer, an *Ophir* infrared hygrometer, an *Eppley* pyranometer, an pyrgeometer and a *Väisäla* temperature and relative humidity probe. Turbulent fluxes of momentum (exchange of momentum between air and sea surface due to wind drag), sensible and latent heat were calculated in real time from integrated observations made by these instruments. The system was installed on the research vessel *S.A. Agulhas* and successfully employed during a six-week cruise in the "Roaring Forties" in winter. The system was also used in a coastal experiment on top of a lighthouse as well as on a small coastal research vessel. A less sophisticated, low-cost system was installed on the *SA Agulhas* to provide automatic measurements during routine cruises. Excellent results were achieved with this instrumentation, demonstrating its appropriateness as well as its robustness under extreme weather conditions.

❑ Winter cruise

A multi-disciplinary cruise was carried out from the *SA Agulhas* during the winter of 1993. The aim was to investigate the interaction of a warm eddy at the Agulhas Return Current south of Africa with the overlying atmosphere during a season when ocean-atmosphere contrasts are extreme. Air-sea interaction measurements were supported by both radiosonde launches and oceanographic measurements. The eddy was a strong source of heat for the atmosphere with latent heat fluxes of up to 500 Wm^{-2}, sensible heat fluxes exceeding 350 Wm^{-2}, but with low short wave radiation inputs due to persistent cloud coverage. This heat flux over the eddy was an order of magnitude higher than shown in climatology for the general region. ERS-1 satellite wind measurements demonstrate that this eddy had a persistent influence on the mesoscale wind field, increasing wind speeds whenever high differences between air and sea temperatures created unstable atmospheric conditions and high values of turbulent heat flux. This establishes the unanticipated importance of mesoscale oceanic features on the atmosphere.

❑ Land-sea experiment

A study of the lower atmosphere west of East London was conducted in November 1993 to characterise moisture inputs from the Agulhas Current to the adjacent plateau. The study region falls in a terrestrial transition zone between the dry area to the west and the sub-humid areas to the east. Instrumented aircraft surveys were flown between the south-eastern Karoo and the warm Agulhas Current while simultaneous measurements were being made at East London with our instrumentation system. Observations by aircraft and radiosondes revealed how the sub-humid front is shifted by large-scale weather systems. Sharp spatial gradients in surface fluxes of about 100 Wm^{-2}/10 km were prevalent. Inland penetration of moisture was shown to depend on background zonal winds as well as on the depth of the marine layer. During easterly winds, for instance, landward moisture fluxes were greatest in a plume 2 km deep. Combining these disparate instrument platforms allowed us to establish the overland fluxes of moisture from the Agulhas Current for the first time.



❑ Prince Edward Island crossings

These relief cruises take place annually and fortuitously cross an array of oceanic features including the Agulhas Current, the Agulhas Return Current, the Subtropical Convergence and the Subantarctic Front. Calculation of the turbulent fluxes of momentum, latent and sensible heat over these features requires the simultaneous measurement of wind speed, sea surface temperature, air temperature and air humidity. A low-cost measurement system was installed on the *SA Agulhas* in 1994. Radiosonde releases linked the surface forcing to the remainder of the atmosphere. In 1995 the full resolution of the radiosonde data was stored for the first time and this operation was repeated in 1996 and 1997 with extra radiosonde ascents above strategic parts of the Agulhas Current. Comparative detail of conditions in the atmospheric boundary layer over these contrasting features was thus acquired. This places the enormous effect of the Agulhas Current on the atmosphere into better perspective.

ACASEX

The researchers say that this was the first research cruise ever dedicated to an investigation of air-sea interaction over the Agulhas Current proper and took place during the autumn of 1995. It aimed to investigate the exchanges between ocean and atmosphere, the net heat budget of the ocean and the structure of the marine atmospheric boundary layer over the best-developed and most intense part of the current, namely between Port Elizabeth and Port Alfred. It was shown that the core of the Agulhas Current transfers about five times as much water vapour to the atmosphere as the surrounding ocean. Surface heat fluxes were over 200 Wm^{-2} above the current in contrast to a negligible amount over the shelf. The sensible heat flux reversed sign. When air was advected towards the coast the surface latent heat flux increased from about 160 Wm^{-2} over the seaward border to 270 Wm^{-2} over the current and decreased dramatically to approximately 40 Wm^{-2} over cool shelf water. This spatial heat flux gradient was reflected in the overlying atmosphere. A convective boundary layer over the current was replaced by a stable boundary layer over the cool shelf. A progressive accumulation of moisture occurred within the boundary layer as the airmass was advected over the current. Mean specific humidity and precipitable water vapour content in the boundary layer over the shelf were 20-25 per cent higher than over the seaward border of the current. These results give credence to the assertion that moisture uptake above the Agulhas Current may contribute significantly to rainfall over the interior of South Africa.

Copies of the final report entitled **Air-Sea Interaction over the Agulhas Current and the Implication for South African Weather** (WRC report 374/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

Some oysters in a 40ℓ square glass aquarium along with round test aquaria, and commercial supplies of seawater salts and shellfish food as used in the research project.

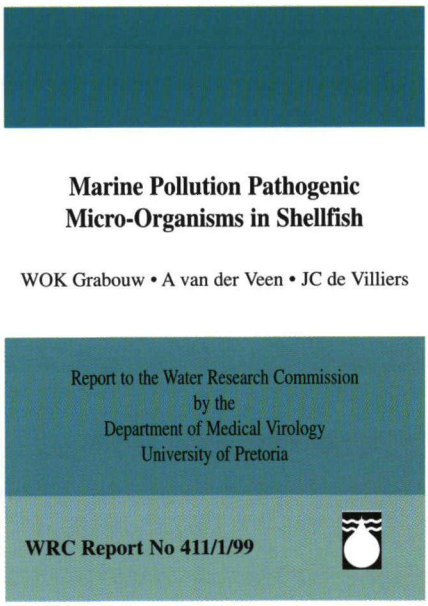
Pathogenic micro-organisms in shellfish studied

The Water Research Commission in collaboration with the Department of National Health and Population Development and the Foundation for Research Development (FRD) funded a research project for the development of procedures and water quality guidelines to safeguard the health of those who wish to use the marine environment for recreation and as a source of food, especially the consumers of shellfish in South Africa.

