

S4 waterbulletin

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WATER RESEARCH COMMISSION
Meet the newly appointed members

WATERGEHALTE
Watergehalteveranderlikes se invloed op rivierlewe bepaal

EFFLUENT TREATMENT
Yeast biomass shows potential for the removal of heavy metals

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UNIVERSITY OF DURBAN WESTVILLE

DEPARTMENT OF CIVIL ENGINEERING CENTRE FOR WATER POLLUTION RESEARCH



PhD Scholarship

As part of the activities of the Centre for Water Pollution Research at the Department of Civil Engineering, University of Durban Westville, the Foundation for Research Development, have made funds available for three years of research leading to a PhD degree. The other activities at the Centre include the ongoing M.Sc(Eng) degree in Water and Environmental Management.

Applications are invited for the three (3) year scholarship to do research in the general field of water and environmental engineering, leading to PhD in Civil Engineering. Applicants should have a good bachelors degree in civil or chemical engineering or at least an honours degree in a water related area. Preference will be given to holders of masters degrees in these fields or those with experience in the water and environment or related industry, or those who have demonstrated ability to carry out research.

Curriculum vitae and copies of certificates including names and contact details of two referees should be sent to the following address, from which further particulars may be obtained:
The Head of Civil Engineering, University of Durban Westville, Private Bag X54001, Durban 4000 Tel. (031) 8202749, Fax. (031) 8202755, Email: Otieno@pixie.udw.ac.za

M.Sc (Eng) Water and Environmental Management

As part of the activities of the Centre for Water Pollution Research at the Department of Civil Engineering, University of Durban Westville, and partly funded by the Foundation for Research Development (FRD), there is an ongoing 12 months programme in M.Sc (Eng) Water and Environmental Management. There are a limited number of scholarships for South Africans supported by the FRD.

The next programme starts in February 1996 and we are currently receiving applications.

The course content takes into account the multidisciplinary nature of water and environmental management and should appeal to graduates of chemical and civil engineering, as well as geography, chemistry, geology, microbiology, biology, environmental sciences and other related science honours graduates.

Among the core courses offered in the programme are:

- Environmental Impact Assessment,
- Water Resources Operations,
- Environmental Pollution and Control,
- Unit Operations and Processes.

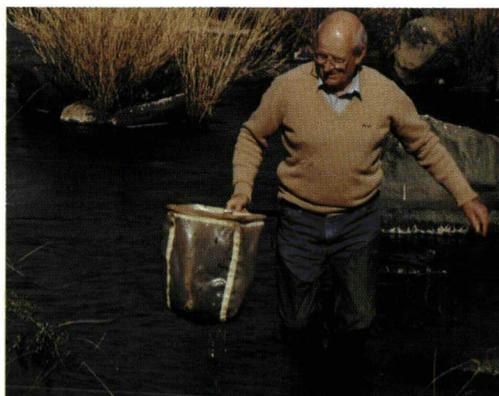
There are several electives on the programme and the student can opt for those that are of interest to him/her.

Further details regarding this programme can be obtained from:

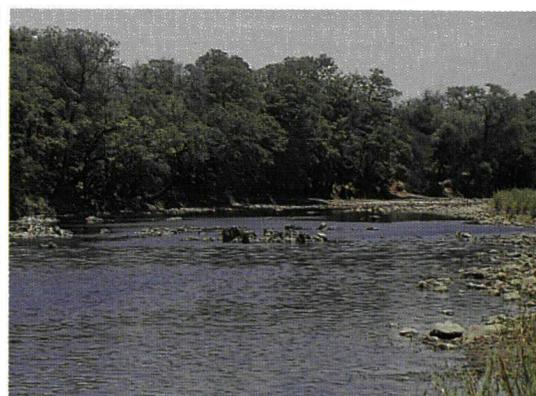
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University of Durban Westville,
Private Bag X54001, Durban 4000**
Tel. (031) 8202749 Fax. (031) 8202755,
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Cover photo: Rainwater percolates through the soil and recharges groundwater. (Photo: Jan du Plessis)

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. Asst Editor: Helene Joubert. Ed Secretary: Rina Human. Layout: Prepress Images, Pretoria. Colour Separations: Lithotechnik. Printing: Beria Printers.

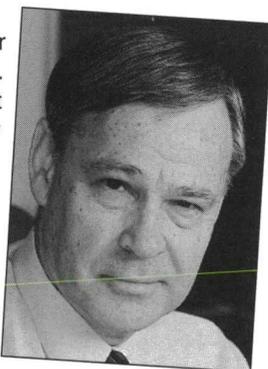
New WRC Commission Members Appointed

The new Board of Commission Members of the Water Research Commission was officially appointed by the Minister of Water Affairs and Forestry, Prof Kader Asmal, on 1 August 1995.

The term of office of the previous Board had expired on 31 July 1995. Prof ET Johnson is the chairman of the newly appointed Board which constitutes fifteen members. The members are:

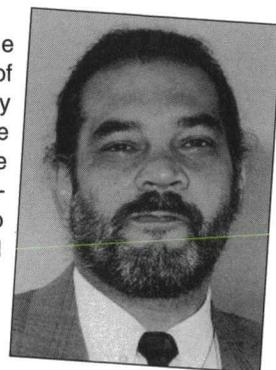
Mr PE Odendaal

Mr Odendaal is the Executive Director of the Water Research Commission. He is also the current Vice-President of the International Water Quality Association (IAWQ). He has been involved in the waterfield since 1963 when he joined the then Water Research Institute of the CSIR. Mr Odendaal joined the Water Research Commission in 1971 as a Research Advisor and was appointed as Executive Director in 1985.



Prof CT Johnson: Chairman

Prof Johnson is the Dean of the Faculty of Science at the University of the Western Cape (UWC). Formerly he was professor and head of the Department of Botany at UWC. He has been very active in environmental education programmes. He is also a member of the Environmental Advisory Unit of the University of Cape Town, and of the Land Development Unit at UWC.



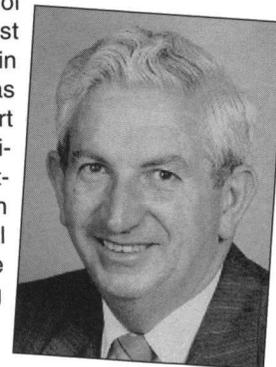
Mr Vincent Bath

Mr Bath is the Chief Executive of Rand Water since 1988. Mr Bath joined Rand Water in 1966 and his career includes involvement in major projects, such as the Tugela Vaal scheme, to improve the water supply in the Rand Water supply region. He was also involved in the planning and development of future water supply systems in Rand Water's area of supply, and with the implementation of an integrated computer system for Rand Water's business activities.



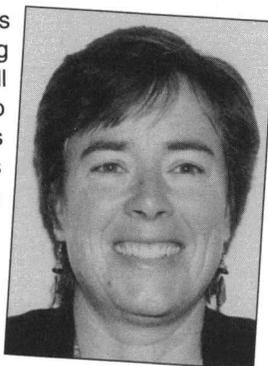
Mr AJ Clayton

Mr Clayton is the City Engineer of Cape Town since 1989. His first appointment as City Engineer was in Windhoek, Namibia, in 1967. He has served as City Engineer of Port Elizabeth. He has extensive experience in water and wastewater treatment, engineering projects and urban planning, as well as environmental matters. He was a member of the team responsible for the outstanding technical development of the Windhoek Water Reclamation Scheme.



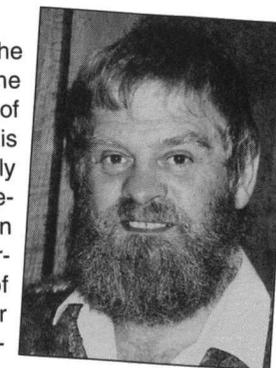
Ms Diana Callear

Ms Callear is consultant to the ANC's Land and Agriculture Centre, advising on rural development policy, as well as land reform issues. Subsequent to doing a BA in Development Studies she studied agricultural economics and obtained a M.Litt in Economics from Oxford University. Her work focus is mainly on African food production and economics in rural areas. She has also been national food strategy coordinator for the government of Botswana.



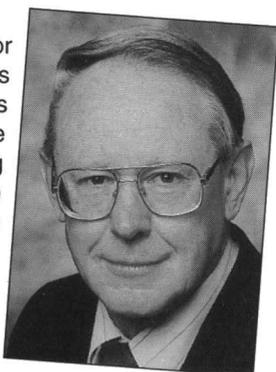
Prof BR Davies

Prof Davies is the Director of the Freshwater Research Unit in the Department of Zoology, University of Cape Town. His particular interest is the aquatic environment, especially river system ecology and management, along with river conservation and rehabilitation. His research interests also include the ecology of coastal lake systems, in particular the ecological functioning of urban-impacted coastal systems.



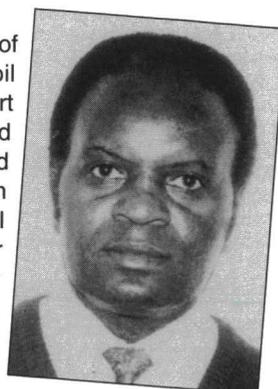
Mr M Erasmus

Mr Erasmus is currently the Director General of Department of Water Affairs and Forestry (DWAFF). His career has been with DWAFF, having joined the Department in 1961 after completing his engineering studies at the University of Pretoria. He has also served as a board member for some of the Waterboards. He has a keen interest in nature and environmental conservation matters.



Prof K Nyamaphene

Prof Nyamaphene is the Dean of Agriculture and Professor of Soil Science at the University of Fort Hare. He has been researcher and consultant on land management and environmental impact assessment in Southern African countries as well as the USA and Spain for a number of years before joining the University of Fort Hare in 1992. He has also served on the Board of Directors of the Zimbabwe National Water Authority.



Mr MS Furumele

Mr Furumele is at present with Goba Moahloli and Associates, consulting engineers and development managers. He has studied at Wits, specialising in water engineering post-graduate level and recently obtained an MEng (Civil and Environmental) degree from Penn State (USA). He started his career with Keeve Steyn Inc, as a design engineer on a variety of projects.



Mrs Angie Phaliso

Mrs Phaliso is currently with Africa Growth Network. She has served as Education and Information Officer of the Johannesburg Civic Association and is actively involved in her community. She is the Treasurer of the Soweto Civic Association and has also been involved negotiating the Transitional Metropolitan Council. Presently she is serving on the Klipriver Impact Assessment Study task team.



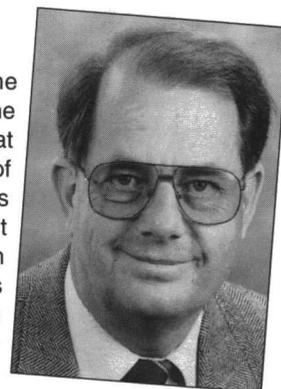
Dr Ania Grobicki

Dr Grobicki is presently director of the South African branch of the engineering company Abbott Grobicki and Associates (UK). She has studied chemical engineering as well as economics. Her research and consultancies have covered aspects such as treatment of industrial effluent and wastewater, as well as landfill design and management. She has also been advisor to the ANC on science, technology and environment policy.



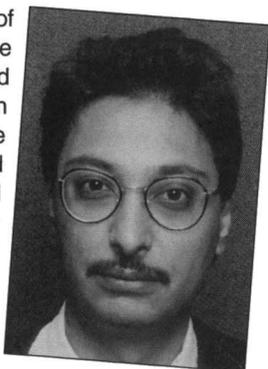
Prof A Rooseboom

Prof Rooseboom is heading the Water Engineering Division in the Department of Civil Engineering at the University of Stellenbosch. Prof Rooseboom's research work has concentrated mainly on sediment transport in rivers. Publications on reservoir sedimentation as well as road drainage, of which he was the main author, are regarded as standard works both locally and internationally.



Dr HC Kasan

Dr Kasan is Head of the Department of Biotechnology at the Technikon Natal. He has a multidisciplinary study background which includes a Graduate Diploma in Engineering at the University of the Witwatersrand. His field of research and expertise is industrial and environmental biotechnology, water and wastewater treatment and management, as well as environmental engineering.

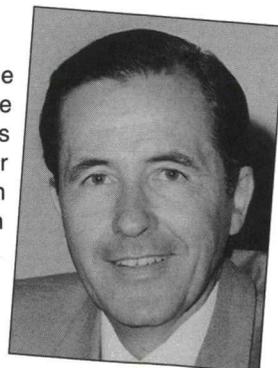


Mr BA Langa

Mr Langa is presently a business executive with the E Bank Division of Standard Bank. He was previously involved in the sorghum beerbrewing and oil refining industries being involved in the technical and engineering side of these processes, before becoming managing director of Brewpack (Pty) Ltd. Mr Langa studied engineering at Beloit College (USA).

Prof PD Tyson

Prof Tyson is the Director of the Climatological Research Group at the University of Witwatersrand. His research with regard to the weather and climatic variability in Southern Africa, is well known and has been published locally and internationally. Prof Tyson has also served terms as Vice-Principal and Deputy Vice-Chancellor of the University of the Witwatersrand.



Dilution of marine discharge studied

Numerous theories and models are available to predict the initial dilutions which can be achieved when a buoyant effluent is discharged to sea via a deep sea outfall. The choice of the technique to be applied is to be decided by the design engineer and must be agreed upon by both the client and the control authority, as it is not practical to utilise numerous techniques for each study or design.

The essential issue is that the technique applied should be considered reliable and the engineer should be aware of the sensitivity of the prediction for the diversity of physical conditions off the South African coast. Confidence in the theoretical prediction can only be gained by comparing the predicted values to actual achievable dilutions under various physical conditions, says Mr WAM Botes of the Coastal Engineering Programme, EMATEK, CSIR, in a report to the Water Research Commission.

The more sophisticated techniques provide more accurate predictions, but, the more detailed the desired output is, the more detailed the input that is required. Taking

the diversity and complexity of the South African coastline into account, the acquisition of data required for model inputs is extremely expensive in terms of manpower, sophisticated equipment and operational expenses.

According to the report simpler techniques can be applied with confidence when extensive data sets are not available, especially when followed up by a few field experiments to determine the actual achievable dilutions. The CSIR (Stellenbosch) undertook a research project, funded by the Water Research Commission, to determine the applicability and accuracy of the theories and approaches which are applied to predict the initial dilution which can be achieved from long sea outfalls for South African coastal conditions.

The report entitled **Dilution studies on large offshore pipelines** (WRC Report no 364/1/94) is available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. Please note: Foreign orders will be charged a list price of US\$ 20 per copy.

WAM BOTES

DILUTION STUDIES ON LARGE OFFSHORE PIPELINES

Report to the
WATER RESEARCH COMMISSION
by the
DIVISION OF EARTH, MARINE AND ATMOSPHERIC SCIENCE
AND TECHNOLOGY, CSIR

WRC Report No 364/1/94



At present 13 marine outfall pipelines are in operation in South Africa, discharging domestic and industrial effluent offshore. The performance of some of these pipelines is checked annually by assessment of the biological and chemical impact on the marine environment.

In 1984 the CSIR did a full scale physical performance check on the Camps Bay pipeline by introducing a conservative tracer into the system and measuring the actual dilutions achieved in the sea. This experiment was successfully conducted and provided a more exact performance evaluation for marine outfall schemes.

During 1991 the Water Research Commission funded the CSIR to conduct similar performance assessments on three pipelines in South Africa over a period of three years to prove that achievable initial dilutions compare favourably with the theoretical predic-

tions to support biological and chemical impact assessments and to facilitate the design process of new pipelines.

The three field experiments performed in this project along with the field experiment conducted at Camps Bay in 1984 are extremely valuable, not only for the researchers of this study, but for the entire engineering and scientific community involved in the design and assessment of sea outfalls and marine water quality in South Africa.

