

S4 waterbulletin

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RIVERS RESEARCH

The ecological status of the Sabie River determined

WATERGEHALTE

Nuwe "gereedskap" ontwikkel om die mikrobiologiese watergehalte van Suid-Afrikaanse riviere te bepaal

WASTE WATER

Researchers test membrane technology for the treatment of tannery effluents

00020052

UNIVERSITEIT



STELLENBOSCH

SMALL DAMS DESIGN COURSE

**THIRD RIVER FLOOD
HYDRAULICS CONFERENCE**

November 1997 Stellenbosch

November 1997 Stellenbosch

A course on the Design of Small Dams is to be offered at the University of Stellenbosch on 3 and 4 November 1997, under the auspices of SANCOLD. Topics to be covered include: Planning; Water Rights; Yield Analyses; Foundations; Embankment Dams; Concrete, Rollcrete and Masonry Dams; Spillways and Outlet Works; Construction; Maintenance and Operation; Dam Safety; Sedimentation.

The registration fee for the course is R900 (R2 500 for persons attending both the course and the conference).

A limited number of persons will be admitted to the course and the registration fee is required by 1 September 1997.

The 3rd International Conference on River Flood Hydraulics is being organised jointly by HR Wallingford and the University of Stellenbosch from 5 to 7 November 1997. Papers from different parts of the world will be presented on: Flood Hydrology; Flood Hydraulics; Flood Plain Management; Flood Control; River Morphology; Reservoir Sedimentation; Flow Measurement; Environmental Aspects.

The registration fee for the conference is R1 900 for persons from the Rand Monetary Area. (£390 for persons from outside this area, who must register with Ms J Watts, HR Wallingford, Howbery Park, Wallingford, Oxon, OX10 8BA England). The registration fee is required by 1 September 1997.

For further information and registration please fill in the following form and forward to:

Prof A Rooseboom, Department of Civil Engineering, University of Stellenbosch, Private Bag X1, MATIELAND, Stellenbosch, 7602
Telephone: +27 (21) 808-4353, Fax: +27 (21) 808-4361. E-mail: AR2@maties.sun.ac.za

Name:

Affiliation:

Address:

.....
.....

Telephone No: Fax No:

Please supply me with the following information:

Further information on the Dam Design Course.

Further information on the River Flood Hydraulics Conference.

Information on Accommodation. *

** (Accommodation arrangements should be made as early as possible as there is an upsurge in the number of tourists visiting Stellenbosch).*

Please indicate:

I will possibly probably definitely be attending the course.

I will possibly probably definitely be attending the conference.

My registration fee** is attached will be forwarded by 1 September 1997

** (Cheques to be made out to the University of Stellenbosch).



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p 24



p 19

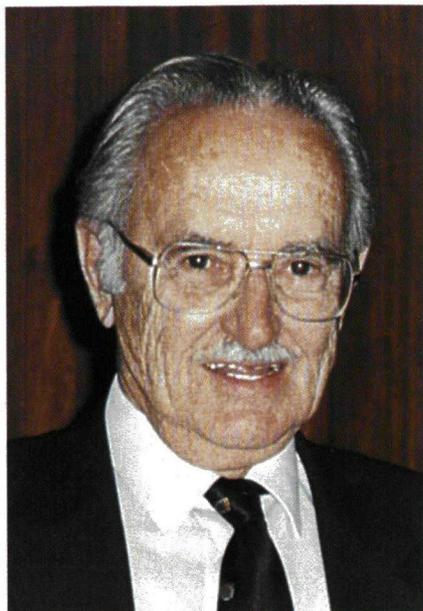
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Cover: Early morning mist over Moreletta spruit. (Photo: Helene Joubert)

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Obituary



Prof Des Midgley

Prof Des Midgley, a former member of the Water Research Commission, died on 13 April after a brief illness.

Born in Durban in June 1914 Prof Midgley completed his schooling at Hilton College and graduated with a BSc degree in civil engineering from the University of Natal in 1934.

In 1952 he was awarded a doctorate for his thesis on the surface water resources of South Africa. Several years later he was awarded an honorary DSc (Eng) by the University of the Witwatersrand and in 1993 he received the Order of Meritorious Service Class 1: Gold.

Prof Midgley was instrumental in the founding of the Wits/CSIR Hydrological Research Unit, which he directed from its inception until his retirement in 1981.

Prof Midgley's expertise in applying basic hydrological principles to issues in a water-scarce environment such as southern Africa earned him an international reputation.

In 1996, aged 82, he was awarded the International Hydrology prize by the International Association of Hydrological Sciences (IAHS).

Prof At Pretorius wins international award

Prof At Pretorius, Professor of Chemical Engineering at the University of Pretoria, and incumbent of the Rand Water Chair in Water Utilisation Engineering, was recently voted Distinguished Lecturer for 1997 by the Association of Environmental Engineers of America (including the USA, Canada and Mexico).

This prestige award is conferred annually by the Association of Environmental Engineers to an environmental engineer who has distinguished himself exceptionally and internationally in his specific field of expertise. It is awarded to a person outside the USA every alternate year.

The award to Prof Pretorius included visiting a number of universities in the USA as a guest lecturer to present papers on his field of specialisation, viz. water utilisation. His main focus areas are the purification of water and the conversion of effluent waste into useful products, such as protein recovery for animal feed. Research done by Prof Pretorius in this field is unique in South Africa.

Prof Pretorius holds a degree in Chemistry and has been specialising in water and biotechnology since 1958.



Prof At Pretorius

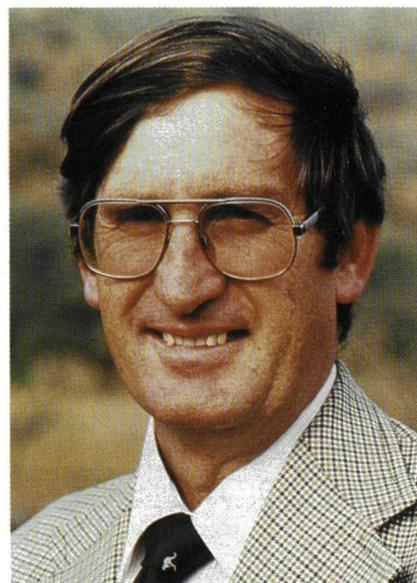
He obtained an M.Sc Engineering degree from the University of California and also holds a Doctorate in Agriculture.

"I am elated that work done in South Africa is now receiving recognition. South Africa has been a leader, for decades, in the field of water utilisation and purification," says Prof Pretorius.

Prof BREEN receives honours

Professor Charles Breen has been awarded a University Fellowship by the University of Natal at the April Graduation Ceremony. This fellowship was awarded to him in recognition of his distinguished academic career.

Presently he is Director of the Institute of Natural Resources at the University of Natal as well as Managing Director of the Kruger National Park Rivers Research Programme which is funded by the Water Research Commission.

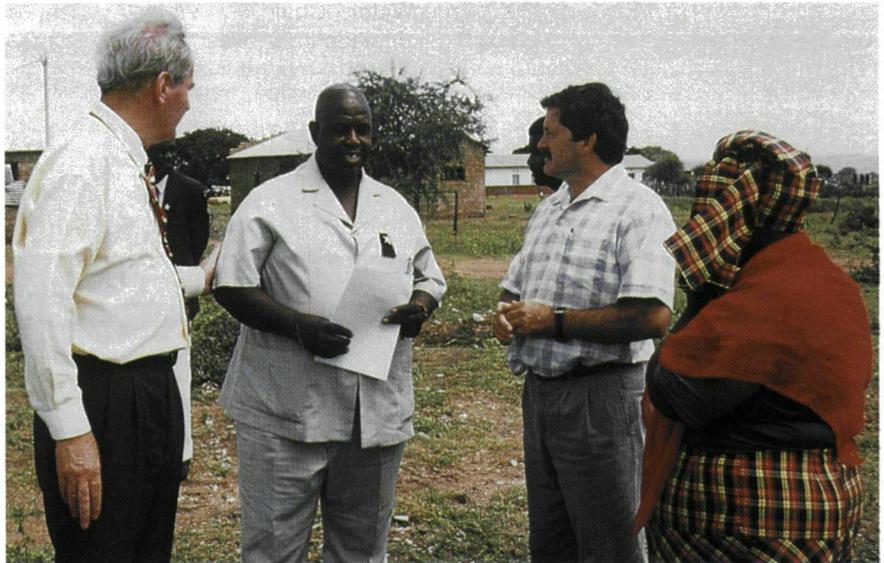


Professor Charles Breen

Rural community receives “Water of Life”

A function hosted on 21 April by the chairman of the UK company Guinness PLC of London, Tony Greener, marked the official conclusion of the Guinness/Mvula Trust Water of Life project - a water supply project which was jointly sponsored by Guinness and Mvula Trust to benefit the remote village of Rietfontein in the Northern Province. Rietfontein is a small rural community of some 2 300 people in the former Lebowa, approximately 250 kilometres from the province's capital Pietersburg. The Water for Life project was initiated during 1995 and was successfully completed late in 1996. It essentially resulted in the total upgrading of the community's water supply by bringing clean, running water to the entire village.

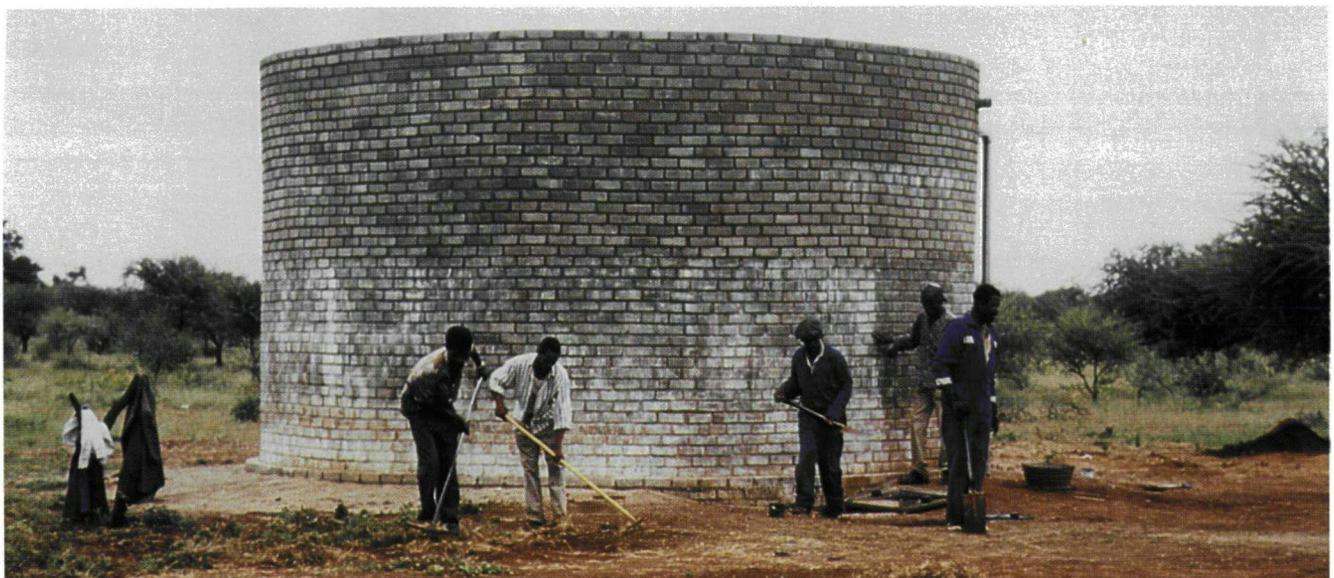
Water of Life (derived from the Gaelic phrase for whisky - uisce beatha) is one of the Guinness Group's main international environmental and humanitarian initiatives, supporting water-related projects created in partnership with community organisations. To date, Water of Life covers over 40 projects across six continents and has brought safe water supplies to over 75 000 people in the developing world. The function was



Pictured at Rietfontein are from left: Jim Doyle (MD Guinness SA) Walter Phalane (Northern Province Dept of Water Affairs), Daan Truter (WSM Consulting Engineers) and Tshepo Khumbane (Mvula Trust).

attended by senior Guinness executives, the Executive Director of Mvula Trust, Piers Cross, the ANC member of Parliament for Pietersburg, Mrs Rejoice Mabudafhasi, the Ambassador of the European Union in South Africa, Mr

Erwan Fouéré, the head of the United Nations Development Programme in South Africa, Mr David Whaley, as well as by representatives from the British and Australian high commissions and the Irish embassy.



The new reservoir at Rietfontein village, Northern Province.

WATER RESEARCH PROJECTS

- TENDERS INVITED -

The Water Research Commission (WRC) wish to invite tenders for the two research projects outlined below, commencing on 1 January 1998.

Research submissions, which effectively address the objectives of the projects as listed, are required. For this reason neither the term nor budget range for these projects are prescribed.



organisation; methodology; duration; annual work programme; opportunities for capacity building; contributions in addition to WRC funding; and annual budgets including capital equipment.

Proposals should reach the WRC by 15 July 1997 and should be made in hard copy accompanied by a Word Perfect version on disc, and be addressed to the Executive Director (attention Mrs Reinette

Proposals should be made, using the following headings: Title; project staff; responsible research

Kruger), Water Research Commission, P O Box 824, Pretoria 0001. (Tel: (012) 330-0340).

The value of water as an economic resource in selected catchment areas of South Africa

Objectives:

1. Determine the water balance and prevailing competition for water resources in one of the following catchments or sub-catchments: Orange River; Vaal River; Great Letaba River; Umgeni River and Berg River.
2. Derive a demand schedule for water for important water use sectors, i.e. domestic, irrigation, forestry, mining, industrial, power-generation and eco-system uses through appropriate system analysis modelling.
3. Quantify the value of water resources at current levels of water

- use, with due consideration of the following factors:
- prevailing and proposed water policies, water rights law and legislation;
 - intensity of water use and relative importance of water inputs in the production cycle;
 - level of household income, community participation and willingness to pay;
 - economic linkages and multiplier effects in each water use sector;
 - value of water to users, adjustment for societal objectives, net benefit from indirect uses and from return flows;
 - degree of technological develop-

ment, reliability of supply and water quality concerns.

4. Compare the economic value with full economic costs (i.e. supply, opportunity and external costs, if applicable) as well as current water tariffs, and assess the incidence and nature of temporary or permanent transfers of water rights already occurring.
5. Explore a variety of scenarios and estimate the changes in the value and price of water resources through appropriate modelling, when negotiated and lawful transfers of rights to available water resources take place within or between existing uses.

Applicability of shallow sewerage systems/simplified sewerage systems for dense urban communities in South Africa - an economic and technical study

Objectives:

1. Literature study on shallow sewerage systems, their international application and development.
2. Evaluate case studies on implemen-

- tation of this technology and create links with countries and institutes successfully implementing this technology.
3. Based on the above, determine its appropriateness for use in South African conditions, technical and

social.

4. Put a cost to this system if it is used in RSA, and compare this with the advantages and disadvantages of other forms of sanitation and sewerage systems.

Handbooks for Community leaders available

The Water Research Commission has recently published a Water and Sanitation Handbook for community leaders in urban and peri-urban areas. This book is available in Sotho, Zulu and Xhosa.

