SA waterbulletin

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WET AND DRY COOLING
WRC report to help industry select the most effective cooling system

VLOEDE
Nuwe rekenaarprogram ontwikkel vir vloedskadebepaling

WASTE WATER
Researchers develop criteria for the co-disposal of sludge liquor and domestic refuse

SANCIAHS/SAICE CONFERENCE '97

17 - 19 November 1997 ▼ Conference Centre ▼ ***University of Pretoria.***

Theme

Integrated hydrological sciences for sustainable water resources management in Africa.

Objectives

The need to recognize the holism of the hydrological cycle and to achieve sustainable development of water resources through integrated management (quantity and quality, all water, the water environment, catchments etc.) have become key principles in the South African water law review. This poses major challenges to hydrologists in terms of a more integrated approach towards their science in research and application.

The Conference will focus on improved understanding of the hydrological cycle and the application of this understanding towards sustainable development of our limited water resources. Of particular interest will be:

- ❑ the hydrological regime in different geographical settings (understanding and quantification);
- ❑ geographical and spatial characterization of water resources;
- ❑ hydrological networks (design, adequacy, integration, results);
- ❑ methods of water resources assessment;
- ❑ approaches to deal with uncertainty and heterogeneity;
- ❑ integration of research and decision making;
- ❑ international river basins; information requirements.

We need to refocus our research and development on the range of knowledge and information requirements for sustainable development, eg. for:

- resource assessment at different scales;
- water allocation for competing uses;
- water use control;
- catchment management;
- community water supply;
- water resource protection;
- water resource enhancement;
- environmental impact assessment; and
- conjunctive use.

Water supply and sustainable development of scarce water resources are at the top of the political agenda of many African countries. It is essential that the hydrological sciences are focused on this need and that African countries share their expertise in this regard.

Organisers

The Eighth Biennial SANCIAHS Conference will be organized jointly by SANCIAHS and the Water Division of the South African Institute of Civil Engineers. Mr Hugo Maaren of SANCIAHS and Prof Faan van Vuuren of SAICE will be on the organising committee.

Conference format

The Conference will only have plenerary sessions (no parallel sessions) to allow for integration across disciplinary fields. Presentation of posters will be strongly encouraged in order to cover the full spectrum of the hydrological sciences.

A series of courses will be run back to back with the Conference. Ideas are invited from SANCIAHS or SAICE members who would like to present a course.

A single key note address and about 40 papers will be presented during $2^1/_2$ days (Monday - Wednesday morning).

Paper deadlines

- ❑ Deadline for abstracts:
  30 April 1997
- ❑ Final papers (in electronic format):
  15 September 1997

Cost

- ❑ Registration fee:
  Approximately R500.00
  (excluding accommodation)

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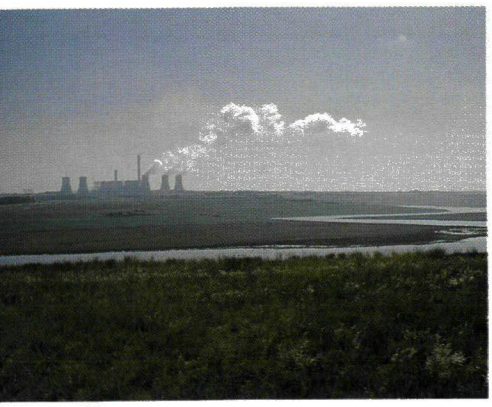

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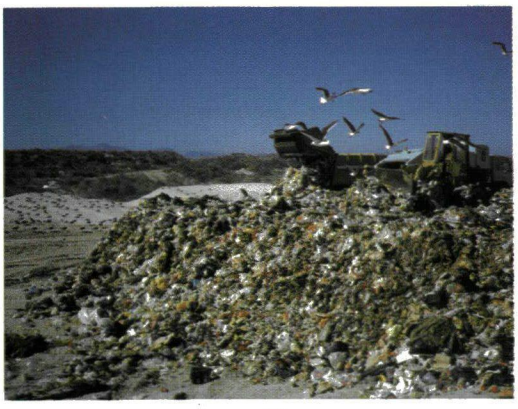

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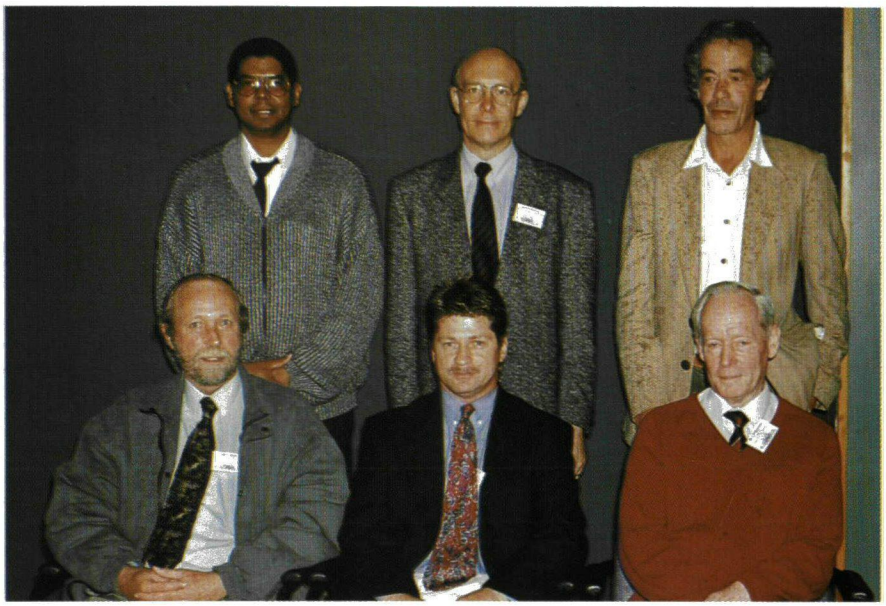
Cover: The Matimba dry-cooled power station near Ellisras. (Photo: Eskom Photographic Services)

SA Waterbulletin is a two monthly magazine on water and water research published by the South African Water Research Commission (WRC), a statutory organisation established in 1971 by Act of Parliament. Subscription is free. Material in this publication does not necessarily reflect the considered opinions of the members of the WRC, and may be copied with acknowledgement of source. Editorial offices: Water Research Commission, PO Box 824, Pretoria 0001, Republic of South Africa. Tel (012) 330-0340. Fax (012) 331-2565. Editor: Jan du Plessis (E-mail: Jan@wrc.ccwr.ac.za). Asst Editor: Helene Joubert (E-mail: Helene@wrc.ccwr.ac.za). Ed Secretary: Rina Human (E-mail: Rina@wrc.ccwr.ac.za). Layout: Chilli Design (012) 345-1155. Colour Separations: Lithotechnik. Printing: Beria Printers.

Experts and Practitioners discuss Treatment of Cape Coloured Waters

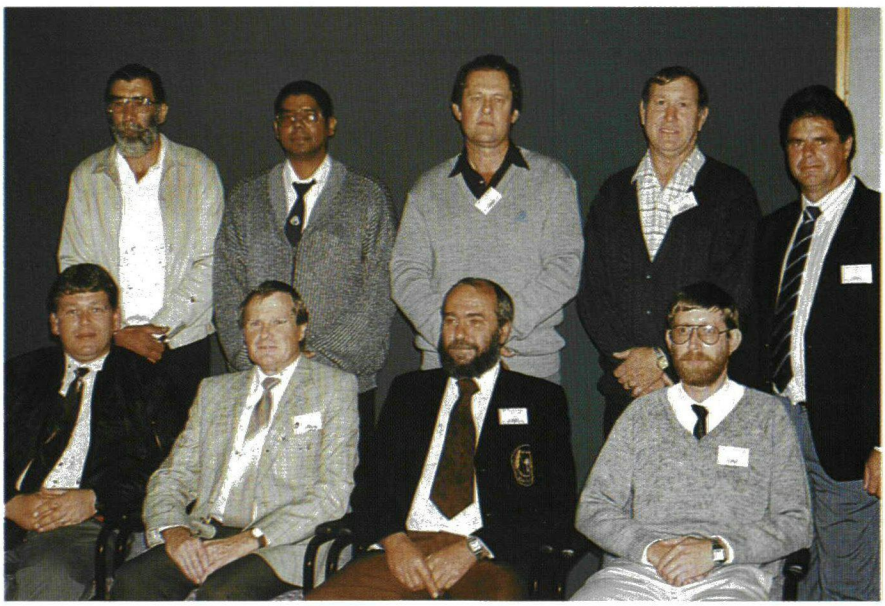
A seminar/workshop on the Treatment of Coloured Water for Potable Use was held in Mossel Bay from 21-23 October 1996. The need for technology and information transfer on this subject to researchers, design engineers, and in particular to water suppliers, became apparent from a Water Research Commission (WRC) project designated to draw up guidelines for the treatment of coloured water.



Keynote speakers and presenters of papers during the first session were: Front, from left: Mr Ian Reid (Ninham Shand), Mr Chris Swartz (Organiser), Mr Ian Morrison (City of Cape Town). Back, from left: Mr Tony Bowers (National Chairman, WISA - Water Care Division), Dr Gerhard Offringa (WRC), Prof Dick Loewenthal (University of Cape Town).

The seminar/workshop was divided into four sessions, the first being an overview of the nature, character and occurrence of coloured water in South Africa, and the treatment options available for treating these coloured surface waters. This was presented by specialists in the field of coloured water treatment. The second session consisted of presentations on various treatment plants and the experiences of a number of municipalities along the Cape south coast, including Cape Town, Mossel Bay, George, Knysna, Plettenberg Bay, and Port Elizabeth, as well as Overberg Water. These presentations proved to be very interesting and stimulated discussion with regard to the peculiar problems encountered in practice in the treatment of these waters.

The third session was a strategic planning session facilitated by the WRC, during which the needs for research and training in this field were listed and prioritised. The seminar/workshop was concluded with visits to the Kleinbrak Water Purification Plant of the Mossel

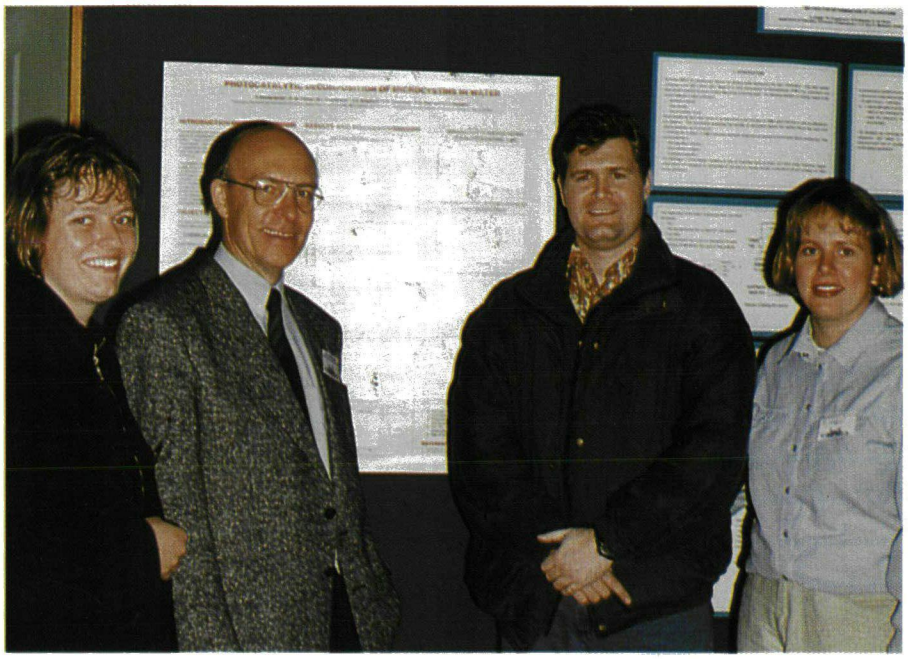


Presenters of papers during the second session, from various municipalities: Front, from left: Mr Steven Smuts (Knysna), Mr Graham Devey (Port Elizabeth), Mr Piet Pretorius (George), Mr Sarel Pieterse (Cape Town). Back, from left: Mr Johan Tegmann (Joubertina), Mr Tony Bowers (WISA), Mr Deon Kitshoff (Overberg Water) Mr Johan Jacobs (Mossel Bay), Mr Pikkie Lombard (Plettenberg Bay).

Bay Municipality, and the relatively new George Water Purification Plant. An interesting aspect of these two plants are that they treat surface water with some of the highest colour levels in the world!

The event was attended by 105 delegates which included researchers, consulting engineers, consultants, Department of Water Affairs and Forestry, Water Boards, provincial and local authorities, as well as equipment and chemical suppliers, from around the country. It was jointly presented by the CSIR Environmentek, the WRC and WISA Water Care Division.

Feedback of the valuable input gained from delegates during the workshop will be given, along with the discussion of guidelines, during training sessions in Cape Town, George and Port Elizabeth planned for the first half of 1997.



Students of the University of Stellenbosch at their poster presentations, together with Dr Gerhard Offringa of the Water Research Commission.

STANDER LECTURE EVENING

The 1996 commemorative Stander Lecture was presented by the honoured and accomplished aquatic scientist, Professor emeritus Brian Allanson (Rhodes University). His paper was entitled "Water management and the vexed question of carrying capacity". The other speakers at this prestigious evening were Professor Chris Buckley (University of Natal), who presented a paper on "French/South African cooperation in water research", and two young leading researchers holding WRC fellowships. Mr Winston Leukes discussed "The Membrane Gradostat Reactor: a new approach to bioremediation" and Mr Grant Mackintosh discussed "Stabilisation of soft acidic waters with limestone".

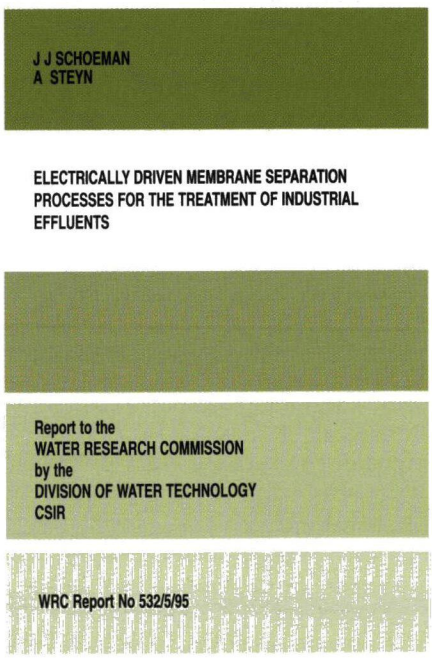
At the Stander Lecture Evening: Dr FC Viljoen (Vice-president, WISA), Prof CA Buckley, Mr W Leukes, Dr SA Mitchell (President, WISA), Prof BR Allanson, Mr DJ Bosman (Director, WISA) and Mr G Mackintosh.