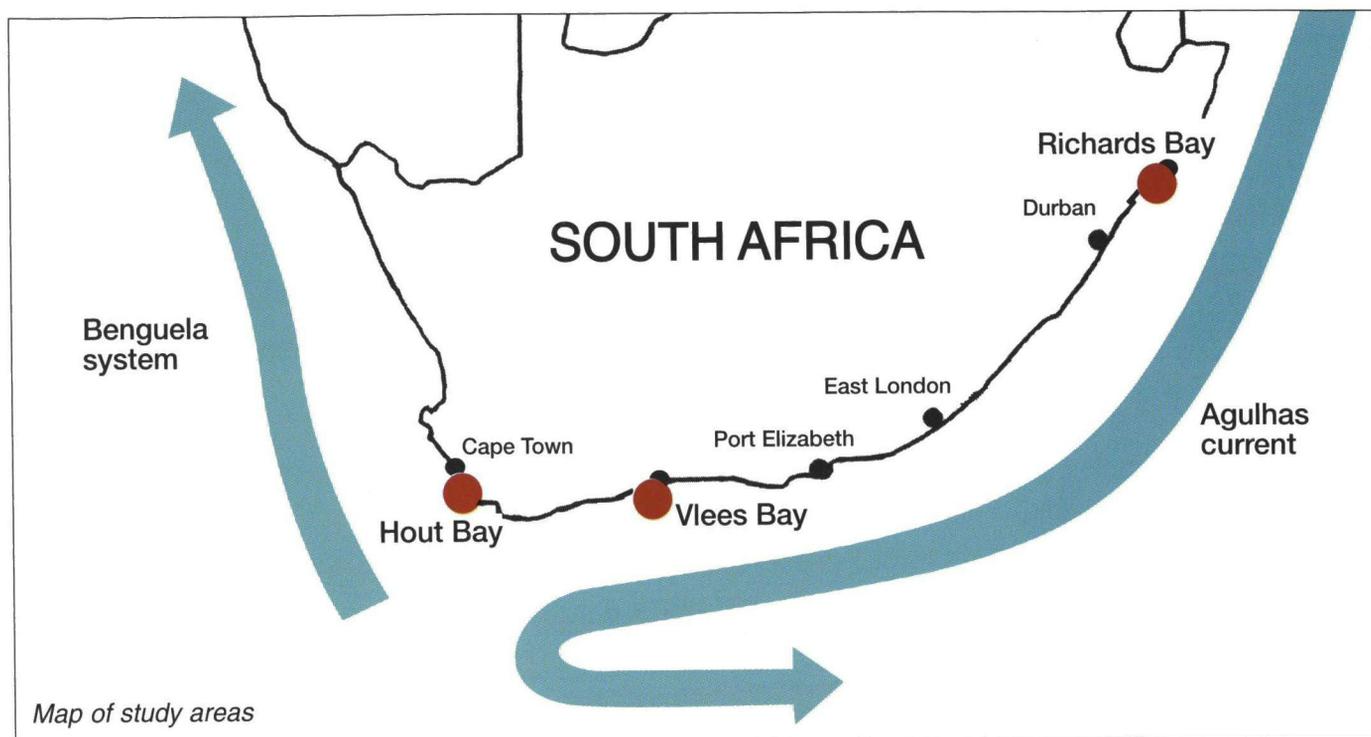
DILUTION

The total achievable dilution which can be expected at a distant location is the product of the initial dilution, secondary dilution, dilution due to the die-off of microbiological organisms and the chemical or biological dispersion of non-conservative substances. The initial dilution is the dilution achieved by the entrainment of seawater during the rise of the buoyant effluent from the diffuser

to the surface of the sea. The subsequent transport of the effluent away from the surfacing effluent plume, referred to as the effluent "boil", brings about further reduction of the effluent concentration. This process is generally referred to as secondary dilution, which is caused by turbulence, eddies and shears, causing further entrainment or mixing of the seawater. Together with the chemical and biological dispersion of non-conservative substances and the die-off or decay of certain organisms during the transport of the effluent (dilution due to decay), the initial dilution and the secondary dilutions determine the ultimate concentrations of pollutants and subsequent impact on the designated uses at any location away from the discharge point.

AIM

The aim of this project was to establish the comparability of actual achievable initial dilutions and theoretically predicted dilutions for a variety of existing



marine outfalls along the South African coastline. This was done in order to make recommendations regarding the applicability of different theories and approaches being used for design of outfalls in South Africa.

STUDY AREAS

The three study areas, Richards Bay, Vlees Bay and Hout Bay, were chosen to represent various deep sea outfall designs and types of effluent as well as the diversity of the physical conditions along the South African coastline. The experiments were conducted in close cooperation with the "owners" of the outfalls and contributed to a great extent to the understanding of the hydraulic performance of the outfalls which should facilitate the normal operational procedures. The field experiment at Hout Bay coincided with the commissioning of the entire new sewage system and together with designers and contractors, the system was commissioned with thorough understanding and verification of the hydraulic behaviour.

METHODOLOGY

The same methodology was followed for the three outfalls. Rhodamine-B dye was

prediluted and released at the head-works. Samples were taken at the head-works downstream of the release point, at the diffuser (by divers or by pipe to the sea-surface) and in the effluent "boil" to determine the initial dilutions as well as the dilutions in the moving effluent field. Samples were taken from a larger survey vessel, equipped with an accurate electronic navigational system as well as from more mobile ski-boats. The growth of the effluent field was recorded by circumnavigation and at each location an attempt was made to take aerial photographs. From these field experiments it was found that the photographic recording of an effluent field is difficult, due to the unpredictable weather conditions and high dilutions.

SECONDARY DILUTION

The moving effluent field, after the initial dilution process, was monitored to obtain an estimate of the achievable secondary dilutions. The recorded secondary dilutions were limited to approximately five times within 200m from the "boil" whereafter only an additional twofold dilution can be expected even as far as one kilometre away from the discharge location. The verification of the available techniques (analytical or numerical) which

are used for the prediction of achievable secondary dilutions was not done, as this was not within the scope of this study.

RESULTS

For the Richards Bay outfall, application of the stagnant uniform theory was not realistic due to the dynamic conditions present on the day of the exercise, resulting in under-estimations of greater than six times for the dilutions on days when current velocities exceed 30 cm s^{-1} . However, for the moving water theory, embodied in a model from the Environmental Protection Agency (EPA, USA), the overestimation of the achievable dilutions is between 1,1 and 1,6 and similar to the prediction according to the Wright theory which refers to individual rising plumes and makes provision for a linear, stratified environment. According to the Water Research Centre (WRc, UK) approach, the predicted dilutions for the actual conditions compared extremely well with the measured conditions. The WRc approach takes buoyancy dominated and current dominated conditions into consideration for achievable dilutions.

The predicted dilutions for the Vlees Bay outfall, using the EPA model, the Wright theory and the WRc approach, compared

well with the measured dilutions. The ratios between measured and predicted dilutions were 0,7 to 1,2; 1,2 to 1,3 and 1,1 for the three approaches, respectively.

The discharge from the Hout Bay outfall was subjected to a strong thermocline in the water column which meant that samples had to be collected by divers at the thermocline. According to the report the ratio of the measured and the predicted mean dilution is close to unity; 0,7 to 1,4 for the EPA model and 0,9 using the Water Research centre (WRc) approach.

Although surface dilutions were more than 12 times greater than the initial dilutions measured in the trapped "boil" at a thermocline located approximately 10m below the surface, the plume was still visible. The transport of the mean effluent field (trapped) may also be completely different to the transport of the visible surface field, especially during strong wind conditions.

DATA ANALYSIS

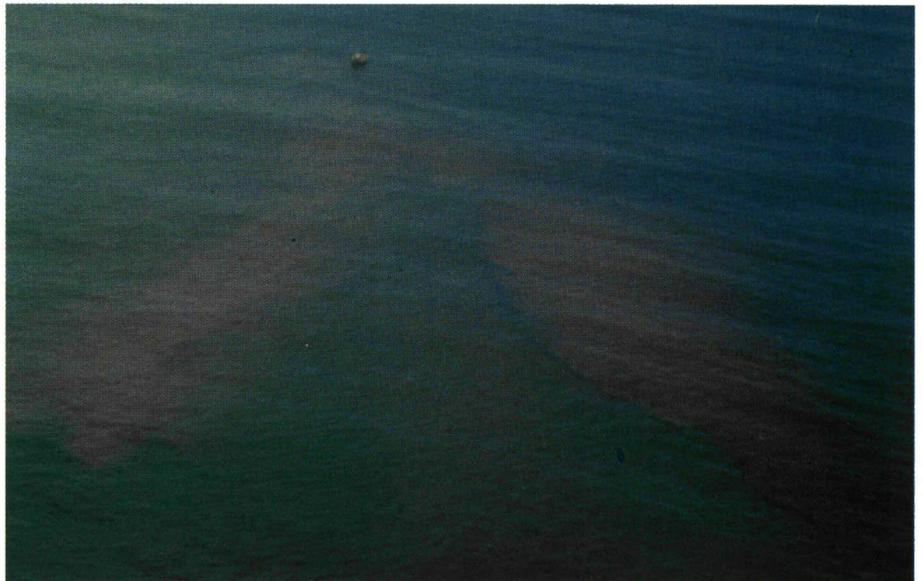
With regard to the statistical analysis of the data, a conservative approach was followed by assuming the "average" dilution refers to the highest concentration that could be detected. Considering past experience, along with the results obtained from the present series of field tests and the approach followed by the WRc, a more realistic approach was followed for this project by comparing similar statistical parameters for the predicted and measured dilutions.

According to the report the application of the "stagnant uniform" theory to a dynamic receiving environment is not a realistic approach, as the under-estimation of dilutions will be more than six times if ambient current speeds exceed 30 cm s^{-1} , irrespective of the theory that is applied, as seen in the Richards Bay example cited.

The researcher say when taking the ambient conditions into account, the predicted dilutions according to the EPA model, the Wright theory, and the WRc approach compared well with the measured dilutions. Although the EPA model provides a slightly more conservative



Vlees Bay: The surfacing effluent ("boil")



Vlees Bay: Transport of the effluent field

prediction considering the simplicity of the technique, the results of the WRc approach compares extremely well with the prototype measurements.

CONCLUSION

According to the report the three field exercises in this study provided sufficient information for a range of ambient conditions to confirm the confidence with which the available theories can be applied, also taking into account the

availability of physical data regarding currents and stratification.

Furthermore this research has demonstrated that by using the fairly simple technique suggested by the WRc, the overall predictions are as accurate as the prediction by more sophisticated methods. However, this does not mean that the more sophisticated models should be disregarded for specific applications where more details on the behaviour of a rising plume may be required.

Chemical speciation computer modelling is a tool that will enable a large number of industries to gain a greater understanding of the chemistry of their aqueous streams and to find solutions to their own particular problems, says Dr Carol Kerr Pollution Research Group, University of Natal (Durban) in a report to the Water Research Commission.

The report emanates from a research project on phase diagrams of complex precipitates with special emphasis on chemical speciation computer modelling. This research centred around finding a method to enable industries to predict the behaviour of their aqueous chemical systems in a concentrating and precipitating environment. The method had to be sufficiently flexible so as to accommodate changing factory conditions, plant upsets, or changes in process methods. Computer modelling of chemical systems offered the flexibility required.

Chemical speciation computer modelling offers a dynamic tool and method of investigation which allows the chemistry of waters and wastewaters to be studied from a perspective not usually available outside large analytical laboratories, says Dr Kerr. The acquisition of chemical speciation data would be of practical use to industry to determine the fundamental reasons for precipitation problems, and chemical speciation modelling allow industry to investigate possible remedial measures.

The report entitled **Research on phase diagrams of complex precipitants** (WRC Report no 309/1/94) is available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 20)

Researcher studies precipitants in industrial waters

The limited amount of water available in South Africa, together with environmental considerations, has resulted in many industries employing some sort of desalination measure in order to recover and reuse water and chemicals, and to reduce the volume of effluent requiring disposal. The desalination equipment (generally crystallising evaporators, reverse osmosis or electro-dialysis plants) is used either as an end-of-line effluent treatment process, or as part of a closed loop recovery system within the production process.

Regardless of the desalination technology used, fouling and scaling of heat or mass transfer surfaces is a common problem which often results in equipment being used below design specifications, in order to avoid the precipitation of unwanted solid phases. This in turn often leads to increased water and chemical consumption and effluent production, as operators try to suppress precipitation through dilution or the use of scale inhibitors. The reasons for unwanted precipitations are varied. The basis of this research project was to provide assistance to industry to deal with precipitation problems.

AIMS

The aims of this project were:

- to develop techniques for the determination of a phase diagram of complex precipitates which occur in desalination plants,
- to acquire graphical or tabular data indicating envelopes of precipitation,
- to acquire solubility design data for the

barium carbonate sulphate removal process,

- to generate data which could assist in the verification of computer models of aquatic equilibria (such as Stasoft).

In defining the methods by which the project aims would be fulfilled, several factors had to be taken into account. These were that:

- any solution reached had to be of general interest to the industrial community and not tailored to site specific cases.
- the feed solution entering desalination equipment is often the result of a number of other processes and cannot be considered in isolation
- the desalination equipment might be an integral part of process operations and a key component of a recycle loop. Any solution reached, would have to be capable of being demonstrated without disruption of factory operations.

CHEMICAL SPECIATION

Discussions with factory personnel indicated that there was a general awareness that different chemical species of a given ion could exist in solution, yet few process chemists had considered examining the chemical speciation of their systems in order to determine which species could be controlling the system chemistry. There was also an ignorance of how to determine which species were present in an aqueous system.

Chemical speciation is the term used to describe the nature of individual components in solution. The most feasible way

of introducing the concept of chemical speciation and to demonstrate the benefits of having a full chemical speciation of a water, was through the use of chemical equilibrium speciation of a water, employing chemical equilibrium speciation computer programs. Through chemical speciation studies it is possible to:

- determine the precipitation potential of feed streams.
- characterise water by chemical species rather than by total concentration of ions. This would give greater insight and understanding of the chemistry of a system and would allow better understanding of the chemistry of a system as well as precipitation and how to prevent it.
- model various treatment scenarios and their impact on the distribution of species.
- predict the influence of changing concentration, changing temperature, or the addition of other chemicals.
- understand the chemical behaviour of systems better.
- allow operators of desalination equipment to model their own site specific cases and arrive at their own conclusions.

COMPUTER MODELLING

In the course of this project four different computer programs were used. The choice of program was determined by the complexity of the problem and the amount of information available, however, of the programs used the MINTEQA2 has the greatest potential to be accepted as a tool for chemical system analysis.

The MINTEQA2 Version 3.0 chemical speciation program, released by the EPA (USA) in 1990, has reduced the level of expertise required for chemical speciation modelling. The power of the technique, and the extensive thermodynamic database, including solid phases, led to an extensive application of the program in this project to augment the more practical approach initially adopted.

APPLICATION

The report includes precipitation problems which have been encountered dur-

ing the course of this project. These are presented as a series of examples of how a knowledge of chemical speciation assisted in understanding the problem. They illustrate the practical use of computer speciation programs.

The general nature of the examples presented in this report included:

- the importance of an adequate knowledge of the chemical system involved,
- an examination of the role of ion pair formation on the precipitation of a solid phase,

C A KERR

RESEARCH ON PHASE DIAGRAMS OF COMPLEX PRECIPITANTS

Report to the
WATER RESEARCH COMMISSION
by the
POLLUTION RESEARCH GROUP
DEPARTMENT OF CHEMICAL ENGINEERING
UNIVERSITY OF NATAL

WRC Report No 309/1/94

- the optimisation of chemical dosing and process control,
- the determination of the degree of saturation in a concentrating system,
- the effect of temperature on the solubility and nature of the solid phase,
- the effect of oxidation state,
- the effect of adsorption on the distribution of chemical species,
- difficulty in modelling environmental problems,

The varied nature of the examples presented in the report, indicates the potential of chemical speciation as an aid to problem solving. According to the report phase diagrams (of complex precipitants) relevant to each site specific case studied

in this project could be generated using chemical speciation computer modelling. Dr Kerr says that it would not have been possible to study the examples cited to such an extent without the computer programs.

CONCLUSIONS

Chemical speciation computer programs are suitable for application to precipitation problems. (The initial reaction from industry to the use of computer models in particular MINTEQA2, has been very encouraging.)

MINTEQA2 is a versatile and easy tool to use which can be used to examine aspects of aquatic chemistry, such as ionic and organic complexation, solubilities of solids in ionic solutions, and adsorption phenomena. These phenomena have a direct bearing on the precipitation process.

The use of chemical equilibrium speciation programs offers access to speciation data, to engineering and water scientists who traditionally would not have used this technique.

Clean technologies, waste minimisation and pollution prevention should be the first considerations in solving precipitation problems.

Personnel from individual plants and factories are the best suited to model site specific problems. An outsider might be capable of technically executing the chemical modelling but factory personnel are familiar with their chemical systems and can appreciate the interactions between different areas of the plant and are in a better position to critically evaluate the computer predictions.

TESTS

Although the use of chemical speciation programs has provided a means to deal with precipitation problems with greater insight, there remains a need for practical methods to monitor the degree of saturation of concentrating solutions, with respect to the common scaling minerals. According to the report a number of small-scale tests have been developed which help determine the fouling potential of streams undergoing concentration.

