ACTIVITY ONE: WATER QUALITY IN OUR RIVERS

This LIFE SCIENCES lesson looks at visible animal life to determine the health of our rivers and streams.

miniSASS is a simplified form of the South African Scoring System. It is a technique that can be used to measure the health of a river and the general water quality in that river. Developed by Umgeni Water and Ezemvelo KZN Wildlife, it uses the composition of invertebrates living in rivers and is based on the sensitivity of various animals to water quality. However, it does not measure bacterial or viral contamination of the water, so it is unable to determine if the water is potable (you can drink it) or not.

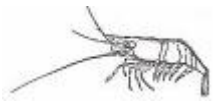
So, are you ready for some environmental action and to find out the condition of your stream or river?

1. The best place to find insects is where the water is fairly fast flowing, and where there is some vegetation growing in, or on the edge of the river.

2. Look for invertebrates in as many of the different habitats as you can find at the river site. The insects can be collected by holding a small net/sieve in the current and then disturbing stones, vegetation and sand just upstream of the net. The current will then wash the dislodged invertebrates into the net. Turn stones over and brush invertebrates off using a clean paintbrush or your hand. Do this for about 5 minutes while ranging across the various riverine habitats.

3. Rinse the mud from the net and place the contents into a plastic tray (2 litre ice cream container). Ensure there is water in the container for those invertebrates collected from the stream.

4. Identify each group using the identification sheet given on page 2. **Once you have finished identifying the sampled invertebrates, they must be carefully returned to the river.**



Flat worms

Flat worms are characterised by their flattened shape and soft bodied, worm-like form. They have an arrow-shaped head with two dorsal eyespots and are generally mottled or dark grey in colour. Flatworms move with a gliding action and are generally scavengers or carnivores.

Leeches

Leeches are segmented organisms that have very flexible bodies. When moving they expand to become long and thin, and then contract to become short and stubby. They have suckers on both ends of the body that are used for feeding and locomotion. Leeches are variable in colour, from grey, to red brown and black. They swim with a fast, snaking movement and are found under stones, vegetation and debris.

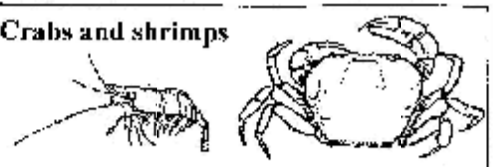
Worms

Worms are long and segmented and have a cylindrical shape much like small earth worms. Their colouring is usually pink to brown. They are usually seen writhing around in debris digesting the substrate they feed on.

Snails

Snails are molluscs with hard shells that vary in size, shape and colour. Habitats vary, with some snails such as limpets clinging to rocks, whereas clams and muscles are found in sand. The more common snails move over stones and vegetation. Some snails are host to bilharzia, a serious health hazard for humans.

Crabs and shrimps

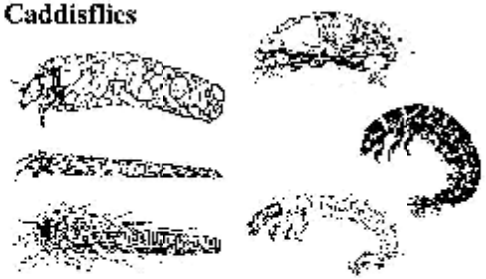


Crabs and shrimp form part of the order Decopoda (ten legs) and have bodies and legs hardened to form a tough shell. They have four or five pairs of legs, and eyes that are carried on stalks and are movable. Crabs are scavengers that feed mainly on leaf litter but will feed on animals when given the chance. Shrimps are mostly scavengers or deposit feeders.

Stoneflies

The nymphs of adult stone flies usually have two long tails and three pairs of legs each having two claws at the tip. A characteristic feature of stonefly nymphs are the tufts of gills on the side of the body as well as gills between the two tails. Wing pads on the thorax are often dark and obvious. Some species run across the substrate very efficiently and are potent predators on other invertebrates. Other species are smaller and feed on plant material. Most live in well oxygenated, clean water.

Caddisflies



The aquatic larvae of adult caddisflies have a hard head with three pairs of legs which are attached to an elongated, soft body. Finger-like gills on the abdomen and anal appendages can be seen with the naked eye. Some caddisflies construct portable shelters/cases from sand grains, bits of vegetation and/or silk that are glued together to form a characteristic case shape. Most of the case-building types cannot swim whereas the case-less type swim freely across the substrate. Some feed on algae and detritus whereas others are predators.

Damselflies

Damselflies have elongated bodies with generally three broad tails/gills on the tip of the abdomen. Damselflies are carnivorous and have a 'mask' over the lower part of the face which hinges out to reveal a pair of pincers with which they catch their prey. They are often to be found in vegetation growing on the edge of rivers.

Dragonflies

Dragonfly nymphs are robust creatures that are stout and have a large head and protruding eyes. Some have short legs whilst others have long legs. They do not have tails, but swim using 'jet propulsion' by forcefully ejecting water from the abdomen. Dragonfly nymphs are usually the largest organisms found in a sample and are the most powerful invertebrate predators in the water.

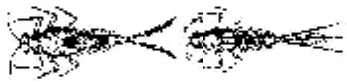
Bugs and Beetles

Bugs can be defined as having a piercing and sucking beak for mouthparts, and two pairs of membranous wings. Beetles on the other hand have 'jaws' and outer wings that are hardened to protect the inner wings. Some bugs and beetles are well adapted to swimming, such as water boatmen, backswimmers, pond skaters and water striders. Most bugs and beetles are carnivorous, but some feed on algae.

Mayflies

Mayfly nymphs vary greatly in shape and size and live only for a day or two. In this time they will never feed and live to mate and lay eggs in the water. Mayflies fly close to rivers and lakes, usually swarming in the early evenings.

Minnow mayflies

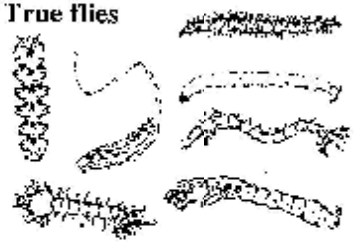


These mayflies have a narrow head and a small, slender, but not flattened body. They have leaf shaped gills on both sides of the abdomen and two but more commonly three tails, depending on the species.

Other mayflies

Other mayflies are characterised by an elongated body, large head, well-developed mouthparts and stout legs. They live in a variety of habitats including burrowing in mud, crawling amongst decaying leaves, and scurrying over stones in fast flowing currents.

True flies



Most fly larvae have a fairly indistinct head but elaborate tail ends. They often have small, soft legs (prolegs), segmented bodies and have the appearance of maggots. Some have bristles/ spines and antennae. True flies live in a variety of habitats including sand, mud and stones in fast flowing water. They can either be carnivorous or filter feeders.

Scoring:

1. On the table below, circle the sensitivity scores of the identified insects.
2. Add up all of the sensitivity scores.
3. Divide the total of the sensitivity score by the number of groups identified.
4. The result is the average score, which can be interpreted below.

GROUPS	SENSITIVITY SCORE
Flat worms	3
Worms	3
Leeches	2
Crabs or shrimps	7
Stoneflies	14
Minnow mayflies	6
Other mayflies	13
Damselflies	4
Dragonflies	7
Bugs or beetles	6
Caddisflies	9
True flies	2
Snails	4
TOTAL SCORE	
NUMBER OF GROUPS	
AVERAGE SCORE (Divide 'Total' by 'Number of groups')	

Interpretation of the miniSASS score:

Although an ideal sample site has rocky, sandy, and vegetation habitats, not all habitats are always present at a site. If your river does not have rocky habitats use the **sandy type** category below to interpret your scores.

