FORUM FOR GROUNDWATER

Introduction

First Issue, May 2006

Welcome to the first issue of our "Forum for Groundwater"! The purpose of this document is two-fold: Firstly, it will act as a discussion forum for CSIR people and others interested in groundwater and related subjects. We have many such people within our organisation and elsewhere and this will help to bring us together. It will also help to raise the profile of groundwater at the CSIR and hopefully within South Africa too. Groundwater in South Africa has historically been overlooked.

Secondly, the Forum will help to tell other interested people out there about our groundwater interests and activities, and this will help to establish links with potential partners. Contributions from "guest" experts outside the CSIR will also appear from time to time.

The famous "Kuruman Eye" in the Northwest Province, South Africa, discharges 20 million litres of water per day from a dolomite aquifer, and is reputed to be the biggest spring in the southern hemisphere (picture: J Cobbing).

The Forum will have a strong focus on groundwater in South Africa and elsewhere in Africa, linking friends and colleagues in this important sector. It's intended that the Forum will be a forum for ideas, a "shop window" for research work, a way of communicating with others interested in groundwater, a way of asking other experts for advice, and so on.

So if you have a page or two of text (plus a picture or two?) on a groundwater-related topic, please let us know. General comments and suggestions are also welcome.

The aim is to keep Forum articles short and fairly informal – readers can contact the authors directly for full articles, reference lists, and further information.

In this issue Johan de Beer discusses the history of groundwater on the Witwatersrand gold mines – in the next issue John Bean will be writing about the challenges posed by minewater decant today as some gold mines close down.

Alan MacDonald writes from the UK about the important role groundwater will have to play in meeting the Millennium Development Goals in Africa.

Tony Turton gives us a run-down of some of the work his group has been doing in the field of groundwater management.

Aussie Austin deals with the delicate but critical subject of appropriate sanitation, and Jude Cobbing introduces the African Water Facility and its work.

"Forum for Groundwater" is coordinated by the CSIR Groundwater Research Group, part of the Water Resources Competence Area. Views and opinions expressed in this Forum are those of the individual authors.

The CSIR is one of the leading scientific and technology research, development and implementation organisations in Africa. For more information, please go to www.csir.co.za

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If you are interested in contributing to the Forum, please contact Jude Cobbing (above). Articles should be less than 800 words, and pictures or diagrams are welcome.

In this issue:

Groundwater and Mining in the Witwatersrand Basin – a historical perspective - *Dr. Johan de Beer, CSIR (retired)*

The Witwatersrand Basin has been the greatest source of gold in the world and groundwater has played a pivotal role in its development.

The Witwatersrand Basin is a roughly oval structure, 350 km long in a northeast-southwest direction and 150 km across. The Witwatersrand Supergroup, deposited between 3000 and 2700 million years ago, consists of a lower division, the West Rand Group and an upper division, the Central Rand Group. The latter contains the gold-bearing conglomerates. The sediments have been strongly deformed and are frequently faulted. The rocks are highly indurated, have been subjected to low-grade metamorphism and mostly silicified so that there is very little remaining pore space.

Water encountered in the mines is associated with joints, fractures and faults. From a groundwater perspective the Malmani dolomites from the Transvaal Supergroup is the most important overlying unit. Dykes cut the older rocks and play a very big role in the hydrogeology because they form groundwater compartments that are especially significant in the dolomites.

Water, the start of mining and the early settlement
The localities of most world cities were determined by the availability of water, but Johannesburg is different. Its locality was determined by the presence of gold.

In 1886, after the initial discovery of gold on the farm "Langlaagte" and at the start of mining, the delvers and prospectors arranged their camps close to the mining activity and drew water from fountains, hand-dug wells and local creeks.

Water is, of course, essential for human consumption, but mining without water is impossible. In 1898 the Waterworks Company requested the geologist Dr Draper to find a good supply of water. He sited a borehole at Zuurbekom, some 27 km south of the town, and this source has been used ever since.

