SA waterbulletin

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RIVER ECOSYSTEMS
SA researchers' new methodology rapidly determines instream flow requirements.

WATER AND SANITATION
New guide for communities on choosing sanitation available

MEMBRANE TECHNOLOGY
Researchers develop biotechnology for treatment of organic pollutants

International Conference on Integrated Drought Management

- Lessons for Sub-Saharan Africa -

20-22 September 1999

at the CSIR Conference Centre, Pretoria

The main objective of the conference is to understand more fully the factors predisposing people and landscapes to heightened drought vulnerability, to work towards strategies and actions which can reduce drought vulnerability, and move towards sustainable development. Emphasis will be placed on drought and social equity. The themes will cover:

- ❑ Challenges of forecasting for sustaining natural resource management.
- ❑ Climate variability: implications for sustainable natural resources management.
- ❑ Building drought resilience for the "at risk ": strategies that reduce vulnerability of fragile ecosystems and communities.
- ❑ Integrating drought considerations into policy: key principles

The conference should give impetus to regional and international co-operation in drought management, and make sub-Saharan Africa a focus region for the International Decade for Natural Disaster Reduction 1990 - 2000.

Who should attend ?

The conference is intended to bring together a broad constituency of researchers, academics, practitioners, consultants, developers, policy-makers, planners, community leaders and media who have a common interest in the effective management of drought in all its manifestations.

Exhibition

An exhibition will be held alongside the conference . Manufacturer, suppliers, consultants and contractors are invited to apply for a stand. Please mark the applicable section on the enrolment form inserted in this issue of the SA Waterbulletin.

Drought Planning Workshop

An optional pre-conference workshop on Drought Planning will be held 16-17 September 1999 at the Agricultural Research Council (ARC) in Pretoria. The workshop will be led by Dr Don Wilhite, a world expert on drought from the National Drought Mitigation Centre in Lincoln, Nebraska, USA. Topics will include: An overview of drought concepts, contingency planning, vulnerability, drought triggers and indices, information needs, monitoring, and policy issues. Please indicate your interest in the workshop on the draught conference enrolment form.

Registration and Accommodation

Please find the applicable enrolment and accommodation form inserts in this issue of the SA Waterbulletin. Kindly complete and forward the forms to the addresses as indicated on the forms.

Information and enquiries

For full conference details and a programme, please contact:

Conference Secretariat:
Conference Planners
Tel: +27 (0)12 667-3681
Fax: +27 (0)12 667-3680
E-mail: confplan@iafrica.com

or

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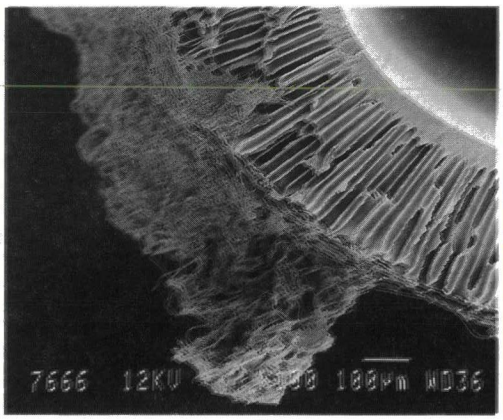

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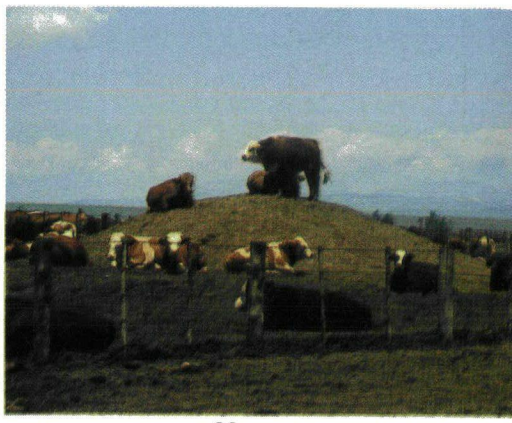

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Cover: SA researchers' BBM methodology rapidly assesses instream flow requirements (p 20). (Photo: Helene Joubert)

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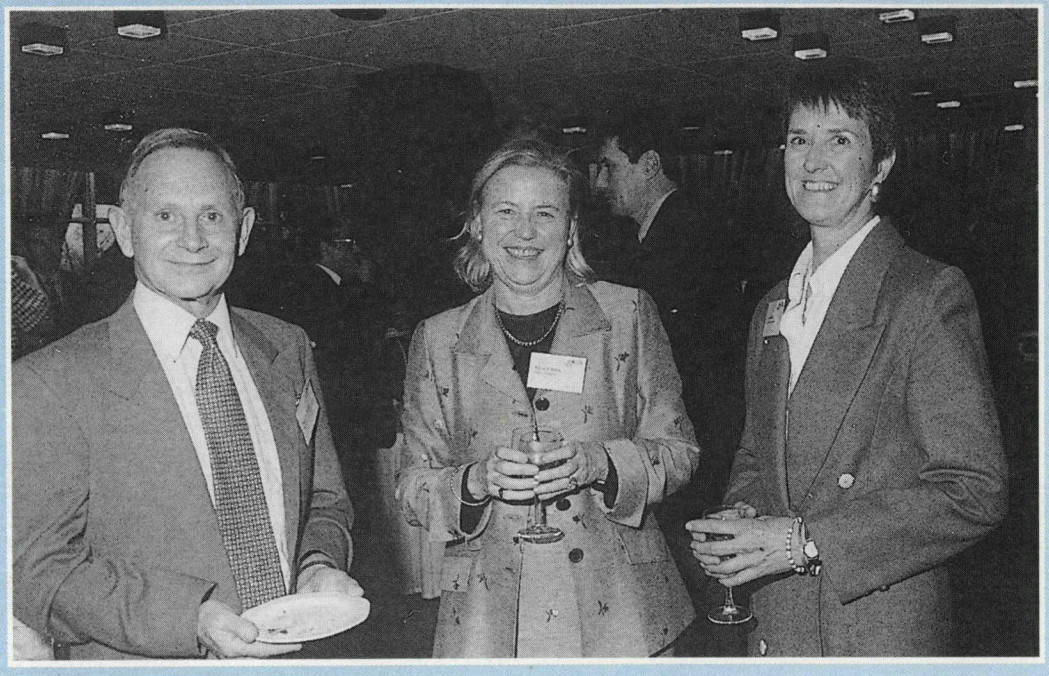
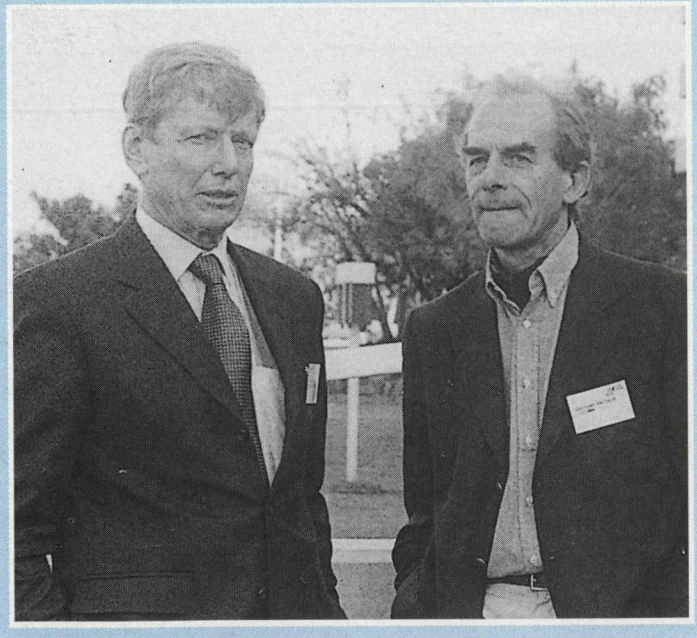
French and SA Scientists meet ....



The Workshop organising committee: Dr George Green of the Water Research Commission, having a word with Dr Anne d'Albis, CNRS, and Dr Jane Harris of the CSIR.



Dr Patrick Le Fort, Scientific Attaché at the Embassy of France in South Africa, in conversation with Prof Georges Vachaud, Directeur de Recherches CNRS, and Head of the Programmes on Water Research at the CNRS.

Michel Astruc and Bernard Legulse were amongst the delegation of French scientists and researchers who attended the Workshop.

A workshop to provide an opportunity for French and South African scientists to present and discuss water-related issues was held in Pretoria from 5 to 7 July 1999, and was followed by a field trip to Mpumalanga. The aim of the interaction was to identify potential joint programmes for the mutual benefit of water research in South Africa and France.

Professor Bernard Legube of the Centrx Reserches National Scientific (CNRS), and Chairman of the Research Laboratory Laboratoire de Chimie de l'eau et de l'Environment at the University of Poitiers and Dr Georges Vachaud, Directeur de Recherches CNRS, Head of the Programmes on Water Research at CNRS and Chief Editor of the Journal of Hydrology, conducted an exploratory visit to South Africa in November 1998. They identified Water Quality and Treatment, and Water Resources as topics of relevance for research in both countries.

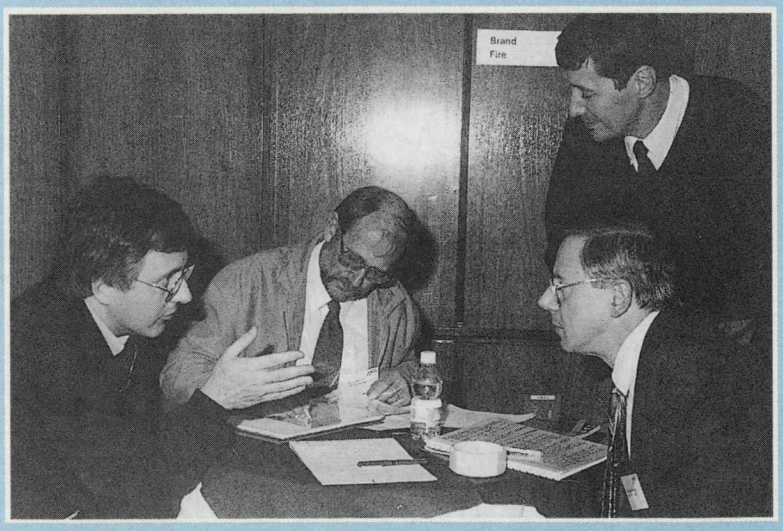
The success of the workshop is reflected in the seventeen possible collaboration projects identified by the participants. Additional discussion and refinement of the projects will be led by a champion and project team as named during the proceedings. Potential collaboration on other projects - both current and proposed elsewhere - was also identified among several of the individuals.

The field trip was designed to provide an overview of some of the issues within the water sector of South Africa. Industrial effluent, water-related agricultural practices, and biological monitoring procedures were examined in some detail.

Sponsors for the workshop were the Centre Nationale Recherche Scientifique (CNRS), the French Embassy in South Africa, the Council for Scientific and Industrial Research (CSIR), the Water Research Commission (WRC), the National Research Foundation (NRF). The organising committee consisted of Dr Anne d'Albis, CNRS, Dr Jane Harris of the CSIR and Dr George Green of the Water Research Commission.

Grant Mackintosh, CSIR Stellenbosch, John Geldenhuys, Rand Water, and Dick Loewenthal from the University of Cape Town were amongst the South African researchers at the Workshop.

A group of French and South African researchers discussing possible collabrative research on membranes and oxidation.



French and South African groundwater scientists exploring potential collabrative research projects.

SASAQS gather at Swakopmund

SASAQS 1999 delegates gathered on the rocks outside the Swakopmund aquarium on the desert Namibian coast.

The Southern African Society of Aquatic Scientists (SASAQS) gathered at Swakopmund, Namibia for their 35th annual conference, which was held from 27June to 1July. Gathering at Swakopmund gave delegates the chance to see some of the most water-scarce areas in southern African.

Water as the limiting resource in arid regions, the need to preserve the ecological health of our aquatic resources, as well as research and management of water, were some of the main themes of a very successful conference which attracted water scientists and managers to Swakopmund from all over southern Africa.

More than 160 delegates from most of the countries in southern Africa attended the conference which was organised by Namibian members of the Society under the able direction of Dr Shirley Bethune of the Namibian Department of Water Affairs. The conference attracted an encouraging diversity of disciplines and specialities: 32 water resource managers, mostly from the government sector; eight members of conservation organisations; and a large number of post-graduate students from the universities; as well as the professional and academic researchers who make up the majority of the Society's membership. Proceedings were dominated by river ecologists, but there were also sessions presented by estuarine and marine scientists; fisheries biologists; hydrologists and geomorphologists; and by specialists on wetlands and lakes.

The conference was opened by the Namibian Minister of Agriculture, Land and Water Affairs, the honorable Helmut K Angula, who emphasized the importance of fresh water in aiding Namibian development, but also warned about the need to protect water resources for sustainable utilisation.

The advantage of attracting a mixture of disciplines as well as managers and researchers is that the presentations and discussions can address the real problems of providing urgent short-term solutions to water supply problems - many millions of people in southern Africa still do not have access to clean water or adequate sanitation - while protecting the ecosystems which provide the water. This theme of sustainable utilisation and protection is very much at the core of the new South African Water Act passed by the SA parliament last year, and many of the conference presentations addressed methods of implementing the ecological sections of the new act.

The conference ended with a banquet sponsored by NAM Water and Rossing Uranium, at which the Society's silver medal was presented to Dr Tally Palmer of Rhodes University for her contribution to the ecological principles in the South African Water Act, and a gold medal was presented to Professor Charles Breen of the Institute for Natural Resources in Pietermaritzburg, for a life-time of excellent contribution to research and training in the aquatic sciences. Professor Breen supervised many of the students who are now senior researchers in the field of water research. Presently he is also the Managing Director of the Kruger National Park Rivers Research Programme, and has been instrumental in the development of the Consortium for Estuarine Research and Management.