The project was carried out by a research team from the Department of Medical Virology at the University of Pretoria comprising WOK Grabow, A van der Veen and JC de Villiers. The researchers say the most obvious approach to formulating realistic water quality guidelines is to base it on correlations between the quality of seawater and seafood and the incidence of related infections among bathers and consumers.

"The establishment of these correlations required advanced epidemiological studies and detailed analysis of the seafood and water concerned."

The researchers say for a start literature on infections associated with the consumption of sewage contaminated shellfish in many parts of the world has been reviewed. As a result of the risk of infection, the shellfish market is extremely sensitive and any indication of contamination may be considered sufficient to reject supplies or close down industries with devastating economic implications. "South Africa has a substantial market for shellfish, both in terms of a commercial industry and private consumption by the general public. The literature revealed that specifications and strategies to control the safety of shellfish in South Africa are in need of revision and updating, particularly with regard to viruses which are responsible for the great majority of infections transmitted by shellfish."



Against this background, methods for the recovery of selected viruses, faecal bacteria and phages from shellfish meat have been evaluated and optimised. A practical and highly efficient procedure for the recovery of viruses and indicators has been established. The procedure is based on the homogenisation of shellfish meat in a pH 8,5 glycine-saline buffer followed by direct analysis of the homogenate for bacteria and phages, and centrifugation for analysis of the supernatant for viruses using cell culture propagation or molecular techniques. Evaluation in tests on shellfish collected at selected sites along the coast confirmed that the procedure was suitable for research on viruses in shellfish and related marine environments, as well as

routine monitoring of the quality of shellfish supplies.

The new procedures were applied in tests on representative samples of commercial supplies on the local seafood market. The results revealed that sometimes shellfish exceeded the quality limits recommended for faecal bacteria and phages. These findings indicate a potential health risk and call for more detailed investigation of the quality of local shellfish supplies. The results may warrant revision of quality specifications and quality control strategies.

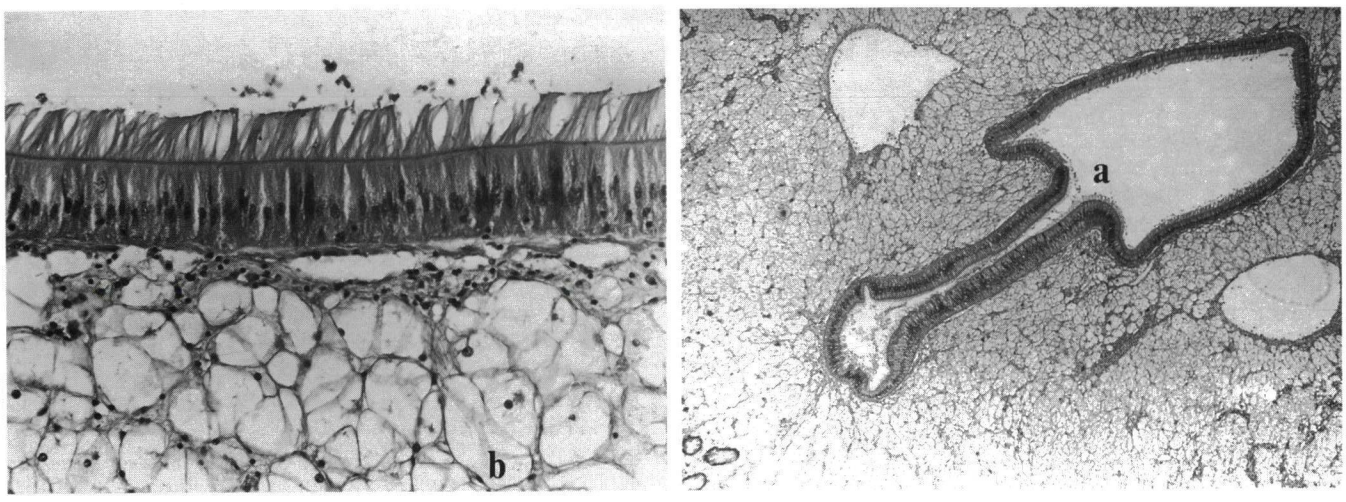
The depuration of selected faecal bacteria, human viruses and phages by seeded oysters has been investigated by using tanks of seawater under controlled laboratory conditions. Viruses and phages were still detected after five days in the oysters, while faecal bacteria were not detected for longer than two days. The researchers say these findings imply that commonly used depuration procedures based on the retention of shellfish for one or two days in clean water and tests for faecal bacteria to monitor depuration are not reliable. The results show that somatic and F-RNA (male-specific) coliphages are more reliable indicators of viral depuration than faecal bacteria such as coliforms and streptococci.

Studies on sources of faecal pollution were carried out at a major mariculture site in Saldanha Bay. Indications of faecal contamination were detected in some samples of mariculture mussels. The results suggest that wastewater discharged into the Bay was a potential source of faecal contamination. However, it would seem that seabird droppings may account for at least some of the faecal organisms isolated from mussels. Droppings from various seabird species on the mussel rafts contained high counts of faecal coliforms, faecal streptococci, somatic coliphages and F-RNA coliphages, but obviously no human viruses. This implies that identification of the source of faecal indicators may prove important in quality control at mariculture sites and natural harvesting grounds. Methods for distinguishing between faecal pollution of human and seabird origin have, therefore, been investigated. It has been found that *Bacteroides fragilis* HSP40 phages which are highly specific for human excreta could be used. Indications are that sorbitol fermenting bifidobacteria and certain types of F-RNA coliphages which are specific for human excreta could also be included in a battery of indicators for distinguishing between faecal pollution of human and animal origin.

The researchers say that despite numerous anecdotal reports on gastroenteritis associated with the consumption of shellfish harvested from natural beds, efforts to find cases for epidemiological confirmation and identification of the pathogens involved were not successful. In one outbreak of gastroenteritis in the southern Cape, small, round structured gastroenteritis viruses were detected in some patients' stools, but epidemiological data eventually suggested that a supply of contaminated curried fish sold by a street vendor was the most likely source of food poisoning. Stool specimens from a number of additional gastroenteritis patients were obtained, but in no case was it possible to establish an epidemiologically meaningful association with the consumption of shellfish. The study was successful in so far as that it offered an opportunity to develop technology for the first molecular detection of small round structured gastroenteritis viruses in gastroenteritis stools in South Africa. However, the researchers say that the infrastructure for early detection of infections related to the consumption of shellfish, the recording of epidemiological details, and collection of patient specimens, would have to be improved for meaningful studies on infections associated with the consumption of shellfish.