Until 1903 the supply of water was entirely in the hands of private companies. That year the Rand Water Board, a non-profit statutory organisation focused on bulk water supply, came into being. By 1908 the board's sources of water supply to Johannesburg were as follows: There were two unused wells at Milner Park. There was a well at the Staib Street depot of the board and three boreholes at New Doornfontein. The rest of the water was drawn from boreholes at Zwartkopjes, south of Johannesburg (the biggest supply) as well as at Zuurbekom. In 1923 the first water from the Vaal River Barrage reached the city and the shortages and very high dependence on groundwater started declining.

Expansion of mining
At the end of the 1800s the Witpoortje Break formed the western boundary of the Rand. In 1910 the Pullinger brothers came very close to finding the westward extension when they sank a shaft on the site of the subsequent Venterspost mine. The shaft was abandoned when they struck huge quantities of water at a depth of about 30 m below surface in the dolomite and operations were flooded out.

The extension of the gold fields to the east also took time, because the Witwatersrand rocks were overlain by dolomites and Karoo age strata. In 1908 the Geduld Mine started operations on the East Rand, but a drive released an enormous in-rush of water which flooded the mine and put back production by eighteen months.

In the 1930s Dr Rudolph Krahmann, a German geophysicist, used magnetometer data to map the westward extension of magnetic shales in the West Rand Group under the dolomites, and by inference the gold-bearing Central Rand Group. Drilling spectacularly confirmed the geophysical results, but the six new mines of the West Wits Line were not brought into production easily.

Modern-day groundwater discharge from a mine near Krugersdorp, Gauteng Province (picture: J Cobbing).

The surface dolomites are often more than a kilometre thick, could be weathered down to a depth of 200m and often contain vast volumes of water. The shaft sinkers used the Francois cementation process to stem the huge influxes of groundwater. This was however not the final battle with water. Considerable volumes of water have been found in all the goldfields, which lead to the pumping of water to prevent the flooding of workings.

In December 1962 at West Driefontein the dolomitic rocks at surface also led to one of the most catastrophic sinkhole events in recorded history, when 29 lives were lost by the sudden disappearance of the three-storey crushing plant into a collapse that measured more than 50 m across. In 1964 a house on Blyvooruitzicht Mine disappeared into a sinkhole with the loss of a family of five.

Water at times entered the mines catastrophically, as happened at West Driefontein in November 1968. At the height of the inflow 450 000 cubic metres a day was entering the mine. The pumps could not handle it and the mine had to be evacuated. Plugs were set in underground workings and emergency pumps were installed to save the mine. After this event the dewatering of the Venterspost, Bank and Oberholzer compartments started. Even the Free State mines encountered severe water problems. An inrush of water flooded the Merriespruit Mine in 1956 and it was only dewatered after 1963.

Down-scaling of mining

During the expansion of mining the threat of groundwater to mining was effectively handled by pumping programmes and the dewatering of dolomitic compartments. As a mine reaches the end of its lifetime and closes, and if the water generated from that mine is no longer pumped, it can enter other mines through interconnected workings or geological structures. By flowing through the old workings, the water is polluted, primarily through the oxidation of sulphide materials which occur in the primary ore. The resulting acid mine drainage contains large quantities of salts (sulphate and chloride), significant concentrations of toxic heavy metals and trace elements such as copper and arsenic as well as radionuclides.

Gold production peaked in 1997 and as the mining in large parts of the basin draws to a close, the environmental threat of polluted mine-water decanting at the surface has become a reality. This legacy is a challenge that will keep the groundwater community engaged for many years to come.

Dr. Johan de Beer (JHdeBeer@mweb.co.za) retired at the end of March 2006 as head of the Water Resources Competence Area after 41 years associated with the CSIR.