WRC report highlights advantages of electrically driven membrane separation processes for industry

The implementation of electrically driven membrane separation processes such as electrodialysis (ED) and its variants into the South African market place will lead to better pollution control, water savings, resource recovery and effluent volume reduction. This is the view expressed by two researchers from the Division of Water Technology at the CSIR in a report to the Water Research Commission on the use of these processes for the treatment of industrial effluents.

The report, compiled by JJ Schoeman and A Steyn who carried out the research, offers the following to potential users of ED technology:

- **It presents the basics of electrically driven membrane separation processes for effluent treatment;**
- **It presents process design criteria for treatment of nickel and chrome bearing effluents with electrodialysis and electro-electrodialysis;**
- **It presents process design criteria for treatment of spent pickling acid; sodium nitrate; sodium sulphate and sodium acetate effluents with bipolar electrodialysis; and**
- **It shows the economics of electrodialysis and bipolar electrodialysis for the treatment of industrial effluents.**



Copies of the report entitled **Electrically driven membrane separation processes for the treatment of industrial effluents** (WRC Report 532/5/95) can be obtained free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 20).

Electrically driven membrane separation processes such as electrodialysis (ED) and its variants - electrodialysis reversal (EDR); electro-electrodialysis (EED); and bipolar electrodialysis (BED) are technologies that are suitable for the reclamation of water and chemicals from industrial effluents.

The conventional ED and EDR processes, for example, are applied successfully in overseas countries for the desalination of brackish waters for potable use. In South Africa the EDR process is applied at Tutuka Power Station for the treatment of cooling tower blowdown for water recovery and effluent volume reduction.

Conventional ED is successfully applied in Japan for treatment of nickel rinse water in the electroplating industry for nickel and water recovery from electroplating rinse waters. Conventional ED also has the potential to be applied for the treatment of chromium, cadmium, copper and zinc electroplating rinse waters for water and chemical recovery. Electro-electrodialysis can be used for the recovery of chromium from spent chromium plating baths and rinse waters in the electroplating industry.

Bipolar electrodialysis (BED) is applied in the USA for acid recovery (nitric and hydrofluoric) from spent pickling acid produced in the steel manufacturing process. Bipolar electrodialysis technology has the potential to be applied for:

- Regeneration of waste ion-exchange regenerant;
- Acid recovery from spent battery acid;

The electrodialysis pilot plant used in this study.

- Acid and caustic soda recovery from sodium sulphate and sodium nitrate effluents;
- Purification of acids and bases;
- Organic acid (acetic; citric and amino) recovery from industrial effluents.

OBJECTIVES

The main objectives of this investigation were to:

- Evaluate ED for treatment of nickel and chromium rinse waters for metal and water recovery;
- Evaluate EED for treatment of chromium drag-out for chromium recovery;
- Evaluate BED for the regeneration of waste ion-exchange regenerant;
- Evaluate BED for acid recovery from spent pickling acid effluent;
- Evaluate BED for acid and caustic soda recovery from sodium sulphate, sodium nitrate and sodium acetate effluents;
- Determine the economics of the processes.

RESULTS

The researchers say in the report nickel drag-out can be treated cost-effectively with ED for nickel and water recovery in the electroplating industry. A plant payback period of approximately two years is possible. Pilot studies on nickel drag-out showed that nickel in the ED feed could be concentrated from 3,5 g/*l* to approximately 28 g/*l* in the ED brine. Nickel recovery rates varied between 0,83 and 1,0 kg Ni/m²/d. Full-scale ED nickel/water recovery plant data showed that a nickel concentration level of approximately 50 g/*l* could be reached in the ED brine. Approximately 97 per cent of the drag-out can be recovered for reuse. Therefore, ED can be effectively applied as a metal/water recovery technology in the electroplating industry.

Chromium can be recovered from chromium rinse water with ED. Chromium in the ED feed could be concentrated from 1 300 mg/*l* to 6 900 mg/*l* in the brine. Brine volume comprised approximately 20 per cent of the treated feed water volume. Therefore, effluent volume can be significantly decreased for subsequent further treatment of the ED brine for chromium removal with conventional precipitation technology. The chromium concentration level of the ED product is high (approximately 400 mg/*l*). Ion-exchange treatment will be required to reduce the chromium level in the ED product to low concentration levels (< 0,1 mg/*l*). Electrical energy consumption for chromium recovery/ removal was high (3,1 to 8,7 kWh/kg Cr). Chromium recovery rate varied between 0,12 and 0,26 kg Cr/m²/d.

It appears that it should be possible to use the EED process effectively for chromium recovery from chromium drag-out for reuse in the plating bath. Chromium could be concentrated from 48 g/*l* (CrO3) to 240 g/*l* (CrO3) in the EED product. This concentration level is of sufficient strength for direct reuse in the plating bath. Electrical energy consumption, however, was high (38 kWh/kg Cr). Membrane life time and the economics of the process are unknown. However, it appears that this process will be too expensive for the electro-

plater to use. Further work will be required to evaluate this process properly for treatment of chromium drag-out.

The bipolar electrodialysis process appears to function effectively for treatment of spent pickling acid effluent for acid recovery for reuse in the pickling process. A nitric acid concentration level between approximately 2,0 and 2,5 mol/*l* could be obtained with ease. Hydrofluoric acid recovery, however, was poor when the nitrate concentration level in the feed water was high. However, the hydrofluoric acid concentration level in the acid product increased dramatically when most of the nitrate was removed from the feed. A hydrofluoric acid concentration level of approximately 2,5 mol/*l* could be obtained towards the end of a run. Almost no effluent will be produced when BED is used for treatment of spent pickling acid effluent. All the chemicals produced in the process (acids and bases) can be reused in the process itself or in the pickling process. Consequently, the BED process should be the ideal solution to solve the spent pickling acid effluent problem experienced by stainless steel manufacturers. A combination of the diffusion dialysis and BED processes will function more effectively than BED alone for treatment of spent pickling acid effluent. This, however, will depend on the quality of bound or complexed acids present in the spent pickling acid effluent. It appears that there is a significant amount of bound acid present in spent pickling acid effluent.

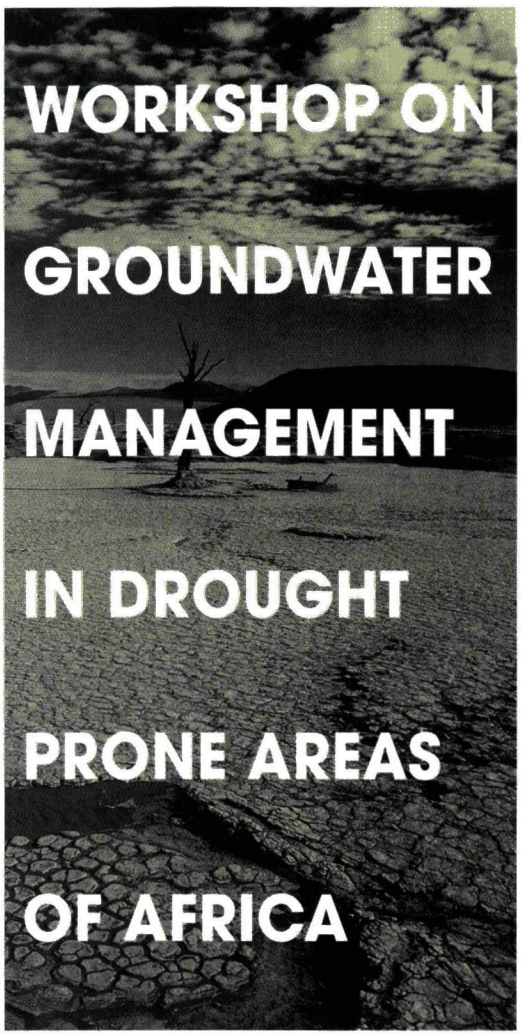
A bipolar electrodialysis cell.

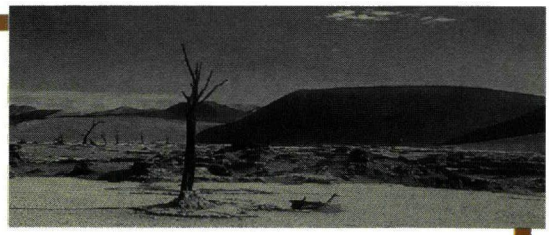
MEMBRANE FOULING

Membrane fouling can lead to the failure of membrane separation process for effluent treatment. The fouling potential of the effluent for the BED membranes should therefore be determined through long-term laboratory or pilot studies. This will ensure that proper process design criteria will be developed for treatment of the spent pickling acid effluent. Preliminary results have shown that the capital cost for a 1 750 *l*/h BED plant for treatment of spent pickling acid will amount to approximately R14,8 million. The annual membrane cost will amount to approximately R2,7 million. Preliminary results have shown that the capital cost for a combination of the diffusion dialysis and BED processes for a 1 750 *l*/h plant will amount to approximately R11,5 million. (R2,3 million for diffusion dialysis and R9,2 million for BED). Operating expenses for the diffusion dialysis process will amount to R1,3 million for membrane replacement (annual cost), approximately R35 000 for spare parts for pumps and approximately 14 kW electrical energy will be used in the process. Operating expenses for BED will amount to approximately R1,4 million for membrane replacement (annual cost) and approximately 1 290 kW electrical energy will be consumed in the process.

Preliminary tests showed that it would be possible to convert sodium nitrate effluent effectively into nitric acid and caustic soda with the BED process. Acid and caustic soda concentration levels of approximately 2 mol/*l* could be obtained with ease when sodium nitrate solution (approximately 10%) was treated with BED. Electrical energy consumption for acid production was determined at approximately 2 000 kWh/ton acid. Electrical energy consumption for caustic soda production was determined at approximately 3 000 kWh/ton caustic soda. The capital cost for a BED plant to treat 3 600 kg per day sodium nitrate solution (10 to 15%) is estimated at R1,6 million. This cost excludes membranes, at an estimated cost of R72 000/set, with a one year life time and any pretreatment or site specific cost. The expected DC power consumption would be 27 kW.

The researchers say that it would also be possible to convert sodium sulphate effluent effectively into acid and caustic soda with BED. Acid and caustic soda concentration levels of approximately 2mol/*l* could be obtained with ease when sodium sulphate solutions (approximately 10 and 20%) were treated with BED. Electrical energy consumption for acid production varied between approximately 3 800 and 4 600 kWh/ton acid. The electrical energy consumption for base production varied between approximately 3 500 and 6 500 kWh/ton caustic soda. Current efficiency was lower than expected and this matter warrants further investigation, say the researchers.





27 and 28 February 1997

Lilongwe, Malawi

THE PROJECT TEAM:

- Hydrogeology Group of the British Geological Survey
- Malawi Ministry of Irrigation and Water Development
- South African Department of Water Affairs and Forestry
- Ghana Water and Sewerage Corporation
- UK Institute of Hydrology

THE ISSUES:

The historical and present groundwater drought experience in Malawi, the Northern Province of South Africa and the northern region of Ghana highlight some of the major difficulties facing the donor agencies and government departments. These include the obvious shortcomings of drought relief programmes, lack of routine monitoring and the need for longer term analysis and assessment of resources.

WHO SHOULD ATTEND:

Invitations are being sent to all the relevant Government agencies in Southern Africa, and to all the NGOs known to be involved in the water sector in this region. Researchers, consultants and contractors will also benefit from the presentations and the discussion sessions. The Workshop will additionally focus on establishing a network of interested parties, and will identify how, and by whom, the implementation of drought relief strategies should progress

ENQUIRIES:

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Save water with air-cooled heat exchangers

"Large quantities of water are presently required for cooling in the power, chemical, petro-chemical, process and other industries. For example, approximately 2*l* of water are evaporated to generate 1 kWh of electrical energy i.e. to allow 10 bulbs of 100 W each to burn for one hour," says Professor DG Kröger from the Department of Mechanical Engineering at the University of Stellenbosch in a report to the Water Research Commission in which he evaluates the performance of wet and dry cooling towers.

He says the main objective of this study, funded by the Water Research Commission, was to supply information that is required to make an informed decision as to the most effective cooling system that should be selected for a certain plant, taking into consideration technical, environmental and cost factors.

"Three computer programs have also been prepared for the performance evaluation of three different types of cooling systems (direct dry-cooling, indirect dry-cooling and wet-cooling). With the available information it is, however, possible for an engineer to prepare similar programs for the many different types or combinations of industrial air-cooled systems as found in practice."

Copies of the report entitled **"Cooling tower performance evaluation"** (WRC Report 478/1/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 40).

In view of the very extensive theoretical and experimental work that has been done, it is now possible to evaluate the performance characteristics of large industrial cooling systems to a high degree of accuracy.

With this information, the report says, it is possible to design cooling systems, or to evaluate critically, systems to be purchased by South African industries. Improved new designs catering for the particular needs of a plant in a particular area can lead to enhanced performance, e.g. less or no cooling water is required for generating power, producing steel or chemicals. The cooling systems of existing plants can be modified and improved to increase electrical output and other products at lower costs. New plants can be located in areas where no water is available or which is ecologically sensitive and where pollutants cannot be discharged.

According to the report the programs have already been used by ESKOM to evaluate cooling system performance locally and internationally where no such facilities were available in the past.

"If correctly applied, the degree of accuracy possible in predicting cooling system performance is exceptional.

"For example, the present program for natural draught dry cooling towers was employed to predict the performance of a dry-cooling tower at the Kendal power plant and it was found that the prediction of the heat rejection rate was within 1.5 per cent of the measured value!"

The contents of the report is structured as follows:

■ **Air-cooled heat exchangers and cooling towers** (Chapter 1)

In this chapter the reader is introduced to the many different types of wet and dry cooling systems that are found in practice.