Results obtained in this study and recommendations in the international literature were used to formulate a protocol for the microbiological analysis of shellfish, and to recommend limits for the microbiological quality of shellfish intended for human consumption. The methods are practical, simple, reliable and inexpensive and can be carried out by microbiological laboratories with basic facilities and expertise. The recommended limits are realistic and within reach of most commercial mariculture shellfish suppliers, as well as naturally occurring shellfish in unpolluted marine environments.

Copies of the report entitled **Marine Pollution Pathogenic Micro-Organisms in Shellfish** (WRC report 411/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25).



Microscopic thin sections of frozen oysters exposed to poliovirus showing the digestive tract with epithelial cell lining and cilia (a), and fatty tissue (b). The dark spots on the enlargement are cell nuclei.

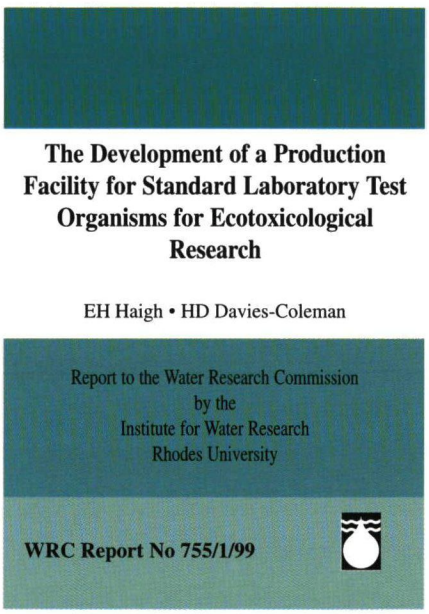
Breeding selected invertebrate species in the laboratory for ecotoxicology research

South Africa is very poor in natural lakes, and its surface water resource occurs as flowing rivers, many of which have been impounded. Thus, most of the country's indigenous aquatic flora and fauna is adapted to flowing water. In addition, a large number of people from disadvantaged communities rely directly on these waters for their daily requirements, and these same waters are abstracted for treatment and subsequent reticulation to urban areas. This makes the effective determination of water quality important.

The setting of guidelines for water quality for the natural environment involves both the reviewing of established guidelines from around the world as well as the experimental investigation of those suitable for indigenous riverine organisms. To satisfy this need, the Water Research Commission has funded two projects at the Institute for Water Research at Rhodes University, namely, the artificial stream project and the standard laboratory organisms project.

In the artificial stream laboratory, which is now operational at Rhodes, toxicological work is undertaken which requires a steady supply of indigenous macro invertebrates as test subjects. To ensure an uninterrupted supply of these organisms of known quality and origin for ecotoxicology research the standard laboratory organisms project was initiated in which invertebrates ranging from mayflies to crabs and flatworms were screened and several species selected as candidates suitable for laboratory cultivation.

Both projects are part of a large initiative within the Institute for Water Research to develop the science of ecotoxicological monitoring in flowing waters to a useable level.



ORGANISMS

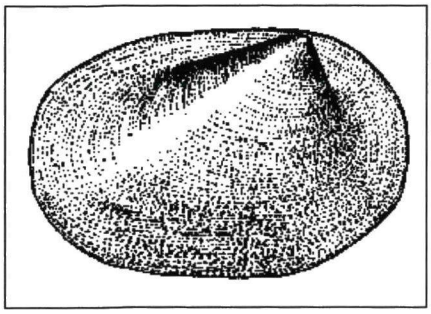
A final report, describing the development of a production facility for laboratory test organisms, has recently been published by the Water Research Commission in Pretoria. The report was written by EH Haigh and HD Davies-Coleman from the Institute for Water Research at Rhodes University. The researchers say this project followed on a previous study aimed at the development of techniques for the mass culture of selected organisms from running water for use in laboratory studies of ecotoxicology.

"During the first project two organisms were selected from a list of potential candidates after screening. Mass culture techniques for one of these, the freshwater limpet *Burnupia stenochorias*, were developed in the previous project to a point where large numbers can be reliably produced, but there are still aspects that need further clarification. The second candidate organism, the mayfly *Adenophlebia auriculata,* has shown potential, but the mass culture techniques require more work before this can be used in large scale experiments." After determining the mass culture requirements of the organisms, the next step was to determine the design parameters for a large scale production facility, the development of which is described in the report.

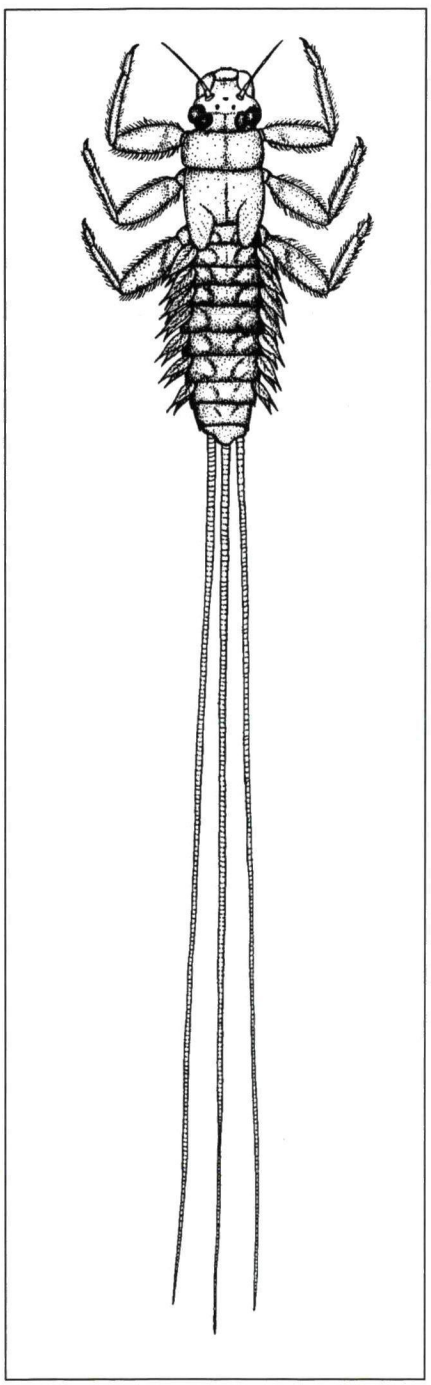
AIMS

The aims of the project were:

- To complete the experimental and field investigations on the selected test species *Burnupia stenochorias* (Field studies of natural reproduction and laboratory studies on the same and on handling techniques); and *Adenophlebia auriculata* (Laboratory studies on artificial fertilization, metabolism and osmoregulation as well as the rearing of hatchlings).
- To test the experimental techniques at a larger production scale, and to test the suitability of various biological filtration systems at this larger scale to ensure optimal water quality



Limpets (size: 3-4 mm, max. 7 mm) prefer a firm substrate with little current.