Ecological category (Condition)	River Category	
	Sandy Type	**Rocky Type**
Unmodified (**NATURAL** condition)	> 6.9	> 7.9
Largely natural/few modifications (**GOOD** condition)	5.8 to 6.9	6.8 to 7.9
Moderately modified (**FAIR** condition)	4.9 to 5.8	6.1 to 6.8
Largely modified (**POOR** condition)	4.3 to 4.9	5.1 to 6.1
Seriously/critical modified (**VERY POOR** condition)	<4.3	<5.1

Send your results to minisass@ground-truth.co.za to contribute to a developing picture of river quality in SA. miniSASS is available from Share-Net, PO Box 394, Howick, 3290.

Tel (033) 3303931 extension 124/143/144 or download it from www.ground-truth.co.za

Report

1. Write a report on the findings of this water quality assessment. Your report should take the form of an experiment, with the following headings:
    - Aims
    - Objectives
    - Methodology
    - Results
    - Discussion
    - Conclusion

    Your discussion should include possible causes of poor water quality, if this is the case. Or, if the water quality is good then reasons for this should also be given.

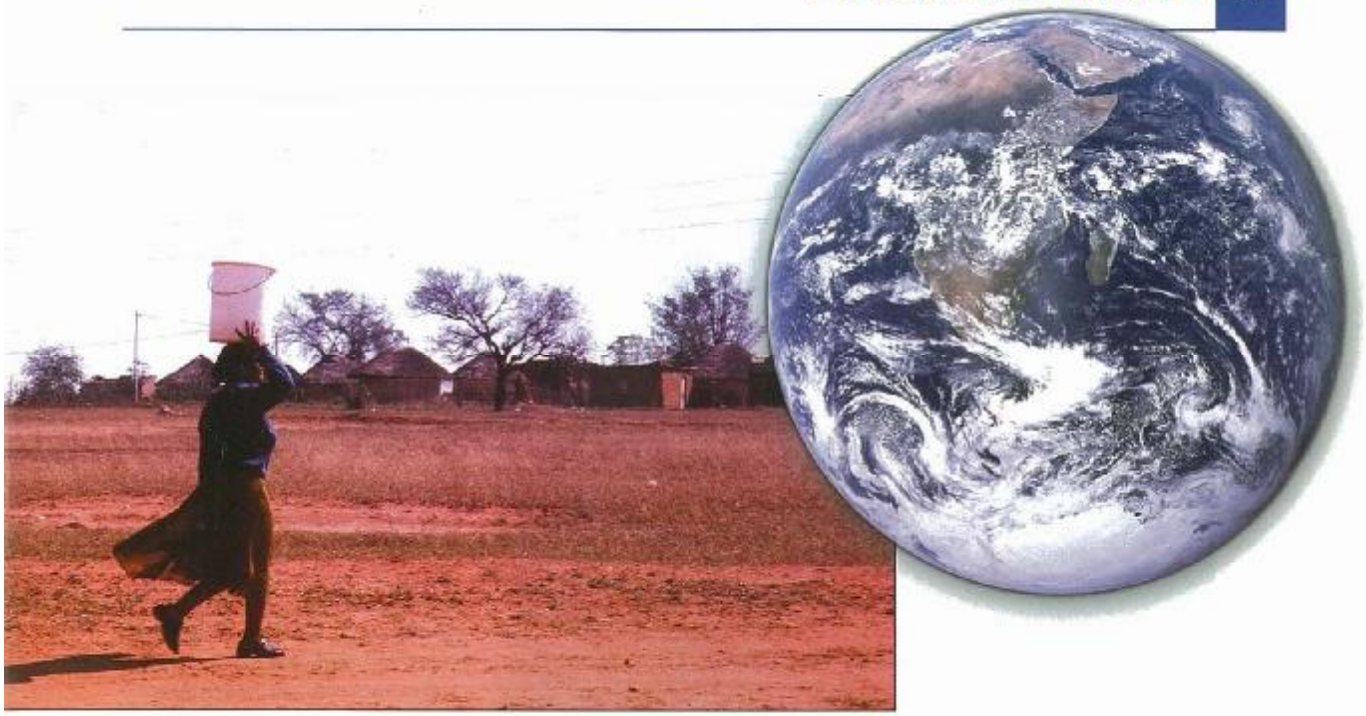
Criteria to assess learners during this life sciences lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner complied with the instructions given by the teacher.						
The learner collected invertebrates and added the data to a given table.						
The report covers the relevant headings.						
The report is written logically, using the learner's own vocabulary.						
The report demonstrates that the learner has grasped the concept and importance of river quality						

ACTIVITY TWO: CLIMATE CHANGE IN SOUTH AFRICA

During this GEOGRAPHY lesson, learners look at the impacts that climate change may have on the water quality within South African rivers and resources.

Give learners a copy of the article *"Climate Change: The Last Straw for Communities at Risk?"* on pages 5 to 9 and let them read through it. Explain terms that they may not understand.



CLIMATE CHANGE:

The Last Straw for Communities at Risk?

Much has been said about the potential effects human induced climate change will have on Southern Africa, its biodiversity, its water resources, the economy of the region and the health of its people. However, this phenomenon is only one stressor in the lives of the area's most vulnerable communities, and should not be viewed in isolation, experts warn. Lani Holtzhausen reports.

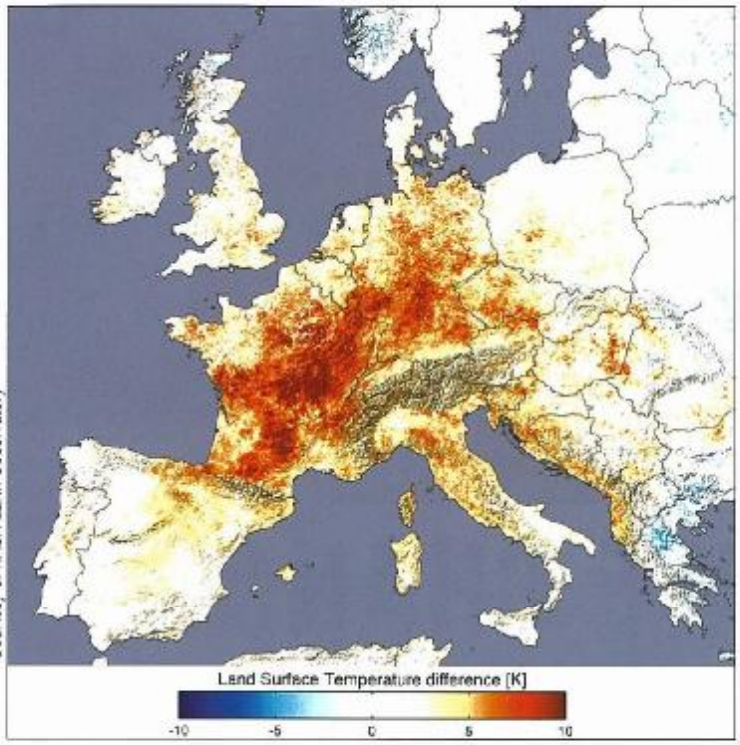
Most scientists agree that climate change is happening, and will continue to happen in the foreseeable future even if the global gas emissions responsible for this phenomenon are curtailed significantly in the short to medium term. According to South Africa's National Climate Change Response Strategy, approved by Cabinet in September 2004, there is now more confidence than ever before that global climate change is a threat to sustainable development, especially in developing countries. It could undermine global poverty alleviation efforts, and have severe implications for food security, clean water, energy supply, environmental health and human settlements.