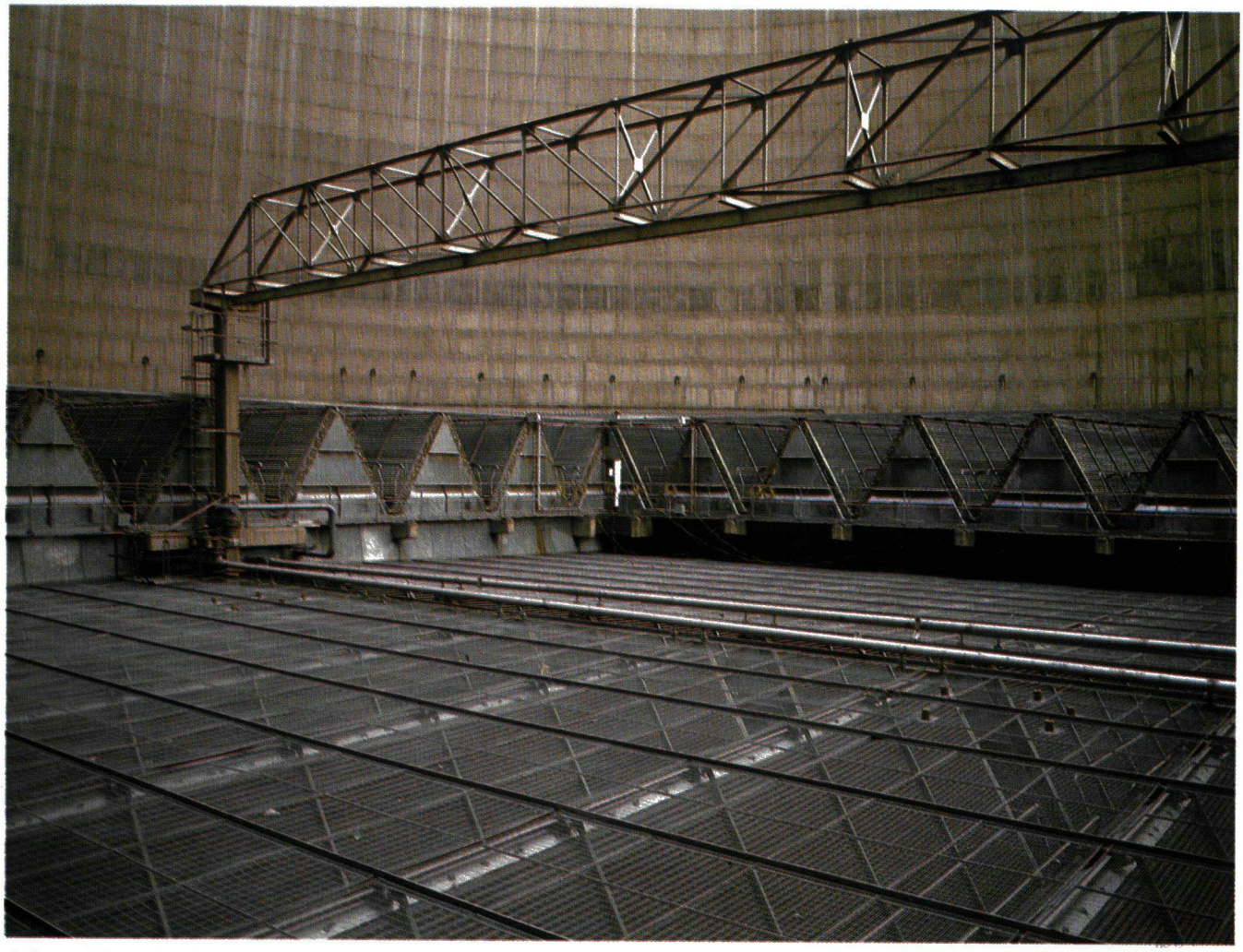
Mechanical draft wet-cooling towers can be either of the induced or forced draft type. Although technical considerations usually dictate the choice of a particular cooling system, historic and other local factors have often in the past played a major role in the selection of the type of cooling system.

Mechanical draft cooling towers can be quite small (both induced draft and forced draft) but very large induced draft single cell units (fans of up to 15 m in diameter) or multi-cell units of different geometries have been constructed. The fill may be arranged for cross-flow or counter-flow. While counter-flow units may require more cooling water pumping power, cross-flow units tend to be more sensitive to winds.

Where very large cooling plants are required, hyperbolic concrete natural draft cooling towers become an attractive alternative. Although they may initially be more expensive than mechanical draft systems, no fan power is required. In very windy areas counter-flow arrangement of the fill is preferred as is the case in most large cooling towers in South Africa. Although many large cross-flow cooling towers are in operation throughout the world, there does appear to be a trend towards the counterflow arrangement.

In areas where cooling water is expensive or not available, air-cooled heat exchangers become cost effective. Although air-cooled heat exchangers have found application in the petro-chemical and process industries for many years, they have only during the last few years become more common at power plants. This is particularly so in the case of combined cycle plants and to a lesser extent at very large base load plants.

Dry-cooling plants may be of the direct or indirect type. In the case of the for-



A-frame air-cooled heat exchangers.

mer, steam is ducted directly from the turbine exhaust to the mechanical draft air-cooled condenser. This configuration is attractive in areas where fuel costs are low or the power plant is relatively small. The largest of these types of cooling systems are found at respectively the Matimba and Kendal power plants in South Africa.

In areas where a limited amount of cooling water is available, dry/wet cooling systems have been constructed. The most successful of these systems are the Heller type cooling towers incorporation spray or jet condensers and auxiliary evaporative coolers for more effective power plant operation during exceptionally hot periods. These systems also include mechanical draft evaporative preheater/peak coolers which make operation possible during sub-zero ambient conditions and assist in enhancing performance when ambient temperatures are high.

The fundamental conservation equations of mass, momentum and energy form the basis for solving fluid flow and heat transfer problems. The characteristics of these equations are discussed and they are presented in a form that makes them applicable directly to the performance evaluation or thermal-flow design of cooling systems.

■ **Fluid mechanics** (Chapter 2)

This chapter introduces certain fundamental fluid dynamic concepts and relations that are essential for the flow dynamic design of cooling systems. The basics relevant to viscous flow are presented primarily to define much of the terminology used in later chapters. Details are given for flows in differently shaped ducts (round, elliptical, flattened) as they occur in practical heat exchangers.
Equations relevant to both laminar and turbulent flows are presented. The dependence of these equations on thermo-physical properties, especially when operating under non-adiabatic conditions are elaborated on.

Reference is also made to different studies concerning the flow characteristics in heat exchanger manifolds. Drag coefficients are listed for different geometries and loss coefficients are given for screens and gauzes (protective screens in fan systems or for protection against hail).

■ **Heat transfer** (Chapter 3)

The fundamentals of heat transfer that are relevant to the performance evaluation or design of cooling systems are presented.

Details of conduction in cartesian and cylindrical coordinate systems are given. The concepts of convective and

overall heat transfer coefficients are defined.

Analytical and empirical equations for determining the convective heat transfer coefficient under laminar, transitional and turbulent flow conditions in different geometries are presented.

The influences of secondary flow patterns due to buoyancy effects on these transfer coefficients are described.

With the information available on conduction and convection heat transfer, it is possible to evaluate the performance of different extended surfaces or fins. Simplified equations are also presented for design purposes.

The fundamentals of condensation heat transfer are treated in considerable detail since they are of relevance in the design of air-cooled steam condensers. A number of useful equations that quantify the transfer coefficient and the pressure drop inside ducts are presented. Many of these equations are new and were developed during this research project. Some of these results will undoubtedly result in the improved design of air-cooled steam condensers in future.

The transfer equations are incorporated in the definition of the logarithmic mean temperature and the effectiveness - NTU methods as applicable in the design of heat transfer equipment.

■ **Mass transfer and evaporative cooling** (Chapter 4)

In this chapter psychrometric principles are applied in the performance evaluation of cooling towers, evaporative coolers and systems incorporating adiabatic pre-cooling. Since there is usually both a heat and mass transfer process between air and some wetted surface, information on mass transfer is presented. Because of the analogy that exists between momentum, heat and mass transfer, there is a similarity in the equations employed.

A series of empirical equations describing the mass transfer coefficient in different geometries is presented. The origin of the psychrometric chart and its different characteristic curves are described.

A detailed deduction of the fundamental equations that are relevant to the design of evaporative coolers is presented. The analysis is applicable to both cross-flow and counterflow coolers. Various empirical equations for the relevant transfer coefficient and pressure loss coefficients are given.

A significant amount of cooling occurs in the rain zone of a wet cooling tower. A detailed analysis is presented which ultimately results in an expression for the transfer coefficient as a function of among other parameters, the mean droplet diameter in the rain zone.

This new equation as well as more sophisticated equations with which the transfer coefficients can be predicted in circular and rectangular rain zones were developed as part of this research project.

To reduce losses of cooling water to the environment, droplet or drift eliminators are installed above or after the fill in a wet cooling system. The performance characteristic of different eliminators were determined experimentally and correlations are presented for use in the design of cooling towers.

To enhance the performance of dry cooling systems during periods of high ambient temperature, spray or adiabatic pre-cooling of the air may be considered. Details of how adiabatic pre-cooling will affect the performance of a cooling system are given.

■ **Heat transfer surfaces** (Chapter 5)

The most expensive and most critical component of any air-cooled heat exchanger is the heat transfer surface area. Owing to the relatively low heat transfer coefficient on the air-side, extended surfaces or fins are required to increase the surface area density, thereby improving the overall conductance, resulting in a lighter and more compact heat exchanger.

The performance characteristics of extended surfaces are normally determined under idealised conditions in windtunnels designed specifically for this purpose. Details of how such surfaces should be tested as well as different procedures for interpreting the results are presented. A novel new method for presenting the results is proposed. This method has in general been well received by individuals involved in evaluating the performance of heat exchanger test bundles. A detailed numerical example is presented to show how the method is to be applied.

Further empirical equations are presented with which the air-side heat transfer coefficient as well as the pressure drop for different fin geometries and tube layouts can be evaluated. Tube row correction factors are also given.

To ensure good performance of finned tubes it is important that the thermal contact between the fin and the outer tube surface is sound. Poorly wrapped-on or extruded fins have been found to be quite unacceptable for application in large cooling systems. Even in the case of galvanised finned tubes great care must be taken during the galvanising process to ensure a cavity free region between the fin and the tube.

A detailed study was conducted to determine the influence of free stream turbulence on the performance of finned tube heat exchanger bundles. It was clearly shown that high turbulence in the upstream air can considerably increase the effective heat transfer coefficient.

■ **Fans** (Chapter 6)

Different types of fans find application in air-cooled heat exchangers and evaporative coolers including axial-, centrifugal, mixed- and cross-flow types. Since the fan is a critical component of the air-cooled heat exchanger its selection and incorporation in the design of the total cooling system is very important. When selecting a fan for a particular application, factors such as cost, performance (stability of operation, ease of control, power consumption, flow range), mechanical arrangement (convenience of installation), self-cleaning blade properties and noise emission must be taken into consideration.

The performance characteristics of fans are determined in test facilities that must comply with specifications as set out in one of many codes or standards. An example of a particular test facility is described in detail and particulars are presented whereby test data obtained in such a facility can be evaluated to give the performance characteristics of a particular fan.

A detailed study was conducted to determine the influence of the fan tip clear-

ance on performance. Results show that a large tip clearance can have a very negative effect and that every effort should be made to minimise tip clearance.

When installing a fan in a practical installation the interaction of the structure with the fan (fan system effect) usually reduces fan performance. Results are presented with which this effect can be quantified. Details of plenum losses and shroud effects are also presented.

■ **Natural draft cooling towers** (Chapter 7)

Natural draft cooling towers are found in power plants throughout the world. Different shapes and types of structures exist, but their fundamental function is the same, i.e. to create, by means of buoyancy effects, the flow of air through the fill or bundles of finned tube heat exchangers.

An analysis is presented for the evaluation of dry cooling towers having the heat exchanger bundles located horizontally in the base of the tower or vertically along its periphery. The analysis presented in this chapter is by far the most detailed of any work to date and incorporates much new design information that was generated during this investigation and was not previously available.

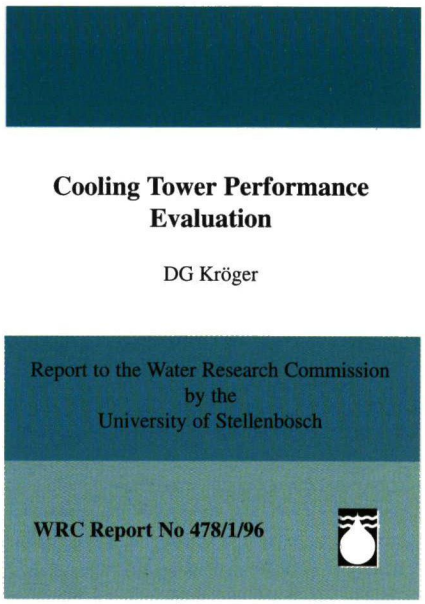
Among the new information is an extensive experimental investigation into the inlet losses and flow distribution in cooling towers. Outlet conditions were also investigated numerically.

The problem of cold air inflow into the top of the cooling tower is also addressed. Different models are presented with which the onset of cold inflow can be determined. With this information it is thus possible to design a cooling tower such that cold inflow does not occur.

■ **Air-cooled heat exchangers** (Chapter 8)

In this chapter the reader is introduced to different types of air-cooled heat exchangers as found in various industries. The geometric characteristics of typical air-cooled heat exchangers as found in the petro-chemical industry are described and performance analyses for forced and induced draft units are presented. This section is followed by an analysis of an air-cooled condenser as found in direct dry-cooled power plants. These analyses are the most sophisticated methods presently available and incorporate all the newest research results obtained during this study.

A section is given to the description of the problem of the presence of non-condensables in steam condensers. Various types of dephlegmator or de-aerator concepts are described and their merits are evaluated.



In any successful design of an industrial air-cooled heat exchanger details must be available whereby inlet losses to the heat exchanger can be quantified. Extensive tests were conducted during the project in order to quantify these losses. New empirical equations are presented for this purpose. These equations take into consideration fan platform height, walkway width, inlet roundings, fan unit width, etc.

In addition to inlet flow losses recirculation of hot plume air tends to reduce the performance especially in the case of forced draft heat exchangers. The problem is analysed numerically and the results are compared to experimental data. Practical empirical equations are presented for application in design.

■ **System selection and optimisation** (Chapter 9)

In the design of a base load power plant, the selection and matching of various components is of the utmost importance in order to achieve effective operation and power output. Details are presented in this chapter, showing how the cooling system can be optimised in a particular power plant. A similar approach is followed in the case of a large petro-chemical or process plant.

■ **Environmental effects** (Chapter 10)

The performance of all air-cooled heat exchangers and cooling towers are affected by changes in ambient conditions. Changes in temperature generally exert the biggest influence while winds, inversions, rain, snow, hail and solar radiation have a lesser effect.

In this chapter the dynamics of the atmosphere are expressed in terms of equations that are employed in the design of cooling systems. The lapse rate is deduced for dry air as well as for air containing a considerable amount of water vapour.