Line drawing of a mayfly nymph (approximate size: 20 mm in length).

conditions for both the culture of selected diatom species in periphyton and the animals.

- The investigation of design features and costing for a laboratory dedicated to the large-scale production of the selected species.

RESULTS

- ***Burnupia stenochorias*** **(Limpet)**

Field study. Limpets were measured every two weeks for a year, and at the same time egg production was noted. No specific cohorts (group of individuals of the same age) could be identified from the growth data, but the use of various biological growth models suggest that it may take up to 2 years to reach maximum size of a shell length of 7.5mm. Part of the reason for this slow growth is that there is no growth at all during winter. However, under warmer conditions the growth rate is faster. Eggs were present throughout the year, but there was a well defined peak from September to mid January.

Length, width and height of the shell as well as wet mass were recorded, and wet mass correlated most closely with length from the populations from running water.

It was found that the limpets preferred a firm substrate with little current.

Laboratory study. Commercially available tropical fish food was found to give better growth and higher fecundity than the natural diet of diatoms. The highest egg production was found to occur within the first four weeks of sexual maturity. Beyond this, it is impossible to make generalizations because individual variability was so large.

It was found that all overwintering limpets of >3mm shell length contained mature ova.

The limpets proved difficult to handle, but this could be done successfully if they were kept on plastic sheets, and the plastic moved. This obviates the necessity for actually touching the limpets themselves.

- ***Adenophlebia auriculata*** **(mayfly)**

Mayflies are widespread in flowing water, and are generally good biomonitoring organisms. This particular species has been shown suitable for this type of work as it is both widespread and common, and it is easy to maintain nymphs in laboratory culture.

In field populations, adults emerged for most of the year (September through June), with a nymph taking 1800 - 2000 DD (Degree Days) to complete its life cycle. Eggs are laid throughout the stream, but the larvae tend to settle in areas of slow current.

Towards the end of the previous study eggs of this mayfly were successfully fertilised artificially and it appeared that this technique could be perfected during the course of this project. However, this was not the case, and repeated attempts were unsuccessful. Apart from this, this species of mayfly is a good candidate in all other respects for ecotoxicological work, and it was feasible to catch nymphs in the surrounding rivers in sufficient numbers for useful work to be done.

- *B. stenochorias.* By the end of this project it was possible to produce nearly all the experimental material needed of this organism.

- *A. auriculata.* While the laboratory breeding of this organism has not been cracked, rearing techniques for the nymphs have been buttoned up, and can be done on a large scale.

- A dedicated production facility has been designed using criteria derived from the work done during this and the previous projects. The facility includes the production of sufficient food for the organisms to be cultured.

Copies of the complete report entitled **The Development of a Production Facility for Standard Laboratory Test Organisms for Ecotoxicological Research** (WRC report 755/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 30, via surface mail).

UAWS 2000 CONGRESS

PARTNERSHIP AND SUSTAINABLE DEVELOPMENT FOR WATER AND SANITATION

Durban, South Africa **20-25 February 2000**

The 10th Union of African Water Suppliers (UAWS) Congress and Exhibition in Durban will be the first time this Congress is held in Southern Africa. At the last Congress held in Casablanca, Morroco, in February 1998 some 800 delegates from more than 38 countries attended.

This Congress and Exhibition, to be held under the banner of the newly merged International Water Association (IWA), is of major importance and significance for the southern African region. It will provide an excellent opportunity for those all those involved in the water sector in South Africa, both in manufacturing and in the field of water services, to meet with potential customers from Africa and many other parts of the world.

THEMES

The themes to be addressed during the Technical Sessions at the Congress are:

- The Institutional Reforms in the Water Supply and Sanitation (WWS) Sector in Africa.
- Sanitation: Wastewater Re-use and their By-products in Africa.
- Innovations in the Control of Water Quality.
- Water Supply and Sanitation in Peri-urban Areas, Informal Settlements and Small Municipalities.
- The Financing of Urban Sanitation: Institutional, Technical, Sanitary and Environmental Aspects.
- Information Technology and Information Management in the Water Sector.
- Performance Indicators.

EXHIBITORS FORUM

Exhibitors Forum sessions will be held every afternoon giving exhibitors the opportunity to present new technologies which have been developed for the water sector.

ENQUIRIES

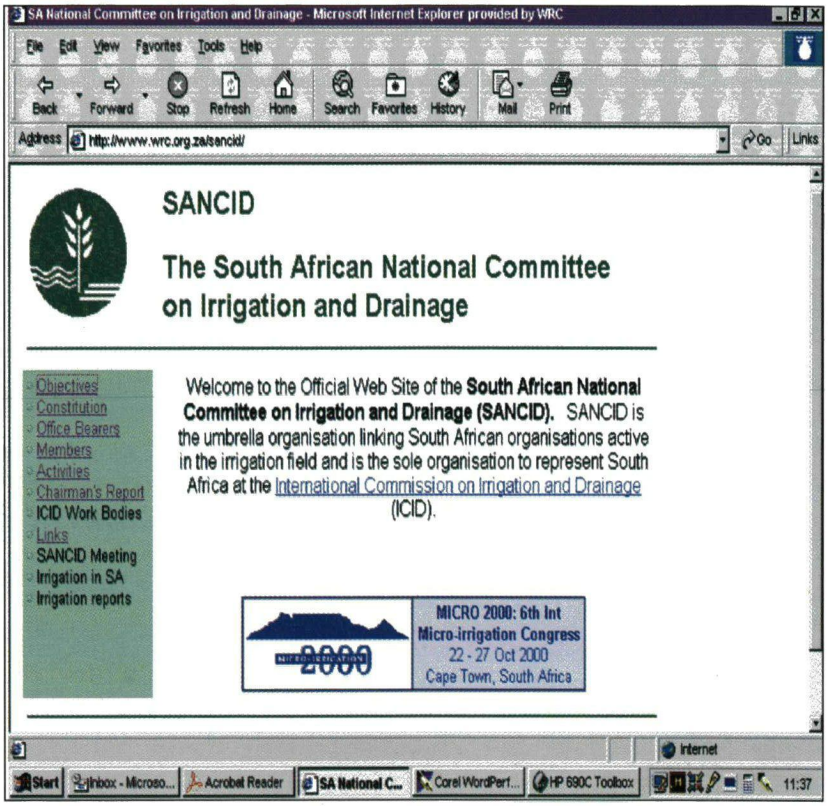
Should you be interested to attend or to exhibit at the 10th UAWS Congress please direct your request for further information to:

Congress International
18 Rapson Road,
Morningside 4001
DURBAN,
South Africa

Tel: +27 (0)31 312-3494 or 312-3442
Fax: +27 (0)31 303-5875
E-mail: ci@dbn.lia.net

Web site for SANCID
http://www.wrc.org.za/sancid

In accordance with its mission to promote the effective transfer of information in the water sector, the Water Research Commission (WRC) has set up a web site for the SA National Committee on Irrigation and Drainage (SANCID) which is accessible from the WRC's Internet site.



SANCID is the umbrella organisation linking South African organisations active in the irrigation field and is the sole organisation to represent South Africa at the International Commission on Irrigation and Drainage (ICID). In this respect, the main objectives of SANCID are to promote South African and African participation in the activities of ICID, including participation in the activities of other bodies established or to be established by ICID. The organisation is also committed to actively contribute to the stimulation and promotion of research and the development of technology in the fields of irrigation, drainage and flood control in South Africa.

The following information about SANCID is currently available on the web site:

- **Objectives**
  A complete list of the organisation's eleven objectives
- **Constitution**
  The full constitution as finally accepted at the eighth meeting of SANCID on 29 November 1993.
- **Office Bearers**
  Names and e-mail links to the present office bearers
- **Members**
  List of South African members of the organisation
- **Activities**
  A list of conferences and related activities of member organisations until the year 2001
- **Links**
  Direct links to the web sites of related South African and international organisations
- **Chairman's Report**
  The full text of the annual report by the chairman as presented on 23 April 1999

A direct link to the MICRO 2000: Sixth International Micro-irrigation Congress, planned for 22-27 October 2000 in Cape Town, South Africa, is also provided.

For more information, please contact Francette Myburgh:
E-mail: fmyburgh@wrc.org.za

SA WATERKALENDER

The Water Research Commission is placing this calender in order to assist with the co-ordinating of water events in South Africa.

You are invited to send information about conferences, symposia or workshops to the SA Waterbulletin.

Address:
The Editor,
SA Waterbulletin,
P.O. Box 824,
0001 Pretoria
Tel (012) 330-0340
Fax (012) 331-2565

Legend:
- ❍ An SA Water Event arranged for these dates.
- ❑ 2nd SA Water Event scheduled for these dates.
- × 3rd SA Water Event scheduled for these dates.

See conferences and symposia pages for events.

2000

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Die Waternavorsingskommissie plaas hierdie kalender om te help met die koördinering van watergebeurtenisse in Suid-Afrika.

Alle belanghebbendes word uitgenooi om inligting aan SA Waterbulletin te stuur.

Adres:
Die Redakteur
Posbus 824
0001 Pretoria
Tel: (012) 330-0340
Fax: (012) 331-2565

Gids:
- ❍ Een SA Watergeleentheid vir hierdie dae.
- ❑ 'n Tweede SA Watergeleentheid vir dié datums.
- × 'n Derde SA Watergeleentheid vir dié datums.

Sien Konferensies- en Simposiumbladsy vir aangeduide geleenthede.

2001

JANUARY

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SOUTHERN AFRICA 2000

IAWQ/IWSA
FEBRUARY 16 - 18
A joint specialised conference on particle removal from dams and reservoirs will be held in Durban.
Enquiries: Mr D Nozaic, Umgeni Water, PO Box 9, Pietermaritzburg 3200. Tel: (033) 341 1111. Fax: (033) 341 1084.

WATER SUPPLY & SANITATION
FEBRUARY 21 - 25
The 10th UADE/UAWS congress with the theme "Partnerships and sustainable development in the water supply and sanitation sector" will be held in Durban.
Enquiries: UAWS Administrative Secretary, 01 BP 1843 Abidjan, Cote d'Ivoire. Tel: +225 241443. Fax: +225 242629. E-mail: uadewup@africaonline.co.ci (or in South Africa - e-mail: ci@dbn.lia.net Tel: (031)-303 5875. Fax: (031)-312 3494.

WATER WEEK
MARCH 20 - 26
The South African Water Week will be held throughout the country during the third week of March 2000.
Enquiries: Department of Water Affairs and Forestry, Communication Services Division, Private Bag X313, Pretoria 0001. Tel (012) 336-7500. Fax: (012) 324-6592.

CEMSA 2000
MARCH 27 - 29
The 2nd international conference and exhibition on integrated environmental management in South Africa will be held in East London.
Enquiries: Creative Public Relations, PO Box 18227 Quigney, East London 5211. Tel: 0431 437267. Fax: 0431 26914.