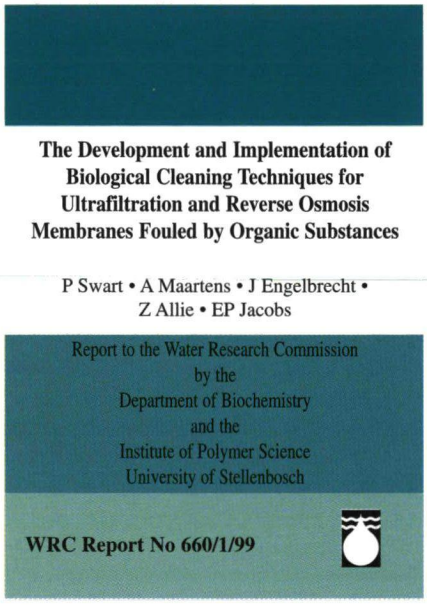
At a ceremony in Pretoria during the previous week, the Society's gold medal was presented to Professor Kader Asmal for his visionary direction of the development of the new South African Water Act. The gold medal has only been awarded to five recipients previously in the 36 years since SASAQS was founded.

Developing biological cleaning techniques for cross-flow filtration membranes

The most challenging obstacle to the full implementation of modern pressure-driven filtration processes, apart from the production of chemically inert high-efficiency membranes, is the fouling phenomenon, an inherent consequence of any high pressure effluent or polluted water filtration process. This is the view of researchers at the Department of Biochemistry and the Institute of Polymer Science at the University of Stellenbosch in a report to the Water Research Commission (WRC) on biological cleaning techniques for ultrafiltration and reverse osmosis membranes.

The researchers, P Swart, A Maartens, J Engelbrecht, Z Allie and EP Jacobs, say fouling, characterised by the irreversible adsorption of foulants onto the membrane surface, causes a rapid decline of flux through the membrane (with a resultant productivity loss) which can be reversed only by effective foulant removal. The problem of fouling becomes more acute when high pressure filtration processes are applied to effluents of biologically related industrial processes such as in the abattoir and also the paper and pulp industries which produce large amounts of hydrophobic foulants with a large affinity for the typically non-polar ultrafiltration and microfiltration membranes.

The researchers say the classical approach to foulant removal in the past has been the use of harsh chemical treatment procedures in combination with mechanical cleaning operations. However, the repeated use of these cleaning operations drastically shortens membrane life in systems used in high organic foulant producing industries. In addition, the traditional chemical cleaning regimes such as chlorine and alkaline treatment, have added significantly to industrial pollution.



In recent years most research have been directed towards membrane and membrane module development, while comparatively little research has gone into solving and preventing the problem of fouling. Milder and environmentally more friendly cleaning regimes are, however, available for the removal of biologically derived foulants from polymer membranes.

The use of enzymes, in combination with biodegradable detergents, is according to the researchers an attractive alternative to the classical cleaning regimes used to date. Previous studies by the membrane fouling research group at the University of Stellenbosch on abattoir and wool scouring effluents have shown that enzymes, as biocatalysts, can be used effectively in combination with detergents to reduce fouling and restore flux through previously fouled membranes.

The investigation described in this report follows on a previous WRC project in which characterisation and enzyme-based cleaning techniques were developed using abattoir and wool scouring effluents as model systems. The report is divided into three parts. Part one deals with the characterisation and quantification of membrane foulants in Cape brown water, the development of techniques for the removal of these foulants, an investigation of foulant prevention methods and the evaluation of these processes. In Part two an investigation of organic foulants in effluent from the Mondi Paper and Pulp mills at Piet Retief is described. Static and dynamic fouling of polysulphone membranes were carried out, adsorbed foulants were characterised and enzymatic as well as mild chemical and mechanical cleaning systems were evaluated. Part three describes the use of specialised enzyme mixtures for the removal of proteins and lipids from membranes fouled in abattoir effluent.

Copies of the report entitled **The development and implementation of biological cleaning techniques for ultrafiltration and reverse osmosis membranes fouled by organic substances** (WRC report 660/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

Researchers assess the feasibility of artificial groundwater recharge in South Africa

Artificial groundwater recharge has gained acceptance worldwide as an effective method of conserving water for future use, for improving water quality, for averting saline water intrusion and for many other uses, say researchers from the Cape Water Programme, a Division of Water Environment & Forestry at the CSIR.

In a report to the Water Research Commission (WRC), the researchers, EC Murray and G Tredoux, say artificial groundwater recharge is considered as a practical, cost effective and environmentally acceptable water management alternative for water supply authorities, rural communities and farmers. In South Africa the idea has found only a few full scale applications but these have proved the viability of the technique, especially for primary aquifers.

The report emanates from a study aimed at assessing the feasibility of using artificial recharge technologies in South Africa for community water supplies.

The report says that the aim of recharging subsurface water sources for water supply purposes is to rapidly replenish aquifers with water that would otherwise be lost through evaporation and stream flows. This conservation technique is of special significance in semi-arid and arid areas.

"Because most of South African aquifers are located in fractured rock environments, borehole injection schemes would be the preferred technology for aquifer recharge. However, the limited available storage in fractured rock aquifers, makes the technology applicable (or successful) only in intensely weathered fractured environments and dolomitic aquifers. These type of systems are prone to clogging if not properly managed, and therefore, injection schemes require relatively advanced management."

Copies of the report titled **Artificial Recharge - a Technology for Sustainable Water Resources Development** (WRC report 842/1/98) are available free of charge on request from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$25).

South Africans are faced with the daunting task of supplying an ever increasing population with water from a very limited water resource. Surface water resources are to a large extent concentrated in the eastern one-third of the country and the remaining two-thirds of the country relies heavily on groundwater. The groundwater occurs mainly in localised secondary aquifers which in many areas are being depleted as a result of excessive abstraction or frequently recurring drought conditions. Recharge of these aquifers is generally from the natural precipitation. Unfortunately, on average only about three per cent of the mean annual precipitation infiltrates deep enough to recharge the groundwater.

Artificial recharge and the principles of conjunctive use offer a valuable tool for augmenting the rather limited natural recharge. In large areas of the country the precipitation occurs in the form of thunderstorms. These produce flash floods with most of the water rapidly leaving the catchment. Infiltration is minimal and recharge negligible. By capturing this surplus water and artificially recharging it, the groundwater resources would receive additional replenishment thus boosting the amount of water available for later abstraction.

The artificial recharge of shallow unconfined or semi-confined aquifers occurs unintentionally on a local scale throughout South Africa. Farmers practise the building of earth embankments for the capture of surface runoff, thereby creating mini-artificial recharge schemes. These are, however, very localized and typically lose their efficiency with time.

Many examples exist of operational artificial recharge schemes in the USA, Europe, Israel and Australia. These either use treated wastewater or river water and are mainly intended for irrigation purposes. Only two large-scale "planned" schemes exist in Southern Africa, both of which involve unconfined sandy aquifers that provide bulk water supply to urban communities along the arid west coast. However very little, if any, attention has been given to secondary aquifers that represent the

source of water supply over much of the South African interior.

The aim of this Water Research Commission funded study was to assess the feasibility of using artificial recharge technologies in South African community water supply schemes. In order to meet the aim, the following objectives were identified:

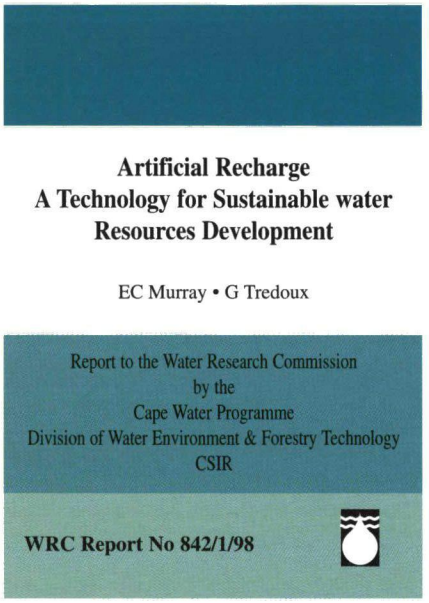
- those artificial recharge techniques appropriate to South African conditions and needs must be determined;
- the assessment must include concepts such as conjunctive use, groundwater catchment management and groundwater dams (subsurface and sand storage dams);
- the appropriate technologies must be linked to areas/regions/hydrogeological settings;
- basic guidelines must be developed for establishing artificial recharge schemes; and
- a pilot scheme must be designed to test the concept (field site identification, and pilot scheme and test programme design).

RESULTS

The two main hydrological factors which determine the potential for artificial recharge in South Africa are the availability of raw water and the ability of the aquifer to physically receive surplus water. In relation to the water source, the reliability of the raw water and its quality is of prime concern. Possible water sources include ephemeral and perennial rivers, dams, municipal wastewater and storm runoff. In view of the high evaporation rates it can be cost effective to store water underground rather than at the surface. If rivers or dams are to be used for artificial recharge, it may be necessary to reduce the turbidity of the water in order to prevent clogging.

In relation to the aquifer acceptance potential, the permeability of the aquifer (and the soil horizons above the aquifer if infiltration methods are applicable) and the storage potential of the aquifer are the key factors which will determine the suitability of an aquifer for artificial recharge.

Secondary aquifers with high permeability and storativity are most suitable for receiving additional recharge water. Such aquifers include the dolomitic aquifers in the Northwest Province, and the intensely weathered and fractured hard-rock aquifers which are found throughout South Africa. In many parts of the country, however, only low permeability hard-rock aquifers exist. Artificial recharge may still be an appropriate method to enhance limited natural groundwater resources.



The following specific conclusions were reached :

- Unconfined, primary aquifers such as unconsolidated alluvial or dune sands are usually recharged by inducing river or lake water into the aquifer, or by infiltrating water from seepage basins or trenches into the aquifer. In the case of confined primary or secondary aquifers the recharge water needs to bypass the confining layers in order to come into contact with the most permeable part of the aquifer. Therefore, seepage trenches or boreholes are needed. The creation of artificial aquifers, or sand storage dams, is an innovative way to create subsurface storage space in ephemeral river beds, particularly in hot, semi-arid to arid regions.
- Artificial recharge schemes commonly involve surface or wastewater capture, treatment, pumping, distribution and water quality monitoring.

  In order for these processes to be efficient, careful planning and management is needed. This requires competent personnel dedicated solely to the task of managing the scheme. One of the key management functions is to minimize clogging.
- Both primary and secondary aquifers are suitable for artificial recharge in South Africa. Suitable primary aquifers include sandy alluvium (which may feed underlying weathered and fractured hard-rock aquifers), and coastal sand aquifers.

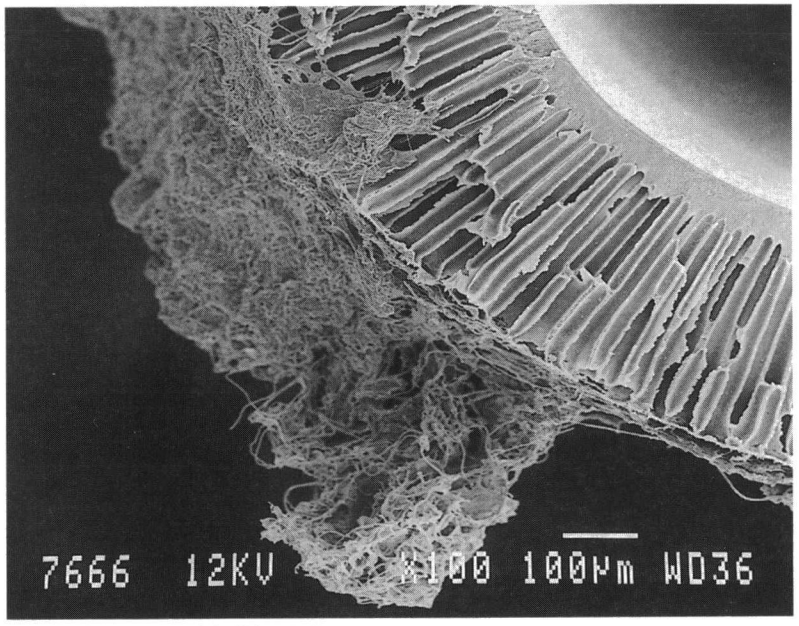
  Secondary aquifers with high permeability and storativity are most suitable for receiving additional recharge water. Such aquifers include the dolomitic aquifers in the Northwest Province and the intensely weathered and fractured hard-rock aquifers which are found in various parts of the country.
- A phased and multi-disciplinary approach is needed to plan an artificial recharge scheme. In the report two examples of guidelines are described. The first example applies to recharge basins schemes and the second example applies to borehole injection schemes.

RECHARGE SCHEMES

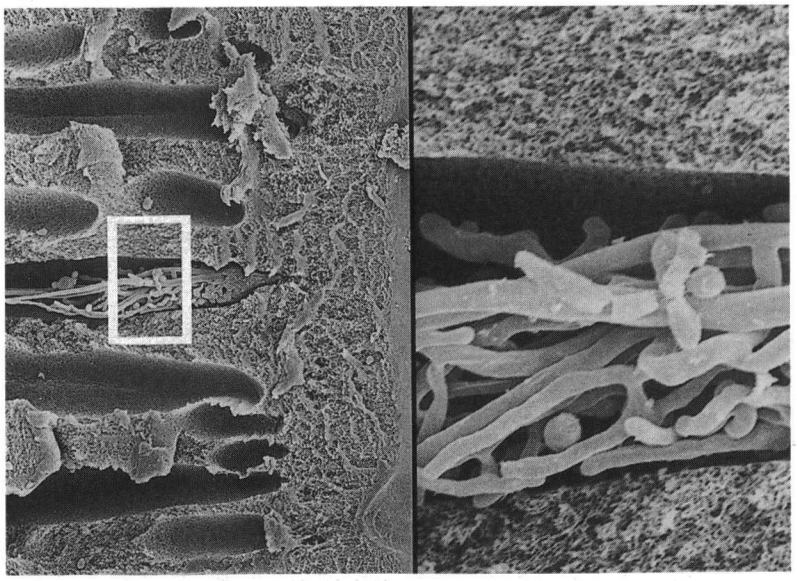
" It was an objective of this study to conceptually design one or more pilot artificial recharge schemes which could serve to demonstrate the applicability of artificial recharge in South Africa. In view of the scarcity of schemes utilising a fractures aquifer, it was considered a priority to have at least one scheme in such a geohydrological setting. A further criterion for the selection of potential test sites was that the community or town had to be in need of obtaining additional water supplies. This was intended to ensure the interest of the community in developing, maintaining and monitoring of the recharge facility. The availability of a potentially suitable aquifer and a source of recharge were basic requisites for considering any site.

