THE WATER WHEEL

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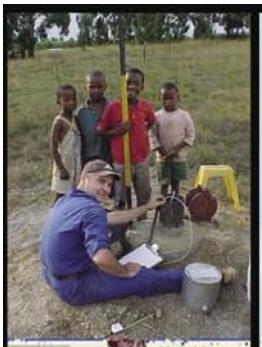
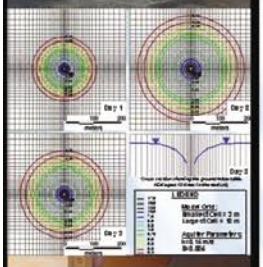
KEEPING SA'S DRINKING WATER SAFE









JMA (Jasper Müller Associates) was founded on 1 October 1988, as a 1 man Professional Practice, specializing in environmental geohydrology. It has since grown into one of the biggest geohydrological specialist firms in South Africa, and currently employs 17 people, 9 of which are professionally qualified, and registered, earth and environmental scientists with SACNASP.

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A word from the editor

Who's our Typhoid Mary?

For those who've never heard of her, Mary Mallon or Typhoid Mary was an Irish immigrant who was the first known healthy carrier of typhoid fever in the US.

She was first recognised as a carrier of the typhoid bacteria during an epidemic of typhoid fever in 1904 that spread through Oyster Bay, New York where she worked as a cook. Although she always vehemently denied being a carrier of the disease, 51 direct cases of typhoid fever and at least three deaths were directly attributed to her, and she was eventually confined to quarantine for life.

While the rest of the world is mopping up in the wake of some of the most powerful tropical storms in history, South Africa has to deal with its own 'Typhoid Marys', those in our local authorities who cause death and destruction while denying that anything is amiss as they sit in their cushy office chairs.

The reality, however, tells a different story. The small town of Delmas, in Mpumalanga, is still reeling after at least five deaths and more than 600 cases of typhoid and 3 300 cases of diarrhoea were diagnosed due to contaminated groundwater. In the same province, Chrissiesmeer made headlines when *E. coli* was found in one of the town's reservoirs, while trout farms in Dullstroom are losing business over sewage streaming into their dams from the dilapidated municipal system.

The problems are not bound to small towns. In Cape Town, concern has been expressed over the apparent overload of the city's wastewater treatment infrastructure, with one official quoted as saying many of the municipality's sewage treatment plants were "on the verge of collapse."

A water tank stands in front of the Delmas Local Municipality during the recent typhoid outbreak.

And while New Orleans and Texas could blame Mother Nature for their disasters there is no excuse for what is happening in our municipalities. The 'lack of capacity' mantra has become an easy utterance in defence of the appointment of seemingly incompetent, uncaring political allies.

It was back in March when the Department of Water Affairs & Forestry (DWAF) completed an assessment of drinking water quality in several of the country's municipal areas. It was found that a staggering 63% of Water Services Authorities (WSAs) in the country do not comply with set criteria for acceptable drinking water quality management. This includes not delivering water of an ideal or good quality and not regularly monitoring drinking water quality.

Provinces with the worst drinking water quality performance were found to be Eastern Cape, KwaZulu-Natal, Limpopo, Mpumalanga, Northern Cape and North West, who are all performing below the national average. In fact, in the two worst performing provinces, KwaZulu-Natal and North West, only 43% of WSAs have the perception that they comply to drinking water quality, while only 50% and 57% of the WSAs in the respective provinces actually monitoring the quality of their drinking water. This means that the actual figure could be much worse.

Following the destruction of Hurricane Katrina, the US Department of Health and Human Service (HHS) waived the standard eligibility and enrolment requirements that beneficiaries of government benefits must meet. "No one who has been a victim of this disaster should be prevented from getting benefits they need because of government red tape," said HHS Secretary Michael Levitt in announcing the waiver.

Let us not wait for another disaster before we deem it fit to cut the red tape and assist the communities whose lives depend on our actions.

Letter to the editor

Baseflow and groundwater

Congratulations on your latest edition of *the Water Wheel*. I look forward to this publication landing on my desk as it is full of interesting information. The September/October 2005 issue was no exception, particularly because of the focus on groundwater. However, I must take exception to the definition of baseflow presented in the article "*Groundwater - more valuable than gold*" (Water Kidz, page 28). As we try to get a better understanding of the interaction between surface and groundwater, it has emerged that scientists looking at different components of the hydrological system use and understanding terms differently.

This obviously leads to a high degree of misunderstanding and confusion. The term *baseflow* is a non-process related term for sustained low flow in a river during dry or fair weather periods (i.e. low amplitude, high frequency flow events). Baseflow is not a measure of the volume of groundwater discharged into a river or wetland, but it is recognised groundwater contributes to this component of river flow.

When we want to describe the groundwater component of river flow, the term groundwater contribution to flow or groundwater contribution to baseflow is appropriate. While I understand the tone and pitch of your article, it is crucial we don't perpetuate myths and misunderstandings; and we ensure both specialists and non-specialists use terminology correctly. Any of your readers interested in this topic may want to read WRC publication TT 218/03 entitled "*Surface water - groundwater interaction in a South African context: a geohydrological perspective*".

Roger Parsons,
Parsons and Associates Specialist Groundwater Consultants

Water Users Might Pay for Alien Removal

Water users might soon be contributing to the removal of invasive alien plants. *The Water Wheel* has learnt that the Department of Water Affairs & Forestry has started a strategic level investigation into the feasibility and viability of implementing a user charge, possibly as a component of the water resource management charge, to cover the cost of clearing invasive plants primarily in the mountain catchment areas and riparian areas of the country.

About 750 tree and 8 000 introduced to South Africa species are regarded as wattle, and eucalyptus spe- water resources; reduce intensify flooding and fires; rivers, siltation of dams, quality while threatening

other plant species have been over the years. About 200 invasive, including certain pine, cies. These alien plants waste the country's ability to farm; cause erosion, destruction of and estuaries, and poor water indigenous plants and animals.

It has been estimated that species in South Africa is more than the current premier alien busting Thus it is hoped to develop users to contribute to the

to remove all the invasive alien will cost R1,6-billion, which annual budget of the country's programme, Working for Water. a fair mechanism to get water control of the problem.

According to James Cullis of Ninham Shand, who is undertaking studies into the impact on invasive alien plants as part of this investigation, these non-riparian alien plants in the high mean annual precipitation catchments of South Africa are estimated to have a sizeable impact on the total yield of the country, particularly in terms of the yield from major dams and run-of-river estimates. If the spread of this vegetation is not managed and a state of full invasion is reached, the yield of major dams could be reduced by some 4% (511 million cubic metres a year) and the average run-of-river yield by 8,6% (875 million cubic metres a year). This is quite significant for a country where every drop counts.

In turn, the impact of riparian invasive alien plants is estimated to be highly significant. The estimated current level is 523 million cubic metres a year, and this is predicted to become as high as 1 314 million cubic metres a year if allowed to reach a fully invaded future scenario. This total combined impact on yield due to riparian invasive alien plants in all catchments and non-riparian plants in the mountain catchment areas represents 4% of the current total volume of currently registered water use in the country. If not controlled this could increase to 16%.

International Call for Proposals

The International Foundation for Science has called for research proposals in the field of sustainable sanitation and greywater reuse.

Supported by the Swedish International Cooperation Agency (SIDA), the initiative is aimed at strengthening scientific capacity in the fields of sustainable sanitation and greywater reuse in developing countries.

Research grants are awarded up to a maximum value of US$12 000 or one to three years. The deadline for applications is 31 December. *For more information visit* www.ifs.se/Programme/ifs_sida_specialcall.asp

Project Hopes to Guide Greywater Users

The Water Research Commission (WRC) has launched a new project to develop guidelines for the sustainable use of greywater in small-scale agriculture and community gardens.

Household and food gardens have significant potential to contribute to food security; however, a shortage of water to supplement rainfall remains an impediment in many areas in South Africa. Greywater, the untreated household effluent from baths, wash basins, and laundry, can be a valuable addition.

A scoping study to evaluate the fitness-for-use of greywater in urban and peri-urban agriculture, which is being undertaken for the WRC at present, indicates that much is already known locally and internationally about the positive and negative impacts of greywater use. However, there appears to be great uncertainty among local authorities on what their approach to greywater use should be.

Bylaws to regulate greywater use are either confusing or do not exist. Furthermore, there appears to be a lack of guidance to potential users about the potential impacts of greywater use in small-scale agriculture and gardens.

The WRC-funded project hopes to address some of these issues through the development of appropriate guidelines.

Girls Must Come First

Key international female leaders have called for more attention and funds to help the millions of African women and girls suffering disproportionately for lack of basic water and sanitation.

"Unsafe water, inadequate sanitation and poor hygiene habits play a major role in child mortality," said UNICEF executive director Ann Veneman. "Bringing basic services to Africa's women and girls could transform their lives and boost child survival in the region." She was joined in her plea by other leaders in development, including Hilde Frafjord Johnson, Norway's Minister for International Development, and Maria Mutagamba, Uganda's Minister of Water.

In rural Africa, 19% of women spend more than an hour on each trip to fetch water, an exhausting and often dangerous chore that robs them of the chance to work and learn. Women without toilets are forced to defecate in the open, risking their dignity and personal safety. Education suffers too: more than half of all girls who drop out of primary school do so for lack of separate toilets and easy access to safe water.

Water Restriction Relief For Cape Town

Capetonians are sighing huge sighs of relief following the ease of the stringent water restrictions put in place last year.

Water restrictions have been reduced from 20% to 5% after the City met its savings targets and the area saw more winter rain. Water tariffs have also been lowered.