Yeast biomass accumulates heavy metals from effluent

There is great potential for the use of both live and non-viable yeast cells as biosorbents for heavy metal removal from effluents and wastewaters. This is the conclusion reached by researchers in project reports to the Water Research Commission, entitled "**The use of yeast biomass and yeast products to accumulate toxic and valuable heavy metals from wastewater**".

Conventional methods for removal of heavy metals from wastewater streams include chemical precipitation, chemical oxidation or reduction, ionic exchange, filtration, electrochemical treatment, and evaporative recovery. Such processes may be ineffectual or extremely expensive when initial heavy metal concentrations are in the range of 10 - 100 mg/l and discharge concentrations are required to be less than one mg/l. This area of operation is therefore open to competition from bioaccumulation processes.

Micro-organisms are known to play an active role in the solubilisation, accumulation, transport and deposition of metals in the environment. Micro-organisms are known to accumulate metals from

dilute metal ion solutions and thereby concentrate the metal. This would facilitate the restoration of metal contaminated water and the recovery of valuable metals. Furthermore, the need for a cheap, non-polluting, biological method for the treatment of wastewater for reuse is an ongoing concern, worldwide.

The researchers JR Duncan, D Brady and AD Stoll, Department of Biochemistry and Microbiology, Rhodes University, has attempted to define the heavy metal bioaccumulation potential of yeast and yeast products, and to elucidate the mechanisms of this accumulation, with a view to eventually utilise this biomass commercially for metal removal and/or recovery from wastewaters.

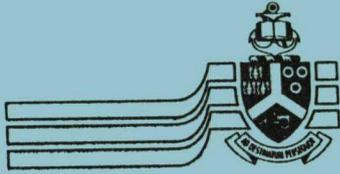
The project reports, WRC Report no 392/1/93* and WRC Report no 464/1/94**, both entitled "**The use of yeast biomass and yeast products to accumulate toxic and valuable heavy metals from wastewater**", are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. Foreign orders are US\$ 30* and US\$ 25** respectively per copy.

Water is an important though often underrated resource. Water availability and quality are of paramount importance in socio-economic growth in South Africa. Calculations have shown that according to the present growth rates of population and industry in South Africa, the demand for potable water will exceed the available supply by the year 2020.

Metal ions contribute to the pollution of water and are often toxic, as they may be concentrated in certain organisms and passed on, at high concentrations, to humans. The importance of this problem is highlighted by the fact that humans are now the largest agent in the biogeochemical cycles of trace metals on a global scale and the toxicity of these metals now exceeds that of all radio active and organic wastes released into the environment.

Many industrial and mining processes produce wastewaters containing heavy metals, which represent highly toxic effluent on the one hand and, in the case of the mining industry, a loss of valuable metals. More stringent control of effluent quality as well as the increasing demand in South Africa for high quality potable water makes the removal of toxic metals from wastewater a priority.

Methods of metal removal such as ion-exchange and precipitation have been, in many cases, either not efficient or have not proved to be cost effective. Biotechnology based processes however, appear to offer an economic and efficient alternative to these methods.



Universiteit van Pretoria

DEPARTEMENT CHEMIESE INGENIEURSWESE

AFDELING WATERBENUTTING

1996

NAGRAADSE OPLEIDING

IN

WATERBENUTTING

BIng(Hons) & BSc(Hons)
MIng, MSc & PhD

1996

KORTKURSUSSE

- WATERGEHALTEBESTUUR
13-17 Mei 1996
- BEDRYF VAN WATERSUIWERINGSAANLEGTE
16-20 September 1996
- BEHANDELING VAN NYWERHEIDS- EN
VERKOELINGSWATER
21-23 Oktober 1996

Die Afdeling Waterbenutting word gerugsteun deur die Leerstoel vir Waterbenuttings-ingenieurswese wat deur Rand Water geborg word. Die Afdeling bied die volgende opleidingsprogramme aan:

- nagraadse opleiding in waterbenutting op 'n gereelde basis vir ingenieurs en wetenskaplikes; en
- kortkursusse in aanlegontwerp en -bedryf en ander onderwerpe op 'n ad-hoc-basis vir 'n wyer gehoor.

Bondige inligting oor die vereistes, kursusinhoud en studiereëlings word hiermee aanvullend tot die amptelike jaarboek verskaf. Skakel prof W A Pretorius (012/420-3566), Mnr J Botha (420-3568) of Dr C F Schutte (420-3571) vir meer inligting. As u vir enige van hierdie kursusse wil inskryf, voltooi asseblief die aangehegte antwoordstrokie.

1. NAGRAADSE PROGRAM

Die nagraadse program is op studie vir die grade BIng(Hons), BSc(Hons), MIng, MSc en PhD gerig, met die hoofdoel om multidisiplinêre kundigheid in, en navorsing oor water- en afvalwatertegnologie en watergehaltebestuur te bevorder.

1.1 INSKRYWING

(a) **Voorname om te registreer:** Bogenoemde antwoordstrokie is slegs vir hierdie Afdeling se rekords nodig. Dit vervang nie die amptelike aansoek om toelating en registrasie nie.

(b) **Aansoek om toelating:** As u vir nagraadse studie wil registreer, maar nie die voorafgaande jaar by UP geregistreer was nie, moet u aansoek doen om toelating. Dit moet so gou as moontlik geskied, maar kan ook tydens registrasie gedoen word. Aansoekvorms is by Akademiese Administrasie: Ingenieurswese (012/420-2142) beskikbaar en 'n aansoekfooi van R30,00 is betaalbaar. Studente wat vir nie-graaddoeleindes wil registreer moet ook aansoek doen om toelating.

(c) **Registrasie:** Alle studente moet jaarliks registreer. Registrasie geskied op 23 Januarie 1996 (tydens die eerste blokweek) om 14:45 in lesingsaal 2-4, Waterbenuttinggebou, UP-suidkampus. Die registrasiegeld is dan betaalbaar.

1.2 HONNEURSGRAAD

(a) **Toelatingsvereistes:** 'n BIng-graad (verkieklik in Chemiese of Siviële Ingenieurswese) of 'n BSc-graad met minstens Wiskunde I, Fisika I en Chemie I (verkieklik met Chemie of Mikrobiologie as hoofvak) word vereis.

(b) **Struktuur:** Die honneurskursus strek oor 'n tydperk van twee jaar deeltydse studie. Daar word 8 vakkursusse in die Afdeling Waterbenutting in dié siklus aangebied.

Module 1 bestaan uit 4 vakkursusse waarin die klem op die wateromgewing en drinkwatersuiwering en -behandeling val.

Module 2 bestaan ook uit 4 vakkursusse met die fokus op afvalwater en die behandeling daarvan. Module 1 is nie 'n voorvereiste vir module 2 nie, sodat studente in enige jaar met studies kan begin.

(c) **Kursusvereistes:** Minstens 64 eenhede moet geslaag word, waarvan 40 eenhede verpligtend die volgende vakkursusse (8 eenhede elk) moet wees: WCH 780, WWS 780/787, WMB 780, WAE 780 en WAR 780/787. Die oorblywende 24 eenhede mag uit die ander vakkursusse in Module 1 of 2 of uit goedgekeurde nagraadse vakkursusse in ander departemente gekies word. Die studiereëlings vir vakkursusse in ander departemente verskil van die blokweekreëlings en die betrokke departementshoofde moet daarvoor geraadpleeg word.

1996 : Module 1 : Watersuiwering en -behandeling			
Eerste semester		Tweede semester	
WWG 780 - Watergehaltebestuur WCH 780 - Waterchemie		WWS 780/787 - Watersuiwering WWB 780/787 - Waterbehandeling	
Blokweek 1	22-26 Januarie	Blokweek 1	17-21 Junie
Blokweek 2	25-29 Maart	Blokweek 2	26-30 Augustus
Eksamen	30 Mei - 1 Junie	Eksamen	7-9 November

1997 : Module 2 : Afvalwater (voorlopieg)			
Eerste semester		Tweede semester	
WMB 780 - Watermikrobiologie WAE 780 - Eenheidsprosesse		WAR 780/787 - Riolsuiwering WAN 780/787 - Nywerheidsafvalwater	
Blokweek 1	20-24 Januarie	Blokweek 1	30 Junie-4 Julie
Blokweek 2	24-28 Maart	Blokweek 2	1-5 September
Eksamen	5-7 Junie	Eksamen	6-8 November

(d) Inhoud van vakkursusse vir 1996 (Module 1):

WWG 780 Watergehaltebestuur

Watergehaltebestuur: beginsels, beleid, strategieë en wetgewing. Hidrologie en geohidrologie. Wateraanvraag, -voorsiening en optimale benutting. Watergehalte: parameters, riglyne en modellering. Natuurlike watergehalte en suiweringprosesse. Besoedeling: diffuse en puntbronne. Vaste-afval: generering, bekamping en disponering. Geïntegreerde opvanggebiedbestuur.

WCH 780 Waterchemie

Beginsels van algemene, fisiese, organiese, ewewigs- en kolloïedchemie. Beginsels van chemiese en instrumentele analyses. Suur-basis ewewigte, oplosbaarheids-ewewigte, oksidasie-reduksie ewewigte. Beginsels van proseskinetika.

WWS 780/787 Watersuiwering

Waterbronne, -gehalte en gehaltevereistes. Eenheidsprosesse: koagulasie (destabilisasie, vermenging en flokkulasie), besinking, flottasie, filtrasie en ontsmetting. Suiveringskemas: seleksie, ontwerp en bedryf. Chemikalieë. Slykhantering. Laboratoriumondersoeke. Vloekarakterisering. Gehaltebeheer en bedryfsrekords.

WWB 780/787 Waterbehandeling

Watergehalte en prosesseleksie, chemiese oksidasie, ontsmetting, belugting en lugstroping, adsorpsieprosesse, membraanprosesse, ioonuitruiling, stabilisasie en versagting.

(e) Vakkursusse vir 1997

WMB 780 Watermikrobiologie
WAE 780 Eenheidsprosesse (vir afvalwater suiwering)
WAR 780/787 Riolsuiwering
WAN 780/787 Nywerheidsafvalwater.

1.3 MEESTERSGRAAD

- (a) **Toelatingsvereistes:** Soos vir die honneursgraad.
- (b) **Kursusvereistes:** Die graad waaroor 'n kandidaat reeds beskik, bepaal die kursusvereistes.
- (i) 'n Kandidaat met 'n BIng- of BSc-grad moet minstens 128 eenhede slaag, waarvan 64 eenhede soos vir die honneursgraad. Die oorblywende 64 word verkry deur 'n goedgekeurde verhandeling, soos in 1.3(c) uiteengesit.
 - (ii) 'n Kandidaat met 'n honneursgraad in waterbenutting moet minstens 64 eenhede slaag, saamgestel soos die oorblywende eenhede in (i) hierbo.
- (c) **Verhandeling:** 'n Skriftelike verhandeling en minstens een eweknie-geëvalueerde publikasie gebaseer op navorsing deur die kandidaat, en 'n eksamen gebaseer op die verhandeling en studieveld moet geslaag word. Die onderwerp moet in oorleg met die dosent wat as leier optree, bepaal word. Die eksamen kan onder sekere omstandighede ter syde gestel word.

1.4 DOKTORSGRAAD

Kandidate in besit van 'n toepaslike MIng- of MSc-grad of gelykwaardige kwalifikasie sal vir doktrale studie aanvaar word. Kandidate met 'n toepaslike honneursgraad en 'n aanvaarbare publikasierekord sal ook oorweeg word. 'n Doktorsgraad kan toegeken word op grond van navorsing wat 'n wesenlike bydrae tot die wetenskap lewer en wat soos volg vir beoordeling voorgelê word:

- 'n proefskrif en minstens 3 eweknie-geëvalueerde publikasies vir 'n PhD: of
- 'n proefskrif saamgestel uit 'n aanvaarbare aantal internasionaal erkende publikasies oor 'n bepaalde en/of navervante onderwerp vir 'n Ding of DSc.

Aflegging van 'n eksamen gebaseer op die proefskrif en studieveld kan in albei gevalle vereis word.

1.5 KURSUSGELDE: (Die bedrae is benaderd vir 1996 bereken, met die aanname dat dit ca. 10 % hoër as die 1995-kursusgelde sal wees).

Graad	1* jaar	2*, 3* & 4* jaar	5* jaar
BIng(Hons)/BSc(Hons)	R 6 800	R830	R3 300
MIng/MSc na honneurs	R 5 500	R830	R3 300
MIng/MSc na BIng/BSc	R11 000	R830	R3 300
Doktorsgraad	1* jaar	2* & 3* jaar	4* jaar
PhD	R5 900	R830	R3 300
DIng	ca.R2 000	-	-
Nie-graaddoeleindes : R840 registrasie + R720 per vakkursus			

1.6 FINANSIËLE STEUN

Beurse en lenings is vir nagraadse studie by UP beskikbaar. Besonderhede kan by Studente-administrasie (012/420-2846) verkry word. Eksterne navorsingsfondse kan gemobiliseer word indien die onderwerp betyds (minstens 6 maande voor registrasie) in oorleg met die projekteier/promotor gekies word. In sulke gevalle kan 'n salaris aan voltydse studente betaal word

1.7 AKKOMMODASIE

Universiteitsakkommodasie gedurende blokweke kan gereël word met Mnr R G Luus (012)420-2745

2. KORTKURSUSSE

(a) **Algemene Program**
 Daar word drie kortkurse vir 1996 geskeduleer. Bykomende kortkurse kan op versoek gereël word. Die geskeduleerde kortkurse word oor tydperke van 3 en 5 dae onderskeidelik aangebied en na suksesvolle voltooiing word 'n sertifikaat deur die Universiteit aan deelnemers uitgereik. Kortkurse word gemik op bestuurders, ingenieurs en tegnisi wat betrokke is by water- en afvalwaterbestuur en -tegnologie.

KORTKURSUS 1 : 13-17 MEI 1996

WATERGEHALTEBESTUUR
Kursusinhoud

- Wetlike en beleidsaspekte met betrekking tot waterbesoedelingsbeheer en watergehaltebestuur.
- Massa en energiebalanse, waterhuishouding, optimisering van watergebruik, minimalisering van afvalgenerering.
- Behandelingsprosesse insluitend : oksidasie/reduksie, chemiese presipitasie, membraanprosesse, aktiewe koolstofbehandeling, ioonuitruiling.
- Behandeling en wegdoening van konsentrate.
- Mynwater: minimalisering en behandeling van suurmynwater.

KORTKURSUS 2 : 16-20 SEPTEMBER 1996

BEDRYF VAN WATERSUIWERINGSAAANLEGTE
Kursusinhoud

- (a) Filosofie en beginsels van watersuiwering.
 (b) Rouwaterienskappe.
- Watersuiweringstappe - teorie en praktyk.
 (a) Koagulاسie - destabilisasie
 - vermenging
 - flokkulasie
 (b) Verheldering - besinking
 - flottasie
 - filtrasie
 (c) Ontsmetting - chlorering
 - ander metodes
- Slykhantering: behandeling en disponering.
- Laboratoriumwerk - teorie en praktyk:
 (a) Bedryfsveranderlikes.
 (b) Vloei-karakterisering.
- Gehaltebeheer en bedryfsrekords.
- Dataverwerking en rekenaartoepassings.

KORTKURSUS 3 : 21-23 OKTOBER 1996

BEHANDELING VAN NYWERHEIDS- EN VERKOELINGSWATER
Kursusinhoud

- gehaltevereistes vir verskillende aanwendings
- versagting, ontsouting, demineralisasie
- stabilisasie en voorkoming/inhibisie van korrosie
- chemiese oksidasie en adsorpsie
- belugting en lugstropping
- ontsmetting en beheer van biologiese groei
- waterherwinning

(b) **Registrasie**
 Kortkurse word deur die Laboratorium vir Gevorderde Ingenieurswese (LGI) geadministreer. 'n Aparte brosjure met inskrywingsvorm word vir elkeen uitgereik. Vul die antwoordstrokie in om u naam vir dié doel op ons verspreidingslys te plaas.

(d) **Kursusgelde vir 1996**
 Kursusgelde beloop R1 950 vir kortkurse 1 en 2, en R1 500 vir kortkursus 3. Dit sluit volledige notas, tee, koffie en middagetes in vir die duur van die kursus. Verblyf is nie by die bedrag ingesluit nie.

VOORNEME OM VIR NAGRAADSE STUDIE/KORTKURSUSSE TE REGISTREER

Ek beoog om in 1996 vir die volgende kursus(se) te registreer:

1. Nagraadse studie:

Beoogde kursus: (Merk in toepaslike blokkie).