Research funded by the Water Research Commission (WRC) has confirmed this, with credible regional projections made available using the latest general circulation models, as well as regional climate models and empirical downscaling techniques. "This is the closest we have ever come in South Africa in projecting exactly what will happen to the region as a result of climate change," reports Prof Bruce Hewitson of the Climate Systems Analysis Group at the University of Cape Town. The other universities who participated in this collaboration were the universities of KwaZulu-Natal (KZN), Pretoria and Witwatersrand (Wits).

HIGHER TEMPERATURES, LOWER RAINFALL

The country as a whole is projected to become warmer, with the highest

increases in the interior. Increases in temperature is already being experienced, with 2005 expected to become the warmest year on record, beating 1998 as the warmest year yet recorded. Higher temperatures mean more evaporation, which is projected to increase by 10% to 20%.



Courtesy of NASA Earth Observatory

"Increases in temperature is already being experienced, with 2005 expected to become the warmest year on record, beating 1998 as the warmest year yet recorded."

This is not great news for a country such as South Africa which already has a high-risk hydroclimatic environment, with low rainfall to runoff conversion and a high inter-annual variability of climate. According to Prof Roland Schulze of KZN University this implies increased evaporation and water losses from dams and increased irrigation demand as soils will dry out more often. "The impact of climate change on the water sector might be felt on the water sector sooner than we think. We could see a significant reduction in runoff in

Left: Europe experienced a historic heatwave in 2003. Here the daytime land surface temperatures of 2003 compared to the previous three years are shown.

COULD SA FARMERS SUE FOR CLIMATE CHANGE DAMAGE?

In the not too distant future, a group of local farmers lose their maize crops due to a severe drought. They go on to sue a number of international fossil fuel companies for damages caused by human-induced global warming.

Improbable? Perhaps not, maintains Myles Allen of the Department of Physics at Oxford University. Speaking via telephone link at the National Climate Change Conference in October last year, he said that civil liability could be another vehicle for redistributing the costs of climate change and reducing emissions. "There is increasingly strong evidence for the human influence on global and regional temperature changes," he told delegates, citing the example of the 2003 European heat wave which led to more than US$10-billion of uninsured damages and between 22 000 and 35 000 heat-related deaths.

According to Allen, the contribution of past greenhouse gas emissions to some present climate risks, including recurring droughts in southern Africa, may already exceed 50% – the threshold for civil tort actions. By 2030 more than 50% of anthropogenic greenhouse gas loading will be due to post 1990 emissions.

"Plaintiffs must show that, more probably than not, their individual injuries were caused by the risk factor in question, as opposed to any other cause. So we must ask how human influence on climate has affected the risk of an extreme weather event." But who will be the defendants? Allen explained that about 80% of the present greenhouse gas emissions emanated from the products sold by no more than 20 identifiable companies.

Over the coming decade, both the cost and inevitability of climate change will become clearer, fuelling demands for compensation for floods and droughts, heat wave damages and deaths, threats to water supplies, coastal erosion and hurricanes, he maintained. "The risk, even if remote, of a successful class-action damages suit would have far more impact than any conceivable follow-up to the Kyoto Protocol."

certain areas in the west of the country by as early as 2015," he says.

At the same time the eastern half of South Africa, especially the escarpment and eastward is likely to become wetter, with more rainy days and increases in rainfall intensity, which have implications for, for example, soil erosion and flooding. On the positive side, this might result in greater groundwater recharge. The interior regions to the west of the eastern escarpment show more ambiguous changes in rainfall, with some parts likely to experience slight increases and other slight decreases.

Worrying, however, is that most winter months in the Western Cape show a drying trend. This is consistent with the suggestions that the region will experience weaker frontal systems, whose core will be further south than at present. There are also suggestions across the country of increased inter-annual variability. This means we are likely to see more floods and droughts, with prolonged dry spells being followed by intense storms.

All aspects of the water sector will be affected, including water supply, the incidence of waterborne diseases, and even the Ecological Reserve. South Africa might even have to renegotiate its international water agreements with its neighbours with whom it shares 70% of its water resources.

VULNERABLE COMMUNITIES

But climate change is not only about changes in the earth system, it is also about the impact of these changes on vulnerable communities. According to Prof Coleen Vogel, Professor: BMW Chair in Sustainability at Wits, research into climate change has been largely one dimensional to date. "For many, the focus thus far has been on the projected impacts of climate change, for example, on the environment, human health, and water resources. We need a multi-faceted approach to climate change, focusing particularly on the human dimension of this phenomenon."

It is believed that the impacts on both rural and urban communities, particularly in the absence of effective risk-reduction strategies, are expected to be significant in a changing climate scenario and require an effective response. In communities where access to clean water is already a problem, a slight decrease in rainfall has an amplified effect, for example. So climate change will become another stress that cities have to deal with, along with growing informal settlements, pollution, poverty, and health issues, to name but a few.

WHAT THEY SAY ABOUT CLIMATE CHANGE

"From improved disaster management and emergency response planning to the decisions we make about the materials to build our houses, climate change will require adaptation in almost all spheres of life." – **Minister of Environmental Affairs & Tourism, Marthinus van Schalkwyk**

"We run the risk that our grandchildren and great grandchildren may not be able to enjoy the visual splendour of the fynbos of the Western Cape or the daisies of Namaqualand." – **Minister of Minerals & Energy, Lindiwe Hendricks**

"A much neglected aspect of climate change understanding is the role that the continuing and pervasive poverty that afflicts more than a third of the people on this planet has on climate change, and the impacts that climate change will in turn have on the most marginalised in the global context." – **Minister of Science & Technology Mosibudi Mangena**

"Climate change is a serious risk to poverty reduction and threatens to undo decades of development effects." – **Minister of Agriculture, Thoko Didiza**

"We have learned to live with the fact that our water resources are scarce and highly variable in space and time. Now we will have to learn to adapt to a climate that is already changing and will continue to change – possible for 100 years – irrespective of how successful we are in reducing emissions of greenhouse gases into the atmosphere." – **Minister of Water Affairs & Forestry, Buyelwa Sonjica**

Drier conditions exacerbated by climate change could see the Cape West Coast and Namaqualand's floral splendour become a rare occurrence.

"The most pressing challenge is to strengthen the social, economic and environmental resilience of the poorest and most vulnerable against climate change and variability," notes Prof Vogel.

COMMUNITIES IN PERIL

The WRC research emphasised this with two case studies undertaken on the vulnerability of communities to climate change in the Thukela catchment in KZN. The one case study was undertaken in the small-scale community of irrigation farmers at Mūden while the other was done in a large-scale commercial sugarcane farming community in the area.

KZN has a long history of past climatic stress events, and it is possible that the area may experience future climate stresses. In addition, several farming and other livelihoods in the area are resource dependent, with many requiring water for small or larger-scale agricultural activities. The area is also characterised by high levels of poverty and other stresses, including HIV/AIDS, malaria and cholera.

"The impact of climate change on the water sector might be felt on the water sector sooner than we think. We could see a significant reduction in runoff in certain areas in the west of the country by as early as 2015."