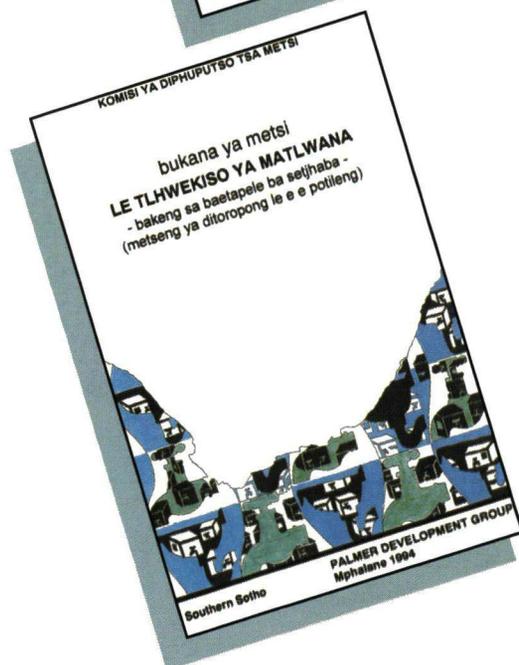
It is a most informative publication compiled by the Palmer Development Group. Illustrations throughout will help the reader comprehend the various aspects of water and sanitation provision.

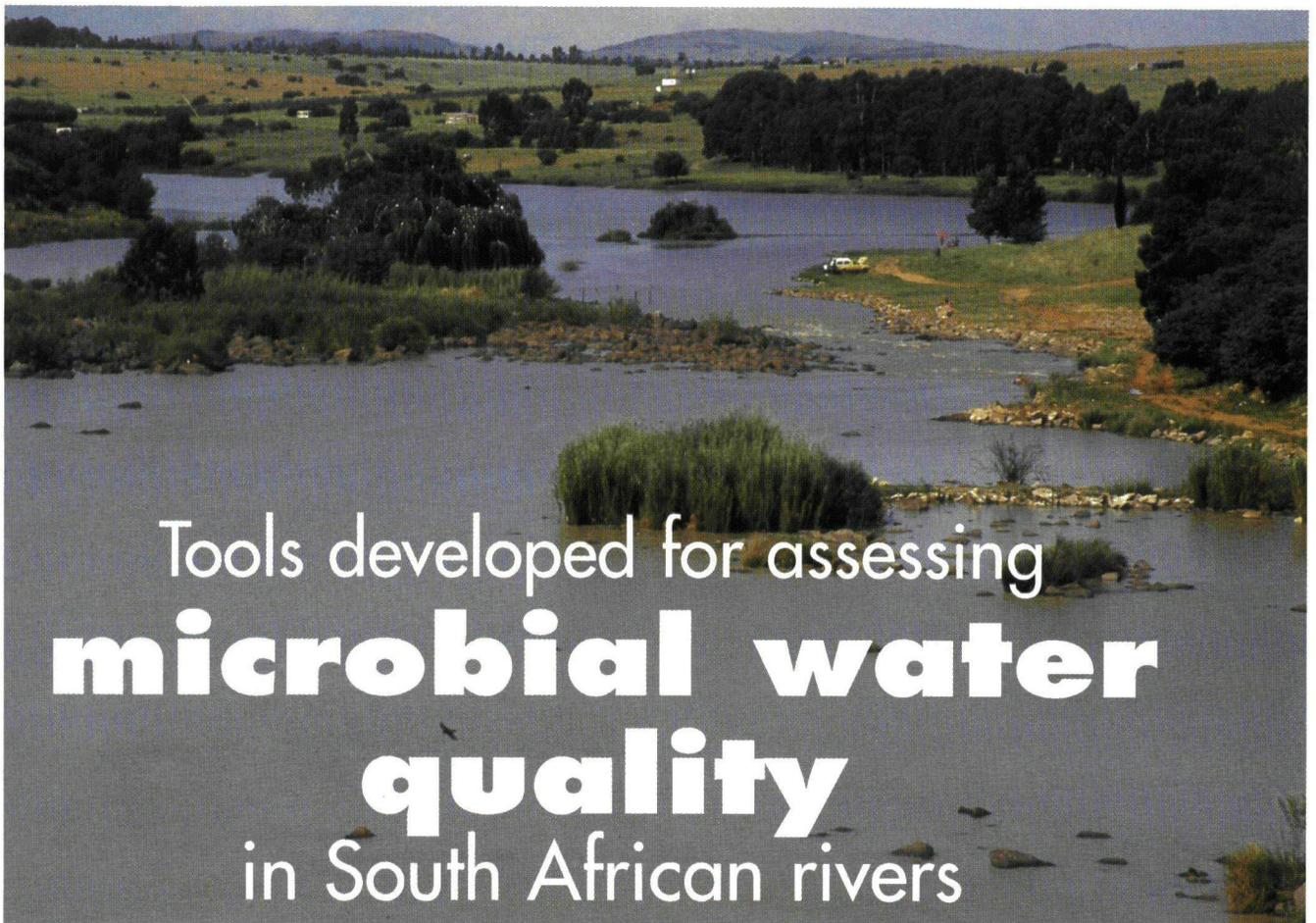
The contents deals with:

- how water gets into a tap
- how sewage is removed and where it goes
- how different water supply systems work
- how different sanitation systems work
- how much water people use
- the cost of water and sanitation systems
- who pays for these services
- what you need to know when negotiating for water and sanitation services.

Please note that the contents of this book was compiled for use within an urban context, it is therefore not necessarily applicable in a rural context.

The **Water and Sanitation Handbook for community leaders (urban and peri-urban areas)** can be ordered free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. Please indicate choice of language (Sotho, Zulu or Xhosa) clearly. Foreign orders: US \$10 per copy.





Tools developed for assessing microbial water quality in South African rivers

The results of an investigation aimed at developing guidelines and tools for the management of microbial water quality of South African rivers have been released by the Water Research Commission in the form of a final report.

According to the report the microbial water quality of rivers in South Africa has been under increasing threat of pollution in recent years, due to the rapid demographic changes occurring in the country. In many areas a lack of sanitation, for example, results in high levels of microbial water pollution. The report says microbial water quality can, however, only be managed effectively when information is available on the level of microbial pollution in the river and the contribution of point and non-point sources. "A need therefore existed to develop tools and guidelines for the investigation of microbial water quality of the country's rivers."

The investigation was carried out by researchers from the Division of Water, Environment and Forestry Technology at the CSIR in collaboration with Rand Water. The researchers, SN Venter, MC Steynberg, G du Plessis, CME de Wet, D Hohls, N Rodda and R Kfir, say that apart from the overall aim of developing tools for microbial water quality assessment, three secondary aims supported the main objective. These were:

- ❑ To evaluate the capabilities of existing microbial water quality models relative to South African conditions;
- ❑ To apply selected models to a suitable catchment, and
- ❑ To develop recommendations to assist in setting microbial guidelines, and tools to assist in the evaluation of the applicability of such guidelines.

The project was later extended and additional project tasks were proposed to address the information gaps resulting from atypical climatic conditions during

the first two years of the project. The three aspects to be addressed were:

- ❑ Additional monitoring of high flow conditions;
- ❑ The estimation of site-specific microbial decay constants; and
- ❑ The investigation of microbial decay over distance in the absence of multiple inputs.

METHODOLOGY

The project was divided into three stages. The objective of the first stage was the acquisition of relevant information, technology and expertise regarding microbial water quality monitoring. This was approached by conducting literature reviews and by evaluating the available modelling tools. Literature regarding microbial water quality guidelines and microbial water quality modelling was also reviewed.

The purpose of the second project stage

was to obtain data that could be used for the application of the selected model in a catchment. The Rietspruit catchment was identified as a suitable study site because the conditions in this catchment are not unique and are likely to reflect the situation experienced in many other catchments. Most catchments situated in, or close to, urban areas would have similar inputs, for example, effluents from wastewater treatment works and industrial plants as well as non-point source pollution, which can originate from informal settlements. Data on the microbial quality of the surface water in this type of catchments are usually very limited, as was the case for the Rietspruit catchment before the start of this project.

The third project stage involved the application of the QUAL2E model to simulate instream water quality in a stretch of the Rietspruit. The success with which a microbial variable such as faecal coliform count may be simulated in a river depends largely on the quality of input data available. Therefore, the success with which the river system can be characterised in terms of these input data e.g. flows and water quality of the headwaters, sources and abstractions, largely determine the success of the microbial water quality modelling. During this stage other tools, such as the *in situ* determination of decay rates by means of membrane diffusion chambers, were also investigated.

RESULTS

From the literature review of water quality guidelines it was suggested that the guideline values to be targeted in a catchment should be the most stringent values given for the most sensitive water use. The study therefore concentrated on tools that could be used to assess the present microbial water quality in a catchment as well as evaluating the various management options that could be implemented to achieve the targeted microbial water quality guideline values. The achievement of the targeted guideline values should, however always be balanced against the possible adverse effects on the environment in achieving these values.

The literature review on microbial water quality monitoring indicated that there are several water quality models available that include a microbial component. Despite the advantages of stochastic

models, the data requirements of these models were too extensive to make their use feasible in the study and therefore, various deterministic models eg. QUAL2E, CE-QUAL-RIV1 were further investigated. The review concluded that the river water quality model QUAL2E should be selected for the modelling studies. The main reasons for this choice was the relative simplicity of the model, the modest data requirements when compared to similar models, and the ready availability of both the model and personnel trained in its use.



Tools for Microbial Water Quality Assessment of South African Rivers

SN Venter ● MC Steynberg ● G Du Plessis
CME De Wet ● D Holhls ● N Rodda ● R Kfir

Report to the Water Research Commission
by the
Division of Water, Environment and Forestry
Technology, CSIR
and Rand Water

WRC Report No 380/1/96



The purpose of the second project stage was to obtain data that could be used for the application of the selected model in a catchment. A situation analysis, placing particular emphasis on microbial water quality, was performed for the Rietspruit catchment. The catchment was characterised in terms of its land uses, water uses and point as well as non-point pollution sources. The historical monitoring data, which addressed predominantly chemical water quality, were also documented. Thereafter, a monitoring network and sampling programme were designed to be able to assess the microbial water quality and its relationship to physico-chemical water quality in this catchment. Particular attention was given to the data requirements of the water quality model.

Data were collected over a period of three years (1991 - 1993). This period was dominated by low flow conditions due to low rainfall from April 1991 to

September 1993. In order to compensate for the lack of data during high flow conditions, intensive sampling was undertaken during high flow conditions from October to December 1993 as part of the extended project. It was found that the water quality recorded during this period did not differ significantly from the data collected during the previous summer rainfall periods.

Analysis of the microbial water quality in the catchment showed that, based on the South African Water Quality Guidelines the water in the Rietspruit cannot be used directly for domestic purposes. It is also not ideally suited for full-contact recreation, since the levels of bacteria, viruses and parasites measured at some of the points exceeded the target guideline range.

The major contributor to the high levels of faecal coliforms in the river was the Kleinriet River. This tributary of the Rietspruit drains both a formal settlement and an adjacent informal settlement area. The poor water quality in the river is a result of non-point source pollution caused by blocked sewers or a lack of formal sanitation facilities. The Kleinriet River was also a major contributor towards the high levels of coliphages, enteric viruses as well as heterotrophic plate counts measured for the Rietspruit. It also contributed towards the presence of parasites in the river.

The average level of faecal coliform bacteria in effluents from three of the four works that discharge into the Rietspruit was often higher than the relaxed general effluent standard of 1 000 *E. coli*/100 ml. The Ennerdale wastewater treatment plant was the only plant which met this relaxed standard most of the time. The industrial point sources that enter the river via the Leeuwspruit and Iscor canal, contained lower levels of faecal coliforms and had some dilution effect on the faecal coliform levels in the river.

A first order decay model is typically used as a first estimate of the decay pattern of coliform counts. Attempts to calibrate the model by selecting a decay rate constant for which the model output would most closely resemble the measured data did not succeed. Therefore, as part of the project extension, the decay rates for *E. coli* were determined *in situ* at two locations in the river by means of membrane diffusion chambers. The measured rates at two loca-



tions were very similar and were within the range of typical values for similar conditions reported in literature.

The modelling studies showed that in the case of highly microbiologically contaminated water (faecal coliform counts of $> 1\,000$ counts/100 ml) the decay pattern of faecal coliforms could be successfully simulated using the decay rate constants determined by means of the *in situ* chamber studies and the first order decay model. In most problematic catchments, where microbial pollution is of major concern, e.g. as a result of highly contaminated run-off from urban settlements with poor or no sanitation, the model would give a good indication of the travel time (and distance) required before counts in the river would decrease to levels of 1 000/100 ml and would be useful as a management tool. At lower counts the variability in the microbial data and the deviation from the first order decay pattern were observed to be higher, relative to the predicted counts. Care should therefore be taken in the use and interpretation of first order models applied under conditions where the faecal coliform count is less than 100/100 ml.

CONCLUSIONS

Microbial water quality modelling can be useful as a management tool in the case of highly microbiologically contaminated

catchments. In these problematic catchments the QUAL2E model would be able to give a good indication of retention time required for microbial counts in the river to reach the suggested guideline values. The model is however, greatly dependent on input data and the modelled catchment should be well characterised, in particular, reliable hydrological data should be available. The cost (in terms of time and resources) associated with data collection must be weighed in terms of its usefulness for management purposes.

It is often assumed that discharges containing high loads of faecal bacteria do not pose a health threat simply because faecal bacteria die off within a short period of time. The validity of this assumption can easily be tested for a specific case by making a rough estimation of the microbial water quality at various points downstream of the point of discharge. Such an estimate can be obtained by using a simple mass balance approach based on available flow data and the bacterial decay rate constant. The bacterial decay rate constant can either be determined *in situ*, by using membrane diffusion chamber studies, or estimated from values reported in literature.

Both the microbial water quality data, the modelling and other tools used showed that bacterial die-off will only have a lim-

ited effect in improving the microbial quality of the water in the Rietspruit catchment. Because of the high level of faecal coliforms, the reduction in their numbers by die off did not significantly improve the water quality within the short river retention time (in the order of three days) in the catchment. From this it was concluded that die off will only reduce the faecal coliforms to acceptable levels in a river if either the initial number of bacteria is low, or if the hydraulic retention time within that river is much longer than in a river such as the Rietspruit. It was also concluded that an improvement of the microbial water quality by means of dilution will only be successful if the inputs into the river are of sufficient volume and microbial quality to be effective.