BIng(Hons)	<input type="checkbox"/>	BSc(Hons)	<input type="checkbox"/>	MIng	<input type="checkbox"/>
MSc	<input type="checkbox"/>	PhD	<input type="checkbox"/>		<input type="checkbox"/>

Akademiese kwalifikasies reeds verwerf:

Instelling:

Graad: Jaar verwerf:

Hoofvakke

2. Kortkurse:

Beoogde kortkursus:

Kortkursus 1 : Watergehaltebestuur

Kortkursus 2 : Bedryf van watersuiweringaanlegte

Kortkursus 3 : Behandeling van nywerheids- en verkoelingswater

3. Persoonlike besonderhede:

NAAM: MNR/MEV/MEJ/

POSADRES:

ORGANISASIE:

POSISIE BY ORGANISASIE:

AARD VAN WERK/ONDERVINDING:

TEL:(. . . .). FAKS: (. . . .)

Handtekening

Datum

Pos of faks aan:
 Die Hoof
 Afdeling Waterbenutting
 Dept Chemiese Ingenieurswese
 Universiteit van Pretoria
 0002 PRETORIA
 Faks: (012) 43-6683

PREAMBLE

Soil erosion and sediment transport have social and economic consequences that impact the living environment and the quality of life of all our people. In turn, human activity and modes of social and economic organisation influence land and water utilisation and the management of such resources. In the search for appropriate conservation and rehabilitation practices it is necessary to understand the complex relationships between people and natural resources. Especially in South Africa where policy has had far-reaching consequences in this regard there is an urgency to create a forum for the development of a comprehensive strategy to harmonise human and natural resources.

The specific objective of the workshop is to appoint an organising committee for a conference in 1996 and identify and formulate the directives for such a conference.

FORMAT OF THE WORKSHOP

This workshop will bring together the social- and natural scientists in an attempt to achieve closer integration and better focus.

Recognised scientists have been invited to introduce various aspects of the present situation. Tim Hart will be the discussion leader and there will be ample opportunity to raise and discuss relevant matters. The workshop will produce proceedings with:

- a) Executive summaries of invited papers
- b) Directives for a future conference

A panel of experts will be elected from the participants to provide a framework for the planning of the proposed conference.

PROSPECTIVE SPEAKERS AND TOPICS

(25 minutes each + 15 minutes discussion time)

Keynote : Prof Jeff McCarthy

Topics:

- Policy impacts
- Integration of human and natural resources
- Natural Resources in SA
- Sediment delivery and process in rivers
- Erosion processes
- Land use practices and erosion
- Impacts on ecology
- Rehabilitation of degraded areas
- Social and political issues
- Foreign aid experience in Africa
- Demographic issues
- Indigenous knowledge

Other Speakers include:

Tim Hart	Dr Derek Scotney
Prof Albert Rooseboom	Dr Hendrik Kirsten
Prof Allen Bennie	Dr Jacky King
Mr At van Coller	Dr Catherine Cross

WORKSHOP ATTENDANCE

Registration fee will be R100 per person.

Participants will be responsible for own travel and subsistence costs. Registration fee covers teas, coffees, 2 lunches and cocktails. The venue can accommodate 150 delegates.

ENQUIRIES

If you have any enquiries please contact:

H Maaren
Water Research Commission
Tel: (012) 330 0340 • Fax: (012) 331 2565
E-mail: hugo@wrc.ccwr.ac.za

APPLICATION TO ATTEND WORKSHOP

Please fill in and return
by 26 October 1995 to:

Water Research Commission
P O Box 824
PRETORIA
0001
Fax (012) 331 2565
E-mail: hugo@wrc.ccwr.ac.za

NAME: _____

ORGANISATION: _____

ADDRESS: _____

POSTAL CODE:TEL: _____

FAX: _____

If more than one person of your organisation wishes to attend, please copy this application form for them to fill in.

A cheque for the amount of R..... is included

(Please make cheques payable to the Water Research Commission)

**The
WATER RESEARCH
COMMISSION**

**Two-day Workshop
on the theme**

**THE INTERRELATIONSHIP
BETWEEN SOIL EROSION,
SEDIMENT TRANSPORT AND
THE LIVING ENVIRONMENT**

Tuesday 7 November 1995
Wednesday 8 November 1995

Day 1 : 09:00 - 18:00
Day 2 : 08:00 - 17:00

VENUE:
Council for Geoscience
(Geological Survey)
Silverton
Pretoria

A number of micro-organisms have been shown to actively accumulate metal ions and efficiently remove these ions from solutions and effluents thereby decontaminating the effluent with regard to its heavy metal content. Effective systems have also been devised by other researchers for using such biotechnology on a continuous basis, and for the recovery of metals from the biomass.

In the research described in these reports, yeast has been used as the micro-organism for these studies, as it is a readily available waste product of alcohol-based fermentation industries in South Africa and represents a relatively inexpensive source of biomass which requires little pretreatment before it can be utilised for metal binding. Yeasts have also shown, in this and other studies, to accumulate a wide range of heavy metals from both dilute and concentrated solutions. However, the full potential and range of yeast bioaccumulation has not been revealed, nor has the possibility of using modified cells or cell components for industrial bioaccumulation purposes been examined.

AIMS

The project objectives as set out for the initial project was:

- to investigate methods of utilising yeast biomass to accumulate metal ions for removal of toxic metals from effluents or recovery of valuable metals.

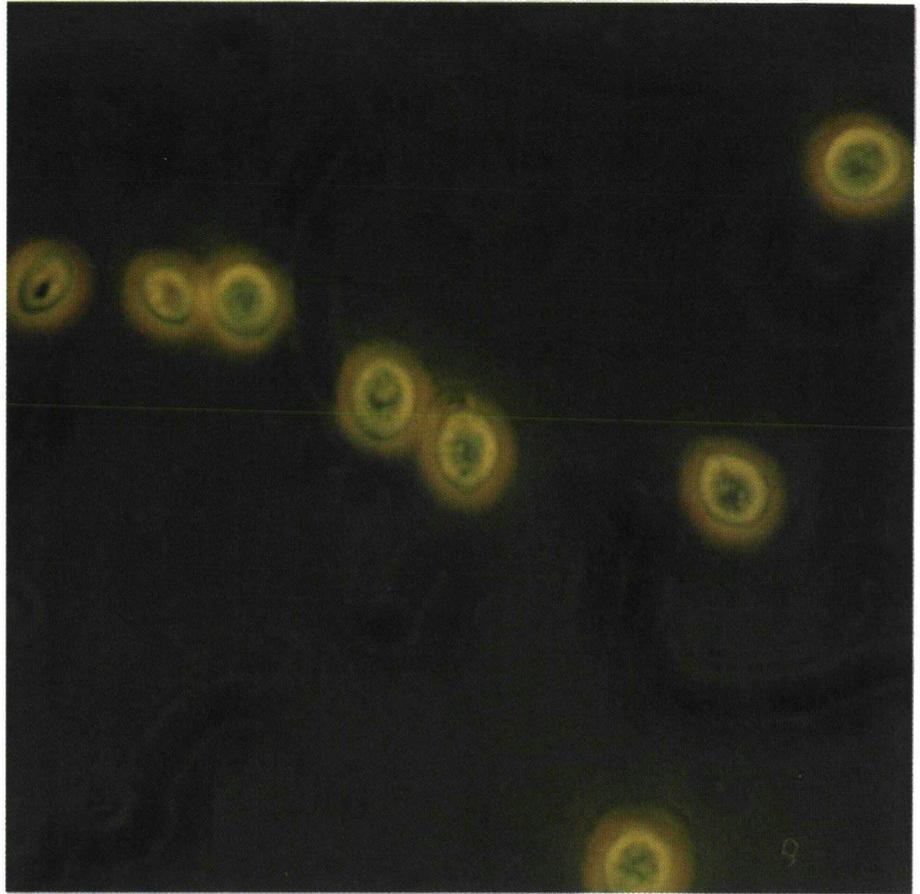
- to identify the components of the biomass responsible for metal accumulations and to determine whether these components are more efficient at metal accumulation than the biomass itself.

The project objectives as determined for the consecutive project was:

- to identify cellular components and chemical groups responsible for metal accumulation by yeasts and to determine the biochemical mechanisms responsible for metal binding or uptake.

- to determine the efficiency and kinetics of heavy metal accumulation at varying metal ion concentrations and to compare the mechanisms of accumulation at the different concentrations.

- to determine the most efficient system



Yeast cell fluorescence under a microscope, after copper bioaccumulation in the presence of a fluorescent dye.

of metal removal from solutions using a column of immobilised cells or cell components.

- to begin to use a yeast biomass system for removal of metals from industrial waste waters.

RESULTS

Saccharomyces cerevisiae cells were found to be capable of accumulating Cu^{2+} in a manner that was proportional to the external Cu^{2+} concentration and inversely proportional to the concentration of biomass.

The accumulation process, in free solution or as immobilised cells, was only minimally affected by temperature variations between 5 and 40 °C or high ambient concentrations of sodium chloride. The accumulation process was, however, considerably affected by variations in pH; bio-accumulation being most efficient at pH 5 to 9, but rapidly decreasing at either extreme of pH. The yeast biomass was also capable of accumulating other heavy metal cations such

as Co^{2+} , Cd^{2+} , Hg^+ , Cd^{2+} .

Yeast cells were fractionated to permit identification of the major cell fractions and molecular components responsible for metal binding. Isolation of the yeast cell walls permitted investigation of their role in heavy metal accumulation. The outer (protein-mannan) layer of the yeast cell wall was determined to be a better Cu^{2+} chelator than the inner (chitin-glucan) layer. It appears that the physical condition of the cell wall may be more important than the individual macromolecular components of the cell wall, in metal accumulation. It was apparent that the cell wall is the major, if not sole contributor to heavy metal accumulation at low ambient heavy metal concentrations.

Experiments on the extraction of certain cell wall components for binding experiments or removal of some components by enzymes before reacting to the cell wall with metals, suggests that all the major types of macromolecules found in the cell wall are important for effective metal binding. Isolation of the three main cell wall

components (chitin, glucan and mannan) was achieved using acid and alkali solubilisation and fractionation procedures. Metal uptake was found to be greater by the isolated components compared to the whole cell walls, and copper ions were bound more than cobalt or cadmium ions. Nevertheless, it does appear that the integrity of the cell wall is critical for effective metal binding.

However, uptake of heavy metal cations from solution by isolated vacuoles presented evidence of a mechanism different from that of the cell wallbinding and intracellular accumulation. Studies using X-ray emission electron microscopy and isolated vacuoles have indicated that uptake of cations from solution into the cell is effected by a H⁺/antiport system located within the cell membrane which is affected by the proton (H⁺) gradient. Evidence of the latter system was supplied by monitoring the pH during bioaccumulation. The longer the yeast cells were exposed to the effluent the higher the extracellular pH, indicating an H⁺ efflux from within the cells.

BIOSORPTION

Treatment of the biomass with hot alkali yielded two bioabsorbents, one soluble (which could be used as a heavy metal flocculant), and an insoluble biosorbent which could be used in fixed bed biosorption columns. The granular biosorbent was found to accumulate a wide range of heavy metal cations (Cd²⁺, Co²⁺, Cu²⁺, Hg²⁺, Ag²⁺, Fe³⁺, Cr³⁺, Pb⁺ in a semi-specific

manner and could be stored in a dehydrated form indefinitely and rehydrated when required.

By immobilising the yeast in polyacrylamide gel and packing this material into columns, Cu²⁺, Co²⁺ or Cd²⁺ could be removed from influent aqueous solutions, yielding effluents with no detectable heavy metal, until breakthrough point was reached. The immobilised biomass could be eluted with EDTA and recycled for further bioaccumulation processes with minor loss of bioaccumulation capacity.

The yeast biomass could be harvested after bio-accumulation by tangential filtration methods, or alternatively could be packed into hollow fibre microfilter membrane cartridges and used as fixed-bed bio-accumulator.

Cross-flow microfiltration units were successfully utilised to remove metal ions from solution. Results showed that flux rates remain constant and that metal bound yeasts do not form an impenetrable flocculant layer. Initial filtration characteristics are maintained. Yeast cells loaded to a cross-flow hollow-fibre membrane system present a useful method for removing and recovering certain heavy metals from water. This process offers a system that could feasibly be engineered on a large scale.

EFFLUENT TREATMENT

Application of the yeast biomass to heavy metal removal from industrial effluents

revealed that the yeast was able to accumulate zinc and lead from a zinc refinery effluent, as well as a number of metal ions from various electroplating industry wastewaters. Removal efficiencies of 50-70 per cent were obtained.

Wastewaters often contain several different metal ions and the specification of these metal ions is important in metal uptake processes. The high concentrations of some of these metal ions such as those found in the mining and electroplating effluents, may affect the uptake of metal ions of interest by competing for common binding sites.

This would account for the lower percentage uptake of zinc and lead from the refinery effluent when compared to solutions containing only the metal of interest.

Using an immobilised column of nonviable yeast biomass, a removal of 50-65 per cent of the chromium in a tannery effluent was obtained. It appeared that there was some interference with the chromium binding due to the high levels of sodium as well as proteins and tannins present in the tannery effluent.

CONCLUSIONS

Accumulation mechanism

Yeast cells are capable of accumulating heavy metal cations. This research project examined the process of metal accumulation in *S. cerevisiae* by studying the metal binding of various fractions of yeast cells in a sequence likely to parallel that encountered by the influent metal.

The cell wall is an important component in metal cation binding. The cell wall is the first cellular structure with which metals in the extracellular solution come into contact and bind to. All cations appear to bind to the wall in a similar fashion and only differ in the amounts bound. It also appears that the cell wall is both capable of and responsible for, binding of metal cations at lower ambient levels than are bound by the cell interior.

Entry into the cell is facilitated by a H⁺/antiport system. The cell vacuole, acting as the "ion storehouse" of the cell, also appears to be potentially capable of accumulating vast quantities of metals. The heavy metals are sequestered within the vacuole to reduce cellular toxicity.

JR DUNCAN
D BRADY
A D STOLL

THE USE OF YEAST BIOMASS AND YEAST PRODUCTS TO ACCUMULATE TOXIC AND VALUABLE HEAVY METALS FROM WASTEWATER

Report to the
WATER RESEARCH COMMISSION
by the
DEPARTMENT OF BIOCHEMISTRY AND MICROBIOLOGY
RHODES UNIVERSITY

WRC Report No 464/1/94

JR DUNCAN
D BRADY

THE USE OF YEAST BIOMASS AND YEAST PRODUCTS TO ACCUMULATE TOXIC AND VALUABLE HEAVY METALS FROM WASTEWATER

Report to the
WATER RESEARCH COMMISSION
by the
DEPARTMENT OF BIOCHEMISTRY AND MICROBIOLOGY
RHODES UNIVERSITY

WRC Report No 392/1/93

The abovementioned mechanism has important implications in industry where already it has proven capable of removing the majority of heavy metal ions from effluents containing high concentrations of these metals.

Application

It is clear from the results of this research that non-viable yeast cell biosorbents for wastewater treatment, could fill a large number of roles in metal cation recovery from wastewaters. Unlike selective ion-exchangers, biosorbents do not require expensive and complicated synthesis, but only a simple reaction to cause cell death, followed by a drying process to reduce volume and mass. Yeast biosorbents are readily available from fermentation based industries. However, immobilisation of biomass either in columns, gel matrix type systems or in microfiltration systems is required for the application of bioaccumulation in real life situations.

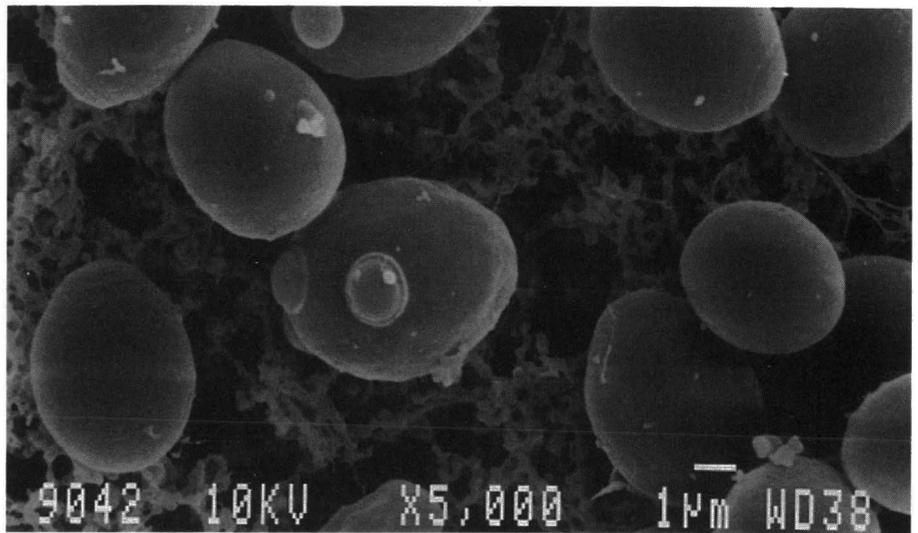
Immobilisation

Column immobilisation of biomass to be used in heavy metal bioaccumulation would have many advantages as it allows for complete removal of heavy metals from solution and recycling of the biomass. The present challenge is to develop a method of immobilisation that is both inexpensive and does not cause a decrease in the bioaccumulation capacity of the biomass, while allowing for effective recovery of the metal and reuse of the biomass. This system may also allow for selective removal of damaged biomass as proposed above.

