SA waterbulletin

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HYDROLOGY
Report published on hydrological modelling in the Eastern Cape

BESPROEIING
Radiobeheerde vliegtuie ingespan om vogstremming by gewasse te bepaal

WATER QUALITY
Research assess biocorrosion in industrial water systems

GROUNDWATER '95

Conference and Exposition on Groundwater Recharge and Rural Water Supply
25 - 27 September 1995
Volkswagen Conference Centre, Midrand

This will be the eighth biennial groundwater conference organised by the Groundwater Division of the Geological Society and the third conference to be organised jointly with the Borehole Water Association of Southern Africa.

Two topics in particular will receive attention during the conference:

AQUIFER RECHARGE

- ❒ Mechanisms and Controls
- ❒ Regional variation
- ❒ Methods for determining recharge

RURAL WATER SUPPLY FROM GROUNDWATER

- ❒ Exploration
- ❒ Appropriate aquifer testing procedures
- ❒ Appropriate abstraction techniques
- ❒ Infrastructure maintenance
- ❒ Management of well fields
- ❒ Social considerations
- ❒ Groundwater vs surface water supplies
- ❒ Aquifer and borehole protection

The programme will also include open sessions on any geohydrological topic or information gained during field investigations or arising from research projects.

TECHNICAL WORKSHOPS

Technical workshops for the groundwater industry, organised by the Borehole Water Association, will be run parallel with the scientific programme sessions.

TECHNICAL EXCURSION

A post-conference technical excursion to view rural water supply schemes is being planned.

COST

Registration will be approximately R750. A reduced fee will be available for members of the Groundwater Division, Borehole Water Association, speakers and bona fide full time students.

A range of accommodation from approximately R110 to R340 per person per night will be available.

ENQUIRIES TO:

Conference Co-ordinator,
Groundwater Division,
PO Box 75728,
Lynnwood Ridge 0040.

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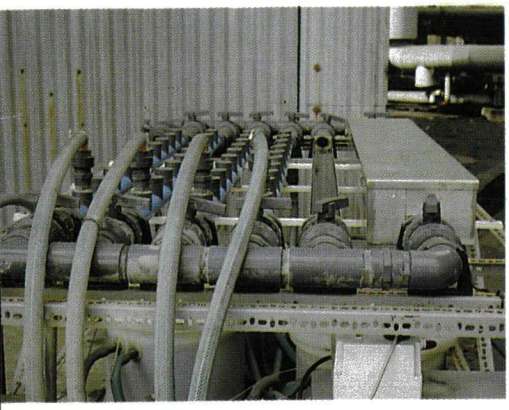

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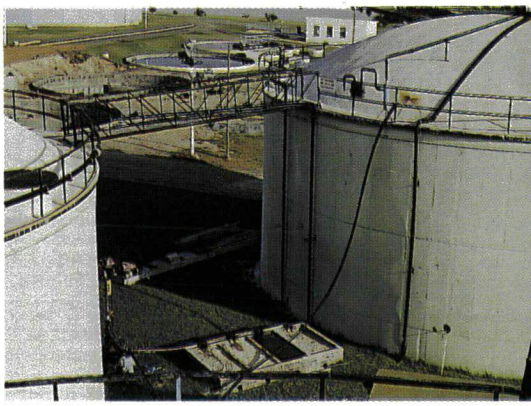

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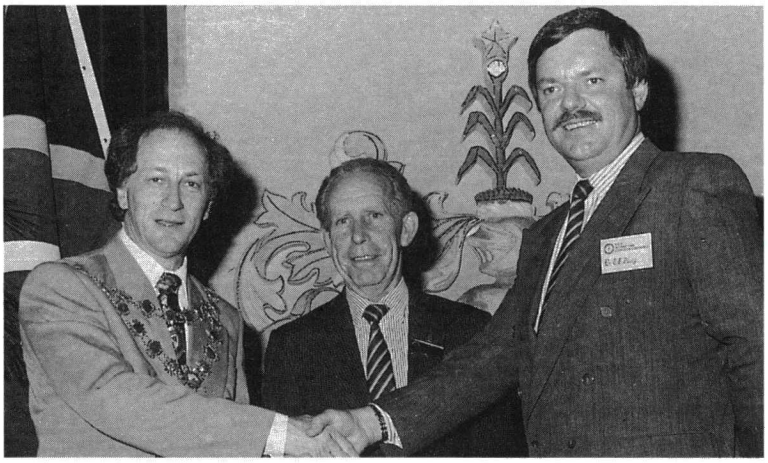
Cover: The Cape Flats Wastewater Treatment Works near Cape Town (Photo: Helene Joubert)

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

Conference looks at Corrosion Control

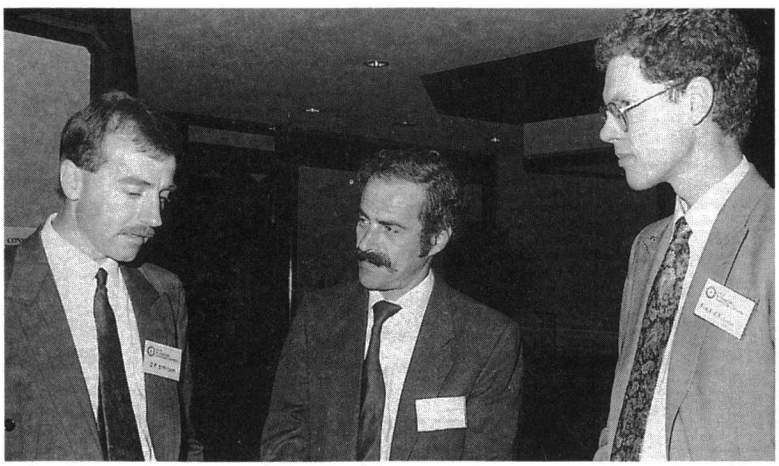


The Mayor of Durban, Councillor Michael Lipschitz, welcoming Dr Colin Alvey, President of the Corrosion Institute of Southern Africa, and Mr Michael Brett, past president of the Institute.

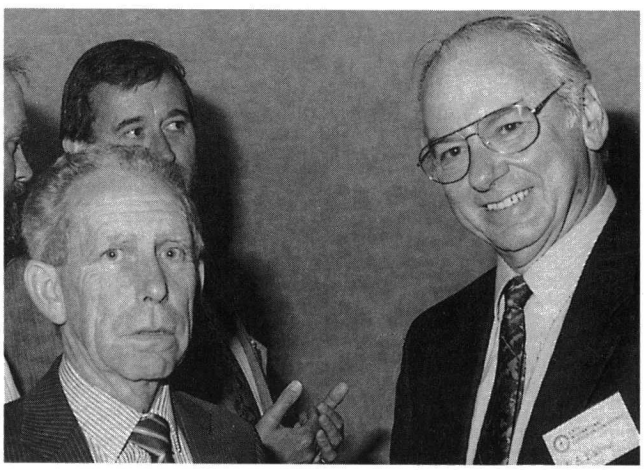
The current corrosion expenditure in the South African economy is estimated at between R11 458 and R14 323 million per annum, according to experts at the recent sixth International Corrosion Conference of the Corrosion Institute of Southern Africa, held in Durban.

Cost effective corrosion control into the 21st century, was the topic of this successful conference which addressed corrosion control on a broad front in terms of corrosion economics, corrosion monitoring, corrosion inhibitors and new developments in corrosion technology.

Dr Colin Alvey, President of the Corrosion Institute of Southern Africa, said "As we move towards the end of this millenium all focus is on the 21st century where technology and cost control will no doubt be major factors in determining the growth of national economies. The New South Africa has to develop a growing economy in order to compete on an international basis. In these endeavours the costs of corrosion must be appreciated and all efforts made to reduce and control these costs."



Mr Joe Strydom (ESKOM) in conversation with Prof Tim Burstein (University of Cambridge) and Prof Chris Pistorius (University of Pretoria).



Mr Michael Brett, chairman of the conference organising committee, with Mr Rob Barbour, Managing Director of ALUSAF, who opened the conference proceedings.

EXPENDITURE

Dr IO Coker, ESKOM, in his paper on corrosion economics, said that in a modern industrial economy the estimated annual corrosion expenditure has an economic cost value equivalent to approximately five per cent of the gross national product (GNP). He pointed out that the major reasons for excessive corrosion expenditure are:

- lack of foresight by management,
- lack of information dissemination,
- minimisation of capital layout and
- lack of basic knowledge.

Prof RA Parkins from the University of Newcastle on Tyne, UK, was a keynote speaker addressing the subject of selling corrosion control. He pointed out that "corrosion is a particular form of waste that depletes a nation's resources" . Discussing the considerable implications of having to replace a corroded structure, he pointed out that the mere production of metals required, caused amongst others, the use of considerable volumes of water.

Prof GT Burstein, University of Cambridge, UK, delivered a paper on "New developments in the understanding of pitting corrosion". This paper considered some of the fundamental questions concerning the origins of pitting corrosion. Focussing on the earliest stages in the development of corrosion pits, it was based on detailed analysis of current transients emanating from passive metals exposed to potentially aggressive solutions.

Mr SC Lore, from USX Engineers and Consultants, Pittsburg, USA, presented a paper discussing the worldwide corrosion performance and cost effectiveness of Cor-ten steels for infrastructure.

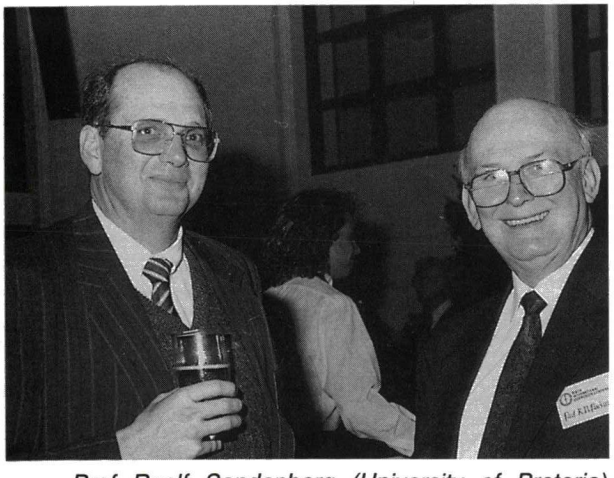
Other papers covered various topics including corrosion of concrete, marine corrosion protection, pitting corrosion of copper in potable water, resistance of mortar linings and concrete to microbiologically influenced corrosion (MIC), biofouling and corrosion prevention in cooling and firewater systems, stress corrosion cracking and corrosion surveillance.

EXHIBITION

A number of exhibitors displayed corrosion protection coatings, technology and services. The use of technology such as cathodic protection for the maintenance of buried ferrous pipelines in the water industry was well illustrated by the Umgeni Water exhibit.

The conference was well attended by delegates representing a wide diversity of industries, companies and agencies which included agricultural engineering, aviation, mining, breweries, paper, metal and chemical industries, petroleum and oil companies, municipalities, SABS, ESKOM, Department of Water Affairs, Umgeni Water as well as consultancies, universities and technikons.

Mr Rob White (SA Stainless Steel Development Association), Ms Cathy Baumer (Dulux), Dr Colin Alvey (President, CISA) and Mr Johan van Wyk (Dulux) at one of the exhibition stands.



Prof Roelf Sandenberg (University of Pretoria) having a word with Prof Redvers Parkins (University of Newcastle on Tyne, UK).

Mr Bob Andrew (JCI Ltd) with Mr Pat Draper and Mr Derek Penhall at the exhibition stand of Draper Penhall and Associates.

Moisture stress in crops evaluated with remotely piloted aircraft

The results of a research project sponsored by the Water Research Commission indicate that the use of low altitude aerial colour infrared photography obtained from remotely controlled aircraft and image processing computers, can be a relative inexpensive technique to assess crop stress conditions.

The project was carried out by two researchers, PS Fouche and N Booysen, from the Department of Soil Science at the University of the North and the major results are summarised in a report recently released by the Water Research Commission entitled "Evaluation of moisture stress in crops by means of remote control aerial surveillance" (WRC Report no 229/1/94). Copies of the report are available, free of charge, from the:
Water Research Commission,
PO Box 824, Pretoria 0001.

Moisture stress assessment techniques can generally be classified into three categories, namely, soil based, plant based and mathematical model approaches.

Of these three categories plant based techniques are the best since they scientifically measure crop water status while soil or meteorological methods only provide estimations of crop water status.

INFRARED

Plant stress measurements with an infrared thermometer have become popular in the past ten years. Digital displays of foliage temperature allow for quick and easy measurements. Using remote control aircraft fitted with an infrared thermometer, a large crop area can be scanned in a short time to assess the crop canopy temperature.

Colour infrared photography and videography have also shown to be sensitive to shifts in the spectral reflectance of crop under moisture stress conditions. Processing these infrared images by computer software, the moisture stress conditions in the crops can be classified into stressed and non-stressed categories.

Comparing this with the canopy temperatures of the crop, a more quantitative estimation of stress conditions in the crop can be achieved.

OBJECTIVES

To further investigate and develop the use of airborne techniques for the assessment of crop moisture stress conditions in South Africa, the Water Research Commission financed a five year project at the University of the North with the following objectives:

- To develop the use of remotely controlled aircraft to serve as an inexpensive platform for remote sensing of crop water stress and other parameters related to the estimation of crop water stress requirements and attainment of maximum crop water use efficiency (plant density, crop growth, nutrient disorders, irrigation uniformity, etc.).
- To develop the use of various onboard sensing techniques for obtaining the required measurements and data. These include colour and

infrared photography, infrared thermometry and infrared video image acquisition.

- To evaluate the accuracy with which moisture stress related parameters can be estimated by means of these remote control surveillance techniques.

- To establish the spatial coverage and resolution attainable with the technique.

RESEARCH PROCEDURES

According to the final report the following research procedures were carried out to achieve the project's objectives:

- Different remotely piloted aircraft were developed and modified as inexpensive platforms carrying onboard sensing instruments for low altitude remote sensing of agricultural crops.