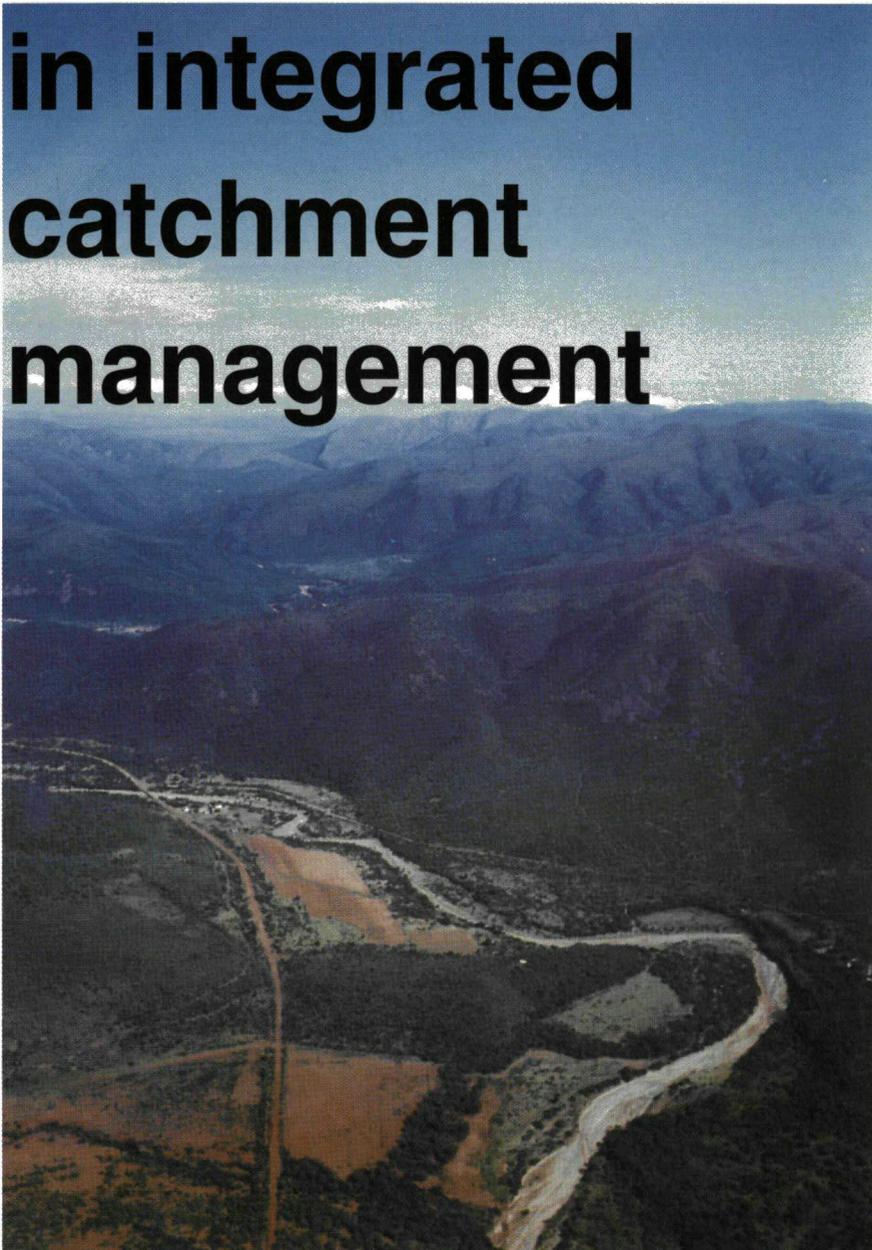
A broad management programme, with predetermined guidelines and/or objectives for the microbial quality of point pollutant sources should be developed and implemented in the Rietspruit catchment to ensure that the water will be fit for its intended uses on a sustained basis.

Copies of the report entitled **Tools for microbial water quality assessment of South African rivers** (WRC report 380/1/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 40, via surface mail).

Discussion document highlights key issues



in integrated catchment management



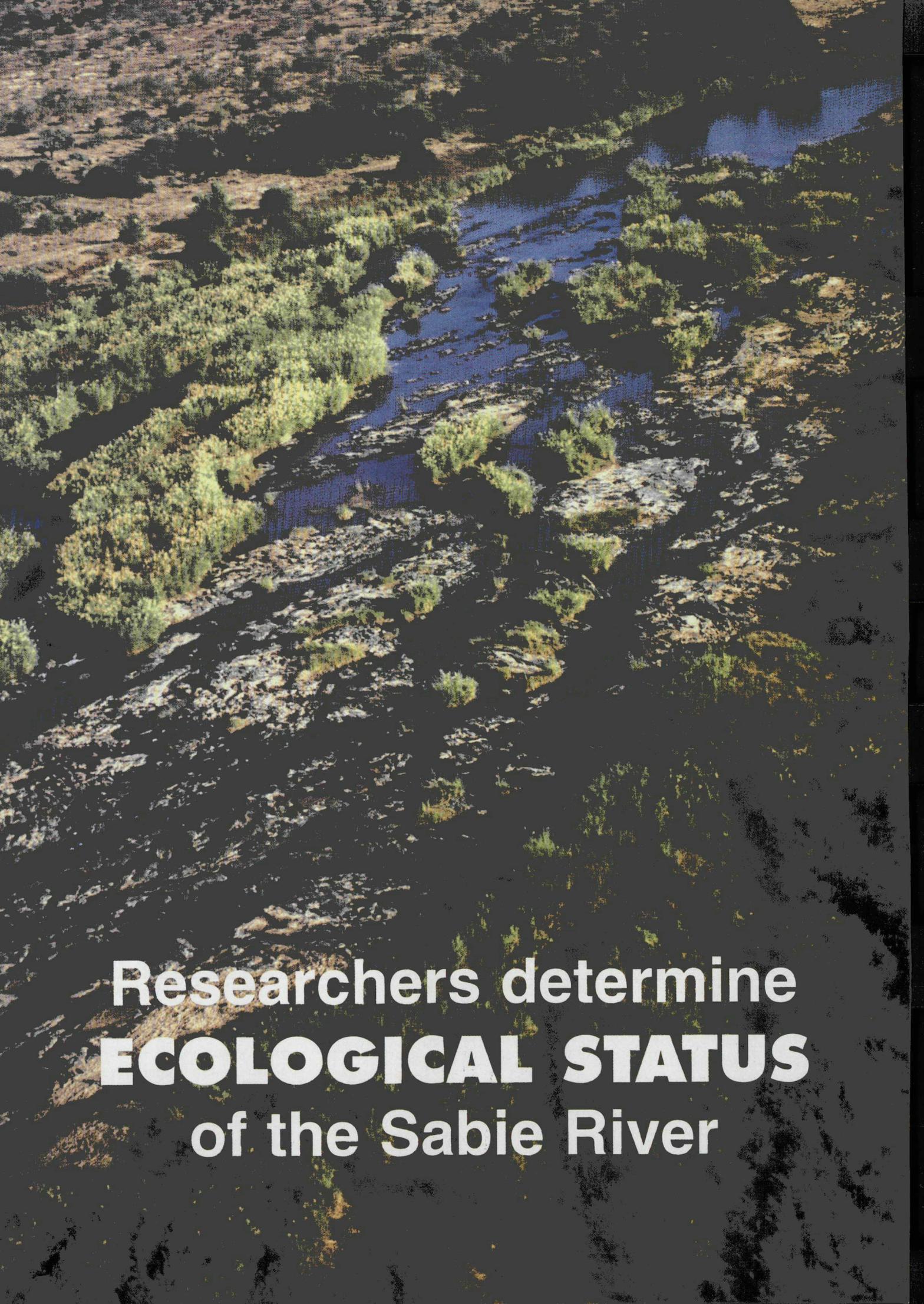
A discussion document on integrated catchment management (and its implications for water resource management in South Africa) is available from the Water Research Commission.

The document, which forms part of the present water law review process, has been designed primarily to meet the information needs of water resource managers within the Department of Water Affairs and Forestry and provides a systematic review of the philosophy and practice of integrated catchment management, followed by a series of suggestions and recommendations for implementation in South Africa.

The existing situation in South Africa is discussed and possible reasons for the successes or failures that have been achieved to date are highlighted. Much of the information contained in the document is based on an evaluation of the appropriateness and possible applicability of overseas experience (Australia, United Kingdom, United States of America, Europe and Africa) to the South African situation.

The core concepts contained within the integrated catchment management approach are examined, together with the processes and institutional arrangements required for success. The publication evaluates and comments on the ways in which a flexible integrated catchment management process links together all of the different stakeholders, helps to identify critical issues and then directs appropriate attention to these issues. The interplay between environmental, social and economic issues is emphasized, together with the institutional, practical, legal and information requirements that are necessary for success.

Copies of the discussion document entitled **The philosophy and practice of integrated catchment management** (WRC report TT 81/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price, including surface mail costs: US\$ 30).

An aerial photograph of the Sabie River, showing a winding waterway through a rugged, rocky terrain. The river is surrounded by dense green vegetation, and the surrounding land is a mix of dark rocks and lighter, scrubby plants. The lighting is bright, creating strong shadows and highlights on the landscape.

Researchers determine
ECOLOGICAL STATUS
of the Sabie River

The Sabie River is presently the least impacted of the six rivers flowing through the Kruger National Park, say researchers in a report to the Water Research Commission. After a catchment study in 1990 identified eight possible new dam sites on the Sabie and its major tributary the Sand River, a research project was initiated with the objective to characterise the present instream chemical, physical and biological conditions in the Sabie-Sand River system, and to predict the consequences of impoundment and increased water abstraction on the riverine biota. The first volume of the research report entitled **A pre-impoundment study of the Sabie-Sand river system, Mpumalanga, with Special reference to predicted impacts on the Kruger National Park (Vol 1: The ecological status of the Sabie-Sand river system)** by researchers DC Weeks, JH O'Keeffe, A Fourie and BR Davies, has recently been published by the Water Research Commission.

This first volume of three of the project report, describes the physico/chemical status of the river and the status of fish and invertebrate communities in the river. The conditions are compared with those in the Letaba River, and the hydraulic habitat preferences of the main fish species and invertebrate groups are described. The second volume documents the effects of the 1991-92 drought, and the third volume assesses the probable effects of planned impoundments on the downstream biota, and includes recommendations for the environmental management of the dams, as well as for the continued monitoring of the Sabie-Sand River system. The project forms part of the multi-disciplinary Kruger National Park River Research Programme.

The specific aims of this project were:

- To characterise the present chemical, physical and biological conditions in the Sabie-Sand River system before any planned impoundments are built.
- To assess the probable extent of ecological disturbances and advantages resulting from future regulation (particularly within the Kruger Park), and to recommend management guidelines to minimise impacts and contribute to water management.
- To collect basic biological and hydro-geomorphological data to calculate instream flow requirements for the river system.
- To assess the probable effects of river regulation in the Mpumalanga Lowveld against the effects already recorded for regulated systems of the western Cape (Palmiet River), and eastern Cape (Buffalo River).
- To develop a long-term surveillance system which will provide information on change (eg invertebrate composition, riparian vegetation, channel morphology, etc.) within the Sabie-Sand River system, in order to distinguish between natural cyclical change and those changes resulting from river regulation and other disturbances.
- To develop a collaborative methodology which will allow comparisons to be made between data-sets on different Kruger National Park river systems.

During the course of the project, the region was subjected to the worst drought on record. As a result the scope and duration of the project was extended.

Additional aims added later were:

- To characterise conditions during the 1991-92 drought, and assess its effects on the water quality and fauna of the river.
- To monitor the effects of the collapse (February 1993) of the Zoeknog Dam on the Mutlumuvi River.

METHODS

The methods for this study were based on a three tiered approach, in which physico-chemistry, fish and macro-invertebrates were sampled annually at 21 sites. Quarterly samples were taken at 9 of the 21 sites to assess seasonal changes and collect hydraulic habitat information. At three of the 9 sites, Hydraulic transects were surveyed at three of the nine sites to map available habitats for inclusion in IFIM. During the drought period three of the 9 quarterly sites were designated for monitoring at monthly intervals.

Water samples for chemical analysis of nutrients were collected, and river dis-

charges were measured at each site. Macro-invertebrates were sampled in a variety of habitats.

Fish were sampled using three complementary techniques: electro-fishing; valved minnow traps; and gill-nets. Fish were identified to species in the field or a sample was collected for identification.

Microhabitat use and preference data for fish and invertebrates were defined by the hydraulic parameters of flow, depth, substrate and cover.

SABIE-SAND HYDROLOGY

Presently the Sabie River is the only perennial unregulated river traversing the Kruger National Park.

Flow in the Sabie and Sand rivers varies seasonally with summer peaks (February) and low flows at the end of the dry season (October).

Runoff during the 1991 hydrological year closely followed the seasonal pattern and magnitude expected for the Sabie River, while runoff during the 1992 hydrological year was reduced to drought conditions. Base-flows in September 1992 were at their lowest in recorded history, with the lower Sabie reduced to 0.33 m³/s. The lower Sand River stopped flowing at the height of the drought.

PHYSICO-CHEMICAL STATUS

Water quality in the Sabie/Sand River is generally considered to be good, with the exception of elevated turbidity in the Sand River. Tables in the report list the water quality data analysed from 11 sampling sites.

Except for some turbidity and high nutrient concentrations encountered, the results of this project generally confirm that the water quality in the Sabie-Sand river is adequate for all users.

Although The Sabie has been subjected to major water quality problems in the past, the fauna has recovered due to the presence of unimpacted tributaries. The deterioration of flows and water quality in these tributaries would seriously impair the resilience of the river system to cope with further stress.

INVERTEBRATES

Chapter six of the report

- describes the invertebrate communities found in the Sabie, Sand, and other major tributaries;
- assesses changes in the invertebrate fauna from 1990 to 1993, particularly in the drought conditions of 1992;
- describes the differences between the fauna of different habitats and
- define the microhabitat preferences of major groups of invertebrates in terms of substrate, water depth and current speed.

The researchers concentrated on the invertebrate fauna of the riffle communities, as those most likely to indicate differences between river zones, seasons or years. A cluster analysis indicated five major groups of samples that were closely related to the changing flow conditions rather than to seasonal changes or different river zones.

The 1991/1992 drought had a very severe impact on invertebrate abundance as well as diversity. Pre-drought samples were far more diverse in the number of taxa (averaging 29.4) per sample compared to the drought samples. The "recovery" samples following the drought were also depauperate, (averaging 14.3 taxa per sample).

Habitat

An analysis of the most abundant groups in each habitat is presented in the report. The marginal vegetation contained the most taxa (189), while the sediments hosted the least (120 taxa).

The marginal vegetation is the first habitat to be lost when flows are reduced, the researchers therefore consider it to be the critical habitat for conservation. Communities of the sediments were the least diverse, but sediments are the most common habitat, and form the final refuge habitat in pools when flow ceases.

Trichoptera were the most habitat-specific group in both riffles and marginal vegetation and the researchers recommend that this group should be targeted for further microhabitat preference research.

According to the report it appears that

30 cm of medium to fast flowing water (between 0.63 to 1 m/s) through the riffles, would provide conditions conducive to maintaining the maximum diversity and abundance of invertebrates in the river system.

FISH FAUNA

Chapter seven describes the fish fauna in the Sabie-Sand as recorded during the period 1990-93 and aims:

- to assess the diversity of fishes in the system,
- to describe species distribution and abundance;
- to identify representative target species; and
- to describe the habitat requirements of these species.

Forty-nine species of fish were recorded, or are known to have populations within the Sabie-Sand catchment, of which four are alien species. The Sabie-Sand is the most species rich river system in the country, comparable only to the Phongolo River.

Fishes of very small adult size (< 10 cm) make up a high proportion of the Sabie-Sand diversity. Cyprinids are the most abundant taxonomic group (48.9 per cent) including 12 minnows and 8 large cyprinids, 5 of which are mudfishes. Catfish account for 20 per cent of the total diversity, including 7 specialised small species with both *Amphilius* and *Chiloglanis* spp. Cichlids make up 11.1 per cent (5 spp) of the species diversity. *Oreochromis mossambicus* in particular is reported to dominate assemblages in many studies during times of drought.

Distribution patterns

Three patterns in the distribution and abundance within the Sabie-Sand Rivers can be discerned:

- Two broad ichthyological river zones are identifiable, where one group of species replaces another within a narrow temperature range in the Sabie and Sand Rivers. Gradient analysis, classification and ordination techniques all clearly demonstrate these zones.
- Within each zone, additional species appear downstream, due to increased habitat diversity and depth as the river gets bigger.
- Within zones, each tributary sampled in the Sabie-Sand System has a charac-

teristic fish fauna, with variations from a baseline species assemblage. This reflects local habitat availability and stream profile.

Temperature is the best correlate for pattern 1. Temperature, flow regimes and microhabitat requirements need to be considered when explaining a species distribution.

Gradient analysis identified two major fish assemblages: those of the foothill zone (FHZ), and of the lowveld zone (LZ). *Chiloglanis anoterus* and *Barbus viviparus* were identified as the indicator species of the FHZ and LZ zones respectively.