Characteristics of the planetary boundary layer and the formation of inversions are discussed.

All cooling systems are influenced by winds to a greater or lesser extent. Experimental results showing changes in approach temperature difference at different wind speeds for dry- and wet-cooling towers are shown. In general cooling towers where the heat exchanger or fill is located horizontally in the base of the tower, tend to be less sensitive to winds than towers having vertical arrangements around the periphery.

During windy periods the velocity distribution through heat exchangers located horizontally in the base of a natural draft cooling tower is highly distorted resulting in a reduction in performance. This problem can be considerably reduced by installing appropriate windwalls and having relatively deep (in the direction of inlet air flow) tower supports.

Atmospheric inversions reduce the performance of a cooling tower. Various approximate but adequate approaches with which this effect can be quantified, are presented. Since temperature inversions usually occur at night when the demand for power is relatively low, inversions do not pose a serious problem.

Interim guidelines published for livestock watering

A document prepared for the Water Research Commission by two researchers from the University of Pretoria provides a quick reference to water quality guidelines for livestock watering and incorporates recent research results relevant to southern African conditions.

The researchers, NH Casey and JA Meyer, from the Department of Animal and Wildlife Sciences in the Faculty of Biological and Agricultural Sciences at the University of Pretoria, say this information are to serve as interim guidelines that may be used until a Water Quality Guideline Index System, which is being developed for the Water Research Commission, has been completed.

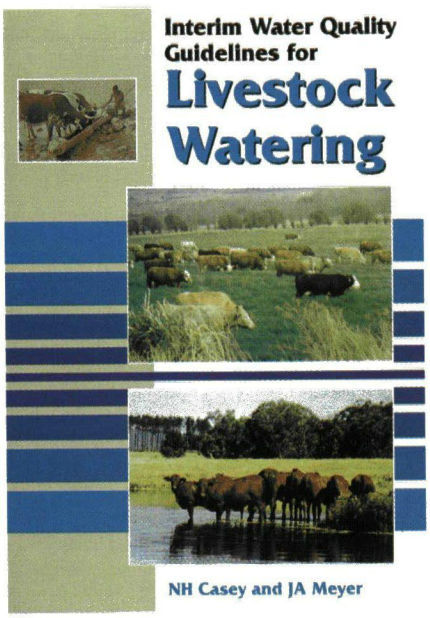
CURRENT SCENARIO

The researchers say that the guideline levels for water quality constituents, and the specific constituents considered to be relevant, differ between countries. This is largely due to environmental differences and indicates the need for each country to have an own set of guidelines with their relevant constituents.

Research regarding levels of acceptability for water quality constituents for livestock drinking water for southern Africa is needed, mainly because the present levels are based largely on assumptions as yet untested in the southern African context. This is due to a lack of locally established guidelines.

Locally developed guidelines differ vastly from one another.

The researchers say the most recent guidelines, as published by the Department of Water Affairs and Forestry (1996), are the first to incorporate, to some degree, the problematic aspect of a water quality constituent having a wide range of effects at the same concentration, depending on the relevant site-specific factors.



SHORTCOMINGS

The shortcomings of the current guidelines are due to the complexity of water and livestock production interactions, centring around the following factors:

■ They do not offer any solution for areas which have inherently saline waters with high concentrations of potentially adverse water quality constituents;

■ They do not take into account, to a large enough extent, the differing water quality requirements, in terms of quality and quantity, of animals due to:

- species tolerances;
- the climatic effect on the animal (macro- and microclimates);
- the feed environment;
- the production system;
- the animal's physiology;
- the animal's production stage;
- the effect of time exposure to the potentially hazardous constituents;
- the effect of a concentrated intake over a short period;
- the physiological effect of exposure to potentially hazardous constituents;
- the economic implications of such exposure for different production systems and production conditions;
- the probable carry-over effect of potentially toxic substances to the user of the animal product after a limited exposure (growth to market weight);
- the synergistic and antagonistic interactions between water quality constituents, and water quality constituents and the environment;
- the actual ingestion of a water quality constituent.

IMPLICATIONS

These factors have the following implications for livestock watering:

A given water source can be fit or unfit for livestock watering depending on the intended use of the water source and the conditions attached to that use.

Arid zones of southern Africa have inherently saline waters with water quality constituents in excess of the recommended limits. Consequently the need to accurately assess the effect of a water source for a given environment on a given livestock production system arises.

Water classification may be incorrect, with water that may be fit for livestock watering classed as unfit, and vice versa. Both imply that the utilisation of water may be less than optimal due to the format of the current guidelines.

Copies of the report entitled **Interim water quality guidelines for livestock watering** (WRC Report TT 76/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 15).

Criteria developed fo co-disposal of sludge

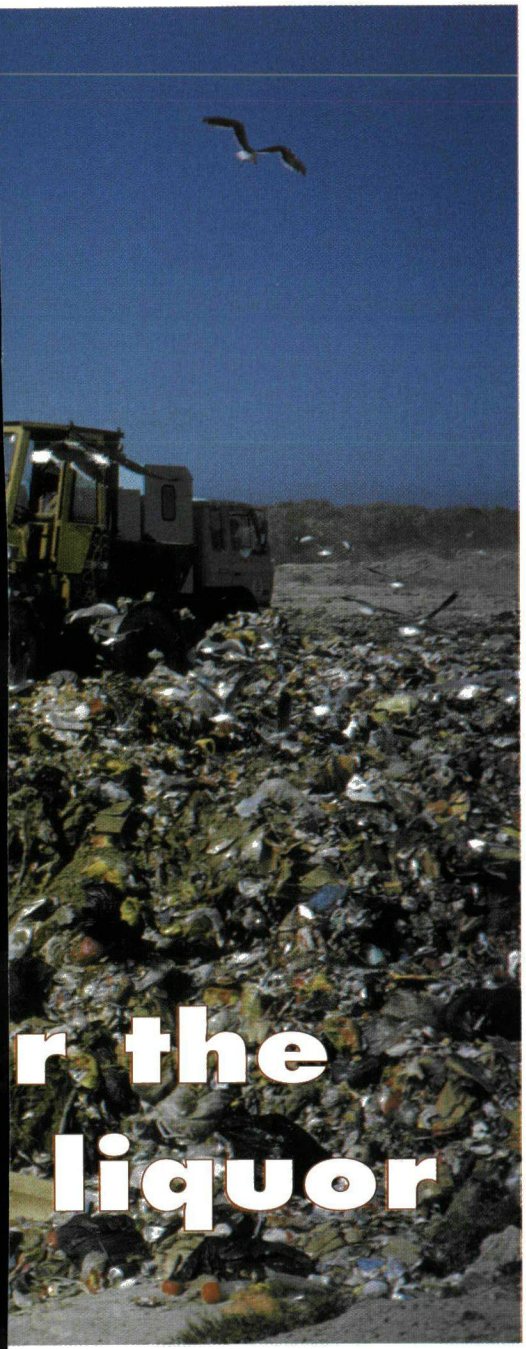
The research was carried out at the Coastal Park landfill site which is adjacent to the Cape Flats wastewater treatment plant.

A final report which summarises the results of a research project aimed at developing practical criteria for the landfill co-disposal of domestic refuse and anaerobically digested wastewater sludge liquor, is available from the Water Research Commission in Pretoria.

The report shows that there are many advantages to co-disposing normal waste and sewage sludge in the same landfill site and it is currently being practised in many parts of the world, especially in drier areas which have a perennial water deficit.

The research was carried out under a three-year contract between the Cape Town City Council and the Water Research Commission and the research team consisted of PH Novella, WR Ross, GE Lord, MA Greenhalgh, JG Stow and KS Fawcett.

Copies of the report entitled **The co-disposal of waste-water sludge with refuse in sanitary landfills** (WRC Report 391/1/96) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 25).



Waste water and domestic refuse represent the major sources of polluted wastes generated in urban areas. These wastes have undesirable characteristics necessitating further processing and transformation into end-products to render them environmentally acceptable. South Africa currently produces about 40 million tons of domestic refuse per annum and about 12 million tons per annum of wastewater sludge from biological treatment processes. Roughly 95 per cent of domestic refuse generated in South Africa is still disposed of on land, in landfills.

Sanitary landfilling, whereby the waste is compacted and covered with a soil layer each day, offers the most versatile method for the disposal of solid wastes in an economical and environmentally sound manner. Co-disposal (or joint disposal) in its widest sense, is understood to be the calculated and monitored interaction of wastewater sludge (or selected difficult industrial and commercial wastes) with municipal refuse in a properly controlled landfill site.

The co-disposal of wastewater sludge and refuse in sanitary landfills is not a new concept and is being practised in many parts of the world, especially in drier areas which have a perennial water deficit. Over the last two decades, much progress has been made towards ensuring that the co-disposal practice is carried out in an environmentally sound way. However, different approaches to co-disposal have led to quite different experiences and attitudes, with the result that different perceptions of the values and dangers of the co-disposal practice have developed.

In comparison, the co-disposal of wastewater sludge with refuse in sanitary landfills in South Africa has not been widely implemented to date, due to various reasons. One such reason is that wastewater sludge has always been accepted as a good soil conditioner and has been widely used by farmers as a fertiliser. However, the continued land application of wastewater sludge could decrease if the Department of Health's Draft Guide (1991) relating to sludge disposal is implemented in South Africa. An acceptable alternative to land application as disposal method will then have to be found for those wastewater sludges that contain pollutants (such as heavy metals) which could cause food chain contamination. The controlled co-disposal of wastewater sludge with refuse in a landfall is such a disposal option.

MATERIALS AND METHODS

The research was carried out at the Coastal Park landfall site which is adjacent to the Cape Flats wastewater treatment plant. This area experiences a Mediterranean climate (hot dry summers and cool wet winters) with the average evaporation exceeding the rainfall by some 600 mm per year. This type of climate necessitated the co-disposal process to be optimised for both winter and summer periods.

■ Construction of Experimental Landfill Lines

Two refuse lines were utilised; one in which the sludge liquor was co-disposed with refuse and one with no sludge addition (which acted as a control). Both lines received the same amount of refuse (some 30 tons per day) and were treated in the same manner during each run. The two lines were each 2,5 m high and 6 m wide and were separated by a rubble berm.

Landfilling proceeded in a top to bottom method with the refuse collection vehicles discharging their loads on the top of the working face of the experimental lines. The landfill compactor (CAT 9 592 kg) then spread the refuse down the 4:1 slope of the face in layers some 300 to 400 mm thick. Once this was completed, the wastewater sludge liquor containing some 2,2 per cent total solids (m/v) was applied to the refuse in predetermined volume ratios by means of two 50 mm flexible hand-held hosepipes attached to a sludge tanker. As soon as the predetermined volumes of refuse and sludge had been applied, the refuse/sludge mixture was compacted using the steel wheeled landfill compactor. The compacting procedure was standardised and each section of the line received four passes (down and up represent one pass) with the compactor wheels. The identical procedure was carried out on the control line containing refuse only. Both lines were covered with a 100 to 150 mm sand layer after each daily run.

Optimisation of the refuse/sludge co-disposal ratios as well as operation at the optimum ratios was carried out for each seasonal period over some 18 months and involved 50 experimental runs.

■ Landfill Monitoring Programme

Because of the heterogeneous nature of the unsorted and unmilled domestic refuse used in the experiments there were certain constraints in the collection and interpretation of the data from the landfilling procedures. The following tests were carried out on the co-disposal and control lines in order to compare and evaluate the two operations:

- Operational parameters - the workability of the refuse and sludge mix-

tures by means of the landfill compactor and the manoeuvrability of the machine in the mixtures were selected as important practical operational criteria;
- Moisture content of the landfilled waste;
- Density and compaction of the landfilled waste;
- Landfill biogas constituents;
- Leachate generation and selected quality parameters;
- Meteorological considerations.

RESULTS

■ Landfill Compactor

Landfill compactors are generally required to work for extended periods, and excessive downtime should be avoided as a result of cleaning of the machine or for other damage as a result of the sludge co-disposal operation. The experimental runs established that excessive addition of sludge liquor caused the belly plate of the landfill compactor to sink too deep into the refuse/sludge mixture, thus retarding the manoeuvrability of the machine.

The following terminology was developed to describe the workability of the landfall compactor machine:

- Critical Working Ratio - was that ratio of refuse to sludge at which the landfill compactor machine was just able to work successfully in the mixture;

- Safe Working Ratio - was that ratio of refuse to sludge at which the landfall compactor machine was able to work successfully for extended periods without getting damaged or stuck. The Safe Working Ratio was developed to ensure that the landfill compactor would not labour unnecessarily during full-scale operation. A practical safety margin of 33 per cent was added to the Critical Working Ratio to achieve this.

Table 1 summarises the results of the experimental runs on workability of the landfill compactor machine in relation to the co-disposal ratios (by volume and mass) of the refuse to sludge liquor for the winter (wet) and summer (dry) periods in the Western Cape.

The Safe Working Ratio of refuse to sludge liquor (by volume) for the winter and summer seasons was determined to be 6:1 and 4:1 respectively.

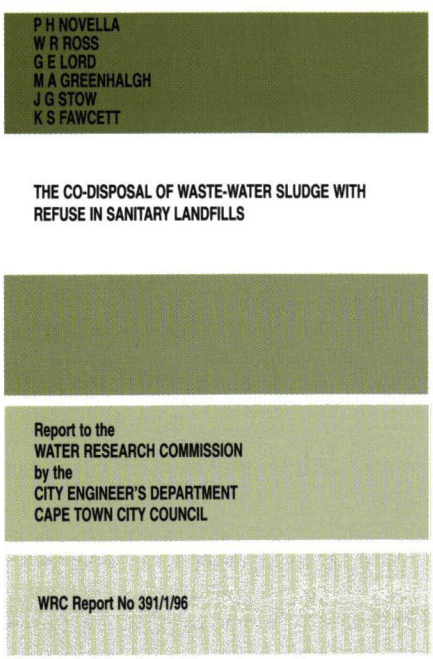
SEASON	CRITICAL WORKING RATIO		SAFE WORKING RATIO	
	By Volume	By Mass	By volume	By Mass
WINTER	4,5:1	1,5:1	6:1	2:1
SUMMER	3:1	1:1	4:1	1,3:1

NOTE: All ratios are "refuse-to-sludge liquor"
Average density of refuse: 335 kg/m³
Average solids concentration of sludge: 2,2% (m/v)

Table 1: Results of the co-disposal experiment runs for winter and summer periods

■ Compaction and Bulk Density of Landfilled Waste

Ten *in situ* bulk density determinations were carried out to compare the degree of compaction of the landfilled refuse in the co-disposal and control experimental lines. The median density in the co-disposal line (1 368 kg/m³) was determined to be only some 5.6 per cent higher than that of the control line (1 295 kg/m³). An explanation for the small difference between the *in situ* densities of the co-disposal and control lines was possibly the fact that their moisture content were very similar (some 30 per cent).