- Three crops, namely, soybean, wheat and maize received irrigation treatments which resulted in well watered and moderately stress conditions. A remotely piloted aircraft carrying an infrared thermometer and video equipment was used in sensing the crop canopy temperature of the three crops.

- Variables were measured every second day and included canopy temperature by aerial surveillance, ambient air temperature and soil moisture potentials. Infrared aerial photography was also conducted simultaneously over the period when stress conditions developed on the crops.

- The obtained colour infrared transparencies were scanned into and processed on a computer using image processing software. The processed images were compared with canopy temperature data of the crops obtained by infrared thermometry.

RESULTS

- The large aircraft having wingspans of up to four metres with payload capacities of up to five kilograms, were more suitable for carrying infrared thermometers and video equipment. They needed landing strips of not more than 50 metres by 5 metres. The smaller aircraft, with maximum wingspans of 2 metres could carry 35 mm cameras of up to one kilogram mass. These aircraft could be used in more confined areas on smaller landing strips of up to 30 metres in length. Some of these aircraft were also equipped with an autopilot and parachute retrieval system for ease of operation in difficult flying areas.

- Canopy temperatures of the crops, as measured by aerial surveillance, gave a much quicker method than the ground method to assess moisture stress development on the crop.

- The T-value (canopy temperature minus the air temperature) was shown to be effective in assessing moisture stress in crops such as soybean, maize and to a lesser extent, on wheat.

- The crop water stress index also signalled at higher threshold values the need for irrigation on both crops such as soybean and maize. Successful use of the crop water stress index depends on the determination of a corrected non-water stress baseline which could change throughout the growing season.

- The temperature stress difference value which gave the difference between the canopy temperature of water stressed and well watered plots, also differentiated between different days of irrigation and developing stress conditions on soybean and wheat.

- All three moisture stress indices could be used positively to estimate developing moisture stress on the short term crops. A highly significant correlation was also found between canopy temperature, canopy temperature minus the air temperature and the temperature stress difference for both soybean and wheat over the study periods from 1989 to 1992.

- Aerial infrared photographs taken of soybean and wheat at different stages of the irrigation cycle and processed on a computer, showed that the computer images gave a positive differentiation of developing moisture stress areas on the crops. Stressed areas could also be quantitatively expressed as percentage area values of the total irrigated area.

- Areas of moisture stress development were also observed from the air by a multispectral video camera. The best results in differentiating between low moisture and high moisture stress areas, were obtained using a narrow band infrared filter on the video camera. Although resolution proved to be poorer than the colour photographic infrared images, computer imaging still showed differences in the moisture stress conditions on the crops.

- Using low altitude aerial infrared photography and computer processing, rootrot diseased trees in citrus, avocado and cashew nut orchards could be identified and differentiated from healthy trees.

- In a wheat field experiment that was fertilised at different levels of phosphorus, areas with phosphorus deficiency and sufficient phosphorus could be classified on the processed aerial colour infrared image. Soil phosphorus and wheat yield correlated well with the classified colour infrared image.

A report summarising the results of this research project called "The technical support for the application of dynamic membrane plants for the treatment of industrial effluents" (WRC Report 274/1/94) compiled by RB Townsend, is available on request from the: Water Research Commission, PO Box 824, Pretoria 0001. Overseas price: $25.

INDUSTRIAL EFFLUENTS

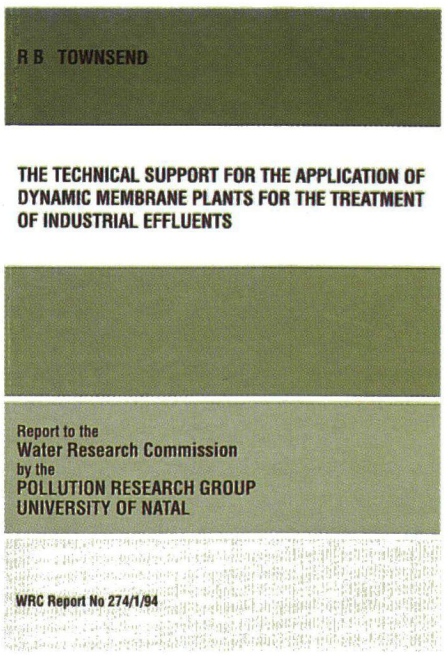
From 1977 to 1992 the Water Research Commission funded a number of research projects which related to the development of dynamic membranes for the treatment of industrial (primarily textile) effluents.

Dynamic membranes are membranes that are formed in situ when a dilute colloidal suspension of one or more additives is passed over the surface of a porous support, eg porous stainless steel substrates. Some of the more promising "formed-in-place" membranes which were developed are the hydrous zirconium (iv) oxide membrane and the hydrous zirconium (iv) oxide/polyacrylate composite membrane.

These membranes show considerable potential for their use in the treatment of effluents with high fouling characteristics.

In the 1980s three companies commissioned effluent treatment plants employing the dynamic membrane technology. These were:

- A modular demonstration plant at Gubb and Inggs Ltd, Uitenhage, for the treatment of wool scouring effluents. This plant was constructed during the period 1986 to 1988 and was funded as a Water Research Commission project.
- A full-scale plant for the treatment of textile scouring and dyehouse effluents. This plant was commissioned in 1984 and was funded by Mym Textiles in Umzinto, Natal.
- A small plant for the treatment of acrylic emulsion polymerisation wash water was installed by Supacryl (Pty) Ltd in Durban in 1985.



These three companies produce effluent which could not be treated to reuse quality using conventional techniques. Two of these companies selected innovative dynamic membrane technology because they were sited in water scarce regions and water recycling was necessary. The third company recognised the world-wide commercial potential of this innovative technology and had investigated its potential for treating an intractable industrial effluent.

TECHNICAL SUPPORT NEEDS

The demonstration plant at Gubb and Inggs was designed to integrate effluent treatment with the manufacturing process from one wool scouring line. The degree of integration, together with the complexity of the dynamic membrane plant made it essential for the company to have recourse to outside technical support.

The plant at Mym Textiles was intended to treat separately effluents from the dyeing, rinsing and scouring operations of the factory. At the time of installation, this plant was the largest of its type in the world. The plant did not perform to expectations and technical assistance from the supplier CARRE Inc. (USA) was not forthcoming.

After the commissioning of both these plants it was found that their performance was lower than expected.

Supacryl installed an effluent treatment plant employing dynamic membranes to treat the effluent arising from high pressure washing of their emulsion polymerisation vessels. However, the interaction between the effluent and the membrane resulted in

WRC funds technical support for dynamic membrane plants

The modular demonstration plant at Gubb and Inggs Ltd in Uitenhage for the treatment of wool scouring effluents.

extremely poor permeate fluxes. The possibility existed that if this plant was successful, Supacryl would have negotiated with the Water Research Commission to license the technology internationally.

Many of the problems experienced by the operators of these plants were caused by the lack of understanding of the principles of operation of dynamic membrane plants. The companies were also unable to provide suitably qualified staff to ensure the effective operation of their plants. The user base of this technology was small and consequently there was no commercial company to provide the required back-up for the technology.

The Water Research Commission therefore contracted the Pollution Research Group from the University of Natal to assist the users of the dynamic membrane technology by:

- Ensuring that plants would perform to specification;
- Re-establishing industrial confidence in the dynamic membrane process as a method of treating industrial effluents to reuse quality; and
- Ensuring technology transfer of advances in the field of dynamic membranes.

RESULTS

Wool Scouring: Gubb and Inggs

During the first year of operation of the modular demonstration plant, many of the mechanical problems which interfered with the operation of the plant were rectified. Technical assistance was given to the factory personnel to operate the plant according to the design specification. Regular on-site membrane formation was implemented during this period. As a result, it was possible to operate the ultrafiltration plant for a period of approximately four months according to the design average flux of 37 to 40 $\ell/m^2/h$.

In April 1989 Gubb and Inggs expressed reservations about the economic viability of the process, because the permeate from the ultrafiltration process would require secondary treatment prior to reuse in the rinse stage of the wool washing process, and requested that the focus of the project be shifted to treat the wool rinse liquor and that the factory evaporation ponds be included in the treatment philosophy.

The project objectives were amended and technical assistance was given to the factory personnel by way of:

- Advice on changes necessary to treat the rinse water;
- The design and commissioning of an automated membrane formation plant;
- Trials on alternative membrane types, including cross-flow microfiltration using woven fabric tubes, of a wool washing effluent with similar characteristics to the rinse liquor produced by Gubb and Inggs;
- Identification of the bacterial growth in the effluent.

The results of this technical assistance and further investigations were as follows:

- The plant was operated at the design specification for wool scouring effluent.
- The automated membrane formation plant which although subject to delays in the engineering of the project, was successfully commissioned and was used on a routine basis by the factory staff for the formation of the hydrous zirconium (iv) oxide membranes.
- Since July 1991 the plant has operated on rinse effluent at an average permeate flux of 65 ℓ/m²/h. The permeate quality was acceptable .
- A trial was conducted on the use of a dual layer Zr/PAA membrane. The results of this trial showed that permeate of excellent quality could be obtained. The flux varied from a starting value of 60 ℓ/m²/h to a value of 22 ℓ/m²/h after one month of operation. It was felt that this flux was not sufficiently high to continue trials.
- Woven fabric tubes were used in laboratory cross-flow microfiltration tests. Carpet scouring effluent, similar to the rinse effluent, was processed using tubes precoated with either fumed silica or precipitated hydrous zirconium (iv) oxide. It was found that complete clarification could be achieved, but that the colour removal was not significant (the colour of the process water would affect the final wool quality). The permeate flux varied from 80 ℓ/m²/h to 50 ℓ/m²/h.
- Information about new ceramic modules was acquired and two of these modules were purchased and used for factory trials at Gubb and Inggs. These modules have a thin zirconia or alumina layer sintered to a ceramic base. The pore size of the thin layer is homogeneously small and can be specified between 10 nm and 0,5 µm.

The results of these trials indicated that the formation of a standard hydrous zirconium (iv) oxide membrane on a 0,1 µm zirconium oxide ceramic module may have advantages over the porous stainless steel supports which are in current use. It was possible to operate these modules at a flux of 200 ℓ/m²/h (approximately three times that of the porous stainless steel modules) even though the inlet pressure was only 10 per cent of that of the porous stainless steel supports.

Dyehouse effluent treatment plant: Mym Textiles

The original design of the dynamic membrane plant at Mym Textiles provided for the treatment in separate trains of the scour, rinse and dye effluents from the factory. The design fluxes for these units were 84 ℓ/m²/h, 128 ℓ/m²/h and 68 ℓ/m²/h, respectively, to produce 560 kℓ/d of permeate. From the time of commissioning of this plant in November 1984, this performance was never realised.

Numerous investigations were carried out as to the effectiveness of the plant and several process changes were made. Eventually the plant only treated dyehouse effluent.

In January 1988, the Pollution Research Group was requested to assess the performance of the plant and it was ascertained that the average permeate flux was 10 ℓ/m²/h, equivalent to a production of 44 kℓ/d of permeate. Colour rejection of the membranes varied from 0 to 70 per cent.

As a result of this assessment, the Pollution Research Group made a number of recommendations:

- The corroded sections of the porous stainless steel modules be replaced and the modules housed in open troughs;
- The performance of different membranes be evaluated on factory dyehouse effluent under laboratory conditions by the Pollution Research Group, and subject to the results obtained, a section of the membrane plant be re-membraned with the appropriate membrane, under the supervision of the Pollution Research Group;
- Pipework be altered to allow higher velocity operation.

The management of Mym Textiles agreed to the implementation of these recommendations on a section of the plant, referred to as the DYE-2 plant, which consisted of 12 modules. After start-up, the refurbished plant was monitored closely for a period of ten weeks. During this period the performance of the refurbished section of the plant was as follows:

- An average flux of 33 ℓ/m²/h was achieved;
- Colour removal was generally better than 95 per cent. At this level

slight discolouration of the permeate was visible and corresponded to an average ADMI value of 120. Conductivity (dissolved solids) removal was better than 70 per cent and the average conductivity of the permeate was approximately 10 S/m, equivalent to the factory softened water;

- Low temperature operation was possible without detrimental effect to the permeate flux. Colour rejection was also enhanced by low temperature operation.

Consequently the heat exchangers were removed from the plant resulting in lower steam and maintenance costs for the factory.

As a result of the performance of the DYE-2 plant, the factory management decided to continue with the refurbishment of the effluent treatment plant and another section of the plant, referred to as the DYE-3 plant, consisting of a further 14 modules was repaired and remembraned under the direction of the Pollution Research Group.

The results obtained after completion of this refurbishment were similar to those obtained with the DYE-2 plant. The total treatment capacity of the effluent plant after completion of this work was increased to 140 kℓ/d. This was sufficient to treat all the concentrated dyehouse effluent. A further section of the membrane plant consisting of eight modules was considered spare capacity and the evaporator, intended for further treatment of the concentrates, was withdrawn from service.

A comprehensive manual for membrane formation was prepared for the factory staff together with computer spreadsheets to facilitate performance monitoring.

Wash water effluent treatment plant: Supacryl

Initially the standard hydrated zirconium (iv) oxide membrane formation procedures were used on this plant. This led to certain constituents of the effluent

The effluent produced by the companies could not be treated to reuse quality using conventional techniques.

forming secondary membranes which although producing permeate of acceptable quality, resulted in a very low flux. These secondary membranes were extremely difficult to clean and remove.

The Pollution Research Group consequently carried out investigations on the following aspects:

- Pore modification of the porous stainless steel membrane supports with suspensions of fumed silica and precipitated hydrous zirconium (iv) oxide, prior to membrane formation;
- Formation of an "inert" microfiltration membrane for the treatment of the effluent;
- The use of woven fabric tubes in place of porous stainless steel for the treatment of the effluent;
- Small-factory evaluation of woven fabric tubes for effluent treatment.