A large number of pilot studies were proposed, only ten of these had enough information available for evaluation. Brief information is provided in the report on each of these. Six of those evaluated have been identified tentatively for further study. These are Kenhardt, Calvinia, Williston and Karkams in the Northern Cape, Windhoek in Namibia and a farm near Rustenburg.

Developing biotechnological systems for the treatment of organic pollutants



Scanning Electron Microscope (SEM) photograph showing T.versicolor *biomass attached to capillary membrane.*



Electronmicrographs of a section through a capillary membrane showing fungal penetration (the box indicated on left is enlarged on right).

The Water Research Commission (WRC) has published the results of a study in which a selected range of biological agents were identified and characterised with respect to their potential for bioremediation while at the same time an immobilised enzyme bioprobe was successfully developed and patented, using polyphenol oxidase as the biocatalyst.

The study was carried out by researchers from the Department of Biochemistry and Microbiology at Rhodes University in collaboration with the Institute for Polymer Science at the University of Stellenbosch. They were SG Burton, A Boshoff, W Edwards, EP Jacobs, WD Leukes, PD Rose, AK Russel, IM Russel and D Ryan.

Copies of the WRC report summarising the research titled **Membrane-based biotechnological systems for the treatment of organic pollutants** (WRC report 687/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

The importance of the preservation of high quality water resources, on both national and global scales, is well recognised as a major consideration in future industrial growth potential. The presence of organic pollutants such as phenols, polycyclic aromatics, coal tars, chlorinated solvents and polychlorinated biphenyls (PCB's), pesticides such as DDT and atrazine, dyes and polymeric humic materials, is a rapidly growing problem. They are found in industrial wastes of various origins, such as oil press wastes, coal-conversion waste waters, bleach plant wastes, the pulp and paper industry, and the timber industry. Most of these compounds are chemically very stable with respect to the chemical processes normally effective in chemical and biological degradative reactions. This can lead to the accumulation of intractable toxic contaminants in static waters, and to the concentration of potential carcinogens and chronic toxins in the higher strata of ecological systems. In addition, the organisms involved in biological processes such as anaerobic digestion, which might be expected to remove these pollutants, are susceptible to poisoning by the aromatic compounds, which would compound effluent treatment problems.

Biotechnology presents a new and adaptable aproach to dealing with problems such as water pollution. Within this field, biocatalysis (the application of living cells or isolated enzyme systems to catalyse organic pollutants in vitro) provides enormous potential for transformation of undesirable pollutants into harmless products (at the very least) or (more advantageously) valuable by-products. Conventional methods for the removal of aromatic compounds such as phenols from wastewaters are known to produce more toxic derivatives, have high operating costs, a low level of efficiency and are applicable to a limited concentration range.

This Water Research Commission project proposed the development of two biotechnological approaches to the bioremediation of organic pollutants, namely:

- the non-specific oxidative degradation of organic compounds utilising the peroxidase activity of white rot fungi, and
- the removal and conversion of phenolic compounds using an isolated polyphenol oxidase enzyme system.

The specific objectives of the study were:

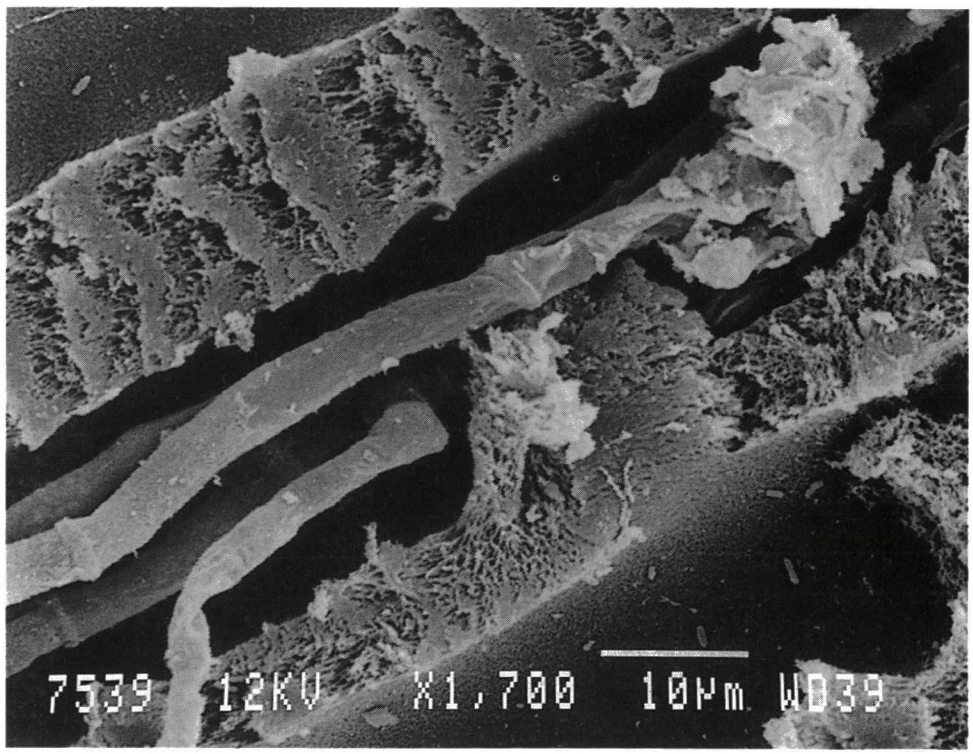
- The development of enzymic and microbial systems for application in bioreactors for removal of organic pollutants from effluents. This includes identification of suitable organisms and enzymes, and characterisation and optimisation of these biocatalytic systems for removal of the selected test pollutants in synthetic and real effluents.
- The utilisation of capillary and other configurations of membranes to develop high contact, high rate, high volume bioreactors for application of the biocatalytic systems. This would require development and optimisation of membranes suited to the immobilisation of isolated enzymes and whole cell microbial systems. The application of these reactors would then be optimised and adapted for larger scale application.

RESULTS

A novel transverse flow module, of which a prototype had been developed previously, was adapted and successfully utilised in bioreactor systems where fungal biofilms were grown continuously, and were shown to be capable of significant pollutant removal from influent solutions. The following results were obtained using this bioreactor configuration.

- **Fungal biofilms in membrane bioreactors and their application in bioremediation. The white rot fungus *Phanerochaete chrysosporium***

Phanerochaete chrysosporium was used as a model fungus to test the potential of fungal biofilms for bioremediation. Under the conditions under which the system was tested, it was found that cresol removal efficiency of 100 per cent could be achieved at a productivity of 508 mg of cresol removed per m^2 per hour. This means that 113 litres of a 100 mg/ℓ p-cresol-containing synthetic effluent could be treated using a 1m^2 reactor per day in single pass operation. Greater throughput could be



Scanning Electron Microscope photograph showing fungal hyphae growing through macrovoids of a capillary membrane.

achieved by operating the reactor in recycle mode at higher fluxes.

❑ ***Trametes versicolor* as an alternative white rot fungus for bioremediation**

Since the *P. chrysosporium* discussed above is not an easy organism to work with, alternative fungal systems were sought to provide more rapid growth and enzyme production. *Trametes versicolor* was identified as such a candidate, and was found to be more readily cultured and applied. It was successfully demonstrated that the white rot fungus *T. versicolor* has significant potential in bioremediation of organic pollutants.

❑ ***Neurospora crassa* as a biocatalyst for bioremediation**

An investigation of the capacity of free fungal biomass to remove phenols from solution showed that cycloheximide-induced biomasss of *N. crassa* was effective in catalysing the removal of both *p*-cresol and phenol. Cultures exposed to varying concentration of p-cresol were found to be capable of up to 80 per cent removal of *p*-cresol, which represents a removal capacity of up to 4 g per litre. Similarly, cultures exposed to the same concentrations of phenol were capable of 100 per cent removal of phenol at a similar rate. Cultures of *N. crassa* grown in tenfold dilutions of a black petroleum effluent were found to remove up to 80 per cent of cresylics present within 4 days.

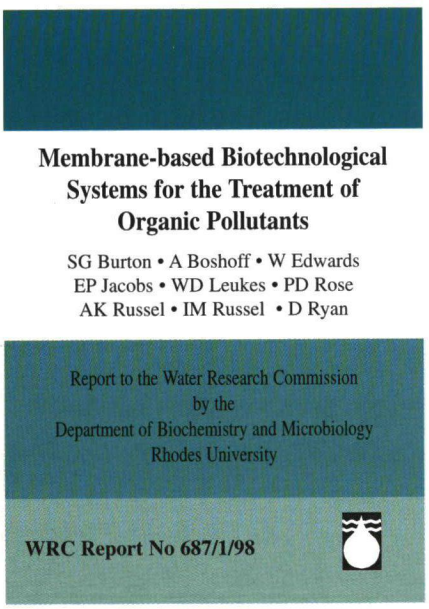
❑ **Studies using isolated polyphenol oxidase for bioremediation**

In this study, the use of capillary membranes as an immobilization matrix for polyphenol oxidase was used to achieve a separation of the enzyme from the reaction solution. From the results shown it is obvious that polyphenol oxidase is efficient at converting phenolic species when immobilised on a membrane and there is considerable potential for productivity improvement.

❑ **Development of a bioprobe using immobilised polyphenol oxidase to detect phenols in water**

Polyphenol oxidase, extracted from mushrooms, and immobilised on membranes, was used in the development of a bioprobe.

The bioprobe showed a broad substrate specificity and was sensitive to low phenol concentrations such as may be found in environmental samples. It was also shown to be active over a wide pH and temperature range. The presence of various salt and metal ions did not affect the bioprobe activity and the bioprobe was able to detect phenol and *p*-cresol in effluents. Thus the bioprobe promises to be applicable in a wide range of water samples as found in the environment, including in industrial effluents. Thus, the results show that the development of a bioprobe as described is feasible and a South African patent has been registered.



❑ **Alternative sources of oxidative enzymes**

In the search for alternative sources of oxidative biocatalytic activity, a bacterial strain was investigated, and its potential in dephenolising an industrial effluent was demonstrated. It was found that there is considerable potential in using the novel strain RUOR, immobilised on membranes. However, optimisation is required to achieve comparable pollutant removal efficiency to the submerged culture. The bacterial strain RUOR was found to be capable of catalysing the biodegradation of phenols, with a maximum removal capacity of 33,6 per cent phenol from an industrial effluent achieved over a 48 hour period. It appeared that low (up to 0,4g/ℓ) concentrations of the effluent had no major inhibitory effects on the growth of RUOR cells.

A research report on biodegradable compounds and microbial regrowth in water has recently been published by the Water Research Commission. Researchers JA Grundlingh, E Kotze, C Nel, and ME de Wet of Rand Water, say in the report that the presence of biodegradable organic carbon (BDOC) and/or assimilable organic carbon (AOC) in drinking water can give rise to bacterial regrowth in the water distribution network.

Although most of the organic compounds contained in the raw water are removed during the water purification process, all are not removed. Part of the organic compounds are present in the form of dissolved organic carbon (DOC), of which a portion named biodegradable organic carbon (BDOC) can be mineralised by heterotrophic micro-organisms. Assimilable organic carbon (AOC) is that part of the BDOC which can be converted by micro-organisms into bacterial regrowth and cause deterioration of the water quality.

Bacteria from the coliform group, as well as *Aeromonas* and *Pseudomonas* species, are associated with bacterial regrowth. These organisms are opportunistic pathogens, and if present, can cause serious problems.

However, to be able to predict bacterial regrowth in water distribution networks, and recommend possible adjustments to the water treatment process, it is essential to use reliable methods for determining the quality and quantity of biodegradable and/or assimilable organic compounds in the water. According to the report presently no clarity exists on direct methods for determining these compounds. All the methods being used are based on indirect measurements which are a function of bacterial growth.

AIMS

The aims of the research project were:

Biodegradable compounds and bacterial regrowth investigated

- ❑ to evaluate some of the available methods to choose the most suitable method(s) to determine biodegradable organic carbon present in water,
- ❑ to determine the extent to which results, obtained with these methods, are comparable,
- ❑ evaluate different treatment processes with respect to the removal of biodegradable organic carbon, by using the most suitable methods, and
- ❑ to determine a possible minimum concentration of biodegradable organic carbon at which no growth of heterotrophic or coliform bacteria, especially *Aeromonas* and *Pseudomonas* species would be expected.