The development of a system with numerous sequential equilibria, such as a column system, allows for a practically complete removal of metals. The conformation of the bioaccumulation system can therefore modify the level of bioaccumulation to an enormous degree. The use of immobilised biomass in conjunction with other processes, such as microfiltration systems, may allow for extremely effective bioaccumulation processes.

Cross-flow Microfiltration

According to the report the use of cross-flow microfiltration (CFMF) units in bioaccumulation processes also appear promising. The application of CFMF is relatively recent and the full potential of



A scanning electron micrograph of *S. cerevisiae* yeast cells.

CFMF technology in bioaccumulation is not presently obvious. The use of serial batteries of CFMF-based yeast bioaccumulators could reduce the concentration of toxic heavy metals in wastewaters significantly. It would also ensure that all particulate matter and harmful microbes were simultaneously removed.

Tangential flow technology is also applicable to bioaccumulation as it may be used to retain biomass prior to or during the bioaccumulation process. Similar to, but to a greater extent than pre-packing of cross-flow filters with biomass, the biomass is fixed in place by immobilisation. Immobilisation has the advantage of allowing a more varied range of configurations of biomass and bioaccumulation systems.

It should be borne in mind that biological bioaccumulation processes need not be complete systems on their own, and that a particular process may not be applicable to all situations.

Desorption

In many respects the desorption of metals from biomass may be as important as the bioaccumulation process. The use of certain elutant solutions allows for specific desorption of specific metals from biomass, thereby increasing the specificity of the bioaccumulation system considerably.

COMMENTS

An advantage of bioaccumulation processes is their specificity for heavy

metals. However, specificity of metal accumulation by organisms is relative. Although most microorganisms (including the yeast in this study) preferentially accumulate heavy metals, cation competition will always occur if the competing cation is in sufficiently high concentrations. The bioaccumulation of metals from wastewaters would therefore be most effective if the biomass was in contact with relatively pure and concentrated metal ion solutions. This demands separate treatment of individual wastewaters as far upstream in the process as possible. In effect metal bioaccumulation processes would be most cost effective and competitive at metal concentrations just below those at which traditional processes are economical.

Biosorbent technology is, however, still embryonic and much improvement could be effected by novel engineering processes and a more detailed understanding of the mechanism and factors affecting biosorption processes.

Widespread commercial acceptance of biological metal accumulation systems has not occurred. The reasons for this are the lower metal uptake capacity and suspected fragility of the organisms, but these problems could be overcome if there was improved knowledge of accumulation mechanisms and the parameters for process scale up. The use of *T. ferrooxidans* in ore leaching took many years and a few failed attempts before economic success was finally achieved. The industrial community will only accept bioaccumulation systems that are reliable and technically sound.

THE EFFECTS OF WATER QUALITY VARIABLES ON RIVERINE BIOTAS

Rivers as the main sources of water in South Africa are under threat from water regulation, pollution and abstraction, and suffering deteriorating water quality.

Water quality refers to those physical and chemical attributes of a water sample that determine its value for a specific purpose.

It has long been accepted that a certain minimum water quality is required for domestic, industrial, agricultural and recreational purposes. But the quality of water required for natural aquatic ecosystems has, until recently, received little attention.

Water quality guidelines for domestic, industrial, agricultural and recreational use are more or less universally applicable, even though critical values may differ slightly from country to country.

However, attempting to establish water quality guidelines for aquatic ecosystems is far more complex, as the water quality requirements of the biota may vary from continent to continent and from river to river, as well as from species to species,

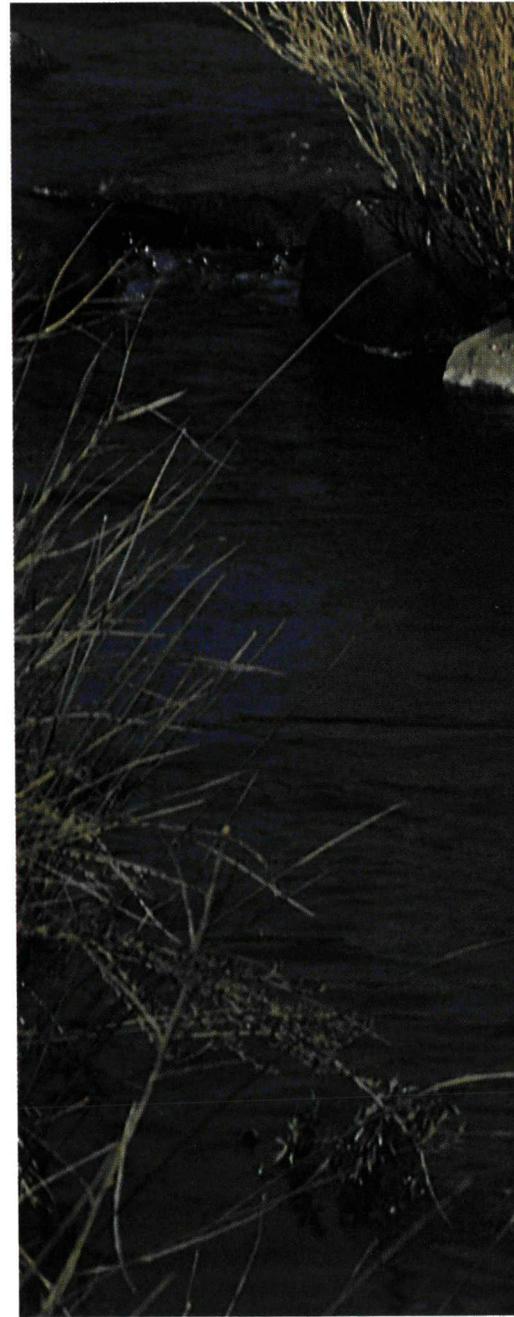
A recent research project entitled "Effects of water quality variables on riverine biotas" was funded by the Water

Research Commission and undertaken by HF Dallas, JA Day and EG Reynolds, researchers at the Freshwater Research Unit of the University of Cape Town. The project centred around the collation and synthesis of available river water quality data and suitable ways of generating new field data on river water quality, as the traditional methods for estimating the biological integrity of stream ecosystems are rather time consuming and sometimes the mathematical treatment of results is controversial.

AIMS

The aims of the project were:

- to provide a literature synthesis;
- to develop a database derived from local and international sources (including both published information and water quality records of the Department of Water Affairs and Forestry), and to determine the most appropriate ways of storing and analysing the data;
- to select a number of water quality variables for detailed examination;
- to determine the rough distribution of the major types of rivers and riverine habitats and zones within South Africa based on water quality;
- to determine empirically the relationship between water quality and ben-



Dr. Mark Chutter (above) developed the SASS r

thic macroinvertebrate community composition from data available on both polluted and unpolluted sites and, where possible, to verify these in the field.

WATER QUALITY

Chapter One of the report briefly explains what determines the physical and chemical attributes of natural waters and how these affect the aquatic organisms. The requirements for setting South African water quality guidelines for aquatic ecosystems are discussed. The

A NATIONAL BIOMONITORING PROGRAMME



The Department of Water Affairs and Forestry is designing a biomonitoring programme to supplement and extend its existing water quality monitoring and assessment programmes.

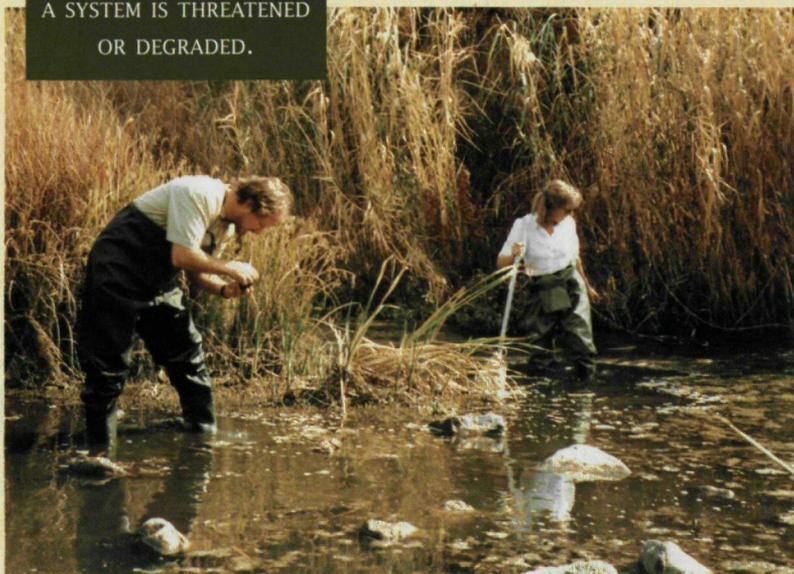
The ecological health of South African water resources is currently not well documented. This is mainly due to the lack of a national programme to monitor, assess and report on the health status of the country's aquatic ecosystems.

It is necessary to understand the nature and consequences of environmental change to effectively protect aquatic ecosystems. If not, ecosystem protection will remain limited to the treatment of problem symptoms (e.g. eutrophication of dams), rather than dealing with the causes (e.g. catchment mismanagement).

The development and application of monitoring techniques play a critical role in the ongoing process of harmonising economic development, human welfare and environmental protection. Incorporating biological and ecological measurements into resource management policy, legislation and decision-making, will ensure that future generations can continue to depend on healthy aquatic ecosystems for their most basic need - water.

"AQUATIC BIOMONITORING" REFERS TO THE GATHERING OF BIOLOGICAL DATA IN BOTH THE FIELD AND THE LABORATORY TO MAKE ENVIRONMENTAL ASSESSMENTS OR MANAGEMENT DECISIONS REGARDING FRESHWATER ECOSYSTEMS.

BIOMONITORING IS USED TO KEEP A FINGER ON THE PULSE OF NATURAL SYSTEMS, SO THAT CORRECTIVE ACTION CAN BE TAKEN IF THE BIOLOGICAL INTEGRITY OF A SYSTEM IS THREATENED OR DEGRADED.



WHY A BIOMONITORING PROGRAMME?

The Department of Water Affairs and Forestry is the custodian of South Africa's water resources. With respect to water resource management, part of the Department's mission is to protect the health of aquatic ecosystems. Without their effective protection, water resource development cannot be sustainable.

In support of this mission, the Department has to:

- set ecologically sound management objectives related to the health of aquatic ecosystems
- monitor and audit whether those objectives are actually being achieved, and
- implement appropriate management actions in those cases where environmental objectives are not being met.

Monitoring programmes are necessary to produce the information on which management decisions can be based. To ensure sustainable use of the country's water resources, appropriate information on aquatic ecosystems has to be collected. Long-term monitoring is required to detect trends and to better understand the functioning of aquatic ecosystems.

USING BIOLOGICAL INDICATORS

The use of biological indicators, in addition to traditional water quality monitoring techniques, can greatly enhance knowledge of aquatic systems and their response to management actions.

Aquatic organisms are adapted to live within certain environmental limits, and have a range of tolerances to many environmental stressors. If changes to the environment cause these stressors to exceed the organism's tolerance range, community structures may collapse and modified communities may develop. By monitoring indicator attributes of aquatic communities, adverse environmental changes can be detected.

The most common communities used as biological indicators are macro-invertebrates and fish, both of which respond fairly quickly to changes in the environment. Through relatively simple and rapid techniques, biological data are summarised to reflect environmental change and the total status of aquatic resources.

Factors such as geomorphological characteristics; hydrological and hydraulic regimes, chemical and physical water quality and riparian vegetation all affect aquatic ecosystem health. These factors could be included as ecosystem indicators in a biomonitoring programme.



PURPOSE OF THE BIOMONITORING PROGRAMME

The specific purpose of the biomonitoring programme will be to directly monitor, assess and report on the health status and trends of aquatic environments, including rivers, dams, wetlands and estuaries in South Africa.

The data collected by the programme could also be used to support:

- assessments of the likely impacts of changes in water quality and/or flow regime on the health of aquatic ecosystems
- the formulation of ecologically-based environmental quality objectives
- regional and national audits of the status of aquatic environments

The experience gained from this programme will contribute to developing protocols for ecological investigations on a catchment, reach or site-specific level. An example of a site-specific application is assessing the effect of an effluent discharge on the health of aquatic ecosystems.

WHO WILL BENEFIT?

The programme will be designed primarily to meet the information requirements of water resource managers.

Other users of the information provided by the biomonitoring programme may include:

- national, provincial and local authorities with responsibility for environmental management
- national, provincial and local environmental protection and nature conservation organisations concerned with aquatic ecosystems
- effluent dischargers required to comply with conditions aimed at protecting the health of the aquatic environment
- interested and affected individuals and groups in communities, non government organisations and academic institutions.

DESIGNING THE PROGRAMME

The design and testing of the aquatic ecosystem health programme will be phased as follows:

PHASE 1

- assess the information required for the effective management of aquatic ecosystems
- decide what information can be produced by a biomonitoring programme
- reconcile the information needs of water resource managers with the degree to which the biomonitoring programme can produce the required information.

PHASE 2

- design the monitoring network, i.e. monitoring sites, monitoring variables and frequency of monitoring
- specify data collection procedures
- develop data analysis and information reporting mechanisms and procedures.

PHASE 3

- develop additional biomonitoring methodologies where needed
- test components of the design as they are defined
- demonstrate the complete programme on a pilot scale to prepare for full-scale implementation.

The design will also incorporate an analysis of start-up cost, operating cost, long- and short-term human resource requirements, training needs, institutional coordination, equipment needs and maintenance requirements.



TIME FRAME

Phase One of the design will be completed by the end of 1995.

Components of Phase Two are already being designed. Phase Three is scheduled to commence in mid 1996, and be completed by the first quarter of 1997.

During Phase Three, certain aspects will be implemented on a pilot scale. Full implementation will commence once the detailed design has been completed.

A NATIONAL UNDERTAKING

Design and implementation of the programme will require the expertise of aquatic scientists throughout the country. In addition, the contributions of roleplayers, who will eventually participate in the implementation of the programme, will ensure that it is designed to be practical, cost-effective and easily maintained.

ENQUIRIES

If you are interested to learn more about the programme or to become involved, please contact:

**The Director,
Institute for Water Quality Studies,
Department of Water
Affairs and Forestry,
Private Bag X313,
0001 PRETORIA
Tel: 012 - 808 0374
Fax: 012 - 808 0338**



and bioassessment technique which was verified in this WRC project.

researchers also address the question of the gap between data needed to provide adequate guidelines and the actual information presently at hand.

LITERATURE REVIEW

One of the major aims of the project was to produce a review of information on the effect of individual water quality variables on riverine ecosystems. Chapter Two of this report very briefly discusses the review entitled "The Effect of Water Quality Variables on Riverine Ecosystems : A Review", which has been pub-

lished by the Water Research Commission (see SA Waterbulletin, Volume 20 No 2, March/April 1994). This detailed review of the literature available, highlighted the relative scarcity of local information on the effects of water quality variables on riverine ecosystems. Some one thousand references have been entered into a literature database, which is available from the authors being updated continually.

WATER QUALITY VARIABLES

The researchers discuss the selection of

water quality variables for detailed examination in chapter Three of the report. They say that the variables of concern for aquatic ecosystems can be divided into three categories, based on their toxicity, persistence and natural variability from region to region, these are:

Cumulative toxins:

the trace elements which include aluminium, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, silver, selenium, tin, thallium, vanadium and zinc, as well as biocides.

Non-cumulative toxins:

include un-ionized ammonia, chlorine, cyanides, detergents and oil dispersants, fluoride, nitrite, nitrate, oil and grease, phenols and sulphides.