The Marite River is a major tributary of the Sabie River and important as a cold water refuge for FHZ species.

The Sand River has a very small FHZ with a very sudden FHZ to LZ transition. Diversity in the Sand River LZ was high (above 20 spp per site), and most species were small with larger riffle/run species appearing when deeper habitats became available.

Assemblages

Baseline or typical fish assemblages were defined for the Sabie-Sand Rivers using only samples taken prior to the 1991-92 drought.

Within the FHZ six ecologically important species accounted for 92.3 per cent of the average catch. *C. anoterus* dominated the FHZ baseline catch (70 per cent) with the cyprinids and the minnow *B. eutaenia* accounting for a further 27 per cent.

Eleven ecologically important species made up 82.6 per cent of the average baseline assemblage of the LZ, including a suite of cyprinids (7 species comprising 56 per cent), five of which are minnows. Three pool and backwater cichlids species, made up 26 per cent of the average annual catch.

Seasonal changes within the FHZ baseline assemblage were not marked. The cyprinids increased in percentage proportion of the catch by the end of the wet season, probably as a result of summer breeding and the presence of many young fish.

Seasonal changes within the LZ were very marked. At the start of the dry season (May) 75 per cent of the core species catch was typically cyprinid species. However, by the end of the dry season cichlids increased to over 50 per cent of the fish sampled. Changes in species abundance and composition were not confined to zones and season, but included the effects of disturbance, both natural (the drought) and anthropogenic (the failure of Zoeknag Dam).

Drought was one of the major determinants of species pattern, particularly within the LZ. The LZ fish assemblage, at the end of the dry season in November and that characteristic of the drought years are strikingly similar, suggesting a similar and predictable response of the biota to low flow conditions. Cichlids were more abundant than cyprinids throughout the drought.

Fish assemblages during the recovery phase after the drought were quite different from both pre-drought and drought LZ assemblages.

Flow

Flow was the strongest factor determining habitat. Flow preference was used to divide the baseline shallow-water fish assemblage into habitat groups which included:

- Fishes of Backwaters and Pools - preferring zero flow and some type of direct instream cover provided by all types of substrate.
- Fishes Marginal to Flowing Waters - species preferring quiet waters (zero velocity) but mostly in close proximity to flow (velocities of >0.2 m/s) and direct instream cover.
- Fishes of Runs - species preferring slow to moderate velocities in runs (>0.4 m/s) and some cover, mostly instream velocity, or the visual cover of marginal vegetation and roots.
- Fishes of Riffles and Rapids - these species preferred the high velocities and turbid flows of riffles and rapids (>0.4 - >1.5 m/s).

LETABA COMPARISON

In chapter eight of the report results of the Sabie-Sand river research are com-

pared with the findings of Dr Mark Chutter and Ralph Heath from their research on the Letaba River (Relationships between the low flows and the river fauna in the Letaba River WRC Report no 293/1/93).

The Letaba is a larger system than the Sabie, having a channel length 105 km longer than the Sabie to the Mozambique border, and a catchment area more than twice the size of the Sabie-Sand. The Sabie, however, is perennial, whereas the Letaba used to be a perennial river, but impoundment and water abstraction has turned it into a seasonal system.

A Pre-impoundment study of the Sabie-Sand River System, Mpumalanga with special reference to predicted impacts on the Kruger National Park

Volume One
The ecological status of the Sabie-Sand River System

DC Weeks* • JH O'Keeffe# • A Fourie* • BR Davies*

Report to the Water Research Commission
by the

*Freshwater Research Unit, University of Cape Town, and
#Institute for Water Research, Rhodes University

WRC Report No 294/1/96



The water quality of both the Sabie and Letaba systems are good, although dissolved salts and nutrient concentrations are higher in the Letaba than in the Sabie,

Thirty-nine fish species have been recorded from the Letaba River compared to 49 species recorded from the Sabie-Sand system. Thirty species from this study were common to the Letaba and Sabie Rivers, while 27 species were common to the Letaba and Sand Rivers.

A comparison of the macro-invertebrate populations highlighted the greater diversity of the Sabie-Sand system (135 taxa), but also confirmed that the Letaba (110 taxa) is far from impoverished. Eight taxa were exclusive to the Letaba,

while 35 groups were exclusive to the Sabie-Sand.

Although the above comparisons confirm that the Sabie River contains a more diverse fauna than the Letaba, Chutter and Heath conclude that too much emphasis has been placed on flow as the determining factor for fish and invertebrate communities. The differences in diversity between the Sabie and the Letaba are probably the consequence of a number of factors, which include habitat diversity, the lack of instream barriers in the Sabie, lower turbidity in the Sabie, as well as a constant flow of water.

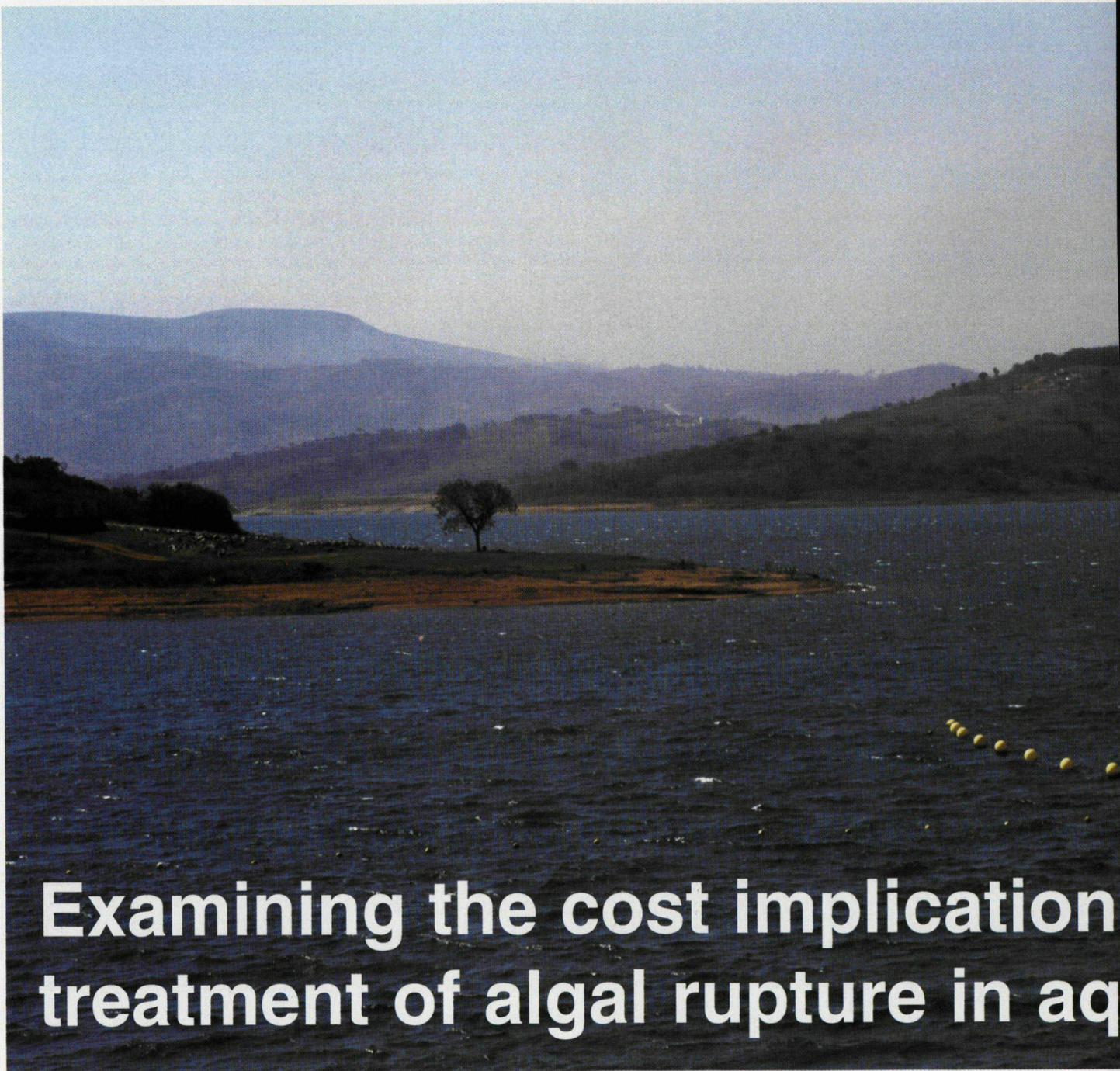
CONCLUSION

The results of this three year survey have shown that all the species recorded in the Sabie river during Pienaar's survey in 1978 are still present in the river, and that the riverine fauna of the Sabie still appears to be as diverse as ever. The communities had not yet fully recovered from the drought when sampling stopped in May 1993. Should low flow conditions become the norm, the communities in the Sabie river will change considerably.

Gold-mining pollution virtually wiped out the natural fauna in the middle reaches early in the century. The remarkable recovery of the river fauna is attributed to the presence of refuge tributaries in the system.

The middle reaches of the Sand River have been reduced to seasonal flow during most years, with the result that the communities are significantly different from those of the perennial reaches. Therefore the maintenance of the perennial upper warm tributaries is of vital importance as refuges for recolonisation.

The report **A Pre-impoundment Study of the Sabie-Sand River System, Mpumalanga, with special reference to predicted impacts on the Kruger National Park (The ecological status of the Sabie-Sand River System)** (WRC Report no 294/1/96) is available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. Foreign orders: US \$35 per copy, via surface mail.



Examining the cost implications of treatment of algal rupture in aqueducts

Inanda Dam - a view from the dam wall.

An investigation has been carried out by the Scientific Services Division of Umgeni Water in KwaZulu/Natal to establish the occurrence and implications of algal cells being ruptured in the aqueduct between an impoundment and the receiving waterworks.

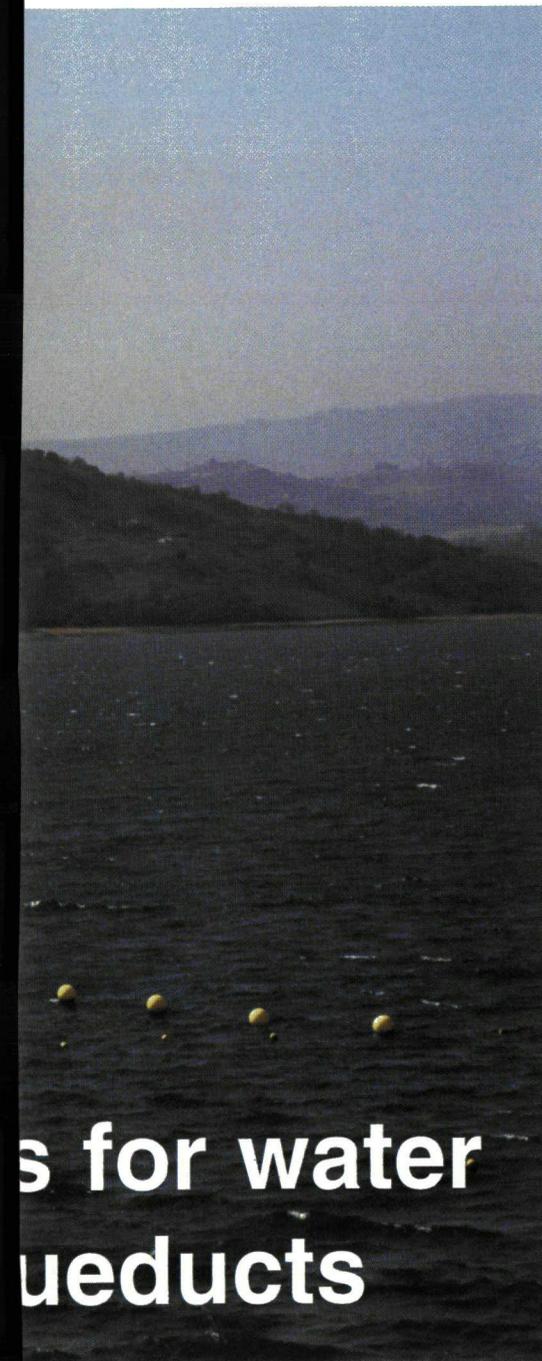
The investigation was initiated in response to the observation that algal blooms in the main basin and in the abstraction tower at Nagle Dam appeared to severely affect water treatment costs despite the fact that very few of the cells were present in the raw water entering Durban Heights Waterworks.

This raised the question of whether the same situation would arise in the potentially more eutrophic Inanda Dam system where algal numbers are likely to be several times greater than are found in Nagle Dam. Because the Inanda Dam

system had not yet been completed when this work was undertaken, the entire aqueduct system had to be simulated to examine possible algal rupture.

In a report released by the Water Research Commission the researchers, CWS Dickens, PM Graham and S Freese, say that the techniques developed in the course of this investigation have application in any system of water transfer from an impoundment by aqueduct.

The researchers say that the investigation was designed to firmly establish:



s for water ueducts

HISTORICAL EVIDENCE

High numbers of *Microcystis* in Nagle Dam did not reflect in algal counts of untreated waters entering Durban Heights Waterworks. Chemical and physical determinants did not give any indication of a deterioration of water quality.

Historical algal and flow data was used in a statistical examination of the effects of the aqueducts between Nagle Dam and Durban Heights Waterworks on algal numbers. Indications from these results are that many algal genera are being lost in their passage from the dam to the works. This loss in algae appears to be most significant for vacuolate blue-green algae viz. *Microcystis* and *Anabaena*.

EFFECT OF ALGAL RUPTURE

A detailed examination of historical water quality surrounding a significant algal bloom in Nagle Dam in February 1990 was undertaken. This bloom severely impacted on water treatment at Durban Heights Waterworks. Of all the routine water quality determinants examined none, besides the comparisons of algal numbers (and to a lesser degree chlorophyll *a*) between the dam and the waterworks, gave a clear indication of a change in water quality due to the presence of the algal bloom or due to the rupture of algal cells in the aqueduct.

pH was shown to be slightly elevated at the waterworks compared to the dam although it is possible that this variable may be co-varying with some other water quality variable. It was also obviously not possible to monitor pH as an indicator of algal blooms as this determinant is a variable in its own right and dependent on varying local limnological conditions.

MEASURING ALGAL RUPTURE

Due to relatively low algal counts in Nagle Dam, during the project, direct estimation of *in situ* algal loss in the dam to the waterworks aqueduct was not possible. To deal with this problem, and to examine *in situ* algal loss, a novel technique of adding concentrated *Microcystis* algal scums with a lithium marker to the head of the aqueduct was used to accurately show that between 61 and 72 per cent of the *Microcystis* cells

were lost during their passage through the aqueduct.

INANDA DAM

An algae and lithium tracer technique was employed to examine the extent of algal rupture through the Inanda Dam abstraction tower. Results indicate that there appears to be minimal algal loss after passage through this section of the Inanda to Wiggins Waterworks system.

SIMULATIONS

Algae were subjected to simulated aqueduct pressure and water velocity conditions in an experimental, laboratory scale, chamber. Percentage algal loss for the Nagle system in this chamber (69 per cent) was comparable with *in situ* algal loss (61 to 72 per cent). The simulation chamber therefore provided a reasonable model of *in situ* algal rupture conditions. The simulated Inanda Dam to Wiggins Waterworks system produced negligible algal loss after treatment.

MODELLING

Using data collected after subjecting *Microcystis* algae to a wide range of simulated aqueduct conditions, a mathematical response surface model was developed to describe the conditions producing the maximum degree of algal rupture over the range of pressures, water velocities (and hence shear) and times that algae would be exposed to in the respective Nagle and Inanda Dam to waterworks systems. Pressure was shown to be the most significant factor accounting for algal rupture. The combined values of pressure and velocity that lead to maximum rupture are in the region of 1 320 kPa and 1.6 m/s, respectively. The duration for which these rupture forces are applied was shown to produce very little effect indicating that rupture probably takes place during the initial period of their application.