The influence of sludge co-disposal on the compaction of refuse was studied in more detail in the Box Tests. A major benefit accruing from the wetting of the incoming refuse by addition of sludge liquor was the change in physical transition from a highly bulky solid waste to that of a semi-solid state. The wetted refuse became less rigid and softer which enabled it to be better compacted. The Box Tests indicated that the compaction effect was greatly influenced by the placement moisture content of the waste. Increase of the moisture content in the range 35 to 55 per cent (achieved by a refuse/sludge volume ratio of 6:1) resulted in a 25 per cent improvement in the compaction.

■ Moisture Content of Landfilled Waste

Ten moisture determinations (at a depth of 1 m) was determined in order to compare the moisture content of the landfilled refuse in the co-disposal and control lines. Analyses indicated that the moisture content of the refuse/sludge mixtures within the co-disposal line (in the range 22 to 46 per cent) were significantly less than the theoretically calculated value (in the range 37 to 62 per cent). It was evident that less moisture was being held in the refuse than was expected. The lower moisture content was probably due to a combination of factors such as evaporation, leachate migration and methodology of the moisture determinations.

Three depth profile sampling runs were also carried out at various places in both experimental lines in order to ascertain the variation in the moisture content of samples taken at 0,5 m intervals down from the surface. The results indicated no significant differences in the moisture content at depths down to 2,5 m.

■ Leachate Generation

A leachate collection system (7 m x 7 m HDPE liner) was installed during week 20 in a section of each of the co-disposal and control lines. The volumes of

The wastewater sludge liquor was applied to the refuse with two 50 mm flexible hand-held hosepipes attached to a sludge tanker.

leachate from the experimental lines were monitored over two winter periods and two summer periods. The results indicated that leachate production only followed the rainfall pattern during the first winter rainfall period (1992) and far less leachate was produced during the second winter period (1993). In comparison, no significant volumes of leachate were collected from the control line during the same monitoring periods.

An explanation for these results could be the high annual evaporation rate at Coastal Park which exceeds that for rainfall by some 600 mm. The results indicated that the Coastal Park landfill has a capacity to hold increased amounts of moisture during most of the year. However, in order to minimise the production of excess leachate it is suggested that co-disposal be practised in the Western Cape only during the months when evaporation exceeds rainfall. If all-year co-disposal is to be practised then leachate collection as well as recycling and treatment should be considered.

■ Landfill Gas Constituents

It is widely accepted that co-disposal of an anaerobically digested wastewater sludge with domestic refuse could speed up the onset of the methanogenic phase in a landfill and thus hasten the stabilisation of the waste.
Three gas extraction wells were inserted into each of the experimental lines in order to monitor the concentration (not gas volumes) of the landfill gas components (such as CH_4, CO_2, N_2, and 0_2). The analyses indicated that the formation of methane gas was initially delayed in the co-disposal line. This phenomenon could be due to increased concentration of volatile acids in the co-disposal line as a result of accelerated acido/acetogenesis.

Pressure and temperature measurements were subsequently carried out on the gas extraction wells in order to quantify the production of biogas from the two experimental lines. The results indicated insignificant differences between the co-disposal and control lines. The low temperatures and low pressures recorded, indicated a landflll of low microbial activity.

CONCLUSIONS

The results of this research have provided practical operational criteria for the landfill co-disposal of domestic refuse and anaerobically digested wastewater sludge liquor. The main conclusions to be derived from this research are summarised as follows:

❑ The application of sludge to land as a fertiliser or soil conditioner is generally regarded as the most sensible sludge disposal option. However, the impact of pending sludge legislation policies in South Africa may prohibit the agricultural utilisation of sludges containing high concentrations of pollutants such as heavy metals and pathogenic bacteria. In such instances, and also where there are no agricultural demand for the sludge, it is likely that much greater use will be made of landfill co-disposal as an alternative sludge disposal option.

❑ The controlled co-disposal of wastewater sludge with refuse is a landfill strategy which can play an important beneficial role in the overall management of these two waste streams.

❑ The importance of moisture in solid-state anaerobic decomposition has been highlighted for optimising the physical, chemical and biological conditions for accelerated stabilisation of the landfilled waste. This reduces the long-term care requirements of the landfill and allows earlier productive final usage of the site surface.

❑ Additional moisture is added to a landfill during a sludge co-disposal practice. As a result, proper water balance management must be practised so as not to exceed the field capacity of the landfill, especially during wet seasonal periods. Consideration should thus be given to the provision of containment liners so as to facilitate the collection, treatment and disposal of the leachate as an essential part of the overall landfill management.

❑ Landfill co-disposal technology needs to be recognised by the policy and regulation community and managed by the waste management industry to the prescribed Minimum Requirements of the Department of Water Affairs and Forestry.

❑ Landfills should be sited adjacent to wastewater treatment plants so as to enable various options to be exercised for the treatment and utilisation of the sludge, leachate and biogas end-products. Such an integrated waste management strategy would be advantageous in terms of improved pollution control.

❑ Local authorities or companies wishing to co-dispose wastewater sludge with refuse must apply for a permit within the framework of both:

- the Minimum Requirements of the Department of Water Affairs and Forestry, and
- Section 20 of the Environment Conservation Act, No. 73 of 1989.

❑ It is recommended that should the details of this report be utilised elsewhere, cognisance be taken of the local conditions in the Western Cape to assist in the adoption of the technology.

Rekenaarprogram ontwikkel vir die bepaling van vloedskade

Alhoewel Suid-Afrika 'n relatief droë land is, kom vloede wat betekenisvolle skade veroorsaak, gemiddeld een maal elke twee jaar voor. Volgens berekeninge het die gemiddelde jaarlikse vloedskade van R11,2 miljoen in 1974/75 na R133,9 miljoen (teen konstante 1990-pryse) in 1989/90 toegeneem met 'n hoogtepunt van R428,6 miljoen in 1987/88.

'n Vraag wat dikwels na vore kom, is wat gedoen kan word om vloedskade in die toekoms te verminder. Dié vraag verwys na vloedskadebeheermaatreëls wat in werking gestel kan word.

Om die optimale kombinasie van vloedskadebeheermaatreëls vas te stel wat in 'n vloedbestuursplan opgeneem kan word, word beplanningshulpmiddels benodig. 'n Essensiële hulpmiddel is 'n rekenaarprogram waarmee die skade as gevolg van verskillende vloede vir relevante grondgebruike beraam kan word. Sodanige rekenaarprogramme is egter nie vir Suid-Afrika beskikbaar nie. Daarom het die Waternavorsingskommissie besluit om navorsing by die Departement Landbou-ekonomie aan die Universiteit van die Vrystaat finansieel te steun waarin gepoog word om rekenaarprogramme vir die bepaling van vloedskade in Suid-Afrika te ontwikkel. Dié rekenaarprogramme integreer hidrologiese inligting van vloede met topografiese eienskappe van die vloedvlakte, grondgebruike binne die vloedvlakte en vloedskadefunksies van die verskillende grondgebruike. 'n Vloedskadefunksie (verliesfunksie) beskryf die verwantskap tussen die skade aan 'n spesifieke grondgebruik vir verskillende oorstromingsdieptes en/of tye van oorstroming.

VERSLAG

'n Opsomming van die navorsingsresultate is onlangs deur die Waternavorsingskommissie in die vorm van 'n finale verslag beskikbaar gestel. Die verslag bestaan uit drie dele en is deur MF Viljoen, LA du Plessis en HJ Booysen saamgestel.

Deel 1 is 'n samevatting van die bevindings van die geheelondersoek en bestaan uit vier hoofstukke. Na die inleiding (Hoofstuk 1) word in Hoofstuk 2 terminologie en konsepte verduidelik wat nodig is om die bevindings van die navorsing, soos in Hoofstuk 3 ten opsigte van die besproeiingsgebied aangegee en in Hoofstuk 4 ten opsigte van die stedelike gebiede, te verstaan.

In Dele 2 en 3 van die verslag word meer volledig oor spesifieke aspekte van die navorsingsprojek gerapporteer.

Afskrifte van die verslag, getiteld **Die ontwikkeling van vloedskadefunksies en 'n rekenaarprogram om die voordele van vloedbeheer- en vloedskadebeheermaatreëls te bepaal** (WNK-verslag 490/1/96) is gratis verkrygbaar vanaf die Waternavorsingskommissie, Posbus 824, Pretoria 0001.

Die doelstelling van die navorsingsprojek kan as volg opgesom word:

■ Die ontwikkeling van vloedskadefunksies om potensiële skade vir die verskillende grondgebruike in die afgebakende vloedvlakte van die ondersoekgebied te bepaal.

■ Die ontwikkeling van 'n rekenaardatabasis waarin die vloedskadefunksies geberg kan word, asook die toepassing daarvan op die ondersoekgebiede.

■ Die ontwikkeling van 'n rekenaarprogram om die voordele van verskillende kombinasies van vloedbeheer- en vloedskadebeheermaatreëls met behulp van die vloedskadefunksies in die rekenaardatabasis te bepaal.

ONDERSOEKGEBIED

Die doelstellings is afsonderlik vir stedelike- en besproeiingsgebiede in die ondersoekgebied uitgevoer.

As stedelike gebiede is die Vereeniging munisipale gebied langs die Vaalrivier en die Upington munisipale gebied langs die Oranjerivier gekies.

Die besproeiingsgebied kom stroomop en stroomaf van Upington voor, naamlik vanaf die Gifkloofstuwal tot by die Manie Conradiebrug by Kanoneiland. Dit is 'n oppervlakte van ongeveer 4 500 ha wat oor nagenoeg 40 kilometer strek en agt besproeiingsrade insluit.

RESULTATE

■ Vloedskadefunksies is vir die verskillende grondgebruike in die besproeiings- en stedelike gebiede bepaal. In geval van die besproeiingsgebied is vloedskadefunksies vir die verskillende gewasse, naamlik wingerd (volgens kultivar), wisselbou en lusern bepaal, sowel as vir akkerbou- en wingerdgrond en geboue. By stedelike gebiede is vloedskadefunksies vir die residensiële sektor in Upington en vir die residensiële en kommersiële sektor in Vereeniging ontwikkel.

■ Rekenaardatabasisse om vloedskadefunksies in te berg, is vir die stedelike en die besproeiingsgebied bepaal. In die geval van stedelike gebiede is Anuflood, 'n Australiese rekenaarprogram, aangepas vir Suid-Afrikaanse omstandighede, gebruik en is die vloedskadefunksies volgens die formaat van Anuflood geberg. Vir die besproeiingsgebied is die databasisse volgens 'n Geografiese Inligtingstelsel (GIS) benadering ontwikkel en het dit topografiese, hidrologiese en ekonomiese databasisse behels wat onderling met mekaar verbind is.

■ Rekenaarmodelle om verskillende kombinasies van vloedbeheer- en vloedskadebeheermaatreëls te bepaal, is vir die ondersoekgebied ontwikkel. Vir die stedelike gebiede het die model die aanpassing van Anuflood vir die gebiede behels. Drie insette, naamlik vloedskadefunksies, hidrologiese data en grondgebruiksdata moes onder andere in Anuflood ingevoer word. Vir die besproeiingsgebied is twee benaderings ondersoek, te wete 'n matriksbenadering en 'n GIS-benadering. Na oorweging van voor- en nadele, is op die GIS-benadering besluit en die rekenaarmodel daarvolgens ontwikkel.

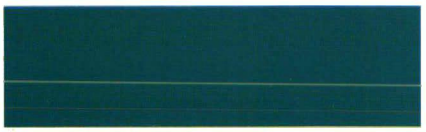
■ Die aanwending van die rekenaarprogramme is vir beide die stedelike- en besproeiingsgebied geïllustreer.

Die volgende is byvoorbeeld aangetoon:

❑ Die modelle kan gebruik word om die gemiddelde jaarlikse skade (GJS) vir die betrokke ondersoekgebied te beraam.

Vir die besproeiingsgebied (Gifkloofstuwal tot Manie Conradiebrug) is byvoorbeeld getoon dat direkte GJS R1 600 per hektaar besproeiingsgrond beloop vir 'n 5 Maart-vloed teen 1992-pryse. Dit gee R7 miljoen vir die betrokke besproeiingsgebied en R43,1 miljoen vir die Benede-Oranjerivier tussen Boegoebergdam en Augrabies waterval. Figuur 3 toon aan hoedanig die GJS volgens plaaslike, streeks- en nasionale gesigspunte varieer. Hierdie inligting is belangrik by die vasstelling van die aard en omvang van vloedskadebeheermaatreëls wanneer voordele teen kostes opgeweeg word.

Wat stedelike gebiede betref, is byvoorbeeld vasgestel dat die GJS vir Upington se residensiële sektor R0,64 miljoen beloop en R0,12 miljoen vir Vereeniging. Die "lae" GJS vir Vereeniging se residensiële sektor word hoofsaaklik toegeskryf aan die berekeningsprosedure waar van onvoldoende



Die ontwikkeling van vloedskadefunksies en 'n rekenaarprogram om die voordele van vloedbeheer- en vloedskadebeheermaatreëls te bepaal

Deel 1: Samevattende Verslag

MF Viljoen LA du Plessis HJ Booysen

Verslag aan die Waternavorsingskommissie deur die Departement Landbou-ekonomie Universiteit van die Oranje-Vrystaat

WNK Verslag No 490/1/96

Die ontwikkeling van vloedskadefunksies en 'n rekenaarprogram om die voordele van vloedbeheer- en vloedskadebeheermaatreëls te bepaal

Deel 2: Besproeiingsgebied

MF Viljoen LA du Plessis HJ Booysen

Verslag aan die Waternavorsingskommissie deur die Departement Landbou-ekonomie Universiteit van die Oranje-Vrystaat

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Die ontwikkeling van vloedskadefunksies en 'n rekenaarprogram om die voordele van vloedbeheer- en vloedskadebeheermaatreëls te bepaal

Deel 3: Stedelike gebied

MF Viljoen LA du Plessis HJ Booysen

Verslag aan die Waternavorsingskommissie deur die Departement Landbou-ekonomie Universiteit van die Oranje-Vrystaat

WNK Verslag No 490/3/96

hidrologiese data gebruik gemaak moes word. Die syfer is hoër as die kommersiële sektor van Vereeniging se GJS (R54 000) maar aansienlik laer as die GJS vir die nywerheidsektor wat R0,75 miljoen beloop.