Groundwater and Rural Water Supply in Africa – *Dr. Alan MacDonald, British Geological Survey*

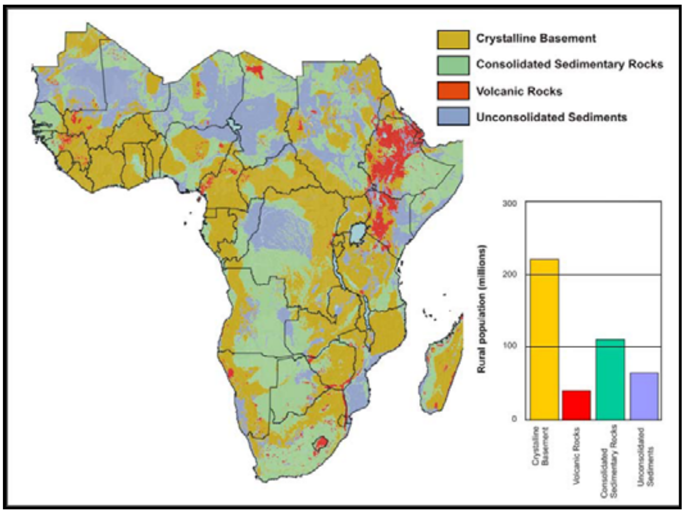
There are still at least 1.1 billion people across the world without access to safe drinking water. Many of these people live in rural areas and are among the poorest and most vulnerable to be found anywhere in the world. In sub - Saharan Africa, 300 million people have no access to safe water supplies – approximately 80% live in rural areas. Significantly increasing the coverage of rural water supply in Africa is fundamental to achieving many of the internationally agreed Millennium Development Goals (MDGs).

Why groundwater?

Over much of Africa, groundwater is the only realistic water supply option for meeting dispersed rural demand. Alternative water resources can be unreliable and difficult or expensive to develop: surface water is prone to contamination, often seasonal, and needs to be piped to the point of need; rainwater harvesting is expensive and requires good rainfall throughout the year.

• Groundwater resources are often resistant to drought.
• Groundwater can generally be found close to the point of demand (if you look hard enough with appropriate expertise).
• Groundwater is generally of excellent natural quality and requires no prior treatment.
• Groundwater can be developed incrementally, and often accessed cheaply.
• The technology is often amenable to community operation and management.
• Groundwater is naturally protected from contamination.

Existing information that is vital for developing groundwater resources is not readily accessible. Lessons learnt from successful or unsuccessful projects are not being used incrementally as a basis for new projects.



A simplified hydrogeological map of sub - Saharan Africa with an insert showing the number of rural people living on each of the hydrogeological environments (map: A MacDonald).

• Basic information, such as geological and groundwater maps, are missing or difficult to get.

• Grey literature, such as consultants' reports, is not collated and the knowledge is lost to other projects and future generations.
• Databases of borehole data and water quality, which have proved so useful in many countries, have now fossilised – or been lost.

As a result, some are drilling boreholes almost blind, with often very poor success rates and poor quality water – this is an ineffective use of funds. Even in new projects, the lack of groundwater expertise referred to above often does not allow proper collection of new data – which in its turn would support future work.

Critical Research Gaps

The required increase in development of groundwater resources to help meet the MDGs for water has raised the significance of several research questions. These research issues must be addressed to increase effectiveness of rural water supply projects and to ensure security and sustainability of supply:

Finding groundwater in difficult areas. Areas where sustainable groundwater sources are hard to find (such as poorly weathered bedrock and mudstone areas) often have the greatest problems with health and poverty. Helping to solve water problems in these difficult areas may have greater impact on reducing poverty in sub- Saharan Africa than drilling many more boreholes in areas where it is relatively easy to find water.

Groundwater quality and health. Elevated concentrations of naturally occurring elements in water, such as arsenic and fluoride, can have catastrophic health impacts on local communities. Little is known about the distribution of these elements across Africa and the environmental factors which control their distribution at a village level. Much more needs to be known about where these elements are likely to be elevated and how to mitigate the impacts.