The case studies showed that how a community deals with the risks of climate change is dependent on the context in which that community finds itself at the time, including the manner in which the community gains access to resources, how well they are linked to development activities and, more critically, how those activities are institutionalised.

In Mūden, which is already prone to droughts and flooding, research showed rather than climate change being the key and overarching 'driving' or 'stress' factor, there were several multiple stressors that enhanced vulnerability and constrained adaptive capacity of the small-scale farmers to climate change. These include lack of institutional organisation, lack of access to information and broader governance issues related with relevant authorities.

The commercial farmers, on the other hand, were almost just as vulnerable, with macro-economic and related factors, including the low price of sugar, the strong local currency, legislation, land distribution, high input costs and labour issues, enhancing their exposure to climate variability.

It is essential that all of these stressors are taken into account when assessing the vulnerability of farmers and when implementing plans for assistance and development, particularly if such events increase in frequency and magnitude, the research team concluded.

"The most pressing challenge is to strengthen the social, economic and environmental resilience of the poorest and most vulnerable against climate change and variability."

The South African government has indicated its commitment to assisting the country adapt and prepare for climate change. However, it is clear from this research that one size will not fit all when designing future institutional and local response interventions to enhance adaptation to climate variability in the short term and climate change in the longer term.

It is certain that while the picture is slowly becoming clearer, we are a long way off from knowing all there is to know from this phenomenon that is climate change. We can do little to control the timing and intensity of the expected hazardous events in the short term. All we can hope for is to increase our capacity to cope with the projected extreme climatic events, and increasing climatic variability.

Much still needs to be done to protect vulnerable communities against the onslaught of climate change.

Weather extremities brought about by climate change, such as increased flooding, is only one of the stresses vulnerable communities in urban areas have to deal with.

NEWSFLASH – NEW BOOK ON CLIMATE CHANGE IN AFRICA

A new publication on climate change in Africa is due to be published this year.

Funded by the organisation, System for Analysis Research and Training (START), the book will be an updated, reviewed, scientific synthesis of global change research in sub-Saharan Africa over the last few years, according to Editor Luanne Otter of the Climatology Research Group at the University of the Witwatersrand. Featuring authors from Africa, the book will be presented in five parts, namely past and present climates; human elements; major elements of water, carbon and nitrogen; transport and transformations; global change impacts; the vulnerability of Africa to global change and the adaptations required to adjust to these changes. For more information, visit http://crg.bcb.wits.ac.za or E-mail: Luanne@crg.bcb.wits.ac.za

The Water Wheel January/February 2006

Report:
Write a report on the impacts that climate change may have on the water quality in South African rivers, streams, dams and lakes.

Remember: *Climate change is an extremely broad topic. Do not try to cover the whole topic. Focus on a single topic, and a single region as climate change varies from region to region (an example of a focus could be the impact of a change in temperature and the effect that this may have on Cholera). Remember there is much uncertainty about climate change, so you must cover both sides of an argument. Sources of information: Internet; newer books (Climate change is a fairly new subject); the Department of Water Affairs and Forestry; Google scholar; climate related websites.*

Your report should have the following headings:

- **Introduction**
- **Literature review** (Writing in your own words what has already been established by other researchers, e.g. trends in weather patterns and the effects on water quality).
- **Discussion** (Discuss the differing views that you will have come across in the literature review and give an opinion as to what you think may occur based on the literature).
- **Conclusion**

As a class:
Once the learners have written their reports, discuss climate change, focusing on the potential impacts on South Africa.

Criteria to assess learners during this geography lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner was able to acquire information correctly and from relevant sources.						
The learner did not deviate from the topic of water quality and climate change.						
The learner demonstrated coherent essay structure.						
The report is written logically, using the learner's own vocabulary.						
The learner answered the question satisfactorily as regards to climate change and water quality.						

ACTIVITY THREE: METHODS OF WATER QUALITY MONITORING

During this LANGUAGES lesson, learners look at an article covering water quality and then do a comparison between this type of water quality assessment and various other types. Following this activity, is a comprehension.

Essay:
Read through the article on pages 12-14, *'Diatoms – A New Dimension to Water Monitoring'*. Write an essay comparing water monitoring using diatoms versus other water monitoring techniques that you may think of. An example would be water monitoring using diatoms versus water monitoring using macroinvertebrates. *Research on this topic will have to be done using the Internet, books, magazines, scientific journals etc.*

Comprehension:
Using the article on pages 12 to 14, '*Diatoms – A New Dimension to Water Monitoring',* answer the questions that follow. The questions must be answered in full sentences unless stated otherwise.

1. In **your own words** explain how diatoms are used to assess water quality.

2. Until recently, the use of diatom monitoring in South Africa has been non-existent. Why, and what has been used in its place?

3. How do diatoms differ from other biotic indices?

4. In your opinion, is it better to assess water quality using diatoms or other biotic indices?

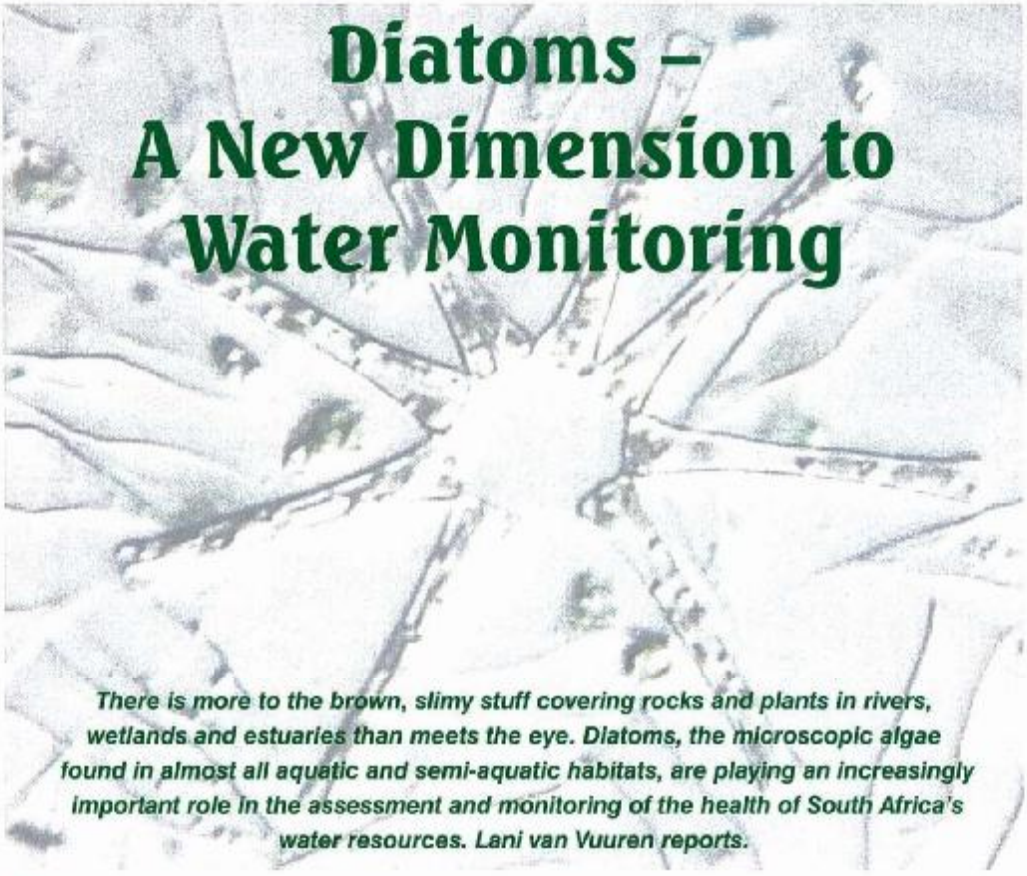
5. Can diatoms be used to assess conditions in past river systems? Explain.