Meanwhile, the municipality has announced a number of initiatives to reduce water demand as well as to plan for future water supply schemes. These include an integrated water leaks project to be introduced throughout the city following a pilot project in M'fuleni; as well as an effluent re-use scheme from the Potsdam Wastewater Treatment Plant. This scheme will ultimately supply some 38 Ml per day of treated effluent for industrial use and irrigation.

At 83% full Theewaterskloof Dam is looking much better than it did a year ago.

Water by Numbers

- **R1-billion** – The value of concessionary funding made available to eligible municipalities by the Development Bank of Southern Africa over the next three years as part of its new targeted infrastructure programme. The aim is to redress the persistent backlogs in service delivery.
- **R13,8%** – The percentage that the average price of water increased in South Africa in the year to July. This is the second-biggest increase in the world, according to an international report.
- **840-million** – The estimated number of people that do not have access to sufficient, nutritious and safe food in the world. This is 13% of the world population. About 95% of these vulnerable people live in sub-Saharan Africa.
- **R30-million** – The funds set aside for research in the Limpopo Basin by the Challenge Programme on Water and Food. Research projects are being undertaken under the themes crop water productivity improvement; multiple use of upper catchments; aquatic ecosystems and fisheries; integrated basin water-management systems; and global and national food and water systems.
- **746 m³** – The quantity of water storage per person in South Africa. In North America, the quantity of water storage per person is about 6 150 m³.
- **22%** – The percentage of the population of Ethiopia that has access to safe water. This is the lowest in Africa. Ethiopia also has the least number of people that have access to safe sanitation on the continent – only 6% of the total population.
- **87** – The number of municipalities that do not have access to in-house engineers, according to Minister of Water Affairs & Forestry Buyelwa Sonjica.
- **121 km** – The length of the new raw water pipeline to be constructed under the Vaal River Eastern Subsystem Augmentation Project. The pipeline will pump about 160 million m³ a year from the Vaal Dam to the Knoppiesfontein diversion structure, in Secunda, mostly for use by Eskom and Sasol.

New Boost for Science In Africa

Lack of quality science education, severe shortages of basic services, HIV/Aids, disaster management and desertification are only some of the focus areas of the newly-established African office of the International Council for Science (ICSU).

ICSU is a non-governmental organisation which, through its international network, plans and coordinates interdisciplinary research to address major issues of relevance to science and society.

The African office, the first of four planned regional offices, will facilitate capacity building, including quality science education, training and research. Core objectives are to facilitate networks within Africa and increase participation of African scientists in international programmes.

"The regional office will facilitate the mobility of African scientists within the continent, including the creation of regional and interdisciplinary scientific programmes, conferences and exchanges across the continent, said Prof Sospeter Muhongo, director of ICSU-Africa at the launch earlier this year. The office is based at the National Research Foundation in Pretoria.

Drostdy Builds Best Water Network

The Hoër Tegniese Skool Drostdy from Worcester, in the Western Cape, walked away with this year's first prize in the Rand Water-South African Institution of Civil Engineering Centenary Schools Water Competition.

The competition, which was launched in 2003 when both organisations celebrated a hundred years of existence, draws entries from across the country. Learners are tasked to design a model water distribution network to distribute water equally between three points using two different pipe diameters. They are then judged on how well they execute the task. They are allowed three tries in one hour.

The learners from John Ross College, in Richards Bay came second, followed by the learners from Umqhele Comprehensive School in Ivory Park, in third place.

Nomzama Ntuli of Rand Water with the winning team of Hoër Tegniese Skool Drostdy, Elizma Syphys, Annelie van Zyl, Gerhard Paxton and Isak Bosman. Organiser Johan Burger is standing behind.

Water Diary

KNOWLEDGE MANAGEMENT
NOVEMBER 21-23
An International Conference on Indigenous Knowledge Systems in Africa and their relevance for Sustainable Development will be held at the University of Brussels. *Enquiries: Prof Emmanuel Boon, Tel: +32 2 477 49 35; E-mail: eboon@vib.ac.be*

INFRASTRUCTURE
NOVEMBER 22-25
The First African Infrastructure Congress 2005 will be held at the Sandton Convention Centre, in Johannesburg. Sessions will address infrastructural opportunities, risk perceptions throughout Africa and appropriate financing tools, among others.
Web: www.terrapinn.com

DESERTIFICATION
NOVEMBER 22-24
The UNESCO Chair of Desertification, Sudan, is organising a regional workshop on combating desertification, to take place in Khartoum. *Enquiries: Mubarak Abdallah, E-mail: mubarakaba@yahoo.com*

WATER MANAGEMENT
NOVEMBER 29-DECEMBER 2
The Pan-African Water 2005 Conference will be held at the Sandton Convention Centre, in Johannesburg. *Web: www.terrapinn.com*

ENVIRONMENTAL WATER QUALITY
NOVEMBER 30 – DECEMBER 2
The Fifth training course on environmental water quality in water resource management will be held in Randburg, Johannesburg. *Enquiries: Pieter van Eeden, Tel: (011) 972-5298; Fax: (011) 972-5298; E-mail: Pieter.vaneeden@absamail.co.za*

WATER RESOURCES
DECEMBER 26
The First International Conference on Water Resources in the 21st Century will take place in Alexadria, Egypt. This conference will present the more recent technological and scientific developments associated with the management of surface and groundwater resources. *Enquiries: E-mail: ewra2005@ewra.com; Web: www.ewra.com/pages2005/contents.htm*

WATER AND FOOD
JANUARY 23-26
CGIAR is organising a working conference on Enhancing Equitable Livelihood Benefits of Dams Using Decision Support Systems, to be held in Nazareth, Ethiopia.
E-mail: damdss@cgiar.org; Visit: www.waterforfood.org/livelihoods/

GROUNDWATER
FEBRUARY 1-4
An international conference on groundwater for sustainable development will take place in New Delhi, India. *Enquiries: Dr M Thangarajan, E-mail: mthangarajan@hotmail.com or mthangarajan@eth.net*

Shattering Prevailing Capacity Myths

WRC research manager Heather MacKay

Water sector professionals need to let go of prevailing myths with regards to capacity, and face up to the new reality. So said Dr Heather MacKay, outgoing research manager at the Water Research Commission at the Second Water Colloquium held at the CSIR in September.

DBSA institution specialist Jan Koster

According to MacKay, one of the prevailing myths in the industry is that the country does not have enough technical and scientific capacity to implement water policy and provide basic services. "The reality is that we are short of capacity in certain key areas or disciplines, but not across the board. However, it is true that where a lack of experienced professionals does exist, it can cause bottlenecks in the implementation process which makes it seem that there are skills shortages everywhere."

Another prevailing myth is that South Africa cannot retain skilled, experienced water professionals. This is true to an extent, noted MacKay, but only for the public sector. "The new reality is that in many technical fields most professional capacity is located outside the public sector, while the government is still responsible for service delivery. Therefore, we need to look at innovative procurement processes and ways to manage these highly skilled mobile individuals."

The point was emphasised by Jan Koster, principle institution specialist at the Development Bank of Southern Africa, who noted that an estimated 74 municipalities did not employ any technical expertise. "Training does not equal capacity building as many believe," he said. "For true capacity building to exist there also needs to be an enabling environment (including the necessary processes and systems support) in addition to the training."

Koster encouraged municipalities to approach policy implementation in a structured, planned way, rather than the present *ad hoc* initiatives and crisis management that are being undertaken in many local authorities at present.

Call for papers

Interested parties have until 25 December to enter their submissions for the International Water Association Specialist Conference on Sustainable Sludge Management: State of the Art, Challenges and Perspectives.

The conference will be held at the Crocus Expo Centre, in Moscow, Russia, on 29-31 May, 2006.

Sludge management remains one of the most critical environmental issues of today. The purpose of the conference is to discuss sustainable strategies for sludge management, mainly focusing on reusing and recycling options.

For more information, Tel/Fax: +7 095 101 4621; E-mail: IWAconference@sibico.com; *Visit:* http://IWAsludge.sibico.com

Opportunity for post-graduate research

There is an opportunity for research towards a PhD or at Post-doctoral level for a hydrologist at the Institute of Water Research, Rhodes University.

The successful applicant will work in the field of environmental flows in non-perennial rivers in South Africa. Much of south-western Africa is arid or semi-arid and the ecosystems are fragile. However, any human habitation or development depends on there being water available and so the competition for this scarce resource can become critical. This interesting area of work is important for the sustainable management of the environment and development in these semi-arid and arid regions.

Enquiries: Prof Denis Hughes, Address: Institute of Water Research, Rhodes University, PO Box 94, Grahamstown, 6140, E-mail: denis@iwr.ru.ac.za

Capetonian's Dying Garden Wins Him National Prize

When his garden started dying due to the strict water restrictions imposed by the City of Cape Town last year, Mark Joubert was not willing to give up without a fight. But his new innovation is not only helping to sustain some greenery around his house. It also won him a prize at the Design's Institute's 2005 Prototype Awards.

The Garden Res-Q unit uses greywater from a home bathroom to irrigate a small to medium-sized garden. The irrigation process takes place immediately once the shower is switched on or the bath is emptied, without the need to first store greywater in large tanks. In addition, the irrigation process is completely automated and, as such, requires no intervention by the home owner.

The unit is connected directly to the outside drain pipes of an existing bath or shower where the greywater is filtered of hair and lint, and a low-pressure pump is activated to pump the water through a normal garden hose. Once the water has been turned off in the bathroom, the pump automatically switches off and ceases the irrigation process until the next bath or shower.

Joubert explains that the product was originally developed for his own use over about six months. "I first suggested to my wife and children that when showering, they could stand in a 25 ℓ bucket which we could empty on the garden after each shower. However, when I ended up being the one doing all the emptying of the buckets on the garden each morning, I decided to look at a less laborious solution."