Non-toxins with a natural regional variation:

include alkalinity, biological oxygen demand, calcium, carbon dioxide, chloride, chlorophyll a, colour, conductivity, TDS, salinity, dissolved organic carbon, dissolved oxygen, magnesium, pH, phosphate, polyphenolics or humates, potassium, sodium, sulphate, suspended solids, temperature and turbidity.

BIOLOGICAL AND CHEMICAL DATABASE

The database has been constructed using data extracted from most of the available literature and unpublished reports pertaining to South African rivers, in which biological and chemical data have been collected concurrently.

In all, about 97 000 records have been entered for 1830 taxa and about 48 water quality variables. The earliest records are for the Berg River in the early 1950s. Some of the studies have examined numerous sites sampled monthly or seasonally over a year or more.

Major considerations in constructing this database have been:

- upgrading computer facilities to deal with the vast number of data-points;
- design of the structure of the database to provide quick and easy access; and
- assessment of the compatibility of the chemical and physical measurements provided in each study.

As a result of the incompatibility of some data-sets, the researchers decided not to attempt to subject the data to multivariate analyses at this stage. The value of the database lies in its ability to provide recorded tolerance values for many variables of concern for most invertebrate taxa. It is possible, for instance, to interrogate the database for occurrences of particular species related to each chemical variable, region by region or over the whole country, or to ascertain the number and identity of taxa associated with particular suites of chemical conditions.

The researchers say that in spite of the inherent weaknesses of the database, it should be noted, however, that:

- it would be logistically and financially impossible to obtain a similar set of data today, and
- the database includes the only data that reflect historical conditions, and therefore more closely reflect natural conditions than the conditions found today almost anywhere in the country.

The biological and chemical data-base is the only collection of virtually all the relevant empirical data available for South Africa.

Thus far, all the data have been entered and verified and the files imported into MicroSoft Access. Records for any species, area or variable can be retrieved. No attempt has yet been made to determine the extent to which multivariate correlation analyses can validly be performed.

H F DALLAS
J A DAY
E G REYNOLDS

THE EFFECTS OF WATER QUALITY VARIABLES ON RIVERINE BIOTAS

Report to the
WATER RESEARCH COMMISSION
by the
ZOOLOGY DEPARTMENT
UNIVERSITY OF CAPE TOWN

WRC Report No 351/1/94

CHEMICAL CATEGORISATION OF SOUTH AFRICAN RIVERS

The categorisation exercise was designed to produce preliminary "Environmental Management Regions" (EMRs) for which appropriate region-specific water quality guidelines can be developed. Several approaches were used, including multivariate analyses of sites and Department of Water Affairs

and Forestry subcatchments. However, the researchers say that it turned out that classification of sites rather than of rivers is more appropriate. This issue is discussed in chapter Five of the report.

Nevertheless, the results of these analyses have been synthesised with various other published and unpublished studies to produce a map of preliminary EMRs. The regions are the south-western Cape; coastal Natal; the arid interior and eastern Cape coast; the upper Orange/Vaal catchment; and the north-east. According to the report further work will be needed before certain catchments bordering some of these regions can be assigned to EMRs.

FIELD VERIFICATION METHODOLOGY

The project team also explored the methodologies that could be used in a verification process. Two methods of benthic macroinvertebrate sampling were compared, namely the traditional quantitative box-sampling method, and qualitative or rapid bioassessment,

The rapid bioassessment method being specifically the newly developed South African Scoring System (SASS) method. The "SASS" rapid bioassessment technique as developed by Dr Mark Chutter, has the potential to assisting in the field verification of empirical data. The robustness of this technique was tested in the field work on the Berg River and is discussed in Chapter Six.

The reliability of each method in differentiating site characteristics in terms of water quality were examined, as was the relationship between the methods. The two methods were remarkably alike in distinguishing between sites with different water quality. The qualities of the SASS method are discussed in the report in relation to those proposed for an "ideal" biotic index.

The report entitled "**The effects of water quality variables on riverine biotas**" (WRC Report no 351/1/94) is available, free of charge, from the Water Research Commission, PO Box 824, Pretoria 0001. Foreign orders: US\$ 30.

ENHANCING WASTEWATER TREATMENT EFFICIENCY WITH BIOAUGMENTATION

Nature has the ability to recycle and purify itself. However, in recent years the demand placed on the environment by large amounts of toxic, hazardous and often recalcitrant pollutants exceeds its capacity to recover. To try and help Nature cope various bioaugmentation technologies have been developed.

Bioaugmentation involves the use of specially selected and adapted microorganisms to try and optimise the natural capacity of indigenous microbial populations to degrade and recycle "difficult" compounds. Biodegradation techniques are versatile and can be utilised at various stages of waste treatment. It consists of controlling the pH, oxygen supply or anaerobicity as well as controlling the temperature and supplying essential limiting nutrients to minimise the stress on waste treatment systems. Applications include the removal of contaminants from raw materials prior to processing, treatment of wastes before discharge, treatment of effluent streams and the decontamination of soils, sediments surface water and groundwater.

In an investigation financed by the Water Research Commission, two researchers from the Division of Water Technology at the CSIR, RA Oellermann and K Pearce, applied bioaugmentation specifically to the treatment of wastewaters. The breakdown of a variety of pollutants was investigated using commercially available supplemented microbes or specially selected and adapted microorganisms

from acclimated biomass. This provided the basis for establishing the criteria essential for product specification and performance as well as the guidelines for their safe and controlled use.

RA OELLERMANN
K PEARCE

BIOAUGMENTATION TECHNOLOGY FOR WASTEWATER
TREATMENT IN SOUTH AFRICA

Report to the
WATER RESEARCH COMMISSION
by the
DIVISION OF WATER TECHNOLOGY, CSIR

WRC Report No 429/1/95

The application of bioaugmentation in wastewater treatment was originally the result of efforts to solve urgent operational problems, such as shock loads in treatment plants or to make a remedial response to spilling emergencies. In most cases, the addition of bacterial cultures either assisted the operation to return to normal or helped reduce the

danger of the spilling pollutant. These successful applications have stimulated the use of bioaugmentation at municipal treatment works. The use of biosupplements did not require alterations to existing treatment works and this represented a major benefit. The costs incurred were for the product to be added which was minimal compared to the construction of new or upgraded plants. An additional advantage was that biosupplements employ naturally adapted microorganisms which were environmentally friendly and did not pose a health hazard.

Research in South Africa in the field of bioaugmentation was limited. According to the researchers, biosupplements have appeared on the South African market without having been tested under local conditions. This stressed the need for some form of control over the sale and use of such products. It was therefore necessary to establish guidelines on the evaluation of biosupplements to ensure that they met specifications and were safe to use.

The results of the investigation is now available in the form of a final report. The report is entitled "**Bioaugmentation technology for wastewater treatment in South Africa**" (WRC Report 429/1/95) and can be obtained free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 15).

Comparing chlorine and chlorine dioxide as pre-oxidants and algicides in the production of potable water

The excessive enrichment of the tributaries of the Vaal River Barrage Reservoir draining the Witwatersrand with plant nutrients have resulted in algal blooms and algal related water purification and quality problems, especially for the bulk water supplier, Rand Water.

Algae in the raw intake water interfere with the physical and chemical water purification processes and pass through the purification system resulting in water of aesthetically unacceptable quality being produced. Furthermore, algae not only produce neuro- and heptoxins that could be detrimental to the consumer's health, but algal products may also act as trihalomethane precursors and as a source of carbon for microbiological and other heterotrophic growth.

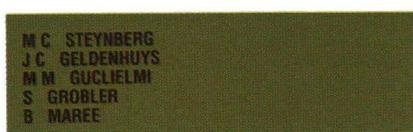
Rand Water considered several purification technologies and its effect on water purification costs. This showed that pre-oxidation of algal laden water could be a cost effective algal control measure.

At present Rand Water is using chlorine gas as pre-oxidation at its Vaal River Barrage Reservoir intakes. However, to ensure that the pre-oxidation of raw water is to the best interest of Rand Water's consumers, a research project was formulated in collaboration with the Water Research Commission to compare the efficiency of chlorine and chlorine dioxide as pre-oxidants and algicides in raw water abstracted for the production of potable water. The research was conducted by MC Steynberg, JC Geldenhuys, MM Guclielmi, S Grobler and B Maree, all from the Department of Scientific Services at Rand Water.

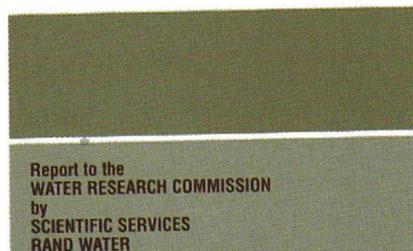
RESULTS

Results from the study on the role of water quality on chlorine and chlorine dioxide indicated that:

□ The residual oxidant concentrations decreased with time - with the highest decrease during the first moments after oxidant addition.



THE INFLUENCE OF WATER QUALITY ON THE EFFICIENCY OF CHLORINE DIOXIDE AS PRE-OXIDANT AND ALGICIDE IN THE PRODUCTION OF POTABLE WATER



WRC Report No 281/1/94

□ Residual oxidant concentrations after contact time decreased inversely with increases in the effluent concentration.

□ After the same contact period, significantly higher chlorine dioxide concentrations than chlorine concentrations were present at equivalent dosages; and

□ More trihalomethanes (THMs) are formed with increased effluent ratios and higher chlorine concentration in water mixtures. The highest concentrations were recorded after 24 hour contact time, using 10 mg/l chlorine. No THMs were formed when chlorine dioxide was used.

Results on the oxidation of algal suspension indicated the following:

□ A contact time up to 30 minutes is necessary to inactivate algae with chlorine,

compared to a maximum of 10 minutes needed when chlorine dioxide was used at equivalent dosing rates.

□ Chlorine dioxide was two to ten times more effective than chlorine as an algicide. This variation in efficiency is dependent on the algal concentration and algal species.

□ Algae differed regarding their resistance to oxidation. *Cosmarium laeve* var *distentum* was the most resistant algae against the action of chlorine, while *Scenedesmus quadricauda* was the most resistant against chlorine dioxide.

□ Electron microscopical investigations showed limited external damage to the cells due to oxidation. Significant damage to the membrane systems of the cells was, however, observed.

□ THMs (a maximum of 35 µg/l) were formed by chlorination of algal suspensions after two hours contact time. No THMs were formed when chlorine dioxide was used as a pre-oxidant.

According to the researchers the study indicates that chlorine dioxide would be the best oxidant for pre-oxidation. However, the cost comparison indicates that chlorine dioxide will approximately be 1,61 times more expensive to use as an oxidant.

A report summarising the research work is currently available. It is entitled "The influence of water quality on the efficiency of chlorine dioxide as pre-oxidant and algicide in the production of potable water" (WRC Report 281/1/94) and can be obtained free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 25).

Impact of waste disposal activities on groundwater resources assessed

A literature review on the impact of domestic and industrial waste disposal practices on groundwater supplies and the associated health implications has recently been published by the Water Research Commission.

Written by JFP Engelbrecht of the Division of Water Technology at the CSIR, the review says that although groundwater only contributes about 15 per cent to South Africa's water supply at present, it is of great importance when one considers that hundreds of towns and villages use groundwater for their water supply.

Groundwater is constantly being effected to a greater or lesser extent by the application of fertilisers and pesticides, urban development, disposal of domestic refuse to land, sewage sludge disposal, mining activities and in particular, the disposal to land of effluents with high concentrations of chemicals and sludges produced by industry. Groundwater contamination by leachates from the above presents the real problem and will increase if not managed properly, the review says.

LEACHATE

Landfilling has been and continues to be one of the major disposal methods for both domestic and industrial wastes in South Africa. The unstable and dispersed movement of liquids through the body of a landfill of results in the leaching of soluble compounds, which were originally present in the waste or which were formed through chemical and biochemical processes, together with transferable organic and inorganic materials, and micro-organisms like bacteria, protozoa, helminths and viruses.

As municipal landfills are covered by a low permeability layer only when dumping is terminated, rainfall furthers the process of decomposition and leaching. The rainwater percolates through a landfill and the leachate penetrates the soil and recharges the groundwater. The percolation can be controlled by various means

but is practically impossible to completely prevent infiltration of precipitation.

The pollution threat of leachate, real or potential, to surface and groundwater has long been realised and has been the key consideration in landfill site design to prevent serious and costly problems. However, in many recent cases, the protection of groundwater has become the leading objective for licensing landfill sites. The review says that in recent years, the number of documented sites in which landfill leachate is known to have contaminated the underlying aquifer has been on the increase, but only a few cases have

JFP ENGELBRECHT

AN ASSESSMENT OF HEALTH ASPECTS OF THE IMPACT OF DOMESTIC AND INDUSTRIAL WASTE DISPOSAL ACTIVITIES ON GROUNDWATER RESOURCES

Report to the
WATER RESEARCH COMMISSION
by the
DIVISION OF WATER TECHNOLOGY, CSIR

WRC Report No 371/1/93

been studied in detail with regard to geochemical processes, the attenuation of contaminants and the occurrence of potentially hazardous organic chemicals in leachates from municipal landfills.

The review concludes that groundwater pollution from waste disposal activities is a fact of life. Overseas it has already created serious environmental problems and the cleanup of contaminated groundwaters may ultimately cost billions of rands to rectify, if ever. In South Africa indications are that the problem also exists but published data is scarce. The review says the solu-

tion to groundwater pollution is best described by the aphorism: "Prevention is better than cure".

REPORT

The review report is structured as follows:

■ Chapter 1 gives a general introduction on groundwater contamination and states the objectives of the study. It also describes the importance of groundwater as a drinking water resource together with the contamination thereof.

■ Chapter 2 provides a general introduction on industrial waste disposal. It addresses leachate generation and types of contamination from different industries. A few case studies are included to give a perspective of the extent of the problem.

■ Chapter 3 includes an introduction on municipal waste disposal and leachate generation. Some information on chemical and microbiological contamination are reviewed.

■ Chapter 4 deals with the health aspects of groundwater contamination. Detailed information on the sources of groundwater contamination, the importance of some inorganic, organic, biological contaminants and infectious diseases is presented.

■ Chapter 5 consists of a short discussion on legislation and Chapter 6 outlines the conclusions of the study.

■ Chapter 7 provides a general recommendation and suggests further research that may still be needed.

Copies of the review entitled "An assessment of health aspects of the impact of domestic and industrial waste disposal activities on groundwater resources" (WRC Report 371/1/93) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 15).

Researchers study pollution in the Olifants River

The biota of the Olifants River in Eastern Transvaal will benefit to a large extent from the establishment of critical levels of pollution in the river. Such information can also be utilised in the management of the Kruger National Park rivers, as precautionary measures can then be taken to conserve vulnerable aquatic organisms. This is said in a report released by the Water Research Commission about the effects of pollutants on fish in the Olifants River.

The report recommends that for future management of the Olifants River drastic measures should be taken to reduce the impact of mining activities on the water quality of the Selati River and also, indirectly, the lower Olifants River (especially during low flow periods).

"It is important that enough water to be released to the Olifants River from Phalaborwa Barrage to dilute the Selati River water during droughts and winter periods. However, if the water quality of the Selati cannot be improved, it should at least be maintained at its present status, as a further degradation in water quality cannot be afforded."

The research was conducted by JHJ van Vuuren and HH du Preez from the Department of Zoology at the Rand Afrikaans University in collaboration with AR Deacon of the Research Division, National Parks Board, in Skukuza.

The researchers say that until recently most of the toxicological studies were conducted as acute exposure experiments where death of the test organism was taken as the only variable measured. However, it is clear that disfunction of physiological systems occur long before death and, therefore, it is important in the conservation of river biota in an area such as the Kruger National Park to determine the effect of pollution on the survival of

aquatic organisms long before effects are noted. This will ensure that the necessary precautions are in place before aquatic organisms are negatively affected by effluents containing sub-lethal levels of pollutants.

J H J VAN VUREN
H H DU PREEZ
A R DEACON

EFFECT OF POLLUTANTS ON THE PHYSIOLOGY OF FISH IN THE OLIFANTS RIVER (EASTERN TRANSSVAAL)

Report to the
WATER RESEARCH COMMISSION
by the
DEPARTMENT OF ZOOLOGY
RAND AFRIKAANS UNIVERSITY

WRC Report No 350/1/94

POLLUTION ASSESSMENT

The researchers say that water and sediment quality is important in pollution assessment and samples were taken for analysis at selected sites along the Olifants River in the Kruger National Park. The same sampling was done at two sites outside the Park in the Olifants and Selati Rivers before their confluence. This was done to determine the water quality entering the Kruger National Park, which pollutants (specifically metals) are present in the water, and whether dilution of pollutants was evident downstream.