The results of these investigations were as follows:

- Fumed silica or precipitated hydrous zirconium (iv) oxide could be used to produce a stable pre-coat on porous stainless steel tubes. This pre-coat could be removed by simple chemical means.

The experiments with silica or precipitated hydrous zirconium (iv) oxide demonstrated that pore modification resulted in improved flux and rejection properties of hydrous zirconium (iv) oxide (Zr) or poly(acrylic) acid dual layer membranes (Zr/PAA);

- Laboratory tests using pore modified porous stainless steel supports produced conductivity rejections of 70 to 80 per cent, a total carbon rejection of 99 per cent at a flux of 50 to 60 ℓ/m²/h. The tube could be cleaned by simple chemical means.
- Pre-coated woven fabric tubes clarified the effluent and produced total carbon rejections of up to 99 per cent. The flux varied from 35 to 65 ℓ/m²/h depending on the pre-coat material. Fumed silica and precipitated hydrous zirconium (iv) oxide formed a pre-coat that was more resistant to disturbances such as plant shut-down than the china clay or carbon black.
- It was demonstrated that, although emulsion-containing effluents could be treated using a variety of membranes on porous stainless steel substrates, the problems encountered when the emulsion particles penetrated the substrate or further polymerised in the tubes, rendered the plant extremely difficult to operate. It was considered that any membrane system employing rigid supports was not suitable and it was recommended that the use of porous stainless steel be abandoned.

RESEARCHERS SCRUTINISE BIOCORROSION

Corrosion of metals in industrial water systems is very often the product of both electro-chemical processes and the activity of microorganisms on the metal surface. Biocorrosion or microbially influenced corrosion (MIC) contributes to a large degree to corrosion losses sustained by industry. However, it is difficult to evaluate the extent of microbial activity quantitatively in the overall sphere of corrosion.

Microbially influenced corrosion may constitute as much as 32 to 38 per cent of the (total) corrosion of industrial water systems, says researchers Dr GM Wolfaardt and Dr REM Archibald (Watertek, CSIR), emphasising the importance of biofouling and microbially influenced corrosion in the incidence of corrosion problems in industrial water systems in their report " Research on the effect of biocorrosion in water systems" to the Water Research Commission (WRC).

The research project on the effect of biocorrosion in water systems was initiated by Watertek, CSIR, and funded by the WRC to investigate microbially influenced corrosion (MIC) with regard to the factors influencing both biofouling and quantitative measurements of MIC.

The main thrust of the project was directed at developing an apparatus for quantitative measuring of biocorrosion in a water system, while simultaneously evaluating the *in situ* effectiveness of potential biocides to control microbial growths or biofouling, which results in biocorrosion of that system.

The report **Research on the effect of biocorrosion in water systems** (WRC Report no. 253/1/93) 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 $25.

One of the prime issues facing major water using industries in South Africa is the problem of using water more efficiently in order to reduce water consumption and the cost of effluent treatment. Many industries practise water recirculation as a means to effect such reductions. However, while this strategy has its advantages, it often leads to deterioration of the quality of the water, creating favourable conditions for the proliferation of microorganisms. Such an accumulation of microorganisms, and their excretory products, in water systems is generally referred to as biofouling. Biofouling in industrial water systems is usually characterised by the colonisation of microorganisms on surfaces in contact with water. A serious consequence of this phenomenon is microbially influenced/induced corrosion (MIC) or biocorrosion.

FACTORS INFLUENCING MICROBIAL GROWTH

Ignorance of the important role of sessile bacteria in biofouling and the factors promoting their growth, may explain why traditional strategies of corrosion control in industrial water systems have failed so often.

While there has recently been greater interest in microbially influenced corrosion (MIC) and its control, many questions remain with regard to the factors influencing biofouling and the quantative measurements of MIC.

In this research project the effects of some physical and chemical parameters on biofouling and microbially influenced corrosion rates were investigated.

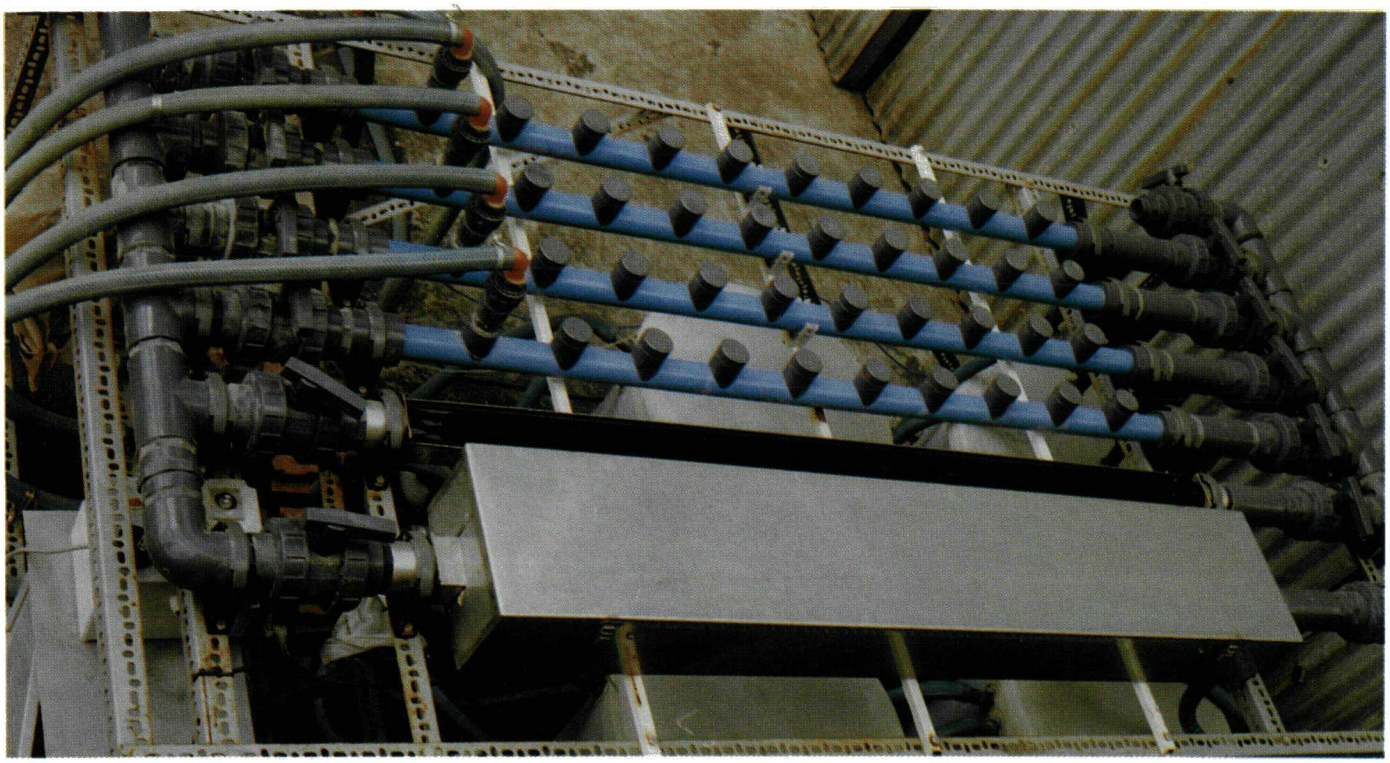
With regard to the intrinsic factors affecting the growth of micro-organisms in industrial waters, the project has shown that the flow rate of the water, the surfaces properties of the substrate and the dissolved organic carbon concentration of the water have a meaningful influence on biofilm development. These factors do not impinge directly on biocorrosion, but affect the development of biofilms that are a prerequisite for biocorrosion.

ORGANIC CARBON

The total carbon and dissolved organic carbon values varied notably in water samples collected from a variety of industries, ranging from 10.4 to 398 mg/l. Results obtained in this study showed that colonisation rates increase with increasing concentrations of dissolved organic carbon.

SURFACE TYPE

Different metals show a wide range of susceptibility to corrosion, therefore also to microbially influenced corrosion. According to the report much research has been done on the corrosion susceptibility of different metals, however, very little attention has been given to microbial responses to different metals. In this pro-



A view of the biofouling rig from above, showing the stainless steel box containing the UV irradiated channel and the open untreated channel (black area) next to the stainless steel box.

ject three different materials, namely stainless steel, aluminium and glass, were used as a substrate surface to determine the rate of biofouling on different surfaces. Stainless steel was the most rapidly colonised surface and glass the slowest.

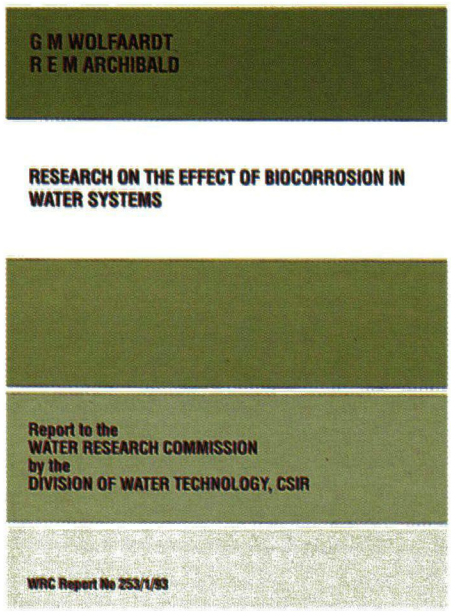
FLOW RATE

There was an inverse relationship between colonisation rate and the flow rate. Thus colonisation rates were highest under conditions of zero flow, and decreased as the velocity of the water flow increased. The experiments also showed that the initial period of rapid colonisation in the first hour was followed by a lag phase. However, after four hours, the number of bacteria attached to the surface increased rapidly, probably as a result of cell division. An increase in nutrient levels resulted in a reduction of the lag phase.

SULPHATE CONCENTRATIONS

Corrosion caused by sulphate reducing bacteria (SRB) was a focal point in this investigation. These organisms use sulphate as an electron acceptor. Therefore the availability of sulphate in water should have an effect on their activity. Sulphate levels vary over a wide range in industrial water systems. While techniques for the effective removal of sulphate from industrial water systems exist, little is known about the actual concentrations of sulphate required by sulphate reducing bacteria to have a significant effect on corrosion processes in water systems. A laboratory experiment was conducted in order to learn more about this relationship.

Mild steel coupons were subjected to chemostats (1 000 ml glass reactors with airtight lids) containing mixed cultures of

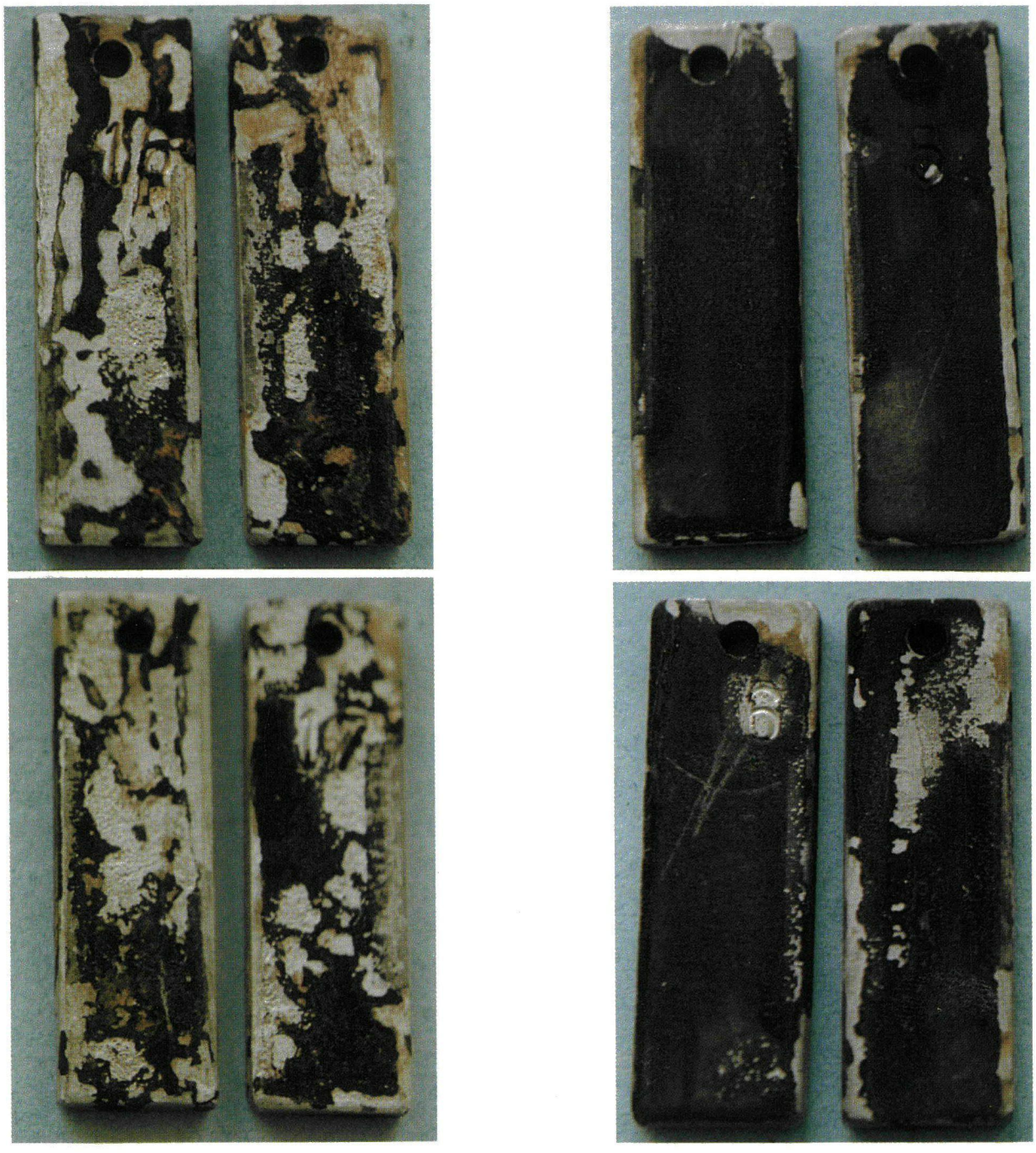


SRB isolated from a variety of industrial water systems. Anaerobic conditions were maintained in each chemostat during the first series of experiments, while a second series of experiments were conducted under aerobic conditions.