A simple hose pipe attached to the down pipes had little effect. "My shower always backed up, and we now had showers ankle deep in dirty water," Joubert tells *the Water Wheel*. "It was then that I designed the first prototype of the Garden Res-Q. It was extremely ugly and bulky, but did the job beautifully."

According to Joubert, the most demanding challenge was to get a unit that was small and simple enough for the average handyman to install yet was effective in doing the job for which it was designed. Material and components also played a significant role – the unit is installed outside the house and any material used, therefore, has to stand up against the harsh South African sun.

The Garden Res-Q unit, which uses wastewater from the bath or shower to irrigate the garden.

Apart from the award, the response from the public has been overwhelming, with the first bulky prototype installed in 50 homes by word of mouth alone. At the time of writing, the final commercially acceptable mould was in the process of fabrication, and the first units were to be made available this month.

Joubert hopes to make the product a household name in South Africa, starting in the Western Cape where the ongoing water restrictions have been a major blow to home owners. Distribution channels will be set up to service other parts of the country during 2006. In the longer term, Joubert hopes to set up export channels to countries such as Australia.

With quality chemicals, at the right dose, even the smallest water treatment plant can deliver high quality water.

What's That in Your Water?

Chemicals such as chlorine have been used to treat our drinking water for more than a hundred years. Today, chemical disinfection is considered the essential and most direct way to inactivate or destroy pathogenic and other microbes in drinking water. However, it is equally important to ensure the quality of the chemicals used for this task.
Lani Holtzhausen reports.

Water quality is essential for healthy living, as recent outbreaks of water-related diseases in Mpumalanga and Gauteng illustrate. Every day more innovative chemical blends are found to disinfect drinking water. "With the right blend of quality chemicals, correctly dosed, even the smallest water treatment plant can produce good potable water from almost any source," reports Dr Gerhard Offringa, research manager at the Water Research Commission (WRC). However, quite the opposite can be said from substandard products.

According to the World Health Organisation (WHO), chemical contaminants in drinking water originate from a variety of sources, including treatment chemicals used in the production of drinking water. Processes used for manufacturing of water treatment chemicals may result in the presence of impurities that are of potential health concern. Some of the trace impurities that may end up in drinking water include formaldehyde, ethylene dichloride, ammonia, carbon tetrachloride, mercury, and aluminium, to name a few.

In small dosages these substances might not be immediately toxic, but may cause severe damage to health

over time. Water users might have an increased risk to cancer, Alzheimer's disease, liver and kidney damage, among others. These products may also accumulate in the environment.

"Chemicals are best controlled by the application of national regulations governing the quality of the products themselves rather than the quality of the water," states the WHO in its Guidelines for Drinking Water Quality. "It is important that water supply agencies properly manage any chemicals that they use. In many cases, the best control is through management practices, such as optimisation of the treatment process, and regulation of materials and chemicals that come into contact with drinking water, rather than through monitoring and chemical analysis."

However, while South Africa has laws regulating drinking water quality there are no regulations for the chemicals used to provide that water. The problem is compounded by the fact that, in a recent survey by the Department of Water Affairs & Forestry, it was found that only 58% of Water Services Authorities (WSAs) actually regularly monitor their drinking water quality.

"Chemical contaminants in drinking water originate from a variety of sources, including treatment chemicals used in the production of drinking water."

OUTDATED STANDARDS

The WRC is funding a two-year project, undertaken by Umgeni Water, to rectify the situation. The project is aimed at compiling a report containing recommendations regarding standards and standard procedures for the control and evaluation of the process chemicals used in this country. It is hoped that this report will serve as the basis for the updating and re-issuing of present standards governing these products and the creation of new standards where these do not currently exist.

The recent typhoid fever outbreak in Delmas, Mpumalanga, has stressed again the importance of clean water to protect human health. However, ensuring the safety of the product the water is treated with is just as important.

Dr Offringa tells *the Water Wheel* that initial investigations have found existing standards for water treatment chemicals to be extremely outdated, with several standards issued more than 20 years ago. In addition, there are many treatment chemicals for which no national standards exist, in spite of the fact that some of these are used extensively in the water and wastewater treatment industry. For example, ferric sulphate, ferric chloride, bentonite and activated silica.

Other examples of treatment chemicals that are widely used are coagulants and flocculants. Traditionally inorganic chemicals such as aluminium sulphate were used for primary coagulation of potable water, but over the last few decades polymeric coagulants have become more widely used. These polymeric coagulants are at present not subject to any type of formal legislation in South Africa despite the potential for adverse health effects (some commercially available polyamine flocculants may contain chloropropanol isomers which may be carcinogenic).

UNSCRUPULOUS PLAYERS

With no local regulatory process, it has been left largely to manufacturers to police themselves regarding the contaminant levels in their products. Companies such as Süd-Chemie and Zetachem have sought registration at the US Food and Drug Administration for some of its products, while others such as NCP Chlorchem are ISO 9002 compliant and rely heavily on on-site quality and safety testing.

When purchasing products large WSAs review chemical formulations and conduct complex product testing, but there are numerous smaller local authorities who are in no position to conduct such a sophisticated review and analysis of products, and who do not have the resources for such an evaluation. It is on these

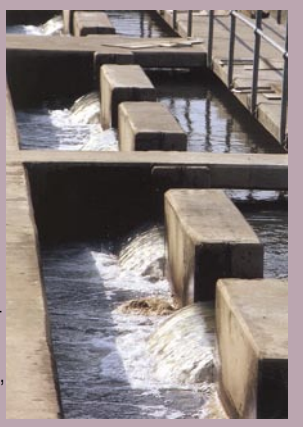
WSAs that unscrupulous treatment chemical suppliers prey.

"The seriousness of the problem can be seen in cases such as in Kwa-Zulu-Natal where small towns were found to be supplied with chemicals made for industrial use, i.e. not for human consumption."

The lack of regulation has left the door open to numerous fly-by-night operators who undermine the industry by supplying products that have undergone no assessment, notes Susan Cole, strategic business unit team leader – Specialities, at NCP Chlorchem, the country's only producer of commercial chlorine for water treatment. "These products might seem cheaper, but without analysis there is no telling where they come from or what they contain. Some are imported and packaged in someone's backyard." The company has even found a foreign product being stored in its labelled drums in an attempt to make it seem more credible.

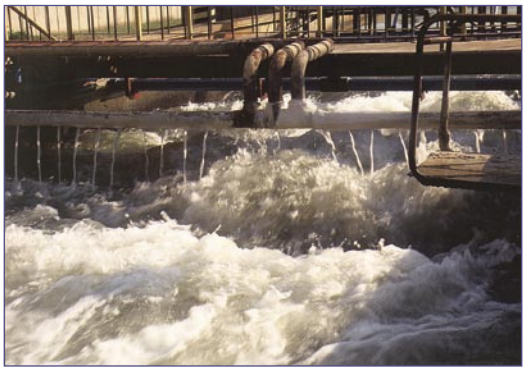
The seriousness of the problem can be seen in cases such as in Kwa-Zulu-Natal where small towns were found to be supplied with chemicals made for industrial use, i.e. not for human consumption. Products have also been found to be diluted so as to supply them more cheaply. This means it will not be effective when using general dosing guidelines. "Apart from the serious danger to consumers, these operators place the entire industry in disrepute while underscoring our product," comments NCP Chlorchem marketing director Ed Robinson.

EXAMPLES OF DRINKING WATER CHEMICALS



Coagulation and flocculation: Acrylamide copolymers, aluminium chloride, aluminium sulphate, bentonite, ferric chloride, ferric and ferrous sulphate, kaolinite, polyaluminium chloride, polyamines, starch, polyethyleneamines, resin amines, sodium aluminate.
pH adjustment: Calcium carbonate, calcium hydroxide, calcium oxide, carbon dioxide, magnesium oxide, potassium hydroxide, sodium bicarbonate, sodium bisulphate, sodium carbonate, sodium hydroxide, sulphuric acid.
Corrosion control: Dipotassium orthophosphate, disodium orthophosphate, monopotassium orthophosphate, phosphoric acid, polyphosphoric acid, potassium tripolyphosphate, sodium calcium magnesium polyphosphate, sodium polyphosphate, sodium zinc polyphosphate, zinc orthophosphate.
Corrosion inhibitor: Sodium silicate.
Sequestering: Ethylenediamine tetraacetic acid (EDTA), tetrasodium EDTA.
Disinfection and oxidation products: Anhydrous ammonia, ammonium hydroxide, calcium hypochlorite, chlorine, iodine, potassium permanganate, sodium chlorate, sodium chlorite, sodium hypochlorite.
Algicide: Copper sulphate, copper triethanolamine complexes.
Softening: Calcium hydroxide, calcium oxide, sodium carbonate, sodium chloride.
Taste and odour control: Activated carbon, chlorine, chlorine dioxide, copper sulphate, ozone, potassium permanganate.
Dechlorinator and antioxidant: Sodium metabisulphite, sodium sulphite, sulphur dioxide.

Source: WHO



A recent survey by the Department of Water Affairs & Forestry found that only 58% of Water Services Authorities actually regularly monitor their drinking water quality.

The industry has welcomed the WRC project in the hope that it will purge the sector of these unscrupulous players that play so callously with people's lives. Robinson hopes that the guidelines for new standards will also provide terms of reference for the development of further standards for future substitute products. "We see the industry evolving and new products being introduced all the time, we do not want to be in the same situation 20 years from now."








Water Engineering Courses
November 2005

Course 1: Pumping Station Design
28 – 29 November 2005

Persons in the Planning and Design of Pump Station should attend this course. The background theory and design practice will be highlighted. A typical practical problem will be discussed and the delegates will be guided through the solution.