6. Can diatom indices be used on rivers that have stopped flowing, such as seasonal rivers? Explain.

7. As far as human resources are concerned, what is one of the main challenges in South Africa?

8. What happens to cosmopolitan species, which are tolerant to pollution, when naturally prevailing conditions change?

Diatoms – A New Dimension to Water Monitoring



There is more to the brown, slimy stuff covering rocks and plants in rivers, wetlands and estuaries than meets the eye. Diatoms, the microscopic algae found in almost all aquatic and semi-aquatic habitats, are playing an increasingly important role in the assessment and monitoring of the health of South Africa's water resources. Lani van Vuuren reports.

Diatoms are one of the most common types of phytoplankton. They are delicate unicellular organisms that have a yellow-brown chloroplast (rather than a green chloroplast colour) that enables them to photosynthesise.

Dr Bill Harding of DH Consulting, a phytoplankton ecologist, explains that the cell walls ("skeletons") of diatoms are made of silica, almost like a glass house. The construction of the cell wall, called the frustule, consists of two halves (known as 'valves') that fit into each other like a pill box. These valves are ornamented by a variety of other structures.

Diatoms were discovered shortly after the invention of the microscope. It is reported that their varied shapes and beautiful ornamentation of their cell walls made the study of the diatoms and related siliceous organisms a favourite pursuit of the microscopical pioneers.

Interestingly, the frustules can persist in the environment long after the organisms have died. This attribute extends into fossil records and supports accurate historical and paleolimnological determinations of what conditions used to be like, making these algae a favourite tool of modern ecological and evolutionary researchers.

DIATOMS AND WATER QUALITY

Within the last two decades diatom indices have gained considerable popularity throughout the world as a tool to provide an integrated reflection of water quality. Water quality assessment protocols based on the use of diatoms are well developed. For example, diatoms are now a mandatory component of the European Water Directive Monitoring.

Dr Harding explains that diatoms are primary producers located at the bottom of the food chain. Accordingly, their responses at this level (assemblages and type of species present, among others) reflect what is happening at the interface between the water they live in and the chemical-trophic response. "A change in nutrients, salinity, pH or a number of other factors will allow some members of the diatom community to grow and

reproduce more quickly while others are outcompeted, thus the community composition as a whole changes in response to changes in environmental conditions." Up to 70% of what happens in the water quality can be reflected in diatom assemblages.

It is said that many aquatic systems being studied are not supported by good information on their water chemistries, and require fairly lengthy monitoring programmes to provice the same. One or two diatom samples per year can provide this. Unlike other biotic indices, diatom communities change in response to average water quality conditions rather than 'spikes' such as those brought on by pollution spills. They are also not washed away as easily as invertebrates, for example.

As Dr Harding points out, diatom indices can potentially be used in any river system. "Even ephemeral rivers may be monitored in dry periods as the diatom cells persist, and can be sampled after the river stops flowing."

COSMOPOLITAN SPECIES

Another interesting characteristic of diatoms is that even though there is a high degree of endemism, many species are cosmopolitan or 'multinational'. This means that in many cases, environmental conditions allow for the development of the same species in Europe as in Africa as in Australia and so forth. This is important as methodologies and results from these methodologies may be used to compare river systems across provinces, countries, and even continents.

"Unlike larger animals, diatoms cannot be re-located to a new river or propagated as part of captive breeding programmes."

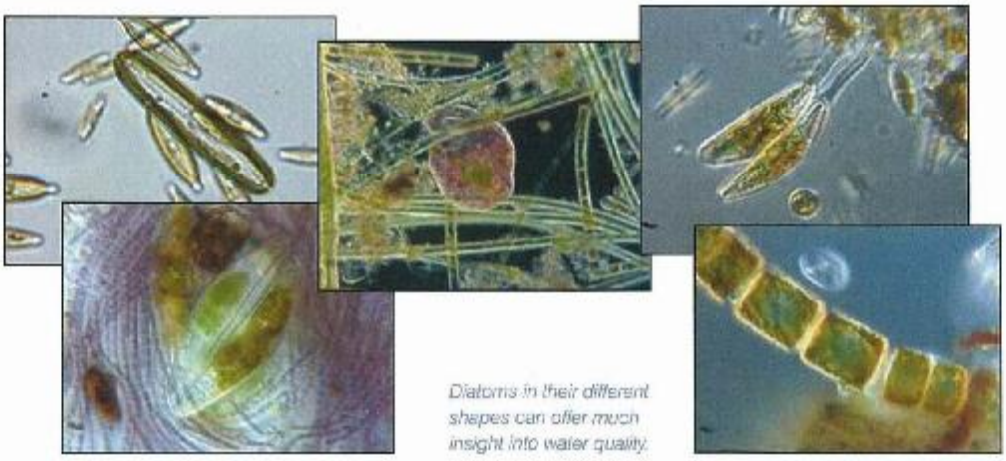
Diatom-based monitoring has proved to be very useful in regions such as Europe to monitor shared rivers and water resources, reports Dr Jonathan Taylor of the School of Environmental Sciences & Development at North West University. This cosmopolitanism does have a down side, however. "Typically, when conditions are changed from those naturally prevailing, cosmopolitan species tolerant to pollution will become dominant in an assemblage. There are relatively few of these universal dominant species, but they occur all over the world, and will outcompete endemic species sensitive to pollution should conditions favour them," notes Dr Taylor.

This underlines the importance of conserving the integrity and health of water resources not only for larger aquatic species, such as fish, frogs and insects, but also for the tiny microorganisms that live in them. "Unlike larger animals, diatoms cannot be re-located to a new river or propagated as part of captive breeding programmes," stresses Dr Taylor.

DIATOM MONITORING IN SOUTH AFRICA

South Africa has a long and proud history of diatom research, mainly as a result of the work of pioneer diatom specialists such as the late Dr Bela Cholnoky. In fact, unbeknown to many, South Africa possesses one of the most comprehensive collections of diatoms in the world.

This substantial collection of documents, slides, unprocessed sample materials and various records and observations dates back to the 1950s. At present, it is housed at the offices of CSIR in Durban. This collection is considered of cardinal value, as it contains samples of diatoms from many rivers in South Africa prior to development, i.e. before the construction of weirs and dams.



Diatoms in their different shapes can offer much insight into water quality.

A thick layer of diatom cells attached to boulders.

Diatoms inhabiting sediments.

It is hoped that this collection, which has largely been gathering dust, will be properly curated and actively managed in the near future. "This is a vital national resource of biodiversity which needs to be housed where it can be brought into the electronic age and also continually developed," notes Dr Harding.

Despite this vast collection of knowledge in the country, the use of diatoms in South African water quality studies has been virtually non-existent, until recently. A possible reason for this has been the perceived difficulty in the use of diatoms for biomonitoring. To date, other biotic indices have been favoured for freshwater health monitoring, including fish, riparian vegetation and invertebrates. In addition, the study of diatoms remains a specialist field, and there are only a handful of experts in the country.