Under anaerobic conditions there was a progressive increase in the corrosion rate of mild steel up to a sulphate concentration of 400 mg/l, after which there was no further significant increase in corrosion rate.

However, under aerobic conditions the corrosion rate showed a marked increase compared to the corrosion rate under anaerobic conditions. Under aerobic conditions the corrosion rate of mild steel at a sulphate concentration of 1 000 mg/l was approximately twice as great as the corrosion rate at 400 mg/l.

The researchers concluded that although sulphate reducing bacteria (SRB) are obligate anaerobes, they benefit from a mutualistic relationship with aerobic organisms composing the consortium of microorganisms in the biofilm and thus the introduction of oxygen to the anaerobic system resulted in higher corrosion rates in the oxygenated system than in the strictly anaerobic system at corresponding sulphate concentration levels. This finding has important implications



Two sets of coupons from each channel after cleaning, showing the effect of corrosion. The four coupons on the left are from the untreated channel and the four coupons on the right are from the UV treated channel.

with regard to oxygenating water systems as a method to control or reduce the activity of sulphate reducing bacteria.

BIOFOULING RIG

Most important in this project was the development of a research laboratory apparatus known as the biofouling rig. This unit was designed as a single piece of equipment to measure microbially influenced corrosion (MIC) quantatively, and at the same time to evaluate several biocides simultaneously *in situ*.

The section of the apparatus designed to measure microbially influenced corrosion quantatively, was based on the essential principle of comparison of the corrosion rate of a set of coupons exposed to ambient conditions with that of a set of coupons on which all microbial activity had been eliminated. Theoretically the difference in the corrosion rates is a measure of the microbially influenced corrosion. The efficiency of this technique therefore depends on the ability of the apparatus to achieve this state of sterility. The sterilising agent used in the apparatus was ultraviolet (UV) light.

The biofouling rig apparatus consisted of two channels containing mild steel coupons immersed in water from a common source. One channel was irradiated with UV light to eliminate bacterial growth

on one set of coupons. Modifications were made later to enhance the sterility of the water passing through the UV irradiated channel. Corrosion rates and microbial growth rates in these two channels were then compared in various situations.

The field trials indicated that the biofouling rig has the potential to determine microbially influenced corrosion (MIC) quantatively. However, the major problem to be solved is to find a method of sterilising one set of coupons completely without affecting the electro-chemical corrosion processes. Even though the elimination of all microbial growth on the UV irradiated coupons was not achieved in the field trials, substantial differences between the corrosion rates of the UV irradiated coupons and those of the coupons exposed to ambient conditions at the Iscor Works, were observed. According to the report this indicates that with only partial sterilisation of microbial activity, microbially influenced corrosion (MIC) accounts for at least 32 - 38 per cent of the total corrosion rate, and that the real contribution of MIC to corrosion may be much greater.

EVALUATION OF BIOCIDES

Biocides and biodispersants are the most commonly used means to control or eliminate biofouling in industrial water systems. One problem however, is the selection of the most effective biocides for a particular application. The researchers say that too often laboratory tests of a biocide have been very promising, but when applied in the field it is a failure. This failure may often be ascribed to the methods of evaluating a biocide in the laboratory. Conventional methods of evaluation often test the responses of a pure culture of organisms in the planktonic phase and under highly controlled conditions. However, in the field the biocide must be applied to a mixed culture of organisms in a dynamic environment. Furthermore biofouling is a surface phenomenon, and biocides that are highly effective against bacteria in the planktonic phase, may be quite ineffective against sessile bacteria.

In conclusion the researchers say that the part of the biofouling rig designed to compare or evaluate a number of biocides simultaneously, under conditions closely approximating those existing in industrial system, shows promise. However, field trials of this part of the apparatus indicated that a number of problems need to be solved: some aspects require redesign and some refinements are necessary on this potentially useful test rig.

CERTAIN ALGAL BLOOMS IN SA WATERS IDENTIFIED AS TOXIC

A number of dams in South Africa are from time to time experiencing high concentrations or blooms of floating blue-green algae. According to the Department of Water Affairs and Forestry, recent research has shown that some of these blooms produce toxins. However, not all blooms necessarily produce toxins and the level of toxicity fluctuates constantly. Toxic blooms have been identified in amongst others the Hartbeespoort, Roodeplaat and Rietvlei dams.

In response to a worldwide increase in the number of toxic blue-green algal blooms, the Institute for Water Quality Studies of the Department of Water Affairs and Forestry is implementing a national surveillance network on different water bodies on a priority basis. This network will determine the extent of the problems in water bodies throughout South Africa. Where possible the public will be advised when toxicity is identified at any impoundment. The Institute is currently investigating sampling and analysis techniques better suited to South African conditions. Other water supply institutions are aware of the problem and are also monitoring the situation.

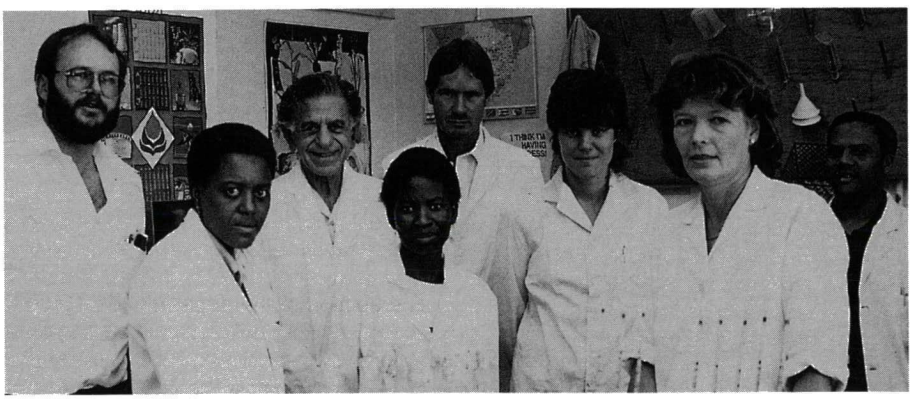
SCUM

Potentially toxic blue-green algae often form a surface scum which looks like blue-green paint or jelly. Symptoms of contact with toxic algae include skin rashes and eye irritation. As a safety precaution prolonged contact with all thick algal scums should be avoided. Water containing scums should on no account be drunk. However, normal recreation on impoundments should not be affected.

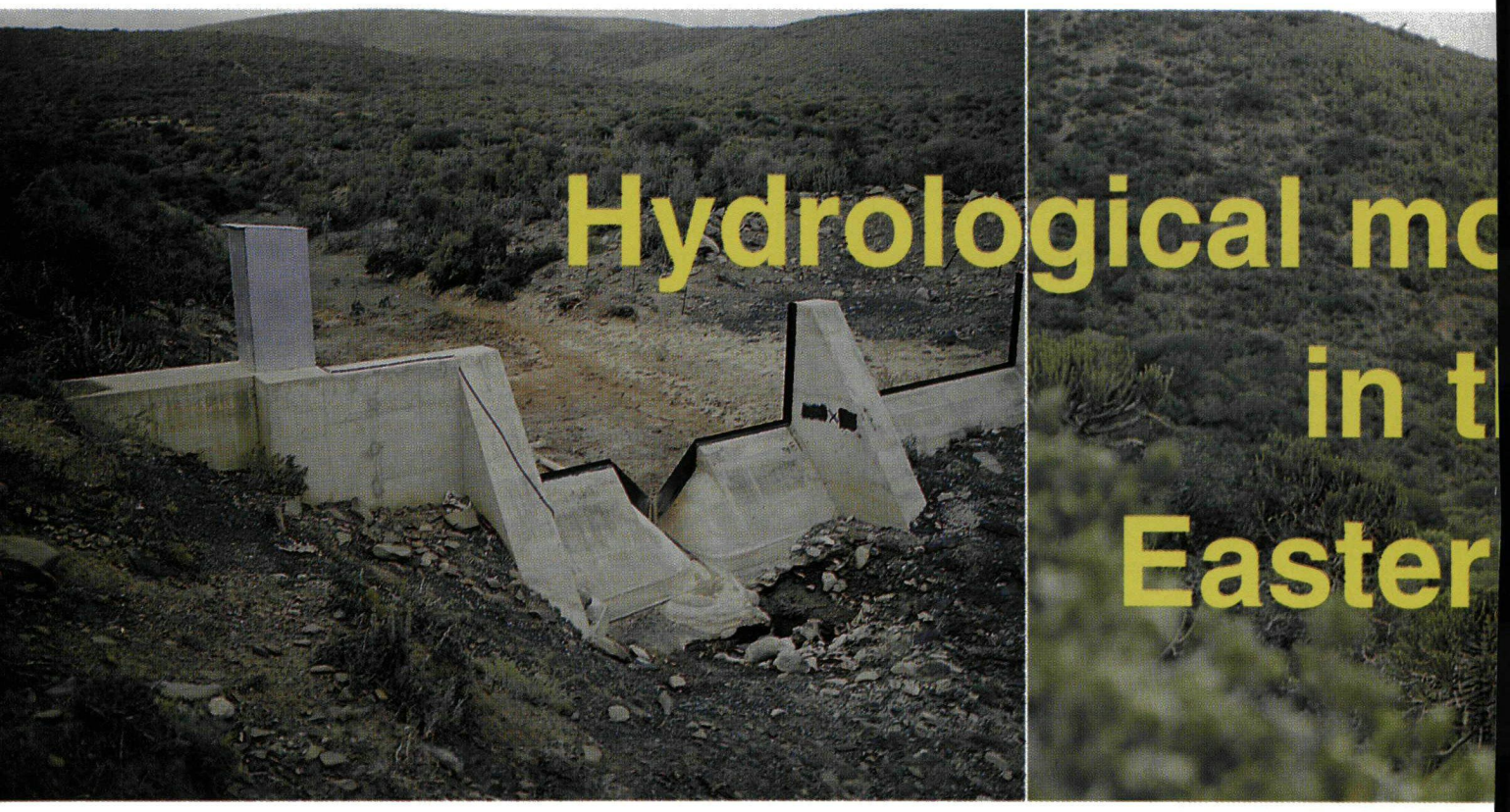
No human fatalities have been traced to contact with toxic blue-green algae. There is, however, some evidence of a possible risk of long-term effects in humans drinking water from affected water bodies. These risks are, however, only apparent once certain toxin levels are reached. A number of animals have died after ingesting large quantities of toxic algal scums and farmers and pet owners should ensure that their animals do not have access to affected areas. The proliferation of toxic blue-green algae is not a new phenomenon. It has been identified and studied throughout Europe, Scandinavia, Australia, North America and the United Kingdom. Although the cause is unknown, it is believed that factors such as warmer temperatures and increased nutrient concentrations in the water favour the development of these blooms.

The Department says an information brochure is also available and will be widely distributed. For more information contact the Director: Institute for Water Quality Studies, telephone (012) 808-0377.

LEARNING ABOUT WATER MICROBIOLOGY



The Division for Water Technology at the CSIR in Pretoria recently held the first of three introductory courses in water microbiology. Pictured here are (from the left) Gerrit Idema of WATERTEK (lecturer), Mildred Sebetoane, Alex Kouloumbis, Margaret Tlabela, André Welters, Belinda du Plessis, Pauline Coubrough of WATERTEK (lecturer) and Lionel Sampson. The next course is scheduled for 14 to 17 February 1995.



Hydrological mo in t Easter

"To contribute to an improvement in the applicability of hydrological models in South Africa with an emphasis on semi-arid environments". This was the main aim of a five year project funded by the Water Research Commission at the Institute for Water Research at Rhodes University in Grahamstown.

According to the final report on the project which was recently published by the Water Research Commission, the main aim of the project was to be achieved through three primary objectives, namely:

- To quantify the physical characteristics (relief, soil, landuse, etc.) of the new Bedford research catchments some 90 km north of Grahamstown so that they can be established as long term research areas in a semi-arid environment;
- To improve the general applicability of hydrological models through the development of a flexible approach to their basic structure; and
- To improve the soil moisture budgeting component of hydrological models by concentrating on monitoring and modelling vertical and lateral moisture fluxes at or near the base of the root zone.

The authors of the final report, DA Hughes, K Sami and KA Murdoch, say that the first objective arose out of the closure of the former Ecca research catchments due to the development of a major water supply scheme within their boundaries. It was considered at the time that it was important to replace the Ecca catchments as they were the only instrumented semi- arid research catchments in South Africa. To effectively replace them it was necessary to not only select a new area, but also to establish instrumentation and to carry out some baseline surveys of their characteristics. It would then be possible to not only use the new catchments to provide a basis for some of the process studies and model developments that form a part of this specific project, but also to establish them for future research efforts by Rhodes University scientists and others.

The second objective refers to improving the general applicability of hydrological models. It was realised early in the project that this objective could not be achieved by simply developing existing or new models. It was necessary to pursue this objective within a more general framework of the techniques used to set up the information that models require, run the models and examine the simulation results. The objective was therefore eventually interpreted to mean that the project would attempt to improve the approaches to applying a range of hydrological models, as well as developing a more flexible approach to the basic structure of some models. One example is allowing a choice of methods for simulating some sub-components of catchment hydrology on the basis of the amount of information available or the specific response characteristics of the catchment being modelled.

The researchers say the final objective has also undergone some modification during the course of the project. The essence of the objective was to use field based process studies of soil moisture and groundwater recharge, carried out within the new Bedford catchments to gain a better understanding of soil moisture fluxes within semi-arid soils. The results from these field studies would then be used to develop new and improved approaches to the soil moisture budgeting component of catchment hydrological models. While the essence

A catchment area in the semi-arid Eastern Cape region.

of the objective has remained unchanged, the project team has not restricted itself to the 'base of the root zone', but has investigated various aspects of the hydrology of semi-arid soils, including infiltration characteristics, channel transmission losses into alluvial material, re-infiltration of slope runoff, as well as the mechanisms involved in groundwater recharge into fractured rock aquifers and the estimation of recharge rates.