VISUAL APPEARANCE

Light and electron microscopy showed simulated aqueduct treated algal cells with a deflated appearance although no sub-cellular fragments were ever positively identified as coming from ruptured algal cells. This lack of positive identification of fragments may have been a limitation in preparation techniques however. The deflated appearance of pressure treated cells confirmed the work of

- whether algal rupture is indeed occurring in the Nagle to Durban Heights Waterworks system;
- to estimate rupture in the Inanda Dam to Wiggins Waterworks system, and then
- to look at the implications of this rupture on water treatment as algal cell contents are released into the water.

The investigation was also designed to establish the governing principles causing algal rupture in aqueducts.

other authors in showing the effects of pressure on gas vacuolate algal cells.

CONSEQUENCES

Associated with historical algal blooms in Nagle Dam there was a corresponding increase in treatment costs at Durban Heights Waterworks. This was out of proportion to the number of algae entering the waterworks and could only be anticipated by monitoring algal numbers in the Dam.

Investigations into the treatment consequences of algal rupture have shown that coagulant demand increased by up to 700 per cent if cells were ruptured. This effect was more significant at higher cell numbers (ca. 1 million cells/ml). At a more reasonable cell number (100 000 cells/ml) the increase in coagulant demand was up to 240 per cent. The same trend, with differing efficiencies, was observed with the four coagulation chemicals investigated in this research.

The pre-chlorination demand of untreated samples increased with cell concentration irrespective of whether the algae were ruptured or unruptured. This was expected as chlorine breaks up intact cells. Where samples were first treated with coagulant sufficient to obtain a turbidity of <0,5 NTU, and then filtered, there was a significant increase in the chlorine demand of ruptured over unruptured samples particularly when algal numbers were 1 million cells/ml.

The release of geosmin into the water was found to be several fold greater if cells were ruptured. It was not possible during the time of this investigation to more clearly assess the impact of taste and odours on water treatment as these were present in extremely low concentrations in the *Microcystis* scums that were collected from Inanda Dam. It appears that the production of these compounds is erratic and unrelated to cell number.

Dissolved organic carbon concentrations and turbidities also increased as a result of cell rupture but this was only clearly noticeable at very high cell concentrations.

TREATMENT COSTS

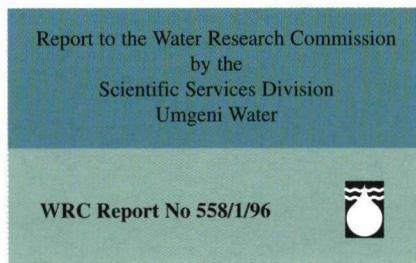
Coagulant costs were shown to increase significantly with the percentage of ruptured algae in the water. Therefore in the

case of there being 100 000 cells/ml, subjected to 67 per cent rupture (as in the Nagle-Durban Heights system), the increase in coagulant cost would be between 35 and 85 per cent. Of those tested a polyaminepolyaluminium chloride (PA-PACl) blend was found to be the least influenced by algal rupture although it was the most expensive. $FeCl_3$ was the most cost efficient at lower cell concentrations but was slightly less efficient than alum at higher cell concentrations. The cost merits of $FeCl_3$, and alum were balanced by higher sludge production when compared to PA-PACl.



Algal Rupture during Abstraction from Reservoirs and the Consequences for Water Treatment

CWS Dickens ● PM Graham ● S Freese



The impact on treatment cost of the release of taste and odours causing chemicals, such as geosmin, is likely to be far more significant than that attributable to coagulant demand.

In early 1994 a severe bloom of *Anabaena* in Nagle Dam, with geosmin concentrations of up to 1970 ng/l, necessitated dosing powdered activated carbon (PAC) at up to 15 mg/l to remove the taste and odours produced by up to 30 000 cells/ml of *Anabaena*. These figures were the extremes experienced for this period but on an average dosage of 10mg/l PAC, over the two month incident, costs for PAC alone were in the region of R950 000. If one included laboratory tests and personnel costs for this incident then the real costs would probably be in the region of R1 million. It is likely that the problem is being exacerbated by the rupture of a high percent-

age of the *Anabaena* cells. It is predicted that treatment costs would be much lower if cell rupture did not occur. This was obviously a particularly "productive" taste and odour scum as algae collected during other phases of this investigation contained little geosmin although algal numbers were orders of magnitude higher.

SUMMARY

The researchers say there is a large body of evidence in this study which suggests that algal rupture is taking place in the aqueducts between Nagle Dam and Durban Heights Waterworks. This has significant implications for the treatment of water abstracted from this dam particularly when the algal complement of this water is dominated by blue-green algae such as *Microcystis* and or *Anabaena*.

Simulation work suggests that for the Inanda to Wiggins Waterworks system there will be little to no loss of algae in water abstracted from this dam. This is because, in terms of potential rupture forces (pressure and water velocity), this abstraction and aqueduct system is relatively mild.

The implications of this work on the Nagle Dam system suggest that future water abstraction and aqueduct systems should attempt, as far as possible, to minimise the pressure and water velocity conditions in aqueducts, keeping these well below 1 320 kPa and 1.6m/s respectively. Alternatively, algae should be removed from the water prior to passing through an energetic (high rupture potential) system. These recommendations are made so that excessive water treatment costs are not incurred through the necessity of using advanced treatment processes to deal with ruptured algae and associated taste and odours and other cell contents.

Copies of this publication titled **Algal rupture during abstraction from reservoirs and the consequences for water treatment** (WRC Report 558/1/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 20, via surface mail).

Water Quality for Animal Production Investigated

Researchers from the Department of Animal and Wildlife Sciences at the University of Pretoria have identified a need for an index system to assess the suitability of water for livestock production "as the present system does not fulfil this role satisfactorily".

In a report emanating from a research project funded by the Water Research Commission, the researchers, NH Casey, JA Meyer, C Coetzee and WA van Niekerk, say the new index system should be based on the assessment of water intake for:

- (i) toxic variables - to determine the levels of ingestion of the variable concerned, and
 - (ii) palatability variables - to assess the impact on the variables on water requirement and feed intake.
- These will then be combined to form a water quality index.

According to the report a total of 2 293 data sets of borehole water samples from non-hydrogauging stations from the Northern Province, Mpumalanga and North-West Cape were reviewed and the variables fluoride (F), total dissolved salts (TDS), chloride (Cl) and sulphate (SO₄) were found to be the variables of major importance to livestock production based on the incidence of potential-toxicity assessed according to international guidelines.

High risk areas were identified and selected farms were visited in the North-Western Cape and Northern Province regions. On the basis of the results on the data reviewed and the observations from the interviews conducted, research emphasis was placed on fluoride and the palatability effects of primarily chloride, sulphate and TDS. Similar results were obtained from a review of data from the Atomic Energy Corporation data base and recent data (1990-1994) from the Department of Water Affairs and Forestry, with nitrate being an addition to the list of water quality variables with high research priority.

Fluoride

The effects of five different levels of fluoride in the drinking water (< 1 mg/l, 6 mg/l, 10 mg/l, 14 mg/l and 20 mg/l) on the growth and health of South African Mutton Merino (SAMM) wethers to market weight was investigated. No significant treatment effects were observed on growth or health. Thyroid gland weight was significantly affected by the treatment in some of the groups with a rise in thyroid gland weight with increasing levels of fluoride in the drinking water. It was concluded that, although there were no clinical symptoms or histopathological lesions found, fluoride had a significant physiological impact on sheep (hypothyroidism) and fluorosis would have developed with time. It was further concluded that an ingestion of 96 mg F/sheep/d (25 kg live weight) and 122 mg F/sheep/d (42 kg live weight) could be recommended for SAMM wethers for growth to market weight without any adverse effects on growth or health occurring. A similar finding was concluded in a second trial with a level of 15 mg/l fluoride in the drinking water not resulting in any significant effect on growth or health of SAMM wethers to market weight.

Fluoride levels of up to 20 mg/l in the drinking water or at an ingestion rate of up to 3.206 mg F/bird/day, had no negative effects on production characteristics of Ross broilers.

No significant differences between sodium fluoride treatments regarding all major production characteristics were found in Silver Grey Hy-line layers at fluoride levels of up to 20 mg/l or an ingestion rate of up to 4.453 mg F/day/bird over a 74 week period.

Similar findings to those made with SAMM wethers were made with Bonsmara steers exposed to sodium fluoride in the drinking water to a level of 20 mg/l fluoride, with a resultant ingestion of 350 mg F/steer/day during the initial growth phase and an ingestion of

600 mg F/steer/day during the final growth phase to market weight.

Chloride & Sulphate

The effect of chloride and sulphate on the palatability of water was investigated at varying TDS levels and ratios of Cl:TDS and SO₄:TDS. It was found that both variables had a significant adverse effect on the palatability of the water, judged by a decrease in the water intake for both variables and a decrease in the feed intake for the chloride variable. Sulphate appeared to have a negative effect on palatability at a lower level than for chloride. No significant treatment effects were found on growth to market weight or health (clinical observations, and kidney and liver histopathology).

The report says a "zone of preference" in terms of water intake was identified in Friesland steers exposed to various Cl:TDS:SO₄ treatments in the drinking water. The response indicated that water intake may possibly be predicted by establishing the location of a "zone of preference", which aids in assessing the relative importance of water quality variables in terms of toxicological, palatability and adaptation factors. All these factors are important in assessing the effect and thus acceptance of a water source.

Saline water was found to significantly alter the bone [fluoride] in SAMM wethers, compared to fresh water, with a significant negative correlation between salinity and bone [F] being found. A TDS concentration of 3 000 - 6 000 mg/l appeared to have a beneficial effect on hot carcass weight in Bonsmara steers exposed to fluoride in the drinking water.

Copies of the report entitled **An investigation into the quality of water for animal production** (WRC report 301/1/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 30 - postage via surface mail).

Report shows benefits of water supply improvements are variable

Assumptions are often made, usually not based on scientific data, that the supply of clean water will have a positive impact on the health status of a population, however, studies conducted in numerous countries indicate that the benefits of water supply improvements are variable.

This is said in a report published by the Water Research Commission on "**The effect of water supply, handling and usage on water quality in relation to health indices in developing communities**" (WRC report 562/1/96) compiled by B Genthe of the Division of Water Technology at the CSIR and J Seager of the National Urbanisation & Health Research Programme, MRC.

The report says very little information relating the quality of water supplied and the quality of water used (and consumed) and its impact on health is available. Although high levels of faecal contamination are gener-

ally assumed to be associated with diarrhoeal disease, a direct relationship has rarely been found.

"High levels of food and water contamination have been found in the home environment even when clean water was supplied. Improvements in water quality alone seem to have little effect on water handling practices and the subsequent contamination of stored water."

The report says in South Africa many households in developing communities are making use of 'serviced sites' which include outside or communal taps and outside flush toilets or bucket latrines, and it was essential that the impact of these services on health be assessed.

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

This study aimed to investigate the quality of water supplied compared to the quality of water consumed in relation to health indices in a developing community. Various categories of services were included in the study, namely no formal water supply, communal taps used by more than 100 people per tap, outdoor taps on individual plots and in-house taps.

The objectives of the three-year study were as follows:

- Determination of the quality of water at the point of collection and the quality of water after transport and storage;
- Examination of patterns of water usage, including water used for drinking, washing and hygiene purposes, quantity of water used and identification of the treatment of water by the end-user prior to use, and
- Correlation of the water quality with the health indicators of the study population.

The Effect of Water Supply, Handling and Usage on Water Quality in Relation to Health Indices in Developing Communities

B Genthe ● J Seager

Report to the Water Research Commission
by the
Division of Water, Environment and Forestry
Technology,
CSIR

WRC Report No 562/1/96



STUDY DESIGN

The study was designed to assist in providing policy guidelines for the provision of water in developing communities and was conducted making use of the case-

control methodology recommended by a working group for "measuring the health impact of water supply and sanitation" as the epidemiological assessment technique. The case-control study was undertaken to estimate the risk of diarrhoea associated with the quality of water at the source and end user point. More than 300 households were included, of which half were cases and half controls. Cases were preschool children with severe diarrhoea visiting a health facility. Hygiene and sanitation factors, education and socio-economic factors were explored by means of personal interviews and observational studies. Controls of similar age and with a similar type of water supply were selected from the same neighbourhoods as the cases. Water samples from both cases and controls were taken from source supplies (taps) and points of use (in-house), and analysed to assess the microbiological quality. A cross-sectional study recording all preschool children who were brought to all health facilities in the study area was conducted to examine the relationship between differ-

ent types of water and sanitation facilities and diarrhoea among preschool children.

RESULTS

Water provided to the study population was of good microbiological quality and complied with SABS guidelines. However, water was significantly more contaminated after handling and storage than at source. Cases and controls were found to have equally poor water quality after collection and storage, with higher levels of *E. coli* counts observed in control in-house samples. Even though no statistically significant association between poor in-house water quality and diarrhoea was observed, analysis of questionnaire and observational data of the case-control study identified some risk factors for severe diarrhoea among preschool children. A strong association was found between the child's attendance at a day care centre or creche and diarrhoea. An increased risk of diarrhoea was associated with poor knowledge regarding food handling and hygiene; as well as a lower level of knowledge regarding the causes and prevention of diarrhoea, and poor kitchen hygiene.

In the case-control study, poorer water quality was observed where communal taps are used. In the cross-sectional study, a comparatively larger proportion of diarrhoea cases was recorded from areas where communal taps are the type of water supply used, compared to areas where a tap is available on site. This indicates that a private outdoor tap appears to minimise the risk associated with water-related disease. Many other factors such as whether children attend a day care centre or are cared for by a non-family member; hygiene practices; and knowledge of causes and prevention of diarrhoea, were shown as important factors impacting on the health of the population in a developing community.

With regards to providing policy guidelines for the provision of water in developing communities, it appears that the provision of private outdoor taps (as opposed to shared facilities) will contribute to the reduction of the risk associated with diarrhoea.

In summary the objectives of the study were achieved as follows:

- Water quality at point of collection

and after storage was adequately assessed. Seasonal variations could not be determined due to a change in the supply source. A new pipeline was installed with accompanying high free chlorine concentrations, which influenced the water quality significantly. The variations that were observed can therefore not be attributed to a seasonal variation.

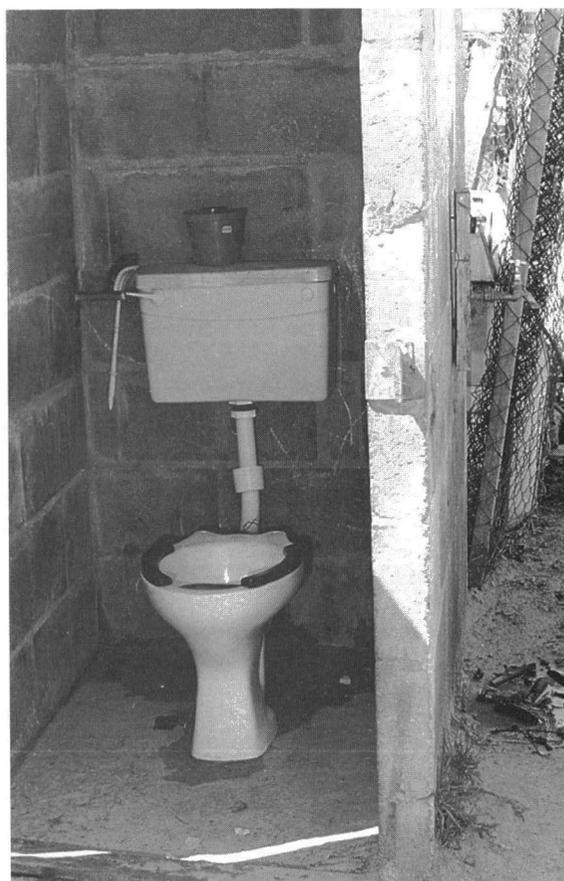
- The patterns of water usage, quantity of water used and treatment of water by the end-user was determined. The average quantity of water used was calculated as 50l/week, which was based on the participants' response to a question enquiring how often their water containers were filled per week. This amount does not reflect the amount of water actually used, but rather the amount that was stored within the household, and was the closest possible estimate.