Drought and climate change. How sustainable are water points during periods of drought? Initial research has indicated that there are many factors that determine how resilient groundwater resources are to drought. Little is known about the variation of these factors, and in particular how renewable groundwater resources are. New research is critical to stop groundwater resources being exploited unsustainably, and to help design water supplies which are drought resistant.

Protecting groundwater resources. On-site sanitation, although critical to the success of water projects and health of communities, can contaminate local groundwater resources. With the current focus on increasing access to sanitation, urgent research is required to ensure that this is done without compromising the quality of groundwater resources on which community water supplies depend.

Dr. Alan MacDonald (amm@bgs.ac.uk) is a hydrogeologist at the British Geological Survey, and is based in Edinburgh, Scotland. This contribution is extracted from a briefing note prepared for the Burdon Groundwater Network of the International Association of Hydrogeologists, which aims to support those working towards the MDGs for water.

Groundwater and Governance in southern Africa – *Dr. Tony Turton, CSIR*

Groundwater is a particularly important resource in southern Africa, since most of the region receives rainfall considerably below the world mean of 860 mm/a and surface water is consequently scarce and unreliable in places. Three basic threats to groundwater are of particular importance: over-utilisation, pollution resulting from the mismanagement of aquifers, and potentially reduced recharge as a result of global climate change.

The first two of these threats can be minimised by the competent management of groundwater, a task which is particularly important in the context of a developing country that needs to sustain rural livelihoods as a core element of social stability.

Plans for managing groundwater are further complicated in southern Africa by the fact that many aquifers straddle international borders, or are "transboundary" in nature, and therefore international cooperation is required for efficient management. It is notable that although there are more transboundary aquifers than transboundary river systems in southern Africa, international agreements aimed at sharing surface water resources far outnumber those that are designed for groundwater management.

Work at the CSIR has shown that management of aquifer systems in southern Africa can sometimes be enhanced if a particular theoretical framework, known as a Trialogue, is adopted. The Trialogue model holds that there are three principal groups important in the management of groundwater, and that efficient management depends on productive engagement between the three. These three groups can be referred to as "Actor-Clusters", since each can be sub-divided into three main elements. The clusters are:

1) **Government**; which can be sub-divided into the legislature, the executive and the judiciary

2) **Society**; which can be sub-divided into civil society, the economy and the natural environment in which these are found

3) **Science**; which can be sub-divided into the natural sciences, the social sciences, and tertiary educational institutions which provide human capital

Complex relationships exist between the three "Actor-Clusters", as well as between the elements making up each cluster. The clusters act in dynamic equilibrium with each other, each being connected by means of a two-way interface.

It seems reasonable to conclude that the quality of those interfaces is of key importance, to the extent that any serious study of governance is likely to benefit by treating these as independent variables in their own right, and this is a core assertion of the Trialogue model of Governance being developed by the CSIR. For example, the quality of the three interfaces determines the extent to which Government can generate the incentives needed to develop Society by allowing Science to inform the decision making process.

By focusing on the interfaces between the "Actor-Clusters", and by testing different scenarios which depend on the effectiveness of the interfaces, it is possible to reach a clearer understanding of the constraints on better groundwater governance. This approach has been trialled in case studies in southern Africa, and has proved to be a useful way to identify the most preferable option, generally one that involves voluntary cooperation between Government and Society, with Science playing a supporting role by providing unbiased technical information.

Dr. Tony Turton (aturton@csir.co.za) is Research Group Leader of the Water Resource Management Group at the CSIR, and the head of the African Water Issues Research Group (AWIRU) at the University of Pretoria. This is an extract from a paper he presented at the International Symposium on Groundwater on 24-27 January 2006 in Alicant, Spain.