REPORT

The final report is divided up into three volumes plus an executive summary. The first volume (compiled by Hughes and Sami, 1992) deals with the physical and hydrological characteristics of the new Bedford catchments and is designed to stand alone as an introduction to anyone wishing to carry out further studies in the area or make use of some of the data that has been collected. The authors say the report describes the hydrometeorological gauging network that has been established and operated during the last five to six years and interprets both the information gained from this source, as well as others, to provide a brief introduction to the climate of the area. The physical characteristics are described in sections on the geology, topography and drainage, soils and alluvial deposits, as well as the land use and vegetation. Most of the spatial information has been digitised using ArcInfo GIS and the coverages are readily available. The soil moisture, runoff and groundwater dynamics of the area are also covered in the report, although it should be appreciated that the length of records is too short to make any firm conclusions.

The second volume (compiled by Hughes and Murdoch, 1993) represent the current version of the user manual for the modelling system (HYMAS - HYdrological Model Application System). This manual provides a detailed overview of what HYMAS is and what it is designed to do and explains the use of all the various computer programs that form part of the system. It includes a guide to installing the system, various sections on how to set up a modelling application and the ways and means by which users can modify or customise certain components of the system to more readily suit their purposes. The models currently contained within HYMAS are also described in some detail, together with the procedures designed to assist with the estimation of their parameter values.

The third volume (by Hughes, Sami and Murdoch) represents the overall final report and contains some summary information from the other two volumes, as well as the details of the hydrological process studies, the background to the development of some of the models and the modelling application system, examples of the application of the models and the overall conclusions and recommendations of the project. There is inevitably some overlap between this volume and the other two. This is necessary so that all three volumes can stand more or less alone and so that readers mainly interested in the contents of any one volume do not need to continually refer to one of the others.

Copies of this final report **"Hydrological models - development and application"** (WRC Report 235/1/93) are available on request from the Water Research Commission. Overseas price: $25.

AIR used for dual digestion of sewage sludge

A report discussing the results of a full-scale investigation into the dual digestion of sewage sludge using air instead of pure oxygen has been published by the City Council of Cape Town.

The report, which was compiled by Andrew J Pitt of the City Engineer's Department (Scientific Services Branch), Cape Town and George A Ekama of the Department of Civil Engineering at the University of Cape Town, is divided into six chapters. Chapter 1 comprises a short introduction while in Chapter 2 an overview of the Athlone Wastewater treatment plant is presented to give an impression of the type and operation of the plant and therefore of the quality and quantity of the sewage sludge produced. This is followed by a description of the operation and monitoring of the full-scale dual digestion plant and the laboratory scale anaerobic digesters operated concurrently in the investigation.

In Chapter 3 the biokinetics and stoichiometry of biological heat generation are briefly reviewed, followed by the development of equations from which the biological heat generation and oxygen utilisation rates were calculated from sludge liquid and air gas flow rates and composition measurements.

In Chapter 4 the results obtained in the investigation are evaluated and discussed. In Chapter 5 simple mathematical models for the steady state design of air oxygenated aerobic reactors in dual digestion systems are presented along with the predicted effects of incorporating pure oxygen supplementation and feed sludge pre-heating. In the last chapter the conclusions drawn from the investigation are set out along with recommendations for further research.

Copies of the report entitled The dual digestion of sewage sludge using air (SSB File Ref no CB2/S13 UCT Report no W80/1993) are available free of charge from one of the authors, Andrew Pitt, Scientific Services Branch, City Engineer's Department, PO Box 1674, Cape Town 8000.

Sludge pasteurisation and increased anaerobic digester treatment capacity are important objectives in municipal sewage sludge treatment. At Milnerton, Cape Town, a pure oxygen dual digestion plant, comprising a first stage autothermal thermophilic (60°C) aerobic reactor followed by a second stage mesophilic (37°C) anaerobic digester, demonstrated that this process was capable of meeting both these objectives. In addition to providing pasteurisation in a simple to operate process, the autothermal heat treatment in the aerobic reactor conditioned the sludge allowing the anaerobic digester to be operated at shorter retention times, thereby increasing the treatment capacity of the anaerobic digester.

A disadvantage of the Milnerton dual digester was the cost of the pure oxygen for aerating the aerobic reactor. If the reactor could be operated with air, it would become a simple and inexpensive option for improving sludge treatment in anaerobic digestion.

OBJECTIVES

The Cape Town City Council in 1989 initiated-a full-scale research project to investigate the dual digestion process employing air rather than oxygen for aerating the aerobic reactor. While the principal objective was to demonstrate the practicability of the process as a means of increasing anaerobic digester treatment capacity, the investigation examined all the claimed benefits of the process, namely:

- ❑ aerobic conditioning for accelerated anaerobic digestion;
- ❑ sludge pasteurisation and pathogen inactivation without adverse effects on the anaerobic digestion process such as biogas and volatile solids removal;
- ❑ no external heating is required for the anaerobic digester.

Apart from evaluating the above claims for the dual digestion system aerated with air, additional objectives of the investigation were to:

- ❑ Define the aeration and heating requirements to achieve autoheating with air aeration and to establish the minimum practical aerobic and anaerobic retention times for the system.
- ❑ Develop a mathematical method based on liquid and gas heat and mass balances for the system allowing prediction of aerobic reactor performance such as reactor temperature, volatile solids removal, etc.
- ❑ Evaluate practical operating problems of the system at full scale over an extended period to assess the reliability and dependability of the system.

❑ Estimate capital, operation and maintenance costs for the system and compare these with conventional anaerobic digestion.

SYSTEM LAYOUT

The dual digester was constructed by building a 184 m^3 liquid volume aerobic reactor inside an existing anaerobic digester, leaving a liquid volume of 1 800 m^3 for anaerobic digestion. The aerobic reactor was aerated by one 20 kW liquid ring compressor, producing a maximum dry air flow rate of 760 m^3 (STP)/h, feeding coarse bubble diffusers set in a ring at the bottom of the reactor. Mixing was augmented with a 10 kW recirculation pump, discharging 396 m^3/h in a horizontal and tangential pattern into the base of the reactor. The anaerobic digester was mixed by recirculating biogas, pumped by a second identical liquid ring compressor. The capacity of the anaerobic digester was too large to allow short retention times to be tested and consequently this was done at laboratory scale.

The aerobic digester was fed with gravity thickened primary sludge (approx. 4 per cent total solids) in batches at 2 to 4 hourly intervals. Influent feed sludge displaced reactor sludge to the anaerobic digester, which in turn displaces sludge to a secondary digester. Feeding was not performed on a draw and fill basis as with most pasteurisation processes. It was recognised that the displacement type of feeding procedure would lead to short circuiting and poor pathogen inactivation performance, but in this prototype plant, this was not regarded as a serious problem.

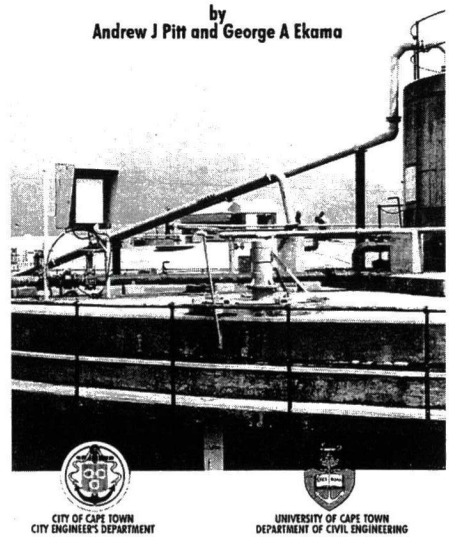
All parameters to allow (liquid and gas) heat and mass balances to be made across the aerobic reactor were measured. This involved measuring many of the influent and effluent liquid and gas flow rates, constituents and temperatures. The materials considered were sludge mass dry solids (total solids, volatile solids and chemical oxygen demand), water oxygen, nitrogen and carbon dioxide. Volatile solids removal in the anaerobic digester was monitored. However, as there were no flow meters to measure the gas flow rate in the biogas recirculation line, it was not possible to conduct gas mass and heat balances on the digester.

RESULTS

The dual digester was monitored daily for a period of 312 days incorporating a full summer and winter season. During this time various operating parameters, such as the air and influent sludge flow rates, were changed to examine the influence of these parameters on the performance of

THE DUAL DIGESTION OF SEWAGE SLUDGE USING AIR

by
Andrew J Pitt and George A Ekama



CITY OF CAPE TOWN
CITY ENGINEER'S DEPARTMENT

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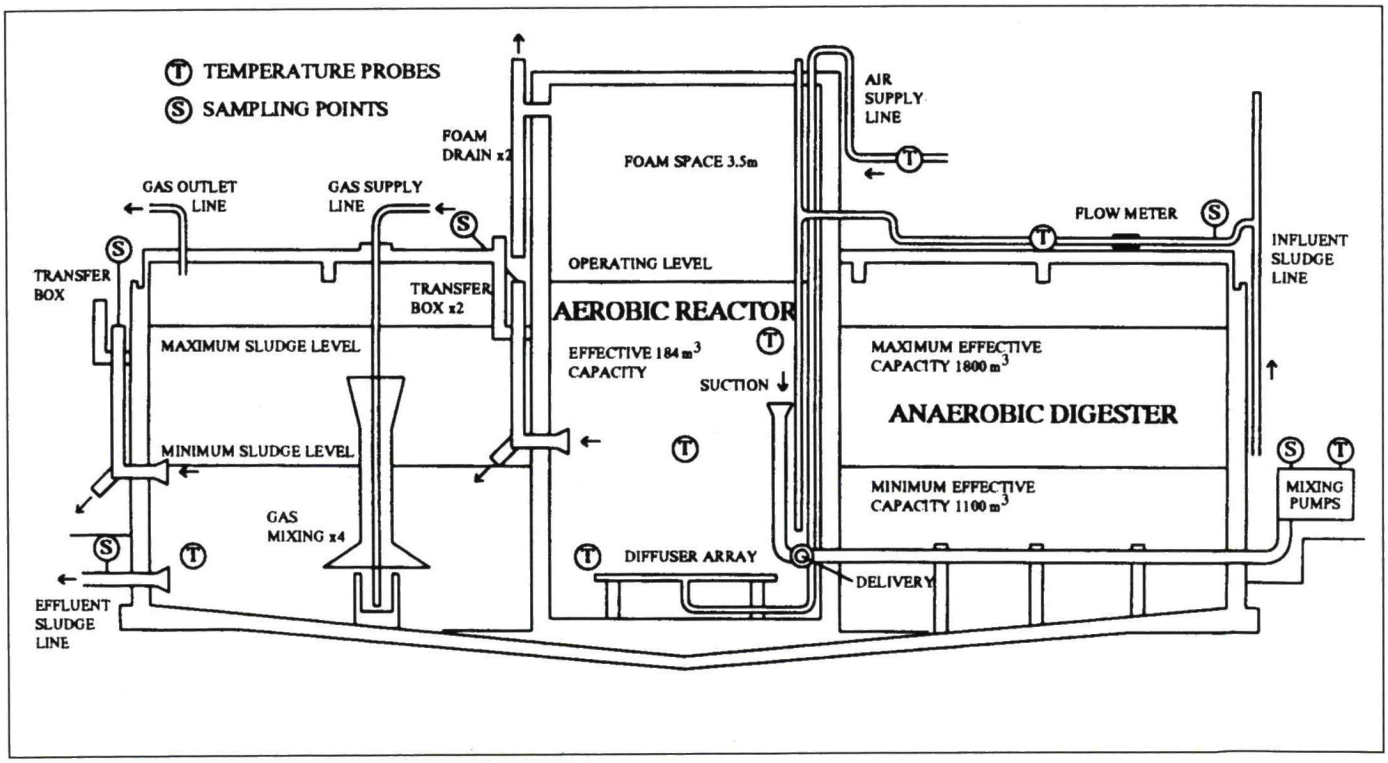
DEPARTMENT OF CIVIL ENGINEERING

the system. The process proved simple to operate and no major mechanical problems were encountered. The aerobic reactor was easily started and reached thermophilic temperatures (approx. 50°C) within 10 days. It was important to ensure that the feed sludge was adequately concentrated to prevent the reactor from becoming substrate limited. A significant foam layer (approx. 3 m deep) was present in the reactor at various



Schematic of the dual digestion plant at Athlone in Cape Town.

CHEMICAL CHARACTERISTICS

Chemical Characteristics*		Feed sludge	Aerobic sludge	Anaerobic sludge
Temperature	°C	20 (12 - 27)	49 (40 - 59)	31 (24 - 36)
Total solids	g/ℓ	45 (24 - 88)	35 (15 - 55)	24 (6 - 70)
Volatile solids	g/ℓ	37 (20 - 74)	28 (12 - 47)	17 (3 - 46)
COD	$g(O_2)/\ell$	64 (21 - 99)	43 (15 - 79)	26 (7 - 72)
pH	–	5.4 (4.8 - 6.1)	7.4 (6.1 - 8.1)	7.4 (7.0 - 7.9)
Ammonia	mg(N)/ℓ	110 (49 - 240)	370 (41 - 700)	760 (570 - 990)
Bicarb alkalinity	$mg(CaCO_3)/\ell$	40 (0 - 460)	820 (0 - 1 460)	2 910 (2 160 - 3 460)

* Mean values are quoted with the ranges given in brackets.

stages during the investigation, particularly when the temperature was in excess of 50°C. Although the foam was difficult to control and could only be managed by reducing the air flow rate, its presence proved beneficial to the process by improving aeration performance.