The course will include:

- Discussion of the various hydraulic and mechanical aspects of pump stations that is undertaken during the planning and design phase.
- Pump selection and dimensioning of the components of pump stations
- Discussion of good practice in pump station design.
- Performing a practical exercise of a pump station design.

Course 2: Transient Flow in Pipe Systems
30 November - 2 December 2005

Planners, designers and managers of pipelines and water infrastructure will benefit from the course. Transient flow assessment is a crucial part of the pressure class selection of pipes during the final design stage, preventing surge pressures, which in numerous cases results in pipe failures. Foreseen and unforeseen operational circumstances can result in undesirable pressure conditions that should be analysed for new pipelines, assessment of the upgrading of existing systems and determining the influence and risk associated with planned operational changes. Surge2000 computer software, to analyse transients in pipe systems will be covered and problems solved in practical sessions.

Course participants will receive a 5 % discount on the price of the programme, should they purchase the program before July 2006. A discount of 5 % on the attendance fee is offered for firms that are users of the SURGE 2000 Software.

Cost per course

In the table below different fee structures are offered. Firstly, there is a discount for persons who attend both these courses. Secondly, there is a discount for organisations that send more than 4 persons to the courses.

Fee structure	Course 1	Course 2	Total/participant
Normal fee	R3 400	R4 800	As indicated
Attending both courses	Course 1 and 2 per person		R7 380
Organisations sending more than 4 participants per course	R2 900	R4 100	As indicated
Organisations sending more than 4 participants to both the courses	Cost per person for both the courses		R 6 800

* Participants who are already registered SURGE2000 users will be granted a 5 % discount for Course 2.

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Project Shows WHAT A LOT WE GOT — But Cautions Care On How We Use It

South Africa is closer than ever in quantifying its groundwater resources thanks to a project led by the Department of Water Affairs & Forestry (DWAF). Results are showing a resource with significant potential, but not all of it can be abstracted sustainably. Lani Holtzhausen reports.

It has been called the country's 'hidden treasure' and 'liquid gold', but to date the question of exactly how much water South Africa has stored underground has remained largely unanswered, much to the frustration of engineers and planners, even hydrogeologists themselves.

Groundwater abstraction is far from new practice. Many of South Africa's indigenous communities survived mostly on groundwater, while the names of many modern-day towns reflect the dependence of early settlers on underground water and its importance in the establishment and spread of settlements (just think of place names such as De Aar and Springs). Even Johannesburg owes its early survival to the availability of borehole water. Yet the first attempt at a synoptic and visual representation of the country's groundwater resources was made only ten years ago. However, these attempts at measuring exactly how much water is stored underground were largely educated guesses rather than being based on algorithms.

MEASURING THE INVISIBLE

In late 2003, DWAF initiated the Groundwater Resource Assessment Phase 2 (GRA2) project, aimed at quantifying the groundwater resources of South Africa on a national scale. The project, which was concluded earlier this year, was carried out by a consortium of consultants comprising SRK Consulting, GEOSS, Water Systems Management and CSIR. It followed on Phase 1, which produced a set of 21 hydrogeological maps covering the country at a scale of 1:500 000, with accompanying explanatory booklets.

GRA2 had five main tasks, namely quantification (of aquifer storage), producing a groundwater planning potential map, calculating ground-

water recharge and groundwater/surface interaction; and the classification of aquifers and water use. It is considered the most detailed, comprehensive, and integrated study of this nature ever undertaken in South Africa. "It was a daunting but rewarding task undertaken by a team which included many of the leading hydrogeologists and other scientists in the country, both on the consultant's and the client's side", Peter Rosewarne of SRK Consulting tells *the Water Wheel.*

A CRUCIAL RESOURCE

Why quantify the country's groundwater resources at all? "Since it is found virtually everywhere in South Africa in varying amounts, groundwater can serve as a strategic resource to rural and urban communities," explains Rosewarne. "It can be used as a renewable resource and is slower to be affected by droughts, whereas, if it does not rain, dams will start to 'dry up' almost immediately. For example, two years of drought in the Western Cape led to dam levels serving Cape Town to drop to 28% of full supply capacity, whereas local aquifers still had relatively high water levels."

"It was a daunting but rewarding task undertaken by a team which included many of the leading hydrogeologists and other scientists in the country."

However, the conjunctive use of ground and surface water resources is usually the most efficient method of utilisation of catchment water resources. Indeed, the National Water Act of 1996 makes no distinction between these different but inter-related phases of the hydrological cycle.

In addition, groundwater can often be developed close to the proposed end-user, and can be relatively cheap to develop. As the approximately 300 towns and smaller settlements which are already dependent on groundwater for their main water supply can testify, groundwater is naturally filtered by the rocks and materials through which it flows.

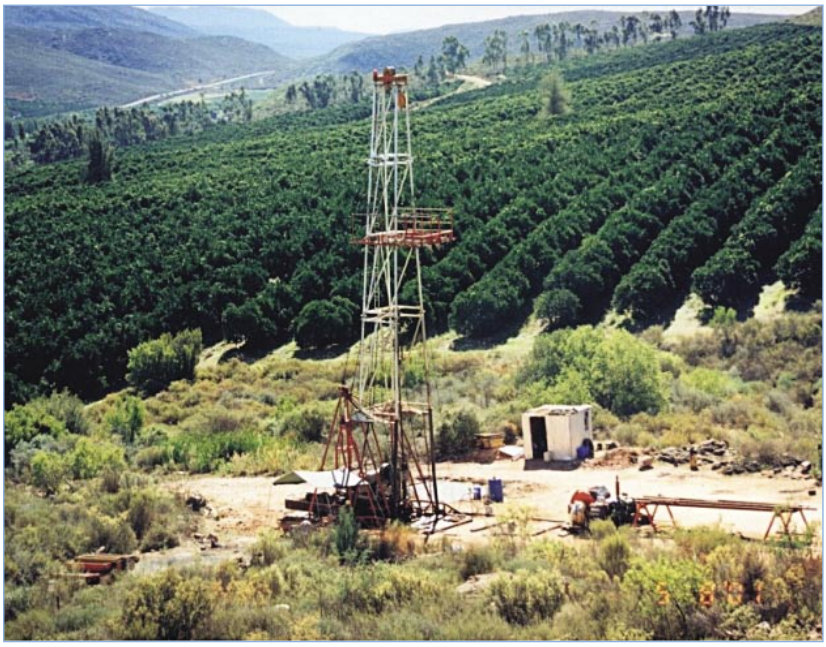
How much groundwater do we have?	
Total volume of groundwater	235,5 billion m^3
Groundwater resource potential	49 billion m^3/a
Average groundwater exploitation potential	19 billion m^3/a
Potable groundwater exploitation potential	14,8 billion m^3/a
Utilisable Groundwater Exploitation Potential	10,3 billion m^3/a

Source: GRA2

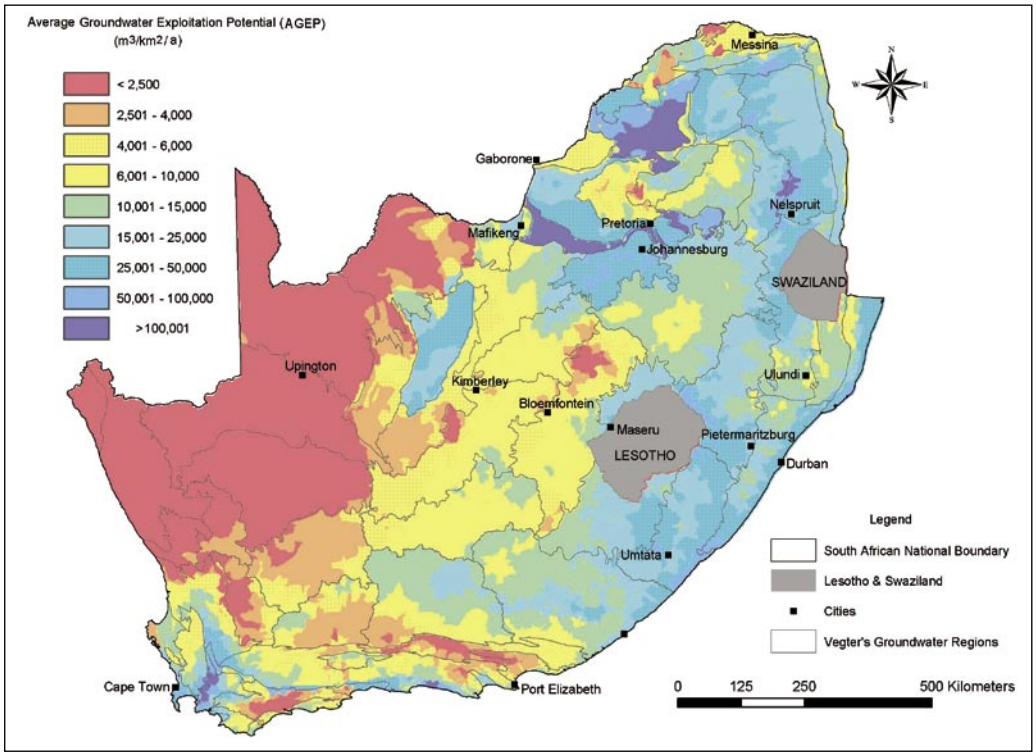
Some of the most favourable areas or aquifers regarding groundwater availability include the dolomites of the West Rand and Far West Rand. It is said that here deep leaching gives rise to some of the highest yielding boreholes in the country (up to 100 ℓ/s). Then there is the Table Mountain Group Aquifers of the Western and Eastern Cape. Here, sustainable borehole yields of more than 10 ℓ/s are common. Other major sources of groundwater are the coastal sand aquifers in the Western and Eastern Cape and northern KwaZulu-Natal.