- No direct relationship between water quality and diarrhoea was found, even though a high level of water contamination was found after collection and storage. However, poorer water quality was observed (after handling and storage) where communal taps are available. Furthermore, a comparatively larger proportion of diarrhoea cases was recorded in the cross-sectional study, from areas where communal taps are the type of water supply used, compared to areas where a tap is available on site.

RECOMMENDATIONS

Investigations into the activities leading to the contamination of water occurring at communal taps are recommended. In addition, the development of technology (engineering approaches) to reduce contamination of water during collection from communal taps should be explored.

The suitability of indicator organisms presently used for assessing drinking water quality and associated health risks



Site and service: private outdoor tap and toilet.

is tenuous. At present there is no absolute indicator organism which complies with the criteria specified for the ideal indicator organism. Indicator organisms have limitations in that certain viruses and parasites are known to be more resistant to disinfection than the indicator organism, *E. coli* and the absence of the latter will not necessarily indicate absence of the former. A search for more suitable indicator organisms is needed and recommended. There would be merit in investigating the association between bacterial pathogens and indicator organisms.

Further research should focus on appropriate holistic health promotion programmes to address the range of practices around water usage, storage and environmental hygiene. An in-depth holistic intervention programme, aimed at a national level, is recommended. The situation with respect to hygiene practices and water quality at day care centres should be investigated to establish minimum requirements and a management system for such facilities, as well as differentiating between problems related to formal and informal day care facilities.

International conference on regionalisation in hydrology

The international conference on Regionalisation in Hydrology held at the Technical University of Braunschweig (TUB), Germany, from 10 to 14 March 1997 was organised jointly by TUB and UNESCO, in cooperation with WMO and IAHS. The conference formed part of the International Hydrological Programme (IHP) of UNESCO and was the second of such conferences - the first one took place in April 1990 in Ljubljana, Yugoslavia.

Regionalisation is one of the major issues in hydrology and includes two main research directions: quantifications of the components of the hydrological cycle at a regional scale as opposed to a plot or small catchment and the establishment of links between hydrological variables and physiographic, climatic and land-use characteristics of the region. The conference aimed to explore new mathematical and computational tools to describe and analyse the behaviour of hydrological systems at all relevant scales. It was expected to synthesize the relevant research information which is fragmented across the diversity of scientific disciplines and therefore contributions were encouraged from the subject areas such as: hydrology, soil science, remote sensing, computer science, mathematics, ecology, etc. The conference was naturally set up as a forum for the presentation of new research results and to define future needs for regional cooperation in international research projects.

The conference topics have been structured as follows:

- Process models for the hydrological cycle;
- Methods for transferring models across scales and from one region to another;
- Coupling of hydrological process models with GIS;
- Remote sensing as a tool for parameter estimation and model validation;
- Use and availability of data; and
- Application.



The conference was opened with Prof Diekkrüger, University of Bonn, describing the German special research programme on regionalisation in hydrology financed by the German Research Society. The main tasks of this programme have been: the consideration of spatial variability of hydrological processes within a given scale; derivation of effective or representative parameters of simulation models for an aggregated area (upscaling), disaggregation of information on a larger scale (downscaling). Also the regional transferability has been one of the main research interests of the programme. The programme has been financed for six years (1992 - 1997) and involved the efforts of a number of research institutions (the universities of Heidelberg, Bonn, Göttingen, Braunschweig, München, Zittau, Aachen, Karlsruhe, Stuttgart, Bochum, Dresden, Münster,



Vladimir Smakhtin

Suderburg and Berlin as well as the Potsdam Institute for Climate Impact Research and German Weather Service). The models and regionalisation techniques that have been developed during the first stage of the programme have been tested on a common (target) catchment of the Weser River which drains into the North Sea and covers an area of 35 000 km². Most of the subsequent presentations have effectively discussed the results of the German regionalisation research programme in more detail and the conference developed into a very interesting excursion into contemporary German hydrology. However, the participants from Finland, Austria, UK, Italy, the Netherlands, New Zealand and Japan also contributed to the success of the conference. Africa has been represented by delegates from Kenya, Ethiopia, Tanzania and South Africa.

The conference has demonstrated that the number of hydrological models continues to grow while hardly any attempt is being made to compare or classify them (obviously not a very rewarding job). Unfortunately, practical applications or foreseen benefits of many of the studies presented have not been discussed. Some well known models (TOPMODEL, MIKE-SHE, USLE)

attract permanent attention and are being tested by different research groups for different purposes.

The South African presentation, "Regionalisation of daily streamflow characteristics in South Africa" from the Institute for Water Research (IWR) of Rhodes University has been aimed at the very practical problem of generating continuous daily streamflow time series for water resource assessment using regional flow duration curves. The demonstration of HYMAS computer software package developed at IWR for setting up and running hydrological models and analysing observed and simulated hydrological variables has attracted the attention of many delegates.

Altogether there were about 40 oral and 40 poster presentations. The posters were very informative and although there were several duplications of oral presentations in the poster session, these only facilitated the discussion and exchange of ideas. There were papers which described the application of tracer techniques in hydrology while, at the same time, some classical regionalisation works (e.g. from Hungary, Slovenia)

aimed at the identification of hydrologically homogeneous regions for the estimation of design flow characteristics, have been presented on posters.

The new software developments to support hydrological analysis were presented by groups from the Institute of Informatics of the University of Münster (Prof U. Streit) and the Section for Hydrology and Water Resources, University of Aachen (Mr C. Gitschel). The Münster University group has developed a GIS based (ARC/INFO and GRASS) system for spatial derivation, transfer and generalisation of hydrological data and parameters. This system - T4HIM (Tools for Hydrological Information, Modelling and Visualisation) has been developed to support the research groups participating in the German Regionalisation Research Programme with common methods for spatial data handling, processing and visualization.

The group from Aachen concentrated their efforts on developing a Hydrological Model Generator (HMG). The HMG is an interactive, window based system which allows catchment runoff models to be designed and modified.

Following the modular design principle, the user can select hydrological simulation functions (each describing an individual hydrological process) from a library of available submodels. The data necessary for both model generation and simulation are kept in a database which combines geographical information, time series, alphanumeric information and source codes of submodules.

During the conference excursion to the Harz mountains the participants had a chance to get acquainted with the history of the present water supply systems in the Lower Saxony and two experimental catchments of the Technical University of Braunschweig where an impressive amount of hydrometeorological data has been collected.

A book with extended abstracts of the conference material has been pre-published, and the plan is to have the oral presentations of the conference published in one of the IAHS "red books" by the end of the year.

*Reported by Vladimir Smakhtin
Institute for Water Research,
Rhodes University.*

Hydrological modelling course presented in Kenya

Professor Roland Schulze and Andy Pike of the Department of Agricultural Engineering at the University of Natal in Pietermaritzburg recently returned from Mombasa in Kenya where they presented a week-long hydrological modelling course on the ACRU model to 26 participants from 18 African countries, ranging from Algeria in the north to the RSA in the south, and from Senegal in the west to Tanzania in the east. The participants were mainly university lecturers and government researchers. The course was held under the auspices of the International Geosphere - Biosphere Programme's GAIM initiative (Global Analysis and Interpretation of Models). IGBP-GAIM has selected ACRU as its catchments hydrological model to assess impacts of environmental, climate and land use change on hydrological responses.

An intensive series of lectures and practical classes were given to very appreciative and enthusiastic participants who want to use the model in their own countries. IGBP-GAIM is purchasing all necessary ACRU model software and documentation and is even providing selected users with Pentium PCs!

This initiative will foster active research collaboration between the Department of Agricultural Engineering and several institutes in the rest of Africa. What impressed participants particularly was the comprehensive model documentation (for which Prof Schulze was recently awarded the SA Institute of Agricultural Engineers medal for best publication in 1996) and the fact that ACRU can be used to help solve real world conflicts on water resources.



Prof Roland Schulze

A similar ACRU modelling course was given by Prof Schulze to MSc and PhD students at the University of Jena in Germany in February this year.



Membrane technology tested for Tannery Effluents

A report recently published by the Water Research Commission (WRC) offers the following to potential users of membrane technology in the treatment of tannery effluents:

- It presents process design criteria for the treatment of tannery effluent streams with membrane technology; and
- It identifies suitable membrane processes that may be used for soak paddle effluent, dyehouse effluent as well as liming and deliming effluents.

The research project, funded by the WRC and carried out by JJ Schoeman and A Steyn from the Division of Water, Environment and Forestry Technology at the CSIR, has shown that:

The salinity levels of tannery effluents discharged into the municipal water treatment system are high (conductivities of 1 500 to 2 000 mS/m) and unacceptable to municipal authorities because it increases the mineralisation of South Africa's limited water resources. Final effluent discharges into municipal water treatment systems should have a conductivity of less than 500 mS/m to render the effluent suitable for discharge into the system. Hence, there is a need to desalinate tannery

effluent effectively, prior to discharge into municipal water treatment systems.

The concentration levels of organic materials and ammonia-nitrogen in tannery effluents are also high. Concentration levels of organic matter and ammonia-nitrogen of 2 000 to 3 000 mg/l Chemical Oxygen Demand (COD) and 450 mg/l have been reported, respectively. COD and ammonia-nitrogen concentration levels of <3 000 mg/l COD and 40 to 50 mg/l ammonia-nitro-

- Ultrafiltration reverse osmosis (UFRO) may be used for treatment of the combined pretreated final tannery effluent;
- Microfiltration reverse osmosis (MFRO) could be used for treatment of the soak paddle effluent; and
- Ultrafiltration reverse osmosis for treatment of the dye-house effluent, liming effluent and deliming effluent.

Copies of the report entitled **Evaluation of membrane technology for the treatment of industrial effluents** (WRC report 590/1/97) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 20, including surface mail charges).

gen, respectively, are regarded as being acceptable discharge concentration levels to municipal water treatment systems. Consequently, it is also necessary to remove excess COD and ammonia-nitrogen from tannery effluents, prior to discharge into the municipal treatment system.

Sulphide and chromium concentration levels in tannery effluents should be less than 40 and 5 mg/l, respectively, prior to discharge. Sulphide and chromium con-

centration levels may exceed these limits in certain cases and have to be removed from the effluent, prior to discharge into the municipal treatment system.

Tannery effluent consists of various streams contributing different salinity, organic and ammonia-nitrogen concentration levels to the final combined effluent. Tannery effluent consists of soak paddle effluent, liming effluent, deliming effluent, tanning effluent and dye-house effluent. The soak paddle and certain parts of the tanning effluent (pickle tan and chrome work) are the major contributors to the salinity level of the final effluent.

REVERSE OSMOSIS

According to the WRC report it may be possible to reduce the contaminant level in tannery effluent to acceptable discharge concentration levels with reverse osmosis (RO) technology. Tannery effluents, however, have a high fouling potential for RO membranes due to the high organic and inorganic concentration levels of the effluents. Little information is available in the literature regarding pretreatment methods for tannery effluent, prior to RO desalination. Ultrafiltration (UF) and/or microfiltration (MF) may be suitable technologies to protect RO membranes from fouling during treatment of tannery effluent. Little information is available regarding membrane cleaning procedures and process performance as a function of time.

Almost no information could be found in the literature regarding treatment of segregated streams in a tannery with membrane technology. Most of the individual streams are highly contaminated with organic matter, with the result that these streams have a high potential to foul membrane systems. However, the combined final effluent is pretreated with coagulants and dissolved air flotation prior to discharge into the municipal treatment system. Consequently, this pretreated, combined final effluent should theoretically have a lower fouling potential for membrane systems. It was, therefore, decided to first evaluate the desalination of the final combined effluent before attempting to desalinate individual streams in a tannery.

Tannery effluents from Hanni Leathers at Nigel were used for the study as they are representative and typical of the type of effluent found at most South African tanneries.

According to the report the combined final effluent produced by Hanni Leathers, despite pretreatment in a Silflo unit, rapidly fouled polysulphone UF membranes. Ultrafiltration permeate flux levels soon dropped to low levels. Permeate flux varied between approximately 100 and 400 l/m²/d. However, it may be possible to control membrane fouling by pH adjustment of the effluent and regular cleaning of the membranes with a warm water rinse, followed by cleaning with an enzymatic cleaning and oxidising agent.

The COD of the UF feed varied between 1 500 and 4 000 mg/l over the test period. However, poor COD removals were obtained. COD removals varied between 6 and 32 per cent. This showed that most of the organic materials in the effluent had relatively low molecular masses (40 000 molecular mass cut-off UF membranes were used).

Chromium, iron, sulphate, fats and oils were removed with UF treatment of the effluent. These chemicals are all potential membrane fouling agents which could have contributed to UF membrane fouling. However, no membrane foulants were removed from the surface of the membranes for analytical identification. Further work should be done to identify these foulants analytically.

Membrane fouling was experienced when the final effluent was treated with UFRO (polysulphone UF and PCI AFC 99 nanofiltration RO membranes). Low permeate fluxes were experienced. Ultrafiltration and RO permeate fluxes of approximately 150 to 500 l/m²/d and 100 to 150 l/m²/d, respectively, were experienced. Fouling of the RO membranes occurred despite the use of ultrafiltered water as feed to the RO membranes. It was noticed that the UF permeate became milky on standing. This could be ascribed to coagulation/flocculation of proteins in the effluent. This material may have contributed to the membrane fouling encountered and these substances should be analysed.

The electrical conductivity of the effluent was not significantly reduced by the nanofiltration RO membranes. The electrical conductivity of the feed solution varied between approximately 600 and 2 500 mS/m. The electrical conductivity of the RO permeate varied between approximately 500 and 1 500 mS/m. Hence, the electrical conductivity remained high, and reductions varied between approximately 29 and 37 per cent. These low reductions may be ascribed to the high percentage of monovalent ions, compared to the divalent ions, in the RO feed.

Good COD removals were obtained with the nanofiltration RO membranes. The COD of the RO feed varied between 1 250 and 2 300 mg/l. Permeate COD varied between 600 and 900 mg/l. Hence, COD removals of between 20 and 66 per cent were attainable.

Membrane fouling was also experienced during UFRO treatment of the final effluent when polysulphone UF (80 per cent recovery) and cellulose acetate RO (70 per cent recovery) membranes were used. The UF permeate flux was low (approximately 250 l/m²/d). It was possible to control UF membrane fouling with regular chemical cleaning. Relatively low permeate fluxes were experienced during RO treatment of the UF permeate. Permeate flux varied between 110 and 350 l/m²/d. Membrane fouling was also experienced despite the UF permeate that was used as feed to the RO unit. Reverse osmosis brine comprises approximately 30 per cent of the RO feed. This brine contains high concentrations of inorganic materials and should rather be disposed of than be used as part of the RO feed solution.

The COD of the RO feed (UF permeate) varied between 2 500 and 5 160 mg/l. The COD of the RO permeate varied between 500 and 1 090 mg/l during the test run. COD removals varied between 72 and 90 per cent. Hence, good COD removals were obtained with RO. However, a significant amount of low molecular mass organics was retained in the permeate.