GEOCHEMISTRY
APRIL 24 - 29
The 5th international symposium on environmental geochemistry will be held in Cape Town
Enquiries: Ms Jodi Fyfe, Postgraduate Conference Division, UCT Medical School, Anzio Road, Observatory 7925. Tel: (021) 406 6407. Fax: (021) 448-6263. E-mail: jfyfe@medicine.uct.ac.za

WATER & WASTE
MAY 23 - 26
A specialist conference on managing water and waste in the new millennium - the challenges for developing areas - will be held in Midrand.
Enquiries: Roelien-M Bakker, IWA Conference, PO Box 6011, Halfway House 1685. Tel: (011) 805-6368. Fax: (011) 315-1258. E-mail: conference@wisa.co.za

WISA
MAY 28 - JUNE 1
The Water Institute of Southern Africa (WISA) will hold its biennial conference and exhibition at Sun City.
Enquiries: Roelien-M Bakker, WISA, PO Box 6011, Halfway House 1685. Tel: (011) 805 6368. Fax: (011) 315 1258. E-mail: conference@wisa.co.za

WATER RESOURCES
JUNE 7 - 9
The 4th biennial congress of the African division of the International Association of Hydraulic Research (IAHR) on conserving and sharing water resources in a water scarce environment will be held in Windhoek, Namibia.
Enquiries: Congress Secretariat, Ms Marelise Serfontein, PO Box 9870, Windhoek, Namibia.
Tel: +264-61-251014/272031/254281.
Fax: +264-61-272032/251014.
E-mail: namlink@iwwn.com.na

IRRIGATION
OCTOBER 22 - 27
The 6th international micro-irrigation congress together with the 51st IEC meeting of the International Commission on Irrigation and Drainage (ICID) will be held in Cape Town.
Enquiries: The Congress Secretariat, PO Box 36815, Menlo Park 0102. Tel: (012) 344 0390. Fax: (012) 344 5643.
E-mail: reservations@parkgables.co.za.

AGROCHEMICALS
OCTOBER 25 - 26
A workshop on the control of adverse impacts of fertilizers and agrochemicals will take place in Cape Town, South Africa.
Enquiries: Prof A Mermoud, Institute of Soil and Water Management (IATE), Swiss Federal Institute of Technology, 1015 Lausanne, Switzerland. Tel: +41-21-693-3726. Fax: +41-21-693-3739. E-mail: andre.mermoud@epfl.ch

HYDROGEOLOGY
NOVEMBER 26 - DECEMBER 1
The International Association of Hydrogeologists' (IAH) XXX Congress 2000 with the theme Groundwater: Past achievements and Future challenges, will be held at the University of Cape Town.
Enquiries: Conference Secretariat, IAH 2000, Conferences et al, PO Box 452, Stellenbosch 7599. Tel: (021) 886-4496. Fax: (021) 883-8177. E-mail address: deidre@iafrica.com.

OVERSEAS 2000

DIFFUSE POLLUTION
JANUARY 16 - 20
The 4th international conference on diffuse pollution will be held in Bangkok, Thailand.
Enquiries: Ms Nitayaporn Tonmanee, Department of Land Development, Phaholoyothin Road, Chatuchak, Bangkok 10900, Thailand. E-mail:ldd@mozart.inet.co.th Tel: +662 579 0111. Fax: +662 562 0732. Web: http://www.ldd.go.th/iawq

AWWA/WEF
JANUARY 30 - FEBRUARY 2
An AWWA/WEF conference on water reuse will be held in San Antonio, TX, USA.
Enquiries: Susan Miller, AWWA, USA. E-mail: smiller@awwa.org Tel:+303-3476181. Web: http://www.awwa.org/tande/awwaconf.htm

IRRIGATION SYSTEMS
FEBRUARY 8 - 10
An international conference on micro and sprinkler irrigation systems will be held in Jalgoan, India.
Enquiries: CVJ Varma, Central Board of Irrigation, Malcha Marg, Chanakyapuri, New Delhi 110021, India. Tel: 91-11611-5984/611-6567. Fax: 91-11611-6347. E-mail: cbip@nda.vsnl.net.in. Website: www.cbip.org

NATURAL RESOURCES
FEBRUARY 14 - 18
An international conference on managing natural resources for sustainable agricultural production in the 21st century will be held in New Delhi, India. **Call for papers.**
Enquiries: Dr AK Singh, Secretary-General, Indian Society of Soil Science, Indian Agricultural Research Institute, New Delhi-110 012, India. Tel: 91-11-5731494. E-mail address: icmnr@bic-iari.ren.nic.in Fax: 91-11-5755529. Internet site: http://www.nic.in/icar/nrm

WATER
MARCH 11 - 17
The 10th world water congress is to be held at the Melbourne Convention Centre, Melbourne, Australia.
Enquiries: Lisa McNaught, ICMS Pty Ltd, 84 Queensbridge Street, Southbank, Victoria, Australia 3006. Tel: +61 3 9682 0244. Fax: +61 3 9682 0288. E-mail: worldwater@icms.com.au

WATER FORUM
MARCH 17 - 22
The second world water forum and ministerial conference will be held in the Hague, the Netherlands.
Enquiries: E-mail: secretariat@worldwaterforum.org Fax: +31 70348 6792.

GLOBAL RESOURCES
MARCH 19 - 23
Water 2000 conference and expo with the theme - Guarding the global resources - will be held in Auckland, New Zealand.
Enquiries: E-mail address: water@nzwwa.org.za Tel: +64 9636 3636. Fax: +64 9636 1234. Web: http://www.nzwwa.org.nz/w2000.htm

REMOTE SENSING
APRIL 3 - 7
A symposium titled Remote Sensing 2000 will be held in Santa Fe, NM, USA.
Enquiries: Dr Jerry C Ritchie, Hydrology Laboratory, Room 104, Building 007, USDA/ARS/BARC-West, Beltsville, Maryland 20705-2350, USA. E-mail: jritchie@hydrolab.arsusda.gov Tel: +301 5047490. Fax: +301 5048931.

METEOROLOGY
APRIL 3 - 7
The 6th international conference on southern hemisphere meteorology and oceanography will be held in Santiago, Chile.
Enquiries: Patricio Aceituno, University of Chile, Casilla 2777, Santiago, 6511227, Chile. E-mail: aceituno@shmo.chile 2000.cl

WASTEWATER
APRIL 4 - 7
A CIWEM millennium conference - wastewater treatment: standards and technologies to meet the challenges of the 21st century will be held in Leeds, England.
Enquiries: Zena Hickinson, AE Technology Transfer, School of Civil Engineering, University of Leeds, Leeds LS2 9JT, UK.
E-mail: z.hickinson@leeds.ac.uk Tel: +44 113 2332308. Fax: +44 113 2332243.