Significant advances in supporting methods and tools have been made in the last few years, however. These have rendered diatoms easier to use as a bio-indicator. Through funding from the Water Research Commission (WRC), an illustrated guide to some common diatom species in South Africa has been compiled by DH Environmental Consulting, in collaboration with KZN Aquatic Ecosystems and North West University.

There is also a stand-alone software-based taxonomic key to the diatom species most commonly encountered in South African rivers and streams. This is a hierarchical, interactive tool that assists the user in learning more about diatoms and diatom taxonomy while seeking identification for an observed species.

In the last few years, indices developed in Europe and elsewhere have been tested in several South African river systems, and have been found useful in reflecting water quality and water quality impacts. In 2005, diatoms were successfully used for the first time as one of the biological indicators for the State of the Rivers Report on the Crocodile West/Marico catchments.

However, as Dr Taylor points out, some of the (possibly) endemic species found in South Africa are not included in international diatom indices. For this reason, diatom indices unique to South Africa are now being developed in a three-year WRC project. In addition, regional assessment using diatom indices are being planned for the Western Cape, KwaZulu-Natal and North West.

COMPARABLE TO THE BEST

According to Dr Harding, South Africa's diatom knowledge compares very well internationally. "We have come a long way within a very short time with a small group of eager and dedicated people." He reports that some of the tools produced are now being used as far afield as India and Peru – an indication of their cosmopolitan application.

Renewed interest in diatoms has awakened a wider recognition of the value of this technique such that it is now being applied across entire river systems, in urban environments and in wetland assessments. Dr Harding notes, however, that the use of diatoms does not replace any of the other biotic indices; it simply augments them.

The lack of trained diatomologists remains a challenge. "We have some very capable people, our problem is that there are too few of them," says Dr Harding. "It is crucial that we inculcate a level of interest in this field of science such that we can attract young scientists with a career interest in working with diatoms and biomonitoring." The good news is that this year at least another four diatomologists will be trained.

It is believed that diatoms have a great future in South Africa. "As recognition grows I see it becoming a mainstay of aquatic ecosystem monitoring and assessment for rivers, wetlands and estuaries", concludes Dr Harding.

For further reading:

- *The South African Diatom Collection: An Appraisal and Overview of Needs and Opportunities* (WRC Report No TT 242/04)
- *A Methods Manual for the Collection, Preparation and Analysis of Diatom Samples* (WRC Report No TT 281/07)
- *An Illustrated Guide to Some Common Diatom Species from South Africa* (WRC Report No TT282/07)

To order any of these reports, contact Publications at Tel: (012) 330-0340 or E-mail: orders@wrc.org.za

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Criteria to assess learners during this languages lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner understood the vocabulary used in the reading.						
The learner was able to answer questions without a significant amount of assistance.						
The essay written was concise and focused in its content.						
The essay was written logically and showed that the learner had done some prior research.						

ACTIVITY FOUR: CONSERVATION OF WATER QUALITY

During this PHYSICAL SCIENCES lesson, learners look at some of the abiotic (non-living) factors affecting water quality and how this may influence the system as a whole.

Make copies of the following article for each person in the class.

Temperature:

The thermal characteristics of running waters are dependent on various hydrological, climatic and structural features of the region, catchment area and river. Running waters in regions of seasonal climates exhibit daily and seasonal temperature patterns, in addition to longitudinal changes along a river course. All organisms have a temperature or range of temperatures at which optimal growth, reproduction and general fitness occur. Changing water temperature may expose aquatic organisms to potentially lethal or sub-lethal conditions. Anthropogenic (human activities) causes of temperature changes in river systems include those resulting from thermal pollution, stream regulation and changes in riparian vegetation. An increase in water temperature decreases oxygen solubility and may also increase the toxicity of certain chemicals, both of which result in increased stress in associated organisms. Many life cycle characteristics of aquatic organisms are affected by temperature, i.e. temperature is the cue for migration, breeding emergence, etc. temperature changes affect metabolic processes and life cycle patterns by altering reproductive periods, rates of development and emergence times of aquatic organisms. Differences in temperature tolerance amongst biota, regional and seasonal temperature differences, should be considered when establishing guidelines for the management of water temperature in rivers.

pH and Alkalinity:

pH is determined largely by the concentration of hydrogen ions (H^+), and the alkalinity by the concentrations of hydroxyl (OH^-), bicarbonate and carbonate ions in the water. Addition of acid or alkali to a water body alters pH. Since pH is a log scale, a change of one unit means a ten-fold change in hydrogen ion concentration. Furthermore, in very pure waters pH can change very rapidly because the change is determined by the buffering capacity, which in turn is usually determined by the concentration of carbonate and bicarbonate ions in the water. The pH of natural water is determined by geological and atmospheric influences. Most fresh waters are relatively well buffered and more or less neutral, pH ranging around 6-8. pH determines the chemical species (and thus the potential toxicity) of many elements in water. For instance, Aluminum is mobilized following acidification. Changing the pH of water changes the concentration of both H^+ and OH^- ions, which affects the ionic and osmotic balance of aquatic organisms. Relatively small changes in pH are seldom lethal, although sub-lethal effects such as reduced growth rates and reduced fertility may result from the physiological stress placed on the organism by increased energy requirements in acid or alkaline waters. Human induced acidification of rivers is normally the result of industrial effluents, mine drainage and acid precipitation. Alkaline pollution is less common but may result from certain industrial effluents and anthropogenic eutrophication. The effects of altered pH on riverine biotas have been investigated by means of toxicity tests, artificial streams and field studies. Such studies indicate that a change in pH from that normally encountered in unpolluted streams may have severe effects on the biota but that the severity of the effects depends on the magnitude of change. Some streams are naturally far more acidic than others and their biotas are adapted to these conditions. Water quality guidelines require that the Target Water Quality (*Target Water Quality is the desired state of the water quality found in a river system)* ranges for pH be stated in terms of the background site-specific pH regime. Guidelines are thus case- and site-specific and take diel and seasonal variation into account. pH values should not be allowed to vary from the range of the background pH by >0.5 of a pH unit or by >5%.

Source: The Effect of Water Quality Variables on Aquatic Ecosystems: A Review. Dallas, H. F. and Day, J. A., 2004. WRC report no. TT224/04.

Activity:

1. Explain how temperature, pH and alkalinity may affect macroinvertebrates if they are exposed to a significant change in these factors.

2. Choose one or two aquatic macroinvertebrates and do some research to find out what conditions they are able to tolerate. Use the miniSASS identification sheet on page 2 to choose your macroinvertebrate.

3. Why is pH able to change very rapidly in very pure waters?

4. What determines pH and alkalinity?

5. List some anthropogenic activities that will influence water temperature, and explain **HOW** these activities will influence water temperature.

6. List some functions in organisms that are reliant on temperature.

Criteria to assess learners during this physical sciences lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner understood the vocabulary used in the reading.						
The learner was able to answer questions without a significant amount of assistance.						
The learner was able to explain his/her findings in a concise and logical manner.						
The learner was able to conduct his/her research without a significant amount of assistance.						