Good turbidity and COD removals were obtained with alum coagulation/floccula-

tion of the soak paddle effluent. Turbidity could be reduced from 1 750 to 60 NTU (96 per cent removal) at an Al^{3+} dosage of 150 mg/l. COD was also reduced from 12 000 to 3 400 mg/l (71,7 per cent removal).

Excellent turbidity removal was obtained from the soak paddle effluent with CFMF (polyester membranes). In one instance turbidity was reduced from 1 700 NTU in the feed to 3,5 NTU in the permeate. COD was reduced from 12 000 mg/l in the feed to 6 730 mg/l in the permeate (43,9 per cent removal).

RO treatment yielded poor results with a concentrated soak paddle effluent. Electrical conductivity was reduced from 7 160 to 3 830 mS/m (46,5 per cent reduction) at a water recovery of approximately 70 per cent. COD was removed from 2 790 to 890 mg/l (68,1 per cent removal). The average permeate flux during a batch RO run was 75,5 l/m²/d. This low flux could be ascribed to membrane fouling and the high osmotic pressure of the feed. The electrical conductivity and COD of the brine were high, 10 780 mS/m and 5 830 mg/l, respectively.

Improved results were obtained during RO treatment of a more dilute soak paddle effluent. Feed electrical conductivity was reduced from 2 700 to 509 mS/m in one case (81,1 per cent removal, water recovery approximately 80 per cent). The average permeate flux was 200 l/m²/d. Ammonia-nitrogen was reduced from 77,98 to 21,8 mg/l (72,8 per cent removal). COD was reduced from 1 070 to 125 mg/l (88,3 per cent removal). Brine volume comprised 20 per cent of the treated volume. The electrical conductivity of the brine was 7 010 mS/m in this case and the ammonia-nitrogen concentration was 165 mg/l. The fluoride, sodium and chloride concentration levels were 9,9; 13 630 and 21 225 mg/l, respectively.

Good results were obtained with treatment of the sump effluent (effluent from soak paddles, fleshing, splitting, delimiting) with RO. Electrical conductivity was reduced from 1 104 to 128 mS/m (88,4 per cent reduction). COD was reduced from 3 720 to 90 mg/l (97,5 per cent removal). The average permeate flux was 330,5 l/m²/d. It may be possible to control membrane fouling with regular

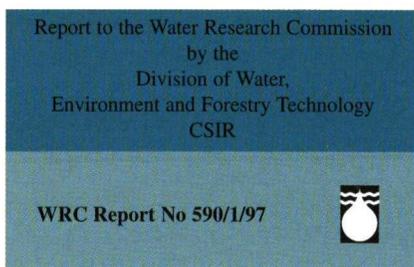
chemical cleaning. The electrical conductivity (3 620 mS/m) and COD (4 330 mg/l) of the brine were high. The brine comprised 12,5 per cent of the treated water.

Membrane fouling was experienced during treatment of the dye-house effluent with UF, but this may be controlled by regular chemical cleaning. Permeate flux was low (approximately 144 l/m²/d). Water recovery was 90 per cent. A COD removal of 67,5 per cent was obtained (reduced from 22 900 to 7 440 mg/l). The brine (10 per cent of feed volume) contained 79 000 mg/l COD and the electrical conductivity was 1 307 mS/m.



Evaluation of Membrane Technology for the Treatment of Industrial Effluents

J J Schoeman • A Steyn



Membrane fouling was also experienced during RO treatment of the UF permeate. The average permeate flux was 272 l/m²/d during a batch run. Water recovery was 80 per cent. The feed electrical conductivity was reduced from 1 181 mS/m to 156 mS/m (86,8 per cent reduction). Ammonia-nitrogen and COD were removed from 456,1 to 64,2 mg/l (85,9 per cent removal) and 6 710 to 963 mg/l (85,7 per cent removal), respectively. The electrical conductivity (3 480 mS/m) and ammonia-nitrogen (1 494 mg/l) concentration levels in the brine were high. The chromium (vi) concentration level in the brine was also high (2,0 mg/l).

Membrane fouling was experienced during the treatment of the liming effluent

with UF. Permeate flux was low (approximately 290 l/m²/d). Water recovery was approximately 90 per cent. A COD removal of 82,7 per cent was obtained (reduced from 21 650 mg/l in UF feed to 3 750 mg/l in UF permeate). The electrical conductivity of the UF brine (1 167 mS/m) as well as the COD were high (67 600 mg/l). The chromium (vi) concentration level of the brine was also high (0,2 mg/l).

Preliminary work showed that little, if any, membrane fouling occurred during treatment of the ultrafiltered liming effluent with RO. The average permeate flux was 687,5 l/m²/d and water recovery was 82 per cent. The electrical conductivity of the RO feed was reduced from 654 to 154 mS/m (76,5 per cent removal). COD was removed from 3 100 mg/l in the RO feed to 280 mg/l in the RO permeate (90,97 per cent removal). The electrical conductivity (1 963 mS/m) and the COD (8 800 mg/l) of the brine were high.

Membrane fouling was experienced when the delimiting effluent was treated with UF. Permeate flux was low (approximately 264 l/m²/d). It was not possible to restore the flux completely after chemical cleaning as was the case with the liming effluent. Further work will be required to evaluate alternative membrane cleaning methods. Water recovery was approximately 90 per cent. The COD of the effluent was reduced from 16 500 to 3 580 mg/l (78,3 per cent removal). The electrical conductivity (1 700 mS/m) and the chromium (iv) (2,0 mg/l) concentration level of the delimiting effluent were high.

Preliminary work has shown that almost no membrane fouling took place during treatment of the delimiting effluent with RO. The permeate flux (average flux) was determined at 467 l/m²/d. Water recovery was approximately 80 per cent. The electrical conductivity of the RO feed was reduced from 1 017 mS/m to 349 mS/m (65,7 per cent removal) and the COD from 3 350 to 620 mg/l (81,5 per cent removal). The electrical conductivity (1 552 mS/m) and COD (9 200 mg/l) of the RO brine were high.

In all the above cases, where individual effluent streams were treated, it is imperative that the brines be disposed of in a satisfactory manner.

International Association for the Properties of Water and Steam (IAPWS) meets in Denmark

Scientists and engineers from fourteen countries attended the annual meeting of the International Association for the Properties of Water and Steam in Fredericia, Denmark, from 8 to 13 September last year. This was the first time that a meeting of the IAPWS had been held in Denmark. At the meeting delegates approved the formal release and publication, for general and scientific use, of the new formulation for thermodynamic properties of ordinary water.

Delegates also received a new industrial formulation which allows for faster calculation times - by at least a factor of five faster than - the 1967 formulation which it now replaces. This new formulation covers both liquid and vapour phases to 1 073 K and 100 MPa as well as the metastable liquid and vapour states and will be tested and evaluated in a range of practical examples.

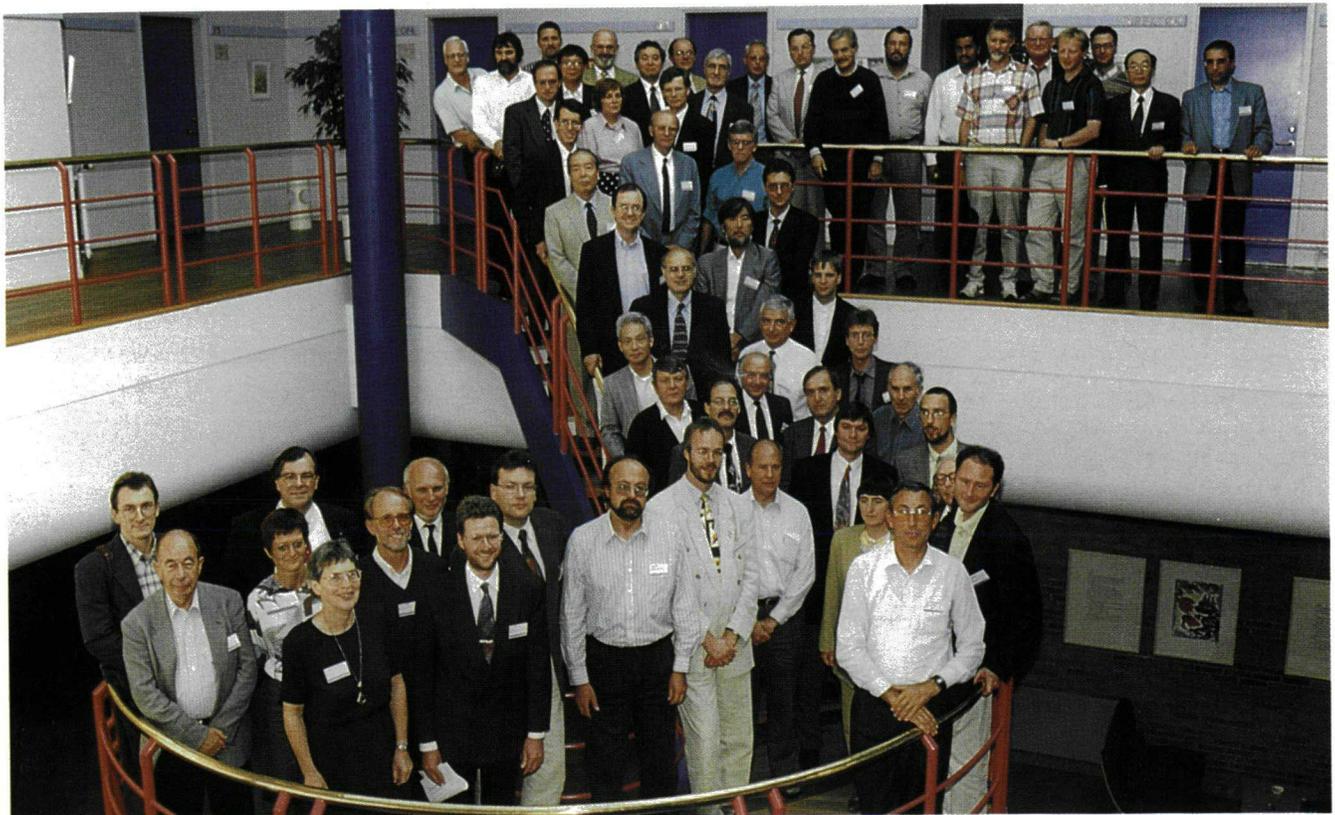
Formal publication is planned for the next meeting in Germany later this year.

A one day symposium was held to discuss "Processes at Supercritical Conditions of Water". Seven papers were presented, emphasizing the relevance of supercritical water properties for aqueous solutions and water mixtures, while reviewing potential industrial applications and developments. The four working groups of IAPWS held meetings separately as well as jointly and covered many subjects including "phase transition phenomena", "pH standardisation and measurement in water at high temperature" and "iron water systems".

Some new IAPWS certified research needs were approved to support research and development in the important areas of properties of salts in steam, pH measurement and potentiometric studies of supercritical aqueous solutions, etc.

IAPWS projects to study volatility and solubility of copper and its oxides, testing and fine-tuning of a new type of heat capacity flow calorimeter for measurements of aqueous solutions at superambient temperatures, and potentiometric measurements in high subcritical and supercritical HCl (aq) and NaOH (aq) solutions for deriving new data on the dissociation constant of water were also approved.

People interested in IAPWS activities should contact the local representative: Barry Conlin, Eskom Technology Group, PO Box 40175, Cleveland 2022. Tel: (011) 629 5430. Fax: (011) 629 5528. E-mail: Conlinb@tri.eskom.co.za **OR:** IAPWS Executive Secretary, Dr Barry Dooley, EPRI, 3412 Hillview Ave, Palo Alto, California 94303, USA.



International delegates to the IAPWS meeting in Fredericia, Denmark.

SA WATERKALENDER

The Water Research Commission is placing this calendar 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.

Die Waternavorsingskommissie plaas hierdie kalender om te help met die koördinerings 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 geleentheidsde.

1997

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SOUTHERN
AFRICA

1997

AQUATIC SCIENCE

JUNE 24 - 26

The Southern African Society of Aquatic Scientists will hold its 34th symposium in Mtunzini, KwaZulu-Natal. The symposium will focus on aquatic research and conservation in the context of industrial development as a special theme, but will cater for all aspects of aquatic research. Enquiries: Rodney Owen or Victor Wepener, Coastal Research Unit, University of Zululand, Private Bag X1001, Kwadlangezwa 3886. Tel: (0351) 93911 x 2549. Fax: (0351) 93162. E-mail: cruz@pan.uzulu.ac.za

CORROSION

JUNE 24 - 26

A symposium on controlling and reducing the effects of corrosion with corrosion-prevention technology will be held at the Holiday Inn, Johannesburg International Airport. Enquiries: The Institute for International Research, PO Box 91052, Auckland Park 2006. Tel: (011) 726-6003/6046. Fax: (011) 726-1304.

WEDC '97

SEPTEMBER 1 - 5

The 23rd WEDC conference will be held at the International Convention Centre in Durban. Theme: Water and sanitation for all. Enquiries: Conference Secretariat, Congress International, 18 Rapson Road, Morningside 4001, Durban. Tel: (031) 233-494. Fax: (031) 232-405. E-mail: ci@neptune.infolink.co.za

ENVIRONMENTAL
MANAGEMENT

SEPTEMBER 8 - 10

A specialised conference on Chemical process industries and environmental management will be held at the Table Bay Hotel, Waterfront, Cape Town. Enquiries: Conference Secretariat: Ms Ammie Wissing, Conference Planners, PO Box 36782, Menlo Park. Tel: (012) 348-4493, Fax: (012) 348-1563, E-mail: Wissing@lafrica.com

ENVIRONMENT

SEPTEMBER 8 - 11

An international conference on health and environment in Africa will be held at the CSIR Conference Centre in Pretoria. Enquiries: The Conference Secretariat, 18 Rapson Road, Morningside, Durban 4001. Tel: (031) 233494. Fax: (031) 232405.

AQUACULTURE

SEPTEMBER 15 - 18

The 4th congress of the Aquaculture Association of Southern Africa with the theme: Aquaculture - an opportunity based on science and technology will be held in Stellenbosch. Enquiries: The Chairman AASA Congress, Mr TT de Villiers, Department of Agriculture, Elsenberg 7607. Tel: (021) 808 5017. Fax: (021) 808 5120. E-mail: dier5@elsburg1.agric.za

WATER AFRICA '97

SEPTEMBER 15 - 19

The second Southern Africa Water & Wastewater conference and exhibition will be held in Harare, Zimbabwe. Theme: "Water security: guarding resources against drought and pollution". Enquiries: Zia Howeson. Tel: (011) 792-9807. Fax: (011) 791-0571.

SEWAGE PLANTS

OCTOBER 2 - 10

A post-graduate training course in water utilisation: Operation of small water purification and sewage plants will take place in Pretoria. Enquiries: The Head, Water Utilisation Division, University of Pretoria, Pretoria 0002. Fax: (012) 43-6683. E-mail: dtouh@fanella.ee.up.ac.za

MEMBRANE
TECHNOLOGY

OCTOBER 21 - 24

The second WISA-MTD workshop and seminar will be held at the Aventura Badplaas resort in Mpumalanga. Theme: Membranes in your industry. Enquiries: Dr Ed Jacobs (secretary - WISA-MTD), Institute of Polymer Science, University of Stellenbosch, PO Matieland, Stellenbosch 7602. Fax: (021) 808-4967. Tel: (021) 808 3178. E-mail: epj@land.sun.ac.za

HYDRAULICS

NOVEMBER 5 - 7

The third in the series of interna-

tional River Flood Hydraulics conferences will be organised by HR Wallingford in partnership with the University of Stellenbosch at Stellenbosch. Topics to be covered include flood hydraulics and hydrology, management of developments on flood plains, flood control, sediment transport and river morphology, flow measurement: social, economic and environmental aspects. Enquiries: Prof A Rooseboom, University of Stellenbosch. Tel: (021) 808-4353. Fax: (021) 808-4361.