The aerobic reactor was able to reach thermophilic temperatures throughout the year although longer retention times were required in the winter months. The average retention time for the period was 4,4 days with the result that volatile solid reduction across the reactor was about 25 per cent, a factor which would impact on the quantity of biogas produced in the digester. Because of the relatively large operating capacity of the anaerobic digester (1 800 m³), the average retention time in the anaerobic digester was long (42 days). With insufficient sensible heat being provided by the sludge from the aerobic reactor, digester temperatures were generally below optimum (37°C) in the range 26°C (winter) to 33°C (summer). Overall removal of volatile solids and COD by the process was 56 per cent and 59 per cent respectively.

The conditioning effects of aerobic pretreatment were demonstrated by a noticeable increase in the sludge ammonium concentration, bicarbonate alkalinity and pH after aerobic treatment. In the laboratory scale study a mesophilic (37°C) anaerobic fed with aerobic reactor sludge operated safely at an eight day retention time and achieved 46 per cent volatile solids removal, whereas a digester fed with raw primary sludge failed at the same retention time, soon after starting up.

Interestingly, the percentage volatile solids removal in the laboratory scale digester at eight day retention time was greater (at 46 per cent) than that in the full scale digester at 42 days retention time (40 per cent). The final sludge from the digester was stable and did not undergo further fermentation. It had an earthy odour similar to that of conventional anaerobically digested sludge. The dewaterability of the final (anaerobic) sludge in terms of specific resistance to filtration was not significantly different from conventional anaerobically digested sludge.

OXYGEN

Irrespective of the presence of foam or not, the reactor operated under oxygen limiting conditions, with the result that the oxygen utilisation rate of the sludge was limited by the oxygen transfer rate of the aeration system.

Under non-foaming conditions, the aerobic reactor was generally operated at an air flow rate fixed at 760 m^3 (STP)/h giving an oxygen supply rate of 1,16 kg $(O_2)/m^3/h$. Under such conditions the oxygen transfer rate (and hence the oxygen utilisation rate) remained relatively constant at 0,15 $kg(O_2)/m^3/h$, representing an oxygen transfer efficiency of 13 per cent.

Under foaming conditions, with the air flow rate reduced to prevent spillage, a decline in the oxygen transfer rate and oxygen utilisation rate was not observed due to a significant increase in the oxygen transfer efficiency: At an average oxygen supply rate of 0,51 kg $(O_2)/m^3/h$ (less than 50 per cent of the normal supply rate), the average oxygen utilisation rate and oxygen transfer efficiency were 0,14 kg $(O_2)/m^3/h$ and 29 per cent respectively, the latter more than double that obtained without foam.

Measurement of both oxygen and carbon dioxide concentrations in the vent gas, and assuming the nitrogen gas mass flow rate through the aerobic reactor remains constant, allowed the respiration quotient (mol CO_2 produced per mol O_2 utilised) and specific heat yield coefficient (MJ heat generated per kg oxygen utilised) to be calculated. The specific heat yield and respiration quotient, calculated from the heat and oxygen mass balances, varied in narrow range and the average values under the different operating conditions were virtually identical to those measured by researchers on the Milnerton pure oxygen reactor in Cape Town and indicate that the measurements were accurately conducted and the materials and heat balances soundly established with the necessary sensitivity to changing operating parameters. The constancy of the respiration and heat yield quotients data for the different operating conditions indirectly verified the heat balance assumption that the vent gas was saturated with water vapour at all influent air flow rates. The average mass of oxygen utilised per mass of volatile solids destroyed in the aerobic reactor was 1,70 $kg(O_2)/kg$(volatile solids). This figure is higher than the usual value of 1,42 kg(COD)/kg(volatile solids) for sewage sludge but it is in agreement with the COD/volatile solids ratio of the influent sludge. The quantity of biological heat generated per mass of volatile solids destroyed was calculated at 22 MJ/kg volatile solids, which shows good agreement with the recognised standard value of 21 MJ/kg volatile solids in autothermal thermophilic aerobic digestion obtained at laboratory scale.

The bacteriological analysis of the sludge indicated a four orders of magnitude reduction in faecal coliforms in the system and with the aerobic reactor above 50°C complete inactivation of Ascaris ova was achieved. The viable Ascaris in the digester sludge were those remaining from the seed sludge employed at the start of the investigation.

DESIGN CONSIDERATIONS

The researchers say the investigation was successful in establishing sufficiently general and accurate heat and mass balance equations to obtain a constant specific heat yield. Knowing the heat yield, these same equations could be used as a design model to calculate the reactor temperature, oxygen utilisation and volatile solids destruction rates for different operating conditions with or without foaming.

With the aid of this model it was estimated that under non-foaming conditions, the minimum aerobic reactor retention time in summer and winter (feed sludge temperatures 25°C and 15°C respectively which would allow for stable operation of the reactor at 50°C is 3,6 days and 5,8 days respectively. At such retention times the percentage volatile solids destroyed is predicted to be 23 per cent and 38 per cent respectively (assuming a feed sludge total solids concentration of 40 kg (total solids)/m^3). Under non-foaming conditions the oxygen utilisation rate remains relatively constant at 0,15 kg(O_2)/m^3/h with the oxygen supply rate at a maximum rate of 1,15 kg(O_2)/m^3/h (an effective oxygen transfer efficiency of 13 per cent).

With foaming, the oxygen transfer efficiency doubled from 13 to 26 per cent, allowing higher oxygen transfer (and hence utilisation) rates at lower influent airflow rates to be achieved. The lower influent airflow rates reduces the vent gas water vapour heat loss rate which allows for either a reduction in retention time whilst maintaining thermophilic temperatures, or an increase in reactor temperature whilst maintaining the retention time. However, even with foaming, the retention times are still considerably longer (3 - 5 days) compared to pure oxygen aerated reactors (1,0 - 1,25 days) principally because of the high water vapour heat loss with the result that the reactor tends towards an autothermal thermophilic aerobic digestion system with high volatile solids removals. In the aerobic reactor the sludge is partially stabilised rather than conditioned and anaerobic digester gas production is reduced.

AERATION CHARACTERISTICS

Aeration characteristics*		No foam	Foam
Air flow rate	m^3(STP)/h	760	320
Oxygen supply rate	kg(O_2)m^3/h	1.15	0.51
Oxygen utilisation rate	kg(O_2)m3/h	0.151	0.140
Oxygen transfer efficiency	%	12.9	28.6

* Mean values are quoted.

SOLIDS REMOVAL

Solids removals*		Aerobic	Anaerobic	Overall
Total solids	%	23	32	48
Volatile solids	%	25	40	56
COD	%	33	40	59

* Mean values are quoted.

VIABILITY OF DUAL DIGESTION WITH AIR

In contrast to dual digestion with pure oxygen, which operates at very short retention times (1 to 1,5 days) but requires the high cost of the pure oxygen, dual digestion with air requires long aerobic reactor retention times (3,6 to 5,8 days) and yields high volatile solids removals with reduced digester gas production. Excessive foaming at temperatures above 50°C requiring lower influent airflow rates may result in insufficiently high reactor temperatures to maintain the digester at mesophilic temperature. Also, the feed sludge to the reactor needs to be sufficiently concentrated so that it does not become substrate limited and therefore sludge pre-thickening should be given serious consideration. A thorough knowledge of the oxygen transfer rate and the oxygen transfer efficiency characteristics of the aeration system is vital as this governs both the biological heat generation rate and the vent gas heat loss rates and therefore the reactor temperature.

It is not considered viable to construct an air dual digester system from scratch. By extending the reactor retention time from, for example, 3 - 5 days to 7 - 8 days, the sludge could be completely stabilised (and pasteurised) in the aerobic reactor and the digester would not be required, that is, the reactor would be designed as an autothermal thermophilic aerobic digester. As an upgrade to an existing anaerobic digester, retention times need to be carefully designed:

- Aerobic reactor:
  1,25 to 1,5 days for pure oxygen
  4 to 6 days for air
- Anaerobic digester:
  12 to 15 days

The ratio between aerobic and anaerobic retention times are therefore 1:10 for pure oxygen and 1:3 for air.

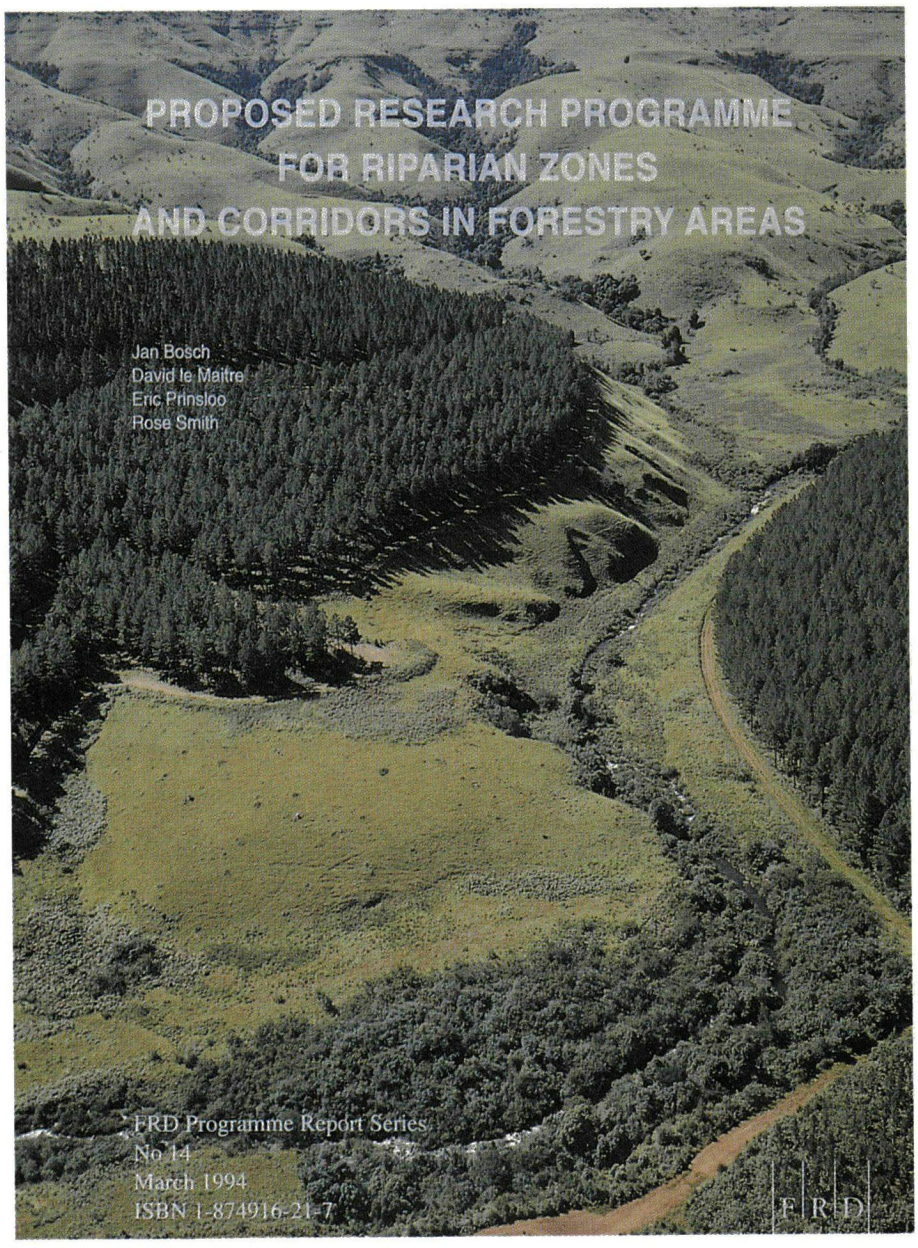
Whilst routine operation of the aerobic reactor under non-foaming conditions is relatively reliable, the occurrence of significant foaming could not be accurately predicted and therefore could not be totally relied upon to provide consistently enhanced performance of the aerobic reactor. With regard to foam level control, positive foam management proved successful by reducing the influent air flow rate to balance the foam production with its collapse. Unfortunately, having to reduce the air flow rate under foaming conditions limits the treatment potential of the aerobic reactor. Excessive foaming can jeopardise the aerobic reactor achieving thermophilic temperatures at the design retention time. One possible foam management scheme which would allow the foam layer to be controlled via the air flow rate without compromising the oxygen requirements of the process, is to supplement pure oxygen into the sludge mixing recirculation stream. This strategy was not tested in this investigation.

Research proposed for riparian zones in forestry

The Foundation for Research Development (FRD) recently published a report which analyses the need for a research programme on the riparian zones in South Africa's forestry areas.

The report summarises a preliminary study carried out in terms of a contract between Forestek (CSIR) and the FRD. The overall aim was to design a research programme to satisfy the need for improved research into, and knowledge of, riparian zone management in forestry areas, and to try to clarify the problems involved.

According to the authors of the report, Jan Bosch, David le Maitre, Eric Prinsloo and Rose Smith, the first step was to review South Affrican and world literature to clarify the role and benefits of riparian and natural open areas in forestry. Secondly a questionnaire was prepared which was distributed to land managers, planners and decision makers and experts at various levels in the major timber companies, provincial conservation bodies and individuals at various research institutions and universities. The questionnaire listed perceived benefits and possible uses of riparian zones.



In the next step, all relevant research organisations and universities were contacted in order to identify and list current research activities in this field and to determine available expertise.

Finally a research strategy was developed to address the three primary needs that were identified, namely:

- ❑ Inventories or surveys aimed at providing a classification, assessing the status of riparian communities and information on baseline water quality.
- ❑ Studies of the functioning of riparian zones, focussing on hydrological and ecological processes and the role of riparian vegetation as a buffer between the adjacent land and the aquatic systems.
- ❑ Improvement of the management of these areas by creating guidelines to help with defining objectives, selecting management options and in making decisions. Another important area for research is to conduct cost/benefit analyses of the different options based on the environmental resource economics methodology.

The researchers say priority should be given to (a) and (c) as these will meet the most urgent requirements, are mainly short-term studies and can be used to direct future research. High priority should also be given to co-ordinating and supplementing the highly fragmented current research work either in forestry riparian areas or relevant to the needs in these areas.