High-yielding aquifers can also be found in the basement granites in the Pietersburg-Dendron-Coetzerdam area, alluvial deposits along sections of major rivers such as the Limpopo and parts of the Karoo Sequence associated with dolerite dykes and ring structures.

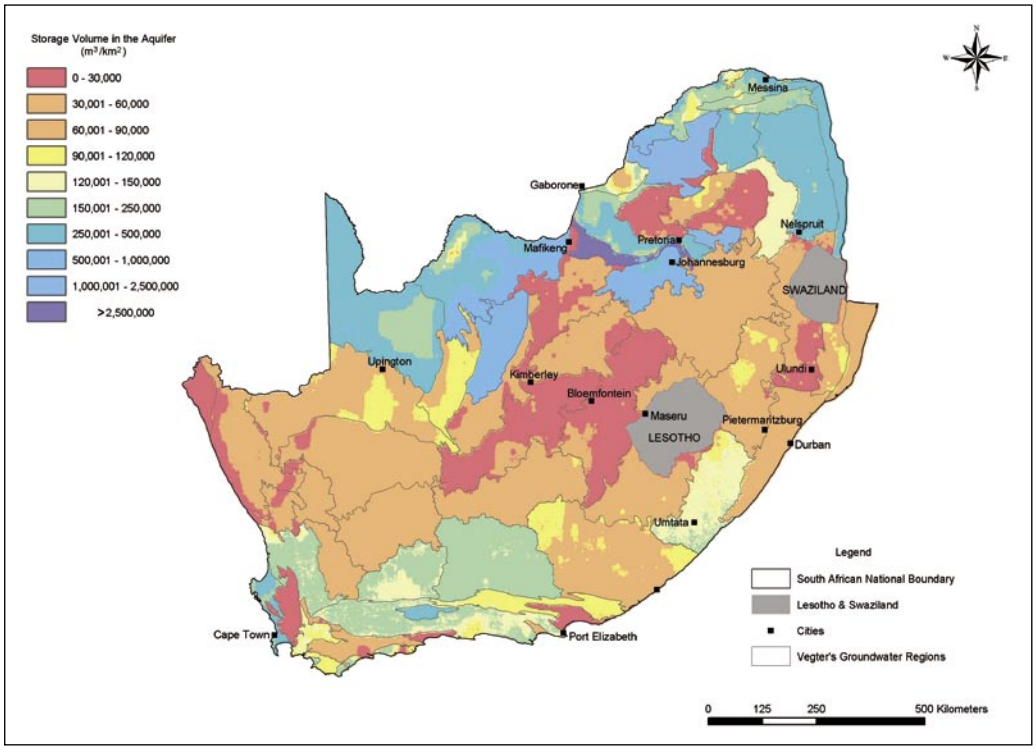
Why has it traditionally been so difficult to quantify the country's groundwater resources? "The most obvious reason is because groundwater is hidden from sight and cannot be measured or quantified by direct methods as with surface water," says Dr Jan Girman of DWAF. "It is also largely (about 90%) contained within fractured rocks. The geometry of these openings is hard to define



Groundwater is set to play an increasingly strategic role in serving rural areas.



Average groundwater exploitation potential for South Africa.



The estimated total volume (m^3/km^3) of groundwater stored in South African aquifers.

accurately. Monitoring records are relatively short and often sparse and widely spread."

The methodologies developed for most of GRA2's tasks were new and improved on previous methods, although they incorporated and built on earlier methodologies, for example, planning potential maps. Developing national level algorithms to provide an accurate yet robust and simple methodology within a geographical information system (GIS) environment was particularly demanding. Another challenge was obtaining acceptable cross-balancing of catchment water budgets between the sub-projects.

SO HOW MUCH GROUNDWATER DO WE HAVE?

In total, some 235,5 billion cubic metres of groundwater may be stored in aquifers in South Africa. Of course, not all of it is usable and can be abstracted. There are many limitations to the possible abstraction of groundwater for use, for example, restrictions to ensure enough water for the environment (the Ecological Reserve), and restrictions on the maximum level drawdown in dolomitic aquifers due to the hazard of sinkhole formation or avoiding intrusion of saline water.

"In total, some 235,5 billion cubic metres of groundwater may be stored in aquifers in South Africa."

The groundwater resource potential is the maximum volume (m^3) of groundwater that can be abstracted per unit area per annum without causing any long-term 'mining' of the aquifer system (i.e. without continued long-term declining water levels). It is not equivalent to the sustainable or optimal yield of the system, which normally takes into account issues such as intrusion of poor quality water, practical and cost issues relating to extracting the water and so forth. The average groundwater resource potential of aquifers in South Africa is estimated under normal rainfall conditions at 49 billion m^3/a, which decreases to 42 billion m^3/a during a drought.

Groundwater quality is one of the main factors restricting the development of available groundwater resources. Quality problems include high concentrations of total dissolved solids, nitrates and fluoride, which can be difficult and expensive to remedy.

Not all of South Africa's groundwater can be abstracted sustainably.

When taking into account limitations such as groundwater quality, the potable groundwater exploitation of aquifers in South Africa is estimated at 14,8 billion m^3/a, which declines to 12,6 billion m^3/a during a drought. Nationally this represents almost a 30% reduction in the annual volumes of available groundwater for domestic supply due to water quality constraints, Rosewarne points out.

Finally, the volume of water that may be abstracted from a groundwater resource may be limited by anthropogenic, ecological and/or legislative considerations, which is ultimately a management decision that will reduce the total volume of groundwater available for development – referred to as the utilisable groundwater exploitation potential. Under normal rainfall conditions this volume is 10,4 billion m^3 and 7,5 billion m^3 under drought conditions.

For general planning purposes, it is recommended that the average utilisable groundwater exploitation potential volume be adopted. It is interesting to note that only about 20% of this volume is currently being abstracted on an annual basis.

THE WAY FORWARD

The results of the GRA2 study have been incorporated into the Water Resources 2005 (WR2005) study, a three-year assessment of South Africa's water resources. Funded by the Water Research Commission, this project will be completed by 2007. This will seek to provide, for the first time, an integrated assessment of the surface and groundwater resources of the country.

The process of groundwater resource assessment is set to continue in the near future, paying attention to the issues of monitoring and protection of groundwater resources, as well as to information products in support of decision makers and general public.

Rosewarne concludes: "There is no doubt that groundwater will play an increasingly strategic role in serving rural areas either as a stand-alone source, in conjunctive use schemes with surface water and as a bridging supply, particularly to assist in drought management and possibly in terms of reducing the effects of climate change."

Access to Clean Water Crucial in Fight Against AIDS

The issues of water and sanitation and HIV/AIDS are inextricably linked, as a recent case study undertaken in Jeppe's Reef, Mpumalanga, pointed out. The research formed part of an integrated health and hygiene education project funded by the Water Research Commission. Report by Alana Potter and Virginia Molose from Mvula Trust.

Where water services are inadequate or inaccessible, the time and monetary costs of accessing clean water in sufficient quantities are high, particularly for HIV-infected people and their caregivers. Access to affordable, accessible and reliable water and sanitation is crucial for people living with HIV/AIDS, and for providing home-based care.

Water is needed for taking antiretroviral (ARV) medication, bathing patients, washing soiled clothing and linen; and for essential hygiene, which reduces exposure to infections. On the other hand, toilets are needed nearby for weak patients.

WHAT'S HAPPENING ON THE GROUND?

Jeppe's Reef is a peri-urban settlement in the west of the Nkomazi local municipal area in Mpumalanga. It is situated in the fertile Nkomazi valley, in close proximity to the Mozambique and Swaziland borders. According to the 2001 Census, there are about 5 200 households in Jeppe's Reef, with an average six members per household. The majority of the population is aged between 15 and 24 years.

Unemployment is extremely high and most people earn their livelihoods from social grants, informal enterprises and limited livestock and food production. At least 15% of the local residents are immigrants or refugees from Swaziland and Mozambique, and have difficulty accessing social support.

The area is serviced by a clinic and the Shongwe public hospital about three kilometres from the centre of the settlement.

HIV/AIDS IN JEPPE'S REEF

Accurate HIV infection statistics are not available for the area. However,

in a random sample of 15 households visited, seven households included people who were actively ill or taking tuberculoses or ARC medication. According to Bridgette Moyana, founder of the iThemba Lethu Home Based Care Group (HBC), the situation is dire. "This area is dying and we are hardly scratching the surface – more than half the households we visit have someone who is sick, mostly young people."

The home-based caregivers interviewed indicated that it had taken years to encourage noticeably sick people to get tested and treated and that denial was a big part of the problem. "Most people know about it, but do not believe people are sick until they see it. Some are locked away and their famlies refuse care – they say no-one is sick here," says caregiver Rose Moyana.

The Shongwe hospital is providing ARV treatment, mostly in the later stages of infection, and after a long wait, and obviously only to people who are willing and able to be tested and know their status. The HBC Groups interviewed also reported that the municipality did not accept that HIV was a serious problem, and claimed they were exaggerating to access donor funding.

WATER AND SANITATION

According to the Nkomazi Integrated Development Plan (IDP), 41% of households receive water from communal standpipes at 200 m, 26% receive water below RDP level, and 14% have yard connections. There are communal standpipes throughout Jeppe's Reef. Water supply from these standpipes is controlled and only accessible between 6 and 10 in the morning.

Most households have pit latrines; some have ventilated improved pit (VIP) toilets implemented five to ten years ago, and a limited number of VIPs recently implemented by the local authority. The IDP states that 55% of households have VIPs, 20% have unimproved pits and 13% have no sanitation service at all.