GROUNDWATER-FRIENDLY SANITATION TECHNOLOGY FOR AFRICA - *Aussie Austin, CSIR*

Sanitation is an extremely complex issue. It is an issue that impacts upon the daily lives of every human being inhabiting this planet, particularly in developing countries where the level of service may be either poor or non-existent. Because sanitation is part of the water cycle, the environmental effects are of concern to us, not only where the service is poor but also in areas that are serviced by seemingly well-operating flushing toilets and sewerage systems. As a result of faulty design, improper operation and lack of maintenance of most kinds of sanitation systems, human excreta contaminate the environment, negatively affecting people, soils and water resources.

Worldwide, ecological problems have resulted from an increasing inability to deal with untreated faeces and sewage. Some developing countries treat only about 10% of their sewage, and even in South Africa reports have indicated that an alarming proportion of sewage in many towns and cities across the country does not reach treatment plants but flows untreated into the rivers. This is regarded as one of the most pressing water quality problems in the country. In many cases, even when sewage reaches the treatment plant, poor operation and malfunction of systems means that partially treated effluent is discharged into the environment. Pollution is not restricted to waterborne sanitation systems, however; where poorly conceived and implemented dry sanitation schemes exist, the negative effects on both surface and groundwater may be considerable.

These problems are endemic to many countries and have undermined development, especially where there is rapid population growth. More attention needs to be paid to the environmental aspects of sanitation systems, especially soil and groundwater, and the technology selected should take cognisance of local conditions.

It is better to protect the environment from faecal pollution than to undertake expensive measures to reduce pollution that has already taken place. Sanitation provision should therefore be ecologically sustainable and not pollute ecosystems and water resources.

As a first step in providing ecologically-friendly sanitation, it should be recognised that waste should be managed as close as possible to its source, preferably without using water to dilute or transport it. Sanitation approaches based on flush toilets, sewers and central treatment plants cannot solve the sanitation problem and should be avoided where possible. The problem is not one of "sewage disposal", but rather the disposal of human faeces and urine.

To handle faeces and urine separately is not a great problem, as the human body produces only about 50 litres of faeces and 500 litres of urine per year. The problem arises when these two are mixed together, because a heavily polluted substance (faeces) is allowed to contaminate a relatively sterile one (urine), and the liquid fraction (including any water that may be added) provides a transport medium for the dangerous faecal material. Urine and faeces should therefore preferably be kept apart from the beginning and not flushed into a sewer or allowed to percolate together into the soil. This approach has given rise to a dry sanitation technology called urine diversion, which isolates pathogens from the environment.

The technology of urine diversion has been used successfully for many years in a number of developing countries, e.g. Vietnam, China, Mexico, El Salvador, Ecuador, Guatemala and Ethiopia, and recently also in a number of African countries, including South Africa where over 40 000 such toilets have already been constructed. CSIR introduced the first urine diversion systems in the country in 1997, in a pilot project near Mthatha, Eastern Cape. The urine is diverted at source by a specially designed pedestal and is not mixed with the faeces. A schematic representation is given in the figure.

A pit is not necessary as the entire structure may be constructed above ground, or may even be inside the dwelling. Ash, dry soil or sawdust is sprinkled over the faeces after each defecation. The ash absorbs the moisture and also controls odours and flies. The dry conditions facilitate rapid desiccation of the faeces and facilitate pathogen die-off, thus making the faeces safe to use.

The desiccated faeces make a good soil conditioner, while the "clean" urine is an excellent source of fertiliser, being rich in nitrogen, phosphorus and potassium. This has important implications for thousands of communities who rely on subsistence agriculture. However, use of the processed excreta is not a precondition for implementation of this technology, as they can be easily disposed of without damage to the environment.