Copies of the report entitled Proposed research programme for riparian zones and corridors in forestry areas (FRD Programme Report Series no 14) can be obtained free of charge from the FRD, PO Box 2600, Pretoria 0001.

EASY-TO-USE TOOLS FOR ORGANIZING YOUR LITERATURE:

BIBLIOGRAPHIC SOFTWARE

If it takes you hours to track down a half-remembered reference, find all the bibliographic details needed for citing a reference or to collate a bibliography in the specific style required for an article or technical report, then it's probably time to investigate the benefits of bibliographic software programs.

There are numerous bibliographic software packages available, each with unique features. Bibliographic software provides the user with two main facilities - firstly, to store, search and retrieve references as most PC based database programs do; secondly, and more important, it provides a means of creating lists of cited works automatically, in several predefined or user-defined formats, without having to retype the references. Most packages will allow these bibliographies to be loaded directly to a word processor document. The more sophisticated packages can interface with a word processor document to allow access to the reference database, so that reference citations can be directly copied into the text of a manuscript while you write.

Standardised input screens simplify the building of reference databases. Provision is made for various document types such as books, journal articles, reports, newspapers, personal communications, conference papers, etc.

There are at least 40 bibliographic software programs available. Selecting an appropriate program from such a large number of possibilities can be difficult. Three programs in particular are highly recommended by the scientific community. These are Pro-Cite from Personal Bibliographic Software Inc, Endnote Plus by Niles and Associates Inc and Reference Manager available from Research Information Systems.

These three programs differ in many respects, eg:

- system requirements eg. Endnote Plus needs 512K RAM and 1Mb hard disk space; Pro-cite requires 640K RAM and 1Mb hard disk space
- total number of references per database eg. Endnote Plus stores up to 32 000, while Pro-cite holds unlimited number of references per database
- number of databases allowed eg. Reference manager only 1 database; both Endnote Plus and Pro-cite allow multiple databases to be created
- definition of publication types eg. Pro-cite provides 20 pre-defined and 6 user-defined forms, whilst Reference Manager has 6 predefined forms and does not provide for user-defined publication types
- number of pre-defined citation styles eg. Pro-cite has 28 standard styles and allows user-defined styles; Endnote Plus comes with 9 predefined styles and unlimited number of user-defined styles.

Pro-cite and Reference Manager are available for both DOS and Windows environments, whilst Endnote Plus is only available for DOS, but with a Windows-like graphics interface.

Bibliographic software packages are dynamic information managing tools that can be a valuable asset to scientists and researchers in the personal organisation of their documents.

Enquiries can be directed to Francette Myburgh, who is a information specialist at the South African Water Information Centre (SAWIC):
Tel (012) 841-3038 or Email:
FMyburgh @ Infoline.CSIR.CO.ZA.

INTEGRATED RIVER BASIN DEVELOPMENT

Report on a conference held at Hydraulics Research, Wallingford UK during September 1994.

This four day conference organised by HR Wallingford and the Institute of Hydrology saw contributions from about 23 different countries, with southern Africa being represented by papers from Namibia, South Africa and Zambia. The papers were grouped into the following topics :

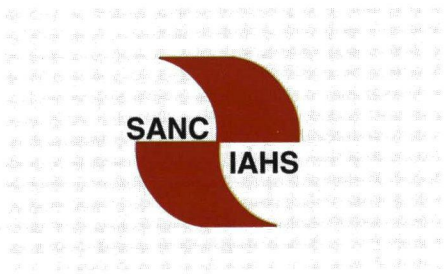
Sustainable Resources
Integrated Quantity and Quality Objectives
Groundwater/Surface Water Interaction
Management of River Flows
Impact of Rural Land Use Change
Erosion and Sedimentation
Impact of Urban and Industrial Development
River Basin Management

It is extremely difficult to summarise a conference of this type in a few paragraphs as the specific issues covered were quite diverse within the overall field of integrated river basin management.

The papers covered topics related to both large and small river systems, planned or proposed management actions as well as reports on the successes and failures of current actions, the details of techniques used to manage integrated river basin development, environmental and social issues as well as economic and engineering issues.

Many of the papers, and even more of the discussions, emphasised the need to consult with all those likely to be affected (Interested and Affected Parties) by developments before the planning process has been completed and implementation is begun. For example, the issue was raised with respect to the control and reduction of flooding in rural Africa as well as to channel rehabilitation and urban river corridor management schemes in UK cities.

Emphasis was also placed on the long tern 'costs' of ignoring the need for an integrated approach to water resource and land use development in river basins. These 'costs' could be measured in terms of the impacts on the natural and social environment as well as on the lack of sustainability of some past developments. Lekan Oyebande (Nigeria) referred to the acute water shortages that resulted from uncoordinated developments in the Niger basin which has led to increasing constraints on the economic growth of the region.



He suggests the need for institutional reforms at national and international levels to promote the integrated approach. Similar sentiments were expressed by other contributors who referred to the fact that the tools to institute integrated basin management are well developed and generally available, but the recognition of the need is not always accepted as a high priority for government support and funding. Craig Woolhouse (UK NRA) discussed the current successes and future opportunities in catchment management planning in the UK and the paper illustrates the level of commitment necessary from a national agency in order that effective, sustainable and acceptable planning can take place.

There were several papers that concentrated on the modelling, simulation and estimation tools available for use in the integrated planning and management of river basins. These varied from stochastic hydrology approaches, through relatively straightforward deterministic approaches for surface water, groundwater or both to more complex approaches and those dealing with water quality, erosion, sediment production and channel sedimentation. Many of the papers followed the growing trend of reporting the use of GIS in modelling studies either as a process to assist in setting up a model or as a full environment in which to operate a model.

Michael Clark and John Gardiner (UK) referred to the need to consider uncertainty in basin planning not just as a products of model simplicity, limited data availability and inadequate measurement resolution. Strategies need to be developed which are not vulnerable to failure due to predictive uncertainty as the costs of such failures are ever increasing. They continue by expressing the need to break down design criteria into 'high-order goals' (sustainability, adaptability, resilience and consensus), 'supporting aims' (reliability, flexibility, robustness and equity) and 'less achievable ideals' (stability, efficiency, inertia and freedom of action).

In general terms there seemed to be a good balance between papers concentrating on general issues of integrated development, specific tools used in planning and management and case studies where integrated approaches have or have not been followed with the concomitant consequences. Regardless of the country of origin (developed or developing, rich or poor) the need for integration of resource use, environmental considerations and social consequences was frequently stressed by authors and participants from the floor. The message must be clear, surely everyone can't be wrong!

The organisation of the conference was excellent, the quality of the presentations generally very good and there was plenty of time for discussion. This short review has certainly not done justice to the range of papers included in the proceedings and anyone interested in this topic is recommended to consult the publication (a hard cover, professionally produced publication from Wiley & Sons) which is well worth obtaining.

D A Hughes
Institute for Water Research
Rhodes University

FROM THE IAHS PRESIDENT

How should professionals in general, and hydrologists in particular, serve society? I have been reflecting upon this issue along my entire professional career, and in the last two years more than ever before. Since I am a member of the Israeli team for the Middle East peace talks, dealing with water, I would like to share some of my experience and views with you.

As scientists our main service to society is in increasing the knowledge and understanding of the world we live in. This knowledge can then be used by engineers to plan, design and operate physical facilities. Scientists and engineers therefore work jointly to craft the basic knowledge into operational tools which are used in building and managing these facilities to meet social needs and goals. The professional knowledge is a necessary foundation for decision making, which in turn is the prerogative and responsibility of the elected officials and the bureaucrats they appoint.

However, there is frequent complaint that professional opinion is not heeded in the decision making process. Only rarely are we given the opportunity to actually participate in it, to bring our expertise into the political arena. I have had such opportunity in the last two years as I participated in the preparations and in the negotiations with the Hashemite Kingdom of Jordan and with the Palestinians, regarding water.

The negotiations took place in Washington, under the auspices of the US and Russia, for almost two years, and now they have been moved to the region itself. The most difficult issues relate to the allocation of waters among the riparians, but this need not be viewed as a "Zero-sum game". Ours is a semi-arid to arid region, and all parties suffer from shortages. These shortages are bound to increase, since we are all using practically the entire natural resource, and the demands are increasing with the size of the population and the standard of living. If there is good will amongst the parties, then professionals can propose creative solutions, which emphasize efficient use of the existing resources and creation of additional waters from conventional sources as well as from new ones, such as desalination and water transfers. The opportunity to convince the authorities that these are the best options resides with the professionals, who must show the hydrological, engineering, economic and environmental feasibility of the proposed schemes.

It is an exciting experience! It has also given me an opportunity to meet hydrologists and water resources managers from the other countries. I hope the talks lead to peace agreements between all parties which will allow professional ties across the borders to be created and strengthened. In the meantime, I have used the meetings to tell these colleagues about IAHS, and encourage them to initiate joint symposia with Israeli hydrologists on topics which are of special interest in our region. I am looking forward to the day, hopefully soon, when we will have the first joint regional IAHS symposium in the Middle East.

Uri Shamir
(From IAHS Newsletter)

ANYBODY GOING TO THE BOULDER ASSEMBLY?

The IUGG General Assembly and the IAHS Symposia are to be in Boulder, USA, 3-14 July 1995. I would like to hear from any SANCIAHS member who plans to attend. We are looking for delegates that can represent South Africa in voting for Committee members.

Hugo Maaren
E-mail: Hugo@wrc.ccwr.ac.za

SPLASH:
Newsletter for the SADC Environmental and Land Management Sector

Splash is a newsletter published three times per year by the SADC Environment and Land Management Sector Coordination Unit. Its editorial policy is to provide space for an open and free exchange of experience and ideas relating to land and water management and related environmental issues.

Articles published in Splash appear under each author's responsibility. The views expressed are not necessarily those of the Coordination Unit or of the Governments of SADC member States. However, the editorial on page 1 is the collective responsibility of the Coordination Unit.

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Ministry of Agriculture
P O Box 24
Maseru 100
Lesotho

Telephone: (266) 322158
Telex: (963) 4414 SADCC LO
Fax: (266) 310190

I would recommend our hydrologists who have an interest in the water resources of southern Africa to contact the editor of Splash.

Hugo Maaren

MINIMUM REQUIREMENTS FOR WASTE MANAGEMENT ANNOUNCED

The Minister of Water Affairs and Forestry, Professor Kadar Asmal, recently launched the long awaited documents regarding MINIMUM REQUIREMENTS FOR WASTE MANAGEMENT. These documents will provide the necessary framework for waste disposal by landfill, as well as the handling and disposal of hazardous waste and monitoring at waste management facilities. The following is a brief summary of the documents.

MINIMUM REQUIREMENTS FOR WASTE DISPOSAL BY LANDFILL

The document adopts the Best Practical Environmental Option (BPEO) to provide affordable environmental protection to both the environment and man. This is achieved by the use of graded requirements based on a unique landfill classification system of both proposed and existing landfills, which takes advantage of local climatic and site specific circumstances. All applicable Minimum Requirements are based on the classification.

This document addresses the full spectrum of landfills in South Africa. This includes proposed landfills, permitted operated landfills, unpermitted operated landfills and closed or abandoned landfills.

The document addresses the landfill development process. This commences with the identification of a disposal need and the classification of a site and is followed by a landfill site selection, investigation, design, preparation, operation, rehabilitation, closure and monitoring.

The document provides information of the permitting procedures as the Landfill Permit System, instituted in terms of the Environment Conservation Act (Act No. 73 of 1989), which is mandatory. In accordance with the Integrated Environmental Management approach, adopted throughout, the document is set for involving the public and the Interested and Affected Parties in determining site feasibility and end use requirements of landfill site.

It is anticipated that the requirements will evolve with changing knowledge, expertise, political, social and economical circumstances in the New South Africa.

MINIMUM REQUIREMENTS FOR MONITORING AT WASTE MANAGEMENT FACILITIES

Ground water is a strategic resource which must be protected in view of the limited water resources in South Africa. This document has become necessary in view of deteriorating ground water quality at many waste management facilities in this country. Protection of water resources requires systematic and organised monitoring.

This document is an attempt to:

- ❑ standardise monitoring procedures;
- ❑ provide information for monitoring systems design; and
- ❑ provide mechanisms for communication on monitoring data between waste management companies and authorities.

In this document, procedures to be followed are recommended and are appropriate to the unique nature of the South African situation. Throughout the document, the emphasis is on what could reasonably be achieved, without compromising on information that would lead to early detection of water pollution.

Implementation of the minimum monitoring requirements is possible under existing legislation. Reporting could also be done through existing mechanisms, such as the Environmental Management Programme Report (EMPR) in the case of the mining industry.

Appeal against compliance with the minimum monitoring requirements based on sufficient motivation, will be considered in instances of special merit.

The National Ground Water Quality Strategy which is currently under development by DWAF will also be taken into account in the formulation of the revised edition.

MINIMUM REQUIREMENTS FOR HANDLING AND DISPOSAL OF HAZARDOUS WASTE

Hazardous waste is waste which due to its toxicity, chemical and physical properties and environmental fate, which required stringent technical control so as no to cause harm to man or the environment. In this document the Department endeavours to ensure a policy of safe and efficient handling, treatment and disposal of hazardous waste in South Africa.

The Minimum Requirements incorporate an Integrated Waste Management Approach, in which waste management is carefully planned in advance, and an Integrated Environmental Management (IEM) approach, by which environmental considerations are integrated in all stages of waste management procedures.

The classification system is an United Nations based system, the International Maritime Dangerous Goods Code which has been incorporated into the SABS Code 0228 and which groups or lists chemical substances in nine classes, described according to chemical and physical definitions.

Wastes are further classified in categories of risk based on the degree of hazardousness. The degree of hazardousness is acquired by extending the definition of Class 6, Toxic and Infectious Substances, to include ecotoxicity and environmental fate parameters as well as human acute and chronic toxicity (including carcinogenicity, mutagenicity and teratogenicity).