Access to affordable, accessible and reliable water and sanitation is crucial for people living with HIV/AIDS, and for providing home-based care.

"This area is dying and we are hardly scratching the surface – more than half the households we visit have someone who is sick, mostly young people."

HOME-BASED CARE

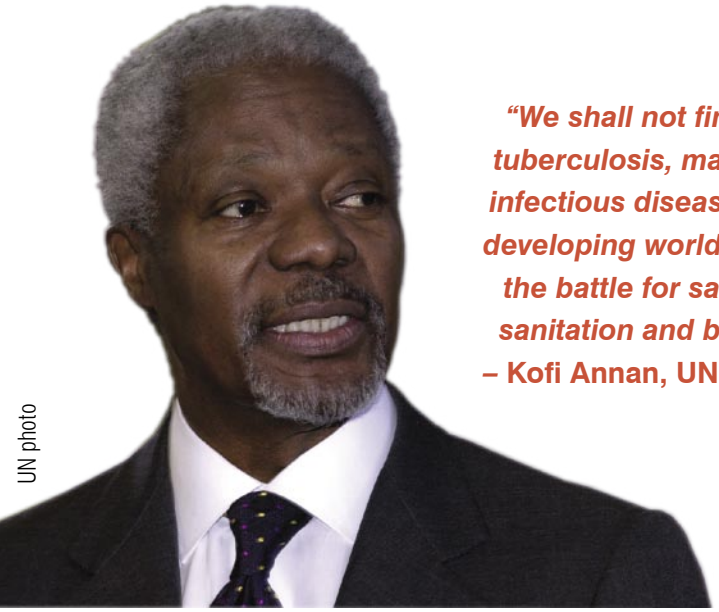
Home-based caregivers undertake a range of activities, including fetching water, bathing patients, washing, laundry, digging pits for solid waste disposal, cleaning households and yards, assisting with access to social, health and other services, and providing counselling, information and support. The iThemba Lethu HBC Group also provides household food gardening training and support.

NEEDS OF AFFECTED HOUSEHOLDS

Controlled water supply makes it difficult for home-based caregivers to carry out their activities, and compromises the impact of health and hygiene education and promotion carried out by community health workers. "When water is not in the yard and also comes out at particular times only, it makes it very difficult for us to wash clothes, clean houses and bath our patients when we visit them during our house call duties," notes caregiver Christina Thwala. Members of HBC Groups indicated that they require 200 ℓ of water a day to care for their patients – 75 ℓ to 100 ℓ for laundry and the rest for cooking, bathing and drinking.

With regards to sanitation, it was felt that spiral toilets are not good for households with sick people. "We often need to carry or accompany a person to the toilet because they are too weak to walk on their own. The spiral toilets do not make it easy for two people to fit in it, but we are happy about the VIPs that are here," says caregiver Sarah Baloyi.

20 HIV/AIDS & WATER



UN photo

"We shall not finally defeat AIDS, tuberculosis, malaria, or any other infectious diseases that plague the developing world until we have won the battle for safe drinking water, sanitation and basic health care."
– Kofi Annan, UN Secretary General

Many AIDS infected households interviewed had unauthorised connections to communal standpipes since people were too weak to fetch water from the communal standpipes. While there seemed to be a degree of tolerance of this on the part of other households, this will ultimately affect the flow rate and sustainability of the scheme.

The home-based caregivers interviewed said their work would be more effective if AIDS-affected households could have taps in their yards. They felt this would enable them to nurse and care for greater numbers of sick people rather than waiting and collecting water to standpipes. They also felt this would enable household level food production, as good nutrition is crucial for the immunity of HIV+ people and for taking ARV medicine. Although trench gardening is used, there is not enough water to sustain food gardens in the dry season.

WHAT CAN MUNICIPALITIES DO?

Firstly municipalities need to address water and sanitation backlogs.

The communication of good water and sanitation use and hygiene practices is an essential element in the fight against HIV/AIDS.

The Strategic Framework for Water Services sets out delivery targets and includes the communication of good water and sanitation use and hygiene practices in its definition of basic water and sanitation services. The relevant municipalities are responsible to ensure basic water and sanitation services, including the communication of effective and hygienic use of these services.

Secondly, municipal water sector development plants need to take into account the impact of HIV/AIDS on water demand, and health districts need to ensure synergy between district health planning and water services development planning. It is equally important that subsidy mechanisms such as free basic water reach those who most need them.

"..... greater integration is needed between water services, health and hygiene education and HIV/AIDS education."

Municipalities need to look at their technology options. Policy makes provision for 'stepping up the ladder' from basic services. Sufficient quantities of water on site and accessible sanitation options are needed for affected households.

In addition, greater integration is needed between water services, health and hygiene education and HIV/AIDS education. The intended health impacts of service delivery can be achieved through improved co-ordination between health and infrastructure divisions and functions in municipalities, and through effective links with relevant health programmes and initiatives. Households also need access to water for productive purposes.

Search Continues For Answers On Health Impact Of Ecosan

While the mass rollout of urine diversion (UD) toilets continues on the outskirts of Durban in the municipality's quest to provide all its constituents with decent sanitation by 2010, questions remain regarding the environmental impact of these systems and the possible reuse of the accumulating waste. A joint research effort between the Pollution Research Group of the University of KwaZulu-Natal and the Water and Sanitation Department of eThekwini Municipality is hoping to come up with some answers. Lani Holtzhausen reports.

A dwarf paw-paw tree grown on waste (front) compared with a tree grown in conventional soil (behind).

The eThekwini UD toilet is of a double vault design, with the toilet pedestal being relocated over the second, empty vault when the first vault has been filled.

The urine is disposed of in shallow soakaways. Sand or ash is added after each defecation to promote desiccation and limit odour and fly problems.

The contents of the first vault are allowed to stand for the period required for the second vault to fill (usually a year). Thereafter, it is recommended that the now dry waste


The research site at the University of KwaZulu-Natal.


Construction of the concrete columns


Filling the columns with waste material. This was reportedly a highly unpleasant task.


The waste material.


The plants grown above the waste showed enhanced growth and yield compared to those grown in the control columns.

- *Photographs courtesy of the Pollution Research Group*

is buried on site at a minimum depth of 250 mm below the soil surface and a tree planted to mark the burial site.

However, as more vaults start to fill up several questions have been raised such as how fast will the buried waste degrade and is there a threat of groundwater contamination by persistent pathogens? It is also not clear whether deep-rooted plants, planted above the burial site, will be able to penetrate and tolerate the anaerobic waste layer. Then there is the possibility of reusing the waste to grow food.

SEARCHING FOR ANSWERS

To answer some of these questions a study site was selected at the university grounds. The project, funded by National Research Foundation, started in August 2004. A total of 24 concrete columns were constructed from conventional manhole pipe rings with a diameter of 75 m and a height of 25 m. Mikey Guness, a research assistant at the Pollution Research Group, explains that 12 of the columns served as experimental treatments while 12 served as controls.

The columns were filled with combinations of soil and urine diversion solid waste collected from toilets nearing filling of the second toilet vault. Berea red soil, a relatively nutrient-poor soil typically found in the area, was used as covering soil and as substitute for the UD wastes

TABLE 1 Combinations of soil and urine diversion waste in treatment and control towers		
Depth	Treatment towers	Control towers
Ground level – 0,25 m	Umgeni river sand	Umgeni river sand
0,25 – 0,75 m	UD solid waste	Berea red soil
0,75 – 1 m	Berea red soil	Berea red soil

in the control columns. Umgeni sand was used as the bottom layer because it displays high leaching potential, providing a 'worst case scenario' for prediction of leaching of contaminations into groundwater.

A total of 20 columns were planted with dwarf paw-paw trees, while the rest were allocated to spinach plants.

Plant growth was monitored weekly. Parameters measured included plant height, stem diameter, number of leaves, and length and width of the three largest leaves present at the time. In addition, the spinach was harvested as necessary and the fresh weight of the harvested leaves recorded.

Leaching from the columns was determined by adding a constant volume of 45 ℓ of water to each column. Leachate was collected from each column and the volume recorded. The leachate samples were then sent to the eThekwini laboratory for microbiological analysis.

CAUSE FOR CONCERN

The results demonstrated that, far from being an inert mass, buried UD waste has a marked impact on the quality of soil above (and by inference below) the waste layer, and potentially of groundwater. This has positive and negative implications, notes Guness.

Analysis of topsoil from experimental and control columns three weeks after filling, immediately before planting, showed that there were significant differences in levels of exchange acidity, manganese, copper and total nitrogen. This demonstrates that UD waste constituents, particularly nutrients, can move upward in the soil column and, therefore, have the potential to affect even shallow-rooted plants which do not penetrate the waste layer. Furthermore, this suggests that microbial contaminants may move to the soil surface after burial and pose a potential health hazard.

Analysis of topsoil from experimental and control columns three weeks after filling, immediately before planting, showed that there were significant differences in levels of exchange acidity, manganese, copper and total nitrogen.

"Evidence of movement from matter from the waste layer to the soil surface is of particular concern with respect to ova of the *Ascaris lumbricoides* (a parasitic roundworm)," Guness tells *the Water Wheel.*

Ascariasis is endemic in the eThekwini municipal region, particularly in poorer communities which are likely to be served by on-site sanitation. One of the main purposes of any sanitation intervention is to provide a barrier between people and infectious agents present in their waste. If buried waste has the potential to release infective ova to the soil surface, it will increase – rather than decrease – the environmental load of this pathogen."