ACTIVITY FIVE: IMPACTS OF DAMS ON RIVERS

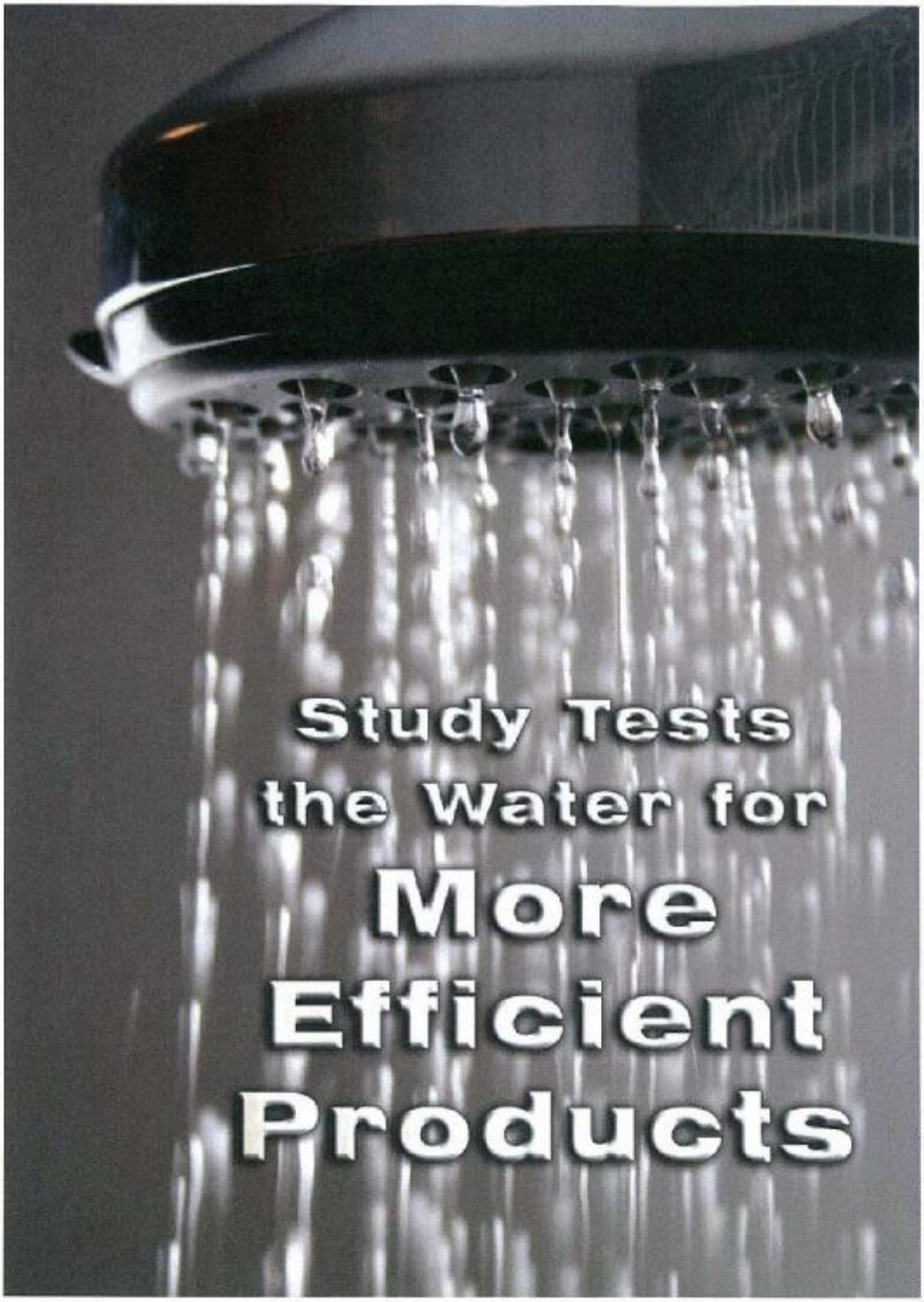
During this LIFE SCIENCES lesson learners will look at the impacts of dams on organisms downstream, and whether it is necessary to have a dam to meet growing demands.

Make copies of the article on pages 18-20 *"Study Tests the Water for More Efficient Products"* and give one to each learner to read.

Activity:
The article discusses water conservation and how there needs to be an improvement in the water conservation in South Africa as a whole. The future number of dams in South Africa is determined by the water demand, which in turn is determined by the amount of water that can be conserved

Discuss as a class:
- Are new dams a necessity if water is conserved and properly managed?
- How can water conservation standards be improved?
- What possible impacts do dams have on organisms downstream with regards to water quality? *(Hint: Temperature differences; pH differences; sediment content).*

Scenario:
Cape Town currently does not have enough water to meet their needs. Therefore the city has commissioned the building of the Berg River Dam. You are a biologist and have been asked to assess the impacts of this dam on organisms downstream of the dam. Research the potential impacts of a dam on downstream systems. You do not necessarily have to do the Berg River Dam. You may choose a dam of any significant size and research impacts that this may have on the downstream system. Sources of information are: libraries, the Internet, journals, magazines, newspaper articles.



All photographs courtesy of www.sxc.hu

Living in an increasingly water-stressed country, South Africans need to become much more water efficient. This is one of the recommendations from a recently-completed study funded by the Water Research Commission (WRC).

Traditionally, water consuming products, such as toilets, showers, washing machines, dishwashers, baths and taps have been designed with functionality, aesthetics and cost in mind. Little attention was paid to how much water these items used.

However, global concerns such as burgeoning population growth and rapid urbanisation amid increased water scarcity has prompted the realisation that water can no longer be used with reckless abandon, and sparked investigations into ways of using water more appropriately and efficiently.

There are many examples of water demand management and water conservation campaigns that have been implemented around the world: the city of Seattle in the US, for example, has reduced its water consumption by 1% each year over the last 23 years despite a 23% increase in its population. In southern Africa, the city of Windhoek has managed to reduce the average consumption from 320 ℓ per person/day to 220 ℓ per person/day over the last 30 years.

Closer to home, water conservation programmes carried out in the various municipalities supplied by Rand Water have seen the annual growth rate in the water supply to the water board's supply area reduce from 3.3% to virtually zero over the last three years, despite a concurrent 3,3% population growth rate. Cape Town, which has been through several years of water stress in the last few years, has developed a holistic water conservation strategy, which includes the promulgation of the most comprehensive water conservation bylaws in South Africa.

***Left:** It is relatively easy and inexpensive to swap out shower fittings with more water efficient products.*

The WRC-commissioned study, conducted by Partners in Development (PID), included four surveys in order to gauge the status and use of water efficient devices in South Africa. Firstly, commercial and institutional settings such as hotels and hostels were investigated; secondly, the suppliers of plumbing fittings were studied; thirdly the architectural profession was surveyed; and finally the knowledge and attitude of 1 428 home owners in ten towns and cities across South Africa were tested.

INCREASED AWARENESS

According to project leader David Still the study found clear evidence that water efficient devices are becoming more common. "From the City of Cape Town's programme to replace all the automatic flushing urinals in public buildings and install Hippo Bag displacement devices in all the old large capacity school toilet cisterns, to the sophisticated infrared operating taps and urinals that are becoming standard at airports, there is a move towards water saving and water efficiency," he says.

"We have the legislation and policies in place, however, we lack the capacity to drive the process."

Speaking at the 10th Annual Water Distribution Analysis (WDSA) Conference, held in the Kruger National Park in August, Still noted that the larger hotel groups were signing on to environmental programmes, one of whose components is sustainable water use, and that there were encouraging examples where university hostels and other public buildings were being retrofitted with water-saving cisterns, taps and showers.