WATER RESOURCES
APRIL 9 - 12
An international symposium on integrated water resources management will be held in California, USA.
Enquiries: Prof Miguel A Marino. Tel: +1 530 752 0684. Fax: +1 530 752 5262 Web: http://www.conferences.ucdavis.edu

WATER RESOURCES
APRIL 30 - MAY 4
An international conference on water resources in extreme environments will be held in Anchorage, AL, USA.
Enquiries: Douglas Kane, University of Alaska, Fairbanks AK99775,USA. E-mail: ffdlk@aurora.alaska.edu Fax: +907 474 7979. Web: http://www.awra.org

WATER SERVICES
MAY 3 - 5
An international conference on the global marketing of water services - comparing quality service characteristics and customer satisfaction - will be held in Torino, Italy.
Enquiries: Noema srl, Via Orefici 4, 40124 Bologna, Italy. E-mail: noema1@alinet.it Tel: +39 051 230385. Fax: +39 051 221894.

GROUNDWATER
MAY 8 - 10
The International Association for Hydraulic Research will hold an international symposium on groundwater in Saitama, Japan.
Enquiries: Dr H Kazama, Saitama University, 255 Shimo-ohkubo, Urawa, Saitama 338-8570, Japan. Tel: +81 48 858 3568. Fax: +81 48 855 1378. Web: http://www.hgl.saitama-u.ac.jp

LAKE MANAGEMENT
MAY 17 - 21
The 8th international conference on the conservation and management of lakes will be held in Copenhagen, Denmark.
Enquiries: Conference Bureau, Herlev Ringveg 2C, DK-2730 Herlev, Denmark. Tel: +45 4492 4492. Fax: +45 4492 5050.

CHLORINATION
MAY 21 - 24
The 2nd international conference on the remediation of chlorinated and recalcitrant compounds will take place in Monterey, CA USA.
Enquiries: The Conference Group, 1989 West Fifth Avenue, Suite 5, Columbus, Ohio 43212-1912, USA. E-mail: 102632.3100@compuserve.com Tel: +800 783 6338. Fax: +614 488 5747.

ACHEMA 2000
MAY 22 - 27
The 26th exhibition-congress and international meeting on chemical engineering, environmental protection and biotechnology will be held in Frankfurt am Main, Germany.
Enquiries: Dechema. Tel: +49 (0) 697564-261. Fax: +49 (0) 697564201. Internet: http://www.woice.de E-mail: woice@dechema.de

IRRIGATION
MAY 23 - 25
A conference and exhibition - Irrigation Australia 2000 - will be held in Melbourne, Victoria, Australia.
Enquiries: Rodney Cox, Exhibitions and Trade Fairs, PO Box 232, Chatswood NSW 2057 Australia. Tel: +61 2 9413 3322. Fax: +61 2 9413 3303. E-mail: syd@etf.com.au

WATER ECOLOGY
MAY 30 - JUNE 2
ECWATECH 2000 will hold the fourth international congress and exhibition with the theme "Water ecology and technology" in Moscow, Russia.
Enquiries: Exhibition Management and Congress Secretariat, PO Box 173, Moscow 107078 Russia. Tel: +7 0959 753 423. Web: http://www.sibico.com/ecwatech/

WATER SURFACES
JUNE 5 - 8
The 4th international symposium on gas transfer at water surfaces will be held in Miami Beach, Florida, USA.
Enquiries: Gayl van de Bogart, University of Miami, 4600 Rickenbacker Causeway, Miami FL 33149, USA. Web: http://cheyenne.rsmas.miami.edu/gas2000.html/

GROUNDWATER 2000
JUNE 6 - 8
A conference with the theme Groundwater 2000 will be held in Copenhagen, Denmark.
Enquiries: MiaCon Meeting and Conference Services, Helsingevej 23, DK-2830 Virum, Denmark. E-mail: gw2000@isva.dtu.dk Tel: +45 45 859727. Fax: +45 45 839727. Web: http://www. isva.dtu.dk/ grc/gw2000/

AWWA
JUNE 11 - 15
The AWWA 2000 annual conference and exhibition will be held in Denver, Colorado, USA.
Enquiries: David Rossiter, AWWA, USA. E-mail: rossiter@awwa.org Tel: +303 3476209. Web: http://www.awwa.org/tande/awwaconf.html

IRRIGATION
JUNE 20 - 24
An international conference on the challenges facing irrigation and drainage in the new millennium - meeting human and environmental needs through sustainability, rehabilitation and modernisation will be held in Fort Collins, CO, USA.
Enquiries: US Committee on Irrigation and Drainage, 1616 17th Street, 483 Denver, CO 80202, USA. E-mail: stephens@uscid.org Fax: +303 6285431. Web: http://www.uscid/org

FLOW ANALYSIS
JUNE 25 - 29
The 4th international conference on flow analysis will take place in Warsaw, Poland.
Enquiries: Prof Marek Trojanowicz, Department of Chemistry, University of Warsaw, Pateura 1, 02-093, Warsaw, Poland. E-mail: trojan@chem.uw.edu.pl Tel: +48 22 8223532. Web: http://www.congress.pbp.com.pl/flow/

WASTEWATER
JULY 3 - 6
The 3rd international symposium on wastewater reclamation, recycling and reuse will be held in Paris, France.
Enquiries: Ms Nicole Couesnon, GBE, Universite Montpellier II, cc057, 34095 Montpellier cedex 05, France. E-mail: wrrr.2000@dstu.univ-montp2.fr Tel: +33 4 6714 3310. Fax: +33 4 6714 4774.

IWA
JULY 3 - 7
The first world congress of the new International Water Association (IWA), formed by the merger of the International Association on Water Quality (IAWQ) and the International Water Services Association (IWSA), will be held in Paris, France.
Enquiries: Aghtm-cfrp, 83 Avenue Foch - B.P. 39.16, 75761 Paris - Cedex 16 - France. Tel: +33 (0)1 53701351 or 53. Fax: +33 (0)1 53701340. E-mail: aghtm@aghtm.org

METEOROLOGY
JULY 10 - 14
A conference with the theme "Meteorology at the Millennium" will be held in Cambridge, England.
Enquiries: Royal Meteorological Society, Executive Secretary. E-mail: execsec@royal-metsoc.org.uk Tel: +18 956 8500. Fax: +18 956 8571.