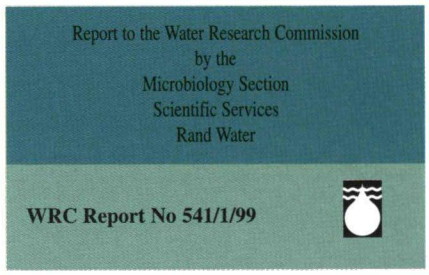
RESULTS

The results and conclusions of the researchers are, in brief, the following:

- ❑ Suitable methods to determine the biodegradable organic carbon in water:
  - The Van der Kooij method is cheaper, however, it is more labour intensive and results are only available after two to four weeks. Both the *Pseudomonas fluorescents* strain P17 and *Spirillum* sp strain NOX must be used during experiments to ensure utilisation of most of the carbon sources available.
  - The AOC analyser used for the Werner method is expensive, but analyses are less labour intensive and results are available within three to five days.
  - The BDOC methods of Joret-Lévi and Billen-Servais are easy to perform, but care must be taken to work in a "DOC free" (dissolved organic carbon) environment to prevent contamination.
  - The Jago-Stanfield method was unreliable.
  - The methods of Van der Kooij and Werner were found to be reliable and were used for the remaining part of the project.
- ❑ Possible seasonal effects on biodegradable organic carbon in water during the conventional treatment process at Rand Water:
  - Increases in the concentration of biodegradable organic carbon occurred during autumn and spring in the raw water through the treatment process until after chlorination.

Biodegradable Compounds and Microbial Regrowth in Water

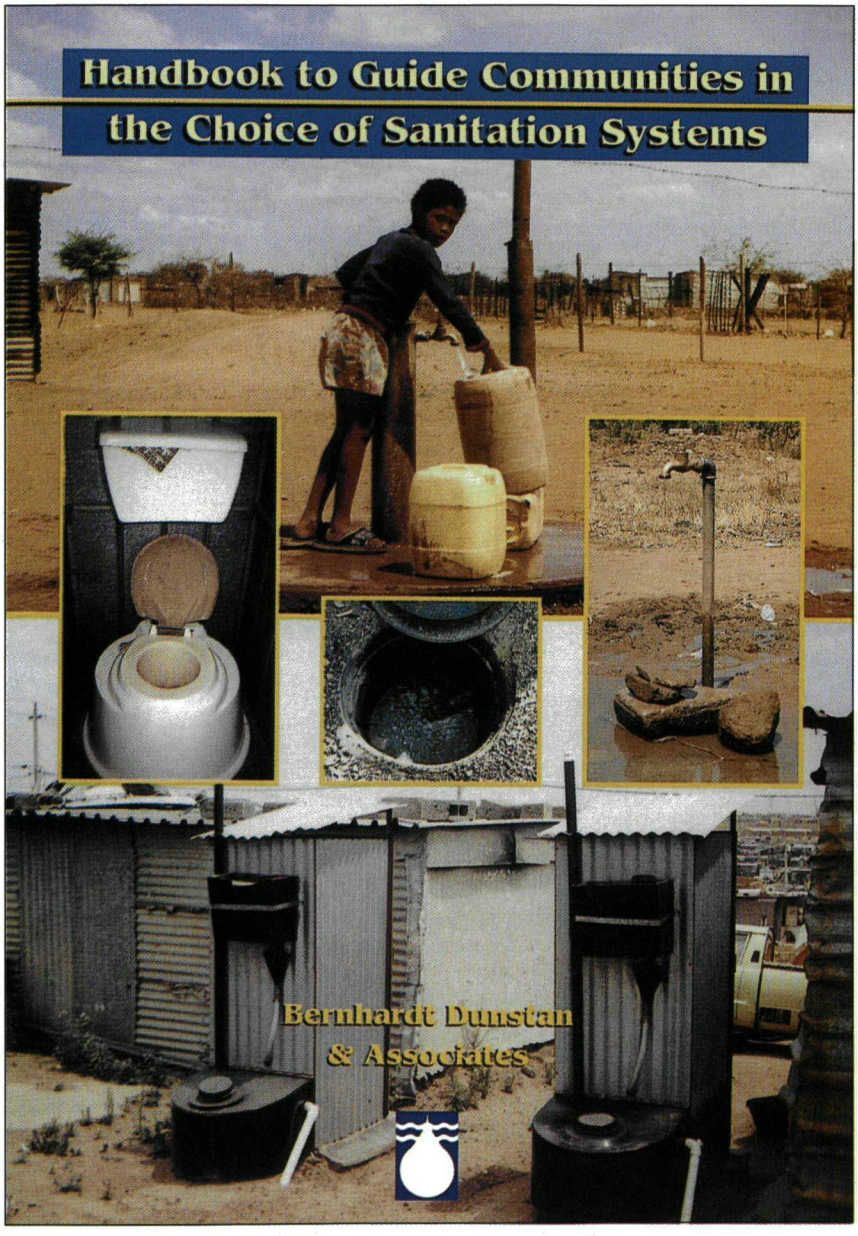
JA Grundlingh • C Nel • E Kotze • CME de Wet



- ❑ Effect of different treatment processes on the concentration and availability of biodegradable organic carbon:
  - All the processes evaluated increased both the concentration and availability of the biodegradable organic carbon in the raw water. Silica/lime vs lime/ferric chloride, high ferric chloride/low lime vs low ferric chloride/high lime and pre-chlorination vs pre-ozonation were evaluated.
- ❑ Biodegradable organic carbon present directly after treatment vs the possible formation in the distribution network:
  - zonation (primary disinfection) and chloramination (secondary disinfection) caused an increase in the concentration of biodegradable organic carbon in water directly after the treatment process.
  - Chlorination as secondary disinfection reduced the biodegradability of the carbon source.
- ❑ Activated carbon for the removal of biodegradable organic carbon:
  - Although the concentration of biodegradable organic carbon decreased during the treatment with GAC (granular activated carbon) the availability increased after each GAC column.
- ❑ A possible minimum AOC (Assimilable organic carbon) value at which no regrowth would be expected:
  - A specific carbon source will have different effects as it depends on the kind of species of bacterial population present.
  - *Pseudomonas* will cause more regrowth problems than *Aeromonas* under the same nutritional conditions.
- ❑ Water treatment methods for the removal of biodegradable organic carbon:
  - Pre-chlorination did not have an influence on the biodegradable organic carbon.
  - Chlorination increased the concentration of the biodegradable organic carbon but decreased the availability, therefore less bacterial growth could be expected.

The report entitled **Biodegradable Compounds and Microbial Regrowth in Water** (WRC Report 541/1/99) is available, free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. E-mail: library @wrc.org.za (Foreign orders: US $25 per copy, via surface mail.)

New handbook helps communities choose appropriate sanitation system



The Water Research Commission (WRC) has recently published a handbook to guide South African communities in their choice of sanitation systems. The aim of the handbook is to make the key findings of a WRC research project easily accessible to communities who are beneficiaries of sanitation projects or who desire to become so in future.

The research results should assist communities in decision-making by giving the necessary background information. This information should stimulate questions and help avoid some of the pitfalls experienced by others.

According to the handbook research was undertaken over a 12-month period in the following areas:

- Soshanguve TT, an independent development trust informal settlement with the same on-site, low flush system installed on every stand.

- Ga-Mmotla, a peri-urban settlement about 20 km north of Soshanguve in the eastern district of the North-West province. Ga-Mmotla, at the time of the research, had unimproved pit latrines but funding had been approved for future upgrade.

- Ivory Park, an expanding settlement in Midrand with a variety of on-site systems, both wet and dry.

In each case, the researchers Bernhardt Dunstan and Associates, were tasked to evaluate the existing on-site systems from a socio-economic point of view and to focus on the processes needed to ensure the introduction of affordable and sustainable sanitation systems for communities.

A variety of methods were used by the researchers including random house-to-house interviews using structured questionnaires, focus groups reflecting the different interest groups, one-on-one interviews and discussions with local authorities, technical people and in some cases, the manufacturers of the systems.

FINDINGS

- All three areas researched reported inadequate sanitation systems.

- In all the areas the women said they were severely inconvenienced by the systems and spent hours of work trying to clean their toilets, often unsuccessfully.

- In all three areas people felt the local authorities were not doing enough to maintain or upgrade the systems.

- There was inadequate knowledge of the link between sanitation and health and the need to educate people. There is especially a need to convince people to encourage children to use the toilets.

- Householders did not have enough knowledge about how to operate and maintain their toilets.

- The payment principle had been ignored or neglected with the result that non-payment mostly prevailed.

" The communities reported poor or non-existent consultation processes at the time of installation of their systems. Women felt particularly excluded.

" There was a strong sense of frustration with malfunctioning on-site systems and a feeling that only a full water-borne flush system would meet the community needs.

GUIDELINES

Guidelines, based on the research findings, have been formulated and reported in detail in the handbook. However, the researchers say some of the questions communities should think carefully about in relation to their own situation are the following:

- If the system requires water, how easy is the access to water? Who will carry the water and how often? What will happen to the people who cannot carry water?

- Where should the toilets be placed? Which way should the door face? How big should the toilet structure be in order to accommodate pregnant women, over-weight people and people who need assistance?

- Who will clean the toilets? Will the Council empty the toilets? Does the Council have the necessary equipment? If the service has to be privatised, what will it cost?

- Can people afford a toilet bucket that is not used for anything else, for cleaning and hand-washing? Can they afford cleaning materials including soap for hand-washing?

- Can the community afford an incinerator for the hygienic disposal of sanitary pads and other refuse which needs to be burnt?

- Can small enterprises resulting form a new sanitation system be run by the community members rather than be outsourced and costly?

- How can new standards of health and hygiene be introduced to a community so that old practices can be changed and replaced by healthy new behaviour? Who is responsible for this education? Council employees, nurses, hygiene officers, teachers, parents or the children themselves? Or is it a combination of all community members?

- If certain substances like household bleach will destroy the working of a particular sanitation system, how will the households be advised of this? Is it sufficient to rely on a manufacturer to provide education or a contractor at the time of installation?

- If ventilated pit latrines are to be installed how can construction be monitored so there is no danger of pits subsiding or of children falling into the pit because of faulty construction?

- How can a community get reliable information about all the different sanitation options and the cost of each?

- Who should decide what the community will have to pay and who is responsible if a manufactured system breaks or stops working? How strong are the working parts in a system? Will they withstand years of tough usage? Are there spare parts easily available? Are the parts affordable?

- What about the government subsidy for sanitation - how does a community apply?

- Can the system be upgraded to a water-borne system in the long term?

These are the sort of questions that should form the basis of a community investigation. They need to be discussed thoroughly in workshop situations to enable as wide as possible a spectrum of people not only to be part of the decision-making process, but also to ensure that the resulting sanitation is affordable and sustainable. Policy makers and practitioners will also benefit from working through this handbook.

Copies of the publication titled **Handbook to Guide Communities in the Choice of Sanitation Systems** (WRC report TT 104/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$10, via surface mail).

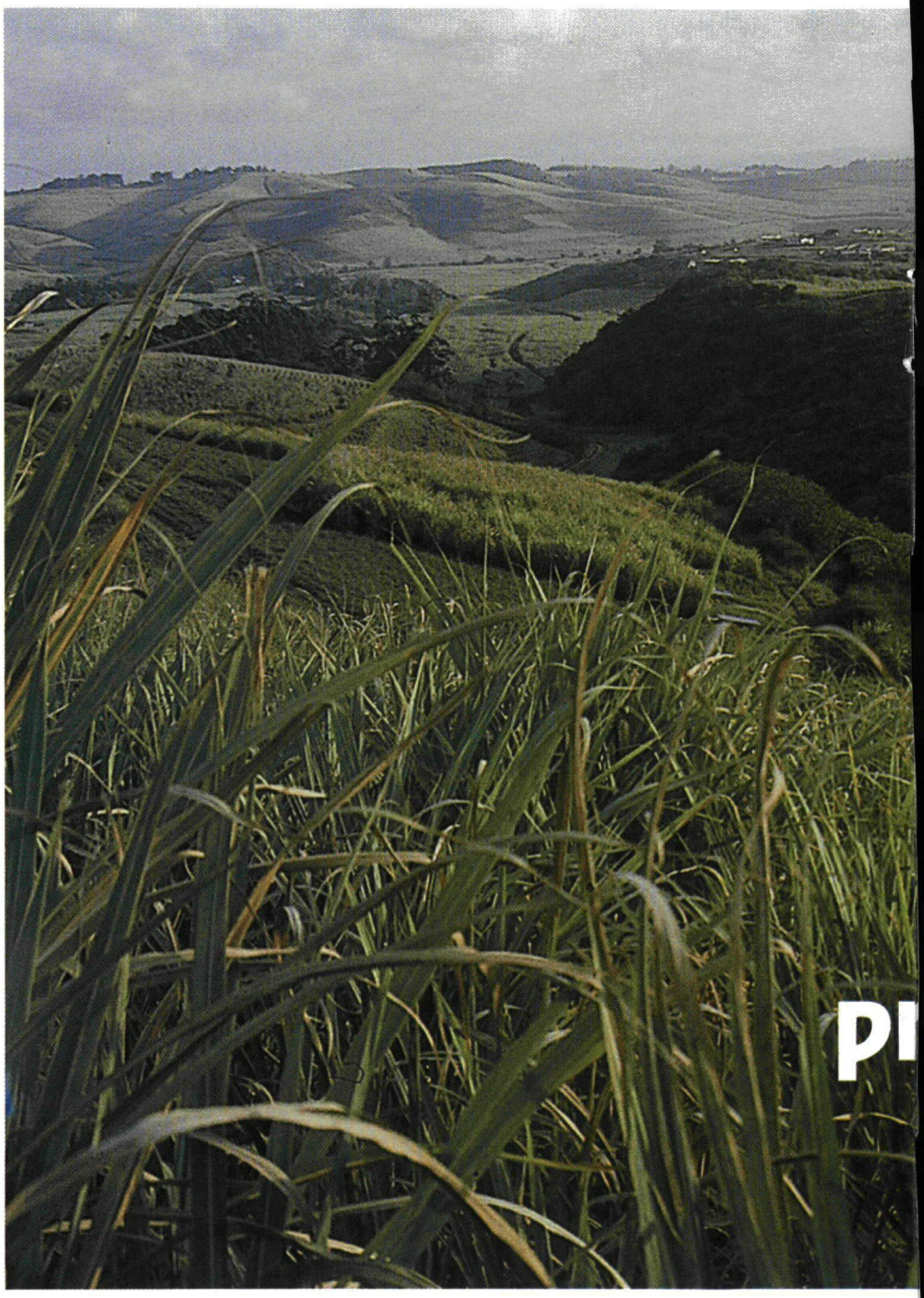
The current area under sugarcane production in South Africa is some 400 000 ha, and according to researchers at the South African Sugar Association Experiment Station in Natal, there is an increasing need to quantify the impact of sugarcane production on the country's water resources. This impact could include reduction in stream flow, modification in flood size (volume and peak) and impact on sediment yield and water quality.