NOODWALLE

❑ Die modelle kan aangewend word om die voordele van vloedskadebeheermaatreëls in die besproeiingsgebied vas te stel.

Ten opsigte van die noodwalle is aangetoon dat die huidige noodwalle daartoe bydra dat die GJS met R450 (teen 1992-pryse) per hektaar verlaag word. Deur hierdie voordeel teen die koste verbonde aan die oprigting en instandhouding van noodwalle te verreken, is bevind dat noodwalle ekonomies geregverdig kan word.

Die effek wat verskillende grondgebruike op GJS het, is ook geïllustreer. Dit is onder meer aangetoon dat die GJS kan wissel tussen R15,5 miljoen vir die besproeiingsgebied tussen die Gifkloofstuwal en Manie Conradiebrug wanneer slegs wingerd verbou word, tot R5 miljoen wanneer slegs wisselbougewasse verbou word.

Vir dambestuur is die waarde wat die verhoging van vloedwateropgaarvermoë om vloedspitse te verminder (deur só 'n dam op te rig of 'n damwal te verhoog) aangetoon. Sou die vloedwateropgaarvermoë by damme verhoog word sodat die waarskynlikheid van vloede om voor te kom met byvoorbeeld 10 en 20 persent verlaag, sal die GJS in die besproeiingsgebied respektiewelik met 9,1 en 16,7 persent verlaag.

Die aanwending van die resultate van die model vir die vasstelling van vloedskadeversekeringspremies is ook aangetoon.

STEDELIKE GEBIEDE

❑ Die modelle kan aangewend word om die voordele van vloedskadebeheermaatreëls in stedelike gebiede te bepaal.

Vir stedelike gebiede is verskillende vloedskadeverminderingsopsies ondersoek. Onder meer is gekyk na die effek van bouregulasies wat ontwikkeling onder 'n sekere vloedlyn verbied, die voordele van tydige waarskuwing-

stelsels en die voordele van strukturele maatreëls soos vloedwalle en vloedverskansing.

Daar is onder meer bevind dat indien residensiële ontwikkeling in Upington en Vereeniging respektiewelik nie onder 1 in 20 en 1 in 50 jaar vloedlyne sou plaasvind nie (bouregulasies), die vloedskade aan die residensiële sektore respektiewelik met 33 en 37 persent sou verminder.

Tydige vloedwaarskuwings is veral vir Vereeniging, wat naby die oorsprong van die vloed geleë is, relevant. Die voordeel van skadevermindering deur ontruiming is die grootste by die kommersiële sektor. Verlenging van die effektiewe waarskuwingstyd van 12 na 20 uur kan tasbare skade in die sektor met nege persent verlaag, terwyl die skade by die residensiële sektor met slegs 4,5 persent sal verlaag. By die nywerheidsektor (vanweë die omvang en massa van voorraad en produkte) sal tydige waarskuwing slegs 'n geringe effek hê.

Vloedverskansing aan geboue en noodwalle is die doeltreffendste by nywerhede, gevolg deur die kommersiële en residensiële sektore. 'n Effektiewe vloedverskansing in Vereeniging sal die GJS van die nywerheidsektor, kommersiële sektor en residensiële sektor met onderskeidelik 48 persent, 26 persent en 4,5 persent verminder.

GEBRUIKERS

Die navorsingsresultate kan in die eerste plek van waarde wees vir persone en instansies wat in die ondersoekgebied gemoeid is met:

- Die beplanning van grondgebruike binne die vloedvlaktes. Dit sluit in dorps, stads- en streeksbeplanners, argitekte, ingenieurs sowel as owerheidsinstansies wat grondgebruiksbeleid bepaal.

- Die ontwikkeling van vloedbestuursplanne wat verskillende vloedbeheer- en vloedskadebeheermaatreëls kan insluit. Plaaslike owerheidsliggame soos Burgerlike Beskerming, vloedbestuurskonsultante en die Departemente van Landbou, en van Waterwese en Bosbou is onder andere betrokke.

- Die vasstelling van versekeringspremies wat in die vloedvlakte op verskillende grondgebruike van toepassing moet wees. Versekeringsmaatskappye het 'n belang hierby sowel as noodlenigingsorganisasies en persone, instansies en besighede wat in die vloedvlakte wil vestig.

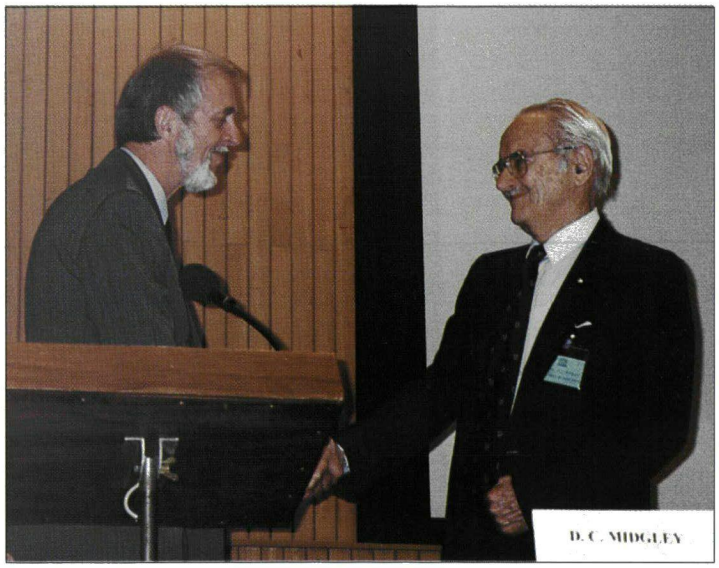
- Die beraming van die aard en omvang van skade wat deur verskillende groottes vloede aangerig sal word. Dié inligting kan van waarde wees vir versekeringsmaatskappye wat skade-eise moet uitbetaal, instansies wat vloedhulp moet verleen en die aard en omvang daarvan wil beraam, ondernemings wat benodigdhede moet verskaf om vloedskade te herstel, ondernemings wat landbouprodukte verwerk of bemark wat in die vloedvlakte geproduseer word, instansies wat beleid moet bepaal ten opsigte van vloedvlaktebenutting en noodleniging soos die Departemente van Waterwese en van Bosbou, van Landbou en van Welsyn, asook Burgerlike Beskerming.

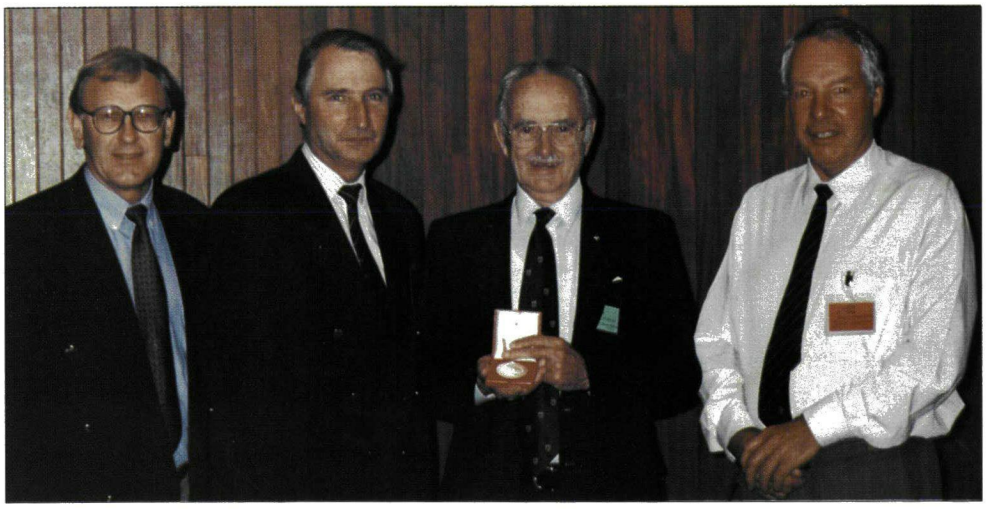
A proud moment in the history of South African hydrology

Professor Des Midgley with his International Hydrology Prize.

Professor Des Midgley received the prestigious IAHS International Hydrology Prize on 19 September 1996 in Paris, France. The prize is awarded annually to hydrologists of long international standing and individuals who show international leadership in the science and practice of hydrology.

These photographs, submitted by Sanciahs secretary, Hugo Maaren, capture the proud moment.





Top: Professor Midgley receives the prize from the President of IAHS, Dr John Rodda.

Left: Some of the South African Sanciahs members who attended the prize-giving ceremony. From left: Professor Roland Schulze (University of Natal), Mr Eberhard Braune (Department of Water Affairs and Forestry), Prof Midgley, and Mr Hugo Maaren (Water Research Commission).

Researcher reports on *Blackfly* control in the Orange River

The Orange River in the vicinity of Kanoneiland.

The Water Research Commission has released the final report of a study on the development of an effective and environmentally safe programme for the control of blackflies along the Orange River.

The researcher, dr RW Palmer, from the Onderstepoort Veterinary Institute, says the study was initiated in July 1991 by Onderstepoort with financial support from the Water Research Commission, in response to complaints from farmers whose stock were being affected by the biting of pest blackflies.

The aims and objectives of this project, as originally proposed, were as follows:

- To determine the efficacy of commercially available, and possibly locally produced, formulations of *Bacillus thuringiensis* var. *israelensis* (BTI) against blackfly larvae in the Orange River.
- To determine the development periods of immature *Simulium chutteri* throughout the year (at different water temperatures) in the Orange River.
- To determine the prevalence of blackfly immature stages and of non-target organisms throughout the year in the upper, middle and lower Orange River.
- To make use of the knowledge gained, through the immatures of *Simulium chutteri* in the Orange River and the BTI trials, to develop a practical and effective programme for the annual control of blackflies along the Orange River.

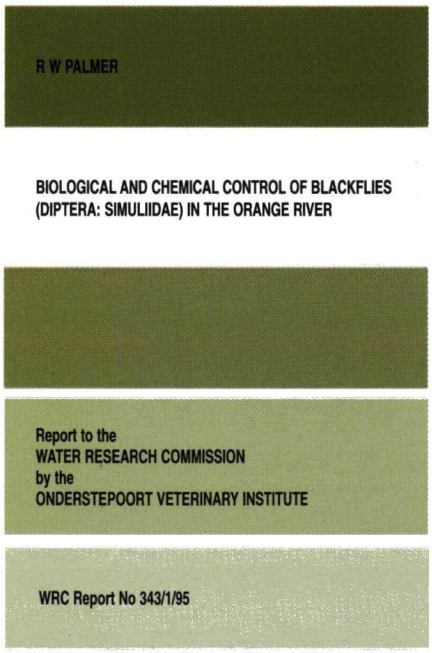
Copies of the report titled **Biological and chemical control of blackflies** (Diptera: Simuliidae) in the Orange River are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US$ 20).

The first attempts to control blackflies in South Africa made use of DDT, which was used in the Vaal and Harts Rivers between 1965 and 1967. These trials were successful in controlling *Simulium chutteri*, but also killed fish and non-target invertebrates, and resulted in excessive growth of benthic algae. DDT was not used again in the control of blackflies in South Africa, and became unpopular in other parts of the world because of the rapid development of resistance, its non-specificity, persistence in the environment, accumulation in food chains and undesirability in potable water. In South Africa the use of DDT to control blackflies was replaced with flow-regulation, which was considered practical, safe and cheap. The method involved stopping river flow for periods long enough to dry and kill blackfly larvae and pupae. This method was used successfully in the Soviet Union. Flow-regulation was tested against *Simulium chutteri* in the Vaal River in 1977, and in the Orange River in 1978. A sixty hour closure of the Vaalharts Diversion Weir reduced blackfly numbers for 30 km downstream. In the Orange River, a 66 hour closure at the Vanderkloof and Boegoeberg Dams reduced blackfly numbers for 370 and 242 km respectively. Despite the initial success of flow-regulation in controlling blackflies, rainfall in 1987 and 1988 was higher than in previous years, and the flow in the river could not be regulated. This resulted in one of the worse blackfly plagues along the Orange River in memory. Furthermore, flow-regulation was not a practical control option for most of the Orange River because of:

- the increased dependence of riparian agriculture on a steady water supply,
- the long distance downstream of impoundments (over 1 000 km downstream of Vanderkloof Dam), and
- the time required for drying-out of rapids. In addition, flow regulation is not target-specific, and it was feared that a drop in water level, incorrectly timed, could be detrimental to the recruitment of certain fish species by exposing fish larvae or eggs.

Because of the problems associated with flow-regulation along the Orange River, the Onderstepoort Veterinary Institute initiated a research project on the biological control of blackflies, using the bacterium BTI. This bacterium has been successfully used to control blackflies in numerous control programmes worldwide. However, BTI is relatively bulky and would be logistically-impractical to apply at flows exceeding 200 m³/s. Furthermore, the efficacy of BTI drops in water which is turbid or contains a high algal content. The aims and objectives of this project were therefore extended to include the testing of the organophosphate temephos.

Other potential methods of controlling blackflies include the sterile-male technique and the use of parasitic nematodes, viruses, protozoa, fungi or predators. However, the evidence indicates that biocontrol agents, with the exception of BTI have had limited success in controlling pest blackflies.



RESULTS

■ Efficacy of BTI

Both BTI and temephos were effective in controlling blackfly populations along the Orange River, although BTI was suited for use in clear water, whereas temephos was suited for use in turbid water (Secchi depth < 12 cm or planktonic algae > 1500 cells/m*l*). The downstream "carry" of larvicides was highly variable, but increased with flow. For BTI the "carry" was usually about 5 km at moderate flow (60-143 m³/s), and up to 20 km at high flow (180 m³/s). The "carry" of temephos was usually about three times further than BTI.

The local production of BTI was considered impractical. However, work conducted during this project was used for the registration of a second BTI product (Vectobac^{R} 12AS). This, together with direct purchasing, resulted in a significant drop in BTI prices, and the saving of approximately R150 000 per annum (in 1993). The registration of temephos is pending further investigations on the medium-term effects of temephos on non-target organisms.

■ Development periods of *Simulium chutteri*

The development rates of larval *Simulium chutteri* were monitored following field applications of larvicides. Development largely depended on water temperature and food quality, and ranged from seven days (in mid-summer) to 37 days (in mid-winter). Recommended time intervals between treatments ranged from six to 32 days. Treatments to prevent a spring outbreak should start in the last week of July. Timing of the autumn treatment should be flexible, and should be in response to any sharp increase in flow in March and April.