The concentration of compounds in wastes, together with the assimilation capacity of sites (total load principal), is taken into account by calculation of the Estimated Environmental Concentration (EEC) from environmental impact (entering into the environment), transport (mobility) and transformation (persistence) data.

The class and degree of hazardousness of the waste is used to determine the level of control or the minimum requirements needed to ensure the safe disposal of that waste. The principle of appeal in matters where a difference of opinion may arise is accepted, but the burden of proof in such cases will rest with the petitioner.

The document provides a guide to appropriate requirements and legal procedures for legislators, local authorities, generators of hazardous waste, managers of hazardous waste disposal and hazardous waste transport companies, and all Interested and Affected Parties.

Enquiries: Mrs Wilna Moolman:
Tel. (012) 299-2474

Waste site assesment: workshops planned

A series of half day workshops are being planned for February 1995 in which the new WASP method for groundwater impact assessment at waste sites will be discussed.

Groundwater resources are often at greatest risk from waste disposal activities, because they are not visible or easily understood. For this reason the Water Research Commission decided to fund a research project into the development of a methodology suitable for South African conditions, which aids in deciding whether a waste site is suitable in terms of its potential impact on groundwater resources.

The project was carried out by Roger Parsons of the Division of Water Technology (CSIR) and Jeff Jolly currently from Groundwater Consulting Services.

Initially the researchers investigated all known methods used world-wide to assess waste site suitability and a system applicable to South African conditions evolved from the existing methods. The system assesses the threat and risk of groundwater resources being polluted by a waste site, ultimately ending with an evaluation of the suitability of the site. The method adheres to the principle that waste and aquifers must be separated - WASP (Waste - Aquifer Separation Principle).

The project has now been completed and the Water Research Commission would like the results of the investigation to reach as wide an audience as possible. A series of half day workshops will therefore be held in February 1995 to explain the method and the WASP principle to all interested parties. The workshops are planned to take place throughout the country as follows:

- Cape Town – 15 February 1995
- Port Elizabeth – 20 February 1995
- Bloemfontein – 21 February 1995
- Johannesburg – 22 February 1995
- Pretoria – 23 February 1995
- Durban – 24 February 1995

Cost for the workshop will be R100 which will include the manuals and computer program plus snacks and drinks after the workshop. The workshops will be restricted to the first 25 applicants per venue. Anyone wishing to attend a workshop, please contact Jeff Jolly at Groundwater Consulting Services in Cape Town (tel (012) 794-7997 or fax (012) 794-2823) for further details.

SA WATERKALENDER

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

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

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

Legend:

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

See conferences and symposia pages for events.

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

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

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

Gids:

- ❍ Een SA Watergeleentheid vir hierdie dae.
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1995

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SOUTHERN AFRICA 1995

WATER MICROBIOLOGY
FEBRUARY 14 - 17

Introductory course. For more information contact Gerrit Idema at Water Technology, CSIR. Tel (012) 841-3948. Fax (012) 841-4785.

WASTE SITE ASSESSMENT
FEBRUARY 15 - 24

A series of half day workshops are planned to take place throughout South Africa. See announcement on page 27.

GROUNDWATER MODELLING
FEBRUARY 27 - MARCH 3

The Institute for Groundwater Studies presents a short course in groundwater modelling. See advertisement on page 32.

GROUNDWATER
APRIL 3 - 7

The Centennial Conference of the Geological Society of South Africa will be held in Johannesburg. See announcement on page 30. Enquiries: Tel & Fax (012) 47 3398.

SAICE
APRIL 11 - 13

The 1995 SAICE congress will be held in Port Elizabeth at the historic Feather Market Centre. Enquiries: Adriaan van Eeden at telephone (041) 55-8741 or write to the Organising Committee, PO Box 23903, Port Elizabeth 6000.

BESPROEIING
MEI 10 - 12

Die tweejaarlikse kongres van die Suid-Afrikaanse Besproeiingsinstituut sal in Port Elizabeth gehou word. Sien advertensie op bladsy 31.

RIVER MANAGEMENT
MAY 14 - 19 1995

The IAWQ conference on river basin management for sustainable development will be held in the Kruger National Park.
Enquiries: Dr Ben van Vliet, Watertech, CSIR. Tel (012) 841-2237 Fax (012) 841-4785.

RESOURCE MODELLING
JULY 5 - 10

The '95 world conference on natural resource modelling will be held at the University of Natal in Pietermaritzburg.
Enquiries: Professor John Hearne, Department of Applied Mathematics, University of Natal, Private Bag X01, Pietermaritzburg 3209. Fax: (0331) 260 5599 Tel: (0331) 260 5626.

HYDROLOGY
SEPTEMBER 4 - 6

The 7th national southern African hydrological symposium will be held in Grahamstown.
Enquiries: Prof Denis Hughes, Institute for Water Research, Rhodes University, Grahamstown 6140. Tel (0461) 24014 Fax (0461) 25049. E-mail: Denis @ iwr.ru.ac.za.

IWSA
SEPTEMBER 9 - 15

The 20th biennial congress and exhibition of IWSA will be held in Durban.
Enquiries: Mrs Ginny Eslick, IWSA Congress International, 18 Rapson Road, Morningside, Durban 4001. Tel (031) 233 494. Fax (031) 232 405.

GROUNDWATER
SEPTEMBER 25 - 27

A conference and exposition on groundwater recharge and rural water supply - Groundwater '95 - will be held at the Volkswagen Conference Centre in Midrand.
Enquiries: Conference Co-ordinator, Groundwater Division, GSSA, PO Box 75728, Lynnwood Ridge 0040. See page 2 of this Bulletin

OVERSEAS 1995

WASTE MANAGEMENT
FEBRUARY 1995

The third conference on appropriate waste management technologies for developing countries will be held in Nagpur, India
Enquiries: Professor P Khanna, Indian Association for Environmental Management, NEERI, Nehru Marg, Nagpur 440020, India.

WATER RESOURCES
MARCH 12 - 16

A symposium on water resources management in arid countries will be held in Muscat, Oman.
Enquiries: Acting Director General, Water Resources Management, Ministry of Water Resources, PO Box 2575, Ruwi 112 Oman.

HYDRO-SCIENCE
MARCH 22 - 26

The second international conference on hydro-science and engineering will be held Beijing, People's Republic of China.
Enquiries: Mr Tan Ying, ICHE '95, IRTCES, PO Box 336, Beijing 100044, People's Republic of China.

AWWA
APRIL 2 - 6

The Australian Water and Wastewater Association's 16th Federal Convention will be held in the Convention Centre at Darling Harbour, Sydney, Australia. Enquiries: The Secretariat, PO Box 388, Artarmon, NSW 2064, Australia. Tel +61 2 413 1288. Fax +61 2 413 1047.

MICRO-IRRIGATION
APRIL 2 - 6

An international micro-irrigation congress entitled "Micro- irrigation for a changing world: conserving resources; preserving the environment" will be held in Orlando, Florida, USA.
Enquiries: Allen Samajstria, University of Florida, Agr. Eng. Department, Gainesville FL 32611, USA. Tel (904) 392-9295. Fax (904) 392-4092.

WATER TREATMENT
MAY 15 - 17

An IWSA specialised conference on advanced water treatment and integrated water system management into the 21st century will be held in Osaka, Japan.
Enquiries: Water Osaka '95, c/o Osaka Municipal Water Works Bureau, 6-28 Minami-ogimachi, Kita-ku, Osaka 530, Japan. Tel 06 (363) 7301. Fax 06 (363) 7362.

GROUNDWATER QUALITY
MAY 15 - 18

An international conference on groundwater quality: remediation and protection (GQ 95) will be held in Prague, Czech Republic.
Enquiries: Conference Secretariat GQ 95, c/o Guarant, Opletalova 15, 110 00 Prague 1, Czech Republic. Tel +42 2 2421 0650 or 2421 0735 Fax +42 2 260 130.

OZONE
MAY 15 - 19

The 12th Ozone World congress will be held in Lille, France.
Enquiries: Mme Michele Rizet, IOA International Coordinator, c/o Societe des Eaux du Nord, 217 blvd. de la Liberte Lille, B.P. 329, 59020 Lille CEDEX, France. Tel 33-2049 4000. Fax 33-2049 4052.

COASTAL ENVIRONMENT
JUNE 13 - 15

The Black Sea regional conference on "Environment protection technologies for coastal areas" will be held at the International House of Scientists, St Constantine Resort in Varna, Bulgaria.
Enquiries: IAWQ - Bulgarian National Committee, c/o USB - Mrs TS Angelova, Oborishte St 35, Sofia 1504, Bulgaria. Tel (+359-2) 43 01 28, 44 11 57. Fax (+359-2) 44 15 90.

ENVITEC
JUNE 19 - 23

The international trade fair for Environmental Protection and Waste Management Technologies will be held in Düsseldorf, Germany.
Enquiries: Messe Düsseldorf, Postfach 10 10 06, D-40001 Düsseldorf. Tel (0211) 45 6001. Fax: (0211) 45 60668.

RAINWATER
JUNE 19 - 25

The 7th international conference of the International Rainwater Catchment Systems Association will be held in Beijing, China.
Enquiries: Dr Mou Haisheng, Dept of Hydrology, Institute of Geography, CAS, Building 917, Datun Road, Anwai, Beijing 100101, PR China. Tel (86) 1 4914289. Fax (86) 1 4911844.

CONTAMINANTS IN WATER
JUNE 29 - 30

A conference on hazard assessment and control of environmental contaminants in water will be held in Copenhagen, Denmark.
Enquiries: Dr Niels Nyholm, Laboratory of Environmental Sciences and Ecology, Building 224, Technical University of Denmark, DK-2800 Lyngby, Denmark.

POLLUTION EVENTS
JULY 24 - 26

An inter-disciplinary symposium on uncertainty, risk and transient pollution events - Acute Risk to the Aquatic Environment will be held in Exeter, UK.
Enquiries: Dr JD Boyle, School of Engineering, University of Exeter, North Park Road, Exeter EX4 4QF, UK.

DIFFUSE POLLUTION
AUGUST 14 - 18

A symposium on diffuse (non-point) pollution will be held in Prague, Czech Republic.
Enquiries: Ing Vladimir Chour, Hydroprojekt AS, Taborska 31, CZ 140 43 Praha 4, Czech Republic.

SEWER SOLIDS
SEPTEMBER 6 - 8

A seminar on sewer solids - characteristics, movements, effects and control will be held in Dundee, Scotland, UK.
Enquiries: Maureen Golden, WWTC, University of Abertay Dundee, Bell St, Dundee, DD1 1HG, UK.

WATER MANAGEMENT
SEPTEMBER 26 - 30

A symposium on integrated water management in urban areas will be held in Lund, Sweden.
Enquiries: Dr Janusz Niemczynowicz, Dept of Water Resources Engineering, University of Lund, PO Box 118, S-221 00 Lund, Sweden.

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. Call for papers. Deadline for submissions December 16, 1994.
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 Sannnomaru, Mito, Ibaraki 310, Japan. Tel +81-292-24-6905 Fax +81-292-33-2351.

CENTENNIAL GEOCONGRESS

South Africa - Land of Geological Superlatives

JOHANNESBURG 3 - 7 APRIL 1995

In celebrating the centenary of the Geological Society of South Africa, which was founded on the 4th of February 1895 at the Chamber of Mines in Johannesburg, this congress will aim to:

- Review the past 100 years of geology in South Africa, Africa and the world in general;
- Expose delegates to the expertise and knowledge of top international experts in the various earth-science disciplines;
- Promote productive professional relationships, joint programmes and the exchange of ideas.
- Offer excursions covering the entire geological record and geographic region of Southern Africa.

Enquiries:
The Congress Organiser, Centennial Geocongress,
PO Box 36815, Menlo Park 0102. Tel/Fax (012) 47 3398.

Die Suid-Afrikaanse Besproeiingsinstituut kondig met genoeë aan

DIE 1995 TWEEJAARLIKSE SABI KONGRES

10 - 12 Mei 1995

Die Edward Hotel, Port Elizabeth

TEMA

Verantwoordelike ontwikkeling, bestuur en bedryf van besproeiingstelsels.

- ❑ Wat is ons probleme?
- ❑ Het ons die oplossings?
- ❑ Oor die hele spektrum?
- ❑ Hoëtegnologie.

FORMAAT

Dag 1 - Inleiding (middag)

Dag 2 - Beplanninng, ontwerp en produkpromosie (voldag)

Dag 3 - Bestuur, bedryf en opsomming (Oggend)

KOSTE

Registrasie: R250 per persoon
Laat registrasie (na 1 Maart 1995): R400
(Hierdie tariewe mag dalk effens verander.)

Voorlopige akkomodasiekoste by die Edward Hotel (nie verpligtend, maar verkieslik)
Gedeelde kamer: R100 per persoon per dag (ontbyt ingesluit)
Enkelkamer: R160 per persoon per dag (ontbyt ingesluit)

NAVRAE

Die Suid-Afrikaanse Besproeiingsinstituut,
Oos-Kaaptak, Privaatsak X27592,
Greenacres 6057.
Tel (041) 331284.
Faks (041) 331583.

The Institude for Groundwater Studies
presents
A Short Course in Groundwater Modelling

Flow and Mass Transport
by
Wolfgang Kinzelbach

The course will be presented by Prof Dr Kinzelbach, internationally acclaimed groundwater remediation specialist
The following topics will be discussed

- 2D and 3D Groundwater Flow and Transport Modelling
- Reactive Chemistry
- Risk Analysis

The theoretical aspects of the course will be applied to case studies during ample computer sessions
Each participant will receive comprehensive documentation and all the computer programs used in the duration of the course

Venue	University of the Orange Free State
Date	27 February to 3 March 1995
Course fees	R 2 500
Contact	Gerrit van Tonder
Telephone	051-4012840
Fax	051-473541
e-Mail	gerrit@igs.usvo.ac.za