In 1992 a joint project between the Water Research Commission, Illovo Sugar Ltd and the South African Sugar Association was initiated to address these issues. The main aims of the project were:

- To measure water yield and quality from steep catchment areas planted to a commercial timber crop.
- To measure the changes in water and sediment yield and water quality when the forested area is planted to sugarcane, requiring different management and slope preparation methods.
- To compare results from the above areas with runoff from natural grassland.

The researchers, EJ Schmidt, JC Smithers, RE Schulze and P Mathews (the latter two are from the University of Natal), say in their final report to the Water Research Commission that the project initially focussed on measuring the hydrological response from eight small catchments located at Umzinto (70 km south of Durban), undergoing a land use change from timber to sugarcane. Various factors resulted in limited data being collected from the catchments during the project. Accordingly, the emphasis of the project was placed on using a hydrological model, validated using available data for sugarcane catchments, to meet the project objectives.

The researchers say the ACRU model, developed in South Africa, was selected as an appropriate model since it is a physical, conceptual model which has been widely tested over the past fifteen years for a wide range of land uses including timber, sugarcane and grassland. The model was verified for sugarcane using data collected during the period 1977 to 1995 at four catchments located at La Mercy near Durban. The model was then applied for various land use scenarios to the Umzinto catchments.



Sugarcane plantations covering the undulating hills of Natal.

RESULTS

Various factors (the worst recorded drought, tree dieback, a fire which killed most of the remaining trees and chronic vandalism of equipment) resulted in limited data being collected from the catchments during the project.

However, the major results and conclusions from the study could be summarised as follows:

- **Hydrological Trends and Relationships**

Based on hydrological data collected from runoff plots and research catchments the following trends were evident:

Impact of sugarcane production on South Africa's water resources studied

- On average, there was a 60 per cent reduction in soil loss and 34 per cent reduction in runoff from plot experiments when minimum tillage as opposed to full tillage methods were adopted. Average annual soil erosion from sugarcane plots ranged from 21 t/ha per year to less than 2 t/ha per year.

- Runoff appears to be mostly affected by soil type (infiltration rate), storm intensity and antecedent moisture conditions. Annual runoff as a percentage of rainfall from four catchment experiments varied between 0 and 25 per cent of annual rainfall. Typically, runoff response is less than five per cent when annual rainfall was less than 850 mm, and rose to above 25 per cent when rainfall exceeded 1 200 mm. Generally a few large storm events produce most of the runoff. During such storms more than 50 per cent of rainfall can run off.

- Crop cover and management practices such as strip cropping, minimum tillage and trash retention appear to reduce runoff and soil loss to a greater extent than conservation structures such as contour banks and waterways. Soil loss declines to a greater extent than runoff as sugarcane cover increases.

- No signs of excessive wash-off of nutrients or minerals from the catchments were evident.

❑ Hydrological Simulation using the ACRU Model

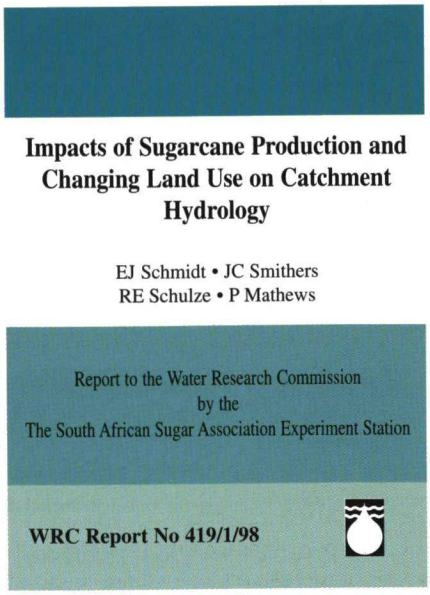
A decision support system to improve estimation of the ACRU model parameters for sugarcane catchments was developed. While the ACRU model adequately simulated runoff volume from sugarcane catchments, certain events were not well presented by the model. This was ascribed to an inadequate representation for the events of rainfall intensity (ACRU is a daily model), initial abstractions prior to runoff occurrence as well as land preparation and crop management practices. Estimation of sediment yield using the modified USLE equation did not prove successful. Generally sediment yield was over-estimated.

Crop cover and management practices appear to reduce rainfall runoff and soil loss. Soil loss declines to a greater extent than rainfall runoff as sugarcane cover increases.

❑ Modelling the Impact of Grassland, Forestry and Sugarcane

The ACRU model was used to simulate the impacts of *Eucalyptus grandis*, sugarcane and grassland on water yield at Umzinto. Based on the model runs, it was concluded that:

- Afforestation had a greater impact on stream flow than sugarcane at Umzinto.
- The impact of land cover on runoff is least when soils are shallow and is exacerbated as the soil thickness increases.
- Differences between runoff response under different land covers is smallest during wet years and seasons.
- On thin soils the runoff simulated from grassland and sugarcane land covers were similar. On thicker soils runoff from grassland generally exceeded that from sugarcane.
- Use of stochastic rainfall series did not provide good representation of runoff conditions during high and low flow periods.



CONCLUSION

This project demonstrated the usefulness of a deterministic model such as ACRU to produce results which are realistic and in harmony with field measured data. The improvements to ACRU's representation for sugarcane will also be of great value to ensure that defensible and realistic scenarios is generated by ACRU in the continuing controversy over the impact various crops have on water utilisation.

The project also allowed preparation of a data base containing hydrological information from sugarcane catchment and plot experiments, which will be invaluable for further research studies.

Copies of the full final report entitled **Impacts of Sugarcane Production and Changing Land Use on Catchment Hydrology** (WRC report 419/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25, via surface mail).

Modelling water balance in a South African grassland catchment

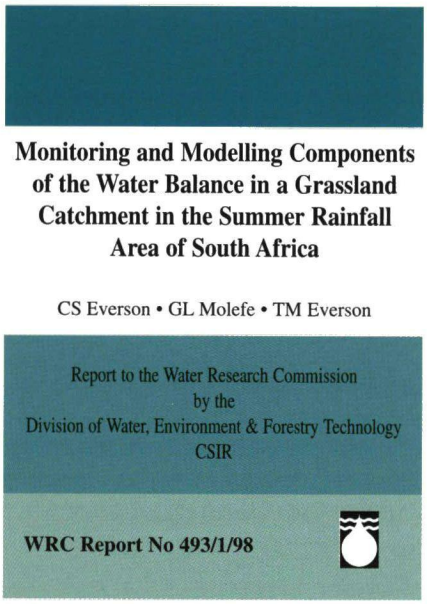
The major catchment areas for South Africa's water resources are covered by natural grasslands which occupy approximately 29 per cent or 350 000 km^2 of the country. With increasing demands for grazing land and afforestation many of these catchments may be targeted for different land management practices, and there is therefore growing concern that such changes will result in reduced water yield from these grassland areas.

To quantify the effects of afforestation and agriculture on mountain grassland catchments, it is necessary to have information on the evaporation losses from natural vegetation to provide a management baseline with which the evaporative losses of other land-uses and vegetation covers can be compared. An understanding of the principal factors (meteorological, plant and soil) affecting the water balance of a grassland catchment is also necessary for planning future water supplies.

Traditionally, estimates of water use of vegetation in gauged catchments are made by determining the difference between precipitation and streamflow. However, these estimates are not precise enough to enable accurate predictions of water yield from hydrological models. Since the water use of natural grassland largely depends on available energy, accurate estimates of evaporation from the vegetation can only be made by quantifying the catchment energy budget.

In a study funded by the Water Research Commission and carried out by researchers from the Division of Water, Environment and Forestry Technology at the CSIR, the Bowen ratio energy balance technique was used to measure the water use of a grassland. This is the first long-term study in South Africa in which all the components of the catchment water balance are measured simultaneously.

According to the researchers, CS Everson, GL Molefe and TM Everson, one of the most difficult hydrological processes to measure and monitor is soil water content. However, with continual advances in soil water measurement there are a number of new techniques available to the scientist. The researchers tested two technologies that are currently used in hydrological research, namely the soil moisture capacitance technique and time domain reflectometry.



The main objectives of the study were:

- To quantify the spatial and temporal patterns of evaporation and soil water within a grassland catchment near Cathedral Peak.
- To describe these processes in terms of the controlling environmental variables.
- To develop and adapt existing modelling frameworks for catchment water balance for use in water resource management planning.

RESULTS

❑ Evaporation losses

The researchers managed to intensely observe four seasons of hydrology, which fortunately included two very dry ones and one rather wet one. This provided the opportunity to study and analyse the hydrological system under a full range of conditions. The study showed that despite the low rainfall actual evaporation remained fairly similar, showing that even in dry years in this normally wet part of South Africa (MAP 1 299 mm) soil moisture is not a main limiting factor in evapotranspiration of grassland. Evapotranspiration from the wet riparian zone was nevertheless still higher than from the uplands.

In summer evaporation losses from north facing slopes was observed to be 10 per cent higher than the east or west facing slopes. In winter this was not leading to significant differences. The Penman-Monteith equation to model evapotranspiration was found to be highly satisfactory.

❑ Hillslope Hydrology

It was clearly established that the streamflow was fed by moisture moving slowly downslope under conditions of unsaturated flow. The saturated zone surrounding the riparian area varied in size with rainfall and season.

Hydrological models that can account for this kind of spatial distribution of soil moisture within a catchment are likely to be the most accurate. Testing the ACRU model on this catchment showed this to be a limitation of the model.

Copies of the report summarising the results and entitled **Monitoring and Modelling Components of the Water Balance in a Grassland Catchment in the Summer Rainfall Area of South Africa** (WRC report 493/1/98) are available free of charge from the Librarian, Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 30).

New methodology determines river instream flow requirements

The impact location of the Riviersonderend study site, upstream of gauging weir H6H008. Diversion of approximately 86 per cent of the natural dry-season baseflow of the river took place at a temporary diversion weir constructed immediately upstream of the location, as seen in the above photograph.

A study funded by the Water Research Commission produced a new methodology, the Building Block Methodoloy (BBM), to assist water resource managers in rapidly determining the instream flow requirements of rivers in South Africa for which little data exists.

Where a water-resource development is planned, the identified flow components (the so-called building blocks) of the river can be combined to describe a recommended modified flow regime that is specific for the river of concern. These "blocks" of flow usually fall into the following categories: dry-season baseflows (low flows), wet-season baseflows (low flows) wet-season floods, dry-season freshes and dry-season subsurface flows. The minimum volume of water required for each "block" is described, thereby defining a minimum flow requirement for maintenance of the river ecosystem.

The research was carried out by RE Tharme and JM King of the Freshwater Research Unit in the Zoology Department, University of Cape Town.

The researchers say in their final report to the Water Research Commission that the continued population increase in South Africa is leading to rapid development of the country's remaining unexploited water. At the same time, there is a growing awareness of, and concern for, the welfare of our natural environment as a sustainable resource. Planners and water managers are increasingly seeking guidance on how to develop water resources with minimum impact to aquatic ecosystems. In the planning of a new water-resource development a new, important question (now routinely asked by the planners and developers) concerns the quantity of water needed by the river itself for ecosystem maintenance. This report presents the results of a study which aimed to present an answer to this question.

IFIM

The North American Instream Flow Incremental Methodology (IFIM), which is the most comprehensive and well known approach currently available worldwide, has been investigated in some depth. Researchers, however, concluded that it will not be used extensively in South Africa. This is mainly because of the exceptionally long time required to achieve a satisfactory result for any one river; its extensive requirement for biological data, which largely do not exist; its questionable ability to accurately describe the low-flow hydraulics of many of our complicated river channels; the difficulty of testing many of its assumptions and of satisfying the requirements that should be met before application of the model. The fact that it is based solely on changes in a physical habitat, with no recognition of biological constraints and its focus on species and community requirements rather than on the holistic requirements of entire riverine ecosystems, is a further disadvantage.

Therefore, in South Africa, where there is severe limitations of time, finances,

trained scientists and available information, it is necessary to develop methodologies and expertise to determine instream flow requirements rapidly, based on existing data.

The overall aim of this study was therefore to increase South African scientists' ability to advise water resource managers/developers regarding instream requirements of rivers by:

- ❑ increasing understanding of the effects of different magnitudes of low flow on riverine biotas, through focussed research on South African rivers.
- ❑ continuing the development of scientifically acceptable methodologies for assessing the water quantity requirements of rivers.

RESULTS

❑ The Building Bock Methodology (BBM)

The researchers give a general description in the report of the dynamic nature of rivers and make the following points in some detail with specific emphasis on aspects important to the riverine biology as listed below:

- ❑ the modified flow regime should mimic the virgin one, so that the natural timing of different kinds of flows is adhered to;
- ❑ the river's natural perenniality or non-perenniality should be retained;
- ❑ most water should be harvested form the river during the wet months and least during the dry months;
- ❑ the seasonal pattern of higher baseflows in the wet season than in the dry season should be retained;
- ❑ floods should be present during the natural wet season;
- ❑ flood durations could be shortened, but within limits that allow flood-related activities, such as fish spawning in flooded areas and movement of larval fish back into the channel, to reach completion;
- ❑ whole floods could be removed but others should be left at full magnitude, rather than having all the naturally occurring floods but at lower magnitudes;
- ❑ the first (or one of the first) flood of the wet season should be retained.