ENHANCED GROWTH

An extremely positive aspect of the project is that growth of the spinach plants was boosted markedly when growing above the buried UD waste. While the paw-paw trees took longer to show as marked a difference, the same trend was evident after eight weeks' growth and, particularly by ten weeks' growth. "Our research showed that even the UD sanitation-only approach adopted by eThekwini Municipality, which does not specifically provide for agricultural reuse, may boost food production from crops grown in a relatively small area immediately above the burial site," says Guness.

Analysis of the volume and quality of leachate from experimental and control columns showed that while the UD waste did not significantly alter the water retention characteristics, both chemical oxygen demand (COD) and microbial indicator organisms were significantly increased in leachate from the columns containing UD waste. This could have potentially damaging effects on groundwater quality.

As Guness notes: "The appearance of COD in the leachate from columns containing UD waste may indicate that degradation is occurring in the waste layer, releasing soluble organic carbon from the predominantly solid organic matter in the waste. Further analysis on soil layers is currently being conducted.

The jury is still out on whether the dry waste from UD toilets can safely be used to grow food. It is only with continued investment in research that all the answers will become known.

WHEN WATER TURNS DEADLY

- Investigating Nitrate in SA Groundwater

Nitrogen is an essential part of our environment. It makes up 78% of the air we breathe and is the most important nutrient for plant growth. But excessive levels of nitrogen – in the form of nitrate – are dangerous. In South Africa, excessive nitrate levels are the main reason for many groundwater resources to be declared unfit for drinking.

Lani Holtzhausen reports.

Rural water supply is being extended and improved with great urgency as authorities strive to provide clean drinking water to all. In remote areas, groundwater is often cited as the cheapest and most sustainable form of water supply to previously unserved communities. However, surveys show that high nitrate levels are common in groundwater is common in arid and semi-arid regions of southern Africa, often exceeding drinking water specifications (i.e. above 10 mg/ℓ). The problem is that, for many communities, this is the only available drinking water they have.

Dr Gideon Tredoux with his colleagues, Dr Pannie Engelbrecht and Siep Talma all of CSIR Environmentek, have been studying the occurrence of nitrate in groundwater for many years. "Rural villages and small towns from the Northern Cape to the far southeast of Limpopo are severely affected by these nitrate concentrations," he tells *the Water Wheel*. "Concentrations range from 50 – 100 mg/ℓ and even well above 100 mg/ℓ in some areas, while in the southern Kalahari concentrations of up to 500 mg/ℓ of nitrate occur in certain areas."

Excessive levels of nitrate (above 40 mg/ℓ) are dangerous to people's health, and may result in infant methaemoglobinaemia. While these health effects are known to occur in South Africa, no comprehensive statistics exist. Dr Tredoux explains that, while methaemoglobinaemia or 'blue baby syndrome' is a notifiable disease, the infants usually arrive at the clinic in such a state that correct diagnosis is very difficult. Thus it is highly likely that the symptoms are not recognised and correctly identified. Often the high nitrate water is also bacterially polluted and other conditions, such as diarrhoea, may mask the nitrate effect and also aggravate the problem.

In fact, one of the only countries with official statistics is Hungary, and only because the country's Department of Health launched a specific campaign to identify and eliminate the occurrence of methaemoglobinaemia. Hundreds of cases with several mortalities were recorded each year in the 1970s until it was virtually eliminated in the early 1990s. Where alternative supplies were unavailable, mothers and infants were even supplied with nitrate-free bottled water.

HIV/Aids is increasing infants' risk of ingesting high nitrate water as HIV positive mothers are advised to refrain from breast-feeding their babies and rather bottle-feeding them. Thus the pandemic has introduced an urgency element for groundwater nitrate control measures in our region.

THE ORIGIN OF NITRATE

Nitrate accumulates naturally in groundwater under certain conditions. Along the western and south-western edge of the Kalahari, and in the Springbok Flats, for instance, elevated nitrate concentrations are derived from natural soil nitrogen. However, the greatest nitrate contribution is through human activities.

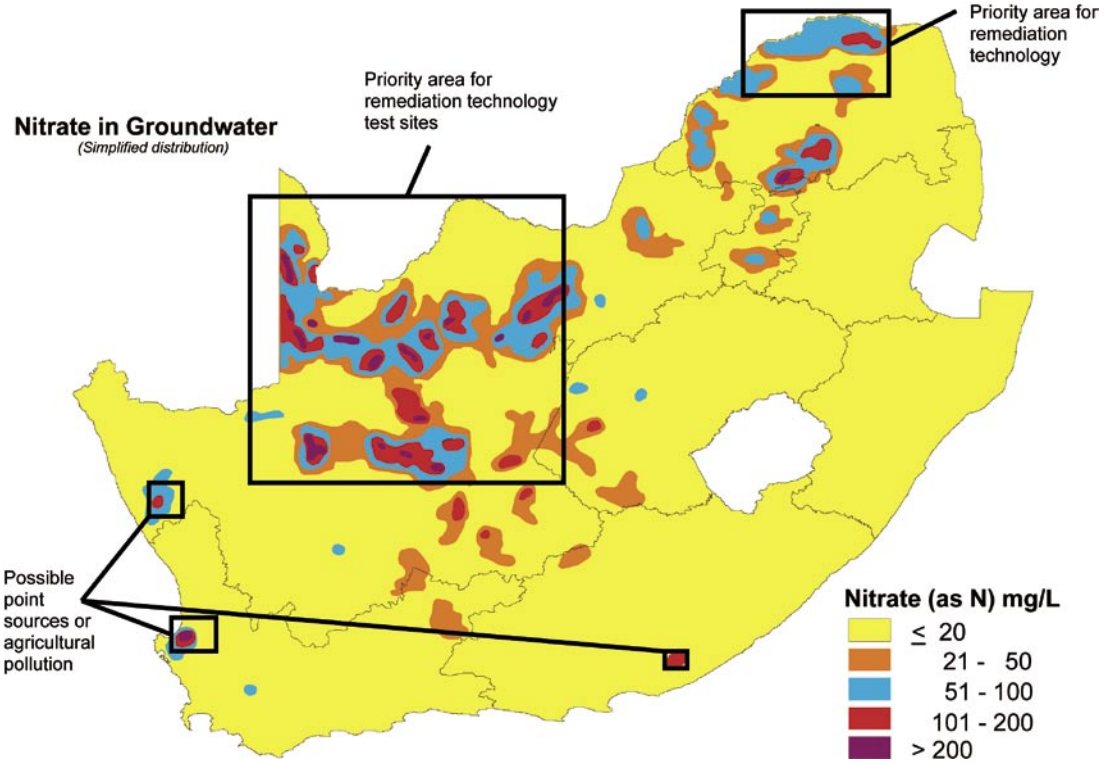
In South Africa, excessive nitrate levels are usually caused through point source pollution. This includes sewage sludge drying beds, land application of sludge, and irrigation of partly treated wastewater. Groundwater pollution of this nature usually occurs around urban centres.

In rural areas, pollution can be caused by the high concentration of livestock at watering points near boreholes, and by inappropriate on-site sanitation. In Delmas, Mpumalanga, many people still make use of the bucket sanitation system. While the causes of the present typhoid outbreak are still under investigation, research into a similar outbreak 12 years ago showed nitrate in the groundwater in addition to faecal pollution.

On-site sanitation has also been identified as a cause of nigh nitrate levels. In Botswana, for example, in the village of Ramotswa, located south of Gaborone. The problem is usually compounded by the fact that surface waste disposal practices, for example, manure, wastewater and refuse disposal, usually occur in the close vicinity of the water source, and all jointly increase the likelihood of pollution.

There is a feeling that to date the nitrate problem has largely been ignored. One reason could be the fact that groundwater in general has only received attention in the last ten years as a viable and sustainable water supply source. The main reason, however, argues Dr Tredoux, is ignorance of the extent of the nitrate problem. “In Namibia, a countrywide groundwater quality survey was undertaken from 1967 to 1982. During this time all farms and rural areas were visited, most of the existing boreholes sampled, the

On-site sanitation has been identified as a cause of nigh nitrate levels.



water analysed and the results provided to the farmers and communities free of charge. Feedback on the quality of the water was also provided and hazards, such as high nitrate, fluoride, sulphate and salinity were mentioned and explained. This created an awareness that lasted for at least a generation."

In South Africa, while we have a fair idea of the geographical extent of the occurrence of nitrate in groundwater, i.e. the potential problem areas, we do not know the nitrate values accurately and certainly not the range of variation in concentration. "The latter is the bigger problem as nitrate concentrations in groundwater can vary widely in certain areas, mostly where it is semi-arid to arid, and the water level is relatively shallow," explains Dr Tredoux. The variability is such that in certain cases water that is suitable for human consumption may become poisonous even for cattle and will lead to nitrate poisoning and livestock losses.

The instability of nitrate in water samples due to bacterial denitrification also leads to inaccurate results when unpreserved samples are stored any length of time before analysis. This presents a serious problem as it is impossible to know which of the thousands of results stored in databases are reliable.

WHY IS EXCESSIVE NITRATE SO DANGEROUS?

Excessive nitrate levels (above 40 mg/ℓ) can be very dangerous to human health.

When bottle-fed infants digest water containing too much nitrate, this nitrate, when converted to nitrite in the infant's body interferes with the oxygen carrying capacity of the child's blood (it replaces the oxygen on the red blood cells).

Children with methaemoglobinaemia, as it is known, will show signs of blueness around the mouth, hands and feet, hence the common name 'blue baby syndrome'. These children may also have trouble breathing as well as vomiting and diarrhoea. In extreme cases, there is marked lethargy, an increase in the production of saliva, loss of consciousness and seizures. Some cases may be fatal.

Expectant mothers are also at risk as spontaneous miscarriage or still birth may occur when too much nitrate is ingested.