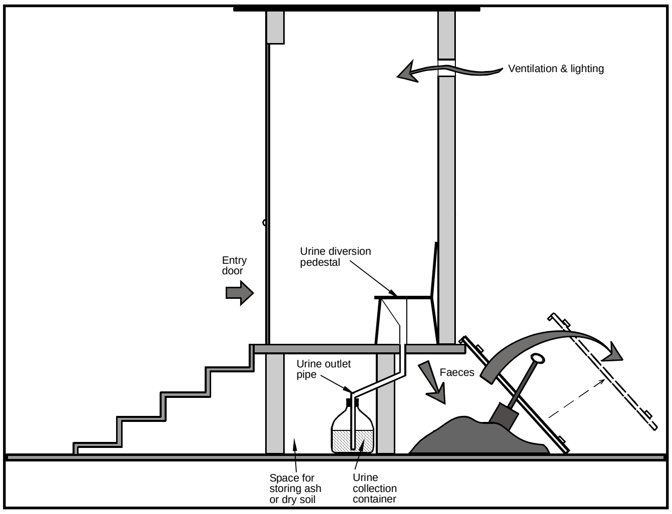


Diagram of a urine diversion "dry sanitation" system (diagram: Aussie Austin).

Aussie Austin (laustin@csir.co.za) is a civil engineer in the Built Environment Unit at the CSIR specialising in alternative sanitation technologies and water resources engineering.

An introduction to the African Ministers Council on Water, the African Water Facility and the African Development Bank – *Jude Cobbing, CSIR*

Background

The African Ministers Council on Water (AMCOW) was formally launched in Abuja, Nigeria, on April 30 2002 to provide political leadership in the provision, use and management of water resources in Africa. AMCOW also aimed to strengthen the ability of governments to provide water and sanitation to Africans.

In 2005 AMCOW set up the Africa Water Facility (AWF) to raise money, accelerate investments and coordinate financial support for water in Africa. The AWF focuses on two main types of activity: Faciliation (such as planning, capacity building, information and knowledge, and monitoring and evaluation); and Investment Programmes, aimed at service delivery.

The AWF is set to raise US$615 million over the next five years, of which about two thirds will be allocated to capital investments, whilst much of the rest will go to facilitation activities. A Governing Council of thirteen members determines the general policy direction of the AWF.

The AWF aims to work within the framework of the African Water Vision, laid out at the Second World Water Forum in The Hague in 2000 by African Ministers of Water Resources, and in accordance with NEPAD principles. The Millennium Development Goals (MDGs) provide a target or benchmark for investments and initiatives.

The AWF operates as a Special Fund under the African Development Bank (ADB), and the ADB board of directors is responsible for the general functioning of the AWF. The ADB retains a Director of the AWF, who is appointed by the President of the ADB, and who is supported by an administrative team.

Mr Bedoumra, Director of the AWF, and Mr M P Compaore, Burkina Faso Minister of Finances and Budget signing the AWF's recent grant agreement in Ouagadougou (picture courtesy of the ADB's website).

The ADB fulfill a similar role to the World Bank, but focus on Africa – as a development bank, they provide concessional loans and grants to support development on the continent. They are based in Tunis, and the current President is Donald Kaberuka, who took office on 1st September 2005. The ADB have recognised the critical role of water to development in Africa, and apart from supporting the AWF, the ADB invests in this field via their own Rural Water Supply and Sanitation Initiative (RWSSI).

So what does this all mean for the CSIR and groundwater?

Whilst much of the work of the AWF will be directed towards infrastructure, it is likely that impartial scientific advice will be required from time to time to ensure the most efficient allocation of resources. As one of the largest research organisations on the continent, the CSIR is well placed to make a substantial contribution. Much work lies ahead for the AWF, and since groundwater is critical to rural water supplies in Africa (see Alan MacDonald's article in this Forum), hydrogeologists will be needed.

The African Water Facility has got off to a good start – the first grant (165 000 Euros) was made on 6 April 2006 to support the establishment of the Volta Basin Authority, which will facilitate cooperation between Burkina Faso, Ghana, Cote d'Ivoire, Togo, Benin and Mali in the management of the water resources of this important river basin.

Jude Cobbing (jcobbing@csir.co.za) is a hydrogeologist in the Groundwater Research Group at the CSIR. His interests include African water supply issues and the development of groundwater across the continent.