At the same sites tissue and organ samples from different fish species were

taken to determine the bioaccumulation levels of selected metals in the fish.

The surveys were conducted over three years to determine whether fluctuations in water metal levels in the water were reflected in the bioaccumulation of these metals. Tissue samples were taken seasonally since drought and flood conditions could have had an effect on metal concentrations in the water.

Experimental exposure of fish to pollutants under controlled environmental conditions was also done after the identification of those metals which may pose a threat to the survival of fish in the river system. A flow-through system was constructed for the exposure experiments and in this way the effect of the pollutant on fish physiology was determined.

According to the researchers the accumulated metals found in the organs and tissues of *Barbus marequensis* gave a good indication of the metal levels to which the fish were exposed, especially when compared with the metal concentrations of fish species from a polluted system, such as the Germiston Lake. *Barbus marequensis* seemed to have been chronically exposed to zinc, copper, lead and nickel, probably at sub-lethal levels. In addition, the fish at the sampling point in the Selati River have been chronically exposed to iron, chromium and manganese, also probably sub-lethally.

The complete results of the investigation is available in the form of a final report entitled "Effect of pollutants on the physiology of fish in the Olifants River (Eastern Transvaal) (WRC Report 350/1/94). Copies of the report can be obtained free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 25).

Sunlight powers membrane distillation unit

The Water Research Commission recently published a report describing the design and construction of a solar membrane distillation unit, built with inexpensive plastic components.

The project was carried out by three researchers, RD Sanderson, M Vreugde and DW Schoeman, from the Institute for Polymer Science at the University of Stellenbosch.

The reason for developing such a unit was the fact that many areas in South Africa which lack a reliable source of potable surface water, do have access to large volumes of brackish groundwater and an abundant supply of solar energy. Therefore, if appropriate technology was available the sun's power could be harnessed to desalinate the salty water for potable purposes.

In simple terms, the process of membrane distillation is one whereby water vapour from a heated solution passes through a microporous membrane and is condensed on a cooling surface whereupon the condensate of high purity is collected. The microporous membrane should be hydrophobic to prevent passage of the formed condensate through the membrane, while allowing water vapour from the heated solution to pass through.

The researchers created a computer simulation model from the relevant equations describing heat and mass transfer in the membrane distillation process and compared it with the results obtained from an

experimental unit constructed in the laboratory. The concept for the unit is very simple: sunlight enters through a clear film, is absorbed on a black bag that contains water but which will allow the water to evaporate freely.

R D SANDERSON
M VREUGDE
D W SCHOEMAN

PROVISION OF POINT-SOURCE WATER BY ENHANCED SOLAR DISTILLATION

Report to the
WATER RESEARCH COMMISSION
by the
INSTITUTE FOR POLYMER SCIENCE
UNIVERSITY OF STELLENBOSCH

WRC Report No 468/1/94

Canvas was used to make the membrane bag for the first experimental model. This was, however, not satisfactory because the canvas was not strong enough to withstand the pressure from the water inside the bag.

A second experimental model was built, using an anodized aluminium plate to absorb the solar heat. The water was placed between the plate and the mem-

brane to allow the water to be heated by the plate. Experiments carried out in direct sunlight showed that the temperature of the black aluminium plate rose to above 80°C. Although this experiment was done in direct sunlight, there was also a great deal of heating by radiation, so that it would be possible to operate the distillation unit on cloudy days.

The researchers say a variety of problems, with leakage being one of the most serious, made it necessary to construct a third model. In this model the heating of the water by sunlight was simulated by means of a heating element in the laboratory. Two pumps were used to circulate the heated water as well as the cooling water which was necessary to keep the condensing surface at a specified temperature.

The results obtained from the aluminium plate and frame model proved that the unit is capable of producing potable water by using solar energy. In a current follow-up project various microporous membrane materials are being evaluated in the solar water distillation unit.

The complete report summarising the results of the investigation and entitled "Provision of point-source water by enhanced solar distillation" (WRC Report 468/1/94) is currently available from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$ 20).

HIGHER DEGREES IN COMPUTATIONAL FLUID MECHANICS FOR WATER TREATMENT PLANTS

The Pollution Research Group at the University of Natal has a Water Research Commission project entitled *An Investigation into the Use of Computational Fluid Mechanics to Improve the Performance of Water Treatment plants.*

In order to promote this technology the Pollution Research Group invites consultants, water author-

ities and equipment manufacturers to enrol their staff at the University of Natal for a masters or doctoral degree in order to gain practical knowledge in the application of this powerful tool.

For further information please contact Prof Chris Buckley at Tel (031) 260-3131, Fax (031) 260-1118, or E-mail: Buckley@che.und.ac.za.



Neutralising acidic mine effluents with limestone

The results of a study which was aimed at developing a method whereby acid waters would be percolated through limestone particles to ensure effective neutralisation, has been published by the Water Research Commission in Pretoria.

The researchers, JP Maree and P du Plessis from the Division of Water Technology at the CSIR, say in their report to the Commission that a fluidised bed was proposed for this purpose. The bed is packed with small chips of limestone and the acidic water together with the recycle stream enters the bottom of the column. The upward velocity of the water fluidises the limestone particles ensuring good contact with the acid water. The neutralised stream passes out of the top of the column. In practise, fresh limestone is added to the top of the bed as it is consumed through dissolution in the acid water.

The researchers say the main advantage of this process is that the neutralising medium, the limestone, can be kept in the reactor as opposed to a rotating drum where the limestone is partially washed out with the treated stream. The fluidised bed furthermore ensures a much more efficient usage of the limestone - by controlling the feed and wastage rates of calcium carbonate to and from the bed, the exact time (and hence the degree of utilisation) of the neutralising medium in the bed can be controlled. The degree to which the acid stream is neutralised is controlled by its retention time in the bed, that is, the bed height. A second advantage of the fluidised bed operation is the attrition that occurs between the closely associated particles which keeps the calcium carbonate surfaces clean of any calcium sulfate or iron hydroxide that might inhibit the neutralisation rate.

CHEMICALS

The researchers say currently chemicals such as lime, sodium hydroxide and sodium carbonate are used for the neutralisation of acid water. However, limestone can also be used which has the following advantages: low raw material cost, non-hazardous nature of the material, low potential of accidental overtreatment and

limestone was only R100/t compared to R280/t for lime.

RESULTS

The findings from this study are summarised by the researchers as follows:

□ **Kinetics.** The kinetics of acid neutralisation using CaCO_3 may be represented by the rate equation:

$$-\frac{d[\text{H}_2\text{SO}_4]_b}{dt} = K S [\text{H}_2\text{SO}_4]_b$$

where K is the rate constant based on surface area, S is the total CaCO_3 surface area available and $[\text{H}_2\text{SO}_4]_b$ is the concentration of acid in the bulk liquid (as mg CaCO_3/l). For effluents with little or no heavy metals, the value of K is $2,45 \times 10^{-3} \text{ min}^{-1} \cdot \text{cm}^{-2}$; for effluents that contain significant quantities of iron, a layer of $\text{Fe}(\text{OH})_3$ forms on the CaCO_3 surfaces that causes K to decrease from the abovementioned value, depending on the thickness of the $\text{Fe}(\text{OH})_3$ layer.

□ **Rate.** It was determined that the rate of neutralisation is directly related to the dosage of CaCO_3 , influenced by the particle size of limestone (the finer the particle, the higher the rate of neutralisation) and the type of metal in solution. The presence of iron(II) retards the rate dramatically while iron(III) has no influence. Aeration marginally accelerated the rate of limestone neutralisation as a result of CO_2 -stripping.

It was determined under continuous conditions that a contact time of 4 min is sufficient for the neutralisation of acid water containing 4 g/l free acid and 580 mg/l

J P MAREE
P DU PLESSIS

NEUTRALISATION OF ACIDIC EFFLUENTS WITH LIMESTONE

Report to the
WATER RESEARCH COMMISSION
by the
DIVISION OF WATER TECHNOLOGY, CSIR

WRC Report No 355/1/94

the production of low-volume, high-density sludge. Disadvantages associated with limestone are the long retention time required for complete reaction and the fact that it is not completely utilised. Should these disadvantages be overcome it will be the preferred alkali to use due to its low cost. The price (1993) of

iron(III), while a contact time of at least 40 min is required for the same water, but which contains iron(II) instead of iron(III).

□ **Water quality.** The limestone neutralisation process improves the quality of the water by removing free acid and acid associated with Fe(III) completely. Sulphate is removed up to the point where the water is saturated with calcium sulphate. The level to which the pH of acid water is increased depends on the metals that will remain in solution during neutralisation. If magnesium is present in the water, it coprecipitates partially with $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$. Iron(III) and aluminium(III) are effectively removed during limestone neutralisation as metal hydroxides.

□ **Reactor type.** A fluidised-bed reactor with multiple stages of increasing diameters is preferred for the limestone neutralisation process as it allows fluidisation of the bigger particles but also prevents washout of the smaller particles in the case where ungraded particle size limestone is used. The cone-shaped and pipe-shaped fluidised-bed reactors perform equally well in the limestone neutralisation process.

□ **Limestone utilisation.** In the case of iron (III)-rich water, the limestone is completely utilised while the ferric hydroxide sludge which is produced is washed out together with the effluent. No bleed-off stream is therefore necessary to get rid of impurities in the limestone or produced sludge. In the case of iron(II)-rich water, gypsum and ferric hydroxide sludge and coated limestone particles accumulate in the fluidised bed reactor. About 70 per cent of the limestone is utilised in the case of water containing 600 mg/l iron(II). It is expected that a fraction of the trapped limestone could be recovered from the waste sludge through a backwash operation.

□ **By-products.** Gypsum and CO_2 are produced which could be recovered as byproducts.

Copies of the report entitled "Neutralisation of acidic effluents with limestone" (WRC Report 355/1/94) are available free of charge from the Water Research Commission, PO Box 824, Pretoria 0001. (Overseas price: US\$20).

Report on European visit



Francette Myburgh, an information scientist at the South African Water Information Centre (SAWIC) recently visited the IRC International Water and Sanitation Centre in the city of Hague, in the Netherlands, where she attended a Briefing Programme focussing on the management of information resources in the field of water supply and sanitation.

The aim of attending this programme was to research options for the alignment of the functions and services of SAWIC to suit the changing needs of the water sector in South Africa.

The briefing programme consisted of self-study and discussions with IRC resources personnel, centering around ideas for and an analysis of the current SAWIC information services and

information transfer mechanisms. The programme included visits to other information centres, which included the International Institute for Land reclamation and Improvement at Wageningen, and the CTA Technical Centre for Agriculture and Rural Co-operation at Ede, where Francette saw information management principles being applied in practice.

In the course of the briefing programme an analysis of the current SAWIC client base as well as the type of information available, required by and provided to clients, and the transfer mechanisms

used, was done. This analysis provided an excellent insight into problem areas, not only with regard to the information requirements of the client, but also with regard to the means of information transfer, as some clients are not equipped to receive information electronically on the computer network.

Francette says researching the activities of other water and sanitation information centres proved a difficult task. The regions chosen for this part of the study were Africa, South East Asia and South America. This part of the study was, however, worth the effort as she was able to gain some information and idea of the organisational

structures, the information services provided, as well as the transfer mechanisms of the centres in these regions. Although these information centres provide very much the same services as SAWIC Francette says this part of the study and the information gleaned has provided her with beneficial insights.

All the organisations she visited or contacted in the course of this visit took a very keen interest in the activities of the South Africa Water Information Centre, and expressed a desire to become involved in the expansion of SAWIC's services.



Martha Pretorius (centre) was recently appointed as the new manager of the South African Water Information Centre (SAWIC). She and her team, Lee Fraser (left) and Francette Myburgh (right) who are both information scientists, are responsible for information retrieval from SAWIC. Should you have any questions or queries pertaining to SAWIC, please feel free to contact the SAWIC team at Tel. (012) 841-3083.

Report on IAHS activities ...

Professor Roland Schulze recently had the opportunity to attend the International Association of Hydrological Sciences (IAHS) activities at the XXI General Assembly of the International Union of Geodesy and Geophysics (IUGG) at Boulder, Colorado in the USA. Here is his brief report back of the assembly and topics that were addressed:

Six IAHS symposia, along with a further five symposia hosted jointly with allied associations of the IUGG, plus four IAHS workshops and an additional three joint workshops were held at the XXI General Assembly of the IUGG during the first two weeks of July 1995.

The IAHS, a non-governmental scientific association with some 70 affiliated National Committees, covered major components of the hydrological cycle and related processes at Boulder through the symposia and workshops convened by its nine Scientific Commissions, which are

- Groundwater
- Tracers
- Remote Sensing and Data Transmission
- Continental Erosion
- Water Quality
- Snow and Ice
- Water Resources Systems
- Surface Water
- Atmosphere/Soil/Vegetation Relations.

Some 450 hydrologists attended the one-to-three day symposia which reflect the contemporary focus in scientific hydrology. Symposium themes were:

- Scale Effects in Sediments and Water Quality
- Monitoring Groundwater Quality
- Biochemistry of Seasonally Snow-Covered Catchments
- Tracer Techniques for Hydrological Systems
- Freshwater Ecosystems and Water Use and
- Sustainable Basin Scale Water Resources Systems

The four Workshop topics were:

- Information Systems in Hydrology
- Predictability, Uncertainty and Prejudice in Hydrology

- Hydrology in Developing Countries and
- Quality Assurance in Hydrological Measurements

while the most relevant joint workshops were about

- Remote Sensing (Soil Moisture, Evapotranspiration)
- Large Scale Modelling in Mountainous Areas and
- Global Water Balances.



For the hydrological community the business part of the Boulder IUGG consisted of the IAHS Plenary Sessions and the Administrative Meetings of the nine IAHS Commissions. Three IAHS plenaries were held over the two weeks, at which business reports were tabled and elections conducted.

The new IAHS President is Dr John Rodda of the UK who takes over from Prof Uri Shamir of Israel, with the new Secretary-General being Dr Gordon Young of Canada who succeeds Henry Colenbrander of Netherlands. In his short inaugural address John Rodda stressed the globality of scale in hydrology, its cross-disciplinary nature, the need to envelope developing countries and the necessity for young hydrologists to come to the fore. His motto during his tenure is to be *"He who is a leader must also be a bridge"*.

At a plenary the International Hydrology Prize was awarded to Prof John Philips of Australia, famous inter alia for his infiltration equation.

The Commission Meetings were often held concurrently; when three meetings were taking place simultaneously, Mr Jeff Smithers was the alternate voting dele-

gate at the second meeting and Mrs Susan Swart (Department of Water Affairs and Forestry) at the third. I want to thank them for willingly performing this task. Current and planned activities were discussed and elections of officers were held, the latter still had the aura of being somewhat a closed shop affair despite a recent "democratisation" of election procedures. Three aspects were highlighted at all the commission meetings, viz.

- the wide collaboration between IAHS Commissions and other bodies (e.g. WMO, UNESCO, the European Geophysical Union) when it came to co-sponsoring symposia world wide;
- the planning of the 1997 IAHS 5th Scientific Assembly to be held in Rabat, Morocco (for which I am on the organising committee); and
- the concept that at least one issue per year of the Hydrological Sciences Journal of IAHS is to appear as a special issue focusing on one of the Commissions, with a series of overview papers.

From a South African perspective the public goodwill and openness as well as the significant role we have to play in a very impoverished African hydrological community constantly came to the fore. Many of the presentations had major relevance to the South African hydrological scene, while on the other hand many presentations appeared "remote" to us, and one constantly had to remind oneself that this was a scientific meeting without many of the applied aspects we have become used to at our more operations-oriented South African hydrological symposia.

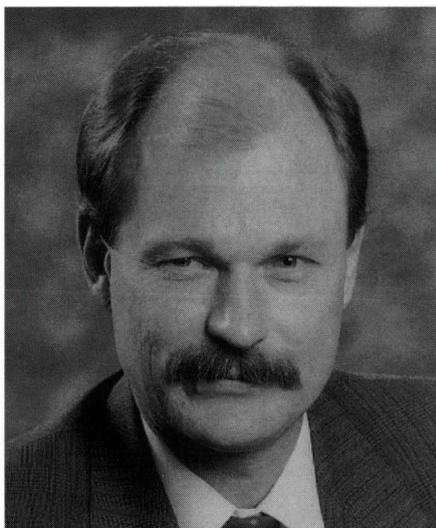
Multiple venues, with non-synchronised presentation starting times sometimes made for difficult decisions what to attend, and quite often the small South African delegation by consensus went to different venues to jointly pick up as much as possible of relevance. A highlight at Boulder again was meeting eminent hydrologists in person, renewing friendships and making new acquaintances, including discussions on future international collaboration.