■ Prevalence of *Simulium chutteri*

A novel method of estimating the abundance of immature blackflies for use in blackfly control programmes was developed and published. The method was based on the visual comparison of blackflies on hand-held, natural substrates, to diagrammatic representations of larvae and pupae on flat surfaces (stones) and cylindrical surfaces (trailing reeds and roots).

Two surveys of the Orange River showed that *Simulium chutteri* population densities were high between Marksdrift and Vioolsdrift, a distance of over 1 000 km. *Simulium chutteri* was present upstream of the Gariep Dam, but numbers were low.

Weekly sampling of *Simulium chutteri* larvae at Gifkloof, near Upington, showed that larval numbers were generally higher in winter than in summer. Lowest numbers occurred in autumn during algal blooms, suggesting that blackfly populations may be controlled

by naturally occurring toxic algae.

■ **Effects of larvicides on non-target organisms**

The short-term (before-after) impacts of BTI and temephos on non-target macro-invertebrates were studied during eight field trials in the middle Orange River. In all trials, blackfly larvae were the most sensitive taxa in the stones-incurrent biotope to both BTI and temephos. The number of non-target taxa (excluding other blackfly species) affected at recommended dosages was three for BTI and seven for temephos. Seven species of blackflies were found downstream of the Gariep Dam, one of which (*Simulium gariepense*) is regarded as threatened. High-dosage applications indicated that BTI has a wide margin of safety, whereas temephos has a narrow margin of safety. Taxa affected by temephos included the caddisfly *Cheumatopsyche thomasseti*, an important predator of blackflies.

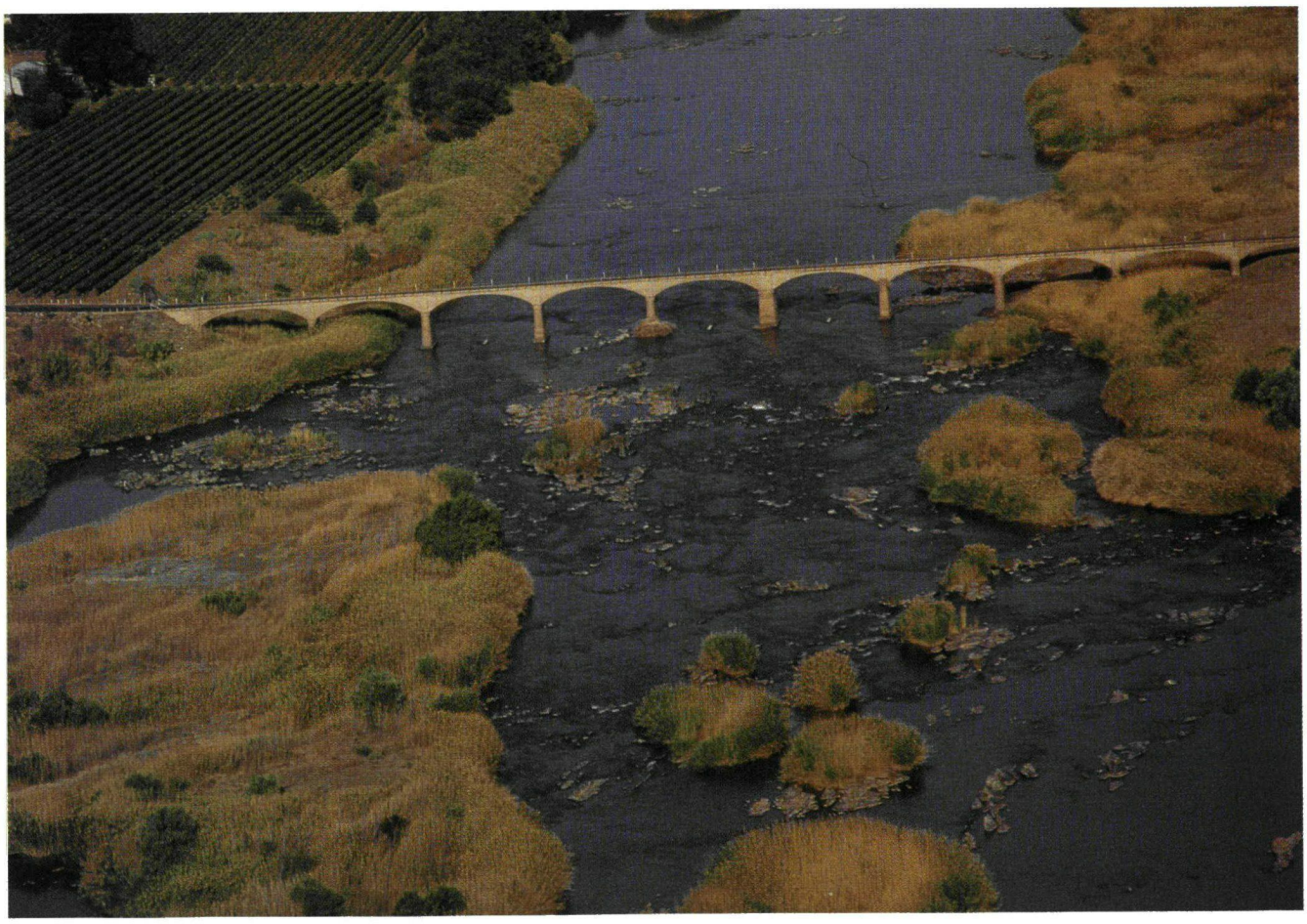
It is concluded that good control of blackflies may be obtained with minimal direct impact on the "non-target" fauna, provided recommended dosages of temephos are not exceeded. Overdosing with temephos should be strictly avoided.

■ **Control of *Simulium chutteri***

The results of this project, and the excellent cooperation between the parties involved, have led to a highly successful control programme. Local farmers were kept informed about the control programme via a newsletter, called "Muggienuus", produced by the Onderstepoort Veterinary Institute. The Northern Cape Agricultural Union found that lambing percentages in 1993/94 were exceptionally good. Likewise, there were no complaints about blackflies from tourists visiting the Augrabies National between 1991 and 1994.

However, the report says larvicides and their application are expensive, and the question which remains in most farmers' minds is how it can be done cheaply? One possible way to reduce costs would be to produce BTI locally. Although BTI is easy to grow, the key to an effective product is in the formulation. The research to produce a product with good dispersal and ingestion properties and a reasonable shelf-life, would be considerable. Furthermore production runs the risk of contamination, which is a constant problem, even in the most sophisticated plants. The volume of BTI required for blackfly control along the Orange River (about 17 000 *l* per annum) does not warrant the expense of a local plant. However, the situation may change if BTI is also used for mosquito and blackfly control in the subcontinent as a whole.

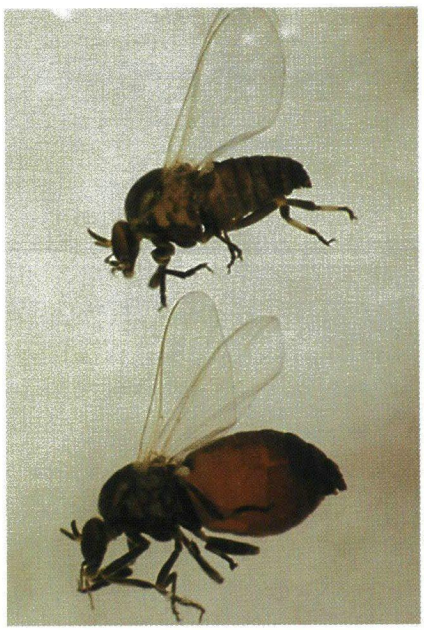
The work conducted during this study was used in the registration of a second BTI product. This opened the market and together with direct purchasing, significantly reduced the cost of BTI which amounted to a saving of about



The Orange River near Keimoes, showing a breeding site for blackflies.

R150 000 in 1993.
The report says another possible way to reduce costs is to use a fixed-wing aircraft instead of a helicopter to apply larvicides. This may be possible only when the flow is high. At low-flow, fixed-wing aircraft fly too fast for accurate applications. Another suggestion is to apply larvicides from bridges rather than incur the expense of aerial applications. Theoretically, bridges could be used at high flow to apply temephos between Prieska and Augrabies, but there are not enough bridges between Marksdrift and Prieska. If bridges alone were used to apply larvicides, 66 per cent of all rapids between Hopetown and Augrabies would be effectively dosed if the "carry" was 50 km. Therefore, bridges alone do not provide a satisfactory method of larvicide application. The construction of permanent structures has been suggested as a solution to this problem. Unless permanent structures were built at each set of rapids, they would not provide the flexibility required for efficient use of larvicides. This is because the rapids that need to be dosed vary depending on the flow. Furthermore, the distance upstream of rapids that larvicides should be applied varies with flow and larvicide formulation. The use of existing bridges and a few extra permanent structures would tend to favour the use of high dosages to increase "carry". Although "carry" does improve with increased dosage, the relation is not linear, and applications become uneconomical once the recommended dosages are exceeded. Since larvicides, and not their application, are the most expensive part of the control programme, it would be best to minimise their use, Furthermore, high dosages, particularly of temephos, are not recommended for environmental reasons. The cost of building and maintaining permanent structures that would withstand floods would be considerable, particularly considering the braided sections of the river, where the river is over 3 km wide.

Another possible method for reducing costs is to forfeit the pre- and post sampling of larvae, and simply get on with the job of applying the larvicide. This approach is extremely short-sighted because it may result in applications at times when it is not necessary.



Blackfly females can double their weight after a blood-meal.

Furthermore, there would be no record of whether or not larvicides worked. There are many reasons for larvicidal failure and it is essential to monitor larval populations to detect such failures and determine the reasons for failure. Once large numbers of adults have emerged, it is simply too late to control blackflies effectively.

The report says it appears, therefore, that there are very few short cuts in controlling blackflies. However, a rough calculation shows that blackfly control still makes economic sense. In 1993 the total cost of controlling blackflies in the Orange River (using BTI applied by helicopter) approached R1 million. (1996: R1,5 million). Assuming that blackflies are nuisance up to 50 km on either side of the Orange River, the estimated cost per stock unit can be determined. In 1993 the river was treated between Hopetown and Augrabies Falls, protecting an area of roughly 50 000 km^2 (taking river bends into account). The carrying capacity of this area is estimated at 5 to 6 ha per sheep, which means that approximately one million sheep enjoyed a blackfly free year. In other words, blackfly control was achieved at an approximate cost of R1 per sheep per annum. The Northern Cape Agricultural Union found that lambing percentages in 1993/1994 were exceptionally high, and one farmer estimated that annual losses due to blackflies during pre-control years exceeded R30 000!

At current prices temephos is about 1.6 times more expensive per litre than BTI. However, temephos carries between 1.5 and 4.4 times further than BTI, depending on flow. When the river is low (<70 m^3/s) the cost of treating a section of river is roughly the same for the two products. As flows increase, BTI becomes increasingly expensive compared to temephos, and may be as much as three times the cost, according to the report.

Not only are larvicides expensive, but they incur environmental costs. The interval between larvicide applications recommended for blackfly control is shorter than that required for the recovery of most non-target fauna. A series of larvicide applications, particularly in an isolated river, with no middle reach tributaries, such as the Orange River, may therefore be detrimental to susceptible species with poor re-colonisation attributes. Repeated application of the same larvicide, particularly temephos, may therefore lead to major changes in the ecosystem and possible damage to ecological processes. Furthermore, each application increases the chances of resistance developing.

Therefore, the best option for blackfly control (both financially and environmentally), is to minimise the number of treatments. Timing of treatments should be stretched out as far as possible, although not too far as to allow large numbers of adult females to emerge.

PUBLIC PERCEPTIONS

The report says the success or failure of insect control programmes worldwide often hinges on public perceptions. In South Africa, public awareness of environmental issues is growing fast and it is increasingly important for the public to be kept informed about the control programme. This means that the people applying the larvicides should be informed about the effects of the larvicides and safety precautions, so that questions of observers may be answered.

SA WATERKALENDER

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

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

Address:
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Tel (012) 330-0340
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Legend:
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- × 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 koördinering van watergebeurtenisse in Suid-Afrika.

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Sien Konferensies- en Simposiumbladsy vir aangeduide geleenthede.

1997

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SOUTHERN AFRICA 1997

AQUACULTURE
JANUARY 20 - 24
A short introductory course will be presented by the Department of Ichthyology & Fisheries Science at Rhodes University. It will consist of a series of lectures, tutorials, practicals and demonstrations on the University's experimental fish farm and a visit to the Port Alfred Marine Laboratory and commercial aquaculture operations in the Eastern Cape.
Enquiries: Mrs Linda Coetzee, Department of Ichthyology and Fisheries Science, Rhodes University, PO Box 94, Grahamstown 6140. Tel: (0461)-318415/6. Fax: (0461)-24827. E-mail: ihlc@warthog.ru.ac.za

WATER RESOURCES
JANUARY-FEBRUARY
WR90 courses will be held at various centres in South Africa. See advertisement on page 32 of this Bulletin.

GROUNDWATER
FEBRUARY 27 - 28
A workshop on groundwater management in drought prone areas of Africa will be held at Lilongwe, Malawi.
Enquiries: Beatrice Gibbs, British Geological Survey, Wallingford, Oxfordshire 0X10 8BB, UK. Tel: (44) 1491 692302. Fax: (44) 1491 692345. E-mail: b.gibbs@bgs.ac.uk

METEOROLOGY
APRIL 7 - 11
The 5th international conference on southern hemisphere meteorology and oceanography will be held at the University of Pretoria.
Enquiries: Conference Planners: Amie Wissing. Tel and Fax: (012) 46-0170.

FORESTS
MAY 11 - 17
A workshop with the theme: Forests at the limit: Environmental constraints on forest function will be held at Skukuza in the Kruger National Park, Mpumalanga.
Enquiries: Ms Tisha Greyling, IUFRO Workshop Secretariat PO Box 95823, Waterkloof 0145. Tel: (012) 346-1517 Fax: (012) 46-7909 E-mail: liaison@cis.co.za

SAICE
JUNE 2 - 4
The 2nd international mining and industrial waste conference will be held in Midrand, Gauteng.
Enquiries: Lesley Stephenson, Conference Secretary, PO Box 327, Wits 2050. Tel: (011) 716-5091 Fax: (011) 339-7835.