Some of the worst offenders for high water usage are government buildings. For example, among the 50 highest water users in Pietermaritzburg, in KwaZulu-Natal, are several public schools which do not have boarding establishments. It is therefore felt the State should take the lead by ensuring its buildings are as water efficient as possible. "This would have an impact on the civil service, which employs over a million people, and the population at large, which would see the State leading by example," said Still.

LOCALLY AVAILABLE PRODUCTS

The increasing market share of water efficient devices is apparent on the showroom floors of the major plumbing suppliers. This is almost in spite of the suppliers, who as a rule do not push water efficiency. "The reason aerated taps, dual flush toilets, water efficient baths, basins and showers are increasingly being sold, is that these are becoming the standard in the countries of manufacture in Europe and the East. While South Africans are sometime still wary of six-litre flush toilets these, or even more efficient designs are now the standard in parts of the US, the UK and Europe," reported Still.

According to Jay Bhagwan, WRC Director: Water Use and Waste Management, lack of strong enforcement and regulation remain the greatest challenges in South Africa. "We have

MAIN RECOMMENDATIONS FROM THE STUDY

Government must lead by example

The State landlord, the Department of Public Works, should embark on an audit of water usage and the presence of water efficient devices in all buildings under their care. This would have an impact on the civil service, which employs over a million people, as well as the population at large, which would see the State leading by example.

SA needs a labelling system for water efficient devices

South Africa should emulate the water efficiency labelling system practiced in other countries, of which the most advanced appears to be the Australian WELS label. The label is not just a general 'green' label, but includes product specific information and a graded rating from 0 to 6 stars.

SA needs a nationally sponsored public education campaign regarding water efficient devices

The State needs to make a case for water saving with the public. This campaign should appeal both to the public's sense of civic duty (it is the right thing to do), while not underestimating their intelligence (answering questions like "Why don't we just building bigger dams?" and "If I am prepared to pay for what I use why can't I use as much as I want?").

Information on water efficient devices must be easily obtainable

The public and even the building industry are still relatively ill-informed about water efficient devices. Water conservation in the built environment should be taught at undergraduate

level to architects and at FET colleges to plumbers. Water saving tips should be regularly distributed with municipal accounts, and should be displayed in appropriate locations.

Municipal bylaws must include provisions relating to water efficiency and water conservation, and ideally there should be convergence across municipalities

It would help if there was more consensus between municipalities on water bylaws, particularly in the case of a large conurbation such as Gauteng, which spans several municipal jurisdictions.

Building codes and bylaws must converge

Bylaws relating to the types of showers, baths and toilets installed in houses are really only enforceable for new housing stock, and even then it seems unlikely that municipalities have enough building inspectors to do this work adequately. It would be far simpler to inspect at the source, i.e. to control what products are sold by the plumbing suppliers.

A section needs to be added to the building code to bring it into line with modern water efficient good practice. If this was done, then the suppliers and specifiers would be able to follow without worrying that they are out of line with standard practice.

Retrofit programmes with rebates (where appropriate) should be encouraged

In South Africa there are many millions of poor people who are not required to pay for their water supply. While the official policy guideline is that each family should get a lifeline amount of water of 6 kℓ free, in some urban areas the reality is that no water is paid for. For people in these areas there is no incentive to conserve water. In such areas, it may pay a municipality to intervene with schemes to retrofit water efficient devices, even if the full cost were to be borne by the municipality.

Water supply pressures must be decreased

Water supply pressures in South Africa are, in general, far above international norms. No more than four bars of pressure is needed for domestic water supply, and municipalities would save both themselves and their customers money if they took steps to regulate the pressure in their systems down to this level.

Informative billing

Even educated customers take little time to attempt to understand or analyse their utility bills, which typically combine water, electricity, refuse removal and sewage charges. With modern technology it would be possible to include simple graphic information, such as a graph showing how water consumption has varied from month to month for the last 12 months. With such easy to read, visual information, consumers can be more easily alerted to leaks or wastage on their properties.

the legislation and policies in place, however, we lack the capacity to drive the process." Bhagwan believes more drive needs to come from the broader society, since water wastage affects us all. "Inefficient use of water is a bad disease which can severely impact our water security in future."

ANTIQUATED BUILDING CODE

While there is some evidence that architects are moving towards an awareness of sustainable water use, the building profession in general is still quite conservative, with a strong tendency to stick to tried and tested products. "This sector is guided strongly by the building code, and the view of respondents to the survey was generally that only if the building codes were changed would they consider implementing more water saving devices.

"The penetration of water efficient devices into the South African domestic market is going to be slow and gradual, probably taking a generation or two to become the norm."

Therefore one of the recommendations from the study is that a section needs to be added to the building code to bring it into line with modern water efficient good practice and legislation. "If this was done, then suppliers and specifiers would be able to follow without worrying that they are out of line with standard practice," said Still.

FINANCIAL CONSIDERATIONS

The 1 428 homeowners surveyed came from a range of socio-economic backgrounds in ten South African cities and towns. A total of 29% of these homeowners indicated that they already had at least one water efficient device in the home.

WHAT IS A WATER EFFICIENT DEVICE?

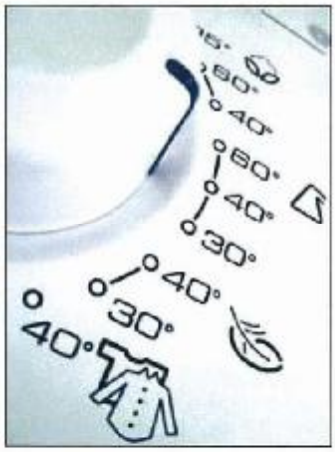
A water efficient device is one which serves the same function as its standard alternative, without any reduction in performance, while using less water.

Typically only about 20% of the respondents in the average town believed they might possibly use too much water, but significantly more (nearly 50%) have considered reducing their water consumption.

According to the study, the factors which prevent people from installing water efficient devices include a lack of knowledge about water efficient devices, the fact that they might not own their own home (renting), or that they cannot afford to make changes, among others. "Conversely the conditions which would persuade people to move to water efficient devices include an increase in the price of water, if rebates were offered for the installation of water savings devices, if there were water restrictions, if they had a better understanding of water efficient devices and if the use of hosepipes was banned."

Whereas it makes economic sense to install water efficient devices in new buildings, the economics of retrofitting water efficient devices to existing housing stock is very variable, depending on the device and setting in question, the project team found.

The quickest and cheapest water efficiency retrofit measure for the domestic market is the aerated shower head. "It is relatively easy and inexpensive to swap out shower fittings and these will



Many water efficient products are now available on the market.

typically pay for themselves in water savings in a few years," noted Still.

However, the economics of changing out toilet cisterns and pans is rather less attractive, unless they are in a setting where they are used by more users than would be found in the average home. "For this reason, large-scale changes to the existing housing stock are unlikely, and therefore the penetration of water efficient devices into the South African domestic market is going to be slow and gradual, probably taking a generation or two to become the norm," reported Still.

To order the report, *The Status and Use of Drinking Water Conservation and Savings Devices in the Domestic and Commercial Environments in South Africa* **(Report No: TT 358/08)** contact Publications at Tel: (012) 330-0340 or E-mail: orders@wrc.org.za

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Criteria to assess learners during this life sciences lesson

Criteria	Outstanding	Meritorious	Satisfactory	Adequate	Partial	Inadequate
The learner understood the vocabulary used in the reading.						
The learner contributed meaningfully to the discussion.						
The learner was able to explain his/her findings in a concise and logical manner.						
The learner was able to conduct his/her research without a significant amount of assistance.						