The conceptual basis of the BBM was derived from the above points, where the various components of flow (building blocks) can be combined to describe the recommended flow regime for a specific river. From a beginning of a set of actions, the BBM is now a well-structured methodology addressing the health of the complete system.

❑ The annual baseflow regime

A point of difference between the understanding of flows between engineers and ecologists at the beginning of this work was that engineers presented flows by volume only, while ecologists stipulated timing and minimum flows for the river. However, a detailed assessment of the effects of low baseflows needed to be made. This was experimentally done in the field by means of diversion weirs installed with help from Department of Water Affairs and Forestry personnel. At three sites flow was reduced to levels ranging from the absolute minimum recorded for the river (Molenaars River site) to significantly lower than the absolute minimum recorded (Riviersonderend river site). The very low flows resulted in temperature increases as well as habitat loss.

The researchers say no clear trends emerged from this experimental work, and the between-river differences were greater that the between site differences.

❑ Relation between the wetted perimeter and hydrological indices

The inflexion on the graph plotting flow to a wetted perimeter was initially thought to have possible biological significance, but was shown in this study to occur at flows substantially higher than normal low flows.

❑ Flushing flows to mobilise sediments

An important habitat in cobble-bed rivers is the underside of the cobbles. This habitat is flushed clean by high flows, and when these do not occur, the diversity of taxa in a river is reduced. A model has been developed (at the moment only validated for the Molenaars River) which predicts the discharge required to maintain this habitat.

Four smaller investigations were also undertaken during the course of this project. These were into the hydrological nature of flushes, the effects of a flood on macroinvertebrate communities, the effects of anthropogenic perturbations on the benthic invertebrates of a river system and the implications of predetermined release policies and dam sizes on the natural flow regime of Western Cape rivers. Brief descriptions of these studies are given in the report.

Copies of the report entitled **Development of the Building Block Methodology for Instream Flow Assessments and Supporting Research on the Effects of Different Magnitude Flows on Riverine Ecosystems** (WRC report 576/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US $40, via surface mail).

The natural character of the river at the control location of the Riviersonderend study site, situated upstream of the impact location and gauging weir H6H008. A Department of Water Affairs and Forestry surveyor is present in the foreground.

Pollutant export from a disused animal feedlot studied

A study funded by the Water Research Commission has emphasised the fact that a seemingly innocuous and fairly common land use practice, that of concentrating cattle on a piece of land to feed them, can result in highly polluted runoff, particularly for the algal promoting nutrients, phosphorus and nitrogen.

According to researcher DE Simpson at Umgeni Water (formerly from the Division of Water, Environment and Forestry Technology at the CSIR) land-use in catchments has been shown by many researchers to be a major determinant of runoff water quality.

INFORMATION NEED

"However, there is a paucity of reliable information on the influence of land-uses in catchments on water quality, in particular for those land-uses with high pollution potentials. There is a need for information on mean runoff quality, annual pollutant washoff loads and the variation in quality with flow."

During the course of an earlier study (WRC project no. 237), two catchments at the Ntabamhlope complex near Estcourt were monitored for runoff water quality. One of them was a small catchment (0.08 km^2) which had for a number of years been used as a wintering enclosure for cattle. The cattle were fed during the winter and therefore the catchment could be described as a feedlot, but not in the sense of a commercially operated feedlot which would be used continuously and probably at a higher cattle density. The results from monitoring runoff water quality during storms showed some very high nitrogen, phosphorus and organic compound concentrations as given by chemical oxygen demand values (COD), ie: up to 10 mg/ℓ for soluble phosphorus, 30 mg/ℓ for nitrate and 500 mg/ℓ for COD. No indication of these high concentrations, which are close to levels commonly found in raw sewage, was given by the analysis of baseflow samples.

"Clearly, runoff from this type of land-use has a high potential to pollute receiving water," Simpson says. "The data set is, however, very limited because runoff was only sampled for one season which was also short (only 4 months). Further sampling needed to be carried out to improve the data base, give greater confidence to the conclusions drawn and further develop flow-water quality relationships for potential use in the Mgeni catchment model being developed in a related project by the University of Natal."

OBJECTIVE

According to the final report released by the Water Research Commission, the overall objective of Simpson's study was to characterise runoff water quality from a disused feedlot and quantify it's pollution potential to receiving waters.

Specific aims were to:

- Determine mean runoff water quality for different flow regimes, and pollutant export coefficients, (kg/ha/a).
- Determine flow-water quality relationships that may be used in models.
- Determine temporal trends in baseflow and stormflow water quality to quantify the residual effect of pollutants stored on the catchment.
- Investigate relationships between the water quality variables for predictive use.
- Make recommendations for use of

the data collected in application to water quality models.

RESULTS

Monitoring began in late 1990 and ended in early 1993, a period encompassing three summer and two winter seasons. During this time, apart from the regular taking of baseflow samples, a total of twelve runoff events were sampled, mostly throughout their hydrographs to give comprehensive quality data during changing flow. Both small and large events were sampled. The data set was divided up into subsets of low flow (baseflow) and high flow (stormflow) data for calculation of mean water quality to characterise the different flow regimes and to further calculate the loads of pollutants delivered during low and high flow. Altogether, 66 baseflow and 179 stormflow samples were taken for this purpose.

There was a considerable difference between the low and high flow water quality means. Suspended solids (SS), soluble phosphorus (TPF), ammonia (NH3) and total Kjeldahl nitrogen (KNU) concentrations for high flow compared to low flow were 38, 37, 5 and 6 times greater respectively. High flow concentrations were of the same order of magnitude as those found in raw sewage.

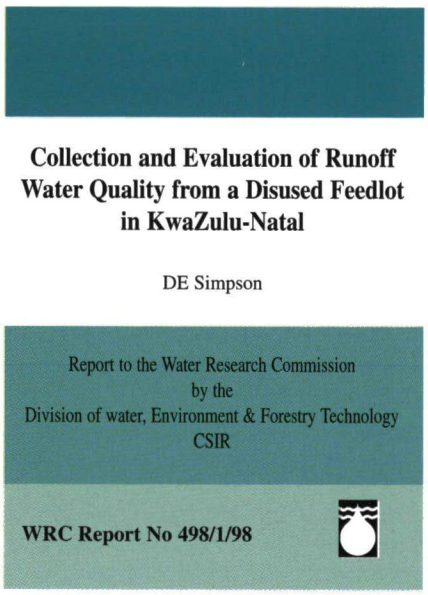
The weighted annual mean runoff water quality for this particular landuse was calculated from daily runoff as recorded and disaggragated into base and quick flow volumes. The results are shown below. Concentrations of the nutrients are very high compared to normal rural river water quality.

Variable	Mean
SS,mg/ℓ	5
Turbidity, NTU	41.1
COND, mS/m	37.3
TPF, µg/ℓ	897
TPU, µg/ℓ	1 626
NO_3, µg/ℓ	4 138
NH_3, µg/ℓ	244
KNF, µg/ℓ	2 177
KNU, µg/ℓ	4 607

Loads of pollutants washed off the catchment and areal export coefficients were calculated from mean analyses and the annual mean runoff. The mean annual pollutant export coefficients are shown below:

Variable	Export(kg/ha/a)
SS	301
TDS	333
TPF	1.18
TPU	2.18
NO_3	5.53
NH_3	0.33
KNF	2.91
KNU	6.16

More than 90% of the annual suspended solids, soluble (TPF) and total phosphorus (TPU) loads and slightly lesser percentages for ammonia and Kjeldahl nitrogen were contributed during high flows.



Using linear regression analysis, equations relating the dependence of suspended solids and particulate nitrogen to flow during stormflow were developed.

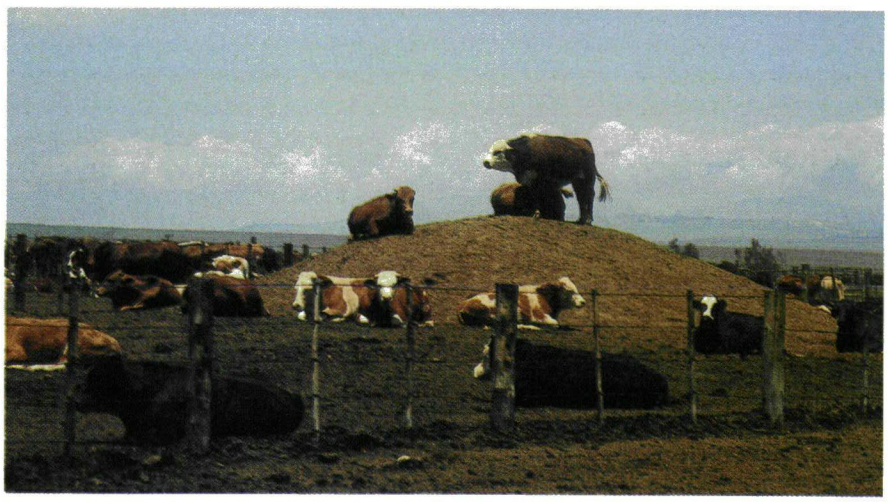
It was calculated that it would take 4 to 5 years from the cessation of the particular landuse practice before the runoff water quality return to more normal levels.

Correlation analysis was carried out between the water quality variables to determine the strength of relationships. The only strong correlations were found between suspended solids, particulate phosphorus soluble phosphorus and soluble Kjeldahl nitrogen.

CONCLUSIONS

- Export coefficients, together with the mean water quality may be used as approximations for smaller landuse catchments, where measurements have not been made.
- Regression equations were developed to estimate constituent concentrations in stormflow from similar landuse catchments.

Copies of the full final report entitled **Collection and Evaluation of Runoff Water Quality From a Disused Feedlot in KwaZulu-Natal** (WRC report 498/1/98) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price of the report: US $20, via surface mail).



Concentrating cattle on a piece of land to feed them, is a fairly common practice, which can result in a runoff with a high pollution potential.

Researchers develop optimisation model for reservoir systems

The Water Research Commission (WRC) has published two reports of a research project, aimed at developing models for the optimisation of the pumping and design policies of reservoir systems. The research was motivated by the high pumping costs experienced by water supply authorities in South Africa. This component of water supply costs is of major importance in the research aimed at the optimisation of urban water supplies. The project was undertaken by the Water Systems Research Group at the University of the Witwatersrand, under the leadership of Prof David Stephenson.

The researchers say that service and distribution reservoirs are used for a number of purposes, such as balancing storage, emergency storage and fire storage. In terms of the daily running of the reservoir, the most important component is the balancing storage. This provides a buffer between the consumers' demands and the supply equipment. The simplest form of reservoir operation would be to supply water at the average demand, and provide a reservoir large enough to meet any fluctuations in the demand. However, this is not feasible as:

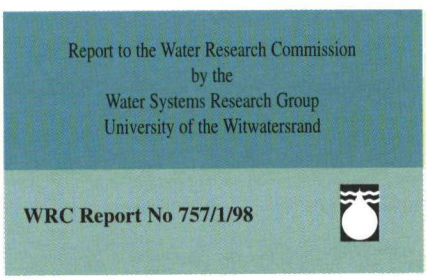
- ❑ average demand is not known with sufficient accuracy,
- ❑ meeting a full year's demand fluctuation would generally require a very large reservoir,
- ❑ the demand changes with changes, such as urbanisation, in the supply area.

Consequently a reservoir can not be built and simply left to run by itself. It needs to be operated on a daily basis.

Most reservoir systems in South Africa, and throughout the world, are run without any formal operation policy. This allows for flexible operation, but does not necessarily result in minimising operational costs. Today many systems are automated as operation costs are rising. However, automation of a system requires development of a formal, mathematical operation policy, which is optimised so that operating costs will be kept to a minimum.

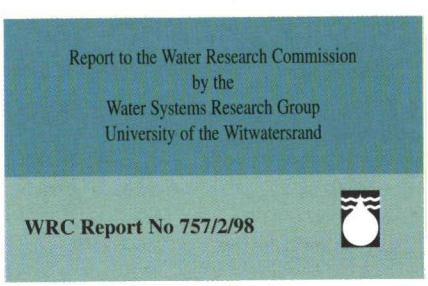
Reservoir System Operational Optimisation

NJ Manson



Capital Cost Optimisation of Pumping and Reservoir System Design

B Barta • N Rowse



AIM

The aim of this research was to develop models which could be used to calculate an operational policy for a reservoir system that will minimise the operating cost of the system. These costs are largely the cost of energy required for pumping.

RESULTS

This research was undertaken as a two phase project with two separate but related subjects, culminating in two complimentary reports (WRC Reports 757/1/98 and 757/2/98) as follows:

❑ **Pumping rules phase report and software program (RSPO)**

(WRC Report 575/1/99 entitled "Reservoir System Operational Optimisation" compiled by NJ Manson.)

A dynamic computer simulation model was investigated which was then used to optimise the rules for pumping operation used by the operators of reservoir storage systems with respect to demand patterns, pumping costs and storage volumes. The research in this phase culminated in the computer program Reservoir System Pumping Optimisation (RSPO), which allows historical demand data to be imported and analysed, a stochastic model of that data to be fitted, and optimum operation policies to be calculated.

The policies calculated by these methods have been shown to be very close to optimum, and useful for the continued operation of the reservoir system. The effect of local optimum points in the cost space was investigated. It was found that there are local optimum points that do tend to prevent the system from finding the global optimum solution, these local minima however, do not reduce the accuracy of the solution by more than one per cent. The researchers also found that the accuracy of the optimum solution obtained was hardly affected by the length of the data set used in the optimisation process.