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. **Call for papers. Deadline: 31 January 1997**. Suitable topics for papers include: Community management of water and sanitation supply; Hygiene, education and marketing programmes; Low-cost sanitation; Non-conventional sources of water; Environmental problems and their solution; Solid waste management; Recycling of wastes; Use of solar energy; Cost recovery techniques; Partnerships with the private sector; Local government capacity building; Groundwater use; Innovative water supply and sanitation solutions; Gender issues; Integrated community development; Balancing delivery and participation; and Management of resources for potable water.
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 new five-star Table Bay Hotel, Waterfront, Cape Town.
Enquiries: Conference Secretariat: Ms Cilla Taylor, Conference Planners, PO Box 82, Irene 1675. Tel: (012) 63-1681. Fax: (012) 63-1680.

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". **Call for papers.**
Enquiries: Zia Howeson. Tel: (011) 792-9807. Fax: (011) 791-0571.

HYDRAULICS
NOVEMBER 5 - 7
The third in the series of international 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. **Call for papers. Deadline: 17 Januarie 1997.**
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. See advertisement on page 2 in this Bulletin.

OVERSEAS 1997

CRYPTOSPORIDIUM
MARCH 2 - 5
An international symposium on waterborne cryptosporidium will be held in Newport Beach, California, USA.
Enquiries: Brian Murphy, AWWA, 6666 W Quincy Ave., Denver, CO 80235, USA. Tel +1 303 347 6194. Fax: +1 303 794 8915.

AUSTRALIAN WATER
MARCH 16 - 21
The 17th Australian Water & Wastewater Association federal convention will be held in Melbourne, Australia.
Enquiries: AWWA, PO Box 388, Artarmon, NSW 2064, Australia. Tel: +61 2 413 1288. Fax: +61 2 413 1047.

REUSE OF WATER
APRIL 1997
A WEF conference on the beneficial reuse of water and solids will be held in Marbella, Spain.
Enquiries: Linda Blankenship, WEF. Tel: +1 703 684 2400. Fax: +1 703 684 2492.

GROUNDWATER
APRIL 7 - 11
An international conference and course on Analytic based modeling of groundwater flow will take place in Nunspeet, the Netherlands.
Enquiries: The Conference Secretariat, MOORGA, Buerweg 51, 1861 CH Bergen, the Netherlands. Tel: +31 7258-99062 Fax: +31 7258 99040

OXIDATION
APRIL 21 - 23
A symposium on oxidation methods for water and wastewater treatment will be held in Berlin, Germany.
Enquiries: IOA European African Group, 83 Avenue Foch, F-75116 Paris, France.

RAINWATER
APRIL 21 - 25
The 8th international conference on rainwater catchment systems will be held in Tehran, Iran.
Enquiries: Mr J Ghoddousi, PO Box 13445-1136, Tehran, IR Iran. Tel: +98 21 6418335 Fax: +98 21 6407214 E-mail: RAIN@ NEDA. NET.IR

WATER INDUSTRY
APRIL 21 - 25
An international water industry exhibition will be held in conjunction with Wasser Berlin '97 in Berlin, Germany.
Enquiries: In South Africa: Mrs E Berger. Tel: (011) 486-2775. Or: Messe Berlin GmbH, IFW/M3, Messedamm 22, D-14055 Berlin. Tel: (030) 30380. Fax: (030) 3038-2079.

IAHS 97
APRIL 23 - MAY 3
The 5th Scientific Assembly of the International Association of Hydrological Sciences will take place in Rabat, Morocco.
Enquiries: Direction Generale de l'Hyraulique, Casier Rabat,

Chellah, Maroc. Tel: +212 7 769008. Fax: +212 7 778696.

SLUDGE

APRIL 30 - MAY 2

A conference on the management and fate of toxic organics in sludge applied to land will be held in Copenhagen, Denmark.

Enquiries: Mia Clausen, Building 115, Technical University of Denmark, DK-2800 Lyngby, Denmark. Tel: +45 45 251613. Fax: +45 45 932850. E-mail: mc@imt.dtu.dk

DEPOLURB '97

MAY 18 - 22

Depolurb '97 - an international conference on waste pollution control and environmental management in large metropolitan areas will be held in Sao Paulo, Brazil.

Enquiries: IAWQ Brazilian National Committee, Rua Conde de Iraja, 260/1 Andar, 22271-020, Rio de Janeiro, Brazil. Tel: +55 21 537 4338. Fax: +55 21 537 7991. E-mail: depolurb@ fage ventos.com.br

WATER SUPPLY

MAY 19 - 22

A conference on reservoir management and water supply - an integrated system - will be held in Prague, Czech Republic.

Enquiries: Dr Petr Dolejs, IWSA/IAWQ Conference, W&ET Team, Box 27, Pisecka 2, 370 11 Ceske Budejovice, Czech Republic. Tel/Fax: +42 38 41624. E-mail: petrdol@marvin.jcu.cz

ASIAN WATERQUAL '97

MAY 20 - 23

Asian Waterqual '97 - the 6th IAWQ Asia-Pacific regional conference will be held in Seoul, Korea.

Enquiries: The Secretariat, SL Kangnam, PO Box 305, Seoul 135-603, Korea. Tel: +82 2 3476 7700. Fax: +82 2 3476 8800. E-mail: koconex@ chollian. dacom. co.kr

WATER SYSTEMS

MAY 25 - 28

An IWSA and IAWQ specialised conference on the Upgrading of water and wastewater systems will be held in Kalmar, Sweden.

Enquiries: Dr Ulf Lidman, Dept of Natural Sciences, University of Kalmar, Box 905, S 391 29 Kalmar, Sweden. Tel: (46) 480-446235 Fax: 480-446262

AD-97

MAY 25 - 29

The 8th international conference on anaerobic digestion will be held in Sendai, Japan.

Enquiries (local): Prof Trevor J Britz, Department of Food Science, University of Stellenbosch, Private Bag X1, Matieland 7602. Tel: (021) 808-3578 Fax: (021) 808-3510. E-mail: voedselw@ land.sun.ac.za

SEWERS

MAY 26 - 28

The 2nd international conference on The sewer as a physical, chemical and biological reactor will be held in Aalborg, Denmark.

Enquiries: Kirsten Andersen, Environmental Engineering Laboratory, Sohngaardsholmsvej 57, DK-9000 Aalborg, Denmark. Tel: +45 98 158522 ext 6522. Fax: +45 98 142555. E-mail: i5ka@civil.auc.dk

ACID DRAINAGE

MAY 31 - JUNE 6

The fourth international conference on rock acid drainage with the theme: "Application of Technology" will take place in Vancouver, British Columbia, Canada.

Enquiries: 4th ICARD, att. Peggy Shepard, Venue West Conference Services, 645 - The Landing, 375 Water Street, Vancouver, BC Canada V6B 5C6. Tel: (604) 681-5226. Fax: (604) 681-2503. E-mail: congress@ venue west. com

GRASSLAND

JUNE 8 - 19

The 18th international grassland congress will be held in Winnipeg, Manitoba, Saskatoon, Saskatchewan, Canada.

Enquiries: Grassland '97, PO Box 4520, Station C, Calgary, Alberta, Canada T2T 5N3. Fax: 403-244-4487. E-mail: amc@forage.org Website: http://www.forage.org

WATERMATEX'97

JUNE 18 - 20

Watermatex '97 - the 4th international symposium on systems analysis and computing in water quality management will be held in Quebec City, Canada.

Enquiries: Dr Paul Lessard, Department Genie Civil, Pavillion Pouliot, Universite Laval, Quebec, QC, Canada, G1K7P4. Tel: +1 418656 7293. Fax: +1 418 656 2928. E-mail: paul. lessard @gci.ulaval.ca

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, Slovevnia. 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

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.

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: 067 73 3237. 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. **Call for papers. Closing date: 31 December 1996.**

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

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 @ vaxca3.unica.it

WATER RESEARCH COMMISSION

CO-ORDINATING COMMITTEE FOR MINING RELATED WATER RESEARCH (CCMRWR)

INVITATION TO ASSIST WITH THE IDENTIFICATION OF MINING RELATED WATER RESEARCH NEEDS

With the co-operation and support of the mining industry, government departments and other interested parties, the WRC in 1993 established a Co-ordinating Committee for Mining Related Water Research (CCMRWR) to, *inter alia*, identify research priorities and co-ordinate the national research effort in this field. Research in this field is presently being conducted in order to improve our assessment of the effects mining have on the water environment and to improve on predictions about mining's future impact. Research is also being conducted into means which can be used to minimize pollution and mitigate or control its effect through suitable treatment methods. As a result of the initiatives taken by the CCMRWR, duplication within the national mining related water research effort has largely been eliminated and research is being conducted more cost effectively.

The CCMRWR plans to evaluate present mining related water research and prioritise its research and technology transfer needs during a workshop towards the end of March 1997. In preparation for this exercise specialists in the field are at present preparing situation assessment statements and identifying research and technology transfer needs.

Interested and affected parties who would like to contribute to the identification of research needs will be welcome to do so. These suggestions will be considered by the CCMRWR during its deliberations. Individuals and organisations who wish to contribute in this regard could be assisted by consulting the situation assessments being prepared by specialists. Copies of the situation assessments and already identified research needs will be distributed to these parties on request. Please contact the WRC in order to obtain a copy. After the CCMRWR workshop in March 1997 all contributors will be provided with the workshop findings.

Individuals and organisations who wish to take part in the identification of research needs are requested to supply their particulars as listed below to Mrs Tokkie van Loggerenberg at the WRC, before **31 January 1997**. Further information can be obtained by phoning Mr Meiring du Plessis or Dr Theuns Erasmus at the WRC.

INTENTION TO SUBMIT RESEARCH NEEDS

Please complete the following form and mail or fax to Mrs Tokkie van Loggerenberg, Water Research Commission, P O Box 824, Pretoria, 001. Fax No. (012) 331 2565.

Name of individual/organisation . . . . . .
Postal address . . . . . .
. . . . . .

Tel. ( ) ..... Fax ( ) ..... E-mail .....

BESPROEIING

Besproeiingsontwerphandleiding

vir Suid-Afrika

Die provinsiale departemente van landbou tesame met die Instituut vir Landbou-Ingenieurswese van die Landbounavorsingsraad te Silverton het gedurende Januarie 1994 besluit om 'n besproeiingsontwerphandleiding te skryf.

Die handleiding bestaan uit 20 hoofstukke wat alle komponente van besproeiing dek, naamlik, grond, water, gewasse en besproeiingstelsels. Die interpretasie van belangrike teoretiese konsepte sowel as die verskillende ontwerpprosedures word geïllustreer deur praktiese voorbeelde.

Die voltooiingsdatum vir die handleiding is Desember 1996. Alhoewel die eerste uitgawe in Afrikaans is, sal die handleiding teen Maart 1997 ook in Engels verkrygbaar wees.

Persone wat belangstel om die handleiding teen R100 (BTW ingesluit) te koop, moet asseblief die onderstaande bestelvorm voltooi en dit saam met die geld na die betrokke adres terugstuur.

IRRIGATION

Irrigation design manual

for South Africa

During January 1994, the provincial departments of agriculture together with the Institute for Agricultural Engineering of the Agricultural Research Council in Silverton, decided to compile an irrigation design manual.

The manual comprises of 20 chapters which cover all the components of irrigation, namely, soil, water, crops and irrigation systems. Interpretation of important theoretical concepts and design procedures has been illustrated with practical examples.

The completion date for the manual has been set for December 1996. Although the first edition will be in Afrikaans, the intention is to have an English version ready by March 1997.

Persons interested in purchasing the manual at R100 (VAT incl.) per copy, should please complete the order form below and return it, together with the money, to the address indicated.

BESTELVORM/ ORDER FORM

Stuur asseblief ..... Afrikaanse kopieë @ R100 per kopie aan die volgende adres:

Please send ..... English copies @ R100 per copy to the following address:

Titel/Title..... Voorletters/Initials..... Van/Surname.....

Adres/Address..... .....

Dorp/Town ..... Kode/Code .....

Tel/Fax .....

Ingesluit my tjek vir R. ..... /Enclosed my cheque for R .....

(Tjeks aan: Direkteur:Instituut vir Landbou-Ingenieurswese)
(Cheques are payable to: Director: Institute of Agricultural Engineering)

POS AAN/SEND TO:

Mnr F H Koegelenberg,
Departement Landbou: Wes-Kaap,
Direktoraat: Landbou-Ingenieurswese,
Privaatsak X1, Elsenburg 7607.
Navrae/Enquiries: Tel (021) 808-5357

Handtekening/Signature .....

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Getting to know and use

WR90

The WR90 publication *Surface Water Resources of South Africa 1990* has been available from the Water Research Commission for approximately a year. Descriptions of the Reports and Order Forms were distributed in a recent issue of the SA Waterbulletin and in some Journals. It is time now to ensure that water engineers and earth scientists are able to make the best use of the vast store of data and design aids in the Reports. The Commission has accordingly arranged for two-day courses at the main centres and mini-courses at other centres to be held during 1997.

The cost of the two-day course is R600 per participant and the mini-course R400, including lunches and refreshments. Participants may purchase a manual and one set of regional maps and appendices for R100 which is roughly half the normal price.

The two-day course will take the form of computer hands-on problem-solving sessions followed, on the afternoon of the second day, by a feed-back discussion session at which it is hoped to identify errors and elicit suggestions for additions, improvements, ideas for future updating of the Survey. The mini-courses will be presentations showing how WR90 information can be used for problem-solving.

TWO-DAY COURSES	DATE	PROBABLE VENUE
Durban/PMB	❍ 10 & 11 February 1997	Univ of Natal - Pietermaritzburg
Grahamstown/Port Elizabeth	❍ 13 & 14 February 1997	Port Elizabeth University
Pretoria/Johannesburg	❍ 6 & 7 February 1997	Pretoria University
Stellenbosch/Cape Town	❍ 28 & 29 January 1997	Stellenbosch University

MINI-COURSES		
Swaziland/Nelspruit	❍ 18 February 1997	Drum Rock Complex
Lesotho/Bloemfontein	❍ 31 January1997	GRI Bloemfontein University
Pietersburg	❍ 21 January 1997	Library Activity Centre
East London	❍ 4 Febuary 1997	King David Hotel

APPLICATION FORM: WR90 COURSE

Name: ..... Organisation: .....

Postal Address: .....

Tel: ..... Fax:.....

I wish to attend the course at: .....

Registration fee: R600/R400 (inc VAT) Purchase of manuals: R100 (inc VAT)

I enclose cheque of: R ..... made out to SRK WR90 Course.

Please complete and return to:
Brian Middleton, SRK, P O Box 55291, Northlands, 2116 before 30 November 1996.
Enquiries to Harriet at Tel.: (011) 441-1265 Fax: (011) 441-1174