DANGER TO LIVESTOCK

The risk of livestock loss through nitrate poisoning is largely unknown among the local population except in Namibia. No statistics are available and information is mostly anecdotal.

One of the largest recently recorded incidences of livestock losses in southern Africa occurred in 2000 on Ghanzi River in the Ghanzi-Karakubis area in Botswana. At least 356 heads of cattle died as a result of nitrate poisoning. In 2002 a further incident of livestock loss occurred at Kautsha, north of Ghanzi, where 28 heads of cattle died. Livestock losses are a sensitive issue as the farmers are at risk not to be able to market their cattle when this is due to a disease, and the farmers may not be aware that nitrate poisoning is non-contagious.

Another confirmed case of nitrate poisoning occurred in 2001 when at least 60 heads of cattle died on a farm near Thabazimbi, Limpopo.

More research is needed to understand the nitrogen cycle in the context of natural groundwater recharge, particularly in the (semi) arid areas. "In the developed countries extensive research has been carried out under humid conditions. However, in the arid zone the transport of nitrate from the soil zone into the groundwater is not fully understood." says Dr Tredoux.

It would seem that in the drier regions a large load of nitrate (and other salts) is stored in the subsurface and this only reaches the groundwater table after intense rainfall events. Preferential flow and other phenomena significantly add to the complexity.

Pregnant heifer that died of nitrate poisoning after being watered.

In the drier regions a large load of nitrate (and other salts) is stored in the subsurface and this only reaches the groundwater table after intense rainfall events. This means that borehole water which did not previously contained high levels of nitrate can now be dangerous.

MANAGING THE PROBLEM

Once an aquifer is polluted it will remain in that state indefinitely. Rehabilitation is a tedious, expensive, and time-consuming operation with limited success. While efficient methods exist to treat nitrate-rich groundwater, these require high technology, are expensive or both. Present treatment methods range from biological denitrification to ion exchange and reverse osmosis although *in-situ* methods (i.e. treating the water within the aquifer) are increasingly being researched.

The cost implications make prevention of the problem all the more important. Although the development of natural soil nitrogen cannot be controlled, anthropogenic nitrogen inputs are manageable and hence most groundwater nitrate problems can be avoided by reducing releases into the soil and subsurface environment.

Dr Tredoux feels that while short- and medium-term action is needed to remedy present nitrate pollution, a long-term groundwater quality monitoring network, geared to measure nitrate accurately, needs to be implemented in strategic and vulnerable areas so as to determine reliable trends over time.

Increasing public awareness is crucial, not only to convey the seriousness of the problem, but to procure funding for developing locally workable management solutions. "While legislation and control are indispensable tools for groundwater protection and management, polluting activities in remote areas cannot be controlled by the authorities," Dr Tredoux points out. "For this reason, the public, including the farming community and rural communities have to be convinced to voluntarily take all necessary steps that will ensure a reduction in environmental nitrogen inputs, and particularly, nitrate leaching to groundwater."

Elevated nitrate levels in drinking water present one of the greatest challenges to sustainable water quality worldwide. It is only with concerted, long-term effort that the deterioration of our precious groundwater resources can be overcome.

FURTHER READING:

- The feasibility of *In Situ* Groundwater Remediation as Robust Low-Cost Water Treatment Option (**WRC Report No 1325/1/04**)
- Nitrate and Associated Hazard Quantification and Strategies for Protecting Rural Water Supplies (**WRC Report No 1058/1/04**)

WATER Kidz

Wiping Out Waterborne Diseases

Earlier this year at least four people died and more than 600 were infected when typhoid fever broke out in Delmas, Mpumalanga. But what is typhoid fever and where does it come from?

Typhoid fever is an acute severe illness caused by the bacterium *Salmonella typhi*. The bacterium lives only in humans. Persons with typhoid fever carry the bacteria in their bloodstream and intestinal tract. In addition, a small number of persons, called carriers, recover from typhoid fever but continue to carry the bacteria. Both ill persons and carriers shed *S. typhi* in their faeces (stool).

Typhoid fever was described as long ago as ancient Greek times, and has claimed many lives over the centuries. In the Anglo-Boer war, for example, the British lost more troops from typhoid fever than from war wounds.

Today, it is estimated that at least 12 to 13 million cases occur per year worldwide. In South Africa, the disease is endemic, meaning that it is constantly present, and occurs at a low level of frequency, although the potential for outbreaks does exist.

HOW DO YOU GET TYPHOID FEVER?

You can get typhoid fever if you eat food or drink beverages that have been handled by a person who is shedding *S. typhi* or if sewage contaminated with *S. typhi* bacteria gets into the water you use for drinking or washing food. Once *S. typhi* bacteria are eaten or drunk, they multiply and spread into the bloodstream. This is why it is so important that you wash your hands after going to the bathroom and before handling or eating food.

Symptoms can be mild or severe and include fever as high as 39˚C to 40˚C, malaise, headache, constipation or diarrhoea, rose-coloured spots on the chest area and enlarged spleen and liver. Most people show symptoms one to three weeks after exposure.

It is said that, if left untreated, about 12% to 20% of people with typhoid will die. However, with appropriate antibiotics, the mortality rate is less than 1%. In untreated cases, the infection usually lasts two to four weeks. About 10% of survivors will relapse, and about 3% will become carriers.

WHAT PRECAUTIONS CAN I TAKE?

- Always wash your hands well with soap and water after going to the toilet and before handling food or eating.

- Boil water before drinking.
- Avoid fruit and vegetables that cannot be peeled, e.g. lettuce are easily contaminated and difficult to wash well.

ANOTHER WATERBORNE DISEASE: CHOLERA

Cholera is an acute, diarrhoeal illness caused by infection of the intestine with the bacterium *Vibrio cholerae.* About one in 20 infected persons has severe disease characterised by profuse watery diarrhoea, vomiting, and leg cramps. In these persons, rapid loss of body fluids leads to dehydration and shock. Without treatment, death can occur within hours.

A person may get cholera by drinking water or eating food contaminated with the cholera bacterium. In an epidemic, the source of the contamination is usually the faeces of an infected person. The disease can spread rapidly in areas with inadequate treatment of sewage and drinking water.

In 2001/2002, South Africa suffered one of the worst cholera epidemics in its history, when more than 100 000 people were infected and hundreds died. The most severely affected areas were the country's poorest provinces KwaZulu-Natal and Eastern Province where millions of people did not have access to clean water and proper sanitation.

IF YOU ARE BEING TREATED FOR TYPHOID FEVER, REMEMBER THE FOLLOWING:

- Take the prescribed antibiotics for as long as the doctor has asked you to take them.
- Wash your hands carefully with soap and water after using the bathroom.
- Do not prepare or serve food to other people.

When you see Cornie van Huyssteen digging in the soil you can be sure he's not gardening. *The Water Wheel* asked this senior lecturer and researcher at the Department of Soil, Crop and Climate Sciences, University of the Free State, about his career as a soil scientist.

WHAT IS SOIL SCIENCE AND WHAT DO SOIL SCIENTISTS DO?

Soil science is the study of the physical, chemical and biological properties of soil. Among others, it involves the management of soils to promote crop growth and protect the environment. We focus on the role of soil as a medium for plant growth, water flow regulation and purification, a habitat for organisms, a recycling system for nutrients and organic wastes and an engineering medium. Knowledge about the properties of the soil tells us, for example, whether the soil has the potential to store enough water to keep plants growing through a drought, to withstand a flood, and provide the right combinations of chemicals to plants so that they will grow properly, for example.

Soil scientists are regularly consulted on a wide array of environmental issues, particularly related to the relationship of soil and water. Soil scientists work in fields such as the conservation of wetlands, non-point source pollution and erosion control; or assessment, environmental monitoring and sample analysis, land use, and waste management.

WHAT RESEARCH ARE YOU INVOLVED IN AT PRESENT?

The Department of Soil Science was established in 1958 and research regarding the role of water in soil has been undertaken continuously since 1974. My current research focuses on the relationship between how soils look and the way water moves in it. Interestingly, my colleagues are researching the application and efficient use of agricultural water to soil (i.e. how much, how often, the risks involved, e.g. the effect of water quality on soils and crops).

WHY WOULD SOMEONE WANT TO STUDY SOIL SCIENCE?

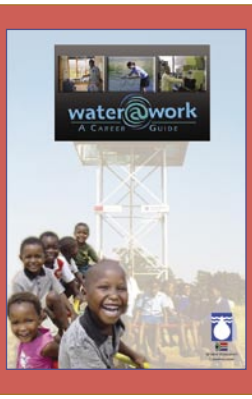
Soil plays a prominent role in the ecosystem. Knowledge in this regard is therefore important to ensure the correct management and conservation of this natural resource. Soil scientists work in- and outdoors, so a passion for nature and its ecosystems and for agriculture would motivate someone to study soil science.

WHAT ARE THE MOST INTERESTING ASPECTS OF SOIL SCIENCE?

Studying a natural entity that most people ignore, yet is of such vital importance for our continued existence on earth, is really exciting. So are the possibilities that are opening up in multi-disciplinary research, because soil has an impact on almost all natural systems.

HOW DOES SA'S KNOWLEDGE WITH REGARDS TO SOIL SCIENCE COMPARE WITH THE REST OF THE WORLD?

South Africa has some of the oldest soils in the world, while the region is also among the driest in the world. Local soil scientists have had to adapt to these challenges and, for this reason, compare to the best in the world. We are also at the forefront of an exciting new discipline in soil science called hydropedology, an intertwined branch of soil science and hydrology that encompasses multi-scale basic and applied research of interactive soil and water processes and their properties in the unsaturated zone of the soil.



For more on this and other careers in water, see *Water @Work* available from the Water Research Commission. To obtain a copy phone Publications at
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