A comparison with historical operating data showed that, although only small savings were achieved, the optimum policy performed at least as well as an experienced human operator.

It should be noted that the findings of the research compiled in these reports

(WRC Report 757/1/98 and 757/2/98) are based primarily on the background of the large Rand Water supply system, considered to be a second tier bulk water supply authority. The Rand Water bulk water supply system is operated and managed to supply the demands for potable water generated primarily by the third tier water supply authorities, which are mainly local authorities and large industries.

❑ **Design parameters phase report and software program (RSDO)**

(WRC Report 757/2/98 entitled "Capital Cost Optimisation of Pumping and Reservoir Design" compiled by B Barta and N Rowse.)

This phase of the research project investigated and evaluated existing design parameters relating to storage capacity for balancing draw-off and pumping and emergency storage in the light of the costing model and the design parameters calculated from it. The model determined and proposed in this report is able to rapidly assess various options for a water supply system with regard to service or distribution water storage and conveyance. The research culminated in the computer program Reservoir System Design Optimisation (RSDO).

The optimal design problem was to find the component characteristics (eg. pipe diameter, pump heads and reservoir volumes) that minimise the total system cost. The capital cost optimisation program - Reservoir System Design Optimisation (RSDO Version 1.01) compiled by the Water Systems Research Group at the University of the Witwatersrand, is a useful tool which is now available to the water supply industry in South Africa. A rapid assessment of various cost optimisation scenarios involving the optimal sizing of the pumps, pipe diameter and balancing storage can be performed by means of this tool on a standard computer facility.

The capital cost optimisation program provides the individual designer with the costing model and the design parameters calculated from it, thus allowing him to improve the current design methods and also to scrutinise the current design standards.

CONCLUSION

Using these models will provide the following benefits for water services:

- ❑ improvement of operational policy relating to pumping regimes and reservoir storage, and
- ❑ minimising operational costs related to the above, especially energy cost savings.

The reports entitled **Reservoir System Operational Optimisation** (WRC Report 757/1/98) and **Capital Cost Optimisation of Pumping and Reservoir System Design** (WRC Report 757/2/98) are available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. E-mail: library@wrc.org.za (Foreign order price: US $25 per copy of each report, via surface mail).

Please note: *Software, or models RSPO, and RSDO complementing the reports are only available on the WRC website (for downloading), http:\\www.wrc.org.za\software\ .*

Enzymes defoul ultrafiltration membranes

The removal of colour arising from humic substances from surface waters for potable use, by using ultrafiltration (UF) as an alternative technology to sedimentation, adsorption and depth filtration has evoked considerable interest both locally and internationally, according to a report published by the Water Research Commission. Moreover, this technology is of particular relevance to the South African context, the report says, since it offers the potential for small scale operation in rural environments which do not have access to municipal water purification facilities.

To try and extend the use of this type of membrane technology, the Water Research Commission funded a project in which a novel capillary ultrafiltration membrane displaying high flux at low pressure characteristics was developed in a collaborative programme between the Department of Biochemistry and Microbiology at Rhodes University and the Institute for Polymer Science (Stellenbosch University).

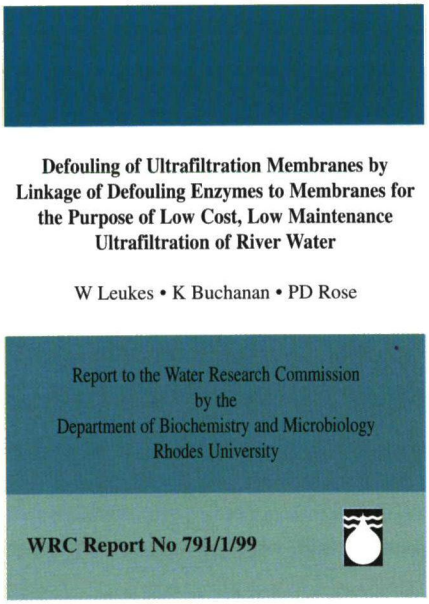
The researchers, W Leukes, K Buchanan and PD Rose say a major problem encountered in the use of pressure driven membrane processes (such as micro-, ultra- and nanofiltration as well as reverse osmosis) is fouling.

FOULING

The consequences of fouling include the following:

- High cleaning costs, since large amounts of expensive cleaning agents are often required to restore the flux of fouled membranes.
- Harsh chemical cleaning agents damage the membrane leading to significantly shortened membrane life, and the cost of membrane replacement is often prohibitive.
- Fouling results in lower-than-expected flux. This is often taken into account when plants are designed to handle a specific volume of liquid by increasing the membrane surface area. This incurs a significant cost.
- Productivity is reduced due to downtime required for cleaning of fouled membrane membranes.

Complex and highly engineered cleaning cannot be implemented in low-cost rural water purification due to lack of skill and resources. The same applies to certain industrial environments. A need therefore exists for the development of self-cleaning membrane filtration systems.



ENZYMES

A novel concept, called the defouling on demand strategy, was proposed as a solution, using activatable enzymes. In this process, enzymes capable of the transformation of humic substances, but which are inactive during the operation of the ultrafiltration procedure are immobilised onto the surface of the membranes. These enzymes, in association with adsorbed humic polymers form a dynamic layer which enhances the ultrafiltration process. Once flux decline reaches a determined low point, the enzymes are "activated" by adding a co-factor. The enzymes then act on the foulant layer, thereby restoring flux. The objective of this study was to evaluate this concept by choosing suitable enzymes and demonstrating that this concept can be applied practically.

Based on available literature, three enzymes were selected as candidates for the defouling process. These were horseradish peroxidase (HRP), soybean peroxidase (SBP) and manganese peroxidase (MnP). Peroxidases were chosen for their known ability to transform humic substances and their requirement for hydrogen peroxide (and in the case of MnP, manganous ion) as a means of activation.

A laboratory experimental procedure was developed to evaluate these enzymes using a stirred ultrafiltration cell with flat sheet membranes. No flux improvement was obtained after activation of immobilised soybean peroxidase. However, flux improvement was obtained from activated horseradish peroxidase and manganese peroxidase, with the latter giving the best performance. Further experiments showed that flux improvement upon activation of manganese peroxidase was considerable and rapid. Control experiments showed that this effect was due to enzyme action and not artefactual. Due to the rapid action of this process, its ease of operation and its safety due to exclusion of harsh cleaning chemicals, it was recommended that further evaluation of this concept is warranted for application to compact units for surface water decolourisation.

ADVANTAGES

The "self-cleaning" membranes generated in this way would have the following advantages over conventional cleaning regimes:

- No flux decline would be encountered since a gel layer is never allowed to

form. This leads to higher efficiency of filtration plants. Therefore, lower membrane surface area would be required to handle the same volume, which would reduce the cost of setting up the plant.

- No down-time is needed for cleaning, which means that the membrane plant can be operated continuously, resulting in much better plant productivity.
- No harsh chemical cleaning agents would be required, which will lead to extended life expectancy of the membranes. The cost of membrane replacement would therefore also be reduced.
- The cost of expensive cleaning chemicals and enzymes would be avoided. The initial cost of the enzymes to be attached would be similar to that of a single enzymatic cleaning cycle. Because the enzymes are attached to the membrane, they can be re-used continuously without the added cost of recovery. Enzymes will be used that do not require frequent replacement.

A fair amount of expertise exists within the research group in the development and operation of immobilised enzyme and cell membrane bioreactors and the opportunity therefore exists to develop a novel and effective low cost solution to the fouling problem. The ultimate aim of developing such a system is to simplify membrane water purification by eliminating the need for frequent, sophisticated cleaning regimes, so that these systems can be used in the poorest rural communities for water purification and/or waste treatment.

Copies of the report titled **Defouling of Ultrafiltration Membranes by Linkage of Defouling Enzymes to Membranes for the Purpose of Low Cost, Low Maintenance Ultrafiltration of River Water** (WRC report 791/1/99) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 5, via surface mail).

Download free software from the Internet

Internet address: http://www.wrc.org.za

No more fumbling with floppies or stiffies attached to the back of a report, no concerns about Y2K compliancy of older software - just click on the appropriate button and download!

Software programs, resulting from WRC funded research projects, may now be downloaded from the WRC's web site on the Internet. Such software programs are designed either to support a specific research report or to be distributed as a stand-alone program. The Internet also enables easy updating of software whenever needed.

The following software programs are available for downloading - free of charge:

SLADS

The Sludge Land Application Decision Support (SLADS) software (developed by K. Murphy) consists of a suite of expert-systems based programs which attempt to provide decision support for professional and administrative staff involved with permitting, site/area identification, site assessment and planning suitable areas for sludge application

WSSM and SSW

The Water Supply Services Model and the Sanitation Services Model are now available to assist agencies responsible for water supply and sanitation in urban areas in the development and evaluation of investment scenarios and tariff policy.

These models were developed by the Palmer Development Group.

RSDO/RSPO

RSDO and RSPO are computer models emanating from the following reports:

- Reservoir system operational optimisation, by NJ Manson. 1998. WRC Report 757/1/98
- Capital cost optimisation of pumping and reservoir system design, by B Barta and N Rowse. 1998. WRC Report 757/2/98

CMMVID

Emanating from a WRC project, the Cross Flow Membrane Module and Potable Plant Design software is an introduction to membranes and their functioning.

The computer program simulates membrane treatment and membrane design for potable water production. The program is able to:

- Provide the module area and packing density of the capillaries,
- Show animated flows of the basic feed stream, permeate and concentrate circuits,
- Explain plant components when clicking on the specific component.

Please Note !

These software programs emanate from projects financed by the Water Research Commission. Although these programs have been approved for distribution, approval does not signify that the contents necessarily reflect the views and policies of the WRC or the members of the project steering committee, nor does mention of trade names or commercial products constitute endorsement or recommendation for use. The WRC is not responsible for the use or application of the software programs or results thereof.

SA WATERKALENDER

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

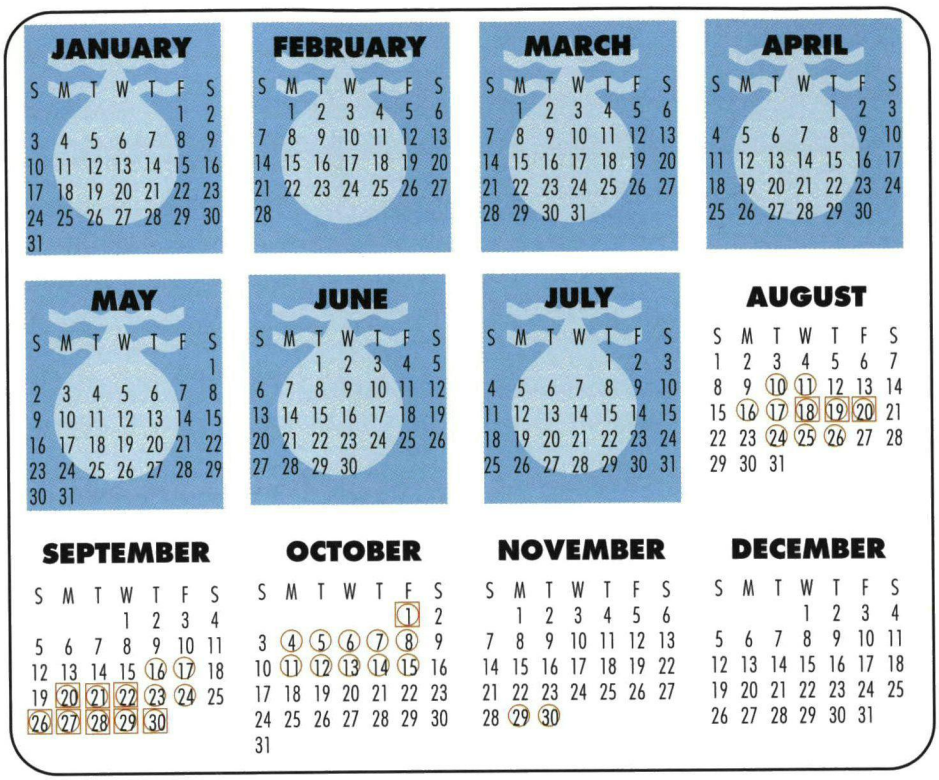
You are invited to send information about conferences, symposia or workshops to the SA Waterbulletin.

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.

1999



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

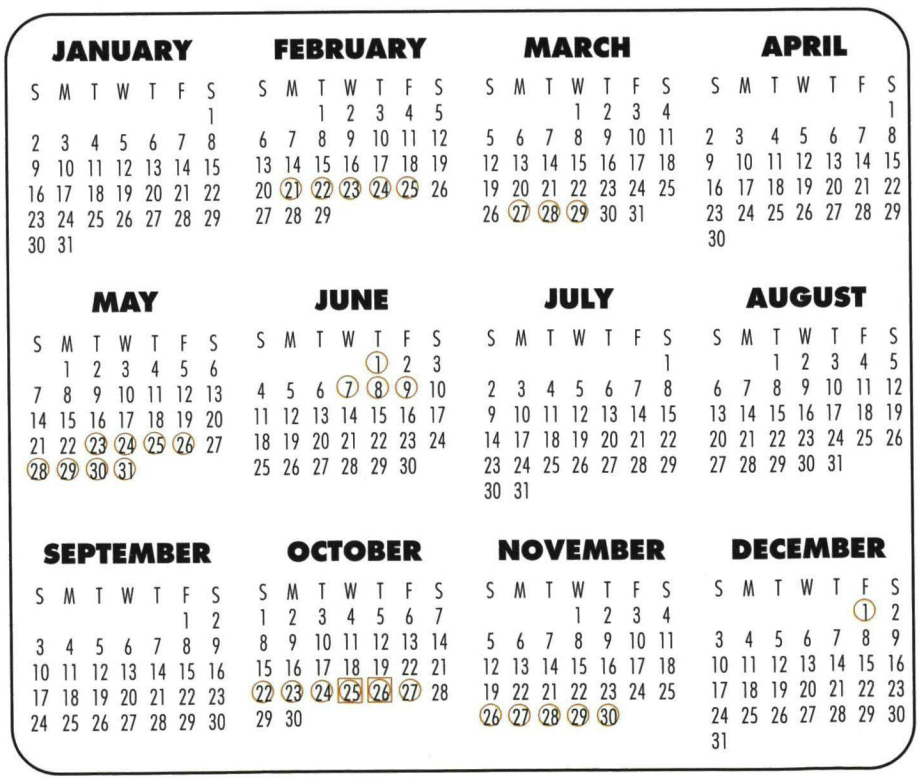
Alle belanghebbendes word uitgenooi om inligting aan SA Waterbulletin te stuur.