DAM DESIGN

NOVEMBER 3 - 4

A course on the design of smaller dams will be offered under the auspices of SANCOLD at the University of Stellenbosch. Enquiries: Prof A Rooseboom, University of Stellenbosch. Tel: (021) 808-4353. Fax: (021) 808-4361.

HYDROLOGY

NOVEMBER 17 - 19

The SANCIAHS/SAICE '97 conference will be held at the University of Pretoria. Enquiries: Hugo Maaren, WRC, PO Box 824, Pretoria 0001. Tel: (012) 330-0340. Fax: (012) 331-2565. Email: hugo@wrc.cwrr.ca.za

WATER & SANITATION

DECEMBER 1 - 5

A conference on standard setting, quality control and coordination for training in the water and sanitation sector will be held in the Gauteng Province. **Call for papers.** Enquiries: The Coordinator: ITN Africa Conference, PO Box 95557, Waterkloof, Pretoria 0145. Tel/Fax: (012) 46-5453.

1998

CEMSA '98

FEBRUARY 9 - 11

An international conference and exhibition on Integrated Environmental Management (IEM) in South Africa will be held in East London. Enquiries: Professor OS Fatoki, University of Fort Hare, Analytical Chemistry, Private Bag X1314, Alice 5700. Tel: 404-22094. Fax: 404-31643. E-mail: fatoki@ufhcc.ufh.ac.za

OVERSEAS

1997

HYDROLOGY

JULY 6 - 10

An international symposium on hydrology in a changing environment will be held in Exeter, United Kingdom.

Enquiries: Dr Bruce Webb, Department of Geography, University of Exeter, Rennes Drive, Exeter, EX4 4RJ, UK. E-mail: BWWebb@exeter.ac.uk Faks: +44 (0) 1392 263342.

INSTRUMENTATION

JULY 6 - 11

The 7th IAWQ workshop on instrumentation, control and automation of water and wastewater treatment and transport systems will be held in Brighton, UK.

Enquiries: Concorde Services, 10 Wendell Road, London, W129RT, UK. Tel: +44 181 743 3106. Fax: +44 181 743 1010. E-mail: 101611.3664@compu serve.com

ENVIRONMENTAL
RESTORATION

JULY 7 - 9

The first international conference on environmental restoration will be held in Ljubljana, Slovenia. Conference themes: river, soil and groundwater contamination, pesticides/PCB/oil pollution, disposal of domestic waste/industrial waste/construction industry wastes and hazardous waste management.

Enquiries: Dr Milenko Ros, Slovenian Water Pollution Control Association, Hajdrihova 19, PO Box 3430, SLO-1001 Ljubljana, Slovenia. Tel: +386 61 1760237 Fax: +386 61 125 9244 E-mail: milenko.ros@ki.si

ACTIVATED SLUDGE

JULY 21 - 23

The second international conference on Microorganisms in activated sludge and biofilm processes will be held at Berkeley in California, USA.

Enquiries: Professor David Jenkins, Microorganisms Conference, Department of Civil & Environmental Engineering, University of California at Berkeley, Berkeley CA 94720-1710, USA. Tel/Fax: 510 527-0672. E-mail: jenkins@ce.berkeley.edu

WATER

AUGUST 3 - 8

The 7th Stockholm water symposium will be held in Stockholm, Sweden.

Enquiries: Water Symposium Company, S-106 36 Stockholm, Sweden. E-mail: sympos@sth-wat.se Fax: +46 8 7362022. Tel: +46 8 7362021.

LARREN '97

AUGUST 25 - 28

An international conference on land reclamation and rehabilitation will be held in Penang, Malaysia.

Enquiries: Larren '97, School of Civil Engineering, Universiti Sains Malaysia, Perak Branch Campus, 31750 Tronoh, Perak, Malaysia. Tel: 605-3676901 ext 5412. Fax: 605-3677440.

IWRA

SEPTEMBER 1 - 6

The 9th world water congress of the International Water Resources Association (IWRA) will take place in Montreal, Canada. Theme: Water resources outlook for the 21st century - Conflicts & Opportunities.

Enquiries: Aly M Shady, Canadian International Development Agency, 200 Promenade du Portage, Hull, Quebec, Canada K1A 0G4. Tel: +1 (819) 994-4098 Fax: +1 (819) 953-3348 E-mail: aly-shady@acdi-cida.gc.ca

SEDIMENTS

SEPTEMBER 7 - 11

An international conference on contaminated sediments will be held in Rotterdam, the Netherlands.

Enquiries: Van Namen & Westerlaken Congress Organisation Services, PO Box 1558, 6501 BN Nijmegen, the Netherlands. Tel: +31 24 323 44 71. Fax: +31 24360 1159.

IRRIGATION

SEPTEMBER 8 - 12

The 48th meeting of the International Executive Council of the International Commission on Irrigation and Drainage (ICID) and the 18th Regional Conference on Irrigation and Drainage will be held in Oxford, England. Enquiries: Oxford Conference Management, 10b Littlegate Street, Oxford. OX1 1QT, United Kingdom.

IWSA

SEPTEMBER 20 - 26

The 21st International Water

Supply Association (IWSA) world congress and exhibition will be held in Madrid, Spain.

Enquiries: IWSA, 1 Queen Anne's Gate, London SW1H 9BT, United Kingdom. Fax: +44 (0) 171 222 7243. Tel: +44 171 957 4567. E-mail: IWSA@ dial.pipex.com

HYDROLOGY

SEPTEMBER 21 - 27

The 27th International Association of Hydrological Sciences Congress will take place in Nottingham, UK. Theme: Groundwater in the urban environment.

Enquiries: IAHS, Nottingham, United Kingdom. Fax: 0115 985 6612. Tel: 0115 985 6545.

CATCHMENT MANAGEMENT

SEPTEMBER 23 - 25

A seminar and workshop on integrated catchment and watershed management will be held at the University of New England in Australia.

Enquiries: John Pigram, Centre for Water Policy Research, University of New England, Armidale, NSW 2351 Australia. Tel: 067 73 2420. Fax: 67 733 327. E-mail: jpigram@metz.une.edu.au

HYDROLOGY

SEPTEMBER 25 - 27

An international symposium on emerging trends in hydrology will be held in Roorkee, India.

Enquiries: Dr DC Singhal, Professor and Organising Secretary (ISETH), Department of Hydrology, University of Roorkee, Roorkee-247667, India. Tel: (091) 1332 72349 (ext 336). Fax: (091) 1332-73560. E-mail: hydro@rurkiu.ernet.in

HYDROLOGY

SEPTEMBER 29 - OCTOBER 1

The second national conference on integrated catchment management: advancing integrated resource management - processes and policies will be held in Canberra, Australia.

Enquiries: ICM, 16 Larch Crescent, Mt Waverley Vic. 3149, Australia. E-mail: rbms @ vicnet.net.au Fax: +61 3 9802 2315.

HYDROLOGY

SEPTEMBER 30 - OCTOBER 3

The 3rd international conference on FRIEND: regional hydrology - concepts and models for sustainable water development will take

place in Postojna, Slovenia.

Enquiries: Ljubljana, Slovenia. Fax: 386 61219 987. E-mail: mitja.brilly@uni-lj.si Tel: 386-61-1254-333.

LANDFILL

OCTOBER 13 - 17

The sixth International Landfill Symposium will be held in Cagliari, Sardinia, Italy.

Enquiries: Ms Anne Farmer, CISA - Environmental Sanitary Engineering Centre, Via Marengo 34 - 09123 Cagliari (Italy). Tel: +39-70-271652. Fax: +39-70-271371. E-mail: cossur@vax.ca3.unica.it

DRINKING WATER

OCTOBER 16 - 19

An international conference on the management of drinking water resources will take place in Madras, India.

Enquiries: M Mariappan, Organising Secretary, Central Leather Research Institute, Adyar, Madras 600 020, India. E-mail: root@niclai.ernet.in Fax: 91 044 4911589. Tel: 91 044 4916351.

WEFTEC '97

OCTOBER 18 - 22

The American Water Environment Federation's 70th annual conference and exposition will be held in Chicago, Illinois USA.

Enquiries: WEFTEC '97 Program, 601 Wythe Street, Alexandria, Virginia 22314-1994 USA. Tel: 1-703-684-2452 Fax: 1-703-684-2471.

OZONE

OCTOBER 26 - 31

The 13th world congress of the International Ozone Association will be held in Kyoto, Japan.

Enquiries: Congress Corporation. Tel: +81 (6) 454 3740. Fax: +81 (6) 454 4711.

LAKES

OCTOBER 27 - 31

The 7th ILEC international conference on the conservation and management of lakes will be held in San Martin de los Andes, Argentina.

Enquiries: Instituto Nacional de Ciencia y Tecnica Hidricas, CC No 46, 1802 Aeropuerto Ezelza, Prov. de Buenos Aires, Argentina. Tel: +54 1 480 0867. Fax: +54 1 480 0094.

IWEX '97

The international water and effluent treatment exhibition, IWEX '97, will be held in Birmingham,

UK.

Enquiries: Tom Tebbat, Exhibition Director, Turret Group Plc, 171 High Street, Rickmansworth, Herts, WD3 1SN, United Kingdom. Fax: +44 1932 221346. Tel: +44 1932 228577.

WATER QUALITY

FEBRUARY 25 - MARCH 1

The first international specialised conference on water quality and its management will be held in New Delhi, India.

Enquiries: CVJ Varma, Central Board of Irrigation & Power, Malcha Marg, Chanakyapuri, New Delhi 110021, India. Tel: +91 11 3015984. Fax: +91 11 3016347. E-mail: cbip@cbipdel.uunet.in

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CHLORINATED COMPOUNDS

MAY 18 - 21

The first international conference on remediation of chlorinated and recalcitrant compounds will be held in Monterey, California, USA.

Enquiries: The Conference Group, 1989 West Fifth Avenue Suite 5, Columbus, Ohio 43212-1912 USA. Tel: 614-424-5461. Fax: 614-488-5747. E-mail: 102632.3100@compuserve.com

MEMBRANE SCIENCE

JUNE 9 - 12

An international conference on membrane science and technology (ICMST '98) will be held in Beijing, China.

Enquiries: Mrs Yanqiao Shi, ICMST'98, c/o Institute of Chemistry, Chinese Academy of Sciences, Zhongguancun, Beijing 100080, China. Fax: +86-10-62569564 OR: 62559373.

IAWQ

JUNE 21 - 26

The 19th biennial conference of the International Association on Water Quality will be held in Vancouver, BC Canada.

Enquiries: IAWQ, Duchess House, 20 Mason Yard, Duke St., St James's, London SW1Y 6BU, United Kingdom. Tel: 44 (0) 171-839 8390. Fax: 44 (0) 171-839 8299.

WISA-MTD

WORKSHOP AND SYMPOSIUM

MEMBRANES IN YOUR INDUSTRY

21 - 24 October 1997

**Badplaas Aventura,
Mpumalanga**

The theme will be new developments in membrane processes and industrial applications. The membrane course will also provide the opportunity to learn the following about membrane processes: operating principles; comparative advantages and limitations; pretreatment requirements; performance evaluation or 'how to keep a finger on the pulse' of a membrane process. The course should enable managers, engineers and technicians to make informed decisions about membrane processes, their application and maintenance.

Preliminary Programme

Day I (October 2) - Courses

- 07:30-08:00 Registration for courses
08:00-16:00 Course I: Membrane processes: Key issues for successful application
08:00-12:30 Course II: Introduction to Minteq A2 Chemical Speciation programme
14:00-17:00 Course III: Introduction to Memsep membrane modelling program
16:00-18:00 Registration for Workshop and Symposium
18:00-19:30 Meet and greet
19:30 WISA-MTD Annual General Meeting

Day II (October 22) - Symposium

- 08:00-13:30 Theme: New developments in membrane processes
15:00-19:30 Poster presentations

Day III (October 23) - Symposium/workshop

- 08:00-13:30 Theme: Industrial applications
15:00-17:30 Unstructured discussions
18:00-19:30 Strategic planning session to identify problem areas and research needs.

Day IV (October 24) - Technical tours

- Technical tours to any two of the following membrane plants (own transport):
- Mondi Paper Mill (Piet Retief): TUF, SWRO, IX
 - ESKOM Tutuka (Standerton): EDR
 - Sasol (Secunda): EDR, TRO
 - Columbus Steel (Middelburg): SWRO

(TUF: tubular UF / SWRO: spiral-wrap RO / IX: ion exchange / EDR: electro-dialysis reversal / TRO: tubular RO).

Registration fees

Day I:	Membrane course I	R750
<i>Provisional fee includes a copy of the book: Water treatment membrane processes. 1996. Ed. J Mallewaile, PE Odendaal and MR Wiesner McGraw-Hill.</i>		
Day I	Membrane courses II & III	R150
Day II, III, IV	Workshop:	
	Students	R100
	WISA members	R250
	Non WISA members	R300

Registration fees include automatic WISA-MTD membership for 1988.

Accommodation

Accommodation has been reserved at Badplaas Aventura by WISA-MTD. A registration form for accommodation can be obtained from the WISA-MTD secretary. Participants must make use of this form to reserve their accommodation, and payments for accommodation must be forwarded directly to the resort management.

Further information

Dr Ed Jacobs (Secretary WISA-MTD)

Institute for Polymer Science
University of Stellenbosch
PO Matieland,
Stellenbosch
7602

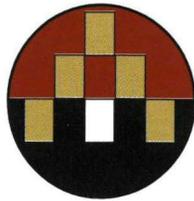
Fax: (012) 808 4967
Tel: (021) 808 3178
e-mail: epj@land.sun.ac.za

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TECHNIKON



PRETORIA

Department of Physical Resources: **Water Care**

Technikon Pretoria offers the following tertiary tuition programs in Water Care:

Students attend classes on a block release basis; four block weeks during each semester (approximately one week per month).

National Certificate (Year 1)

National Higher Certificate (Year 2)

National Diploma (Year 3)

B Tech Degree (Duration: 2 Years - Starting 1998)

EMPLOYERS PLEASE HELP!

We are urgently seeking employers who can assist in offering temporary placement of unemployed (private) students for completion of their experiential training modules (2 x 6 months practical experience).

SHORT COURSES

OPTIMISATION OF A POTABLE WATER PURIFICATION PLANT

(Pretreatment, Chemical Dosing, Settling, Filtration, Disinfection, Distribution, Record Keeping)

DATE: 27-31 October 1997

CLOSING DATE: 13 October 1997

FEE: R1 500,00

COOLING AND BOILER WATER TECHNOLOGY

(Corrosion, Cooling Water, Boiler Water, Water Treatment Analysis)

DATE: Part Time on a block basis: July - November 1997

CLOSING DATE: 7 July 1997

FEE: R600,00

BASIC CHEMICAL WATER ANALYSIS

(Laboratory Techniques, Sampling, Data Processing, Calculations, Analytical Procedures, Practicals)

DATE: 1-5 December 1997

CLOSING DATE: 17 November 1997

FEE: R1 500,00

ENQUIRIES: Mochzell Potgieter, Department Physical Resources, Technikon Pretoria, Private Bag X680, Pretoria 0001. Tel: (012) 318-6232. Fax: (012) 318-6233.