EROSION
JULY 10 - 14
An international symposium on the role of erosion and sediment transport in nutrient and contaminant transport will be held in Waterloo, Canada.
Enquiries: Dr M Stone, School of Urban and Regional Planning, University of Waterloo, Waterloo, Ontario, Canada. E-mail: mstone@fes.uwaterloo.ca Tel: +519 888 4567. Fax: +519 725 2827.

FLOODS
JULY 17 - 19
An international symposium on extraordinary floods will be held in Reykjavik, Iceland.
Enquiries: E-mail: extremes2000@os.is. Web address: http://www.os.is/vatnam/extremes2000

HYDRO-INFORMATICS
JULY 23 - 27
The fourth international conference on hydro-informatics will be held in Iowa, USA.
Enquiries: Web address: http://www.iihr.uiowa.edu/hydro2000

WETLANDS
AUGUST 6 - 12
The 6th wetlands symposium of the international association of ecology - INTECOL VI - "Global wetlands at the millennium" - will be held in Quebec City, Canada.
Enquiries: Ms Elizabeth MacKay, CQVB, Bureau 620, 2875 blvd Laurier, Sainte-Foy, Quebec, Canada G1V 2M2. E-mail: cqvb@cqvb.qc.ca Fax: +1 418 657 7934. Web:http://www.cqvb.qc.ca

URBAN CATCHMENT MANAGEMENT
SYMPOSIUM 2000

FIRST ANNOUNCEMENT

3RD SYMPOSIUM ON CATCHMENT MANAGEMENT IN THE CAPE METROPOLITAN AREA (CMA)

HOSTED BY :
CAPE METROPOLITAN COUNCIL

IN ASSOCIATION WITH :
BLAAUWBERG MUNICIPALITY
CITY OF CAPE TOWN
CITY OF TYGERBERG
HELDERBERG MUNICIPALITY
OOSTENBERG MUNICIPALITY
SOUTH PENINSULA MUNICIPALITY
AND : SAICE

UWC

S A SOCIETY OF AQUATIC SCIENTISTS

DWAF

INSTITUTE OF LANDSCAPE ARCHITECTS SA - CAPE

SAPI

ACTRP VRSS

WISA
The Water Institute of Southern Africa

WILDLIFE AND ENVIRONMENT SOCIETY OF SA

IAIA SOUTH AFRICA

SYMPOSIUM THEME :

'CO-OPERATIVE URBAN CATCHMENT MANAGEMENT'

Previous symposia were held in '96 and '98.

As we translate the philosophies of integrated catchment management into practice, the necessity and benefits of co-operative management of our urban drainage systems becomes increasingly important.

This symposium presents a unique opportunity for practitioners, government officials and community leaders to share experiences, discuss their needs and goals and contribute towards the sustainable management of Cape Town's rivers in the new millennium.

Areas of debate will include :
* **Goals of ICM in an urban context;**
* **Contexts and perspectives;**
* **Case studies;**
* **Tools and strategies.**

Workshop sessions will explore :
* **Restructuring of local authorities;**
* **Community participation and empowerment;**
* **Education, training needs and opportunities;**
* **Urban development guidelines.**

DATE :
Saturday 29-01-2000

TIME :
8H00 - 17H00

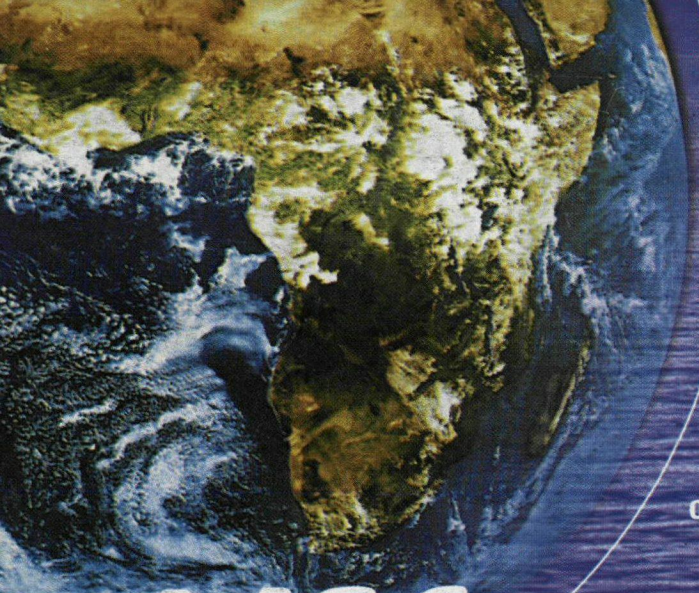
VENUE :
University of the Western Cape

POSTERS :
Exhibition space will be available. Contact Randall Adriaans for more details

REGISTRATION :
To register your interest in attending this event and ensure that you are included on the mailing list for further announcements, details and programme, contact : *RANDALL ADRIAANS*

TEL : 487-2453
FAX : 487-2441
e-mail : radriaans@cmc.gov.za

COST :
R 100 per person



Expand your horizons ...

This unique degree combines the very best in scientific research with industry requirements to make the scientists of today the managers of tomorrow. The programme will equip you with the knowledge and practical skills to become a specialist in the complex and diverse field of water resource management.

MSC WATER Resource Management

Strategic advantages

Empowering people to become key players in the management of one of South Africa's most limited natural resources

Course presenters

The course is presented by leaders in the field from the University of Pretoria, the CSIR and other industrial partners

Course content

The success of this course is based on a multidisciplinary approach, combining theory and research with real life team-building and project management experiences. Fields covered include:

- Environmental paradigms; - governance; - analysis, assessment and modelling
- Water quality management; water conservation and demand management; water supply and sanitation
- At least one of the following elective course modules: International Environmental Law; Philosophy of the Environment; Ecotourism; Polar and Mountain Environments
- A practical group project
- Course duration: one year full time or two years part time

Admission requirements

Candidates must be in possession of a four-year degree qualification (BSc Hons) or equivalent and appropriate subjects in water-related issues. Final admission is subject to approval by the Director of the Centre for Environmental Studies and the Head of the Department of Microbiology and Plant Pathology.

Contact details:

Prof. TE Cloete
Head: Department of Microbiologyand Plant Pathology
University of Pretoria
Tel.: (012) 420 3265
Fax: (012) 420 3266
e-mail: mikro2@scientia.up.ac.za

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