Roland Schulze

New Research Manager appointed ...

Dr Gerhard Backeberg recently joined the ranks of the Water Research Commission as a Research Manager. He will be mainly involved with irrigation research and agricultural water management. Previously he was a Deputy Director of the Directorate: Agricultural Economics, Department of Agriculture.

Dr Backeberg matriculated in 1971 at the Deutsche Schule Hermannsburg in Natal. He studied at the University of Pretoria obtaining a BSc (Agric) majoring in Agricultural Economics. He pursued his post-graduated studies in Agricultural Economics while working for the Department of Agriculture. He was awarded the S₂A₃ Bronze Medal of the South African Association for the Advancement of Science for his MSc (Agric) dissertation. Recently he received a PhD degree from the University of Pretoria. His PhD thesis was entitled "The Political Economy of Irrigation Policy in South Africa", and



Dr. Gerhard Backeberg

dealt with aspects such as: the economy of water policy, water resources and water use in agriculture, water rights, irrigation policies and water markets.

As a Research Leader and Assistant Director of the Directorate: Agricultural Economics, Dr Backeberg has worked extensively investigating and evaluating the agricultural economics of irrigation schemes and developments in various parts of South Africa. He has quite a number of unpublished irrigation and economics related reports of the Department of Agriculture to his credit, as well as invited and contributed papers at conferences. In the past he has also served on the Coordinating Committee for Irrigation Research, as well as on the Steering Committees of some Water Research Commission projects.

He and his wife, Dorothee, have four children, two boys and two girls, between the ages of three and sixteen. When he has free time he enjoys listening to light and classical music, as well as reading, with a special interest in the history of human conflict resolution.

Chair of Exploration Geophysics commemorated

Recently the Department of Geology at the University of Pretoria commemorated ten years of the Chair of Exploration Geophysics in association with the Department. On this occasion Professor Willem Botha, who presently holds the Chair, gave an overview of the financial support, graduates, research and a future

vision with regard to the Chair of Exploration Geophysics.

The National Physical Modelling Facility at the University of Pretoria falls under the Chair of Exploration Geophysics. This facility was developed as part of the National Geophysics Programme under

the auspices of the Council for Geosciences. The development was funded by the Water Research Commission, the Council for Geosciences and the University of Pretoria.

The Facility has the capacity to model frequency domain and time domain electromagnetic methods, which is an essential component in ground water exploration, and to model seismic methods. Though computer software is developing constantly to even higher degrees of sophistication, the Physical Modelling Facility is playing a major role in the testing of computer algorithms, as well as the modelling of 3-D and complex 2-D structures.



Photographed visiting the Facility on this commemorative occasion, are representatives from the two major donors with the Head of the Geology Department and Prof Willem Botha. From left: Prof SA de Waal (Head: Department of Geology), Dr E Stettler (Council for Geosciences), Prof WJ Botha, (Chair of Exploration Geophysics), and Mr M du Plessis (Water Research Commission).

SA WATERKALENDER

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

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

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

Legend:

- An SA Water Event arranged for these dates.
- 2nd SA Water Event scheduled for these dates.
- x 3rd SA Water Event scheduled for these dates.

See conferences and symposia pages for events.

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

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

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

Gids:

- Een SA Watergeleentheid vir hierdie dae.
- 'n Tweede SA Watergeleentheid gereël vir dié datums.
- x 'n Derde SA Watergeleentheid gereël vir dié datums.

Sien Konferensies-en Simposiumbladsy vir aangeduide geleenthede.

1995



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**SOUTHERN
AFRICA****1995****ANAEROBIC PROCESSES**

OCTOBER 25

The first open meeting and mini-workshop of the Water Institute of Southern Africa's Anaerobic Processes Division will be held in Midrand. The theme of the workshop is "Experiences with anaerobic processes in South Africa".

Enquiries: Contact Mr JR Hoffmann at Wates, Meiring and Barnard. Tel (011) 315-0316 Fax (011) 315 0317.

WATER MICROBIOLOGY

NOVEMBER 7 - 10

An introductory course in water microbiology will be held at the Division of Water Technology, CSIR, in Pretoria.

Enquiries: Mr Gerrit Idema. Tel: (012) 841-3948. Fax: (012) 841-4785.

GROUNDWATER

NOVEMBER 7 - 15

The Groundwater Programme of the CSIR presents two courses in Groundwater Data Management using the United Nations Software: Groundwater for Windows (GWW). For full details see advertisement on page 31 in this Bulletin.

WATER CARE

NOVEMBER 29 & 30

The 4th Western Cape water care seminar and trade fair will be held at the Faure Water Treatment Plant, Faure.

Enquiries: Seminar secretary, Peter Novella, tel: (021) 4002-437 fax: (021) 253-848.

1996**GIS**

MARCH 15 - 22

A conference on the application of remotely sensed data and geographic information systems (GIS) in environmental and natural resources assessment in Africa

will be held in Harare, Zimbabwe. Enquiries: The Secretariat, Conference on GIS in Africa, Environment and Remote Sensing Institute (ERSI), PO Box 6640, Harare, Zimbabwe. Tel: 263-4-73-1049/5. Fax: 263-4-73-3797/73-1049/49-5628.

WISA '96

MAY 20 - 23

The WISA '96 conference will be held at the Feather Market Centre in Port Elizabeth.

Enquiries: Conference Planners, PO Box 82, Irene 1675. Tel (012) 63-1681. Fax (012) 63-1680.

AQUATIC SYSTEMS

JULY 15 - 19

A conference on aquatic systems will be held at the Vic Falls Hotel in Zimbabwe.

HYDRAULIC RESEARCH

AUGUST 5 - 7

The International Association for Hydraulic Research - African Division's biennial congress with the theme "From flood to drought" will take place at Sun City. Papers are invited on topics including Problems of temporal distribution, Water schemes due to uneven spatial distribution, Environmental and sociological problems in arid regions and Innovative ways of conserving water.

Enquiries: Miss Genevieve Stephenson, Conference Office, PO Box 327, WITS 2050. Tel (011) 716-5091 Fax (011) 339-7835.

AFRIWATER '96

SEPTEMBER 2 - 5

The AFRIWATER Conference and Exhibition will be held at the Gallagher Estate in Midrand.

Enquiries: Nigel Walker Tel: (011) 318-2009/1189 Fax: (011) 318 1189. International code: (+27 11).

ISIAME '96

NOVEMBER 4 - 8

An international symposium on industrial applications of the Mössbauer effect will be held in Johannesburg.

Enquiries: Prof Herman Pollak (Chairman), Mössbauer

Laboratory, Department of Physics, University of the Witwatersrand, Private Bag 3, Johannesburg 2050. Tel: (011) 716-4053 Fax: (011) 339-8262. E-mail:005KLKS@ WITSVMA. WITS.AC.ZA

OVERSEAS**1995****WASTEWATER RECLAMATION**

OCTOBER 17 - 20

The 2nd international symposium on wastewater reclamation and reuse will be held in Iraklio, Crete, Greece.

Enquiries: Mrs T Furnaraki, Municipal Enterprise for Water Supply and Sewerage of Iraklio, 1 Vironos Str., 71202 Iraklio, Greece. Tel: +30-81-229913, 225833 Fax: +30-81-22 9991

WEFTEC '95

OCTOBER 21 - 25

The Water Environment Federation's 68th annual conference and exposition will be held in Miami Beach, Florida, USA.

Enquiries: Water Environment Federation, 601 Wythe Street, Alexandria, VA 22314-1994 USA. Fax 1-908-885-6417.

LAKE MANAGEMENT

OCTOBER 23 - 27

The 6th international conference on the conservation and management of lakes will be held in Tsukuba and Tsuchiura, Japan.

Enquiries: The Secretariat, Kasumigaura '95, 1-5-38 Sannomaru, Mito, Ibaraki 310, Japan. Tel +81-292-24-6905 Fax +81-292-33-2351.

WASTEWATER PLANTS

OCTOBER 30 - NOVEMBER 1

The 3rd international specialised conference on design and operation of small wastewater treatment plants for tropical and sub-tropical regions will be held in Kuala Lumpur, Malaysia.

Enquiries: Mrs Lorraine Meiring, Water Research Commission, PO Box 824, Pretoria 0001. Tel (012) 330-0340. Fax (012) 331-2565.

WASTEWATER

OCTOBER 30 - NOVEMBER 1

An IAWQ/IWSA workshop on the "Separation of microorganisms from water and wastewater: Theory and practice/ New developments and opportunities" will be held in Amsterdam, the Netherlands.

Enquiries: Amsterdam Workshop '95, International Association on Water Quality, 1 Queen Anne's Gate, LONDON SW1H 9BT UK. Tel +44-71-222-3848. Fax +44-71-233-1197.

OVERSEAS**1996****MICROBIAL PHYSIOLOGY**

JANUARY

An advanced course on microbial physiology and fermentation technology will take place at the Delft University of Technology, the Netherlands.

Enquiries: Dr LA van der Meer-Lerk, Kluiver Laboratory, Julianalaan 67, 2628 BC Delft, the Netherlands. Tel: 31-(0)15-785140 Fax: 31-(0)15-782355.

**BATCH REACTOR
TECHNOLOGY**

MARCH 18 - 20 1996

A conference on sequencing batch reactor technology will be held in Munich, Germany.

Enquiries: Prof. Dr-Ing. Peter Wilderer, Lehrstuhl für Wassergüte und Abfallwirtschaft, Technische Universität München, Am Coulombwall, D-85748 Garching, Germany. Tel: +49 (089) 3209 3700. Fax: +49 (089) 3209 3718.

HYDROGIS '96

APRIL 16 - 19

An international conference on the application of geographic information systems in hydrology and water resources management will be held in Vienna, Austria.

Enquiries: HydroGIS '96, c/o Austropa-Interconvention, PO Box 30, A-1043 Vienna. Tel: +43(1) 588 00110 Fax: +43(1) 586 7127.

MICROPOLLUTANTS

MAY 6 - 7

A workshop on "Natural origin inorganic micropollutants: arsenic and other constituents" will take place in Vienna, Austria.

Enquiries: Mr Pierre Schulhof, Compagnie Générale des Eaux, Quartier Valmy - 32, Place Ronde, 92982 Paris La Defense CEDEX. Fax: (+33) (1) 46 35 31 50.

GEOFILTERS '96

MAY 29 - 31

The second international conference on Geofilters, addressing new developments and advances in all areas of filtration and drainage will be held in Montreal, Canada.

Enquiries: Geofilters '96, Bureau des Congrès, Ecole Polytechnique de Montreal, CP 6079 succ Centre-ville, Montreal

(Qc) H3C3A7, Canada. Tel: (514) 340-3215. Fax: (514) 340-4440.

FOREST INDUSTRY

WASTEWATERS

JUNE 10 - 13

The 5th IAWQ symposium on forest industry wastewaters will be held in Vancouver BC, Canada.

Enquiries: The organiser, Forest Industry Wastewaters symposium, c/o Venue West Conference Services, 645 the Landing, 375 Water Street, Vancouver BC, Canada, V6B5C6. Tel: +1 604 681 5226.

Fax: +1 604 681 2503.

IAWQ

JUNE 23 - 28

The 18th biennial conference and exhibition of the International Association on Water Quality will

be held on the tropical island of Singapore. CALL FOR PAPERS. Enquiries: IAWQ, 1 Queen Anne's Gate, London SW1H9BT, England. Tel: 44-171-222-3848. Fax: 44-171-233-1197.

AQUATECH ASIA 96

JUNE 24 - 26

Asia's specialised water technology forum Aquatech '96, will be held at the International Convention & Exhibition Centre in Singapore.

Enquiries: RAI, 1 Maritime Square 09-49, World Trade Centre, Singapore 0409. Tel: 65-272-2250. Fax: 65-272-6744.

BIOFILM SYSTEMS

AUGUST 28 - 30

The 3rd international IAWQ special conference on biofilm sys-

tems will be held in Copenhagen. CALL FOR PAPERS.

Enquiries: Institute of Environmental Science & Engineering, Att: Mia Clausen, Building 115, Technical University of Denmark, DK-2800 Lyngby, Denmark. Tel: +45 45 9339 08 Fax: +45 45 9328 50.

WATER HONG KONG '96

NOVEMBER 11 - 17

The 10th IWSA-ASPAC regional conference and exhibition will be held in Hong Kong. CALL FOR PAPERS.

Enquiries: Technical Sub-committee, Water Hong Kong '96, c/o Water Supplies Department, 48/F Immigration Tower, 7 Gloucester Road, Wan Chai, Hong Kong. (Attention: Ms Daisy S M HO). Fax: (852) 2824 0578 Tel: (852) 2829 4444.



RECORDING RAINFALL DATA?

**Please Help
a WRC Project**



The Department of Agricultural Engineering at the University of Natal has recently been awarded a research contract by the Water Research Commission to revise short duration (2 minutes - 24 hours) design rainfall estimates for southern Africa. They would like to utilise all relevant data that are currently available in order to obtain design rainfall estimates which are as reliable and representative as possible.

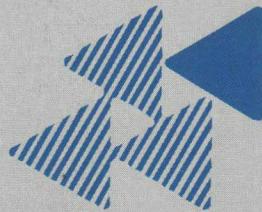
In order to ascertain the extent of the available data they are conducting a survey of all recorded short duration rainfall data and would very much like to contact all organisations with any recording raingauge data, be it from autographic or logging gauges.

If you have, or know of someone who has, such data please contact:

Prof Roland Schulze
University of Natal
Pietermaritzburg
Tel (0331) 260-5489
or Fax (0331) 260-5818
E-mail: Schulze@aqua.ccwr.ac.za.

If your data are not in electronic form (i.e. the data have been recorded autographically, but have not yet been digitised), this WRC project will endeavour to digitise as many new stations as possible, within the constraints of staff and time.

The project undertakes to make available to contributors the short duration design rainfall estimates for all data that they provided to the project and which are used in this study. The final report from this study will also be made available to all contributors.



The Groundwater Programme of the CSIR presents
two courses in Groundwater Data Processing and Management
using the United Nations Software:
Groundwater for Windows (GWW)



Presented by the co-developer of this state-of-the-art software:

Dr. Jasminko Karanjac

- Two courses are being presented:-
 - The first course is 4 days and includes 3 days of training in the use of GWW and the 4th day dedicated to interfacing GWW with groundwater models and geographical information systems.
 - The second course focuses on using GWW as a stand-alone package.
- Each course is limited to 24 people, with each participant having access to a 486
- Each participant will receive a copy of the GWW software, as well as complete documentation.

Dates 7 - 10 November 1995 (4 day course)
 13 - 15 November 1995 (3 day course)

Venue Fleurbaix Estate - Stellenbosch

Course Fees R500 per day (accommodation excluded)
 R680 per day (accommodation & transport included)

Further Information

Julian Conrad or Cheryl Dixon
021 - 887 5101 (tel) or 021 - 883 3086 (fax)
e-mail
jconrad@stellbos.csir.co.za or cdixon@stellbos.csir.co.za



1945 - 1995

INTERNATIONAL ASSOCIATION OF APPLIED ALGOLOGY

7th International Conference on Applied Algology

16 - 19 APRIL 1996

Knysna, Southern Cape

Theme

The theme of the conference will be opportunities from micro and macro algae.

The following topics for sessions are suggested:

- Molecular biology: Challenges and prospects
- Microalgal growth and production systems
- Photosynthesis and algal physiology
- Macroalgal growth and production systems
- Products and constraints
- Algae as bioindicators
- Algae and wastewater treatment
- Downstream processing (harvesting, etc.)
- Economics and commercial ventures

Tours

A number of pre and post conference tours will be offered, ranging from three to ten days. These will include visits to the Kruger National Park, the Cape area with winelands and flora of the Cape and Table Mountain and a trip along the Garden Route. Dr John Bolton of the University of Cape Town will arrange a scientific excursion for those interested in seaweeds.

Registration

Deadline: 30 November 1995.
The registration fee will be R750.
Late registration (after 30 November 1995) will be R950.

The registration fee will cover the costs of the conference together with the banquet, mid-conference excursion, lunches during the conference and all tea and coffee during breaks.

Enquiries

Prof Johan Grobbelaar, Department of Botany and Genetics, University of the Free State, Bloemfontein 9300 Tel: (051) 401-2514 Fax: (051) 488-772 E-mail: jpg@rs.uovs.ac.za