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.

2000



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SOUTHERN AFRICA

1999

WATER QUALITY
AUGUST 16 - 20
A short course on water quality management will be held at the University of Potchefstroom.
Enquiries: Mrs Dydré Greeff, Section for Training Co-ordination, PU for CHE. Tel: (018) 299-2714 or 299-2715. Fax: (018) 299-2726. E-mail: aokdg@puknet.puk.ac.za

AFRIWATER '99
AUGUST 18 - 20
The South African water, waste and environmental exhibition will be held at the Gallagher Estate in Midrand, Gauteng.
Enquiries: Avé Delport, TML Reed Exhibitions, PO Box 182, Pinegowrie 2123. Tel: (011) 886-3734. Fax: (011) 781-1270. E-mail: sue.philipson@tmltrade.co.za.

IRRIGATION
AUGUST 24 - 26
The SABI national congress with the theme - Irrigation in the next millennium - will be held in Bloemfontein.
Enquiries: Ms Riana Lombard. Tel: 021-854-8817.

WATER MICROBIOLOGY
AUGUST 24 - 27
An introductory course in water microbiology will be held at the Division of Water, Environment and Forestry Technology, CSIR, Pretoria.
Enquiries: Pauline Coubrough. Tel: (012) 841-3952. Fax: (012) 841-2506. E-mail: pcoubrou@csir.co.za

WASTE MANAGEMENT
SEPTEMBER 11 - 15
The 4th African international waste management and environmental technology exhibition - Environmental & Waste technology Africa '99 will be held in Johannesburg.
Enquiries: E-mail: specialised@specialised.com Tel: (011) 835-1565. Web: http://www.infodoor.co.za/exhibitions/specialised/

DROUGHT PLANNING
SEPTEMBER 16 - 17
A drought planning workshop will be held at the ARC Convention Centre in Pretoria (to coincide with the International Conference on Integrated Drought Management).
Enquiries: Adri Laas, Private Bag X79, Pretoria 0001. Fax: (012) 323-1157. E-mail: a-laas@igkw2.agric.za

DROUGHT MANAGEMENT
SEPTEMBER 20 - 22
An interdisciplinary international conference on integrated drought management - "Lessons for Sub-Saharan Africa" will be held at the CSIR Conference Centre in Pretoria.
Enquiries: Conference Planners, PO Box 82, Irene 0062. Tel: (012) 667-3681. Fax: (012) 667-3680. E-mail: confplan@iafrica.com

SLUDGE HANDLING
SEPTEMBER 20 - 24
A short course on biological and chemical sludge handling and disposal will be held at the Department of Chemical Engineering (Division Water Utilisation), University of Pretoria. Course fee: R3 500 (VAT exclusive). The fee includes course notes, refreshments and lunches, but excludes accommodation.
Enquiries: Ms E Otto Tel: (012) 420-3566. Fax: (012) 362-5089.

MEMBRANE TECHNOLOGY
SEPTEMBER 26 - 29
The 3rd WISA membrane technology division workshop with the theme - Membrane developments in waste minimisation, water treatment and the process industry - will be held at the Drakensville Resort.
Enquiries: Dr S Burton, Department of Biochemistry, Rhodes University, PO Box 94, Grahamstown 6140. Tel: (046) 603-8443. Fax: (046) 622-3984. E-mail: chsb@warthog.ru.ac.za

CORROSION
SEPTEMBER 26 - OCTOBER 1
The 14th international corrosion congress with the theme "Co-operation in Corrosion Control" will take place in Cape Town. A trade exhibition will also be held for the duration of the congress.
Enquiries: The Secretary, The Corrosion Institute of Southern Africa, PO Box 966, Kelvin 2054. Tel: (011)8025145. Fax: (011) 8043484. E-mail: norust@future-jhb.co.za

TOXICITY ASSESSMENT
SEPTEMBER 26 - OCTOBER 1
The 9th international symposium on toxicity assessment will be held in Pretoria.
Enquiries: Symposium Secretariat, MAK Travel, PO Box 53, Persequor, Pretoria 0020. E-mail: maktravel@icon.co.za Tel: (012) 342-0573. Fax: (012) 342-0568. Web: http://ista9.csir.co.za

WATER & WASTE
OCTOBER 11 - 15
The 11th International Training Network for Water and Waste Management (ITN Africa) conference will be held in Kadoma, Zimbabwe.
Enquiries: The Chairman, ITN Conference, PO Box MP 422, Mount Pleasant, Harare, Zimbabwe. Tel: 263-4-735017/26/35. Fax: 263-4-738120. E-mail: admin@iwsd.icon.co.zw

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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

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.

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. **Call for papers.**
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: deidre@iafrica.com.

OVERSEAS

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HYDROGEOLOGY
SEPTEMBER 6 - 10
The 29th annual congress of the IAH on hydrogeology and land use management will be held in Bratislava, Slovakia.
Enquiries: Marian Fendek, Geological Survey of Slovak Republic, Mlynska dolina 1, 81704 Bratislava, Slovakia. Tel: +421-7-3705355. Fax: +421 -7-371940. E-mail: iahcong@gssr.sk. Web address: http://petra.fns.uniba.sk/IAH99

DRILLING
SEPTEMBER 21 - 22
A conference on horizontal well drilling - the new dimension for water supply - will be held in Baltimore, Maryland, USA.
Enquiries: The American Ground Water Trust, 16 Centre Street, Concord, New Hampshire 03301 USA. Tel: 603-228-5444. Fax: 603-228-6557. E-mail: agwt@aol.com. Website: WWW.agwt.org

WASTE MANAGEMENT
OCTOBER 4 - 8
The seventh international waste management and landfill symposium - Sardinia 99 - will be held in S Margherita di Pula (Cagliari), Sardinia, Italy.
Enquiries: EuroWaste Srl, Via Altinate, 96-35121 Padova (Italy). Tel: +39 049 663860. Fax: +39 049 663960. E-mail: eurowaste@tin.it. Web page: http://www.pengo.it/sardinia99

SEWAGE SLUDGE
OCTOBER 13 - 15
A conference on the disposal and utilisation of sewage sludge - treatment methods and application modalities will be held in Athens, Greece.
Enquiries: Professor Andreas Andreadakis, Organising Committee, Water Resources Department, National Technical University of Athens, 5 Iroon Polytechniou St, 15773 Athens, Greece. E-mail: andre1@central.ntua.gr. Tel: +30 1 772 2897. Fax: +30 1 772 2899. Web address: http://www.iawq.org.uk

BIOFIILMS
OCTOBER17-20
The 4th IAWQ conference on biofilm reactors will take place in New York, USA.
Enquiries:Frank Rogalla, Rua Jerusalem 53/62, Sao Paulo, SP 04510-020, Brazil. E-mail:
Tel: +55 11 970 3715. Fax: +55 11 5503 9897. Web:
http://www.iawq.org.uk/conferen/biofilms.htm

WATER QUALITY
OCTOBER 31 - NOVEMBER 4
The AWWA 1999 water quality technology conference will be held in Tampa, Florida, USA.
Enquiries:Clare Haas, AWWA, USA. E-mail: chaas@awwaorg Tel: +303 347 6194. Web:
http://www.awwa.org/tande/awwaconf.htm

BIOMETEOROLOGY
NOVEMBER 8 - 12
The 15th international conference on biometeorology and urban climatology will be held in Sydney, Australia.
Enquiries:Tour Hosts (Pty) Ltd, GPO Box 128 Sydney NSW 2001, Australia. E-mail: icbicuc@tourhosts.com.au Fax: +61 2 9262 2277. Web:
http://www.es.mg.edu.au/ICB-99

WASTE MINIMISATION
NOVEMBER 14 - 18
An IAWQ international speciality conference on waste minimisation and end of pipe treatment in chemical and petrochemical industries will be held in Meridan, Yucatan, Mexico. Enquiries: Matilde Galvan, Instituto de Ingeniera, Universidad Nacional Autonoma de Mexico, Ciudad Universitaria, Apartado Postal 70-472, 04510 Mexico DF. E-mail: iawq@pumas.iiiigen.unam.mx Fax: +52 5 616 2164. Web:
http://www.iingen.unam.mx/ccco/iawq

WATER DISTRIBUTION
NOVEMBER 15 - 17
The 2nd international conference on the safety of water distribution - balancing chemical and microbial risks will be held in Miami Beach, Florida, USA.
Enquiries: International Life Sciences Institute, USA.
E-mail: meetings@ilsi.org
Web: http://www.ilsi.org/conference.html

BIOTECHNOLOGY
DECEMBER 6 - 17
An advanced course on microbial physiology and fermentation technology will be held at the Delft University of Technology, The Netherlands.
Enquiries:Dr LA van der Meer-Lerk, Institute for Biotechnology, Julianalaan 67, 2628 BC Delft, The Netherlands. Tel: (31-15) 278 19 22. Telefax: (31-15) 278 23 55.

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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@i-nozai-t.iiiet.co.th Tel: +662 579 0111. Fax: +662 562 0732. Web: http://www.ldd.mozart.inet.co.th

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 address: smiller@awwa.org Tel:+303-3476181. Web: http://www.awwa.org/tande/awwaconf.htm

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: 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. **Call for papers.**
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

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.chile2000.cl

WASTEWATER
APRIL 4 - 7
A CIWEM millennium conference - wastewater treatment: standards and technologies to meet the challenges of the 21th 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 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:
hittp://www.awra.org

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

14th International Corrosion Congress

26 September - 1 October 1999
Cape Town, South Africa

Web site: http://www.ee.up.ac.za/mmi/Open.html

The International Corrosion Congress (ICC) is the major event of the International Corrosion Council and is held every three years. Corrosion scientists and engineers from all over the world meet to disseminate information on corrosion control to minimise the costs of corrosion. Previous ICC Congresses have been held in London, Melbourne, Florence, Houston etc. The ICC is being organized by the Corrosion Institute of Southern Africa (CorrISA) in South Africa at the Cape Technikon, right in the heart of Cape Town. This is the first time that this important and prestigious international congress is being held in Africa, and it is an ideal opportunity for all Southern Africans involved with corrosion control to meet with world leaders in this field to discuss their problems. Some 350 papers have been received from 57 countries and about thirty areas of corrosion control will be covered in separate sessions over the five days of the Congress. The full technical programme is available on the Web Site. The breadth of subject matter ensures a stimulating and interesting experience for all those who attend no matter what their area of expertise. Delegates will receive a CD-ROM with the full proceedings of the Congress, and a book of abstracts. In addition lunch, and tea and coffee, in the morning and afternoon, will be provided.

A trade exhibition is being held in conjunction with the Congress and entry is free for interested members of the public.

Conference fees:

Full registration for five days (inclusive of VAT)

Members of CorrISA	R4 104.00
Other delegates	R4 503.00
Accompanying persons	R2 023.50

Daily registration-rate per day (inclusive of VAT)

Members of CorrISA	R1 083.00
Other delegates	R1 197.00

Registration & Enquiries:

The registration form is available on the Web site or contact Alison White for registration forms or any enquiries at:

Corrosion Institute of Southern Africa
PO Box 966
Kelvin 2054
South Africa
Tel: 011 8025145 • Fax: 011 8043484
E-mail: norust@futurejhb.co.za

Announcement of the next National Short Course on

THE ROLE AND USE OF BIOLOGICAL MONITORING IN AQUATIC RESOURCE ASSESSMENT

Currently coordinated by:
Institute for Water Research
Rhodes University
Grahamstown

RHODES UNIVERSITY

AIM OF THE COURSE

Aquatic biomonitoring, or response monitoring, is increasingly used as a monitoring and assessment tool in water resource management. This course will provide a basic understanding of the concepts, advantages, uses and limitations associated with different biomonitoring techniques, including field bio-assessment and toxicity bioassays. The course is designed to address the relevant concepts and the interplay between bio-monitoring and resource management, rather than the technical details of how to conduct monitoring. There will be a balance between theoretical lectures (presented by experts from various organisations), hands-on exposure in the laboratory and field, group discussions and problem solving. Presentations and course material will be in English.

WHO SHOULD ATTEND?

Mid-level managers, planners and other officials from government or private institutions who need and want to improve their knowledge and use of biomonitoring in general.

WHERE AND WHEN?

In Grahamstown, 18 - 22 October 1999.

COST

The course fee is R3 500 per person (excluding accommodation) and includes lecture material and use of field and laboratory equipment.

ENQUIRIES

Dr Patsy Scherman
IWR
Tel: (046) 622-2428 or 603-8532
Fax: (046) 622-4377
e-mail: patsy@iwr.ru.ac.za

or

Dr Nikite Muller
IWR
Tel: (046) 622-2428 or 603-8532
Fax: (046) 622-4377
e-mail: nikite@iwr.ru.ac.za

The national short course was initiated by:
The Institute for Water Quality Studies
(IWQS) of the Department of Water Affairs and Forestry
&
CSIR's Division of Water, Environment and Forestry (Environmentek)